A Study of Polished Stone Tools from Samrong Sen, Cambodia: The French Museum Collections

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# TABLE OF CONTENTS

Abstract .................................................................................................................................................. I  
Acknowledgements .............................................................................................................................. II  
List of figures ....................................................................................................................................... IV  
List of tables ......................................................................................................................................... VII  

## Chapter I

1. Introduction ...................................................................................................................................... 1  
2. The Foundation of Archaeological Research: Samrong Sen and Prehistoric Sites of Cambodia .... 3  
3. Prehistoric site of Samrong Sen and research history ................................................................. 5  
   3.1. Site location ............................................................................................................................... 5  
   3.2. Regional geography .................................................................................................................. 6  
   3.3. Research history ....................................................................................................................... 7  
4. Collections from Samrong Sen ....................................................................................................... 10  
   4.1. Cambodia ............................................................................................................................... 10  
   4.2. Overseas .................................................................................................................................. 10  

## Chapter II

1. Lithic assemblages of Samrong Sen ............................................................................................... 15  
   1.1. General information and problems ....................................................................................... 15  
   1.2. Raw material and residue analysis ....................................................................................... 16  
      1.2.1. Methodology .................................................................................................................. 16  
      1.2.2. Macroscopic descriptions ............................................................................................... 17  
      1.2.3. Mineralogy (Infrared Spectroscopy analysis) ................................................................. 19  
         1.2.3.1. Basic method ........................................................................................................ 20  
         1.2.3.2. Explanation of the infrared spectra ........................................................................ 21  
      1.2.4. Analytical chemistry ....................................................................................................... 24  
2. Analysis of stone tools .................................................................................................................... 31  
   2. 1. Typo-technological study ....................................................................................................... 31  
   2. 2. Morphological characteristics .............................................................................................. 44  
      2.2.1. Measurements .............................................................................................................. 44  
      2.2.2. Cross-sections .............................................................................................................. 48  
      2.2.3. Cutting edges ............................................................................................................... 49
ABSTRACT

The prehistoric site of Samrong Sen has been discovered in the late 19th century. Large quantities of the artefacts were purchased from the villagers by different visitors and archaeologists who visited the site and exported them to Europe or other countries. For the moment many artefacts have been reported from different museums particularly in France. Musée de l’Homme, Paris, Musée d'Histoire Naturelle de Lyon, Musée d'Histoire Naturelle de Toulouse, Département de Préhistoire (Institut de Paléontologie Humaine), Paris, Musée des Antiquités Nationales, Saint-Germain-en-Laye near Paris and a few are displayed at the Museum of Far-Eastern Antiquities in Stockholm.

Polished stone tools from Samrong Sen are the main topic of this study. They belong to different collections and all together comprise around 287 pieces with different tool types. Typology, morphological characteristic, raw material and chemical analysis, micro-wear examination and ethnographic comparison as well as comparison to polished stone tools of other prehistoric sites inside and outside the country are discussed in this dissertation.

The target of this study is to collect and record the maximum data for the cultural assemblage of Samrong Sen, mainly the polished stone tools that kept in European museums, and to save them as a reference for further study of the polished stone implements of the Cambodian prehistory.

Keywords: Samrong Sen, Cambodia, Polished stone tool, Neolithic or Bronze Age

RESUME


Environ 287 outils polis, de divers types ont été étudiés dans toutes les collections. Outils en pierre polis sont le principal sujet de cette étude. La typologie, les caractéristiques morphologiques, les matières premières et l'analyse chimique, la tracéologie et la comparaison avec les données de l'ethnographie aussi bien que la comparaison à des outils de pierre polie d'autres sites préhistoriques à l'intérieur et à l'extérieur du pays sont discutés dans cette étude.

Le but de cette étude est de rassembler et enregistrer le maximum d'informations pour l'assemblage culturel de Samrong Sen, en particulier les outils de pierre polie conservés dans les musées européens et afin de les utiliser comme référence pour l'étude future des outils de pierre polie de la préhistoire cambodgienne.

Mots clés: Samrong Sen, Cambodge, outil en pierre polie, Néolitique et Age du Bronze
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LIST OF FIGURES

Figure 1: Prehistoric sites in Cambodia, discovered before and after Khmer Rouge (modified from Mourer 1994 and Albrecht et al., 2001)

Figure 2: Idealized bird-view plan of Samrong Sen and its contemporary activities areas (Courtesy of L. Vanna, 1999)

Figure 3: Raw materials of polished stone tools from Samrong Sen, obtained from the inventory at Musée de l’Homme, Paris and Musée d’Histoire Naturelle de Lyon

Figure 4: Position of an infrared in the spectra (Courtesy of Louis Keiner, 2006)

Figure 5: A, Stretching vibrations change in inter-atomic distance along bond axis of the molecular. B, Bending vibrations change in angle between two bonds. There are four types of bend: rocking, scissoring, wagging and twisting

Figure 6: Schist spectra of an adze from Samrong Sen (n° 33.17.105) with the specular reflection technique. The operation carried out the Département de Préhistoire Centre de Spectroscopie Infrarouge (MNHN) by Dr. Xavier Gallet, 2007

Figure 7: A, Infrared (IR) spectrophotometer at the Spectroscopy Infrared Centre of the Département de Préhistoire (MNHN) used for the analysis of polished stone tools from Samrong Sen. B, chisel placed on platform and detected by the laser from the lower part (Photos: H. Sophady, 2007)

Figure 8: A: Trunk of Chheur teil (Dipterocarpus alatus), B: Flower and leaves of Chheur teil (Photos: A and B courtesy of T. Ratanak et al. 2005), C: Cambodian people (Phnong origin) in Mundulkiri, Province gathering resin from the hollowed out trunks from Dipterocarpus alatus trees. They usually ignite and burn out the excess resin in the hollows so the trees may produce more resin in time (Photo courtesy of ChKESE, 2006)

Figure 9: Difference resin in the solvent: R is resin reference, n° 1 is mixture resin, n° 2 is chheu chong and n° 3 is chheu teil. 1-3 are modern resin (Photo: H. Sophady, 2007)

Figure 10: Michèle Meyer in preparation the ancient resin: after extraction and filtration the evaporation of the solvent by using the Rotavapor (Photo: H. Sophady, 2007)

Figure 11: Drawing and photo shows the Chromatography method. Aluminium plate is placed in the glass tank and absorbed by solvent (Photo: H. Sophady, 2007)

Figure 12: Plate 1 revealed the sample n° 2 and R have the same Rf and n° 1 and n° 3 have also the same Rf (Photo: E. Gonthier, 2007)

Figure 13: Plate 2 revealed the different chemical composition movement distance. Only n° 1 and n° 3 have the same Rf (Photo: E. Gonthier, 2007)

Figure 14: Plate 3 reveals the difference distance of colour travels from the bottom line where all samples were drops (Photo: E. Gonthier, 2007)

Figure 15: Variety forms and sizes of polished stone adzes of Samrong Sen (Drawings H. Sophady, 2007)

Figure 16: Variety forms and sizes of polished stone adzes from Samrong Sen (Photo: H. Sophady, 2007)
Figure 17: Variety of sizes and shapes of shouldered adzes and axes from Samrong Sen (Photos: H. Sophady, 2007)

Figure 18: Variety forms and sizes of polished stone adzes of Samrong Sen (Drawings H. Sophady, 2007)

Figure 19: n° 8.983.1.149 and 8.983.1.127 represent shouldered adzes with dissymmetry double bevel on cutting edge while n° 33.17.178 represent of shouldered axe with symmetry on cutting edge (Drawings H. Sophady, 2007)

Figure 20: Different forms and sizes of polished stone gouges occurring in the collection (Photos: H. Sophady, 2007)

Figure 21: Different sizes and forms of stone gouges from Samrong Sen and n° 8.983.1.195 is a small stone chisel (Drawings H. Sophady, 2007)

Figure 22: Variety forms and sizes of stone chisels from Samrong Sen with the exception of n° 33.17.3 that is a single pre-form found in the collection (Photos: H. Sophady, 2007)

Figure 23: n° 33.17.37 burnisher (Type 7) polished and dulled on the cutting edge, suggested to be used for burnishing of pottery (Photos: H. Sophady, drawing courtesy of H. Mansuy 1902). N° 33.17.18 celt hammer (Type 8) dulled and heavily damaged on the cutting edge, possibly used as hammer (Photos and drawn by H. Sophady, 2007)

Figure 24: Graph shows the different tool types from Samrong Sen occurring in the collections

Figure 25: Principle section of polished stone tools (Drawings H. Sophady 2000)

Figure 26: Dimensions of the polished stone tools from Samrong Sen

Figure 27: Different cross-sections observed on the polished stone tools from Samrong Sen (Modified from E. Gonthier, 1987)

Figure 28: Varieties of profiles of polished stone tools from Samrong Sen, first column front view and second column side view (Drawings H. Sophady, 2007)

Figure 29: Shouldered adze showing cut marks on both faces. This tool is kept in Département Préhistoire, IPH (Photo: H. Sophady, 2007)

Figure 30: Cutting lines observed by microscope on both left and right sides of the tenon of a shouldered adze. These lines are considered as being the traces of some kind of saw utilised for the stone tool manufacture at Samrong Sen (Photo: H. Sophady, 2006)

Figure 31: Stone implement from Kulai Kua, Bien Hoa province, Vietnam observed in the collections at National Museum of Antiquities, Saint-Germain-en-Laye near Paris. The tools are characterized by deep curve and sharp angle on the shoulder supposed to be made by sawing rather than by flaking (Photos: H. Sophady with the authorisation of the M.A.N., 2007).

Figure 32: Fine paralleled and oblique striation was examined on the edge of the upper face of an adze from Samrong Sen. The pattern reveals that the polishing technique
was to the oblique direction rather than following the symmetry axis of the tool (Photo: E. Gonthier, MNHN, 2007)

**Figure 33:** Edge angles of different tool types from Samrong Sen: collection kept in Musée de l’Homme and Départment de Préhistoire (IPH).

**Figure 34:** Deer antler sockets found at Charavince southern of France. These were used to connect the axe and adze to their handle (Photo: by H. Sophady 2007).

**Figure 35:** Basic hafting methods of polished stone tools. N° 1: Technique of cutting tree branch for making a handle (Drawings by H. Sophady following the explanation of E. Gonthier). Types 1-3 are typical for adzes; types 4-7 for axes; type 1, 4 and 5 are commonly used by the people in Irian Jaya, New-Guinea, Indonesia. (Types 1 and 5: drawn by H. Sophady; types 2, 3, 4, 6, 7, 8 and 9 redrawn from Coghalan, 1943)

**Figure 36:** Tools selecting for microwear analysis. The red circles demonstrate the places were taken photographed for use wear (Photos: H. Sophady, 2007)

**Figure 37:** Use wears patterns of different tool types (Photos: H. Sophady, 2007)

**Figure 38:** Use wears patterns of different tool types (Photos: H. Sophady, 2007)

**Figure 39:** Felling tree by using polished stone adze. Langda, Una group, New Guinea, Indonesia (Photo: courtesy of Anne-Marie and P. Pétrequin, 2006)

**Figure 40:** The Wano ethnic group of the Village Ye-ineri, New-Guinea, Indonesia, splitting wood by polished stone axe (Photo courtesy of Anne Marie and P. Pétrequin, 1993)

**Figure 41:** Stone chisel used to make a hole in a wooden handle, Village Ye-Ineri, Wano group of New-Guinea, Indonesia (Photo: courtesy of Anne-Marie and P. Pétrequin, 1993)

**Figure 42:** Kranorch (Kr’ung language) is the iron tool used by Kru’ng people at Rattanakiri province, Northern Cambodia for clearing ground (Photos: A, H. Sophady and B, G. Albrecht, 2002)

**Figure 43:** Iron tool used by the people of Satum Village, Memot district, Kampong Chan province, eastern Cambodia for clearing ground for agriculture. Inside red circle is a stone shoulder adze of the prehistoric time found in the region by the villagers (Photo: by H. Sophady, 2005)

**Figure 44:** An early Neolithic grave from Ban Kao, Thailand, contained of many grave goods including polished stone adzes (Photo courtesy of Higham, 2002)

**Figure 45:** Map shows the three main zones for adze distribution in Southeast Asia (Courtesy of Duff, 1970)

**Figure 46:** Variety tool types that are not exist at Samrong Sen: n° 1 from Laos, n° from south China, n° 3 & 4 from Malaysia and n° 5 from Philippines (After Duff, 1970)

**Figure 47:** Variety tool types that are not present at Samrong Sen: n° 1 from Indonesia, n° 3 & 4 from Philippines, n° 5 & 6 from Thailand (After Duff, 1970)
LIST OF TABLES

Table 1: Polished stone tools found in the Samrong Sen collections kept in French museums

Table 2: List of stone implements within the different collections

Table 3: Average dimensions of polished stone tools from Samrong Sen

Table 4: Proximal and distal cross-section of different tools

Table 5: Cutting edge condition of polished stone tools from Samrong Sen

Table 6: Profiles of the cutting edges of polished stone tools from Samrong Sen

Table 7: Butt condition of polished stone tools from Samrong Sen

Table 8: Summary of the results of determined angle edges and their association with task-specific activity after Ludomir Lozny (2004)

Table 9: Average angles of different tool types from Samrong Sen

Table 10: Summary of microwear and technological examination

Table 11: Average dimensions of stone tools from Samrong Sen and Circular earthworks
Chapter I

1. Introduction

Samrong Sen is one of the earliest known prehistoric sites in Cambodia. This place has become famous throughout the region and is considered to be one of the most important sites for prehistoric study, not only in Cambodia, but also in mainland and island Southeast Asia because of the varied and abundant artefacts collected from the site. Some archaeological materials with various styles were obtained by systematic excavations conducted by French archaeologist H. Mansuy in 1901 (Mourer, 1970: 42), and numerous of artefacts from illegal excavations by the villagers during the late 19th and early of 20th century. These include: decorated pottery in different shapes and varieties, various types of polished stone implements, stone ornaments, ornaments made from shell and ivory, bone tools including harpoons, projectiles, clay net sinkers, fish hooks, clay anvils, bronze objects, animal and fish bones as well as fragments of human skeletal remains.

Many artefacts were exported by different visitors and archaeologists who frequented visited the site more than one century ago (Moura, 1876; Corre, 1879; Ludovic Jammes, 1887; Mansuy, 1902 & Janse, 1935, & etc). These collections were moved from one place to another for many reasons. Fortunately, we discovered collections presently kept in museums and institutions in France. For instance, Département de Préhistoire, Musée National d'Histoire Naturelle, Paris (Musée de l’Homme), Musée d'Histoire Naturelle de Lyon, Musée d’Histoire Naturelle de Toulouse, Musée des Antiquités Nationales, Saint-Germain-en-Laye and the Département de Préhistoire (Institut de Paléontologie Humaine), Paris. In addition, several objects are currently displayed at the Museum of the Far Eastern Antiquities in Stockholm. I hope that into the future, aside from the museums mentioned above, collections from Samrong Sen will be confirmed in museums or private collections from other countries.

Study of prehistoric finds of Samrong Sen has not been taken into consideration until recently, despite various efforts to describe it (Noulet, 1879, Mansuy, 1902; Mourer, 1994 & Matringhem, 1995). The study of polished stone tools from Samrong Sen is still lacking in relation to detailed information regarding the development of technology, typology, raw material analysis, diffusion and the relationship with different cultural levels of neighbouring regions. For example, Mansuy noted that there are 275 of different polished stone tools in the collection (Mansuy, 1902: 23) and broadly described the specimens. Unfortunately, only 142 stone tools are available in the collection at present. In his publication, Mansuy (1902) provided a classification but it does not include a distinction between axes and adzes. Mourer described, in a very short and general way, the typology characteristics, techniques of manufacture and raw
material (Mourer, 1994:159). Thus, study of polished stone implements derived from this site requires a more detailed analysis.

Stone tools represent some of the best remaining evidence of prehistoric behaviour and cognition. Interpreting this evidence properly requires careful study of typology, morphology, technique of manufacturing, source of raw materials, traceology, spectrographic analysis for examining different rock types, function through comparisons with modern tool types and its correlation to other prehistoric cultures intra and extra region. The objective of this research is to collect as much data as possible on these archaeological materials and present it as an important document for the study of Cambodian prehistory.

Seeing this important need, I have chosen only polished stone tools - particularly the type of axe/adze, shouldered adze/axe, chisel and gouge for this study. They are the main objective of this study. It is not possible to carry out an analysis of all the specimens because of time limitation, the large number of artefacts and their variety. Because the collections are available in France, research and re-examination can be done conveniently in situ.
2. The Foundation of Archaeological Research: Samrong Sen and Prehistoric Sites of Cambodia

The majority of early archaeological investigations in Cambodia were conducted by the French. The “discovery” of the magnificent Angkor Wat complex in 1858 by the French naturalist Henri Mouhot, initiated French archaeological interest in Cambodia. As was common for the period, scholarly interest was primarily focused on classic monumental structures of the historic period rather than prehistoric sites. However, prehistoric research became important subject of study and more interest was generated about these early sites after the discovery of a shell midden site in 1876 known as Samrong Sen.

Since the first investigation of Samrong Sen, the ecological and archaeological significance of the site, as well as other prehistoric sites throughout the country, became legitimised by western archaeologists. Research by foreigners at prehistoric sites increased and pre-Angkorian timelines of the country’s history were created. From Samrong Sen, prehistoric research spread to various sites and time periods throughout the country (Fig.1). While research remained focused at Angkor, individuals such as H. Mansuy, P. Lévy, L. Malleret, B.P. Groslier and R. Mourer opened the window into Cambodian prehistory. A. Pavie (1901) mentioned the shell midden of Kbal Romeas on the coast of Kampot and investigations were continued by J.P. Carbonnel and Delibrias in 1968. J.P. Carbonnel and Guth conducted additional investigations of additional limestone-formed caves at Phnom Laang, also in Kampot (Carbonnel & Guth, 1968). H. Mansuy excavated the shell midden of Samrong Sen (Mansuy, 1902), P. Lévy excavated the open-air site of Mlu Prei to the north (Lévy, 1943), L. Malleret investigated circular earthwork sites in the red soil plateau area of eastern Cambodia and southern Vietnam (Malleret, 1959), E. Saurin began documenting the pebble tools of the Mekong terraces from Kratie to Stung Treng (Saurin, 1966), B.P. Groslier, following Malleret, conducted excavations at a circular earthwork in Memot (Groslier, 1966a & 1966b). R. Mourer explored and documented the large cave settlement of Laang Spean in Battambang, northwest Cambodia, with its prehistoric levels (Mourer, 1970). Carbonnel explored a group of prehistoric sites in the rubber plantations of Chamkar Andong, Chup, Thmor Pich, Peam Cheang and Prek Kok of Kampong Cham province (Carbonnel, 1970). As seen from this sample of work, a varied and valuable amount of research was indeed focused on several Cambodian locations with the goals for better understanding Cambodian prehistory, not at the expense of the larger historic sites but in concert with historic studies. Conterminously, the studies would form the backbone for the known timeline of Cambodia.

Prehistoric research was almost always secondary to the studies of monumental sites such as Angkor and Sambor Prei Kuk and can rather be seen more as a gradual expansion of researchers and research projects. While groups such as l’École Française d’Extrême-Orient
(established in the late nineteenth century), began a period of intensified investigation of the physical remnants of the Khmer Empire from the late 1800s/early 1900s, their scholars such as Groslier and Malleret branched into the prehistoric realm. Most colonial French cultural scientists studied art, architecture and inscriptions, generally addressing stylistic and symbolic issues in the valuable archaeological record provided by monumental architecture, statuary and inscriptions.

Samrong Sen, the focus of this discussion, remains a key site for prehistoric investigations in Cambodia. The site has been studied for the longest amount of time and by a diverse group of scholars. Any discussions on the prehistory of Cambodia ultimately involve the many data sets from this complex site.

![Map of Cambodia with prehistoric sites](image)

**Fig. 1:** Prehistoric sites in Cambodia, discovered before and after Khmer Rouge (modified from Mourer, 1994 & Albrecht et al., 2001)
3. Prehistoric site of Samrong Sen and research history

3.1. Site location

The prehistoric settlement of Samrong Sen is situated around 22km east of the provincial port of Kampong Chhnang. It lies on the east bank of the Steung Chinit, a tributary of the Tonle Sap. The prehistoric occupation layer lies underneath the modern village. Based on GPS (Global Positioning System) data and geographical information, the site is located directly at the central of the country with the latitude of 12° 20’N and longitude of 104° 50’E (Fig. 1). This village belongs to the Kampong Leng district, Kampong Chhnang province and is settled on an irregularly oval mound, with a north-south length of 600m and broadly elliptical in form, 300m in width (Vanna, 1999:8) (Fig. 2).

Fig. 2: Idealized bird-view plan of Samrong Sen and its contemporary activities areas (Courtesy of L. Vanna 1999)

There are two possibilities to reach the site, one by water and second by land routes, but land routes are only accessible to vehicles during the dry season. The most convenient is to travel by water where it is possible to travel the whole year round with the use of a local boat from Kampong Chhnang port across the Tonle Sap to the east and passing through Steung
Chinit. This trip will take 3 hours during dry season when the water level is low and during the flooding season, by using a short-cut it takes around two hours.

3. 2. Regional geography

The area where the site is located is on the eastern bank of the Tonle Sap River, on a vast inundated plain extending up to the western bank of the Mekong River. This enormous area has been geomorphologically classified as belonging to the region of soil of the vigorous floodplains. The region is sub-divided into three zones: meander floodplains, expansive floodplains and lacustrine floodplains (Vanna, 2002: 193-194). Samrong Sen is located in lacustrine zone with other prehistoric sites discovered by L. Vanna like Kien Leas, Kop Ches, Po Prok and Kok Trabeak and the previously known Anlong Phdao (Vanna, 2002:195). Lacustrine floodplains can be distinguished as vast plains surrounding the Great Lake of the Tonle Sap. These plains are flat and featureless with finely textured sediment. The area is characterized by inundated forests, ponds, small rivers which are flowing from north-east during rainy season and flowing back to the Tonle Sap when the water level of the Mekong River recedes during the dry season. Several mountains are situated along the river bank on the right side of the Tonle Sap and approximately 7km or 10km west of the site. These mountains are considered to be the source of raw material for stone tool manufacturing during the site occupation. The plains to the east of Kampong Chhnang are extensive areas, drained by the Tonle Sap River and its tributaries. The areas are covered with recent alluvium and are relatively fertile.

The Cambodian tropical climate is characterized by two seasons. The dry season starts from October until the end of May and rainy season start from June to October. The maximum temperature ranges from 30°C to 33°C during March to April or May and the minimum ranges from 26°C to 29°C during November to February. Every year during the rainy season from June to October the water level of Mekong River rises, the water flows from South to fill the Great Lake and all its tributaries around including Steung Chinit. The shell mound of Samrong Sen and the area surrounding it are flooded during this time. During the dry season from October to May, the water level of Mekong River is lower than the water level of Tonle Sap, the water flows back from Tonle Sap to the Mekong River. When the water level is going down from February to April the whole area is covered by bushes and other water plants which are rich and diverse with fish and other animals. During the dry season, we will see many fishing lots along the Steung Chinit and also the agricultural fields mainly of rice.

In the past, when Mansuy conducted his research at the site he mentioned that the living subsistence of the inhabitants were based on fishing and exploitation for the extraction of mollusc shells for the production of hydrated lime and Kampong Chhnang and Phnom Penh are
the most important markets for lime (Mansuy, 1902: 1). The production of hydrated lime was continued up to 1930s (Demeter et al., 1999: 125) by the villagers of Samrong Sen who destroyed the site heavily. At present, community economics have changed, with living conditions based on fishing and agriculture (planting crops such as rice, corn, lotus and other plants which are possible to grow only during the dry season) and fishing is the most important economic source of the community, because fishing can be carried out perennially. Besides this, they also do a small trade exchange with adjacent communities, particularly at the Kampong Chhnang town. Some families sell spices and food in the village as a small business besides agriculture and fishing. In 1999, there was a population of around 1,237 Cambodians within 235 stilt houses; a school and a new Buddhist pagoda was settled on the mound (Vanna, 1999: 9).

3.3. Research history

The history of the discovery and research on sites were described in detail by previous researchers (Corre, 1879; Fuchs, 1882, 1883; Mansuy, 1902; Mourer, 1994; Vanna, 1999; and briefly mentioned by Solheim II, 1960; etc.). In this paper, I will review the research history from previous reports and add some recent research activities by young Cambodian scholars.

The prehistoric site of Samrong Sen (name of the site was written in different ways in the previous publications, for instance “Somrong-Sen” (Noulet, 1879), “Somron-Seng” (Mansuy, 1902), “Somrong seng” (Heine-Geldern, 1932), “Somrong Sen” (Duff, 1935), “Som-Ron-Sen” (Demeter et al., 1999). Actually, the correct name written “Samrong Sen” was accidentally discovered and reported by M. Rouques, Director of the Fluvial Transportation Company in 1876 (Mansuy, 1902; Mourer, 1994 & Vanna, 1999). After that, the site was visited by J. Moura, lieutenant of the ship Transportation Company and representative of the French protectorate in Cambodia in the same year of the site discovery.

Moura examined this site and collections in a superficial manner, and did not make plans to excavate; however, this explorer collected a few objects from the site and offered them to the Musée d'Histoire Naturelle de Toulouse. A year later doctor J. B. Noulet, curator of the museum, published an article based on the specimens, with uncertain information on the site and published this article in Archives du Musée d'Histoire Naturelle de Toulouse (Noulet, 1879). In 1879 and 1880, Corre, medical doctor of the marines, published an article entitled “excursions et reconnaissances” volumes 1 and 2; this report provided very interesting information regarding the research in Samrong Sen (Mansuy, 1902). Besides the archaeological information, Corre also conducted ethnography which he did on the site. He mentions in his report about an existence of a settlement of around 60-80 villagers living in piled houses and he
describes the daily living conditions that were particularly based on fishing and on burning the shells dug from the mound for lime (Vanna, 1999: 5).

E. Fuchs, an engineer and a head in the field of the mineral ores presented to the l’Association Française pour l’avancement des sciences his primary investigation of the hillock of Samrong Sen and its cultural context (session of the Rochelle sitting of August 26, 1882) (Mansuy, 1902 & Vanna, 1999). In a note on the same topic, Fuchs stated that the rich prehistoric site of Samrong Sen is possibly dated back to only few centuries BCE according to yearly plugging of the Mekong River (Vanna, 1999:6).

Another visitor to the site was Ludovic Jammes, a member of the Society of the Indo-Chinese Studies. He visited Samrong Sen from 1887 to 1888, and collected large quantities of cultural materials from the site and he published a short report with poor scientific information in the Indo-Chinese Magazine (No. 8, 1893) (Mansuy, 1902: 2). H. Mansuy initiated the first test excavation at the site in 1901 (Mourer, 1970: 42) after the site had been reported by previous experts and amateurs as an important archaeological site. Mansuy published the results of his works the next year (Mansuy, 1902). In this publication he demonstrated the plan view of the site and an interpretation of different cultural strata. But, he neither described the location of the excavation units, nor mentioned the methodology of the excavations, nor presented the excavation plans. In contrast, in his publication in the Southeast Asian Archaeology International Newsletter, Issue no. 19, Part II, concerning “A Brief History of Mainland Southeast Asian Prehistoric Archaeology”, Wilhelm G. Solheim II noted that the person who first excavated at Samrong Sen was Ludovic Jammes who published his report in 1891-1892 (Solheim II, 1960:46). However, Mansuy has mentioned that he discovered approximately 60 human bones, mostly long bones (femur, tibia and humerus, & etc.) from all the excavation levels, but none are intact including mandibles (Mansuy, 1902: 23). Three complete pots, abundant pottery fragments and around 10 polished stone axe/adzes were found from these excavations (Vanna, 1999: 6). Bronze objects are rare. Through excavation Mansuy did not find any bronze artefacts, but he obtained some of them from the villagers, but obviously Mansuy could not find out the original situation of those finds. Mansuy republished the result of his research on Samrong Sen in 1923 entitled “Contribution à l’étude de la préhistoire de l’Indochine”. More research on human remains of Samrong Sen discovered by H. Mansuy, was conducted by a group of French researchers in 1998; they have shown that there were at least 20 persons, because of the 20 mandibles and many post-cranial bones were identified. Only three skulls among the Samrong Sen human remains are well preserved and today kept at the Musée de l’Homme, Paris (Demeter et al., 1998:125).

The Swedish archaeologist Olov Janse undertook a small test excavation at the site in 1935 and purchased from local villagers bronze objects that included bangles, sockets,
spearheads, axes, bells as well as stone axe/adzes and some pots and other ornaments made of shell (Vanna, 1999: 7, Stark, 2004: 96), but the publication of Olov Janse’s investigation is still not available. The shell midden of Samrong Sen was subsequently visited and investigated by the following researchers: Worman-1949, Boisselier 1964, Grosliers 1966, Masashi 1968 (Vanna 1999:8).


In 1999, L. Vanna, a young Cambodian scholar conducted research for his Masters and PhD degrees on the floodplains of Samrong Sen. First investigations started in February and March of 1999, surface collections and mapping of the whole site (Fig. 2) were completed. During this time the team recovered approximately 60 pottery fragments with variety of decorations, mostly incised and impressed patterns, a clay sinker, a pot handle with perforation, sandstone grinding stone, three axes/adzes, a few stone flakes and several fragments of fossilized animal bones (Vanna, 1999:13).

Two small test excavation units were dug out in opposite sides: pit I situated on the northern edge of the hill and pit II situated on the southern edge of the hill. Both pits were one by one square meter. One coring was set up in between these two pits to gather information on artefact accumulations and cultural context of the site. The second fieldwork started at the end of June to early July of the same year. The cultural materials explored from the campaign included pottery fragments, tools for pottery making, a small amount of stone implements (axe, adze/chisel and polisher, mostly from surface collection), metal objects (bronze bangle, metal slag), and biological remains including animal and fish bones, turtle carapaces and shells (Vanna, 1999:16-27). Unfortunately, pre-form or hammer stones were not reported by these researchers.

The prehistoric site of Samrong Sen has long attracted archaeologists’ attention and recently the site has been subsequently visited by Cambodian archaeologists and foreigners who are interested in the discipline of archaeology in the country and Southeast Asia.
4. Collections from Samrong Sen

4.1. Cambodia

A great deal of the old collections from Samrong Sen are not available in Cambodia, except a replica of a human skull as seen in the National Museum in Phnom Penh which was donated by the Biological Anthropological Laboratory of the Musée de l’Homme, Paris in 2000. Some archaeological finds are available at the Department of Culture and Finds Arts from Kampong Chhnang province are mostly from recent surface collections, while perhaps others remain with the villagers as well as with antiquity collectors. Only the modern collections derived from the excavations and from surface during the 1999 field campaigns of L. Vanna are possible to be seen in Phnom Penh. Those cultural materials comprise of large amount of pottery fragments, several polished stone tools, a few fragments of bronze ornament, fish and animal bones, pottery making tools, shells, as well as other biological remains. All the materials have been studied by L. Vanna for his Masters (1999) and Ph.D. (2002) degrees.

4.2. Overseas

The collections subject to this study were collected between 1876 and 1938 by different collectors. These collections were offered to different European museums and institutions especially in France.

Musée d’Histoire Naturelle de Toulouse the collections comprise stone specimens, shell and stone ornaments, complete and incomplete pottery, clay net sinker, clay earrings, clay anvils, shell beads, bronze bracelets, bone tools, fish hooks, and several river pebbles. Different types of polished stones are encountered within the whole collection (Table 1). Most of the collections were collected by J. Moura in 1866 and 1877 and some offered to the museum by other collectors the year that these objects arrived at the museum for instance collections of Régnault and C.C. Rousseau is unknown. Some polished stone tools were published by J.B. Noulet in 1879. The collections of Rousseau have inventory numbers, but the collections of Moura and Régnault do not. To facilitate this study we gave new inventory numbers only for the polished stone tools (2004.0.129…). These numbers were suggested by Guillaume Fleury who is in charge of the collections.

Département de Préhistoire (Institut de Paléontologie Humaine) houses a small amount of collections including different types of polished stone tools (Table 1), a few shell ornaments and a clay stamp. According to a small note associated with the collection we know that the objects were exported from the site in February 1906 and sold to the antiquity collectors at the Hotel Drouot, Paris in 1937. These were acquired by Colonel Vésigné, then with the EPHE.
(École Française Hautes Études) and deposited them in the Prehistory Department around 1965 (Claire Gaillard, personal communication, 2007).

Musée des Antiquités Nationales, Saint-Germain-en-Laye near Paris different collections which came from different sources and belong to different collectors are found. Several objects came from Angkor Wat which includes a bronze ring, a stone pestle, and a Buddha sculpture made of wood and stone objects. These collections were donated to the museum by Dr. Corre in 1905. The object from Kampong Thom province was a sole agate bead from Dr. Corre and was offered to the museum in 1905. The collections from Samrong Sen are present in large amounts in the museum but if are less to that of Musée de l’Homme and Lyon. The collections belong to different collectors and donated or sold to the museum over many years. Those objects include polished stone specimens, stone bracelets, clay rings or anvils with and without decoration, bracelets, earrings, rings, beads made of shell, stone and shell pendants, few fragments of bronze bracelets, river pebbles, different kinds of complete shellfish and snails and three fragments of pottery. These collections were donated by different collectors, for instance the collections of G. Knosp which were bought by Hubert in 1904 comprising of 16 objects. The collections of L. Jammes brought to the museum in 1889-1890 contain 21 objects. The collection donated by Dr. Corre 1905 is composed of 7 objects. In the collections donated by Vitout in 1912, the number of objects is unknown. The collection donated by Capitan in 1930 contains 50 objects. The collection donated by Dr. Donneau in 1923, comprise of 7 objects and other collections are mixed together so that we do not know the precise collectors. Besides the collection that mentions specific origins like Angkor Vat, Kampong Thom and Samrong Sen, many collections without precise provenance are available and are mixed together. Some artefacts which include 34 polished stone tools (axes, adzes with and without shouldered, chisel and gouges), pottery, shell and stone ornaments, shell beads, pendants, two fragments of human skull as well as other objects which we do not know the real function are only known to have come from Cambodia and the exact provenience are unknown. These objects were collected by Jammes and offered to the museum in 1930, by Piketty registered at the museum in 1924 and by Capitan donated to the museum in 1930. Some specimens from Indochina are also mixed with the collection of Samrong Sen and collection from Cambodia which are difficult to distinguish because of the similarity of artefact morphology and raw materials. In my opinion, most of the collections from Cambodia and several from Indochina are possibly collected from Samrong Sen because the artefacts are typically and homogenously the same with all collections which precisely originate from Samrong Sen. However, to avoid any mistakes I do not include the polished stone tools within those collections in my study. I only classified them and presented in the inventory. According to the catalogue published by the museum in 1989, there are very few polished stone
specimens from Samrong Sen occurring in the whole collection. These include gouges, shouldered adzes and adzes (Table 1).

L. Jammes, E. Cartailhac brought thousands of objects from Samrong Sen and sold them to different museums in France (Mourer, 1994: 145). In contrast some museums and antiquity collectors did not believe that those collections were taken from a real archaeological site. For instance L. Finot doubted that the collections were original. Anyway, knowing the wealth of these collections, we would be tempted to grant faith to the declarations of L. Jammes and E. Cartailhac. Indeed, on the basis of his own investigation in 1981, R. Mourer discovered 400 artefacts acquired in 1897 by the National Museum of Natural History in Washington from L. Jammes. In 1983, this collection, through R. Mourer, was offered generously by the Smithsonian Institution to the Musée d'Histoire Naturelle de Lyon to complete other collections from Samrong Sen brought by L. Jammes and stored in this museum (Mourer, 1994: 145). Within this collection 70 polished stone tools were encountered which include axes, adzes, shouldered adzes/axes, gouges and chisels (Table 1).

A large amount of the materials were brought by H. Mansuy in 1902 to Musée de l'Homme, Paris and saved them as treasure from the rich archaeological site of Samrong Sen. According to the numbering system of the Musée de l'Homme (33.17.001…), the two first digits (33) indicate the year when the collections entered the museum, and second digits (17) indicate the number of the collection during this particular year. So, as the number of the Mansuy collections begins at 33 we can logically suppose that 1933 is the year when collections arrived in the museum (R. Mourer and O. Romain personal communication, 2006). Mansuy himself published two short papers on his first excavation (Mansuy, 1901, 1928) but neither he nor anyone else published anything about the large collection.

Recently, Aude Matringhem, made an extensive study of the collections in Musée de l'Homme. She submitted a «mémoire en vue de la l'obtention de la maîtrise d'histoire de l'art et d'archéologie» entitled «Le matériel archéologique de Samrong Sen, Cambodge». Her study was concentrated on pottery and jewellery, and she listed 543 objects among the collections of H. Mansuy. These included pottery fragments with various decorations, a few complete pots, clay anvils, clay balls, stone bangles, net sinkers, bone projectiles, stone core waste from stone bangle production, clay seals, bronze bracelets, bronze spear heads, and shell ornaments (bracelets, dishes, beads, earrings etc.). Polished stone tools were not included in her study. Large quantities of polished stone tools (Table 1) are mixed with stone implements from Indochina, particularly from Pho-Binh-Gia, Tonkin, Vietnam (Mansuy, 1909: 531-543).

The person to study the collections was L. Vanna from Cambodia. For his studies on Samrong Sen, he had an opportunity to see the collections of H. Mansuy kept in Musée de
l'Homme in 2005. He studied the materials and completed an inventory, taking photographs of all the tools. However, he has not published his report.

Besides the museums in France, the collection of Samrong Sen can be seen in other countries in Europe. For example I visited the Museum of the Far Eastern Antiquities in Stockholm in 2002 during the 9th International Conference of the EurASEAA. Several objects from Samrong Sen which include stone axes, spindle whorls, 4 whetstones whose function is yet unknown, and a possible spindle whorl made of shell are displayed in that museum and those artefacts were collected by J.G. Andersson in 1936-1938. He undertook some archaeological fieldwork in islands close to Haiphong with the permission of EFEO in Hanoi. He visited Cambodia and Laos briefly, but didn't excavate there. According to the catalogue the 7 objects from Kampong Chhnang were all found on the ground on top of a hillock (Eva Myrdal, personal communication, 2006).
Table 1: Polished stone tools found in the Samrong Sen collections kept in French museums

Collection kept in Département de Préhistoire (Musée de l’Homme), Paris

<table>
<thead>
<tr>
<th>N°</th>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Axe</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Adze</td>
<td>104</td>
</tr>
<tr>
<td>3</td>
<td>Shouldered adze</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Shouldered axe</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Gouge</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>Chisel</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>Hammer</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Polisher</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Unidentified</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>Pre-formed</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>Total</td>
<td>142</td>
</tr>
</tbody>
</table>

Collection kept in Musée d’Histoire Naturelle de Toulouse

<table>
<thead>
<tr>
<th>N°</th>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Axe</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Adze</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>Shouldered adze</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Shouldered axe</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Gouge</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Chisel</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Total</td>
<td>44</td>
</tr>
</tbody>
</table>

Collection kept in Département de Préhistoire (Institut de Paléontologie Humaine), MNHN, Paris

<table>
<thead>
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<th>N°</th>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Axe</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Adze</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Shouldered adze</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Shoulder axe</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Gouge</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Chisel</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>Total</td>
<td>18</td>
</tr>
</tbody>
</table>

Collection kept in Musée des Antiquités Nationale, Saint-Germain-en-Laye

<table>
<thead>
<tr>
<th>N°</th>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Axe</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Adze</td>
<td>42</td>
</tr>
<tr>
<td>3</td>
<td>Shouldered adze</td>
<td>11</td>
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<tr>
<td>4</td>
<td>Shouldered axe</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Gouge</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>Chisel</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Fragment</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Total</td>
<td>71</td>
</tr>
</tbody>
</table>
Chapter II

1. Lithic assemblage of Samrong Sen

1.1. General information and problems

The stone collections of Samrong Sen show a remarkable homogeneity. In dealing with such a large amount of specimens from different localities, it is impossible to make a complete check of all features of every tool. It was also found out that in the large categories a great range of variation is observed such that types previously defined using an arbitrary approach soon lost their meanings. It is not certain whether these collections in reality are native from Samrong Sen or rather imported from other places in the region. According to the inventory it is clear that Mansuy, Jammes as well as other collectors obtained them in Samrong Sen, but whether they came from similar contexts as the other collections is difficult to say. For instance, Mansuy has mentioned that he obtained some objects from Anglong Phdao, a prehistoric site located around 12 km southeast of Samrong Sen. Unfortunately, Mansuy did not classify them and grouped them into one assemblage, thus are now impossible to sort out. Another problem occurring for this study is that few specimens are not recorded in the inventory and some exist in the inventory but are missing in the collection, therefore I did not include these materials in my study. Finally, without a more detailed study of the different contexts of each typology, the raw material used and its sources, it is impossible to determine the origin of the tools. In these circumstances my study is based upon what appears to be the soundest guiding principle in the previous studies of J.B. Noulet 1876-1977, H. Mansuy 1902, R. Mourer 1994, Vanna 1999, the original inventory of the collectors and personal contact with people who are responsible for the collections. For the history of the collections, the people in-charge of the collections were asked: O. Romain for the collection in Musée de l’Homme, Emmond Deirdre for the collections of Musée d’Histoire Naturelle de Lyon and former director R. Mourer and Guillaume Fleury for the collections at Musée d'Histoire Naturelle de Toulouse, Christine Lorre for the collections at Musée des Antiquités Nationales, Saint-Germain-en-Laye and Eva Myrdal for the Far Eastern Antiquities Museum, Stockholm.

Anyway, the typological classification, function, technique of manufacture, raw material, chemical examination for residual remains on tool surfaces as well as comparison with tools from other sites in the region for better understanding of the living subsistence and behaviour of the site’s inhabitants and their adaptation to the environment is already too broad a subject compared to the previous works on Samrong Sen.
**Table 2: List of stone implements within the different collections**

<table>
<thead>
<tr>
<th>N°</th>
<th>Localities</th>
<th>Collections</th>
<th>Years</th>
<th>Amount of items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Département de Préhistoire, MNHN, Paris (Musée de l’Homme)</td>
<td>H. Mansuy</td>
<td>1902</td>
<td>142</td>
</tr>
<tr>
<td>2</td>
<td>Musée d’Histoire Naturelle de Lyon</td>
<td>L. Jammes</td>
<td>1897</td>
<td>71</td>
</tr>
<tr>
<td>3</td>
<td>Musée d’Histoire Naturelle de Toulouse</td>
<td>J. Moura, F. Régnault, C.C.Rousseau</td>
<td>1876</td>
<td>11, 18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Musée des Antiquités Nationales, Saint-Germain-en-Laye</td>
<td>L. Jammes</td>
<td>1889</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vitout</td>
<td>1912</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corre</td>
<td>1905</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Département de Préhistoire, MNHN, Paris (Institut de Paléontologie Humaine)</td>
<td>Vésigné</td>
<td>1906?</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>289</strong></td>
</tr>
</tbody>
</table>

**1.2. Raw material and residue analysis**

The polished stone implements appeared at the beginning of the Neolithic period. Generally, it is difficult to determine on the finished tool whether the source of the raw material is unknown near the site or in the region. Raw materials are the object selected by prehistoric men for making their tool, according to criteria related to proximity, quality, destination of the objects, imperative economic and technological tradition, etc. This memoir attempts to examine raw material of the specimens and organic remains on the surface of a few of them for understanding the natural rock composition, on the other hand the chemical elements that were selected and used by the prehistoric people at Samrong Sen. Analytical treatments were carried out in different laboratories with different equipments and methods.

**1.2.1. Methodology**

There are several techniques that are useful for the examination of the substance and structure of organic and inorganic materials, these include: chemical and physical analysis, mineral or sediment analysis, Raman and Infrared spectroscopy; nevertheless, they are all
based on the material’s interaction with energy. This interaction permits the creation of a signal that is subsequently detected and processed for its information content. However, analytical methods rely on scrupulous attention to cleanliness, sample preparation, accuracy and precision (D. Christian 2003). Raw material examination of polished stone tools from Samrong Sen is mainly based on the information provided in the inventory of the Mansuy and Jammes’s collections. Analysis of raw materials requires a lot of time and it is impossible to process all the specimens; for this reason only few of them were selected for Raman and Infra-red spectroscopy analysis. Therefore the information resulting from this study regarding the raw material is still limited.

1.2.2. Macroscopic descriptions

Different types of stones are always composed of many substances. Some of them are look different or similar or have the same or different chemical compositions, patterns and colours. After the inventory, the polished stone tools from Samrong Sen are frequently made from different rocks like phtanite, quartzite, schist, rhyolite, diorite, porphyry, chalcedony, sandstone, hornfels and many other unknown rocks. 37% of the objects are made from phtanite, 7% from porphyry, 3% from hornfels, 3% from diorite, 1% from quartzite, 1% from schist; from 1% chalcedony, one piece from sandstone and 47% are undetermined. This data rests on the inventory and the determination made by the collectors (Fig. 3).

Phtanite is a type of silex or chert and can be black or grey. The texture is very fine and compact. This kind of rock is very hard, resistant; thus it is convenient for stone tool manufacturing and perhaps it is easy to find and very common in the region. Porphyry is almost similar in texture and colour as phtanite and it is difficult to distinguish between both of them without precise examination techniques to know the exact natural substance of the rock. Hornfels is another type of rock that was used for tool making at Samrong Sen. The colour of this stone varies from light to dark grey and it is fine grained and compact. Hornfels is commonly found on the red soil plateau eastern of Cambodia and southern Vietnam. Sandstone can be of grey or light grey colour, the rock being composed of fine sand mixed with other materials. The texture is not very compact if compared to phtanite and others but it is also hard. Sandstone was also used for polishing at Samrong Sen. Schist is another type of rock characterized by thin or thick layers according to natural processes; the texture is very fine compact; it is grey in colour. This kind of rock perhaps is not common at Samrong Sen, since in the collection it is very rare. Quartzite is light grey or beige in colour, composed of large grains but it is solid. Rhyolite is very rare but present: only a single pre-form is made of this kind of rock. It is grey in colour; the texture is very fine with very tiny paralleled structure which looks like wood fossil. Some types of stone cannot be determined in terms of texture and composition
because they are heavily patinated on the surface due to weathering and sediment deposition. This type of stone is probably basalt and it is more represented compared to schist, rhyolite, quartzite etc. Many other raw materials which are undetermined have different colours (light grey, dark grey, beige, light brown, brown, black, light green or jade). Rock texture can be different or similar to each other. Some have very fine grains and compact, sandy. Some stones are composed of more than one colour like grey and beige or light green in the same piece. Some show several thin light brown colour layers while others have light green with black irregular oblique lines. All these stones require systematic analysis to obtain exactly the natural composition and use it as the main reference for comparison with local materials. There is also a need for further geological research in Cambodia. Macroscopic description can not always provide exact information regarding raw material because of weathering, polishing and erosion on tools surface. Utilisation could also change the natural pattern and colour. Modern methodology analysis can provide more details way about chemical and physical substances of the different stones which were used by prehistoric people at Samrong Sen.

![Different raw materials of polished stone implements from Samrong Sen](image_url)

**Fig. 3:** Raw materials of polished stone tools from Samrong Sen, obtained from the inventory at Musée de l'Homme, Paris and Musée d'Histoire Naturelle de Lyon

Regarding the raw material of polished stone from Samrong Sen, the massif of Kampong Leng is a potential place to explore for finding a stone workshop and quarry. Unfortunately nobody carries out the investigation of this approach because of the difficulty to access these mountains due to safety reasons. Moreover, the precise study of geology from those mountains or other local raw materials are not available up to now therefore it seems difficult to make any conclusions for local production and where all these stones were coming from. It is important to consider that perhaps some stone implements were imported from other places as the result of trade which we do not know exactly, but the evidence of the exchange
can be judged by the presence of marine shells at Samrong Sen which is around 300 Km from the coast.

1.2.3. Mineralogy (Infrared Spectroscopy analysis)

Infrared spectroscopy is one of the most powerful methods available in analytical chemistry with applications across a wide range of field. The spectroscopic analysis permitted researchers to know with precision elements of the different constituent of tools produced by man from variety of natural material. Infrared spectroscopy is a technique of how molecules of the components absorb infrared radiation and convert to heat. Infrared spectroscopy is used both to gather information about the structure of a composite and as an analytical object to assess the purity of a component. Infrared spectra are acquired on a special instrument, called an Infrared Spectrometer.

Electromagnetic spectrum refers to the seemingly diverse collection of radiant energy, from cosmic rays to X-rays to visible light to microwaves, each of which can be considered as a wave or particle travelling at the speed of light. The waves differ from each other in the length and frequency. The infrared region is divided into three parts: the near, middle and far infrared. The middle infrared region is of greatest practical use to the organic chemist. This is the region of wavelength between $3 \times 10^{-4}$ and $3 \times 10^{-3}$ cm (Fig. 4).

![Electromagnetic Spectrum](image)

**Fig. 4:** Position of an infrared in the spectra (Courtesy of Louis Keiner 2006)
Infrared spectroscopy or molecular spectroscopy or vibrational spectroscopy was invented by Frédéric William Hershel in 1800 (Fröhlich and Gendron-Badou 2002). This method can provide the capacity to measure crystallized substance and offer exhaustive results on the object analysis. The operation can be done quickly and without destruction of the object.

1.2.3.1. Basic method

The spectroscopic examination is based on the interaction between substance and an electromagnetic spectrum of the infrared radiation. Infrared radiation is electromagnetic radiation of a wavelength longer than that of visible light and shorter than that of micro waves. The wavelength contained between 2.5 μm and 50 μm, typically, when a molecule is exposed to infrared radiation, it absorbs specific frequencies of radiation. The different component of the matter’s complex vibrations depends on the links between the atoms that are enlivened of matter, it is called the vibrations modes. The frequencies which are absorbed are dependent upon the functional groups within the molecule and the symmetry of the molecule (Fig. 5). Certain groups of atoms absorb energy and therefore, give rise to bands at approximately the same frequencies. Absorption can be divided into two major absorption modes: molecular groups and specific modes. For example carbonates = 1400 cm\(^{-1}\) -1450 cm\(^{-1}\) represents molecular groups and calcite 712 cm\(^{-1}\) represents specific absorption modes (Fröhlich and Gendron-Badou, 2002).

The major types of molecular vibrations are stretching and bending. Every molecule has inflexible bond lengths and bond angles. This is not the actual case, since bond lengths and angles represent the average positions about which atoms vibrate.
Fig. 5: A, Stretching vibrations change in inter-atomic distance along bond axis of the molecular. B, Bending vibrations change in angle between two bonds. There are four types of bend: rocking, scissoring, wagging and twisting. (Infra-Red Absorption Spectroscopy. Theoretical Principles-Quiz. Sheffield Hallam University School of Science and Mathematics, online learning) http://teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/irspec1.htm

1.2.3.2. Explanation of the infrared spectra

The interpretation of infrared spectra involves the correlation of absorption bands in the spectrum of an unknown compound with the known absorption frequencies for types of bonds. Data is produced in the form of a spectrum, with many bands that represent chemical bonding between two particular atoms or a group of atoms in a molecule. The spectrum is subsequently compared to a set of known reference materials for identification and interpretation.

The wave number, plotted on the X-axis, is proportional to energy; therefore, the highest energy vibrations are on the left. The percent transmittance % is plotted on the Y-axis and absorption of radiant energy is therefore represented by a “trough” in the curve: zero transmittance corresponds to 100% absorption of light at the wavelength (Fig. 6).
Fig. 6: Schist spectra of an adze from Samrong Sen (n° 33.17.105) with the specular reflection technique. The operation carried out at Département de Préhistoire Centre de Spectroscopie Infrarouge (MNHN) by Dr. Xavier Gallet, 2007

Analysis of motions on infrared spectra can be very difficult if we are dealing with substances of unknown structure. Fortunately, the infrared spectrum can be divided into regions: one is the functional group region and another is the fingerprint region. The functional group region is generally considered to range from 4000 to approximately 1500 cm\(^{-1}\) and all frequencies below 1500 cm\(^{-1}\) are considered characteristic of fingerprint region (Fröhlich and Gendron-Badou, 2002). The fingerprint region involves molecular vibrations, usually bending motions, which are distinguishing of entire molecule or large fragments of the molecule. The functional group region tends to include motions, generally stretching vibrations, which are more localized and characteristic of the typical functional groups found in organic molecule. Used together, both regions are very useful for confirming identification of a chemical substance.

In addition to identifying the molecule using IR spectroscopy, other information can be obtained. In particular the frequency of the stretching is related to the ratio of the strength of the bond and the reduced mass of the atoms involved. If the reduced mass is known then the strength of the bond within the molecule can be estimated. For a given value of the reduced mass, a vibration of long wavelength (small frequency) corresponds to a long bond (weak bond) and one of short wavelength (high frequency) corresponds to a short bond (strong bond).
In order to interpret infrared spectra, having some background in chemical and physical discipline or we need model of the physical process involved when a molecule interacts with infrared radiation would be useful, because every numbers appear on spectra is represent the chemical substance of the organic or inorganic materials. This is only a very notion of the infrared spectroscopy technique.

To understand the rock composition of raw material of polished stone implements from Samrong Sen, it is very important to do examination and use it as reference for further analysis. With this method we selected only 13 different objects with diverse raw materials that are known from the inventory and 3 specimens that are of unknown raw material to do analysis to confirm the information from the collection inventory. The analysis was carried out at the Musée de l’Homme (MNHN) under the direction of Prof. François Fröhlich and Dr. Xavier Gallet. Infrared (IR) Spectrophotometer Brucker Vector 22 was used (Fig 7, A and B). The object was placed directly on the small platform and the laser beams pass through the first micrometers of the object. This operation is sophisticated but only the objects have flat, smooth and clean surface will be detected.

![Fig. 7: A, Infrared (IR) spectrophotometer at the Spectroscopy Infrared Centre of the département de Préhistoire (MNHN) used for the analysis of polished stone tools from Samrong Sen. B, chisel placed on platform and detected by the laser from the lower part (Photos: H. Sophady 2007)](image)

The results of the analysis reveal that most of the specimens their surfaces are very polluted by exogenous products. Presence marked of the phyllosilicates of kaolinite in the strips 3700 cm\(^{-1}\), 3698 cm\(^{-1}\), 3620 cm\(^{-1}\), 1039 cm\(^{-1}\), 1036 cm\(^{-1}\), 1030 cm\(^{-1}\), 1006 cm\(^{-1}\), 1000 cm\(^{-1}\), 914 cm\(^{-1}\), 637 cm\(^{-1}\), kaolinite and quartz in the strips 539 cm\(^{-1}\), 430 cm\(^{-1}\), calcite is deeply involve in the strips 1420 cm\(^{-1}\), 879 cm\(^{-1}\). This conceals and make difficult the interpretations of the IR spectra, but feature remain is present of the sediment surrounding. Organic matters are present
very strong in the strips to 1525 cm\(^{-1}\), 1433 cm\(^{-1}\), 1515 cm\(^{-1}\) due to the excessive manipulations by the researchers or pollutions. The majority of the specimens are mostly silicate rocks which are confirmed by the presence of the silicate molecular group ([SiO\(_4\)]), around 1100 cm\(^{-1}\) but they also present different compositions which indicate different natural rocks. Among the samples that we chose for this examination a few of the results clearly confirm what we know from the inventory but some shows entirely different results while a few other unidentified spectra. For instance a gouge (33.17.199) which we know from is made from black phtanite in the inventory is in fact basalt as revealed by the IR spectra analysis. More information of the analysis of individual objects is available in the index of this paper.

### 1.2.4. Analytical chemistry

Analytical chemistry is the analysis of organic materials to gain and understanding of their chemical composition, structure as well as function. Some stone specimens from Samrong Sen have remains of some kind of organic materials on tools surface such as resin and bronze oxidation which are visible with or without microscope. It is very important to do a comparison between the ancient and the modern resin to find out if the prehistoric people at Samrong Sen used some kind of resin the same as modern resin that we know at present. In Cambodia two type of resins are known and used by the Cambodian people for waterproofing wooden boats and for traditional candles (Chanlos) and also used for fishery equipment and for improving fish storage as well as trade. Chor Tek (liquids resin) collected from Chheur teil (Dipterocarpus alatus) and Chor Chong (solid resin) collected from (Shorea vulgaris). These resins are still collected by the Cambodian people in some parts of the country, for instance in Kratie, Steung Treng, Rattanakiri, Mondulkiri, Prah Vihear, Siem Reap, Kampong Thom, Pusat and Koh Kong provinces (Fig. 8).
Fig. 8: A: Trunk of Chheur teil (Dipterocarpus alatus). B: Flower and leaves of Chheur teil (Photos: A and B courtesy of T. Ratanak et al. 2005). C: Cambodian people (Phnong origin) in Mundulkiri, Province gathering resin from the hollowed out trunks from Dipterocarpus alatus trees. They usually ignite and burn out the excess resin in the hollows so the trees may produce more resin in time (Photo courtesy of ChKESE 2006)

The analysis was carried out at the Département de Chimie et Biochimie du Muséum National d'Histoire Naturelle, Paris, under the direction of Michèle Meyer and Erik Gonthier.

The ancient resin was taken from one adze which is kept in the Département de Préhistoire (Institut de Paléontologie Humaine, MNHN). The three types of modern resin used are:

- **Chheu teil or Chor Tek** (*Dipterocarpus alatus*)
- **Chheu chong or Chor Chong** (*Shorea vulgaris*)
- The mixture between **Chheu teil** and **Cheur chong**
These resins were taken from Siem Reap province, Cambodia, where these types of resins are still used by the local inhabitants. The method applied is analytical Chromatography.

Chromatography is the method which studies the separation of molecules based on differences in their structure and/or composition. Chromatographic separations can be carried out using a variety of supports, including immobilized silica gel on glass or aluminium plates (thin layer chromatography), volatile gases (gas chromatography), paper (paper chromatography), and liquids (liquid chromatography) (Stong 1969). In this study we applied the Thin Layer Chromatography (TLC) method for analysis of the ancient and modern resins to compare their chemical composition.

TLC is a method widely employed in the laboratory and is similar to paper chromatography. However, instead of using a stationary phase of paper, it involves a stationary phase of a thin layer of adsorbent like silica gel, alumina, or cellulose on a plate, inert substrate. Compared to paper, it has the advantage of faster runs, better separations, and choice between different adsorbents. Different compounds in the sample mixture travel different distances according to how strongly they interact with the adsorbent. This allows the calculation of an \( R_f \) (Retention factor) value and can be compared to standard compounds to aid in the identification of an unknown substance.

\[
R_f = \frac{D_s}{D_f}
\]

Ds (Distance solvent migration from original dots of sample) \\
Df (Distance every colour migration from origin)

Following is the processing technique of the Chromatography method: the bottles that we used for storage of samples were washed with Acetone. Each sample was weighed to know the exact amount of the sample. For this treatment 1.4850 g was taken from the mixed resin (1); 5.0990 g from Chheu chong (2); 0.9160 g from Chheu teil (3) and 5.5 \( 10^{-3} \)g from the ancient resin as reference (R). Every sample was dissolved in a mixture of Metanol and Dichloromethane (1/1 \( \text{CH}_2\text{Cl}_2/\text{CH}_3\text{OH} \)) and samples were kept for two days in the solvent. After two days the different colours of each samples can be examined: yellow with light green and unclear for the mixing resin (1), yellow for the Chheu chong (2), slightly yellow with light green for Chheu teil (3) and dark yellow for the resin reference (R) (Fig. 9).
Fig. 9: Difference resin in the solvent: R is resin reference, n° 1 is mixture resin, n° 2 is chheu chong and n° 3 is chheu teil. 1-3 are modern resin (Photo: H. Sophady 2007)

Fig. 10: Michèle Meyer in preparation the ancient resin: after extraction and filtration the evaporation of the solvent by using the Rotavapor (Photo: H. Sophady 2007)

The mixtures to be analyzed are loaded on the horizontal line 1 cm from the bottom of the plate and controlled by ultraviolet to be sure that all of them are present on the plate. The plate is placed in a reservoir of solvent so that only the bottom of the plate is submerged (Fig. 11).
Fig. 11: Drawing and photo shows the Chromatography method. Aluminium plate is placed in the glass tank and absorbed by solvent (Photo: H. Sophady 2007)

This solvent is the mobile phase; it moves up the plate causing the components of the mixture to share out between the absorbent on the plate and the moving solvent therefore separating the components of the mixture so that the components are separated into separate “spots” appearing from the bottom to the top of the sample plate.

With TLC method we tried to treat the sample with three different solvents for comparison of the results. First, we tried with the solvent of Cyclohexane (C₆H₁₂). The second phase we used the mixture solvent (⅔ of Cyclohexane and ⅓ Dchloromethane) and last we used only the Dychloromethane as migration solvent.

The first plate revealed the distance of chemical elements migration of sample n° 1 and n° 3 same Rᵣ but different from the resin reference R. Only sample n° 2 exposed the same Rᵣ with resin reference R (Fig. 12). This phenomena indicated that sample n° 2 comprise the same chemical substance with R.
Second plate shows different distance of elements migration but nothing happen with the resin R. On this plate only sample n° 1 and n° 3 have the same Rf (Fig.13).

Fig. 12: Plate 1 revealed the sample n° 2 and R have the same Rf and n° 1 and n° 3 have also the same Rf (Photo: E. Gonthier, 2007)

Fig. 13: Plate 2 revealed the different chemical composition movement distance. Only n° 1 and n° 3 have the same Rf (Photo: E. Gonthier, 2007)
Third plate shows the different distances of colour movements from the original spots. First row colour movement of R and n° 2 display the same \( R_f \) (1, 5cm from the original colour dots), and colour movement of n° 1 and n° 3 also display the same \( R_f \) (1, 2cm from the original colour dots). Second row shows the chemical component movement dots from the original colour spots between n° 2 and n° 3 similar \( R_f \) but very weak (2 cm from the original colour dots). In the third row only sample n° 2 shows the colour movement distance (3, 8 cm from original colour dot) this spot is also very weak and nothing happens with other samples. The last row revealed that the colour movement distance of each sample is going up to the solvent movement distance (5 cm from the original colour dots) (Fig. 14).

**Fig. 14:** Plate 3 reveals the difference distance of colour travels from the bottom line where all samples were drops (Photo: by E. Gonthier 2007)

In conclusion plate 1 indicated that sample R and n° 2 have the same substance of mixture and n° 1 and n° 3 also have the same chemical substance. Plate 2 indicated n° 1 and n° 2 have the same chemical composition for the first row of colour movement distance and sample n° 1 and n° 3 comprise the same chemical substance. The third plate displays sample n° R and n° 2, sample n° 1 and n° 3 have the same chemical substance for the first row of colour travels, and second row the sample n° 2 and n° 3 reveal the same chemical components. The last row indicated that all samples comprise the same chemical molecules. Thus we can make assumption that all modern resin comprises the same chemical composition like the ancient resin that remains on adze. But the ancient resin contains some kinds of molecules which do not exist in the modern resins. This phenomenon is shown by the strong molecule
migration appearing on plate 3. It is plausible that the prehistoric people at Samrong Sen used some kind of organic materials or other types of unknown resin to mix up with the two kinds of resin that is known so far to make them stickier for sophisticated or multiple functions. For the moment this is only a preliminary analysis therefore it is impossible to provide more precise information on the resin remains on the tools from Samrong Sen. More scientific analysis of different methods is needed for this study to get a more reliable result.

2. Analysis of stone tools

2.1. Typo-technological study

Typology of the polished tools of Samrong Sen is related to the ability to correctly identify the tool types. Tool classification usually poses some problems because of the similarity between types, particularly between adze and chisel, adze and axe. In his short publication Mansuy made an effort to divide the polished stone tools of Cambodia into six groups according to the artefacts’ morphology and the situation of the cutting edge, but he did not clearly distinguish between axe and adze as well as the types with shouldered (Mansuy, 1902: 9-13). He placed in the first group the axes having an extremity appropriated to hafting without regard to the active part. The second group consists of triangular forms which a symmetrical longitudinal section and no bevels. The third group contains the type of which the cutting results more or less from an oblique bevel on one face; this type is by far most abundant and should be classified as adze. The fourth group includes the instruments of which the cutting edge is produced by the meeting of both faces. The fifth is constituted by a set of small proportionally long and narrow instruments, with the summit almost as large as the cutting edge; Mansuy considered these objects as real chisels. The last group is undoubtedly the gouges with a concave cutting edge. As a result the classification presented in this memoir is rather different from that mentioned by Mansuy in his first publication and from the analysis by L. Vanna in this dissertation, who attempted to classify them into five types based on their difference or similarity (Vanna, 1999: 62-64), without distinguishing the difference between axe and adze and using the term ‘axe-chisel’ as Mansuy did.

Study of typology can help us understand the technique of manufacturing, functions, and correlations to other prehistoric cultures both in, and outside the region. There are two general ways of establishing the typological classification of a stone industry: one can attempt to classify the implements according to function as deduced from ethnographic comparisons, according to their forms, or according to still more conjectural data; or on the other hand, one can assume an apparently more objective attitude and establish a classification depending on shape, technique of manufacture, or a combination of the two (Cahen & Van Noten, 1971: 211). In the present study, the polished stone tools of Samrong Sen are classified into eight categories according to their morphology, especially shape and the profile of the cutting edge.
Besides new methodologies used for the study of polished stone tools many Neolithic or early Metal Age sites have also been applied to this assemblage.

**Axe (Type 1):** This type is characterized by symmetrical bilateral bevelled cutting edge, which is convex, straight and sometimes oblique. In the collection of Samrong Sen, axes appear in variety of sizes and shapes but in small amount compared with adze, chisel, gouge and shouldered adze (Fig. 24).

**Adze (Type 2):** Another important stone object, more frequently encountered in the collection than other tool types, is called adze. We distinguish adzes from axes by the cutting edge: adzes have cutting edge asymmetrical in cross-section and sometimes with only one bevel whereas axes are symmetrical in cross-section of the cutting edge. The adze is said to be simple when nothing distinguishes the heel of the blade, both parts showing continuity. An adze is composite when the bevel and the heel are in discontinuity. Theoretically, the cutting edge of the tool is perpendicular to the long axis of the handle and is characterized by a single bevel; in general it also presents an asymmetrical double bevel. Bellwood says that the term adze implies a single bevel, as opposed to the double bevel of an axe (Bellwood, 1975:12). In dealing with axe and adze, attention was also paid to use-wear striations observed on the cutting edges. Micro striations perpendicular to the cutting edge indicate the utilisation as an adze, while utilisation as an axe leaves striations diagonal to the cutting edge (Albek, 2005:118). Within the Samrong Sen collection adzes are present in higher amount than other tools. On a few specimens of this type, some organic material is visible to naked eye or under microscope: these include resin and shells. One adze shows green colour on its surface, it is possible that this object was in contact with copper or bronze artefacts before it was taken from ground and therefore some oxidation remains on the tool.

The majority of adzes have a regular trapezoidal shape with the sides tapering towards the butt end. The working edge is mostly convex; only in some cases is it straight and oblique with a characteristic adze asymmetry and many of them present a wide single bevel on the cutting edge, while only few exhibit a short single bevel. The adze is presented in variety of dimensions and forms (Figs. 15, 16 & 18)
Fig. 15: Variety forms and sizes of polished stone adzes from Samrong Sen
Fig. 16: Variety forms and sizes of polished stone adzes from Samrong Sen (Photos: H. Sophady, 2007)
Shouldered adze (Type 3): This type is characterized by a flat or oblique shouldered (Figs. 17 & 19). A shouldered adze is characterized by a non-symmetrical double bevel or a single bevel at the cutting edge resembling an adze. Shouldered adzes display variations in forms and sizes. A few of these specimens are considered as having not originated from Samrong Sen; they were possibly collected from other regions by the villagers and later sold to collectors. These tools are made of basalt and are heavily patinated on the surface; this reflects a longer deposition in soil that is highly acid. The technique of production is also different from that at Samrong Sen, as all the specimens are not well polished and remain crude. The form is similar to the typical stone adzes found in the red soil region on the eastern bank of Mekong River. There is more shouldered adzes present in the collection than shouldered axes.

Shouldered axe (Type 4): We separated shouldered axes from shouldered adzes because they are characterized by symmetrical double bevels at the cutting edge like an axe (Fig. 19). They also display variations in forms and sizes. Sometimes it is difficult to distinguish them when the cutting edge is not clearly defined.

The tenon of both types can be short or long, often square or rectangular in cross-section which is supposed to be used for hafting in the handle. The shouldered form of both types can also be subdivided into two varieties. The first variety has a slight shouldered made by flaking and looks crude. The surface is partly polished with remains of flaking stigmata. The second variety is completely flat with square or rectangular shouldered and is perfectly polished. Both shoulders are deeply marked which indicates the technique of cutting by sawing rather than by flaking. Some examples of this variety are kept in Musée d'Histoire Naturelle de Lyon and one in Institut de Paléontologie Humaine, Paris (Figs. 17, nos. 8.893.1.127, 8.893.1.125 & no. I).
Fig. 17: Variety of sizes and shapes of shouldered adzes and axes from Samrong Sen (Photos: H. Sophady, 2007)
Fig. 18: Variety forms and sizes of polished stone adzes of Samrong Sen

Fig. 19: n° 8.983.1.149 and 8.983.127 represent shouldered adzes with dissymmetry double bevel on cutting edge while n° 33.17.178 represent of shouldered axe with symmetry on cutting edge.
**Gouge (Type 5):** Gouges are tools characterized by a grooved form that means that the curved line of this cutting edge is within a plane which is perpendicular to the faces (Fig. 20).

Transverse sections vary from triangular, biconvex to ellipsoidal and plano-convex. When it exists, the handle is in the extension of the axis of the tool like an adze. The dimensions are rather diversified (Fig. 26). One gouge is broken, only the distal part being present, and there is re-flaking on the broken part. Gouges are probably one of those stone implements where some were used without handles; as the craftsman can use it, with the help of hand force (Garanger, 1972) and if they have the handle the position of handle should be parallel to the gouge blade. One gouge is 14.1 cm in length, 5.5 cm maximum width, 4 cm minimum width and 3.33 cm and 2.95 cm in thickness of the triangular cross-section showing a slight shouldered; it is possible that this shouldered form perhaps is used specially without hafting (Fig. 21, no. 8.983.1.2), and the smallest one perhaps also used without handle (Fig. 21, no. 8.983.1.134). Two types of gouges can be distinguished in the collection; the first variety is characterized by a narrow cutting edge and continuity of the shape towards the butt end, the second variety shows a cutting edge larger than the butt end.
Fig. 20: Different forms and sizes of polished stone gouges occurring in the collection (Photos: H. Sophady, 2007)
Fig. 21: Different sizes and forms of stone gouges from Samrong Sen. n°.8.983.1.2 is a gouge have slightly shouldered and n° 8.983.1.195 is a small stone chisel
**Chisel (Type 6):** The most important characteristic of the chisel is that the width is always narrower than that of adzes or axes. Chisels often have a single bevel; sometimes it is difficult to distinguish them from adzes with double bevels. A chisel is another tool type probably also used without handle. Several specimens examined are hardly damaged on the butt end, for example, object numbers 33.17.33 and 33.17.23 (Fig. 22) were possibly directly struck with different types of hammer and used for a long time for heavy cutting or chopping of hard materials. Chisels are also present in different sizes and shape but represent a small part of the total collection.

**Fig. 22:** Varieties forms and sizes of stone chisels from Samrong Sen with the exception of n°. 33.17.3 that is a single pre-form found in the collection (Photos: H. Sophady, 2007)
**Burnisher (Type 7):** There is only a single piece on which the cutting edge is absolutely different from all specimens of type 1 to 6. The form of this instrument does not differ from axe or adze: it has a sub-trapezoidal shape and is made of phtanite. The dimensions are: 6 cm long, 4.1 cm wide on the distal part, 2.1 cm wide on the proximal and a thickness of 0.9 cm. The cross-section proximal and distal is a flattened reed shape, the big base that corresponds to the cutting edge is convex in two directions, transverse and longitudinal; this part is carefully polished to give roundness on the cutting edge. The appearance of this tool indicates a sophisticated use (not as yet defined) for purposes other than cutting (Fig. 23, n°. 33.17.37). Mansuy considered this instrument could have been used for burnishing pottery (Mansuy, 1902: 12).

‘Celt hammer’ (Type 8): Only a single specimen of this type is present in the whole collection. This tool is made of green stone with dimensions: 8.7 cm in length, 4.6 cm maximum width, 4 cm minimum width and 2.3 cm thickness in plano-convex cross-section. This object may be regarded as the modification from an adze, because a bevel is still visible on the lower face. After the cutting edge was damaged, people reused it, but changed its function. The secondary thick edge has many macro and micro chippings that suggest the object was used as a hammer for breaking stone or other hard materials (Fig. 23, n°. 33.17.18). We do not know whether this tool is one of the six hammers mentioned by Mansuy or whether it is a new category which I distinguished from type 2 by its different cutting edge.

*Fig. 23:* No. 33.17.37 burnisher (Type 7) polished and dulled on the cutting edge, perhaps used for burnishing pottery (Photos: H. Sophady, drawing courtesy of H. Mansuy, 1902). No. 33.17.18 celt hammer (Type 8) dulled and heavily damaged on the cutting edge, possibly used as a hammer (Photos and drawings by H. Sophady, 2007)
In total, 286 polished stone tools from the prehistoric site of Samrong Sen were encountered in the collections of different museums in France. Pre-forms, and hammer stones are very rare, shouldered adzes and shouldered axes, chisels, gouges as well as axes are present but in a lesser amount than adzes which have the highest representation in the total collection. Diminution of other tool types are probably because they were lost during transportation from one place to another as the collections changed locations many times since they left the sites; or, they may exist, as yet unidentified in some museums. In dealing with this approach, a good example can be seen in the Mansuy collection at Musée de l’Homme, where he listed 37 shouldered adzes or axes, 198 of adzes, 28 of chisels and 29 of gouges, 6 hammer stones and 20 pre-form of other tool types in his publication (Mansuy, 1902:. 23). In reality, most of these are not found in the present collection.

Based on the profile form on the cutting edge and another morphological characteristics, 11 stone implements were distinguished from a total amount of 286 within the whole collection of Samrong Sen. Adzes comprising 68% represent a larger amount than other specimens such as shouldered adzes and shouldered axes, gouges chisels, and axes while other specimens exist only as a single piece (Fig. 24). It is revealed that adzes are the most important stone tools used by the prehistoric inhabitants at Samrong Sen. Other tool types were also necessary, but the functional requirement was perhaps less than for adzes.

**Fig. 24:** Graph shows the different tool types from Samrong Sen occurring in the collections
2.2. Morphological characteristics

The principle characteristics of polished stone tools (adzes, axes, chisels, gouges and shouldered types) encountered in the collections from Samrong Sen are described below, with more detailed descriptions available in the typological classifications.

Fig. 25: Principle sections of polished stone tools (Drawings H. Sophady, 2000)

2.2.1. Measurements: To characterise the size of the tools we measure the length, the maximum and minimum widths and the maximum thickness. Measurements are always given in centimetres. Average length, width and thickness of different specimens are presented in Table 3.
Fig 26: Dimensions of the polished stone tools from Samrong Sen

A: Shouldered adzes dimensions

B: Shouldered axe dimensions
Fig. 26: Dimensions of the polished stone tools from Samrong Sen

### C: Axes dimensions

<table>
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<tr>
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<td>4</td>
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### D: Chisels dimensions

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<tr>
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<tr>
<td>3cm-&lt;4cm</td>
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</tr>
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</tr>
<tr>
<td>2cm-&lt;3cm</td>
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</tr>
<tr>
<td>3cm-&lt;4cm</td>
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<tr>
<td>4cm-&lt;5cm</td>
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<table>
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<tr>
<th>Chisels thickness</th>
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<tbody>
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<tr>
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<tr>
<td>4cm-&lt;5cm</td>
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<tr>
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<td>5</td>
</tr>
<tr>
<td>2cm-&lt;3cm</td>
<td>4</td>
</tr>
<tr>
<td>3cm-&lt;4cm</td>
<td>2</td>
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</tr>
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<td>5cm-&lt;6cm</td>
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<table>
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<th>Axes thickness</th>
<th>Amount</th>
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</tr>
<tr>
<td>3cm-&lt;4cm</td>
<td>0</td>
</tr>
<tr>
<td>4cm-&lt;5cm</td>
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<tr>
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</tr>
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<td>15cm-&lt;16cm</td>
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<td>0</td>
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<tr>
<td>18cm-&lt;19cm</td>
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<tr>
<th>Chisels thickness</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
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<td>1cm-&lt;2cm</td>
<td>0</td>
</tr>
<tr>
<td>2cm-&lt;3cm</td>
<td>2</td>
</tr>
<tr>
<td>3cm-&lt;4cm</td>
<td>2</td>
</tr>
<tr>
<td>4cm-&lt;5cm</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chisels width</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>2cm-&lt;3cm</td>
<td>4</td>
</tr>
<tr>
<td>3cm-&lt;4cm</td>
<td>2</td>
</tr>
<tr>
<td>4cm-&lt;5cm</td>
<td>0</td>
</tr>
<tr>
<td>5cm-&lt;6cm</td>
<td>0</td>
</tr>
<tr>
<td>6cm-&lt;7cm</td>
<td>0</td>
</tr>
<tr>
<td>7cm-&lt;8cm</td>
<td>0</td>
</tr>
<tr>
<td>8cm-&lt;9cm</td>
<td>0</td>
</tr>
<tr>
<td>9cm-&lt;10cm</td>
<td>0</td>
</tr>
<tr>
<td>10cm-&lt;11cm</td>
<td>0</td>
</tr>
<tr>
<td>11cm-&lt;12cm</td>
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<td>15cm-&lt;16cm</td>
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<tr>
<td>17cm-&lt;18cm</td>
<td>0</td>
</tr>
<tr>
<td>18cm-&lt;19cm</td>
<td>0</td>
</tr>
</tbody>
</table>
Fig. 26: Dimensions of the polished stone tools from Samrong Sen

**E: Gouges dimensions**

**F: Adzes dimensions**
Table 3: Average dimensions of polished stone tools from Samrong Sen

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Adze</th>
<th>Axe</th>
<th>Gouge</th>
<th>Chisel</th>
<th>Shouldered adze</th>
<th>Shouldered axe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Average length (cm)</td>
<td>6.78</td>
<td>5.5</td>
<td>9.32</td>
<td>7</td>
<td>8.33</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Average width (cm)</td>
<td>3.58</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>4.33</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Average thickness (cm)</td>
<td>1.45</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1.77</td>
</tr>
</tbody>
</table>

**2.2.2. Cross-sections:** Tool cross-sections are the shape of a virtual cut through the object perpendicular to its longitudinal axis. In the study of Samrong Sen polished stone tools, cross-sections were examined on proximal and distal parts of each object with reference to the model published by E. Gonthier (1987: 290). Fourteen different section forms were observed on 286 stone tools (Fig. 27). Trapezoidal and rectangular cross-sections are typical for adzes, axes, shouldered adzes, shouldered axes and chisels while plano-convex is common for gouges and for some adzes (Table 4). Triangular, square, bi-convex, ellipsoidal, lenticular, flattened reed as well as a few other forms are also present on some tool types but are rare (Table 4).

![Cross-sections](image_url)

**Fig. 27:** Different cross-sections observed on the polished stone tools of Samrong Sen (Modified from E. Gonthier, 1987)
Table 4: Proximal and distal cross-sections of different tools

<table>
<thead>
<tr>
<th>No.</th>
<th>Cross sections</th>
<th>Adze</th>
<th>Axe</th>
<th>Gouge</th>
<th>Chisel</th>
<th>Shoulder adze</th>
<th>Shoulder axe</th>
<th>Polished</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rectangular</td>
<td>25</td>
<td>43</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Trapezoidal</td>
<td>92</td>
<td>94</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Square</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Plano-convex</td>
<td>19</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Ellipsoidal</td>
<td>10</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Oval</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>2</td>
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<td>7</td>
<td>Bi-convex</td>
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<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Lenticular</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>Triangular</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Triangular curved base</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Slightly triangular</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>Faceted</td>
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<td>5</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>Semi-concave reed</td>
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<td>0</td>
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<td>1</td>
</tr>
<tr>
<td>14</td>
<td>Flattened reed</td>
<td>11</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

2.2.3. Cutting edges: Being the active part of the tool, the cutting edge is usually well polished or retouched in order to make it sharp for use to cut objects like wood, break bones, scrape hides, or soil digging, & etc. For the polished stone tools from Samrong Sen, cutting edges have been described using three different characteristics: trimming, cutting edge condition and profile of form.

2.2.3.1. Trimming: On the trimmed edges, different characteristics of the surface can be seen, for example, polished on both faces, polished on one face only and unpolished on the other face, unpolished on both faces, slightly polished on both faces, slightly polished on one face, polished or unpolished on the other face, & etc. Generally, most of the trimming edges are polished on both faces with a single or double bevel on the cutting edges.

2.2.3.2. Cutting edge condition: Many of the cutting edges are intact, micro-chipping, chipping but some of them have, broken and re-sharpening especially for adzes, gouges and chisels and only a few ones bear re-flaking marks and round (Table 5). A few are broken by utilisation or by accident. Examination of the cutting edge of each tool is essential to understand the way the tool was used by people in prehistoric times. These features indicate that the tools were produced, used and reused in different ways and over long periods. The large amount of tools having intact cutting edges perhaps indicates that these tools were just at
the end of the manufacture process and were not utilised. On the other hand, they were probably used as ritual objects such as burial offerings; therefore, their cutting edges are unused. With regard to chipping or breaks on the cutting edge; it is supposed that these correspond to heavy cutting or chopping of hard materials, but of course, some of them perhaps result from accidental chipping or breaking. In the case of polished stone tools from Samrong Sen, I agree with Dega (2002) that some tools were utilized and fractured on site and either simply abandoned or reworked into other tools (chisels, gouges, small adzes or other tools). In some cases, perhaps the tools were utilized outside the site and they were brought back if they were still good enough for reworking.

Table 5: Cutting edge condition of polished stone tools from Samrong Sen

<table>
<thead>
<tr>
<th>Nº</th>
<th>Cutting edge conditions</th>
<th>Adze</th>
<th>Axe</th>
<th>Gouge</th>
<th>Chisel</th>
<th>Shouldered adze</th>
<th>Shouldered axe</th>
<th>Polisher</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intact</td>
<td>66</td>
<td>3</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>90</td>
<td>32%</td>
</tr>
<tr>
<td>2</td>
<td>Round</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>3</td>
<td>Chipping</td>
<td>43</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>67</td>
<td>24%</td>
</tr>
<tr>
<td>4</td>
<td>Micro-chipping</td>
<td>64</td>
<td>2</td>
<td>12</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>95</td>
<td>33%</td>
</tr>
<tr>
<td>5</td>
<td>Re-flaking</td>
<td>12</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
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<td>0</td>
<td>16</td>
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<td>6</td>
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</tr>
<tr>
<td>7</td>
<td>Broken</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>3%</td>
</tr>
<tr>
<td>8</td>
<td>Total</td>
<td>191</td>
<td>10</td>
<td>29</td>
<td>19</td>
<td>21</td>
<td>10</td>
<td>1</td>
<td>281</td>
<td>100%</td>
</tr>
</tbody>
</table>

2.2.3.3. Profiles of cutting edges: Through observation of profiles of cutting edges, eight types of profile forms are distinguished on 263 stone tools (Fig. 28). Adzes have a few different profile forms, perhaps due to different possible uses; Type 2 and Type 5 is more frequent than others, particularly for adzes (Table 6).

Type 1: the profile is convex on both faces and symmetrical; this is the main characteristic of an axe.

Type 2: the profile shows a flat single bevel on the lower face and a continuous convexity on the upper face.

Type 3: the profile has an asymmetrical double bevel, with a flat lower face and a convex upper face.
**Type 4:** has an asymmetrical double bevel, both faces being flat.

**Type 5:** is slightly convex on the upper face and more convex near the cutting edge, then slightly concave on the lower face; it shows an asymmetrical bevel. Types 2 to 5 are characteristic of adzes or chisels.

**Type 6:** the profile shows a concave lower face and a convex upper face; this is specific for gouges.

**Type 7:** characterizes chisels or adzes, this profile has a steep single bevel; the lower face is flat and the upper face slightly convex.

**Type 8:** is a special tool the function of which is not exactly known. No bevel is found on the distal part, the cross-section is in the shape of a flattened reed and the edges are very rounded.

**Fig. 28:** Varieties of profiles of polished stone tools from Samrong Sen; first column: front view and second column side view.
Table 6: Profiles of cutting edges of polished stone tools from Samrong Sen

<table>
<thead>
<tr>
<th>Profile of cutting edges</th>
<th>Adze</th>
<th>Axe</th>
<th>Gouge</th>
<th>Chisel</th>
<th>Shouldered adze</th>
<th>Shouldered axe</th>
<th>Polisher</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>22</td>
<td>8%</td>
</tr>
<tr>
<td>Type 2</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>114</td>
<td>41%</td>
</tr>
<tr>
<td>Type 3</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>5%</td>
</tr>
<tr>
<td>Type 4</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>18%</td>
</tr>
<tr>
<td>Type 5</td>
<td>42</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>52</td>
<td>9%</td>
</tr>
<tr>
<td>Type 6</td>
<td>0</td>
<td>0</td>
<td>29</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>10%</td>
</tr>
<tr>
<td>Type 7</td>
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<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>7%</td>
</tr>
<tr>
<td>Type 8</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>8%</td>
</tr>
<tr>
<td>Unidentify</td>
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<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td>192</td>
<td>10</td>
<td>29</td>
<td>19</td>
<td>21</td>
<td>10</td>
<td>1</td>
<td>282</td>
<td>100%</td>
</tr>
</tbody>
</table>

2.2.4. Butts: This is the basal part opposite to the cutting edge. Several characteristics are visible on butts of stone tools from Samrong Sen - for instance, flat unpolished, flat polished, round polished, thin, thin chipped, pointed, pointed chipped, hard damage or broken by percussion with hammer stone, antler, bone, wood or other hard or soft hammers. Some of the specimens show re-flaking after the butt was broken. No evidence of a handle is visible on proximal parts and the butts of each tool by ocular inspection or microscope due to the surface weathering and patina on the tool surfaces. In any case, chipping or breaks on the butt of some specimens indicates the way these tools were used and perhaps results from direct smashing with a hammer stone or other hard organic materials. The butt is the section usually attached directly to a wooden handle and was sometimes fixed with wood, bone or antler as a connection between the handle and the tool. Some tools were perhaps used without fixing to a wooden handle. In the case of a chisel or a wedge, perhaps the butt was pressed directly by a hammer stone or wood, bone or antler when it was used for cutting or chopping. The butts presented the following differing forms: flat unpolished butts comprise 29% more than others, flat unpolished and chipped, 16%, thin, 10%, thin and chipped, 11% and broken, 9% (Table 7). Chipping or picking and sometimes breaks are often visible on butts, as result of hitting with hard objects used as a hammer. However, these characteristics such as chipping or picking could have been produced at the beginning when the tools were manufactured for the first time.
Table 7: Butt condition of polished stone tools from Samrong Sen

<table>
<thead>
<tr>
<th>№</th>
<th>Type of butts</th>
<th>Adze</th>
<th>Axe</th>
<th>Gouge</th>
<th>Chisel</th>
<th>Shouldered adze</th>
<th>Shouldered axe</th>
<th>Polisher</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flat unpolished</td>
<td>59</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>81</td>
<td>29%</td>
</tr>
<tr>
<td>2</td>
<td>Flat unpolished chipping</td>
<td>33</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>45</td>
<td>16%</td>
</tr>
<tr>
<td>3</td>
<td>Flat polished</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>14</td>
<td>5%</td>
</tr>
<tr>
<td>4</td>
<td>Flat slightly polished</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>17</td>
<td>6%</td>
</tr>
<tr>
<td>5</td>
<td>Round slightly polished</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>4%</td>
</tr>
<tr>
<td>6</td>
<td>Round slightly polished</td>
<td>9</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>14</td>
<td>5%</td>
</tr>
<tr>
<td>7</td>
<td>Round unpolished chipping</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>8</td>
<td>Thin</td>
<td>23</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>10%</td>
</tr>
<tr>
<td>9</td>
<td>Thin chipping</td>
<td>24</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>11%</td>
</tr>
<tr>
<td>10</td>
<td>Pointed</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>2%</td>
</tr>
<tr>
<td>11</td>
<td>Pointed chipping</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1%</td>
</tr>
<tr>
<td>12</td>
<td>Reflaking</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1%</td>
</tr>
<tr>
<td>13</td>
<td>Broken</td>
<td>18</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>9%</td>
</tr>
<tr>
<td>14</td>
<td>Total</td>
<td>192</td>
<td>10</td>
<td>29</td>
<td>19</td>
<td>21</td>
<td>10</td>
<td>1</td>
<td>282</td>
<td>100%</td>
</tr>
</tbody>
</table>

2.2.5. Surface conditions: Examination of the surface (upper and lower faces, left and right sides) shows that the finished tools display different qualities. Some objects show heavy patina, cracking, fracturing and scratching, scarring and sometimes sediment concretion or other organic remains are still present on tool surfaces. Many of them present depressions, which might be flaking scars from the first stage of the manufacturing process and are still visible even after polishing. Others show fresh fracturing or flaking. Observations on the surface condition help in understanding the manufacturing processes as well as ancient or modern cut marks by intentional or accidental causes. Binocular examination of these stone implements revealed irregular striations of polish - parallel, oblique or perpendicular to the cutting edge and sometimes all three combined. Some striations are visible even without the aid of a microscope. The surfaces can be well polished or partly polished, slightly polished with the flaking stigmata still visible.
3. Technique of manufacturing

3.1. General context

The technique of tool making is one of the most important approaches to which archaeologists or lithic experts always pay attention in order to understand the development of lithic industries in prehistoric times. The processes of manufacture of stone tools are most often difficult to observe, the shaping stigmata difficult to see, because of surface modifications, polishing processes and sometimes the use of the objects. However, the technological processes of adze/axe, chisel and gouge making are more or less comparable in every Neolithic workshop (Truman, 2002: 208, Edmonds, 1995). In reality they slightly differ from each other according to the adaptation to environment of the site, the difference of raw materials, and the skill of tool makers. However, the technique for making polished stone tools can be regarded as composed of three phases in general. The preliminary phase is the selection of preferable raw material; the process starts with primary forming, whereby a bulk of material is flaked from different sides to build up a basic form of the intended tool. In this phase the tool is sketched out but still crude and thick, with marks of flaking on all faces and along left and right sides even on butt. Products of this phase usually are far bigger in size than the required tool, and have not yet attained an even thickness. Cortex is often still remains on the surface. The second phase consists of further shaping by removing smaller and lighter flakes in order to trim the proto-tool and make it smoother. The cortex is almost no longer traceable, and the cutting edge is shaped by unifacial or bifacial trimming. During this phase, the tool already displays the desired shape, before the last grinding and polishing (Truman, 2002: 208) and the last handling equipment.

In spite of our research on the techniques of production, a large number of objects didn't give us any idea on the extraction of the raw material up to the finalization of the tools. In the same way, the functions of these tools remain to be defined with more precision because of the lack of knowledge of archaeological materials and the source materials. On the other hand the macroscopic examinations provide us with some aspects on the manufacturing process that could be trusted.

3.2. Macroscopic observation

3.2.1. Flaking

Flaking is the main technique for stone tool fabrication. Stone tools of Samrong Sen were probably produced following the main three stages (coarse flaking, fine flaking and polishing), because many of them show remains of flaking on surface, but some objects
perhaps were manufactured only by grinding and polishing, especially the tool made from a river cobbles. A few of them indicate re-flaking and re-sharpening on the cutting edge, butt or re-production of the same tool type and one shows an accidental break during utilisation. Unfortunately, flakes and debris are not discovered at the site, except a very few of them encountered by L. Vanna (Vanna, 2002). Only one pre-form made of rhyolite is present in the collection at Département de Préhistoire (Musée de l'Homme, Paris). Six hammer stones and a few polishers were discovered at Samrong Sen and described by Mansuy (Mansuy, 1902: 9). Unluckily, the six hammer stones are not present in any of the examined collections. Considering the absence of large amount of flakes, cores and pre-forms we can deduce that maybe the tooling was not manufactured on the site. It is more plausible, in reason of the predominance of local material, that this manufacturing was done in the neighbouring area, outside the sector invaded by flooding, or that the workshop was located on the lowland nearby the hillock and was covered by sediment deposit. Beside, one can also suspect the collectors to have selected the finished tools, looking better than the pre-forms and flakes.

3.2.2. Sawing

Sawing is another particularity observed in the polished stone tool manufacturing. In the collection of Samrong Sen sawing mark are rare. One shouldered adze revealed several deep cut marks on both surfaces. Some cut marks are parallel to the cutting edge and some are oblique and crossing each other (Fig. 29). These cut marks probably are not related to the manufacture of this object. Possibly the objects were used for sharpening pointed tools. It is difficult to make precise suggestions for these sawing lines but there are clear evidences of deliberate intention rather than accident.

Fig. 29: Shouldered adze showing cut marks on both faces. This tool is kept in Département de Préhistoire, IPH (Photo: H. Sophady, 2007)
It is very interesting to note a shouldered adze that is perfectly polished and the edges of the tenon, square in cross-section, are very sharp. They seem to be cut by a kind of sawing. On both sides of the tenon, several large and deep striations, are visible and could possibly be cut marks from sawing (Fig. 30).

Fig. 30: Cutting lines observed by microscope on both left and right sides of the tenon of a shouldered adze. These lines are considered as being the traces of a kind of saw utilised for stone tool manufacture at Samrong Sen (Photos: H. Sophady, 2006)

In his publication on *Stone Adzes of Southeast Asia*, Roger Duff (1970) recognized the trace of sawn scarf on the right lower edge of stone gouges from Samrong Sen in Mansuy's plate which he suggested to be of Late Neolithic period. He also suggests that the right-angles of the shouldered adzes were achieved by an attrition sawing method (Duff, 1970: 14). Duff described the Late Neolithic stone-working technology as marked by great skill in the techniques of scarf-sawing, and drilling and later including double-crater drilling and the tubular bore technique and possibly these methods deriving the original inspiration from South China (Duff, 1970: 130). In the collection of Neolithic industry from the Santal Parganas, India, F.R. Allchin suggested that the shouldered adzes (Type IV of his classification) were produced by a new technique of sawing off the square shoulders of the tools. This, as suggested, implies the use of wire saw and suitable abrasive and thus indicates not only the cultural affinities but also general chronological position of this shouldered type (Allchin, 1962: 309). He also mentions that the cut marks of the saw are clearly visible on several specimens in the collection. Another good example of sawing for the shouldered adzes are seen at Kulai Kua, Bien Hoa province, northern Vietnam. Nowadays these collections are kept in the Musée des Antiquités Nationales de Saint-Germain-en-Laye near Paris. Two big shouldered adzes are characterized by the
deep curved and sharp shoulders. This form of shoulder is impossible to be made by flaking. They were possibly made by sawing and polishing (Fig. 31).

The technique of sawing has been recorded from some other stone workshop in Philippines (Pawlik, 2007: 5).

![Fig. 31: Stone implement from Kulai Kua, Bien Hoa province, Vietnam observed in the collection at the Musée des Antiquités Nationales de Saint-Germain-en-Laye near Paris. The tools are characterized by deep curve and sharp angle on the shoulder supposed to be made by sawing rather than by flaking (Photos: H. Sophady with the authorisation of M.A.N., 2007).](image)

### 3.2.3. Polishing

Polishing is the last stage of the polished stone tool manufacturing process. This phase is very important; the work requires more care and takes more time than first and second stages. Besides, to make the cutting edge sharp and efficient for a function, the polish to achieve the required bevel on the distal part is indispensable. The polish of the other parts of a tool is also necessary to complete the tool forms and make them easy for utilisation and also for aesthetic purposes and its greater value. The big adzes or axes of prestige were generally entirely well polished. These stone tools were finished either by partial grinding, or edge-grinding or complete polishing. The polishing striations vary from fine and shallow to wide and deep according to type of rock and quality of polishers (Fig. 32). In some tools from Samrong Sen the striations are not visible even by microscope; it is possible that striations may be erased by finer polish with very powder or other materials to make it gloss on surface and can also be the weathering or erosion on tool surface.
Fig. 32: Fine parallel and oblique striations observed on the edge of the upper face of an adze from Samrong Sen. The pattern reveals that the polishing technique was performed in the oblique direction rather than parallel to the symmetry axis of the tool (Photo: E. Gonthier, MNHN, 2007)

For the moment, we can’t provide more precise information regarding the fabrication of polished stone tools at Samrong Sen. To solve this problem we need more intensive fieldwork until we get clear information and evidence to make a new hypothesis for the manufacture of stone tools at this important prehistoric site and from this reconstruct the chain operation.

Nevertheless, the characteristics of the pottery as well as the typological analysis of lithic industry, which reveals diversity of adaptations of the tools and materials employed, attest that the use of stone implements and pottery vessels were already mastered in the Samrong Sen area (Mansuy, 1902; Mourer, 1994, Demeter et al., 1999 & Vanna 1999).
Chapter III

1. Functional observation

1.1. Generalities

Functional examination of prehistoric stone tools is an important aspect for understanding the living subsistence and daily practice of the tool users. A few questions occur when dealing with the function of stone tools: is there any correlation between the form and function of tools? Is there any relationship between form, use and culture? Is there any association between tool users and the site? The last question is what kind of behaviour can be distinguished by examining edge-damage? Simply put, these questions seek to determine what people did with the different kinds of tools they used (Ludomir, 2004: G-1). However, in many respects, the polished stone tools (axes, adzes, chisels or gouges) are some of the most informative among Neolithic tools. Axes and Adzes have mostly been recovered as stray finds in Samrong Sen and many show signs that they were used and reused over long periods perhaps from generation to generation. We can imagine their importance and practical role in various activities including tree-felling, house building, boat construction, clearing, carving, digging for agriculture, weapons as well as burial offering (Albek, 2005; Albrecht et al., 2000; Allchin, 1962; Coghan, 1943; Dega, 2002; Edmonds, 1995, Higham, 2002, 2004; Keeley, 1985; Nguyen, 1980; Willoughby, 1907, & etc.).

To understand the fashion of use of the tools we need to identify few principle characteristics (Monique Ricq, 1983: 12)

- Typological classification of preserved tools and comparison with the modern instruments and ethnography.
- The handle is a very important evidence to explain us about the tool functions.
- Micro-wear analysis to examine the erosions and damages on the cutting edge.
- Residue analysis to identify materials on the surface, such as blood and plants fibre, done either chemically or morphologically (Adran & Randolph, 2004: 2). Moreover, the functional analysis can also be seen through the measurement of the edge angle of the tools. This method also involves a specific morphological approach, except that it is not the tool’s morphology (shape/form) that is studied, but the morphology of the tool’s edge, or its selected parts. Edwin O. Wilmsen 1968, studied the edge angles of flakes and bifaces and identified three categories of angles associated with task-specific activities, the tools with the angle edge between 26° to 35° are mainly used for cutting, tools with the angle edge varying from 46° to 55° are rather used for scraping or heavy cutting and the tools that have an angle edge between 66° and 75° are used for wood and bone working (Ludomir, 2004: G-1).
Table 8: Summary of the results of determined angle edges and their association with task-specific activity after Ludomir Lozny (2004)

<table>
<thead>
<tr>
<th>No.</th>
<th>Edge Angle</th>
<th>Suggested working activity</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26°-35°</td>
<td>Cutting</td>
<td>Wilmsen 1968</td>
</tr>
<tr>
<td>2</td>
<td>46°-55°</td>
<td>Scraping or heavy cutting</td>
<td>Wilmsen 1968</td>
</tr>
<tr>
<td>3</td>
<td>55°-65°</td>
<td>Wood or bone working</td>
<td>Wilmsen 1968</td>
</tr>
<tr>
<td>4</td>
<td>61°(mean)</td>
<td>Wood scraping</td>
<td>Cantwell 1979</td>
</tr>
<tr>
<td>5</td>
<td>70°(mean)</td>
<td>Hide scraping</td>
<td>Cantwell 1979</td>
</tr>
<tr>
<td>6</td>
<td>66°-75°</td>
<td>Work with medium or soft materials</td>
<td>Broadbent 1979</td>
</tr>
<tr>
<td>7</td>
<td>75°-85°</td>
<td>Work with Hard materials</td>
<td>Broadbent 1979</td>
</tr>
</tbody>
</table>

To measure the angle of the cutting edge of stone tools generally we use a protractor goniometer, because this instrument can provide better result for tools that have a flat edge angle, they can’t work very well with tools having convex or concave at the cutting edge. For polished stone tool from Samrong Sen, the edge angles measured only on tools kept in Musée de l’Homme and Département de Préhistoire (IPH) (Fig. 33).

![Fig. 33: Edge angles of different tool types from Samrong Sen: collection kept in Musée de l’Homme and Département de Préhistoire (IPH).](image)

Table 9: Average angles of different tool types from Samrong Sen

<table>
<thead>
<tr>
<th>Average angle of the cutting edges</th>
<th>Adze</th>
<th>Axe</th>
<th>Shouldered adze</th>
<th>Shouldered axe</th>
<th>Gouge</th>
<th>Chisel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adze</td>
<td>57°</td>
<td>56°</td>
<td>64°</td>
<td>57°</td>
<td>60°</td>
<td>56°</td>
</tr>
<tr>
<td>Axe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shouldered adze</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shouldered axe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gouge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chisel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The classification of the objects by function is to be made according to the criteria mentioned above: typological criteria and comparison with modern instruments, is necessary.

Axes have been thought to be used for tree-felling, slitting of wood or breaking bones. Adzes are different from axes by the profile on the distal part which shows asymmetry and sometimes they have a single bevel on the cutting edge. The axe and the adze have completely different handle positions. For the axe the handle is always parallel to the cutting edge and for the adze the handle is perpendicular to the cutting edge (Monique Ricq, 1983: 15). However, this definition doesn't apply always: for example tools with double symmetrical bevel were discovered in Switzerland with the position of handle like the adze (Monique Ricq, 1983:15). Adzes are often used for smoothing wood surfaces and also for clearing and digging ground before planting.

Handle position of the gouge is probably the same as for the adze and gouge was used for wood working, hollowing tree trunks especially for boat construction (R. Mourer, personal communication) and probably for agriculture. It is possible that in the prehistoric site of Samrong Sen, situated in the lowland of the Tonle Sap, boats or rafts were a most useful vehicle for fishing and for travelling during flooding; therefore gouges are the most useful instruments. To date, only in Samrong Sen are these specimens encountered. This is only a hypothesis; in fact we do not have sufficient evidence to support this.

The size of many tools is very small and it is not possible to use them for agriculture or cutting timber; these small tools may only have been used for carpentry or carving. Small chisels and gouges are supposed to be used for decoration on wood, bone or shell especially for making ornaments like stone and shell bangles: at Samrong Sen stone and shell bangles, earrings and shell dishes have been discovered in abundance. In Vietnam small chisels were suggested to be used for production of stone bracelets (Nguyen, 1980: 29). The tool’s function does not always reflect to the tool type, we do not know, a tool possibly be used in multiple functions and if this was the case microscopic examination is not quite successful for the use-wear analysis. Although micro-wear analysis more or less can help us understand precisely the tool’s function.

Sawing is another particularity observed in the polished stone tool manufacturing. In the collection of Samrong Sen sawing mark are rare, except a shouldered adze revealed several deep cut marks on both surfaces. These cut marks probably are not related to the manufacture of this object. Possibly the objects were used for sharpening pointed tools. It is difficult to make precise suggestions for these sawing lines but there are clear evidences of deliberate intention rather than accident (Fig. 29).
1.2. Hafting

Hafting is another approach of the tools' link to their function. But the study of hafting is given less attention than study of tools themselves because the tool's handle or shaft is always poorly preserved in archaeological contexts. Most hafting studies are based on the ethno-archaeological investigations regarding modern tools still in use by different ethnic groups especially in New Guinea, Indonesia. However, some prehistoric handles associated with the adze or axe blades were discovered from various archaeological sites; some are deposited in the museum collections, with or without indication of provenance. Other evidences of the handle can be seen through micro-wear examination. Tool classification helps us to understand the hafting modes of the different tool types. The different forms of wooden handle reflect the tool functions.

Hafting refers to the butt morphology of the stone tool and to a set of elements, including mastic, through which an active tool is attached to a haft or a handle that is held while using the instrument. Keeley classified hafting performance into three principle basic types that, probably and frequently, are combined with one another (Keeley, 1982:799). The first type is stuff or jam haft where the proximal part of the tool is basically inserted into a socket or slot in the handle or shaft and is fixed by wedge. The second is wrapping or mastic (wrapped) or tied haft where the implement is simply lashed to the handle or shaft by ropes or rattan with the addition some kind of glue or resin. Third is the mastic haft where the tool is attached by applying natural glue, resin. Most tools were hafted by mixture of these standard methods, uncommonly by all three. These three types of hafting have different advantages and disadvantages. Jam or stuff haft is a typical method where the attachment of the specimen to its handle is a rapid and simple operation which also facilitates retooling or repairing. The inconveniences of such hafts are that the proximal portions of broken tools may be difficult to extract and more importantly, they characteristically allow the movement of the tool in the haft, which increases breakage and lowers precision of work. Wrapped hafts are often easy to produce and are relatively safe. Sometimes wrapping appears in combination with jam; in this case retooling is easy but slightly more time-consuming than the pure jam hafting. The major disadvantage of the wrapping method occurs because all types of strings or ropes broaden with tension and regularly increase or retract with differences in humidity. This means that the tool is constantly becoming loose in the haft, especially when the latter is in contact with wet material. In reality wrapping technique are plausibly safe except when the tools are being utilized on wet objects or in environments with high humidity like tropical climate weather.

Mastic techniques are often more secure and dependable, permitting almost no movement of the tool. Since even hardened mastic is more elastic than either the stone tool or the handle or shaft, it provides a cushioned setting that reduces breakage. Many materials
generally used as mastics show dramatic increase in viscosity when heated (Keeley, 1982: 800), while they are quite hard at normal temperatures. This means that initial hafting and subsequent retooling require the use of fire, making these tasks slightly more complicated and time-consuming than other methods and making a new tool will be preferred to repairing a broken one. Disadvantage is also increased because the removal of mastic to extract the broken part possibly will require more time.

It is fundamental to present some of the important shafting techniques which were discovered from archaeological sites, museum collections and to compare them to ethnographical evidence. In the tropical regions wooden, bone or antler handles were often absent in the archaeological context due to the weathering and high acidities in the soil, but we can see some of them only in the museum collections without any stratigraphical record. In Europe and Near-East, handles were found in some of the Neolithic sites, for example from the Swiss Lakes, Arpachiyah in Iraq (Coghlan, 1943: 36-38) and Charavines south France. The most important raw material for the adzes or axes handles is bone, antler and wood. Following are the different types of shaftings using various materials which are illustrated by Coghlan in his publication of “The Evolution of the Axe from Prehistoric to Roman Times” (1943).

**Type 1:** This type is a wooden handle of direct mounting for the adze. The adze blade is connected directly to the curve peak by wrapping with rattan or string perhaps enhanced by some kind of resin for stability when using. This mode of hafting is still practiced by the ethnic groups of the New-Guinea until nowadays (A.-M. and P. Pétrequin, 1993). This hafting technique is suitable only for an adze having a long adze blade with thin cross-section and which is moving almost parallel to the face of the tree trunk being chipped. Probably this type of handle was discovered in other sites in the vicinity of Cambodia recently. Obviously, in neighbouring Vietnam, handles have been found (Heng & Mao, 1999: 11), but we have not been able to find certain descriptions or illustrations.

**Type 2:** This type of handle is called knee-shaft (Coghlan, 1943: 40). This type shows another variety of indirect hafting, commonly used for the adzes. The small adze blade is inserted into a horn sleeve socket with the cutting edge perpendicular to the handle. The evidence of this hafting can seen in the many antler sleeve sockets that have been discovered in some archaeological sites in Europe, for instance, the Neolithic sites in eastern France.

**Type 3:** This type is an early and important phase forward in the handle technique. It represents the transitional bone-socket system, in which the tool is not fixed in direct association with its shaft. The tool is connected with an intermediate piece of bone or antler in a position more or less similar to the first type. In this case the handle can be wood, bone or antler. This is typical for adzes because the handle position is transversal to the cutting edge.
Type 4: This is another stuff method where the crude forms of wooden handle have a bigger distal part and thinner proximal one. A hole is made near the thick end of the rough club-like handle, but not going through the other side of the wood, and the axe wedges itself securely into place under the impact of the blows when the tool is in use. This type is typical for the heavy and big axes and used for falling timber or slitting wood.

Type 5: This type shows another variety of direct hafting, but opposite to that of the haft of type 4 and similar to type 9. It is practically a club-haft, although the axe blade is fixed through the slot. Handle form of this type shows increase in size and weight because of a big lump of wood projecting beyond the slot-hole and is good proportion to the size of the axe. The handle is made of wood where the distal part is bent upwards and is narrow to the proximal. Disadvantage of such a heavy shaft-end would be to wedge the axe into its hole with enormous force; and to resist this force, a very strong and clumsy shaft-end is required. To avoid the inconvenience of wedging the axe blade into the hole, binding is possible; wedging and gluing may also be combined. This hafting method is commonly used by the people living at Irian Jaya on the island of Papua Barat, New-Guinea, Indonesia until modern times.

Type 6: This is another direct hafting method where the handle is made of antler. This type is one of the earliest techniques of hafting devised, and it clearly constituted quite a sophisticated system for supporting rough or polished adzes or axe blades with the help of some substance such as resin or wedges for fixing adze or axe in the hole.

Type 7: The handle form is similar to the type 6 and the material can be antler or wood. The axe blade is fastened by rattan or string to the horn socket of the handle. The cutting edge is parallel to the handle axis. This type of handle, also called knee-shaft mounting, has been described by Coghlan as a very significant advance in hafting procedure (Coghlan, 1943: 40). This method offers a safe fixing for the axe blade with fine balance, in the weigh distribution to the greatest advantage for efficiency, and also reasonably thin form which is essential if the tool is to be used to cut to any depth.

Type 8: This is another combination method of hafting. The handle form is similar to type 5. An intermediate deer antler socket is fixed in the handle and the adze blade is inserted in the antler socket. Large amount of antler sockets have been recorded at the Neolithic site of the Swiss Lake dwelling, as well as many of them found in Charavines situated in between Lyon and Grenoble, south of France. The items can be found at the Département Préhistoire (Institut de Paléontologie Humaine, MNHN), Paris.
**Type 9:** This is a technique of direct hafting and typical for axes. The handle is made of a piece of wood. The lower part around the hole is flattened. The hole is oval in shape and the axe blade is inserted into this hole. The axe blade is big and not in balance with its shaft. This type is obviously a development of the slot principle. The disadvantage of this type is that when the axe is in use the axe blade is wedged into the hole and the wood (particularly on the distal part) easily breaks. The holding part of the handle is not long enough for sophisticated use if compared to type 4 and 5.

Considering all modes of handles, it is really not possible to make any conclusions regarding the polished stone tools of Samrong Sen. This is only to provide the basic remarks on the shafting techniques which were applied by the prehistoric people, unfortunately, the handle remains were not discovered at Samrong Sen, but a few adzes and axes keep some kind of resin or glue that was probably used for handle attachment. However, micro-wear analysis of several tools also did not recognize any evidence of hafting. There is no doubt that some tools were used without handle but had the same function as the tools equipped with handle. According to the morphological and typological differences, Keeley noted the difference between hafted and unhafted tools: “A category of hafted tools are likely to be smaller, thinner and narrower and more widely retouched for the reason to insert to the shaft while the unhafted category comprise of large dimensions to be comfortably held and effectively employed” (Keeley, 1982: 801). Dealing with the Samrong Sen specimens, it is probable that some tools were hand-held as for instance the gouge with slight shouldered (Fig. 21, n° 8. 983. 1. 2), two chisels (Fig. 22, n° 33.17.33 and 33.17.23) which were heavily damaged on butt and cutting edge, indicating that they were operated without a handle, and their dimensions are large enough for holding by hand.

*Fig. 34:* Deer antler sockets found at Charavince southern of France. These were used to connect the axe and adze to their handle (Photo: H. Sophady 2007).
Fig. 35: Basic hafting methods of polished stone tools. N° 1: Technique of cutting tree branch for making a handle (Drawings H. Sophady following the explanation of E. Gonthier). Types 1-3 are typical for adzes; types 4-7 for axes; type 1, 4 and 5 are commonly used by the people in Irian Jaya, New-Guinea, Indonesia. (Types 1 and 5: drawn by H. Sophady; types 2, 3, 4, 6, 7, 8 and 9 redrawn from Coghalan 1943)
1.3. Use wear analysis

The methodology of identifying prehistoric stone tool functions has improved significantly since the introduction of microscopic use-wear analysis. This type of study was first introduced in the 1950s by the Russian scientist Sergej Semenov (Semenov, 1964). The same year E. Cecil Curwen attempted to identify the cause of the polished surfaces observed on the edges of several Neolithic serrated blades from various locations in Europe, the Near East and North Africa (Andrian and Randolp 2005: 1). Since then, the examination of micro-wear on stone tools became more important for prehistoric archaeologists. Micro-wear analysis is a modern technology using microscopes with high or low magnifications to determine the function of stone tools. Basically, it can be performed on any set of stone artefacts. However, its application is limited to specific conditions of the preservation of artefacts. Use-wear analysis is less successful on stone tools having high surface patina or on tools made out of coarse-grained rocks. An interesting issue pointed out by Ludomir is the re-sharpening of worn tool edges, in which case, the edge damage represents the last use modification. This is a major issue for microscopic studies (Ludomir, 2004: G-2).

Micro-wear analysis attempts to determine the function of stone tools by examining direct evidence in the form of use-wear and pattern on the cutting edges and by comparing them to experimental tools, whose utilisation is known.

A number of different tool types (7 adzes, 2 gouges, 1 chisel and one shouldered adze) were selected for use-wear analysis. The results were then compared with the functions assumed from their typological classification and with ethnographic data. The analysis was performed at Ferarra University under the guidance of Sara Ziggiotti. All microphotos were taken with a digital camera attached to high and low power microscopes.
### Table 10: Summary of microwear and technological examination

<table>
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<tbody>
<tr>
<td>III</td>
<td>Adze</td>
<td>57°</td>
<td>Rectilinear</td>
<td>Perpen dicular</td>
<td>6.7</td>
<td>4.9</td>
<td>0.9</td>
<td>Polished</td>
<td>Chipping</td>
<td>Tritions and large, parallel and perpendicular to cutting edge.</td>
<td>Slightly concave, gloss and polished</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
</tr>
<tr>
<td>IV</td>
<td>Adze</td>
<td>70°</td>
<td>Rectilinear</td>
<td>Slightly oblique</td>
<td>5.8</td>
<td>4.1</td>
<td>1.4</td>
<td>Polished</td>
<td>Feather</td>
<td>The striations are wide, deep parallel and oblique to the cutting edge.</td>
<td>Slightly gloss</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
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<tr>
<td>XI</td>
<td>Chisel</td>
<td>58°</td>
<td>Slightly convex</td>
<td>Slightly oblique</td>
<td>5.9</td>
<td>2.1</td>
<td>0.8</td>
<td>Polished</td>
<td>Micro chipping</td>
<td>No striations visible</td>
<td>Edge slightly rounded, gloss and polished</td>
<td>Chiseling</td>
<td>Wood, bamboo/ bone</td>
</tr>
<tr>
<td>XIV</td>
<td>Adze</td>
<td>62°</td>
<td>Slightly convex</td>
<td>Perpen dicular</td>
<td>4.1</td>
<td>2.8</td>
<td>0.9</td>
<td>Polished</td>
<td>Heavy chipping</td>
<td>Striations are large but shallow parallel and oblique to cutting edge</td>
<td>Edge facetted and slightly concave, gloss</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
</tr>
<tr>
<td>XVII</td>
<td>Adze</td>
<td>53°</td>
<td>Slightly convex</td>
<td>Slightly oblique</td>
<td>4.6</td>
<td>2.6</td>
<td>0.75</td>
<td>Polished</td>
<td>Chipping</td>
<td>Striations are fine and oblique near the cutting edge</td>
<td>Edge facetted slightly rounded and gloss</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
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<tr>
<td>33.17.19</td>
<td>Gouge</td>
<td>60°</td>
<td>Slightly convex</td>
<td>Oblique</td>
<td>9.7</td>
<td>3.7</td>
<td>1.5</td>
<td>Polished</td>
<td>Heavy chipping</td>
<td>Clearly visible are large and small, long and short and parallel deep and shallow striations. These striations are mostly perpendicular to the cutting edge. Some striations are also present with an oblique angle to the cutting edge</td>
<td>Gloss and polished</td>
<td>Grooving or chopping</td>
<td>Wood or bamboo</td>
</tr>
<tr>
<td>33.17.111</td>
<td>Adze</td>
<td>67°</td>
<td>Convex</td>
<td>Perpen dicular</td>
<td>7.6</td>
<td>3.7</td>
<td>1.7</td>
<td>Polished</td>
<td>A small chipping</td>
<td>Use-wear traces can be seen in form of tiny striations perpendicularly to the cutting edge</td>
<td>Edge rounded and gloss</td>
<td>Scrapping or shopping</td>
<td>Wood, bamboo/hide?</td>
</tr>
<tr>
<td>33.17.155</td>
<td>Adze</td>
<td>81°</td>
<td>Convex</td>
<td>Perpen dicular</td>
<td>13.8</td>
<td>4.8</td>
<td>2</td>
<td>Polished</td>
<td>Feather</td>
<td>Use wear traces are difficult to recognize, striations are not well developed, but two short and parallel striations oblique to the cutting edge are considered as the result of polishing or grinding</td>
<td>Edge slightly rounded and gloss</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
</tr>
<tr>
<td>33.17.157</td>
<td>Adze</td>
<td>59°</td>
<td>Slightly convex</td>
<td>Oblique</td>
<td>12</td>
<td>5.9</td>
<td>1.4</td>
<td>Polished</td>
<td>Macro and micro chipping</td>
<td>Fine and parallel striations are located perpendicular to the cutting edge, also short and wide grooves oblique to the cutting edge are visible</td>
<td>Edge damaged, concave and gloss</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
</tr>
<tr>
<td>33.17.158</td>
<td>Adze</td>
<td>63°</td>
<td>Slightly convex</td>
<td>Oblique</td>
<td>12.4</td>
<td>6.6</td>
<td>1.8</td>
<td>Polished</td>
<td>Broken in the middle</td>
<td>Striations are not clearly visible, but very fine, parallel and perpendicular to the cutting edge should be considered</td>
<td>Edge damaged and gloss</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
</tr>
<tr>
<td>33.17.174</td>
<td>Shouldered adze</td>
<td>65°</td>
<td>Slightly convex</td>
<td>Oblique</td>
<td>8.5</td>
<td>3.3</td>
<td>1.5</td>
<td>Polished</td>
<td>Heavy chipping</td>
<td>Striations are barely visible</td>
<td>Edge chipping, slightly glossy, fracturing line is clearly visible</td>
<td>Chopping/ adze</td>
<td>Wood or bamboo</td>
</tr>
<tr>
<td>33.17.199</td>
<td>Gouge</td>
<td>70°</td>
<td>Slightly convex</td>
<td>Oblique</td>
<td>10.3</td>
<td>2.5</td>
<td>2</td>
<td>Polished</td>
<td>Micro chipping</td>
<td>Large and parallel striations are perpendicular to working edge</td>
<td>Bowl-shaped, gloss and tiny chipping</td>
<td>Grooving/ chopping</td>
<td>Wood or bamboo</td>
</tr>
</tbody>
</table>

**Notes:**
- Art. type: Artefact type
- E. angle: Edge angle
- E. shape: Edge shape
- E. direc.: Edge direction
- M. length: Maximum length in cm
- E. width: Edge width in cm
- D. thick.: Distal thickness in cm
- E. trim.: Edge trimming, ground or polished by using or by shaping/fabrication
- E. damage: Type of fracture, big, small chipping, flaking or still good preserving
- Worked mat.: Worked material
The results of the use-wear examination are summarized in table 10. A description of each tool and discussion of wear traces and technological features follows:

- Object n° III: This adze is made of fine grained rock with black colour. This object was finely polished, except for the dorsal part where a natural depression was left unpolished. The adze shape is tapering to the butt. This typological view is very common and found in a large area of Southeast Asia. Duff classified this form as Type 2 (Duff, 1970). Its cross-section is flattened reed on both parts proximal and distal. There are three tiny lines surrounding the adze blade on the proximal part and another tiny line is appearing near the butt. These lines could be a natural processing of the rock or can be a fracture caused by heavy use. Near the cutting edge is a fracture line clearly visible. This tool has a single bevel cutting edge on the lower face. There are a few small chipping scars visible on the cutting edge. Residues of a resin on the proximal part might be hafting glue to support a binding fixture. The photo of use-wear was taken from the upper face almost in the middle of the straight cutting edge where a very small negative was observed (Fig 36). Striations are not well observed, but they show a slightly concave characterized by few deep and wide grooves perpendicular to the cutting edge, and gloss (Fig. 37). This kind of wear patterns suggest that this tool was used for wood working or felling trees as well as on bamboo or rattan. This tool might have been used for quite a long time and was subject to resharpening (Pawlik personal communication, 2007).

- Object n° IV: This adze is made of fine grained rock. Its texture is compact with dark grey colour. The adze form is trapezoidal; the butt is thin and unpolished. The cross-section is trapezoidal on distal and proximal part. All faces are well polished, although some negatives from the initial of tool preparation remain visible on the proximal part. This object has a single bevel of the cutting edge on the lower face. A small chipping on the ventral face near the working edge to the left lateral side is visible. The cutting edge shows micro-chipping. Evidence for hafting is not recognizable. The photo of use-wear was taken from the upper face near the left corner of the cutting edge (Fig. 36). The striations are clearly visible even to the bare eye. The striations are wide, deep and oblique to the cutting edge, and slightly bright (Fig. 37). On polished artefacts, those kinds of striation patterns on the surface are usually from the manufacturing process, the grinding and polishing. Different kind of striations and their roughness might be the result of different stages of fabrication and successive resharpening and reworking. The use-wear traces are not as developed as the previous ones but the form and morphology of the tool suggests the same hafting mode and a similar use for wood or bamboo working.

- Object n° XII: This is a chisel made of a hard and fine grained rock with brown colour. Chisel form and its cross-section are rectangular. The right side is slightly rounded but polished while the left side has a sharp angle and has been intensively polished. On the left edge of the
dorsal part appears a large groove along the edge. This could be sawing trace, indicating that this chisel was prepared by using sawing technique before grinding. The dorsal part was almost completely polished except for a small part near the butt. The butt present flat and remains unpolished, except for the left edge of the butt. On ventral face, only the distal and the proximal areas are partly polished with remaining flaking scars. The edge has a bevel on the lower face. Micro and macro chipping are visible on both faces of the working edge. The use-wear photo was taken from the lower face with a small chipping near the left angle of the edge (Fig. 36). Striation patterns are not recognizable but flaking and gloss indicates an intensive use for cutting hard objects, wood, bone or bamboo (Fig. 37).

- Object n° XIV: This is a small adze made of very fine grained multi-coloured rock. The ventral face is dark brown and the dorsal face is grey mixed with dark green. This adze is getting smaller towards the butt and is slightly trapezoidal in cross-section. The butt is thick, convex and unpolished; all faces are polished, although preparation negatives remain still visible. Hafting evidence is not visible but the rounded and abraded butt indicates a long continuous contact against the haft rest. It is quite certain that this adze was in use for a long time (Pawlik personal communication, 2007). This small adze has been intensively used and was certainly several times resharpened. There is a single bevel on the lower face. Many small fractures are present along the working edge. The use-wear photo was taken from the upper face (Fig. 36). The use-wear traces are characterized by big and deep striations and gloss. This pattern looks similar to adze n° III. Likewise, this tool was also used for chopping hard material, very likely wood or bamboo (Fig. 37).

- Object n° XVII: Again a small adze made of dark brown and fine grained rock. The adze form narrows down towards the butt; the distal and proximal cross-sections are rectangular. The whole adze blade was completely polished, except for the butt. The butt form is round. The cutting edge is form by a single bevel on the lower face. Small chipping is visible on the lower face of the working edge near the right angle and a big flake scar appears on the upper face of the cutting edge probably due to the working activity. This small adze, perhaps in the same way as adze n° XIV, has been used for a long time. Multiple resharpening reduced the size of the artefact to its present small size. The use-wear photo was taken from the upper face near a large scar to the right (Fig. 36). The striations are fine and oblique near the cutting edge. The facetted on the cutting edge may be due to scraping or resharpenning (Fig. 37). It has been suggested that the smooth and glossy edge points towards a careful working of bamboo with controlled power (Pawlik personal communication, 2007). Unfortunately, no hafting traces could be identified.

- Object n° 33.17.19: This is a gouge made of a fine grained chert or phtanite with dark brown colour. The upper face is well polished while the lower is partly polished with traces of
the previous flaking still visible. The butt is flat and unpolished but chipping occurs on both lateral sides. The cross-section is ellipsoidal on the distal part and bi-convex on the proximal part. The cutting edge is barely damaged with few micro and macro chipping due to the utilisation. The photo of use-wear was taken from the upper face in the middle of the edge between two flake scars (Fig. 36). Clearly visible are long and parallel deep striations. These striations are mostly perpendicular to the cutting edge and sometimes oblique (Fig. 38). The use-wear patterns involve a contact with bamboo or wood but the gloss points towards the contact with a phytolith-rich material like bamboo rather than wood (Pawlik personal communication 2007). Striations perpendicular the cutting edge indicate that this tool was utilisation while holding it as an adze, although hafting traces and residues could not be found.

- Object n° 33.17.111: This adze is made of very fine grained raw material with brown colour. The adze is rectangular in cross-section. The whole adze blade is partly polished; many deep flake scars remain on the surfaces. The butt is flat and remains unpolished. Hafting evidence is not visible and the butt is still flat and well preserved. It is possible that this adze was used without hafting. Only the cutting edge is completely and well polished. It has two asymmetrical bevels. On the ventral face the cutting edge is grounded and polished to become steep while the dorsal face is convex. The cutting is remaining intact. The use-wear photo was taken from the dorsal face in the middle of the cutting edge (Fig. 36). Use-wear traces can be seen in form of tiny striations perpendicular to the cutting edge, abrasion and gloss. These wear traces suggest that the tool was used for scraping or smoothening wood, bamboo or perhaps soft material like hide (Fig. 37).

- Object n° 33.17.155: It is an adze made of basalt. The adze blade is trapezoidal and getting smaller towards the butt. The butt is pointed and thin but a very small flattened platform is visible. Hafting evidence is not recognizable. The cross-section is facetted on the distal part and triangular on the proximal part. The dorsal face is polished mainly on the distal part and along the working edge while the ventral face is not polished except for a small part near the butt. The working edge is convex with a steep unilateral bevel on the lower face. Perhaps this tool was reworked shortly before it was discarded or the manufacturing process was not completed, since no damage can be seen on this fresh looking tool. The photo for the use wear analysis was taken from the upper face in the middle of the cutting edge (Fig. 36). Use wear traces are difficult to recognize, striations are not well developed, but two short striations oblique to the cutting edge are considered as the result of grinding or polishing (Fig. 38). Some gloss and rounding on the edge can indicate a contact with wood or bamboo as well as other soft materials while scraping.

- Object n° 33.17.157: This adze blade is made of very fine grained and dense rock of different colours: grey, light brown, brown and black. The adze shape is trapezoidal; the cross-
section is flattened reed on the proximal part and distal part is slightly trapezoidal. Dorsal and ventral faces are polished but big and deep flaking scars remain visible over almost the whole tool. The butt is flat and unpolished. Abrasion of the right side and several small negatives probably are the result of a direct contact with a wooden or antler shaft. The angle of the upper face of the butt is sharp and flat and perhaps created by sawing and breaking. The cutting edge is slightly convex with micro and macro chipping; the edge is broken at its left angle. The microphoto was taken from the dorsal part near the break (Fig. 36). Fine and parallel striations are located perpendicular to the cutting edge, also short and wide grooves oblique to the cutting edge are visible. This part of working edge is concave and has a bright reflection. Mainly this intensive gloss and the rounding of the edge point towards a contact with bamboo or wood (Fig. 38).

- Object n° 33.17.158: The adze form is pointed towards the butt with a trapezoidal cross-section for both, the proximal and distal parts. This tool is made of phtanite, the rock composition is fine, solid and layered. The colour is brown with some dark green patches. The adze was partly polished on ventral and dorsal face but mainly in the distal zone and working edge. There is a single bevel on the lower face. Both sides are slightly polished and many flake scars are well preserved on both faces. The pointed butt is unpolished but slightly rounded and not fractured. The cutting edge is significantly damaged by a large break in the middle, and several smaller scars on both faces. The heavy damage of the working edge can be accidental or post-depositional (Pawlik personal communication 2007), but could also happen due to heavy-duty use for cutting or breaking hard objects (Fig. 36). The micro-photo was taken from the upper face and the left part of the cutting edge. Striations are not clearly visible but a glossy edge polish seems to be a result of chopping bamboo rather than wood (Fig. 38).

- Object n° 33.17.174: This shouldered adze is made of light green and fine grain chert or phtanite. It form is crude and it is only slightly shouldered. Both lateral sides are unpolished. The dorsal and ventral faces are particularly polished near the cutting edge and partly grounded on proximal part. The cutting edge results from asymmetrical bifacial bevels. The dorsal face is slightly convex while the ventral face is flat to create a transverse cross-section rectangular at distal and square at the shouldered part. Along the edge are various scars and fractures, mainly on the left side where also a fracture line appears. The butt is flat and unpolished. Again, no evidence for hafting can be proven. The microphoto was taken from the ventral face near the fractured part (Fig. 36). Use wear traces are barely visible. The break scars on the cutting edge could be considered as a result of heavy cutting or chopping hard materials like wood or bamboo (Fig. 38).

- Object n° 33.17.199: This gouge is made of black basalt; its texture is very compact and mixed with tiny yellow dots. This gouge has the same form as a chisel, only the cutting
edge is concave and narrower than the proximal edge. It resembles the gouges found in other parts of Southeast Asia and Oceania classified by Duff as Type 4, while Heine Geldern referred to as belonging to the Round Axe Culture (Heine Geldern, 1932). The whole surface of this gouge is well polished only few shallow and small flake scars are remaining on the right side and near the butt. The butt is slightly rounded and complete but almost unpolished. The dorsal face is round and narrows down to both lateral sides and to the cutting edge. The ventral face is flat to create a plano-convexe cross-section on distal and proximal parts. No impact battered traces of contact with a hammer can be found on the butt. Likewise there is no proof for hafting. The cutting edge is still well preserved. The photo of the use-wear analysis was taken from dorsal face in the middle of the convex cutting edge where a small depression is recognisable (Fig. 36). Striations are not clearly defined but visible (Fig. 38). These striations are parallel and perpendicular to the working edge. The bowl-shaped and gloss with a tiny chipping on the cutting edge indicate that the tool was used for planning, carving or smoothening wood or bamboo rather than chopping or cutting.

Concluding remarks:

The stone implements examined in this study were more or less used to work on wood or bamboo rather than hide or meat. Adzes and the shouldered adze seem to be designed for chopping or cutting wood or bamboo, while gouges are considered to be used for smoothening or engraving and for carpentry purposes. Some tools show resharpening or reworking of the cutting edges while other gave information of the manufacturing process. Some artefacts have clearly defined use-wear patterns while on others hardly any wear traces can be seen at all, perhaps due to post-depositional alterations or staining of the tool surfaces. Cleaning with a chemical solvent is recommended before use-wear analysis. Low power analysis alone is not sufficient for microwear analysis, the use of high power or electronic microscope may obtain better results.

There were few visible hafting traces; but resin was still preserved on adze n° III. However, their absence is not a proof that the tools were used unhafted. Damages of the cutting edges were not all caused by utilisation: accidental and post-depositional factors have to be taken into consideration as well.

This study is only an initial investigation and the results are very preliminary. A more intensive research including experimental framework is recommended for future studies.
Fig. 36: Tools selecting for microwear analysis. The red circles demonstrate the places were taken photographed for use wear (Photos: H. Sophady, 2007)
Fig. 37: Use wears patterns of different tool types (Photos: H. Sophady, 2007)
Fig. 38: Use wears patterns of different tool types (Photos: H. Sophady, 2007)
1.4. Ethnographic comparisons

The use of stone tools is still practiced up to now for many generations among different ethnic groups in the Irian Jaya, Indonesia (A.-M. and P. Pétrequin, 1993; Gonthier, 1997). The people are producing and using stone implements (axes, adzes and chisels), made from local rock, for clearing the mangrove forest, constructing huts or boats, cutting bone and meat as well as working wood.

Ethnic groups in Irian Jaya, Indonesia still practice two technical traditions of different origins, transmitted by inheritance, one to the West, and the other to the East of Irian Jaya. Only the communities living in the valley of the central Baliem and the Marind-Anims to the South use these two types of tools jointly, the adze for the wood cutting, the axe to split wood (A.-M. and P. Pétrequin, 1993) (Figs. 39 & 40).

**Fig. 39:** Felling tree by using polished stone adze. Langda, Una group, New-Guinea, Indonesia. (Photo courtesy of A.-M. & P. Pétrequin, 2006)

**Fig. 40:** The Wano ethnic group of the Village Ye-ineri, New-Guinea, Indonesia, splitting wood by polished stone axe. (Photo courtesy of A.-M. & P. Pétrequin, 1993)
Chisels are tools with narrow distal cutting and generally rectangular in form. The cutting edge may be symmetrical bevel or not. Certainly, these tools present a cutting to the two extremities. Chisel can perhaps be used without handle, for sophisticated wood working like carpentry, rather than chopping and splitting logs, to make a hole or groove, and especially to make hole on wooden handles to attach to an axe or adze (A.-M. and P. Pétrequin, 1993) (Fig. 41).

Fig. 41: Stone chisel used to make a hole in a wooden handle, Village Ye-Ineri, Wano group of New-Guinea, Indonesia (Photo courtesy of Anne-Marie and P. Pétrequin, 1993)

Ethnographical observations of the tool functions were made in 2002 and 2004 under the direction of the author and G. and Barbara Albrecht accompany by the second year students of the Faculty of Archaeology at Rattanakiri province, northern Cambodia where different ethnic groups of Mon-Khmer origin are living. The Kru'ng minority uses a kind of tool made of iron, with the handle parallel to the cutting edge, for clearing fields for agriculture. This tool can be compared to the polished stone tools discovered from Neolithic or Metal Age sites in Cambodia as well as in the whole Southeast Asia (Fig. 42).
Another group of Mon-Khmer origins (*Steang*) living in some villages, of the Memot district, Kampong Cham province of eastern Cambodia, in the red soil plateau region where many circular earthworks sites were discovered, is using a similar tool. This is a kind of adze made of iron, with a straight handle in the same line as the tool blade, for digging and clearing grass for agriculture. This tool also resembles the polished shouldered adzes because it has only a single bevel at the cutting edge (Fig. 43).

In Vietnam, people also use some kind of hoes that are similar in many ways to the adzes, for digging. Vietnamese archaeologists suggested that probably in the Phung Nguyen Culture, around 2000 BCE and lasted about 1000 years; people used some kind of adzes in digging also (Nguyen, 1980: 28).
According to personal observations, local populations in the countryside in Cambodia use the polished stone tools as effective medicine. They grind the polished axe or adze with a grinder made of sandstone to get powder to drink against the malaria and fever. Some of them keep the polished stone tools that they found from their fields or discovered by accident, in their granary in order to get more rice, because they think that stone tools will bring them good luck. However, this is only a traditional belief of people living nowadays in different areas and it did probably not exist in the past.

Polished stone tools were probably used as burial goods, as shown through excavations of Neolithic or Bronze Age sites in Southeast Asia and Europe and other area over the world, where polished stone tools in burial context (Fig. 44) are thought to have been used as offering for the dead (Higham, 2002, pp.56-82 & 2004, pp.41-64, Edmonds, 1995, pp.49-80, Whittle, 1985, pp.278-292).

![Fig. 44: An early Neolithic grave from Ban Kao, Thailand, containing many grave goods including polished stone adzes (Photo courtesy of Higham, 2002)](image)

In reality, polished stone tools are the most important witness of everyday life of people in late prehistory. We can not tell more about the specific function of these tools unless evidence of their use is discovered to help in making more exact interpretations.

The techno-typological survey of the polished stone tools from Samrong Sen permitted us to establish an operative succession for the manufacture of these objects.

The experimentations, even founded on ethnological observations, permitted us to obtain further knowledge regarding their utilisation.
In many of cases, the polished stone tools don’t have unique function but in the case of Papuan people, the axes or adzes are prestige or money for marriage (A.-M. and P. Pétrequin, 1993. In the economic point of view, stone tools are not only used as tools or weapons but they were produced for trade or exchange with other communities intra and extra region.
Chapter IV

1. Distribution zoning of stone adzes with quadrangular cross-sections

1.1. From the Samrong Sen Collection

The term “quadrangular adze” refers to stone adzes or other specimens having four angles, when viewed in cross-section. Examples include adze, axe, chisel, and shouldered adze or axe. Quadrangular adzes are common stone implements that have been discovered in large areas of the Southeast Asian Mainland and islands, as well as many islands in the Pacific basin. These adze assemblages are considered as ancestral to later forms of stone implements (Dega 2002:193).

Within the 286 pieces lithic assemblage from Samrong Sen, the majority of cross-sections are quadrangular (60%), followed by plano-convex (12%), ellipsoidal 5%, and “other” (lenticular, biconvex, oval, triangular, etc.) (Table 4). The four angle cross-section varies from rectangular and trapezoidal to a square-shaped morphology. In the Samrong Sen collection, the quadrangular-sectioned stone implements are common for adzes or axes, chisels and shouldered adzes or axes; they also occur with gouges but this is very rare. Regarding an abundance of quadrangular cross-section adzes, axes, chisels, and shouldered-types at Samrong Sen, some authors have noted that the prehistoric site of Samrong Sen is one of the most important distribution zones for polished stone tools having a quadrangular section, with the assemblage correlating to many prehistoric sites across Southeast Asia (Heine Geldern 1932, Bayer, 1948, Loewenstein 1957, Heekeren 1957, Duff 1970).

1.2. In relation with the lithic industry of circular earthwork sites in Cambodia

Excavated prehistoric sites in Cambodia are still limited in quantity. Of the excavated sites, they are located across various landscapes and environments: some are caves; some are open-air sites near the riverbanks or in the floodplain of the Tonle Sap, while some are on the plateau of the red earth area of eastern Cambodia. Most of these excavation sites have yielded small assemblages of polished tools, with the exception being circular earthwork sites that have yielded large quantities during recent intensive fieldwork by different groups of researchers. As two excavated assemblages are now known and provenience, I wish to compare the lithic assemblage from the circular earthwork sites to the stone tools from Samrong Sen. The basis of comparison is to create an understanding between the similarity or differences in the technology of stone tool manufacturing between both archaeological contexts.
The red soil plateau region in eastern Cambodia and southern Vietnam contains many homogeneous circular earthwork sites clustered about the landscape. The sites are characterized by an outer concentric earthen wall, an inner ditch, and central depressed platform. The sites typically contain two entrances, located opposite flanks of the site. The dimension range of the sites varies from 180 m to 300 m in diameter. The sites are thought to have been occupied at least from the late Neolithic or early Metal Age, as based on the recovered artefact assemblages at the sites. Absolute dates have also placed these sites within a c. 3000 B.C.-600 B.C. time frame, although this dating remains a topic of debate until present.

The lithic industry of the circular earthwork is comprised of a large quantity of flakes, unfinished and finished tool types (adzes, chisels, shouldered adzes or axes mostly having quadrangular section), pre-forms, and polishers. Articles published on the sites do not write in-depth about the axe assemblages, beyond descriptive information.

Flakes and debris were discovered in large amounts at the circular earthwork sites and were associated with unfinished tools, fragments, tool performs, and polishers. This debris revealed that tools were manufactured or reworked directly at the sites through flaking, grinding, and polishing techniques. This is quite opposite from Samrong Sen where large amounts of flakes, pre-forms, unfinished fragments, hammer stones, and polishers were found only in small quantities. By morphological comparison, adzes, axes, chisels, and shouldered type adzes from Samrong Sen are more or less different in form, shape, and size when compared to the earthwork assemblages. In particular, adzes with the profile exhibit a flat, single bevel on the lower face and a continuous convexity on the upper face (Type 2). With adzes, the profile has a steep, unilateral bevel; the lower face is flat and the upper face is slightly convex (Type 7). The tools with rounding and polishing on their distal ends were the same that Mansuy considered as probably used for burnishing pottery (Mansuy, 1902) (Type 8). These were not present at the circular earthwork sites. Shouldered adzes with deep and curved shoulders and sharp angles on tenon have also not been found at earthwork sites to date. In general, the dimensions of stone tools from Samrong Sen are larger than tools from the earthwork sites. For instance, adzes, shouldered adzes, and chisels of both archaeological contexts show much difference in average length, width, and thickness.
Table 11: Dimensions comparison of stone tools from Samrong Sen and Circular earthworks

<table>
<thead>
<tr>
<th>Category</th>
<th>Samrong Sen</th>
<th>Circular earthwork</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adze</td>
<td>Shouldeered adze</td>
</tr>
<tr>
<td>Average length (cm)</td>
<td>6,78</td>
<td>8,33</td>
</tr>
<tr>
<td>Average width (cm)</td>
<td>3,58</td>
<td>4,33</td>
</tr>
<tr>
<td>Average thickness (cm)</td>
<td>1,45</td>
<td>2</td>
</tr>
</tbody>
</table>

Interestingly, some tool types discovered at the circular earthworks were not present at Samrong Sen and vice-versa. For example, shouldered picks and arrowhead points were not found at Samrong Sen, but these tools are present at the circular earthworks. Gouges are found at Samrong Sen but not at the circular earthworks. Gouges are a typical stone tools used for carpentry, especially for constructing boats. It is likely that gouges were not important tools at circular earthwork sites because the sites are located far from perennial water sources such as lakes and rivers, while Samrong Sen lies on a river. These differences are not surprising as most prehistoric sites do contain differences in assemblages, as based on adaptations to the particular environment. Fishing, to be sure, was a main resource for subsistence at Samrong Sen, and the artefact record reflects such use (fish hooks, harpoons, points, clay net sinkers). Hunting game likely played a more significant role at the circular earthwork sites, as they are situated far from lakes or rivers. Thus, arrowheads were more common at the inland earthworks while fishing implements were common at Samrong Sen, a riverine site.

However, the sample from Samrong Sen is quite small and lacks proper stratigraphic control while data from the circular earthworks is also limited. Comparisons between the two sites, based directly on the objects themselves, may be done through illustrations and articles, which may provide more information to the assemblages.

1.3 In relation to the countries of Southeast Asia and other islands in the Pacific Ocean

It is difficult to fully assess the origin, typology, and diffusion or movement of stone tools within Southeast Asia as the region is comprised of a large Mainland and many islands associated with different cultural groups, some of which have a similar tradition and environment and some that are completely different. During prehistoric times, these cultures produced and used stone tools which look similar from one to other, especially adzes having four angled sections, which occurred across the entire region. Furthermore, quadrangular
adzes in Southeast Asia also look similar, or some are the same in typology and morphology, to the quadrangular adzes of Eurasia and Europe, as well as many other part of the world. However, some scholar’s efforts to study archaeological remains and compare them to linguistic records has allowed for identifying different cultures. This practice has been around for a long time. The first who investigated stone adze diffusion in Southeast Asia was the Austrian scholar Robert Heine-Geldern in 1932. He reconstructed three prehistoric cultures related to three languages and stone tool types:

- The *Walzenbeilkultur* (Round Axe Culture) belong to Papuan-speaking population.
- The *Schulterbeilkultur* (Shouldered Adze Culture) belong to Austroasiatic-speaking population.
- The *Vierkantbeilkultur* (Quadrangular Adze Culture) belong to Austronesian-speaking population (Heine-Geldern 1932).

The *Walzenbeilkulture* of Heine-Geldern has been debated by some scholars (Bellwood, 1978; Duff, 1970; Ha van Tan 1991) because the Round Axe (axe with circular cross-section), widely applied to a chisel or gouge and having been discovered in Cambodia (Samrong Sen), Vietnam, Philippines, Indonesia as well as in Polynesia and other Islands in the Pacific Ocean, did not explicitly belong to the Papuan-speaking people. The discrete existence of the Shouldered adze Culture and Quadrangular adze have never been successfully confirmed (Ha Van Tan 1991: 354-362). Although there remains debate, the work of Heine-Geldern became fundamental theory for other researchers who studied stone adzes and other prehistoric implements and cultures in Southeast Asia (Colani, 1938; Bayer, 1948; Callenfels, 1951; Heekeren 1957, Loewenstein 1957, Duff 1970, etc.).

Roger Duff (Duff 1970) conducted a more recent, deeper study of stone adzes of Southeast Asia after Heine-Geldern. His study was based mainly on collections, most of which without stratigraphic record and provenance. Those collections were being housed in different museums in different countries of Southeast Asia. Duff’s study classified adze typology and he adapted the Heine-Geldern theory for adze migration, as well as adding some new discoveries and hypotheses. In his typological studied of stone adze, Duff proposed three major distribution zones: **Focus 1** included south China, Formosa (Taiwan) and the Philippines. **Focus 2** incorporated Burma, Cambodia, Lao, Vietnam and northern Thailand. **Focus 3** integrated southern Thailand, Malaya and Indonesia (Fig. 45).

Focus 1 was thought as the original location for the quadrangular adze, later to be distributed across Southeast Asia. The shouldered scraper and hoe were present in south China and Taiwan. Focus 2 considered the local invention of shouldered adze and its spread into Indochina, Thailand, Burma and some parts of India. Focus 3 is considered possibly the home land of pick adzes which are common in Malaysia, Indonesia and Southern Thailand.
The polished stone tools from Samrong Sen look similar to stone tools discovered from some prehistoric sites in Thailand. For example varieties of the quadrangular adze discovered from Late Neolithic assemblage associated with pottery at Ban Kao (Type 2, variety G of Duff classification), (Type 2, variety B and D from Muang Tuat) and from Sai Yok, are similar to adzes or chisels from Samrong Sen. Shouldered adzes from Thailand are also comparable with
the shouldered adzes from Samrong Sen. Duff's classification (Type 8) for the shouldered adzes variety A from Pechabury Province National museum is similar in morphology to the shouldered adzes from Samrong Sen. Others in neighbouring Laos and Vietnam have several varieties of quadrangular adzes, shouldered adzes, and chisels from Laung Prabang (Lao), Binh Long, Vang Lan and Pho-Binh-Gia of Bacsonian massif as well as other stone implements like gouges and chisels from other Late Neolithic sites of Vietnam: Van Dien, Phung Nguyen, Bau Tro, Dong Nai, Quang Binh etc. which resemble the stone instruments of Samrong Sen. These are similar in typological, morphological, and dimensional traits. In Burma, judging from previous documentation, only gouges and shouldered adzes (Type 4 and Type 8 of Duff) are more or less comparable with gouges and shouldered adzes found at Samrong Sen.

Nevertheless, some stone instruments from those countries did not match several stone typologies at Samrong Sen. For example Type 2, variety E, Type 7, variety E and D and Type 8, variety H (Duff's classification) from Thailand have not been discovered at Samrong Sen. Type 2, variety A and Type 8, variety B from Laos are also not found at Samrong Sen.

Comparing with stone implements from Malaysia, four-angle section adzes with unilateral bevel (Type 2, variety A of Duff) were discovered at the Late Neolithic site of Gua Cha in upper Kalantan. The plano-convex section gouges are comparable with rectangular adzes having a unilateral bevel and gouges from Samrong Sen. Shouldered adzes are rare in Malaysia but did exist. Their form is slightly different from shouldered adzes of Samrong Sen by deep unilateral bevel on the cutting edge and with square and flat shoulders, a very short tenon which could reflect development from a metal prototype. Shouldered adzes from Samrong Sen always have bilateral bevel symmetry or dissymmetry, curved or flat shouldered, and tenon often long with square or rectangular sections.

The beak adze is very common in Malaysia but not found at Samrong Sen. Moreover, tools which Malaysia does not share with other stone implements not only with Samrong Sen but also other countries in the region are the “Tembeling knife” (Type 5, variety D of Duff classification). Duff described these instruments as a side-hafted adze; a class of adze with shallow elliptical section and vertical side; and a class of elongate chisel-like adze of considerable size with flaring blade, possibly reflected the influence of metal (Duff 1970:41-59) (Fig 48, n° 3)).

In Indonesia and the Philippines, most of the stone implements more or less are different from Samrong Sen in morphology and some tool types. Judging from Duff's illustrations, most of the tool types in Indonesia do not exist at Samrong Sen, except the simple rectangular section (Type 2) adze and the Melanesoid types, which are comparable to stone adzes or axes of Samrong Sen. Quadrangular adze found in the central Celebes, Indonesia are somewhat similar in morphology to the stone instruments of Samrong Sen. As the same
with Malaysia, shouldered adze are rare in Indonesia, particularly in Java and Sumatra, and also in the Philippines. Some of them have been discovered in Karama River, Central Celebes (Callenfels, 1951: 82-97) but they are crude forms and not well polished when compared to the shouldered adzes from Samrong Sen, the latter in which manufacturing is well developed.

In the Philippines, a few shouldered adzes are displayed in the Batangas and Rizal Provinces Museum of Archaeology (Duff 1970: 124-144). Shouldered adzes are thought to have widely diffused out of Indo-China, south as far as Malaysia and Java, and west into Burma and north-east India, but it is still a question of some theoretical interest whether these tools reached these localities by trade or were made locally under the influence of a new tradition. Moreover, all variety of Duff’s Type 7, which referred to the pick adze of Indonesia and Type 1, variety C from the Philippines, have not been found at Samrong Sen or other prehistoric sites in Cambodia (Fig. 46, n° 5 & 47, n° 3).

Fig. 46: Varieties of tool types that do not occur at Samrong Sen: n° 1 shouldered adze from Laos, n° 2 quadrangular from south China, n° 3 Tembeling knife & n° 4 Type 2 variety E from Malaysia and n° 5 Type 1 variety C from the Philippines (After Duff 1970)
Fig. 47: Varieties tool types that are not present at Samrong Sen: n° 1 pick adze, n° 2 Type E from Indonesia, n° 3 beaked adze & n° 4 Stepped butt (Type 1 variety A) from Philippines, n° 5 Type 2 variety E & n° 6 Type 7 variety D from Thailand (After Duff, 1970).
Regarding the shouldered adze, Heine-Geldern developed a new hypothesis, which had the adze developed in Indo-China after the Hoabinhnian civilisation (Callenfels, 1951: 86). French scholar Madelaine Colani suggested that the shouldered adze may have developed from the edge-ground waist adze which she found during excavations at Bien Hoah Province in Northern Vietnam (Colani, 1938), this later to be invented to a fully shouldered form during the Late Neolithic. This hypothesis was adapted by Duff (Duff, 1970), in which he regarded that the fully shouldered adze was invented in Indo-China where the original location was situated in the Red River basin of Northern Vietnam. (Fig. 45, focus 2). Considering the local invention of shouldered adze, Van Stein Callenfels (1951) stated that the civilisation of shouldered adze was originally of a Mon-Khmer origin (Callenfels, 1951: 86). He mentioned that at a certain time, Austronesian races from Central Asia would have passed through Yunnan and Laos down the Malay Peninsula, bringing with them the rectangular stone adze. From some Austronesian tribes, remaining in Indo-China, the Mon-Khmer had borrowed the idea of rectangular adze and applied their own creation to the shouldered adze. Thus, the technology was well known and wide spread from the Late Neolithic of Indo-China into parts of India, the northern haft of the Malay Peninsula, and Formosa (Callenfels, 1951: 86).

Callenfels stated a hypothesis with little evidence to support it. However, one important aspect should be considered: if we could find additional data on the Hoabinhnian Culture to a specific region or group, then the hypothesis of Callenfels could be followed. Unfortunately, perhaps no one can now answer this question and therefore, the founders of shouldered adze culture remains somewhat unknown. This is too important to be the subject of any but thorough analysis, prepared concomitantly with test excavations in the original area.

One object that could link Samrong Sen to other prehistoric sites in Southeast Asia is gouge, which is referred to the Round Axe Culture of Heine Geldern. Stone gouges are likewise rare in other parts of Southeast Asia. Examples with rounded or elliptical and plano-convex cross-section are known from Burma, Samrong Sen, Batangas Province of Luzon, Philippines, with similar types occurring in some islands of Micronesia, Melanesia and Polynesia (Loewenstein 1957: 843).

Recent archaeological investigations of stone gouges were encountered at archaeological sites in Vietnam and Malaysia. Unfortunately, this special tool has not yet been confirmed in Thailand and Laos. In Malaysia, some gouges were made of flakes of bone and were found at Gua Bintong, Butkit Chuping, Perlis, Gua Madu and Kalantan. These bone gouges are considered as belonging to the Neolithic period (Loewenstein 1957: 843). Bone gouges also occur in certain Mesolithic bone industries of Indo China and Eastern Java. It is uncertain as to whether these bone artefacts are ancestral to polished stone gouges. However,
there can hardly be any doubt about the eventual origin of the gouges, and it is obvious that the first instruments of this kind were simple flakes of long bone with a natural concave cutting edge. These Mesolithic prototypes often survived into Neolithic period and later (Loewenstein 1957: 844).

More interestingly, stone gouges from Samrong Sen are strongly related to the stone gouges found in the Marianas (Micronesia) and to the south-eastern borders of Melanesia, notably the Fiji-Lau-Tonga area (Duff, 1970: 73). Beside stone gouges, adze types from Samrong Sen are quite similar to those in the Marianas and the Fiji-Lau areas of Melanesia. Duff considered that they represented the wide-spread travel of gouge technology from Samrong Sen to, finally, Oceania. It is possible that this was the predecessor of an important class of Micronesian and Melanesian adze (Duff 1970: 74).

The culture of quadrangular adzes reached a wide distribution through the whole region of Southeast Asia and further, to many islands in the Pacific Ocean, even to Hawaii. The quadrangular adze tradition primary appears in a fine developed form from south coastal China, where in turn it might have derived from a more remote origin in the North Pacific. With the increase of migration by boats from South China, the technology was almost certainly transmitted quickly by coastal movement to Indo-China, Thailand, Malaysia, and south-west Indonesia, as well as by the contemporaneous movement to Taiwan, the Philippines, and north-east Indonesia. Cambodia, Laos, Vietnam and northern Thailand may also have been influenced by an inland route from south-west China via Yunnan (Duff, 1970: 126). Regrettably, there is a lack of evidence to support adzes originating from Burma or further India.

The same cultural evolution also occurred in Southeast Asia with the rise of maritime trade from the Southeast Asian mainland to the islands by Austronesian speaking groups: they brought some stone tools and the techniques for adze manufacturing with them to Micronesia, Melanesia, and Polynesia.

With the wide expansion of quadrangular adzes and gouges in Southeast Asia and other islands in the Pacific Ocean, Samrong Sen becomes a more important prehistoric site for studies of Neolithic stone tools and use as the reference for comparison from one to another. This chapter reveals that the prehistoric culture of Samrong Sen is similar to a widely related Neolithic culture of mainland, Southeast Asia, insular Southeast Asia, and Oceania.
Conclusions

The objective of this study is to record and document maximum information on the cultural assemblage from the prehistoric site of Samrong Sen that are now kept in European museums, particularly in France. The main target focuses on polished stone implements occurring in these collections. Large quantities of stone tools were recorded from Musée de l’Homme, Paris; Musée d’Histoire Naturelle de Lyon; Musée d’Histoire Naturelle de Toulouse; Musée des Antiquités Nationales, Saint-Germain-en-Laye; Institut de Paléontologie Humaine, Paris and a few currently on display at the Museum of Far-Eastern Antiquities, Stockholm (table 2). However, these collections do not represent the totality of the artefacts unearthed from rich site of Samrong Sen and we hope that other collections will surface from other museums, private antiquity collectors, or from other countries that will extend and authorize research.

Polished stone tools show a remarkable homogeneity. In dealing with such a large amount of specimens from different localities, it is impossible to make a complete and detailed analysis of all features for every tool. We may notice at this time the method in which the collections were acquired. There is no clear confirmation of excavation, and as far as can be supposed all the series result from casual surface collection or unsystematic excavations during shell exploration for production of hydrated lime made by villagers and often handed over to the missionaries. There can be little doubt that some groups of tools come from particular localities, perhaps from workshops. At least this is the impression gained from closely related groups of tools made of distinctive raw materials, but for all of this we lack key information. We should point out that the mission field, and thus the area from which the objects derived, is the floodplain of the Tonle Sap. Although, this coincidence is accounted for by the method of collection, it may also have a much more profound and interesting significance. This, however, is a topic which can only be studied by further field campaigns.

Stone tools have been divided into eight categories base on their morphological characteristics (adzes, axes, shouldered adzes, shouldered axes, gouges, chisels, burnisher and a tool which was used as a hammer). Axes and shouldered axes are very rare at Samrong Sen as we can see in the collection, while adzes are the most common tool. Chisels and gouges are present but in lower frequencies than adzes. Flakes, debris, pre-forms and unfinished tools are very rare or in any event were not recorded within the collections. By the lack of this evidence, for the moment it is impossible to reconstruct the operation sequence of tool manufacturing at Samrong Sen. However, with careful observation of tool surfaces, it is revealed that at the very least they were made by picking or flaking and finished either by partial grinding or edge grinding, or complete polishing and sawing techniques were applied.
Adzes comprise variety forms and sizes. Trapezoidal form is very common for adzes, axes and gouges, while rectangular is common for chisels. Adze have average dimensions of 6.78 cm, 3.58 cm, and 1.45 cm; axes are smaller with average dimensions of 5.5 cm, 2 cm and 1 cm; gouges are bigger with average dimensions of 9.32 cm, 5 cm and 3 cm, chisels 7 cm, 3 cm and 3 cm, shouldered adzes, 8.33 cm, 4.33 cm and 2 cm and shouldered axes, 7 cm, 3 cm and 1.8 cm. Trapezoidal, rectangular and square cross-sections are very common for adzes, axes, chisels and shouldered types, while plano-convex and ellipsoidal cross-sections are ordinary for gouges. Cutting edge forms vary from straight to convex, and the direction can be perpendicular or oblique. 57% of the edges reveal micro-chipping or chipping, but 32% appear to be intact (table 5). Most of the tools are characterized by unilateral bevel on the lower face and only a few have bilateral bevels, usually dissymmetrical, except for axes or shouldered axes which have symmetrical double bevels. Adzes show different profiles of the cutting edge, perhaps due to different tasks of utilisation. The most common one is characterized by a flat single bevel on the lower face and a continuous convexity on the upper face (table 28). Butts also have different forms and conditions. They are mostly flat unpolished, sometimes thin and rarely polished (table 7).

Judging from inventories, tools from Samrong Sen were made from several types of stone that include: phtanite, quartzite, schist, rhyolite, diorite, porphyry, chalcedony, sandstone, hornfels, as well as basalt. Phtanite is present more frequently than other types. Many of them are of unknown stone. To confirm this information we selected some of them for Raman and Infrared Spectroscopy analysis. Unfortunately, Raman Spectroscopy did not provide any results because of pollution and fluorescence on tool surfaces. Infrared Spectroscopy is also revealing little results due to heavy contaminate on tool surfaces. IR spectra for few of the examined tools indicated chemical compositions corresponding to the rock types mentioned in the original inventory. But some corrections would be made, for example basalt instead of phtanite. For this reason a more complete study of raw materials employed and their sources is obviously needed. Regrettably, this is not an easy matter, as the collections include a wide range of rocks and local comparative material is not to hand. The interest in determining the sources of some of the uncommon stones is obvious. For the moment, the suggestion that stone tools from Samrong Sen were made from local material is still questionable, but probably valid for the majority of them.

When compared to stone tools of circular earthworks, stone tools from shell midden of Samrong Sen exhibit a greater degree of standardization in form and typology. Axes, shouldered/axe axes and gouges are not present at the circular earthworks (Heng & Moa, 1999 & Dega, 2002).
Micro-wear analysis of several tool types of Samrong Sen showed that they are multiple-purpose tools used in heavy and light wood or bamboo working tasks. The adzes perhaps were used to fell tree and chop wood or bamboo and for more delicate tasks, like planing or smoothing wood or perhaps scraping hide. Gouges and chisels possibly were employed for carpentry like grooving, smoothing or carving wood decoration, art objects as well as for making ornaments. This is only a very limited example that we obtained from preliminary work on micro-wear analysis for the techniques of examination are time consuming and require highly sophisticated appliances and demand concentration on technical details. The methodology behind any good micro-wear study must be particularly constructed and carefully implemented. Further micro-wear studies should help us understand the full range of activities that were conducted at the settlement. The microscopic examination of Samrong Sen tools must be complemented by ongoing replication experiments and ethno-archaeological fieldwork if we wish to reconstruct ancient human behaviour in the Samrong Sen area during the transition from Neolithic to the introduction of the Metal Age.

Hafting evidence was not clearly proved, except resin has survived on the surface of one adze and considered to be used as glue for binding adze blade with wooden shaft. Lack of hafting evidence does not mean that all of the tools were used without hafting. For comparison, chromatography methods examined contemporary resin which is still used by the Cambodian people today. The results indicated that the ancient resin and modern contain more or less the same substances. This is only a preliminary result and more scientific analysis is obviously necessary.

Samrong Sen is a most important site exhibiting close relationships to other Neolithic sites in Southeast Asia and many islands in the Pacific Ocean. Stone tools from Samrong Sen, particularly adzes having quadrangular sections are comparable to those found in Indo-China, southern Thailand, and Burma as well as India, Malaysia, Indonesia, Philippines, Melanesia, Micronesia, and Polynesia (Heine Geldern, 1932; Loewenstein, 1957; Heekeren 1957 & Duff, 1970). More interestingly, stone gouges from Samrong Sen are strongly linked to stone gouges found at the Marianas, the Fiji-Lau areas of Melanesia. Duff considers that the wide spread hog-backed gouge which similar to gouges discovered from Samrong Sen is one of the oldest types that have been distribution in Oceania (Duff, 1970:74). It is possible that this was the predecessor of an important class of Micronesian and Melanesian adzes. The diffusion and origins of stone tools is also a main topic for further study by comparison with recent discoveries.

Polished stone tools from Samrong Sen are efficient, effective and helpful tools and were appropriate for a wide range of wood-working activities. The Samrong Sen inhabitants produced these consistent tools at a time when pile houses and boat construction were
essential for the settlement in the flooding zone of the Tonle Sap. The Samrong Sen stone tools and pottery industry is very standardize as well, and it has been suggested that the production of pottery vessels and lithic artefacts was then in the hands of craft specialists (Mansuy, 1902; Mourer, 1994; Demeter et al., 1998 & Vanna, 1999 & 2002). The use of standardized tools may also be an indication of greater manipulation of natural resources. Polished stone tools were used by Neolithic communities but they still played an important role at the beginning of introduction of metal in order to domesticate the natural environment. Semi-sedentary agricultural societies could not function efficiently without stone tools. Standardization in polished stone tool forms and functions was one of the socio-economic changes experienced by the societies that lived in the floodplain zone of the Tonle Sap during the transition of Neolithic to Metal periods of Cambodia.
REFERENCES


ALFRED, F. P., 2007: Analysis of two polished stone adzes from Ille Cave at El Nido, Palawan Island, Philippines (online report)


BELLWOOD, P.; WILLIAM, S. AYRES; FRANCIS J. CLUNE, JR.; JOHN, CRAIB; THOMAS, E. DURBIN; FRANK A. YOUNG; KENNETH P. EMORY; JACQUES FAUBLEE; J. L. FISCHER; EVERETT S. FROST; ROGER C. GREEN; ARNE, A. KOSKINEN; MAC MARSHALL; RICHARD PEARSON; HAROLD M. ROSS; RICHARD SHUTLER, JR., WILHELM G. SOLHEIM II; BELLWOOD, P.S., 1975: The Prehistory of Oceania (and Comments and Reply). Current Anthropology, Vol. 16, No. 1, March, pp. 9-28


EDMONDS, M., (1995): Stone Tools and Society. Working stone in Neolithic and Bronze Age Britain. Published by B. T.Batsford Ltd, 4 Fitzhardinge Street, London W1H 0AH


HIGHAM, C., 2002: Early Cultures of Mainland Southeast Asia


LOEWENSTEIN, J., 1957: Neolithic Stone Gouges from the Malay Archipelago and Their Northern Prototypes. *Anthropos 52*


MARK, E., 1995: Stone Tools and Society. Working stone in Neolithic and Bronze Age Britain. Published by B. T.Batsford Ltd, 4 Fitzhardinge Street, London W1H 0AH


MOUSER, C. and R., 1971: “Prehistoric Research in Cambodia during the Last Ten Years”, Asian Perspective, 14: 35-42


NGUYEN, B. KH., 1980: Phung Nguyen. Asian Perspectives, XXIII (1)


VANNA, L., 1999: *Samrong Sen, early workshop of the material culture in the flooded area of the Tonle Sap River, Kampong Chhang, Cambodia*. Master thesis in the area studies, Sophia University

VANNA, L., 2002: The Archaeology of Shell Matrix Sites in the Central Floodplain of the Tonle Sap River, Central Cambodia (The shell Settlement Site of Samrong Sen and Its Cultural Complexity).

VAN STEIN CALLENFELS, P. V., 1951: Prehistoric sites on the Karama River (*West Torajaland, Central Celebes*). *Anthropos Vol. I, N° 1 October*.


ANNDEXES
ABREVIATIONS

- S.S., Cambodia: Samrong Sen, Cambodia
- Max. Width: Maximum width
- Min. width: Minimum width
- Max. Thickness: Maximum thickness
- Con. of cut. edge: Condition of cutting edge
- Form of cut. edge: Form of cutting edge
<table>
<thead>
<tr>
<th>Inventory No.</th>
<th>33.17. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin</td>
<td>S.S, Cambodia</td>
</tr>
<tr>
<td>Present locality</td>
<td>M. de L'Homme</td>
</tr>
<tr>
<td>Tool type</td>
<td>Pre-form</td>
</tr>
<tr>
<td>Raw material</td>
<td>Rhyolite ?</td>
</tr>
<tr>
<td>Colour</td>
<td>Grey</td>
</tr>
</tbody>
</table>

### Dimensions (cm)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Length</td>
<td>16.2</td>
</tr>
<tr>
<td>Max. Width</td>
<td>5</td>
</tr>
<tr>
<td>Min. Width</td>
<td>3.9</td>
</tr>
<tr>
<td>Max. Thickness</td>
<td>3.30</td>
</tr>
<tr>
<td>Weight</td>
<td>410 g</td>
</tr>
</tbody>
</table>

### Special characteristic

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of cutting edge</td>
<td></td>
</tr>
<tr>
<td>Hight of cutting edge</td>
<td></td>
</tr>
<tr>
<td>Thickness of cutting edge</td>
<td></td>
</tr>
<tr>
<td>Angle of cutting edge</td>
<td></td>
</tr>
</tbody>
</table>

### Morphology

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Con. of cut. edge</td>
<td>Unidentify</td>
</tr>
<tr>
<td>Butt</td>
<td>Unidentify</td>
</tr>
<tr>
<td>Proximal section</td>
<td>Oval</td>
</tr>
<tr>
<td>Distal section</td>
<td>Oval</td>
</tr>
<tr>
<td>Upper face</td>
<td>Un polished</td>
</tr>
<tr>
<td>Lower face</td>
<td>Un polished</td>
</tr>
<tr>
<td>Right side</td>
<td>Un polished</td>
</tr>
<tr>
<td>Left side</td>
<td>Un polished</td>
</tr>
</tbody>
</table>
**Dimensions (cm)**

- Max. Length: 11
- Max. Width: 5.8
- Min. Width: 3.1
- Max. Thickness: 3
- Weight: 255 g

**Special characteristic**

- Length of cutting edge: 3.2 cm
- Height of cutting edge: 1.2 cm
- Thickness of cutting edge: 1 cm
- Angle of cutting edge: 75°

**Morphology**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Con. of cut. edge</td>
<td>Micro-chipping</td>
</tr>
<tr>
<td>Form of cut. edge</td>
<td>Single bevel</td>
</tr>
<tr>
<td>Butt</td>
<td>Flat, un polished, chip.</td>
</tr>
<tr>
<td>Distal section</td>
<td>Ellipsoidal</td>
</tr>
<tr>
<td>Upper face</td>
<td>Partly polished</td>
</tr>
<tr>
<td>Lower face</td>
<td>Partly polished</td>
</tr>
<tr>
<td>Right side</td>
<td>Polished</td>
</tr>
<tr>
<td>Left side</td>
<td>Polished</td>
</tr>
</tbody>
</table>

**Inventory No.**

33.17.13

**Origin**

S.S., Cambodia

**Present locality**

M. de L'Homme

**Tool type**

Chisel

**Raw material**

Schiste avec quartz

**Colour**

Brown
### Special characteristic
- Length of cutting edge: ?
- Height of cutting edge: ?
- Thickness of cutting edge: ?
- Angle of cutting edge: ?

### Dimensions (cm)
- Max. Length: 8.7
- Max. Width: 4.6
- Min. Width: 4
- Max. Thickness: 2.3
- Weight: 162 g

### Inventory No.
33.17.18

### Origin
S.S, Cambodia

### Present locality
M. de L'Homme

### Tool type
Hammer

### Raw material
Hornfels

### Colour
Light green

### Morphology
- Con. of cut. edge: Micro chipping
- Form of cut. edge: Single bevel
- Butt: Flat, un polish, chip.
- Proximal section: Plano-convex
- Distal section: Ellipsoidal
- Upper face: Polished
- Lower face: Polish, remain flaking
- Right side: Polish, small chipping
- Left side: Polish, remain flaking

### Silicate
- Feldspath
- Kaolinite
**Dimensions (cm)**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Length</td>
<td>9.7</td>
</tr>
<tr>
<td>Max. Width</td>
<td>4.7</td>
</tr>
<tr>
<td>Min. Width</td>
<td>3.9</td>
</tr>
<tr>
<td>Max. Thickness</td>
<td>2.4</td>
</tr>
<tr>
<td>Weight</td>
<td>170 g</td>
</tr>
</tbody>
</table>

**Special characteristic**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of cutting edge</td>
<td>3.6cm</td>
</tr>
<tr>
<td>Height of cutting edge</td>
<td>2cm</td>
</tr>
<tr>
<td>Thickness of cutting edge</td>
<td>1.5cm</td>
</tr>
<tr>
<td>Angle of cutting edge</td>
<td>60°</td>
</tr>
</tbody>
</table>

**Morphology**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Con. of cut. edge</td>
<td>Chipping</td>
</tr>
<tr>
<td>Form of cut. edge</td>
<td>Concave</td>
</tr>
<tr>
<td>Butt</td>
<td>Flat, un polish, chipping</td>
</tr>
<tr>
<td>Proximal section</td>
<td>Bi-convex</td>
</tr>
<tr>
<td>Distal section</td>
<td>Ellipsoidal</td>
</tr>
<tr>
<td>Upper face</td>
<td>Polished</td>
</tr>
<tr>
<td>Lower face</td>
<td>Partly polished</td>
</tr>
<tr>
<td>Right side</td>
<td>Polished</td>
</tr>
<tr>
<td>Left side</td>
<td>Polished small flaking</td>
</tr>
</tbody>
</table>

**Inventory No.**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>33.17.19</td>
</tr>
</tbody>
</table>

**Origin**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S.S, Cambodia</td>
</tr>
</tbody>
</table>

**Present locality**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M. de L'Homme</td>
</tr>
</tbody>
</table>

**Tool type**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gouge</td>
</tr>
</tbody>
</table>

**Raw material**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phtanite ?</td>
</tr>
</tbody>
</table>

**Colour**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark grey</td>
</tr>
</tbody>
</table>
Dimensions (cm)

- Max. Length: 6.2 cm
- Max. Width: 4.6 cm
- Min. Width: 2.6 cm
- Max. Thickness: 0.85 cm
- Weight: 40 g

Special characteristic

- Length of cutting edge: 4.6 cm
- Height of cutting edge: 1.1 cm
- Thickness of cutting edge: 0.7 cm
- Angle of cutting edge: 55°

Inventory No.: 33.17.106
- Origin: S.S, Cambodia
- Present locality: M. de L’Homme
- Tool type: Adze
- Raw material: Pellite
- Colour: Grey

Morphology

- Con. of cut. edge: Micro and macro chipping
- Form of cut. edge: Single bevel
- Butt: Flat, un polished
- Proximal section: Trapezoidal
- Distal section: Rectangular
- Upper face: Polished
- Lower face: Polished
- Right side: Slightly polished
- Left side: Slightly polished

Chemical composition:

- Silicate
- Kaolinite
**Inventory No.** 33.17.170  
**Origin** S.S, Cambodia  
**Present locality** M. de L'Homme  
**Tool type** Gouge  
**Raw material** ?  
**Colour** Brown  

**Dimensions (cm)**  
- Max. Length: 6.7  
- Max. Width: 5.2  
- Min. Width: 4.4  
- Max. Thickness: 2.35  
- Weight: 145 g  

**Special characteristic**  
- Length of cutting edge: 4.4cm  
- Height of cutting edge: 3.6cm  
- Thickness of cutting edge: 1.9cm  
- Angle of cutting edge: 55°  

**Morphology**  
- Con. of cut. edge: Chipping  
- Form of cut. edge: Concave  
- Butt: Broken, re-flaking  
- Proximal section: Plano-convex  
- Distal section: Plano-convex  
- Upper face: Polished  
- Lower face: Polished  
- Right side: Polished  
- Left side: Polished
**Dimensions (cm)**

- Max. Length: 10.5 cm
- Max. Width: 3.7 cm
- Min. Width: 2.7 cm
- Max. Thickness: 1.15 cm
- Weight: 65 g

**Special characteristic**

- Length of cutting edge: 3.7 cm
- Height of cutting edge: 1.1 cm
- Thickness of cutting edge: 0.7 cm
- Angle of cutting edge: 49°

**Morphology**

- Con. of cut. edge: Chipping
- Form of cut. edge: Single bevel
- Butt: Broken
- Proximal section: Trapezoidal
- Distal section: Trapezoidal
- Upper face: Polished
- Lower face: Polished
- Right side: Polish, remain flaking
- Left side: Polish, remain flaking

**Inventory No.** 33.17.165

**Origin** S.S, Cambodia

**Present locality** M. de L'Homme

**Tool type** Adze

**Raw material** Pellite

**Colour** Beige & Grey
**Dimensions (cm)**
- Max. Length: 5.1
- Max. Width: 2.5
- Min. Width: 2.1
- Max. Thickness: 2.12
- Weight: 44 g

**Special characteristic**
- Length of cutting edge: 2.5 cm
- Height of cutting edge: 2.3 cm
- Thickness of cutting edge: 1.9 cm
- Angle of cutting edge: 64°

**Morphology**
- Con. of cut. edge: Intact
- Form of cut. edge: Double bevel, dissy.
- Butt: Flat, un polished
- Proximal section: Square
- Distal section: Rectangular
- Upper face: Polished
- Lower face: Polished
- Right side: Polished
- Left side: Polished

**Inventory No.** 33.17.197

**Origin** S.S, Cambodia

**Present locality** M. de L'Homme

**Tool type** Adze or chisel

**Raw material** ?

**Colour** Light grey

**Silicate**
Dimensions (cm)

Max. Length: 12
Max. Width: 5.9
Min. Width: 3.5
Max. Thickness: 2.28
Weight: 230 g

Special characteristic

Length of cutting edge: 5.9 cm
Height of cutting edge: 1.5 cm
Thickness of cutting edge: 1.3 cm
Angle of cutting edge: 59°

Inventory No.: 33.17.157
Origin: S.S, Cambodia
Present locality: M. de L’Homme
Tool type: Adze
Raw material: ?
Colour: Brown

Morphology

Con. of cut. edge: Chipping
Form of cut. edge: Single bevel
Butt: Flat, un polished
Proximal section: Flattened reed
Distal section: Trapezoidal
Upper face: Polished
Lower face: Polished
Right side: Polished, remain flaking
Left side: Polished, remain flaking

Extraction: Tr
Spectre: 33.17.157 ( dans C/plateau)
Technique: Transmission DiGe
Analyzer: Bruker
**Dimensions (cm):**
- Max. Length: 13.8 cm
- Max. Width: 4.8 cm
- Min. Width: 2.3 cm
- Max. Thickness: 2.2 cm
- Weight: 194 g

**Special characteristic:**
- Length of cutting edge: 4.8 cm
- Height of cutting edge: 2 cm
- Thickness of cutting edge: 2 cm
- Angle of cutting edge: 81°

**Morphology:**
- Con. of cut. edge: Micro-chipping?
- Form of cut. edge: Single bevel
- Butt: Flat, chipping
- Proximal section: Triangular
- Distal section: Faceted
- Upper face: Slightly polished
- Lower face: Un polished
- Right side: Slightly polished, flaking
- Left side: Flaking

**Inventory No.:** 33.17.155
**Origin:** S.S, Cambodia
**Present locality:** M. de L'Homme
**Tool type:** Adze
**Raw material:** ?
**Colour:** Grey

**Analytical results:**
- Silicate
- Carbonate
- Kaolinite
- Feldspar

**Spectra:** 33.17.155 In situ (dare Cuts/Soapbody)
**Technique:** Transmission IR
**Optoelect:** Bruker
Dimensions (cm)

- Max. Length: 5.8
- Max. Width: 4.3
- Min. Width: 2.9
- Max. Thickness: 0.60
- Weight: 25 g

Special characteristic

- Length of cutting edge: 4.3cm
- Height of cutting edge: 0.8cm
- Thickness of cutting edge: 0.5cm
- Angle of cutting edge: 48°

Morphology

- Con. of cut. edge: Micro-chipping
- Butt: Flat, un polished
- Proximal section: Trapezoidal
- Distal section: Rectangular
- Upper face: Un polished
- Lower face: Un polished
- Right side: Polished
- Left side: Slightly polished

Inventory No.: 33.17.105

Origin: S.S, Cambodia

Present locality: M. de L'Homme

Tool type: Adze

Raw material: Pellite

Colour: Grey
**Inventory No.** 33.17.196

**Origin** S.S, Cambodia

**Present locality** M. de L’Homme

**Tool type** Adze

**Raw material** Quartzite

**Colour** Beige

**Dimensions (cm)**
- Max. Length 8 cm
- Max. Width 3.8 cm
- Min. Width 1.8 cm
- Max. Thickness 2 cm
- Weight 66 g

**Special characteristic**
- Length of cutting edge 3.8 cm
- Height of cutting edge 2.5 cm
- Thickness of cutting edge 1.9 cm
- Angle of cutting edge Iden.

**Morphology**
- Con. of cut. edge Re-flaking
- Form of cut. edge Single bevel
- Butt Thin, chipping
- Proximal section Triangular
- Distal section Triangular
- Upper face Re-flaking at distal
- Lower face Polished
- Right side Re-flaking
- Left side Re-flaking
**Dimensions (cm)**
- Max. Length: 6.5 cm
- Max. Width: 3.1 cm
- Min. Width: 1.8 cm
- Max. Thickness: 1.12 cm
- Weight: 34 g

**Special characteristic**
- Length of cutting edge: 3.1 cm
- Height of cutting edge: 0.5 cm
- Thickness of cutting edge: 0.7 cm
- Angle of cutting edge: 60°

**Morphology**
- Con. of cut. edge: Chipping
- Form of cut. edge: Double bevel, disyme.
- Butt: Chipping
- Proximal section: Trapezoidal
- Distal section: Trapezoidal
- Upper face: Polish, remain, flaking
- Lower face: Polish, remain, flaking
- Right side: Polished
- Left side: Polished

**Inventory No.** 33.17.49
**Origin** S.S, Cambodia
**Present locality** M. de L’Homme
**Tool type** Chisel
**Raw material** Quartz, Silicate, Feldspar
**Colour** Beige
Inventory No. 33.17.145

Origin S.S, Cambodia

Present locality M. de L'Homme

Tool type Chisel

Raw material Pellite

Colour Brown

Dimensions (cm)

Max. Length 6
Max. Width 3
Min. Width 1.9
Max. Thickness 1.28
Weight 36 g

Special characteristic

Length of cutting edge 2.6 cm
Height of cutting edge 1.2 cm
Thickness of cutting edge 0.9 cm
Angle of cutting edge 65°

Morphology

Con. of cut. edge Micro and macro chipping
Form of cut. edge Single bevel
Butt Round polished
Proximal section Trapezoidal
Distal section Trapezoidal
Upper face Polish, remain flaking
Lower face Polished
Right side Polished
Left side Polished

Silicate
Feldspar
Kaolinite
Inventory No. 33.17.199
Origin S.S, Cambodia
Present locality M. de L'Homme
Tool type Gouge
Raw material Basalt
Colour Black

Dimensions (cm)
- Max. Length 10.3 
- Max. Width 3.8 
- Min. Width 2.3 
- Max. Thickness 2.6 
- Weight 166 g

Special characteristic
- Length of cutting edge 2.6 cm
- Height of cutting edge 2.9 cm
- Thickness of cutting edge 1.7 cm
- Angle of cutting edge 70°

Morphology
- Con. of cut. edge Micro chipping
- Form of cut. edge Single bevel
- Butt Flat, slightly polished
- Proximal section Plano-convex
- Distal section Plano-convex
- Upper face Polished
- Lower face Polished
- Right side Polished
- Left side Polished
Inventory No. 33.17.114
Origin S.S, Cambodia
Present locality M. de L’Homme
Tool type Adze
Raw material Phyllade à feldspath et quartz
Colour Brown

Dimensions (cm)
Max. Length 10.9
Max. Width 5.6
Min. Width 2.1
Max. Thickness 2.15
Weight 174 g

Special characteristic
Length of cutting edge 5.6 cm
Height of cutting edge 2.5 cm
Thickness of cutting edge 1.4 cm
Angle of cutting edge 58°

Morphology
Con. of cut. edge Chipping
Form of cut. edge Single bevel
Butt Flat, chipping
Proximal section Trapezoidal
Distal section Trapezoidal
Upper face Polished
Lower face Partly polished
Right side Polished, remain flaking
Left side Polished, remain flaking