Long-Term Changes in the Organization of Lithic Technology

: A Case Study from the Imjin-Hantan River Area, Korea

by

Yongwook Yoo

Department of Anthropology

McGill University, Montreal

January 2007

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements of the degree of Doctor of Philosophy

Your file Votre référence
ISBN: 978-0-494-32336-6
Our file Notre référence
ISBN: 978-0-494-32336-6

ABSTRACT

This study is intended to furnish an explicability of hunter-gather's organizational model on the lithic technology. The fieldwork area is the Imjin-Hantan River Area (the IHRA) located at the midwestern part of the Korean Peninsula. The archaeological sites included in the fieldwork are Jangsanri (ca 0.2 Mya BP), Chongokni (ca 60 Kya BP), Juwolri, and Kawolri (younger than ca 50 Kya BP). In addition, a previously excavated Upper Palaeolithic assemblage of Janghungri (ca 23 Kya BP) is included in the quantitative analysis of lithic assemblages.

For the background of the research area, chapter II is devoted to demonstrating the general environment of East Asia and current Quaternary research of Korea. Chapter III furnishes the basic knowledge on the geomorphological environment of the IHRA and the research history in this area for the last three decades was elaborated.

Chapter IV is a description on the excavation fieldworks, introduction of the discovered lithic artifacts, and new age determination based on the K-Ar, IRSL, OSL, and AMS dating methods. Chapter V is the general characteristics on the IHRA lithic assemblage. Some descriptive details on the individual artifacts are presented and technological implications of lithic types are delineated. In addition, a general reduction sequence of the IHRA assemblage is proposed.

Chapter VI is a quantitative analysis based on the exploratory data analysis (EDA); some geometric variables of artifacts were operationally defined for the purpose of acquiring more implicative analytical units. As a result of the analysis, it is revealed that the distinct interassemblage variability of raw material composition and of the morphological features of small tools and blanks constrained by differential reduction intensity can be explained in the

context of the long-term-based strategic changes executed by the IHRA hominins.

Chapter VII, based on the results from the fieldwork and lithic analysis, attempted to reconstruct the geological history of the IHRA in terms of hominid's land use patterns and relevant survival strategies. As a final remark, some unsolved issues were diagnosed and future research was expected for the continual research of the IHRA.

RÉSUME

Cette étude a pour but de fournir une compréhension au modèle d'organisation du chasseur-collecteur sur la technologie lithique. Le terrain de travaux est la Région des Fleuves d'Imjin et Hantan (la RFIH) située à la partie mid-ouest de la péninsule coréenne. Les emplacements archéologiques inclus sont Jangsanri (ca 0.2 Mya), Chongokni (ca 80 KyaBP), Juwolri et Kawolri, tandis que l'excavation précedente menée à l'assemblage Palaeolithique de Janghungri (ca 23 KyaBP) est inclus dans l'analyse quantitative des assemblages lithique.

Pour le fond du région de recherches, le chapitre II et III sont consacrés à l'environnement général de l'Asie de l'Est et à la recherche quaternaire courante de la Corée aussi bien que la connaissance de base sur l'environnement géomorphologique et à l'histoire de recherches de la RFIH.

Le chapitre IV est une description sur les travaux d'excavation, l'introduction des objets façonnés lithique découverts, et la nouvelle détermination d'âge basée selon les méthodes chronométriques de K-Ar, IRSL, OSL, et AMS. Le chapitre V est les caractéristiques générales sur l'assemblage lithique de RFIH. Quelques détails descriptifs sur les différents objets façonnés sont présentés et des implications technologiques des types lithithiques sont tracées comme un ordre général de réduction de l'assemblage d'IHRA est proposé.

Le chapitre VI est une analyse quantitative basée selon l'analyse de données exploratoire (l'ADE); quelques variables géométriques des objets façonnés sont définies de façon opérationnelle afin d'acquérir des unités analytiques plus implicités. Le résultat démontre, la variabilité distincte d'interassemblage de composition de matière première, des dispositifs morphologiques de petits outils et des supports contraints par l'intensité

différentielle de réduction explique les changements stratégiques exécutés par les hominins de la RHIH pendant le long-temps d'occupation.

Le chapitre VII, selon les résultats des travaux sur le terrain et l'analyse lithique, essaye de reconstruire l'histoire géologique de la RFIH en termes de modèles d'utilisation de la terre par les hominidés et les stratégies de survie sur une base hypothétique. Pour terminer, une remarque finale concernant quelques issues non résolues étaient analysées en prévoyant les futures recherches continues à la RFIH.

ACKNOWLEDGEMENT

It is a great privilege to express my gratitude for the help, guidance and criticism that have enormously enriched this work. This study could not have been accomplished without the goodwill of my supervising professors, research colleagues, and many specialists in related fields. I also want to thank the support from friends and especially my family who lovingly supported me and have patiently awaited this result with their fingers silently crossed.

My study at McGill was generously supported by the Fonds pour étudiants supérieurs de Corée du Sud by the Ministère de l'Éducation de Québec, and my initial fieldwork research in Korea from 1999 to 2000 was covered by an Internal Social Sciences and Humanities Research Grant (#294214). A library research for the North Korean archives was conducted under the auspices of the Institute of Far Eastern Studies, Korea. The field survey, excavation and data analysis were carried out with the unstinting support of the Palaeolithic Archaeology Laboratory, Seoul National University, Korea.

As one of the most important supporter of my work, I would like to express my sincere gratitude and appreciation to Professor Fumiko Ikawa-Smith who has made my study at McGill possible and my work fruitful in spite of many obstacles. Her guidance and advice gave me a good motivation to complete this work. I am deeply indebted to her for the *sensei no kikubari* to await my final chapters to be done, not to mention for her great perseverance and invaluable encouragement.

I take special pleasure to express my thanks to those professors at McGill who instructed me and played a significant role helping with this work. Professor Michael S. Bisson's excellent command on the Palaeolithic research and great enthusiasm for the methodological soundness led my study to another dimension of research orientation.

Professor James M. Savelle, to whom I owe a great deal for presenting and solving the problematic issues, furnished me with a solid framework for building the background of this work. I also express my gratitude to Professor Bruce G. Trigger for introducing me various theoretical views I have used, as well as for giving greater perspective toward the history of archaeological research. I am deeply sorry that he was not able to read this completed work because of his recent passing. In particular, I would like to emphasize that the last phase of this work was greatly enriched by a special guidance from Professor A. Martin Byers, one of my admired senior archaeologists and mentors, who is full of the aged prudence and the ageless enthusiasm. His valuable comments and open-minded discussion gave me a great deal of invaluable nourishment for editing this work into a legitimate final copy.

Special thanks of appreciation must be extended to three Korean professors who have greatly influenced me to study Korean Palaeolithic as my lifelong interest. Professor Seonbok Yi, my former supervisor and the fieldwork coordinator for this thesis, has always helped me in clarifying difficult issues raised by my thesis and never failed to propose helpful solutions for the problems that would otherwise be beyond my capacity. Professor Kidong Bae, an old instructor who encouraged me to start Palaeolithic archaeology, always showed a good mentorship as a senior researcher for my fieldwork area. I wish to express my deep appreciation for the help of the late Professor Haksoo Kwon who guided me to the "righteous way" of quantitative analysis and encouraged me to study at McGill. His untimely death during my fieldwork in Korea caused me great grief. I must stress that a great deal of this thesis is nothing but a step-forward from the pioneering works accomplished by these three prominent archaeologists.

During my fieldwork in Korea, many people kindly gave me support and assistance. Space allows me to mention only a few of these. Professor Yong-Il Lee, who gave me

invaluable geological instruction during my undergraduate years willingly joined in my fieldwork project, together with Doctor Hyun-Soo Lim, and they conducted a sedimentological analysis as well as produced chronometric dates crucial to this research. I am also grateful for the help of Professor Nagatomo Tsuneto and Professor Soda Tsutomu, whose geological research of the Imjin Hantan River Area from the earlier period played a major part in this thesis. I am very much gratified for their efforts.

Two fellow students to whom I am indebted are to be specially remembered. Kyodong Lee, my senior student and a genuine renaissance man, showed a great versatility in dealing with various research tasks. His technical maturity and resourcefulness always amazed me and led me to attempt to emulate during my budding period of Palaeolithic study. In addition, Dongwan Kim, one of my valuable junior students and a great relief during my arduous fieldwork, showed the very best attitude of what a man of unyielding sincerity got to be. I would like to express my gratitude for them again and wish their future success in their own circle of life.

For the last but not the least, I want to give another special thanks to my family. While I was doing this work, I welcomed a new family member but I also lost one of my dearest one. My wife has been always seated on the next to me when I was riding a mental rollercoaster. Her presence itself was a great pleasure and gave me the determination do this work with all my heart and soul. However, the pioneering source of my motivation to do this work was originally inspired by somebody who led a silent but meaningful life expecting his incompetent son to grow up some day. If this tiny piece of work is worth being dedicated to somebody, that would be to my late oldman.

In memory of Mr. Gilbong Yoo,

who always stayed there

when his son toddled toward him.

TABLE OF CONTENTS

II. GEOGRAPHICAL BACKGROUND

III. GEOLOGICAL FEATURES AND RESEARCH HISTORY OF THE IHRA

IV. FIELDWAORK DATA AND RESULTS

V. THE CHARACTERISTICS OF THE IHRA LITHIC ASSEMBLAGES

VI. THE VARIABILITY OF THE IHRA LITHIC TECHNOLOGICAL ORGANIZATION

VII. THE LONG-TERM CHANGE OF THE IHRA TECHNOLOGICAL ORGANIZATION: A CONCLUSION

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EDITORIAL NOTES

Although the rule of romanizing the Korean place names has been recently officialized, the majority of the academic literature on Korean archaeology still depends on the individually customized usages. In this thesis, the most widely accepted styles will be taken in order to avoid any discrepancies with previous publications. The names of archaeological sites and several geographical locations that will be frequently mentioned in this thesis are listed below. Because most Korean place names can be transcribed with the Chinese characters, the original names both in Korean and Chinese scripts are also displayed.

Usage in this thesis	Original Korean	Chinese Characters	Other Usages
Jangsanri	장산리	長山里	Changsanri, Jangsan-li
Chongokni	전곡리	全谷里	Jeongok-ri, Jeonkok-ri
Juwolri	주월리	舟月里	Chuwol-ri, Joowol-li
Kawolri	가월리	佳月里	Gawol-ri
Janghungri	장흥리	長興里	Janghung-ri
Keumpari	금파리	金坡里	Kumpari, Geumpa-li
Hoengsanri	횡산리	橫山里	Whongsan-ri
Shindapri	신답리	新畓里	Sindab-ri
Namkyeri	남계리	楠溪里	Namgie-li, Namgye-ri
Imjin River	임진강	臨津江	Yimjin River
Hantan River	한탄강	漢灘江	
Chugaryong	추가령	楸哥嶺	Choogaryong

It should be noted that the Korean archaeological sites have the names usually ending with either "-ri" or "-li," which commonly means the smallest municipality of Korea, and the hyphenation of this suffix does not create any connotation of a different meaning in Korean language. In general, a hyphenated title is usually treated as the name of a rural town;

but a non-hyphenated one usually indicates a specific archaeological site, and it is taken as a homonym with the name of the town where the site is located. Therefore, any hyphened name of a town will not be used in this thesis in order to minimize the confusion in the names of the archaeological sites and the towns. Instead, the "-ri" or "-li" will be directly converted into the word "town" when it comes to refer to the municipality of the site area (*e.g.* Chongokni is the archaeological site and the hyphenated terms, such as Chongok-ri, Jeongok-ri, and Jeongok-li, will be substituted with "Chongok Town").

I. INTRODUCTION

(1) Lithic Technological Study as a Research Topic

1. Diversity as an Alternative

During the last few decades, researchers have mainly concentrated on the explanation of the processes encompassing the material expression of various cultural and technological traits (*e.g.* Bar-Yosef 2005; Bordes and Bordes 1970; Jelinek 1994; Kuhn 1995; Mellars 1989). Especially in the field of palaeolithic archaeology, the research trend is towards explanatory models on the various factors responsible for assemblage variability (*e.g.* Bisson 2001; Bordes and Bordes 1970; Dibble 1984, 1987, 1995; Jelinek 1994; Kuhn 1995; Hayden *et al.* 1996; Nelson 1991). Of course, the explanation of changes and the investigation of their background is one of the most important research issues and it should be continually underpinned by methodological and theoretical refinement. What is evident from this trend is that archaeologists try to explore the relationship between the static archaeological record and the dynamic response of the hominins to various external constraints (*e.g.,* Andrefsky 1994; Barton 1990; Kuhn 1995; Rolland and Dibble 1990).

Such a trend in the Palaeolithic research is very useful for explaining the nature of the dynamics involved, but leaves something to be desired as a goal for lithic studies. Lithic studies can be more appropriately carried out by focusing on investigating the connection between prehistoric society's cultural/technological impact on the behavior and practices of the individual manufacturer/user of lithic artifacts. It should be underscored that current research on lithic studies, especially on the technological aspects of lithic artifacts, has been focused on several factors that contribute to the assemblage variability. However, this research trend is substantially limiting otherwise intriguing and valuable issues. A drawback of these studies is that too much emphasis seems to be put on the explanation of relationship between the characteristics of the assemblage and their temporal/spatial significances with a limited scope. Furthermore, this trend is too rooted in past research traditions themselves constructed by the academic background of the major proponents of the different research area: *e.g.* the Bordesian approach to the interassemblage variability of European Middle Palaeolithic (Bordes 1961; Débenath and Dibble 1994); Jia's model of two cultural traditions in the Chinese Palaeolithic (Jia and Huang 1985), Movius' dichotomy of the Old World Lower Palaeolithic traditions (Movius 1944), and so on. If this research trend is "paradigmatic" (Clark 1991: 577- 9), then the struggle to shift away from it and to endorse alternatives must be preceded by the exploration of the diversity and multiplicity of the various hominin survival strategies.

With this in mind, this study is aimed to illustrate one facet of the diversity of pre-Upper Palaeolithic industries. Also it tests several behavioral models concerned with the characterization of lithic assemblages that have been suggested elsewhere (*e.g.* Andrefsky 1994, 1998; Bisson 2001; Brantingham *et al.* 2001; Chatters 1987; Cowans 1999; Dibble 1995; Hayden 1989; Jelinek 1994; Jeske 1994; Kuhn 1992b, 1994; Nelson 1991; Torrence 1989a). Diversity can be understood in various ways and its implications can be interpreted in different contexts; but it should be made clear that this study focuses on the technological features of lithic assemblages, especially on the relationship between the varied constituents of lithic technological organization and the formation of the characteristics of the lithic assemblages.

2. Lithic Technological Organization as a Research Module

One of most frequently discussed fields of lithic studies is technological organization. It was originally suggested by Binford (1979, 1980) to investigate the dynamics of technological behavior as a strategic solution to survival problems. Since then, the term "technological organization" has become a research-specific concept (*see* Kelly 1988; Nelson 1991; Steffen 1998) and various ways of studying technological organization have been proposed. Of these, one approach to the understanding prehistoric technology is to reconstruct the principal steps or component stages constituting the dynamics of prehistoric material cultures (*e.g.* the approach of *Chaîne opératoire* by Boëda *et al.* 1990; Dobres and Hoffman 1994; Gravinna 2004; Lemonnier 1986).

Originally, methods of delineating technological organization were developed to effectively demonstrate the dynamics of living systems (*e.g.* the Nunamiut group by Binford 1980 and Binford 1983); however, because of its conceptual integrity and methodological flexibility, technological organization has gained a lot of popularity among archaeological researchers who wish to approach the cultural patterning of archaeological material with the purpose of deciphering its underlying meaning, with special emphasis on "strategy" and "adaptation" (*e.g.* Bleed 1986; Close 2000; Hayden 1989; Kelly 1988, 1995, Nelson 1991; Shott 1986), rather than explaining the domains of social relationships and symbolism (*e.g.* Dobres and Hoffman 1994: 211).

Related to the focus on technological organization, two principal concepts, which are mutually exclusive, have been widely applied and exemplified with actual archaeological data: the curated vs. the expedient technology. These two concepts directly relate to and illustrate contrasting patterns resulting from different organizational behavior and are quite useful for summarizing and/or characterizing the nature of technological practices maintained by specific groups. But in a sense, their forming a "non-elastic" dichotomy tends to promote a one-dimensional conclusion and its approach has been criticized for its inherent tendency toward over-simplification and/or narrowness of perspective (*e.g.* Nash 1996).

Nevertheless, apart from this limitation of curated/expedient dichotomy, the integrative approach to the organization of technology still has methodological strength for several reasons. First, it is not a fixed, static description of technological elements but a dynamic and flexible characterization of the technological process. Second, it establishes the direction of change occurring so that the observed variables can be explained in terms of this direction; for example, the diversity and intensity of utilization of lithic artifacts can be effectively converted into the indices of specialization and economization as determined by the planning depth (Kuhn 1995). Third, it is very useful for interpreting the quantified data, and is bias-free for transforming data into qualitative interpretation. Fourth, it can suggest several research-specific frameworks; for example, the lithic reduction models (Dibble 1984, 1987, 1995), raw material utilization model (Andrefsky 1994, 1998; Jeske 1989), and the hominin provisioning strategy model (Kuhn 1994, 1995), all of which either directly or indirectly stem from the open concept of technology as research modules. Furthermore, it can be a medium to reconstruct models of the social environment (Dobres 2000; Gamble 1999) as implicated in the interpretation of materialistic features; for example, technology can be understood as a producer and products of personal, practical, and cultural knowledge (Dobres 2000: 97), or as a major object of social networking (Gamble 1998, 1999).

With these advantages, the integrative approach to the technology of lithic assemblages can furnish a solid socioeconomic perspective on the hominin "life planning" strategies as realized in the material residue marking habitual "everyday practices" (Dobres and Hoffman 1994; Hopkins and White 2005). In order to test the exploratory models suggested above, this study will select a group of Palaeolithic assemblages in one part of East Asia. While many pioneering works have been presented and considerable progress has been achieved, the East Asian Palaeolithic research is still at its initial level of accomplishment. This situation is due partly to the relative lateness in the institutionalization of Palaeolithic research as a solid academic discipline and also to the insufficient level of communication and discussion of the major issues at a global scale (Keats 1997; Pope 1997).

The main goal of this research is to clarify the trends of hominin technological adaptation in the midwestern part of the Korean Peninsula from the later Middle to Upper Pleistocene. As one region of East Asia in which converging viewpoints on the significance of variability in the Palaeolithic archaeology have rarely occurred, the Korean Palaeolithic record furnishes a good opportunity to delineate the pattern of local hominin resource exploitation strategy and related technological features.

(2) Regional Background: the Imjin-Hantan River Area

1. Study Area: Past Research and Current Status

The main field area is the Imjin-Hantan River Area (hereafter the IHRA) where archaeological work on numerous sites has produced an abundance of Palaeolithic artifacts over the last three decades. To date, about 40 palaeolithic sites have been identified in this area, of which several were systematically excavated and geologically studied. Because earlier archaeological work in this field (*e.g.* Kim W. Y. and Chung 1979; Kim W. Y. and Bae 1983) has been principally concerned with "the handaxe" as evidence countering Movius' early claims about the "chopper-chopping tool tradition (Movius 1944)" in the East Asian Palaeolithic, the description of the IHRA industry tends to treat it as part of the East Asian Lower Palaeolithic (*e.g.* Bae 1988; Yi and Clark 1983). However, without reliable chronometric dates and appropriate typological systematics, it is not constructive to make an unfounded argument that the overall stone industry of the IHRA falls in the Lower Palaeolithic, both chronologically and technologically, as a parallel to the classic Acheulian industry.

As Yi (1987: 102) perceptively noted, formally "impressionistic" or "intuitive," (Bisson 2000: 3) similarities to the Acheulian industry in a few lithic types cannot automatically identify its temporal basis and technological level. In addition, recently obtained chronometric dates from this area (Yi 2005; Yi *et al.* 2005) indicate that the temporal horizon of the IHRA assemblages cannot be attributed to the conventional Lower Palaeolithic chronology. This issue of the chronology and technology of the IHRA assemblage has recently drawn the attention of many archaeologists and geologists who have presented various positions on the chronological and technological nature of the IHRA industry (*e.g.* Bae 1992a, 1992b, 1995a, 1995b, 2002; Bae *et al.* 1999, 2001, 2004; Choi, J. H. *et al.* 2004a; Choi, K. H. *et al.* 2005; Clark, J. D. 1998; Danhara 2003; Lee Y. S. *et al.* 2001; Matsufuji *et al.* 2005; Nagatomo 2005; Naruse 2003; Rollands 2001; Wee 1996; Yoo 1997; Yi 1996, 1999, 2000, 2002, 2005; Yi *et al.* 1998, 2004, 2005). Given this situation, it is absolutely necessary to establish both solid dates based on different and independent chronometric dating techniques, and adequate descriptive frameworks so as to be able to observe individual lithic assemblages in adequate detail.

2. Research Methods

The first stage presents new chronometric dates in order to reconstruct the geological setting and the site formation processes. This identifies the impact of the environment on the hominin survival strategy. Special emphasis is given to the volcanic activity and fluvial sedimentary condition. The next stage investigates the diachronic changes of lithic assemblage patterns with the purpose of establishing its chronology and technological development. The final stage of this study attempts to recognize the assemblage variability on the site level, and to summarize the characteristics and general tendency of technological evolution across the overall IHRA industry. To achieve these goals, this study will concentrate on; 1) the geoarchaeological observations on site formation process of the area at the regional scale, 2) the documentation of changes in lithic manufacturing techniques and raw material procurement strategies, and 3) the exploration of the significance of the seemingly "static" (Kuhn 2005: 109) expedient technological organization before the emergence of the Upper Palaeolithic.

In order to carry out the actual research for these purposes, the basic methodology is two fold: a geoarchaeological approach to the fieldwork area and a quantitative approach to the available data, principally the lithic assemblages. The geoarchaeological approach is composed of four tasks: 1) field survey and excavation sessions in the field area, 2) sampling and determination of chronometric dates, 3) reconstruction of terrain development and collection of referential data for correlation, 4) identification of rock types, their distribution, and lithogenesis for the purpose of determining the properties of raw materials that were employed by hominins for producing the lithic artifacts. The special chronometric techniques that were employed for this study are as follows: 1) Potassium-Argon (K-Ar) dating method in order to obtain the initial dates of volcanic activity, 2) Optically Stimulated Luminescence (OSL) dating and Infra-Red Stimulated Luminescence (IRSL) dating the stratigraphy of the sediment in which the lithic assemblage is distributed; 3) Accelerated Mass Spectrometry (AMS) dating method in order to measure complementary dates and to establish the temporal division of the stratigraphy.

The quantitative approach includes the following procedures: 1) the collection of the lithic data from excavated sites; 2) documentation of the assemblages including their description, illustration and measurement; 3) the quantification of the raw data; 4) the establishment of hypotheses and construction of explanatory models; 5) the statistical analysis, the evaluation of initial results and the interpretation of the final results. Relevant to this quantitative approach, a hypothetical overview can be made as to the evolution of lithic technology in the IHRA: 1) as hominins reside in various localities of the IHRA, casual flake tools and occasional heavy duty tools are made with locally dominant low-quality material; 2) the inter-site variability of lithic assemblages is dependent on the raw material utilization patterns and the hominin ability to "improvise" necessary tools; 3) the diversity and intensity of technological solutions continuously changes in a slow and steady pace, such that the response to changing external constraints was not rapid even if new adaptive strategies seemed to be urgently required,.

It is anticipated that the chronology of the IHRA industry will be characterized as a long sequence from the later Middle and to the final Upper Pleistocene. This claim will be supported by presenting new chronometric dates and by the macro-scaled nature of the investigation of the geomorphological changes. Furthermore, the apparently static or less-dynamic nature of the assemblage characteristics will be accounted for as a result of the long-term changes cumulatively brought about by the interactions between the environmental constraints and selective task management loosely based on the hominin target-oriented strategy.

(3) Structure of Thesis

Before discussing actual research in the study area and of its data, Chapter II will briefly overview the Quaternary environmental background of East Asia. The physical geography of the Korean Peninsula will be summarized, and recent progress on the understanding of Korean Pleistocene environment will be presented. In addition, because the research area is entirely devoid of fossil data, several faunal and paleoanthropological records will be described in order to survey the overall features of Pleistocene hominins with which the "actors" of the IHRA are believed to be in the same anatomical group.

Chapter III will discuss the geological features of the IHRA. Site formation processes are yet to be fully understood at the regional scale, and the ages of the lithic assemblages are still controversial. Nevertheless, to date, numerous approaches have been presented in the interpretation of geological activities in this area and relevant chronometric dates have been published. A general review of the history of research in the IHRA will be presented and some evaluation of the historical significance of individual research projects will follow.

Chapter IV provides the results of fieldwork. Three sessions of small-scaled excavation (the Juwolri, Kawolri, and Chongokni sites) and the lab work on the assemblages from these and another site (the Jangsanri, Juwolri, Kawolri, Chongokni sites) of the IHRA were conducted. In addition, some crucial archaeological data that was not included in the fieldwork will be presented and discussed in the same context with those fieldwork data.

These "external" data include previously excavated assemblages from the neighboring sites in the IHRA: Keumpari, Hoengsanri, and Janghungri.

Chapter V presents a summary of assemblage characteristics of the IHRA. A typological framework for the IHRA will be proposed and the manufacturing technology for each type will be illustrated. Some discussion will be made on the components of the IHRA assemblage and the general reduction sequence will be reconstructed.

Chapter VI is the description and analysis of the lithic assemblages. Data from four assemblages (the Jangsanri, Chongokni, Kawolri and Janghungri sites) will be quantitatively analyzed and the results will be discussed. First, the raw material utilization patterns and their variation at the site level will be presented. A new technique for the quantitative analysis was devised and its applicability will be demonstrated. Some hypothetical techno-behavioral patterns will be introduced and discussed with emphasis on the utilization and reduction intensity of blanks. Finally the result of these analyses will be discussed in terms of the diachronic changes in the hominin strategic organization of technology of the IHRA.

Chapter VII will delineate the long-term change of the Pleistocene landscape and the hominin role in this changing natural background. Braudel's concept of *la longue durée* will be used as a framework for understanding the macro-scaled temporal rhythm. In addition, the Pleistocene history of the relationship between hominin practices and the changing landscape in the IHRA will be meaningfully narrated with special respect to the evolution of channel flows. As a final remark, evaluation on the result of this study will be made in the context of currently unsolved issues of East Asian Palaeolithic archaeology and some issues concerning theoretical consideration on the Palaeolithic research will be suggested for future work.

II. GEOGRAPHICAL BACKGROUND

(1) Introduction

As one of the major factors that have affected hominin survival patterns, the impact of change in the past environment cannot be overemphasized for interpreting the Palaeolithic record. In particular, the Upper Pleistocene witnessed strong seasonal fluctuation of available resources, and there might have been drastic changes in the distribution of resource patches exploited as food by Palaeolithic hunter-gatherers (Kelly 1995). The changes in diversity of resources and their quantity alter selection pressures on hunter-gatherer group, and eventually bring about the modification of their adaptive patterns (Jelinek 1994).

Chapter II summarizes the geographical and environmental background of East Asia. As the temporal coverage of archaeological material for this thesis will be from the later part of Middle Pleistocene to the Upper Pleistocene, the paleoclimatic data for the last 0.4 Mya will be principally examined in the first section of this chapter. The next section introduces the quaternary environment of the Korean Peninsula, and discusses some major issues in Korean Quaternary environmental studies. As a marginal territory of continental Asia, some basic background on the topography, climate, and the archaeology of site location will be mentioned. Special focus is given to the schematic models on the development of marine and river terraces, the problems of Pleistocene time-scales, and chronostratigraphy. In addition, the interpretation of biological environment based on floral and faunal records will be addressed, and the Korean hominin fossils will be presented in terms of their anatomical features and chronology.

(2) East Asian Environmental Record since 0.4 Mya

1. Environmental History before the Upper Pleistocene

A. General Features of the Middle Pleistocene Climate

Since the beginning of the late Cenozoic, ongoing and strong neotectonic movement has been modifying the geomorphological features of East Asia. Especially, the new uprising of the western sector, represented by the formation of Qinghai-Tibet Plateau, changed the latitudinal circulating current of East Asia, giving rise to the East Asian monsoons (Tong and Shao 1991). The lack of extensive continental glaciers and the predominance of mild monsoon conditions are two important features that generated a relatively moderate and unchanging Quaternary climate in East Asia, compared to other part of continental Eurasia. Some data (*e.g.* Huang W. P. 1991; Qi 1989) also suggest that general climatic oscillations in East Asia before Upper Pleistocene was not extreme enough to change the entire biomass and species diversity in a short time span.

From the later part of the Middle Pleistocene (after ca 0.4 Mya.) to the last Interglacial (ca 125Kya, the OIS-5e), the climate in the eastern part of continental Asia was relatively warm and humid. The pollen data of deciduous-broadleaf plants and some associated fossils of southern Chinese fauna from the beds 8-5 of Zhoukoudian Locality 1 (*e.g. Paleoloxdon namadicus, Ailuropoda,* and *Cunailurnis,* Shi 1991) well-illustrate this as being a mild-monsoon-oriented environment. Similar faunal components are also found far north in the Jinniushan area of Liaoning Province of northeastern China. Parallel to this, the laterite, a dark red weathered layer mostly composed of clay and fine silt, is diagnostic of warm and humid temperature; and this is spread over the Huaihe River Area (33°N- 34°N) about 5- 6° north beyond the current laterite distribution limit (Tong and Shao 1991). The average temperature was calculated to be 3- 4°C higher than the present and annual precipitation was estimated to be 500mm and more (Shi 1991).

In contrast to this, the climate of western China became arid and relatively cold. The Qinghai-Tibet Plateau had risen to over 3000m and formed a natural barrier against the impact of southwest monsoons. The precipitation was obviously reduced in the continent of western China. The loess plateau was covered with alternating landscapes of grassland and forest-grassland. In addition, the snow-line rose and the permafrost zone in the high altitude area expanded in the western mountainous region.

B. Climatic Deterioration since OIS 6

Fig 2.1. summarizes the distribution of climatic zones in terms of temperature and humidity from 0.4Mya to 0.2Mya. It is noteworthy that almost two-thirds of the Korean Peninsula falls in the northern subtropical zone, which suggests that the climatic conditions of most Middle Pleistocene archaeological localities in Korea had relatively high productivity and were in an ecologically rich environment. Although some variation in the local environment would have occurred, a relatively warm and humid climate was prevalent for a substantially long time span at least until the advent of a colder phase in OIS 6 (186Kya to 128Kya).

The warm climatic conditions gradually cooled and the biomass was subsequently affected by the deterioration of environmental productivity. In China, OIS 6 is characterized by a Chinese loess stratigraphic unit (the L2) in various locations which was originally termed as the upper parts of "Lishi Loess" (Ding 1991). The reliability of its chronometric dating and pedostratigraphic correlation is still in question (Zhang *et al.* 1991; Yi 1989). During the cooling and environmentally degrading period of OIS 6, the available niche area was diminished in the northern regions. Few archaeological indicators of hominin occupation are well-documented because the chronological limits of this period are beyond the levels of ^{14}C dating and the duration of this period is too short to be measured by such low-resolution methods as K-Ar and fission track dating.

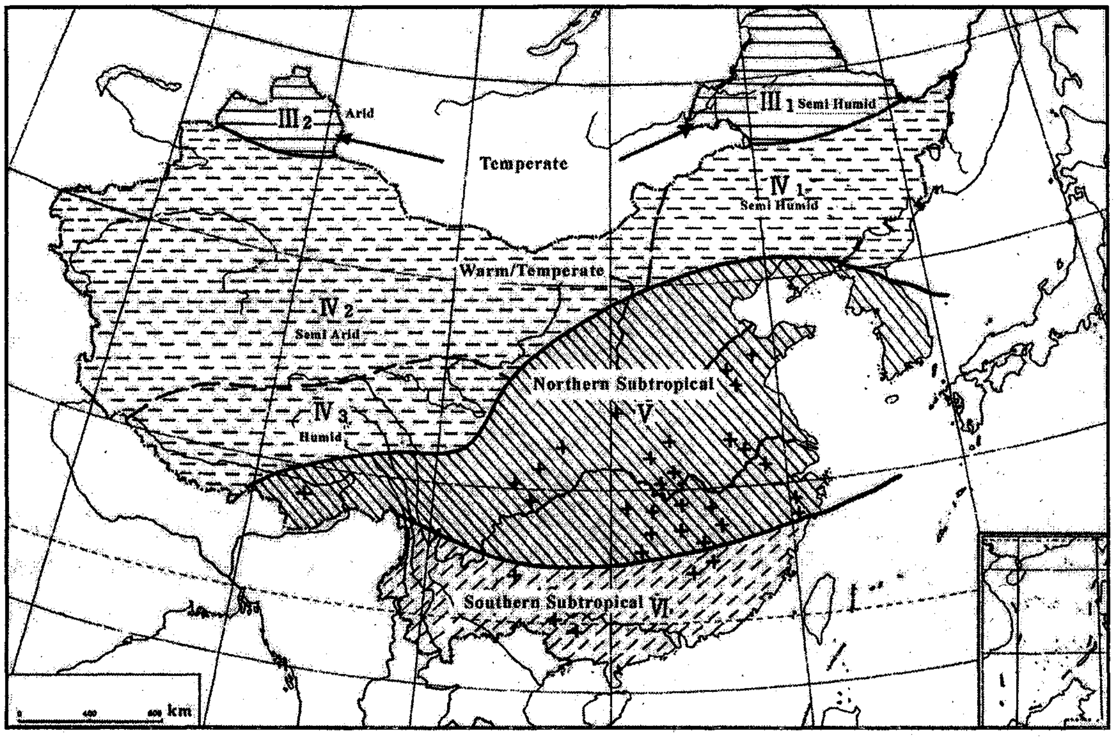


Fig. 2.1. Climatic sketch map of the continental East Asia during 0.4- 0.2 Mya (Re-drawn from Tong and Shao 1991:59)

2. Climatic Fluctuations during the Upper Pleistocene

A. Three Phases of East Asian Upper Pleistocene Environmental History

The last Interglacial (the OIS 5e) was an interval of climate as warm as or warmer than today, and is conventionally labeled the "Eemian" in Europe. Recent observation suggests that it began approximately 130 Kya and ended about 116 Kya, based on the correlation with the uranium-thorium dates of coral reefs (Kukla *et al.* 2002). At the termination of the last Interglacial, the continental East Asian climate became gradually colder and dryer with an unconfirmed number of various stages of warm intervals. In general, however, even though serious environmental stress was imposed, the intensity of hominin occupation throughout the continent was dramatically increased. As a result, the number of archaeological sites continuously increased up until the terminal Pleistocene, constituting evidences of hominin adaptation capacity and diversity.

Tong and Shao (1991) subdivided the upper Pleistocene of continental East Asia into three phases as follows.

1) Phase 1 (128- 90 Kya): It is the warmest and most humid period in the Upper Pleistocene. The temperature was 2-3 °C higher than today, and the sea level was about 5-7m higher than at the present time in the Yellow Sea. Laterite deposits were still developing in the lowlands while some loess deposits occurred in the mountainous areas. A large-scaled transgression occurred in the coastal plains and offshore area of eastern China and the Korean Peninsula.

2) Phase 2 (90- 50 Kya): The warm climate gradually turned cooler and dryer between 70 and 53 Kya. Temperature was 10° C lower than at the present time. The wind force was strong and expanded to the lower altitudes. The sea level was 50- 60m lower in the Yellow Sea than today. Northeast China and the northern part of Korean Peninsula were covered by tundra and steppe.

3) Phase 3 (50- 10 Kya): The atmosphere was the driest and coldest (about 12 °C lower than present). Northeast China and the upper half of the Korean Peninsula were covered with coniferous forest and frozen grasslands. Since 23 Kya, the temperature significantly was lowered further and vast areas of desert and tundra developed. Para- and/or periglacial geological features such as ice wedges developed almost everywhere in the northern part of the continent and sea level reached its minimum to about 150m below the present level. About 15 Kya, the temperature started rising again.

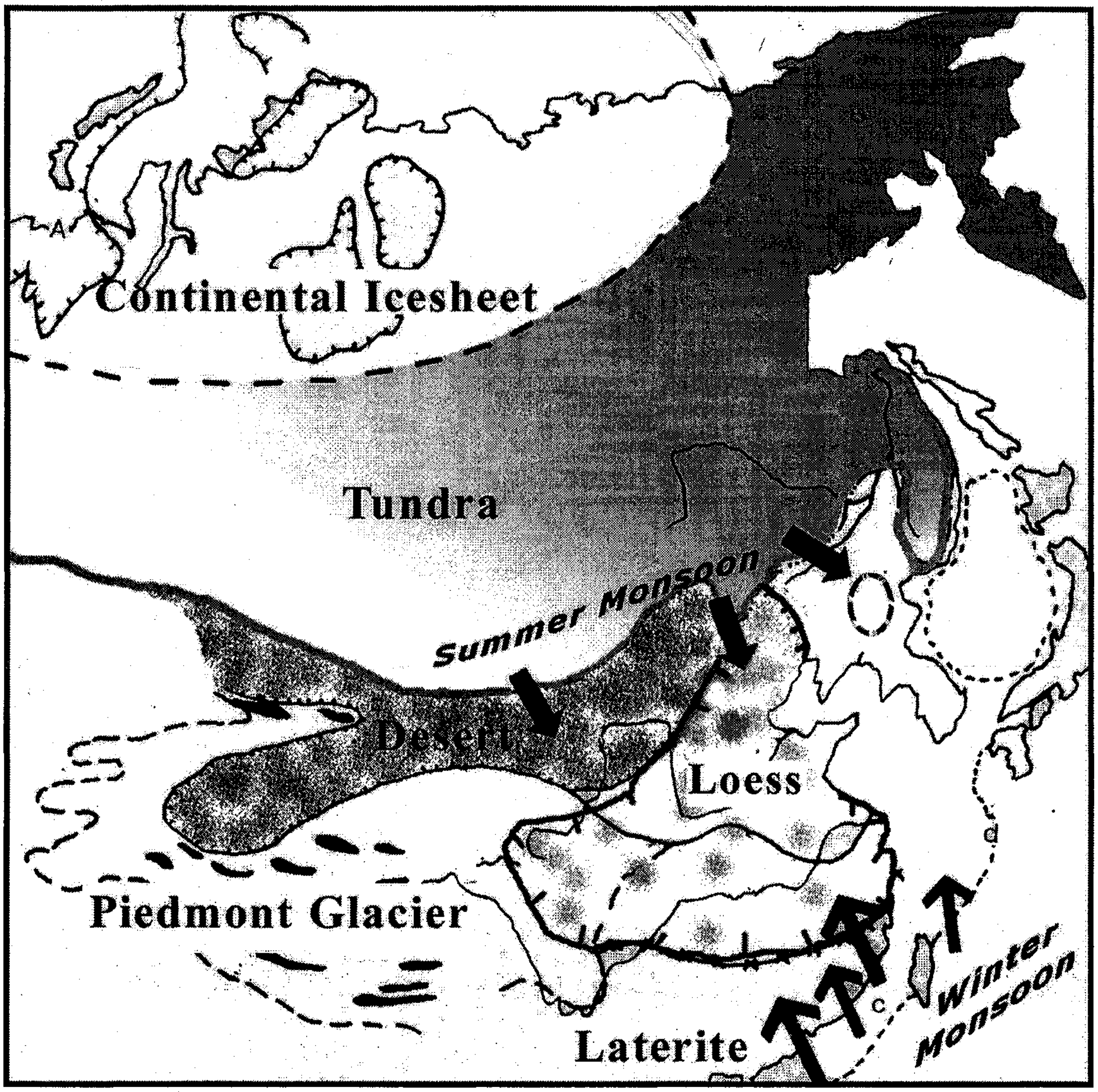


Fig. 2.2. Schematic layout of environmental zones in the continental East Asia during the LGM (Re-drawn from Yi 1989: 111)

In keeping with this sequence of general temperature degradation (Pu 1991), the permafrost area in northern China progressed southward and eastward, partly including northern Korea and Mongolia up to the border between Ningxia and Shaanxi Province of northwestern China. In the southern region, the mountainous glaciers reached their maximum size during the early Upper Pleistocene; subsidiary glacial masses such as piedmont glaciers, large ice caps and valley glaciers progressed eastward about 100-200km from southeast Xizhuang on the Tibetan Plateau (Shi 1991, Fig. 2.2.).

B. Evidence of Climatic Oscillations

It is now known that glacial and interglacial climates are prone to rapid and often large oscillations lasting from a few hundred to several thousand years. The Chinese Quaternary lake core data (Liu *et al.* 1991) and the Japanese eolian sequence in the Kanto area (Yoshinaga 1996) can be roughly correlated. Oceanographic data reveal that the Eastern Sea (*i.e.* the Sea of Japan) underwent remarkable warm and cold cycles from 100 Kya (Tada 1999). The dark layers (Fig 2.3.) containing warm-water diatoms are especially indicative of interstadial climatic conditions and were formed by the influx of the East China Sea Coastal Water. Similar climatic cycles are indicated by the eolian dusts transported from the Asian continent to the Japanese Archipelago (Naruse 1998).

Because of the glacial climate, biomass reached its minimum *ca.*20 Kya (LGM, the Last Glacial Maximum, Watanabe and Sakagami 1999). Globally, the full last glacial is dated around 25Kya to 14Kya with the lowest isotope value around 18 Kya (Clapperton 1995, but 21Kya by some recent calibration from Yu *et al.* 2002). During the LGM, the inland lake level in eastern China was very low due to reduced summer Asian monsoons (Yu *et al.* 2002), and large-scale eolian dust movements occurred from Mongolia and the Gobi Desert.

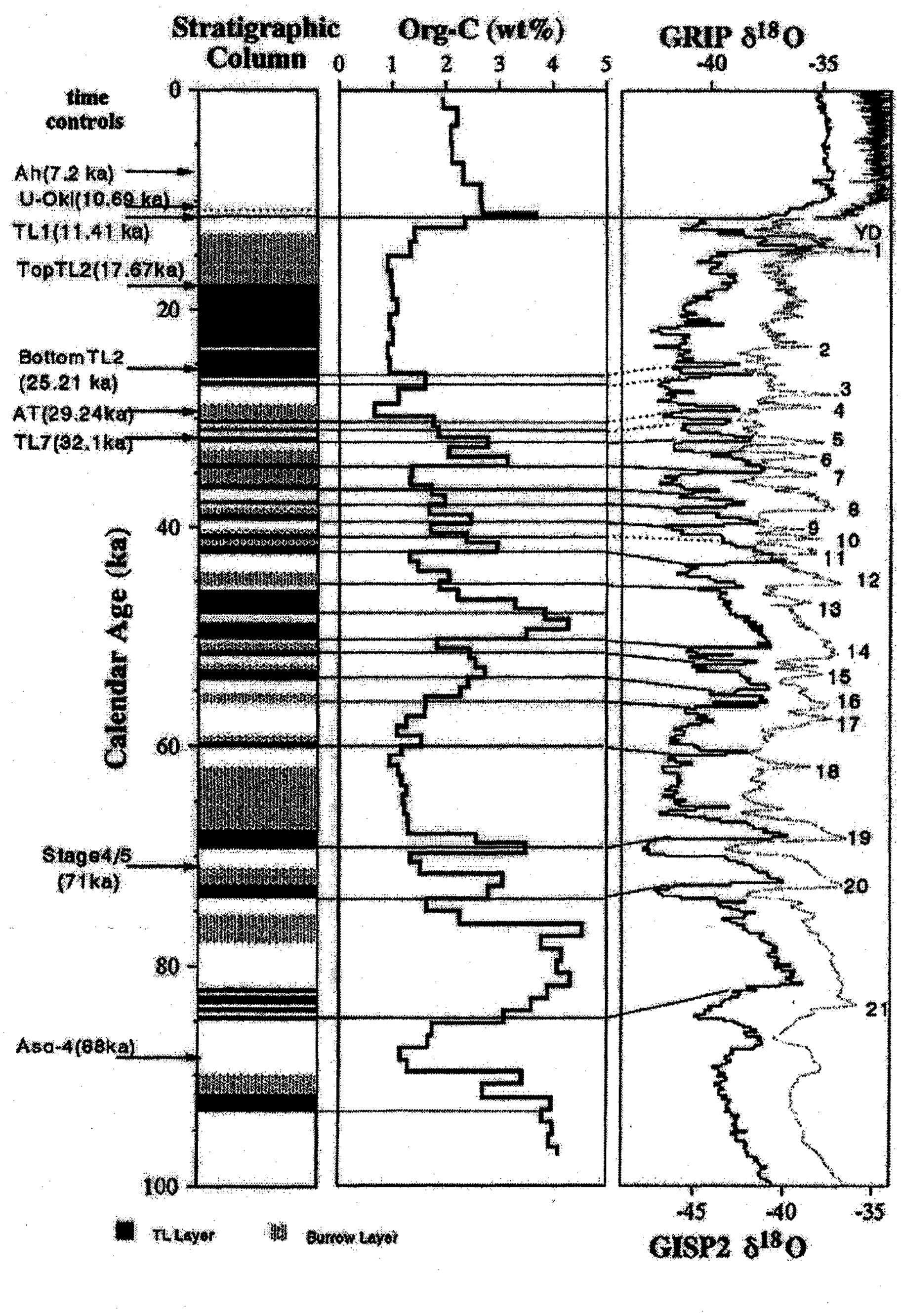


Fig. 2.3. The carbon contents in C-3 core from the Eastern Sea correlated to the δ18 O records of the Greenland ice cores (GISP2). Interstadial numbers on the right. (All dates are calibrated calendar years from Tada 1999)

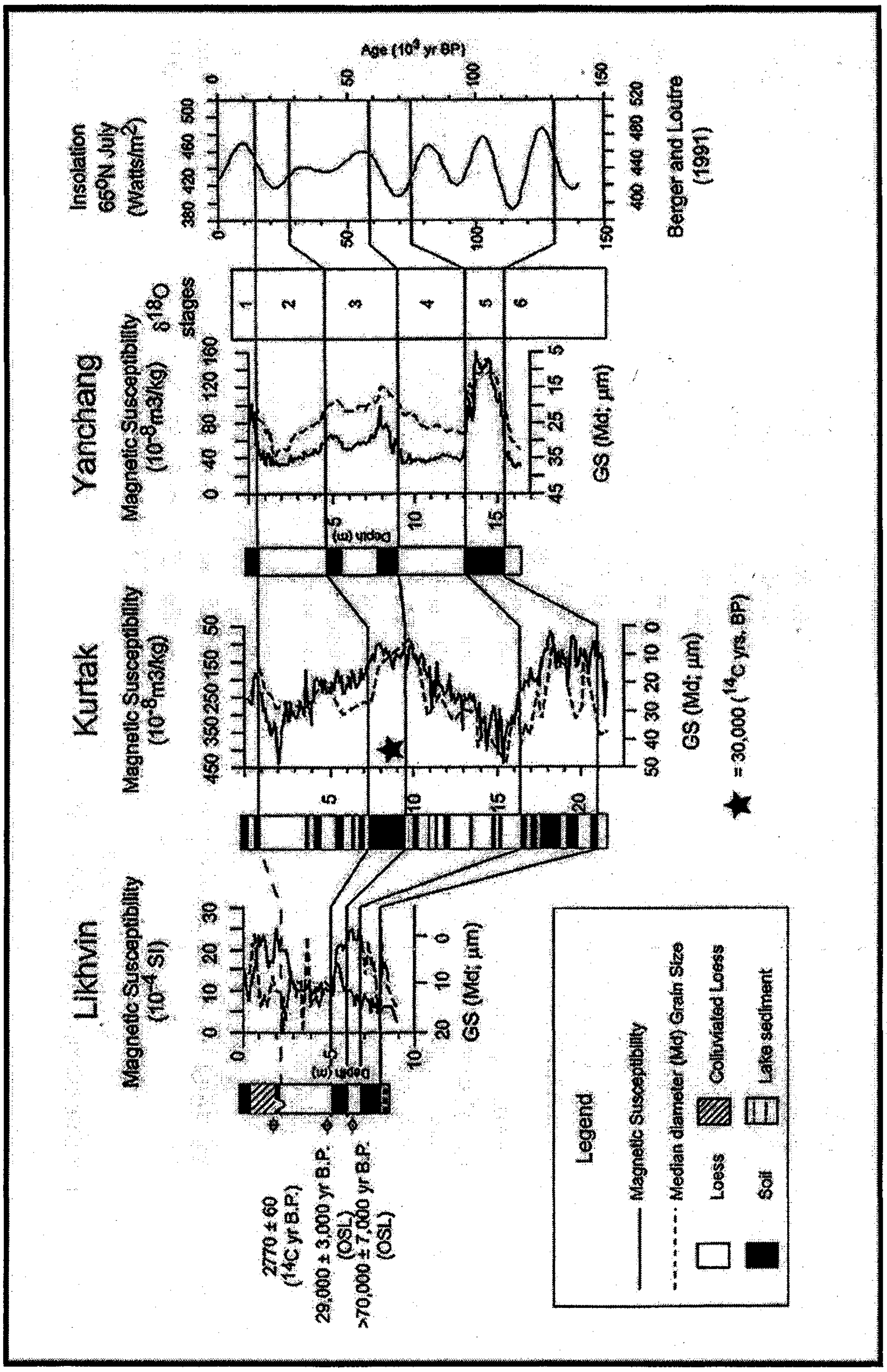


Fig. 2.4. Pedostratigraphic correlation of three cores from European Russia (Likhvin), Siberia (Kurtak), and China (Yanchang) since OIS 6 (From Rutter *et al.* 2003)

Recent work (Rutter *et al.* 2003) of correlating pedostratigraphic data across Eastern Europe, Siberia, and Asia demonstrates that the Chinese paleosol/loess sequence section does not show as much strong oscillations of magnetic susceptibility as those of continental Europe and arctic Siberia. The Chinese section shows that OIS 3 comprises both loess beds and paleosols, reflecting multiple warm and cold periods. However, its OIS 2 shows up as stacked or welded single loess layer that does not have the climatic resolution of the European and Siberian data (Fig. 2.4.). According to these data, it is concluded that the East Asian Upper Pleistocene climate shows more pronounced oscillation during the relatively warmer periods than during the colder ones. For this reason, the correlation of East Asian paleoclimatic data with the subdivision of each OIS stage should be done with caution. Using the European data analogically and characterizing each stage simply into either warm or cold should be avoided.

3. Associating the Environment with Technology : a Hypothetical Overview

A. Hominin Occupation in East Asia

From the above data, a generalization of Pleistocene environmental changes in East Asia during the last 40 kya can be made. First, a relatively mild environment reduced survival stress during the later part of middle Pleistocene. With the onset of the OIS 6, serious climatic deterioration began. However, the archaeological record during this is characterized by the absence of relevant site data. Numerous sub-stages of warm/cold cycles occurred, starting with OIS 5e. There was, however, general temperature reduction (Pu 1991; Shi 1991) and ecologically favorable areas for hominin survival were centripetally constricted around the middle-eastern part of continental Asia until the LGM (ca 20 Kya). It is suggested that, although continuous environmental deterioration could hinder the areal extent of habitat during the Upper Pleistocene, the area below 40°N did not constitute extreme conditions for the positive adaptation of the hominins (Yi 1989: 112). Except for northern Manchuria, the Tibetan Plateau, and some local spots of tremendously low productivity, almost every part of eastern China and Korea was occupied by hominins through their modifying their survival strategy, in particular by advancing their lithic technology.

B. Technological Capacity and Environmental Pressure: A Hypothesis

Insofar as the production of stone tools is concerned, it is still questionable whether a distinct chronological trajectory of technological evolution before the Upper Palaeolithic has been established in East Asia (Gao and Norton 2001; Ikawa-Smith 1978). Relevant to this, Bae (1988: 421) hypothesized that the environment in temperate Pleistocene Asia (*see also* Rollands 2001) was characterized by distinctive seasonality and fluctuation of food-resource availability. Based on his hypothesis, hominin mobility to secure plant food increased greatly and relatively small sized plant resources, such as fruits, nuts and seeds, became the principal staples for daily collection. The process of collecting small-sized food units in the temperate zone was probably labor-intensive rather than technologically efficient.

According to Bae's hypothesis, dependence on stone implements is expected to be minor and occasional. Likewise, technological innovation played a minor role in the total adaptive system of East Asian hominins. From this viewpoint, a speculative argument can be made that the Middle/Upper Pleistocene hominins of East Asia were not subjected to so much environmental pressure as to make impressive technological accomplishments necessary, in contrast to their counterparts on the opposite side of the Eurasian continent- the

Neanderthals (Jelinek 1994; Stringer 1989; Stringer and Gamble 1993).

Juxtaposing the Neanderthal and East Asian hominin (*e.g.* the archaic *Homo sapiens*; Keats 1997; Pope 1997: Wu X. and Wu M. 1985) in the context of their respective habitats and their possible technological responses, some contrasting archaeological features might be observable in their mode of technological evolution. For the Neanderthals, their strategic solutions under critical conditions were rapid and effective modification of tools. In contrast, East Asian hominins were relatively free from the burden of immediate technological response to varying external constraints due to their low dependence on the lithic tools influenced by their labor-oriented provisioning strategies. Compared to Mousterian assemblages, the low percentage of retouched tools and low inter-assemblage variability are construed as the results of low diversity of technological modules shared among East Asian hominins.

However, while East Asian lithic assemblages display little technological development suitable for coping with rapidly shifting resource diversity and distribution, the basic mind-set and attitude toward the manufacture and use of lithic tools would not be much different from those of the Neanderthals because they are also "susceptibly produced by dint of technological provisioning strategies" (Kuhn 1995: 9). In this sense, the difficulty in characterizing and documenting East Asian Palaeolithic assemblages principally lies in the "opacity" of that susceptibility under a relatively less "rugged" living conditions, rather than in the "dullness" of the strategies themselves. Although very effective and reliable, this kind of dynamics in technology tends to appear simple and unsophisticated, and changes cannot be easily detected as to demonstrate the "high-fidelity" of technical susceptibility under relatively stress-free conditions. Environmental factors influencing the technological development will be discussed further in later chapters.

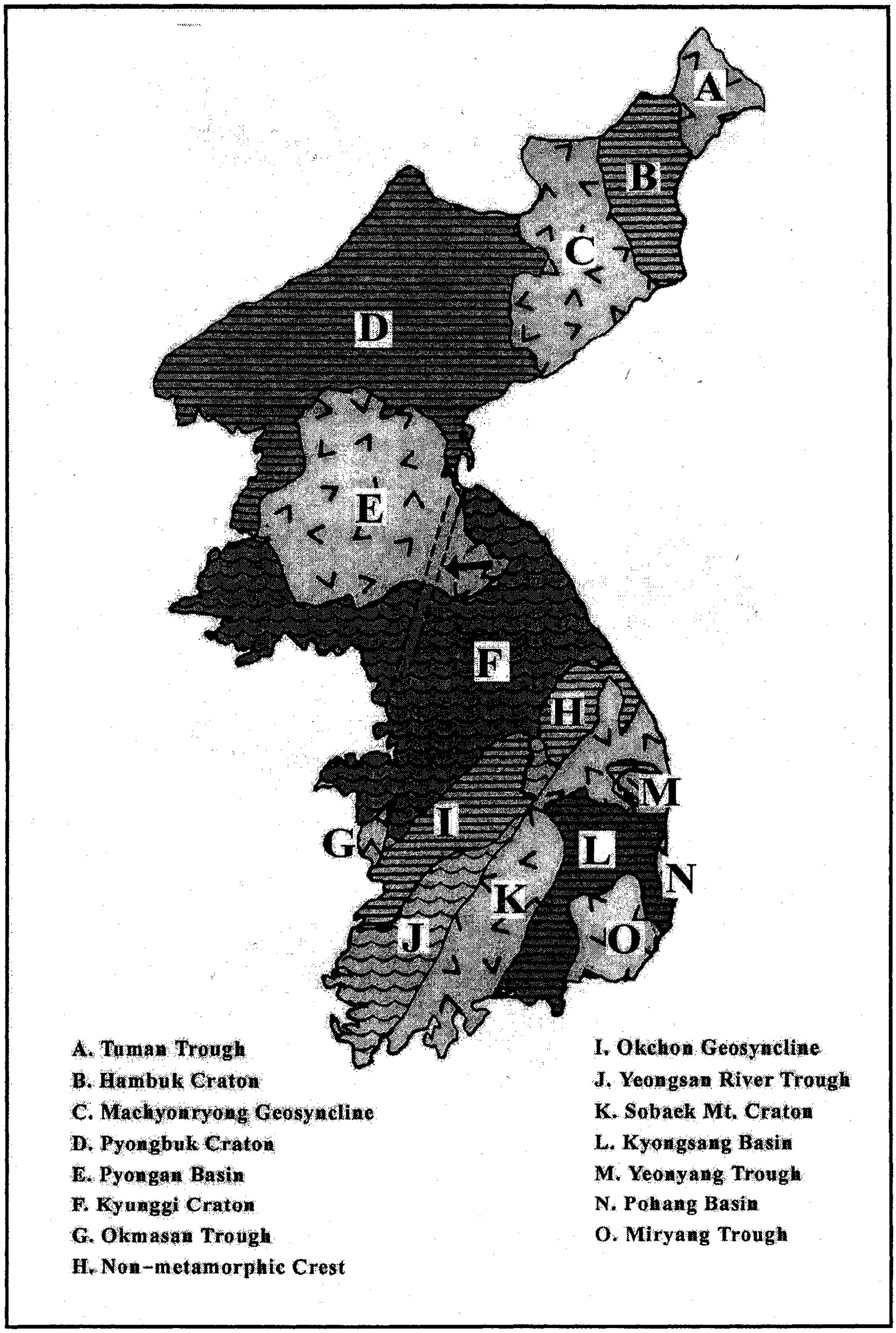


Fig. 2.5. Geotectonic Zones of the Korean Peninsula

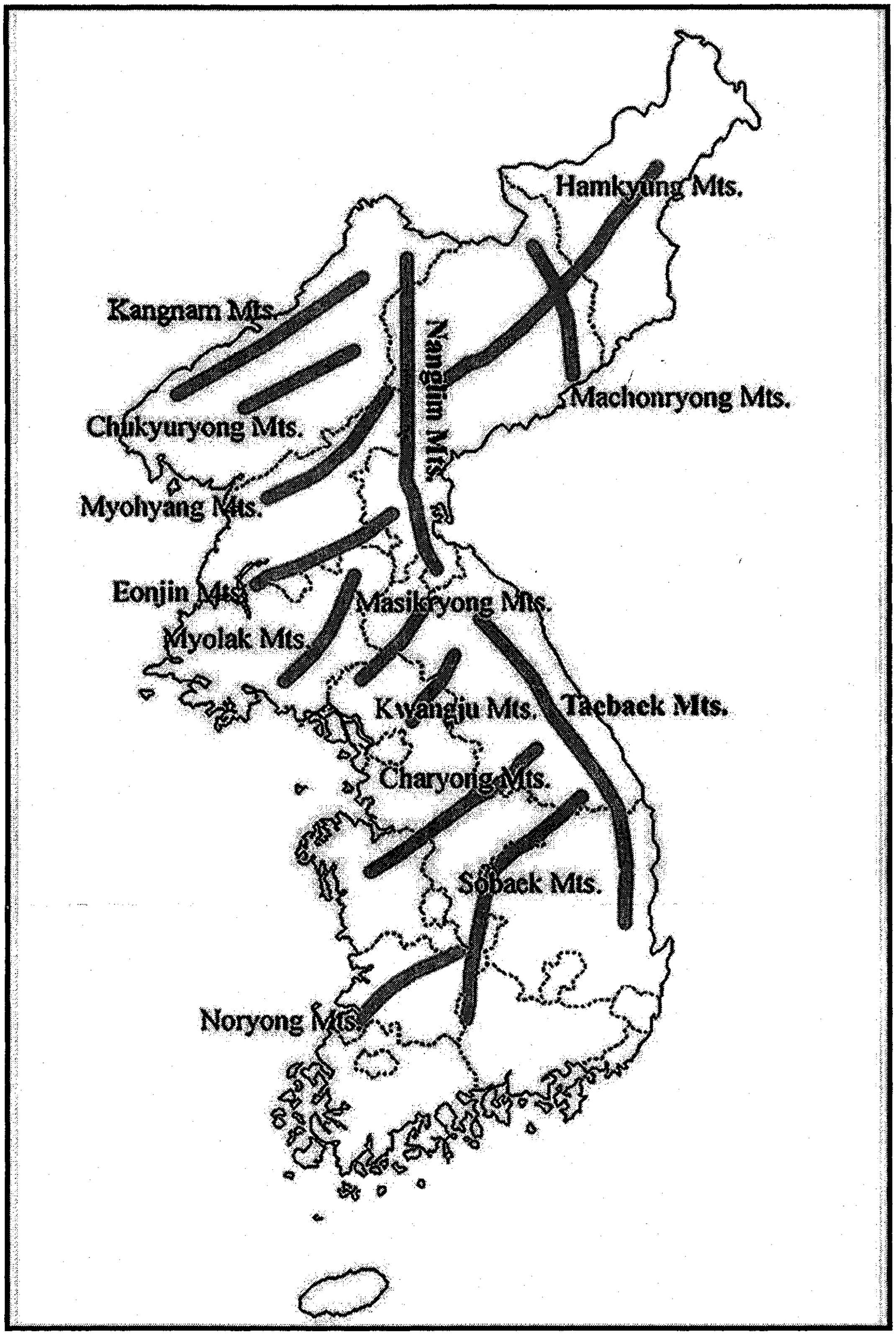


Fig. 2.6. Mountainous Ranges of Korean Peninsula

(3) The Pleistocene Environment of Korea

1. Physical Geography of the Korean Peninsula

A. General Topography and Site Distribution

Korea is a peninsula surrounded by the Eastern Sea to the east and the Yellow Sea to the west. The northern part of the peninsula is connected to continental Asia and currently is occupied by North Korea. The whole peninsula ranges between 33° 06' and 43° 01 ' latitude and between 124° 11' and 131° 53' longitude. The total area of the peninsula is about 221,000㎢ including all adjacent islands. Geologically, Korea is a part of the stable continental land mass but located at the margin of the Circum-Pacific Orogen where vigorous orogenic movement is still under way.

The general topography of Korean Peninsula is formed by the "Daebo Orogeny" from the early Jurassic to the Cretaceous Period (*ca* 180- 120 Mya, Soh 1980). Violent thrusting and innumerable folds accompanied by large scale faulting produced a series of high mountains. This movement occurred mainly in the middle- and southern part of the peninsula and the consequences are well observed by the syntactic granites across the "Okchon Geosyncline Belt" (I of Fig. 2.5.) which traverses from northeast to southwest.

Korea is predominantly a mountainous area and most of channel system is westward because of its west-slanting topography. The land surface consists of generally low mountain ranges with only 5% being above 1,000m. However, the topography is much dissected and even low mountains have steep slopes associated with a relatively early stage of the topographic developmental cycle (Bartz 1972). Two linear mountain ranges traverse the peninsula like vertebrae from North to South- the Nanglim and Taebaek mountains. Several other tributary mountain shoots erupt from these two ranges (Fig. 2.6.). Because of its extensive mountainous area, the peninsula is populated primarily in the midwestern and southwestern regions. Archaeological remains in Korea tend to occur sporadically but their distribution shows a highly clustered pattern dispersed among these mountain ranges.

Most Palaeolithic sites are located within the altitude range of 20m to 70m above the average sea level. This level is almost identical to that of the current residency in Korea, and generally follows along the outskirts of steep mountain slopes. In some cases, Palaeolithic sites have been discovered in several regions of limestone caves which extend far above the slope range. The Okchon Belt, shown as I in Fig. 2.5., is a well-developed calcareous land mass with various escarpments and cavities which is an ideal habitat both for hominins and animals. Because of the calcareous alkalic environment, fossil remains are well-preserved in these cave sites, but most of the other open-air sites rarely produce animal or hominin fossils.

B. River Channel System

At the northernmost border of Korea, two channels– the Yalu River and the Tuman River– originate from the Baekdu (Changbai in Chinese) Mountain and demarcate the peninsula from Manchuria. Below the Yalu and Tuman, numerous river channels run from east to west, parallel to the east-west direction of most mountain ranges. In the southern part of the peninsula, three major channels – the Nakdong, Seomjin, and Yeongsan- run southward and these channels flow through deeply entrenched valley developing a complex network of streams. The availability of water was always a critical concern, and most prehistoric sites are located adjacent to the hydraulic sources such as a major river channel or a lesser tributary. As a result, almost all Palaeolithic localities are distributed near fairly large fluvial channels, with a few cave sites being located at the mountainous area.

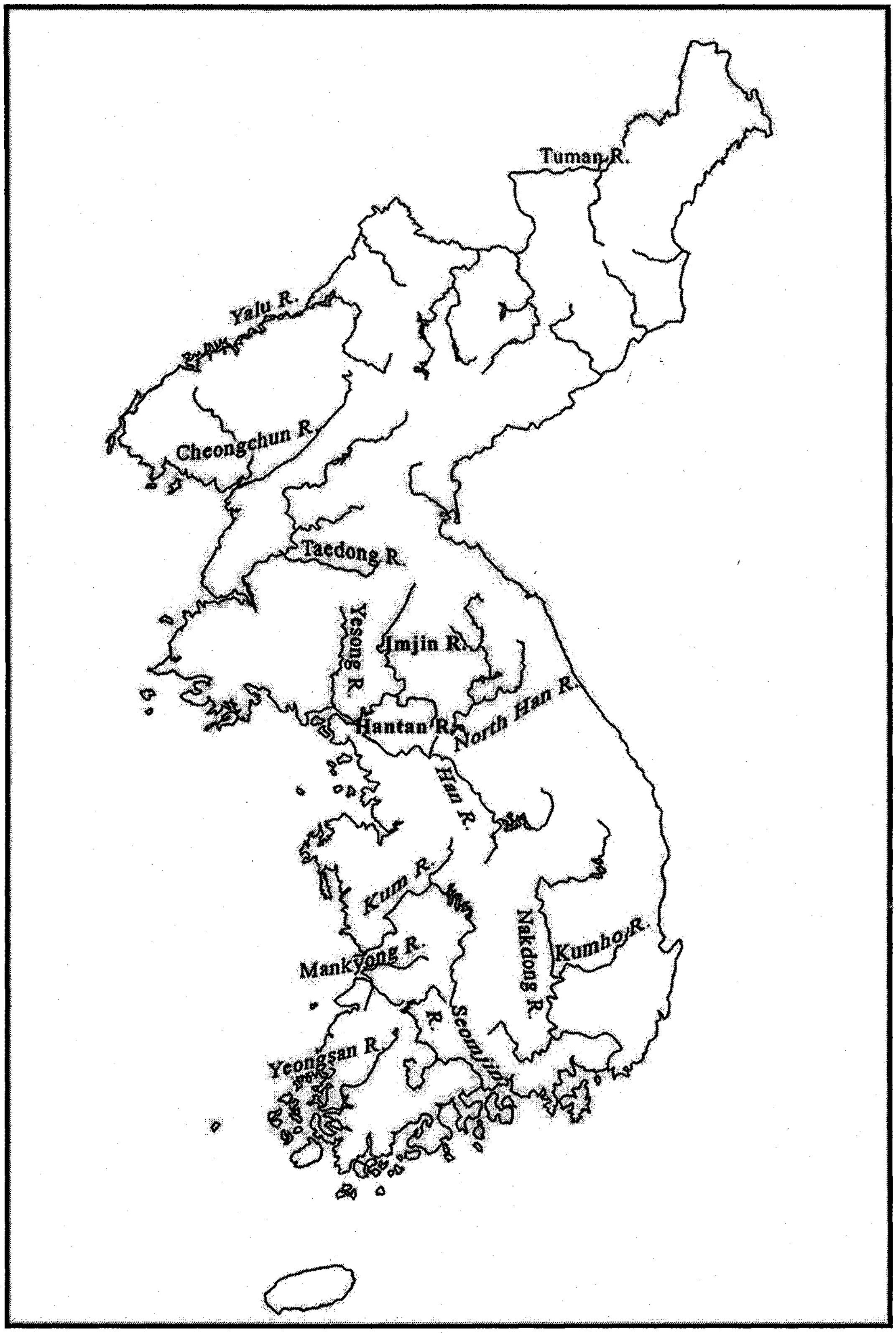


Fig. 2.7. Major river channel systems of the Korean Peninsula

2. Formation of the Pleistocene Marine/River Terraces

A. Lee's Model of the Pleistocene Marine Terraces

Many a Palaeolithic site has been discovered upon the river terrace surfaces which were formed for the most part by the erosion-deposition cycles during the Pleistocene. Terraces developed well on both sides of the major river channels in Korea. Currently, a significant part of Quaternary research in Korea is directed to the study of these river terraces and related geomorphological features. According to Lee (Lee, D. Y. 1987a, 1987b, 1990, 1997, 1998), several stepped marine terraces in the eastern coastal area of the peninsula are composed of five units as follows (Table 2.1.; Fig. 2.8.).

Terrace Sequence	Terrace Surface	Terrace Deposits	Altitude
1st Terrace	Songha Terrace	Songha Formation	3- 5m
2nd Terrace	Na-a Terrace	Na-a Formation	10- 15m
3rd Terrace	Wolseong Terrace	Wolseong Formation	32- 40m
4th Terrace	Eupcheon Terrace	Non-confirmed (?)	50- 60m
5th Terrace	Bongwhaje Terrace	Non-confirmed (?)	80- 90m

Table 2.1. Five Marine Terraces identified in the East Coastal Area (Based on Lee, D. Y. 1977a)

Using this basic five stepwise sequence of terraces, Lee and his colleagues have correlated the overall Korean river terraces to each stage of the coastal marine teraces (*e.g.* Lee, D. Y. 1990, 1997; Lee, D. Y. and J. Y. Kim 1990). Until the most recent synthesis, Lee and his colleagues (Kim, J. Y. *et al.* 1998) have insisted that the general sequence of Korean

Pleistocene deposits correspond to his schematic development of five-step marine terraces (Lee D. Y. 1987b, 1990, 1997, 1998). A summary of his scheme on the geomorphological development and depositional process of marine/river terraces is as follows.

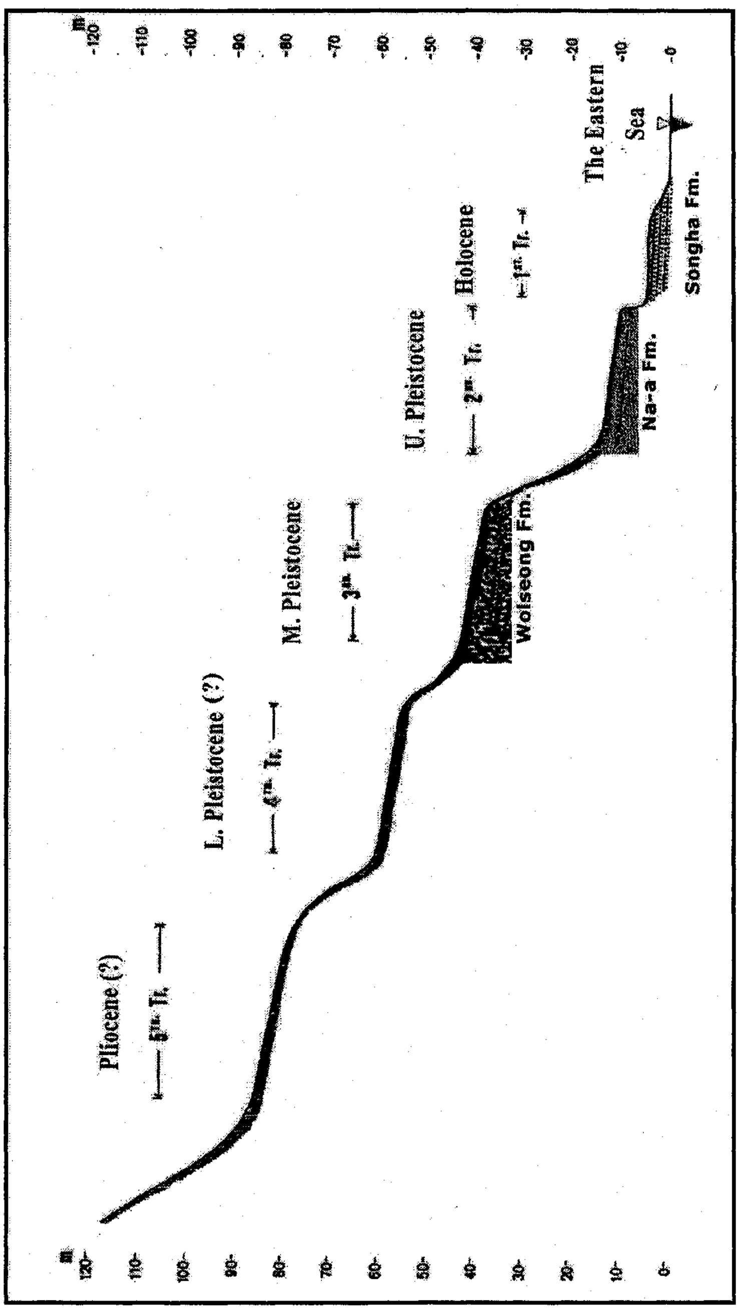


Fig. 2.8. Schematic view of "Terrace Succession" in the Eastern Coastal Area (Re-drawn from Lee, D. Y. 1987b)

1) Lower Pleistocene deposits, although not easily observable, are identified on the 4th marine terrace of the eastern coastal area or its parallel river terrace deposits.

2) Middle Pleistocene deposits started to accumulate about 0.8 Mya, and the third marine terrace surface (the Wolseong Terrace) was also formed during this period. A similar pattern of river terrace surfaces is observed in the upstream channels of the inland area.

3) The Upper Pleistocene deposits began to accumulate about 125 Kya, and the second marine terrace surface (the Na-a Terrace) can be roughly correlated to this period. Owing to the erosion-dominant nature of the environment during the cold phase of the last glacial, the marine and/or fluvial deposits are not well-developed; but slopewash sediments (*e.g.* colluvium) originating from the erosion of adjacent mountain areas form the most common type of Upper Pleistocene deposits.

4) During the Upper Pleistocene, prominent surface features of soil wedges and/or dry cracks developed within deposits in almost all areas of the peninsula. These are believed to be the markers of cold and dry extremes. At least two horizons of such cracks are identified, which indicate repetitive climate deterioration to its maximum including the LGM.

B. Application of Lee's Model to the Inland River Terraces: a Critique

Lee's reconstruction of the development of marine terraces in the eastern coastal area and their correlation to the inland river terraces is still widely accepted among Korean archaeologists (*e.g.* Han 1996, 2004) because of its simplicity and seemingly powerful explicability. Nevertheless, despite these two advantages, the principal question still remains unanswered: what kind of archaeological implications can be extracted from his scheme? In fact, Lee's approach to the age and formation processes of marine terraces is very rudimentary and too clear-cut to be directly applied as an index for the chronology of the Korean Pleistocene archaeological record. Furthermore, his scheme of five sequential marine terraces is questionable as well because there is currently little surviving evidence in the Korean Peninsula, as old as the Lower Pleistocene (Yi 1989; 2000).

Recent developments in luminescence dating techniques have allowed new dates on marine terrace levels to be obtained. Also, this has enabled their diagenesis and formation processes to be based on more solid chronostratigraphy. Choi, J. H. *et al.* (2003a, 2003b) obtained several new OSL (see Choi J. H. *et al.*. 2004b for basic principles of the optically stimulated luminescence dating method) dates for the second terrace level (*ca* 73±6 to 48±8 Kya) and they also acquired the provisional age of the third terrace level (> 125 Kya, OIS 5e) based on the same method (Cheong *et al.* 2002).

Both cases produce much younger dates compared to Lee's scheme. Regarding this, Choi, J. H. *et al.* (2003b) argued that a tectonic uplift of over 40m higher than the global sea level occurred 50- 70 Kya B. P., roughly synchronous with the formation of the second terrace; and this global uplift is also illustrated at the coral terrace of the Huon Peninsula in Papua New Guinea (Chappell and Shackleton 1986). According to this, the five marine terrace steps in the eastern coastal area can be regarded as the products of a mixture of eustatic oscillations and tectonic movements. They are just one of a number of Pleistocene depositional facies, rather than the representative standard of Pleistocene environmental fluctuations in the Korean Peninsula.

Lee's generalization was also criticized by Yi (2000) for its over-simplification, and he regards it as too chronologically "macro-scaled" to be useful for archaeological application. For example, if Lee's scheme can be applied to the dating estimates of many archaeological sites discovered on the river terraces, the maximum that can be expected is that the river terraces were occupied by hominins "sometime" during the Pleistocene, and this means there is no time-scale on which archaeological horizons can be organized. The formation of inland river terraces includes various complicated processes according to the local topography and hydraulic system. In sum, it is safe to conclude that there exists neither direct affiliation nor causality between marine and river terrace developments, and that their chronological correlation should be attempted with caution.

3. Climate and the Biotic Components of the Environment

A. Current Climate of the Korean Peninsula

The climate of Korea is characterized by the mixture of continental and oceanic features with a wide range of mean temperature and annual precipitation. In general, the current climate of Korea is categorized as temperate under the Asian Monsoon system. But according to Köppen's empirical climatic classification (H. J. Kwon 1987), Korea has a cold climate with dry winter (Dw), a temperate climate with humid summer (Cfa), and a temperate climate with dry winter (Cw) zones respectively. In fact, certain parts of the peninsula have even a climate of high altitude (H, mostly in the eastern region of high altitude) and a subtropical climate (Afa, limited to the southernmost part of the peninsula and the Cheju Island).

During the winter season, the Siberian Air Mass directly hangs over the northernmost part of the peninsula and forms an extremely cold winter. The cold and dry continental northwest wind is persistent during the winter season and brings intermittent snow storm. During the summer season, the hot and humid tropical monsoon causes abrupt temperature elevation and enhances the saturation of the air. As a result, the number of rainy days per month peaks from June to August, and alteration of dry and humid days is closely related to the intensity of solar heat. Especially, at the micro-climate level, the Korean Peninsula is highly affected by topographic features and local wind such that the temperature and precipitation in two areas with the same latitude can differ tremendously from each other (Kwon, H. J. 1987).

B. Vegetation and Floral Species Distribution

The vegetation pattern of the Korean peninsula is multi-facetted and micro-patched resulting in a high diversity of dominant species. In general, the distribution of forest corresponds to the contour of the annual temperature, which partly reflects topographical altitude (Fig. 2.9.). While some subtropical and arctic forests are distributed around its two southern and northern extremes respectively, most of the Korean Peninsula is covered by mixed forest with a slight dominance of cold-climate-favoring species such as *Pinus densiflora* (small pine), *Pinus koraiensis* (Korean pine), and *Abies holophylla* (fir). Some deciduous species such as *Acer palmatum* (maple), *Fraxinus rhynchophylla Hance* (ash tree) and *Ginkgo biloba* (maidenhair tree) are also found all over the peninsula but these kinds of species are not indicative of specific climatic habitats.

Non-arboreal plants are very diversified and usually cannot be identified at the species level. Most frequent genera are *Urtica* (nettle) *Chenopodiaceae* (goosefoot), *Bistorta vulgaris* (bistort), *Gramineae* (grasses), *Trapa* (water chestnut), *Compositae* (wild chrysanthemum), *Umbelliferae* (dropwort) and so on. These non-arboreal plants are also identified within the forest environment mixed with other dominant arboreal species and distributed in small-scale clusters.

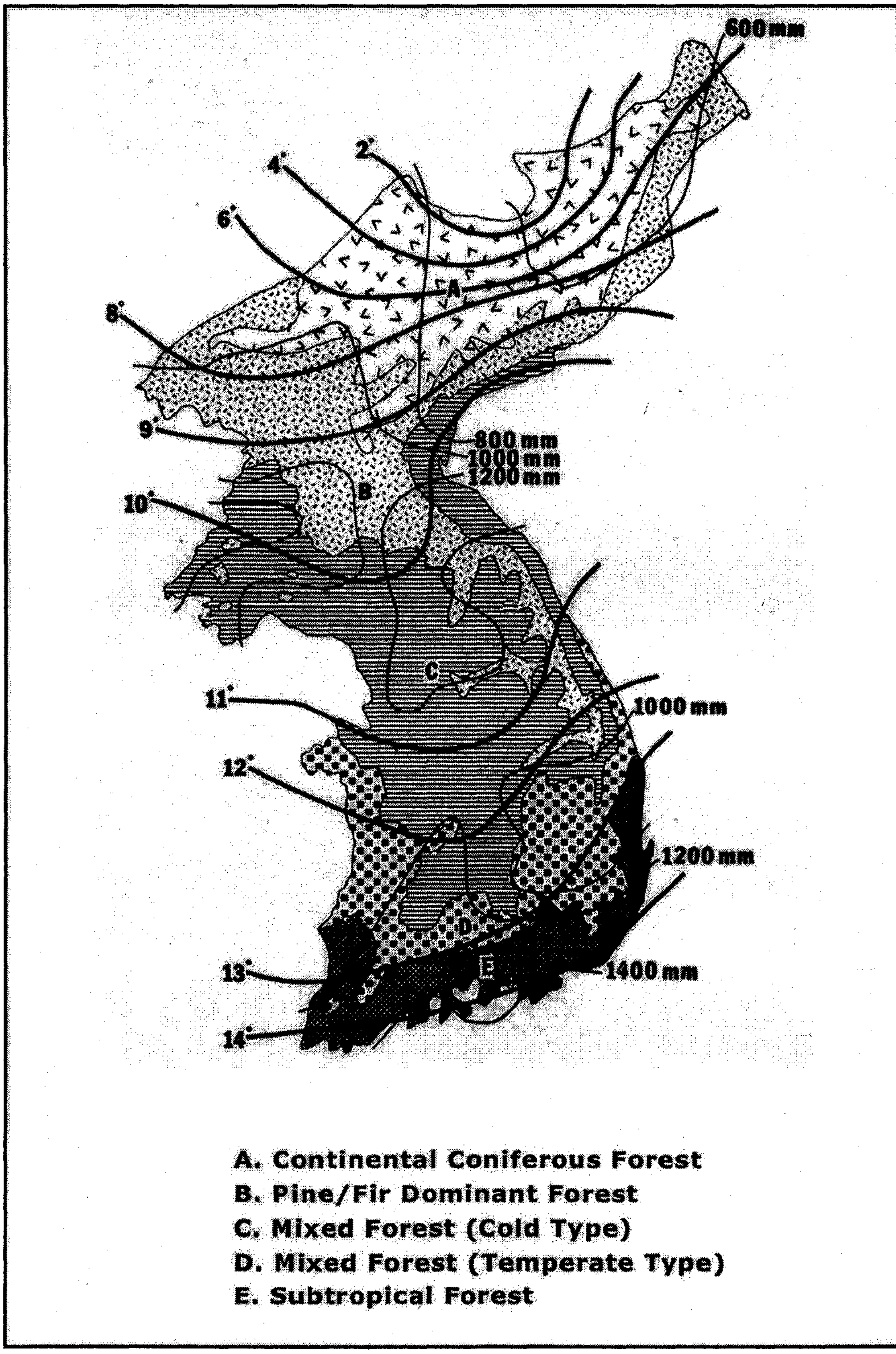


Fig. 2.9. Annual Temperature, Precipitation and Forest Zones of Korea (Re-drawn from Yi 1989:113)

Among these plants, edible resources are quite limited and their dominance did not occur until the Holocene, as recently as 2.3 Kya, which is almost contemporary with the emergence of agriculture in Korea (Yoon *et al.* 2005). It is, therefore, necessary to be cautious about the reconstruction of the palaeoclimate based on the pollen data. Some species which still prevail in Korea tend to indicate just their symbiotic succession rather than the changes in the regional climate.

C. Faunal Species and Distribution

Korea can be divided into two regions with repect to animal species distribution (Bae 1988). The northeastern part of the peninsula is characterized by species such as *Cervus elaphus* (red deer), *Capreolus capreolus* (roe deer), *Panthera tigris altaica* (Siberian tiger), *Naemorhedus goral raddeanus* (Tibetan heude), *Martes flavigula koreana* (Asian marten), and *Cervus nippon kortulorum* (Japanaese deer). These species are also present in northern Manchuria and northeastern Japan, and are generally regarded as species favoring colder climates. The rest of the peninsula has the *Talpa micrura coreana* (Korean mole), *Lepus sinensis coreanus* (Continental hare), *Canis lupus* (timberwolf), *Vulpes vulpes peculiosa* (wild fox), *Selenarotos thibetanus ussuricus* (Manchurian black bear), *Meles meles melanogenys* (Korean Badger), *Felis silvestris* (Asian wildcat), etc. These species are also common in northern China and Japan while some species are migratory and have no fixed habitats.

Pleistocene faunal remains are very scarce in Korea, and most of them have been discovered under special depositional condition such as in caves and rock shelters. Some extinct species, such as *Equus sangwonensis* (Sanwon horse), *Elephantidae sp.* (Elephant), *Bos primigenius* (aurochs), *Megaloceros flabelatus Teihard et Pei* (North Chinese giant deer), and *Panthera spelara Goldfuss* (Cave lion), have been found in the Middle Pleistocene layers of cave sites in North Korea. The Upper Pleistocene faunal remains have also been identified in caves of North Korea and in the lime stone area in the central part of South Korea. They include some extinct species as well: *Bos primigenius Bojanus* (Bojan Aurochs), *Mammuthus primigenius Blumbach* (Mammoth), *Canis lupus* (wolf), *Sus scrofa* (wild boar), *Felis lynx* (wildcat) and so on. (Bae 1988; Sohn 1990).

Family	Species	Common Name	M. P.	M-U. P.	U. P.
Primates	*Homo Sp.*	Hominin		*	*
	Macaca sp.	Macaca	*		
Carnivora	*Nyctereutes procynoides*	Racoon dog		*	*
	Vulpus vulpes	Fox		*	*
	Ursus spelaeus	Cave bear	*	*	*
	Ursus arctos	Brown Bear	*	*	*
	Lutra lutra	Otter		*	*
	Meles meles	Badger	*		
	Mustela sibricus	Polecat		*	
	Hyaena sp.	Hyaena		*	*
	Crocuta ultima	Spotted hyaena			
	Panthera tigris	Tiger	*	*	*
	Pantera pardus	Snow leopard		*	*
	Pantera spelara	Cave lion		*	
Proboscidea	*Elephantidae sp.*	Elephant	*	*	*
Perissodactyla	*Dicerorhinus kichbergensis*	Wooly rhinoceros	*	*	
	Coelodonta antiquitatis	Wooly rhinoceros		*	*
	Equus sp.	Horse		*	*
	Equus sangwonensis	Sangwon horse	*		
	Equus caballus	Dokchon horse		*	*
Artiodactyla	*Sus scrofra*	Wild boar	*	*	
	Megaloceros sp.	Giant deer		*	

Megaloceros sangwonensis	Sangwon deer	*		
Pseudaxis grayi	Silka deer	*		*
Cervus sp.	Deer			*
Cervus elephus	Red deer	*	*	*
Cervus nippon	Japanese deer		*	
Capreolus capreolus	Roe deer		*	*
Ovis cd. Ammon	Mountain sheep		*	*
Bos primigenius	Aurochs	*	*	*
Bison priscus	Bison		*	*
Bubalus sp.	Water buffalo	*	*	

Table 2.2. Mammalian fossils discovered in Korea (M. P. - Middle Pleistocene, M.U. P.- Middle to Upper Pleistocene, U. P. – Upper Pleistocene, from Norton 2000: 74)

Because of highly acidic sediments, faunal remains are not found in association with Palaeolithic artifacts in most cases; and the few have shown evidences of animal resource utilization made by hominin (H. S. Kwon 1996, 1998). Although some bones from several cave sites reportedly display formal modification as "tools" (Sohn 1992), serious taphonomic attention has yet to be paid to this so that the evidence supporting both the claim of bone tools and hunting/butchering is still controversial. In regard to this problem, several authors argue that understanding the Pleistocene faunal remains of Korea is still far from being achieved (*e.g.* Bae 1992; Clark 1982; Norton 2000; Yoo 1997).

4. Hominin Fossil Evidence and Research

A. Nationalistic Biases in Korean Paleoanthropological Research

Since direct evidence of hominin occupation is dependent on the discovery of fossils, their anatomical features and associated archaeological assemblages have been in the key scope of many researchers in Korea. From the mid 70s, North Korea and South Korea have independently conducted archaeological and geological researches in cave sites and rock shelters. However, due to political conflict and competitive nationalism (*see* Trigger 1989, 1995) under the Cold War doctrine, palaeoanthropological studies in both parts of Korea have been biased toward their respective ideological orientations.

Nevertheless, common themes are evident: each "land" has been occupied by the "ancestors" of their own "people" in a single lineage from "a very remote period indeed." Accordingly, the ultimate goal of palaeoanthropology in both regions has been to demonstrate temporal depth in their own national history; fossil records and archaeological evidence of "oldness" have been proxy for the nationalistic protocols on the part of each region. What is nothing but disappointing is the fact that this kind of research style has always been the vehicle of hyper-patriotism and/or anti-colonialism (*see* Trigger 1995), especially in North Korea.

In retrospect, this fervor for entrenching national history in time represents an emotional counteraction against the tattered history of relations between the two countries from the second half of the twentieth century to the present, as well as the political struggle for ensuring their own political land tenure. Whatever the reason may be (*see* Pai 1994 for other perspectives), a dispassionate scientific approach to the palaeoanthropological record has been hindered for the time being and numerous squabbles rather than reasoned debates have occurred. Recent years have witnessed some encouraging endeavors to overcome this research obstacle. New dates and more balanced interpretations of the fossil records have been obtained, and some comprehensive and critical studies on the fossil records have been published (*e.g.* Chung 1996; Norton 2000; Park, S. J. and E. J. Lee 2002).

B. Identified Genus Homo- Fossils in Korea

Location	Age (est.)	Parts	Species
Yokpori	M./U. Pleistocene	Frontal, occipital, parietal	H. erectus (?)
Soongnisan	M./U. Pleistocene	Two molars, scapula, mandible	Archaeic H. sapiens
Ryonggok Cave	Layer 9 (46- 48 Kya by U-series dating)	Cranium (No.7), mandibles (No.1, 2, 6)	Modern H. sapiens (?)
Ryonggok Cave	Layer 10	Cranium (No.3), mandibles (No. 4, 6) femur	Modern H. sapiens (?)
Ryonggok Cave	Layer 11	Temporal, frontal, mandible (fr.), 3 humerus (fr.), 8 vertebrae, 3 innominate, 2 femur (fr.)	Modern H. sapiens
Ryonggok Cave	Layer 12	Maxilla (No. 8)	Modern H. sapiens
Mandalri	Upper Pleistocene	Calvaria, mandible (fr.), humerus, femur, innominate	Modern H. sapiens
Kumchon	30 Kya	Mandible, inciser, axial (fr.)	Modern H. sapiens
Hwadae	0.3 Mya (?)	Skeletal (fr.)	Archaeic H. sapiens (?)
Chommal Cave	40- 60 Kya	Phalanx, metatarsal	Modern H. sapiens
Sangsiri	30 Kya	Left parietal, occipital (fr.), radius, right scapula, right humerus, teeth	Modern H. Sapiens
Kunang Cave	Upper Pleistocene	Talus, metatarsal, phalanx	Modern H. sapiens
Heungsu Cave at Turubong	40- 50 Kya	Nearly complete single juvenile individual	Modern H. sapiens

Table 2.3. Hominin fossils discovered in Korea
(From Norton 2000: 74; Park, S. J. and Lee, E. J. 2003: 42)

Hominin fossils are usually discovered in the same context as other faunal remains. Until now, eight cave sites, one rock shelter and one open-air site have yielded hominin fossils. Five of those eight cave sites (Yokpori, Soongnisan, Ryonggok Cave, Mandalri, and Kumchon) and one open site (Hwadae) are located in North Korea, while the remaining cave sites (Chommal Cave, Kunang Cave, and Heungsu Cave at Turubong) and the one rock shelter site (Sangsiri) are located in the limestone area of central South Korea. Except for an almost complete skeleton of a single individual from the Heungsu Cave site, the rest of the hominin fossils are mostly composed of fragments of various body parts (Table 2.3.)

It is notable that, other than unconfirmed data from Hwadae site, most of hominin fossils are archaic *Homo sapiens* and/or modern *sapiens*. Two skulls and post-cranial bones discovered from Ryongok Cave, originally reported to be *Homo erectus*, have now been re-interpreted as being anatomically modern humans based on their prominent modern-looking general morphology and the dimensions of the crania (Chung 1996; Park, S. J. and E. J. Lee 2003). While three cranial fragments from the Yokpori Cave are arguably regarded as being in the category of more archaic species (*i.e.* possibly *Homo erectus*; Norton 2000: 818), it is still controversial to conclude that the Korean Peninsula was inhabited by hominins older than the archaic *Homo sapiens*.

C. Associated Archaeological Evidence

Archaeological assemblages are rarely associated with hominin fossils. In fact, only one hominin fossil from Mandalri (Kim, S. K. *et al.* 1985; quoted from Han 1990: 380- 9) was discovered in primary context associated with artifacts, there being thirteen lithic specimens made of quartzite and obsidian, most of which are examples of microblade cores, representative of an Upper or terminal Palaeolithic technology (Fig. 2.10.). In addition, a fluted antler shaft and a partly ground antler spatula, which seems to have been used as a stone knapping implement, were discovered. However, since the provenience of these tools is not well-documented, the contemporaneity between them and hominin fossils (modern *sapiens*) is not fully guaranteed.

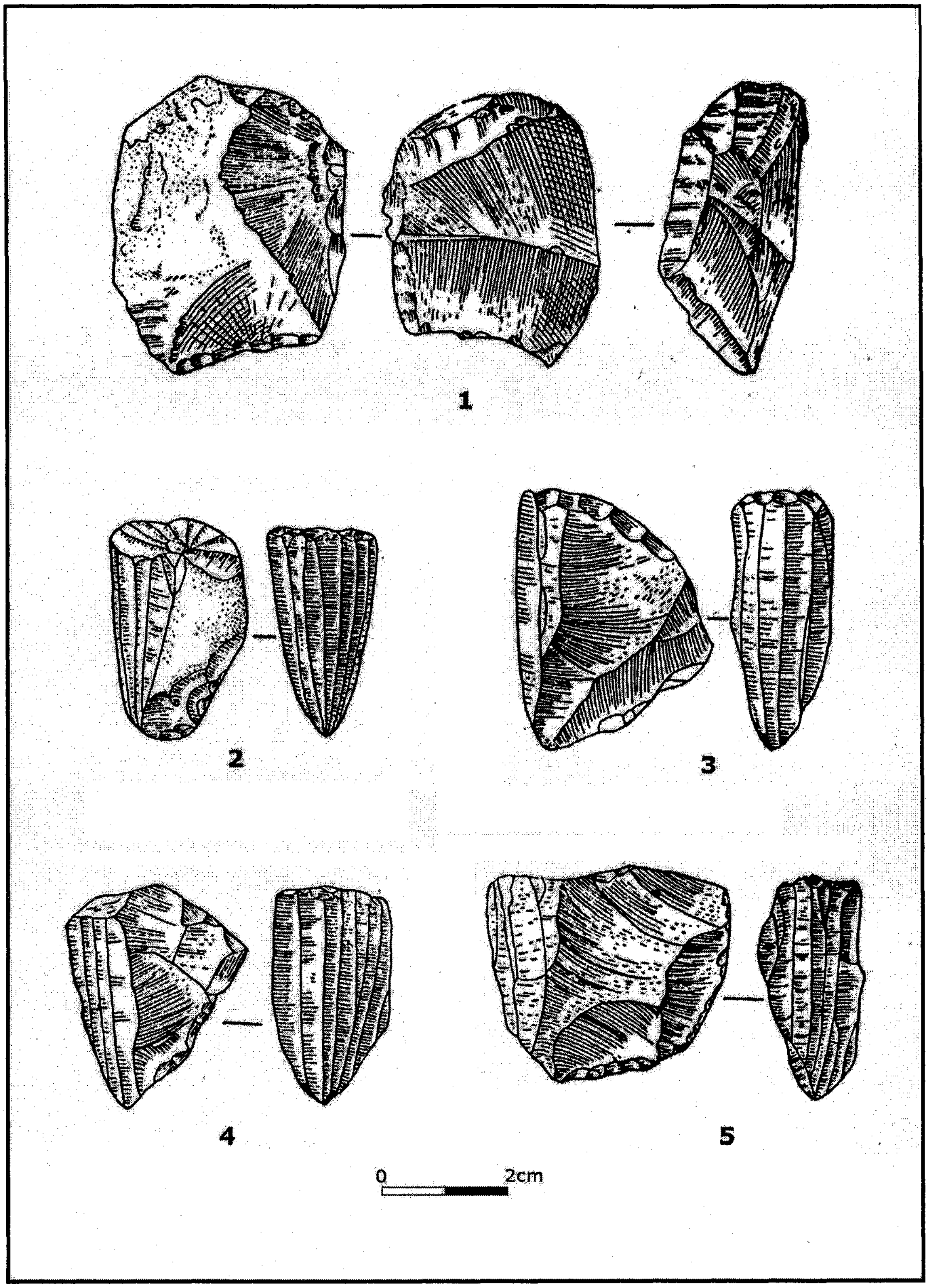


Fig. 2.10. Microcores retrieved from Mandalri Site, Pyongyang, North Korea (From Han 1990: 383)

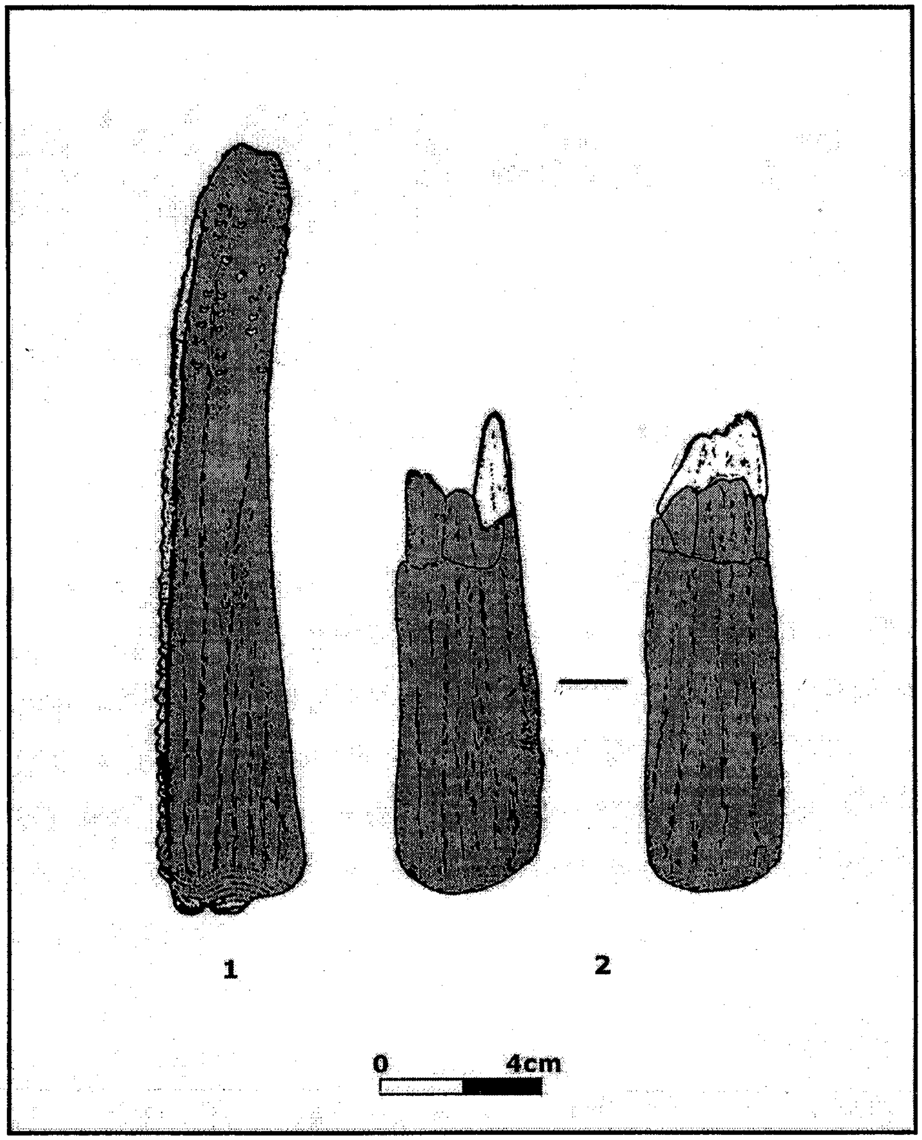


Fig. 2.11. Two Antler tools from Mandalri, Pyongyang, North Korea (From Han 1990: 384)

D. Reconstruction of Hominin Activity

A preliminary study on the reconstruction of hominin social activity has been recently published. Park, S. J. and E. J. Lee (2003) have calculated the physical stress load on the hominins from the Sangsi site and the Ryonggok Cave based on the dimensions of scapulas and femurs. Using Collier's (1989) classificatory scheme of physical load among several social groups, the robusticity of modern sapiens from these two sites have been estimated to be equal to that of the highly mobile modern Australian hunter-gatherers, as classed under Binford's forager model (Binford 1980).

It is, however, still questionable that hominins of the Sangsi site and the Ryonggok Cave had the same level of activity load as that of current Australian hunter-gatherers, and it may be misleading to claim that they had a similar land-use pattern to that of idealized foragers having "high residential mobility, low-bulk inputs, and regular daily food-procurement strategies (Binford 1980: 11)." Collier's classification of physical robusticity of individuals is simply based on the ratio of diameter/length of limb bones, and it is entirely drawn from the empirical statistics of six modern and extinct social groups. The Australian hunter-gatherer marks the lowest value of physical load among the six groups. Thus, the similarity in the robusticity index of limb bones cannot simply indicate similarity in the intensity of physical activity stress. This is likely the result of the similar levels of nutritional disadvantage or of the phenotypes which have similar level of physical capacity.

(4) Summary

Korean Quaternary research has still many serious questions to examine and resolve. The evidence assembled and discussed so far can be summarized as follows.

1) The physical geography of the Korean peninsula is characterized as having a very complex topography. It was formed by several large-scale geological events before the Pleistocene.

2) The archaeological sites are distributed in similar areas of modern occupants, usually in the lower regions of the mountains such as in the basins of valleys. It is also contingent upon

the local topography and the channel system.

3) One of most common Pleistocene geomorphological features associated with site location is the system of river terraces. The formation of terrace deposits is affected by various agencies such as fluvial, colluvial, and eolian actions.

4) Faunal and floral data should be interpreted at the species level, when possible, since the biological zonation of the Korean peninsula is very diversified and patchy. The broad range of cold to warm temperature and the well-established seasonality of the region are two critical factors governing resource availability.

5) Unequivocal evidence of hominin utilization of animal resources is yet to be substantiated. Due to extremely poor preservation, well-associated assemblages with faunal remains are hard to come across in Korea.

6) Hominin occupation in the Korean peninsula is believed to have been initiated in the later part of the Middle Pleistocene, considering the oldest age of fossil records discovered to date. As in the case of faunal remains, association between hominin fossils and lithic assemblages is very limited and their provenience is rarely guaranteed.

Based on this background of the Pleistocene environment of both East Asia and Korea covered in this chapter, it is necessary to elaborate at some length on the current research in the fieldwork area. The next chapter will cover the geographical and geological features of the IHRA as well as present a detailed research history of this area.

III. GEOLOGICAL FEATURES AND RESEARCH HISTORY OF THE IHRA

(1) Introduction

From the first discovery of archaeological evidence in the late 1970s, considerable effort has been exerted to explain the development of the geomorphological features of the IHRA and numerous chronometric dates have been published. In truth, however, the current status of the knowledge on the chronostratigraphy and the overall geological processes is far from complete compared to the amount of available data. What is still problematic regarding this is that contentious issues are still liable to emerge in the course of vigorous discussions, and that methodological limitations are always imposed upon individual research designs.

In this sense, it is of utmost importance to put in order some major issues and critical data; and to trace the development of debates among researchers in the context of the changes in the archaeological paradigms in Korea. This chapter outlines the geographical and geological background of the IHRA and reviews the research history on the age and formation processes of the archaeological record. First, in order to understand the geological processes and the formation of the stratigraphic sequence, the location and landscape of the IHRA will be introduced and the general features of the geological activities will be presented. The later parts of this chapter will overview the results of previous geological and archaeological research during the last three decades and evaluate various issues concerning the formation of the IHRA assemblages with special emphasis on the age determination problem of the artifact horizons.

(2) Landscape and Terrain of the IHRA

1. Geographical Location

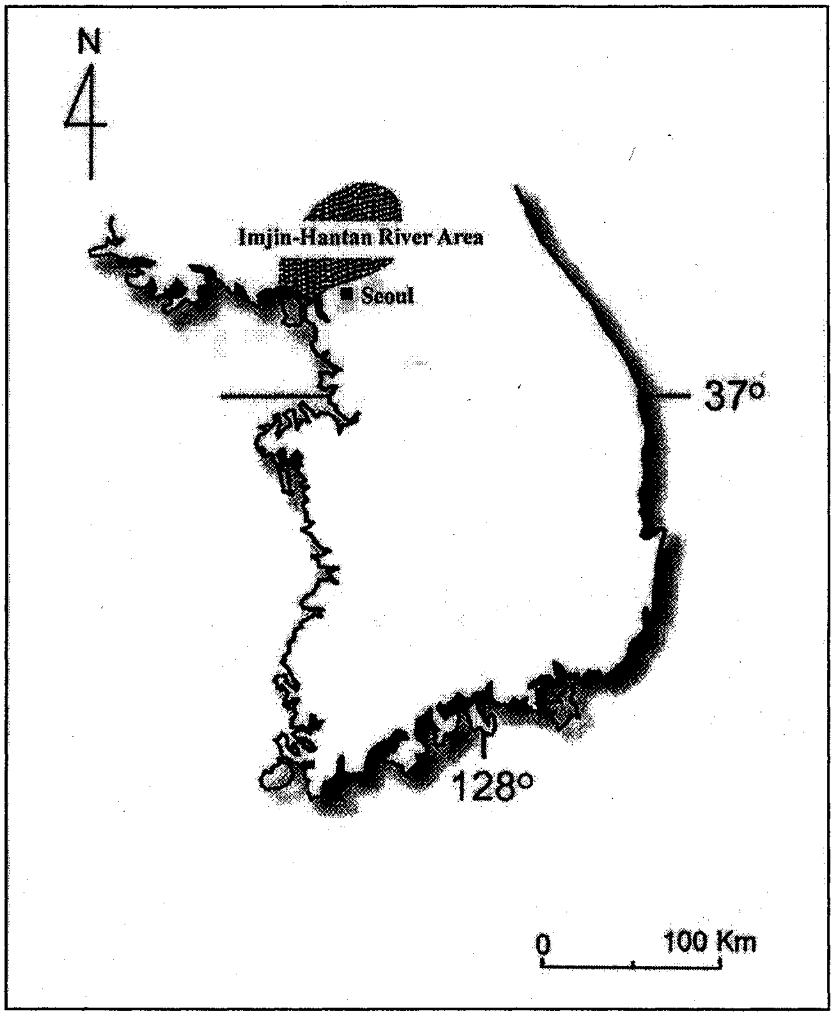


Fig. 3.1. Location and range of the IHRA

A. Area Range

The IHRA is located in the west-central part of the Korean Peninsula (Fig. 3.1.), from approximately 37° 35' to 38° 15'latitude, and from approximately 126° 30' to 127° 20'longitude. It is situated in the Kyunggi Craton Zone (F of Fig. 2.5. in Ch. II) which is composed of erosion-dominant facies. This zone was subjected to a process of gradual lowering of the landmass during the Pleistocene. The IHRA straddles the De-Militarized Zone (DMZ) between North and South Korea, and lies largely in the district of Kyunggi Province, with some part of Kangwon Province to the east. The major cities and counties in this area include Dongducheon City, Paju City, Yeoncheon County, Pocheon County, and Cheolwon County.

B. Configuration of Major Channel System

The Imjin River, the largest fluvial channel of this area, runs through the IHRA from the southernmost part of North Korea. The Hantan River, one of the largest tributaries of the Imjin River, originates in the northeastern part of the IHRA near Cheolwon County and merges with the Imjin River near its center (Fig. 3.2.). These two river channels form the main fluvial drainage system within the area, and are the principal agents responsible for the current landscape of the IHRA.

In addition to these two major channels, several trough streams originating from surrounding hills drain into this main channel. For example, there are the Yeongpyong Stream flowing through the southeastern part at Pocheon City, the Chatan Stream from the northern part of Yeoncheon County, and the Shin Stream following through the southwestern part at Paju City. Bartz (1972: 22- 4) has divided the Korean Peninsula into 14 physiographic regions based on the landscape and principal geomorphological features. She observed an exceptionally depressed geomorphological feature in the midwestern part of the Korean Peninsula and includes the IHRA in the "Imjin River Basin" region because its general terrain is erosional, and formed between the faulted scarp and the tilted land block. This basin is located in the southwestern part of the Chugaryong Rift Valley which crosses the Korean

Peninsula from the northwest of Seoul to Wonsan City on the eastern coast (Fig. 3.3.).

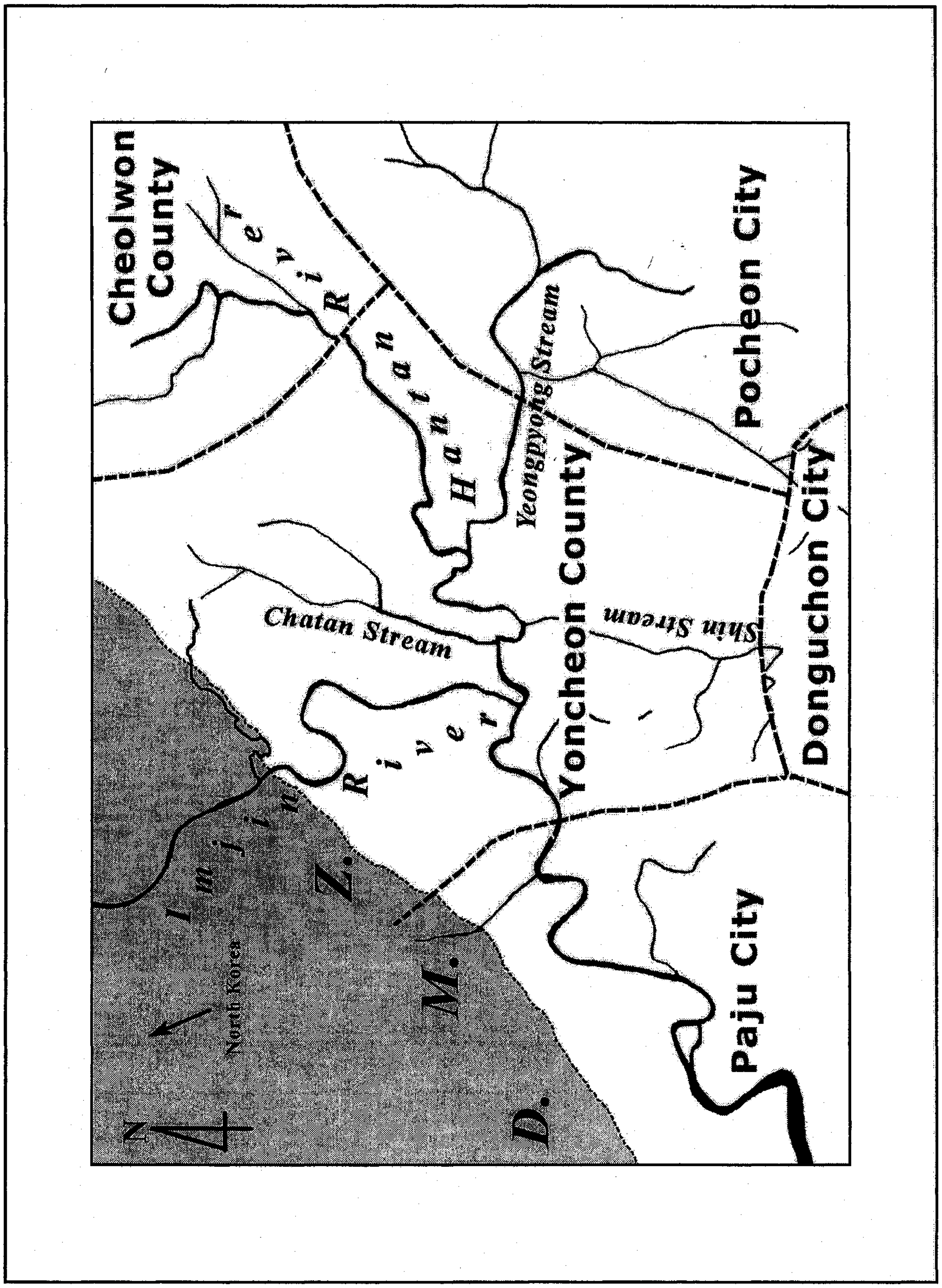


Fig. 3.2. Fluvial channel system and geographical configuration of the IHRA

2. The Landscape of the Chugaryong Rift Valley

A. The Chugaryong Rift Valley

The Chugaryong Rift Valley (the CRV hereafter) is a narrow corridor resulting from tectonic movement. It trends *ca* 15° northeast (Wee 1996: 171), and measures 5- 6km in width (Kim, K. H. and Song 1995). Since Koto's (1903) preliminary fieldwork in the early 20th century, no comprehensive research on the CRV has been undertaken because of its unique position traversing the border between North and South Korea. However, some observations (*e.g.* Lee D. S. *et al.* 1983; Lee K. H. *et al.* 1987; Wee 1996) suggest the CRV is the result of geotectonic rupturing on the Kyunggi Massif during the post-Jurassic Daebo Orogeny.

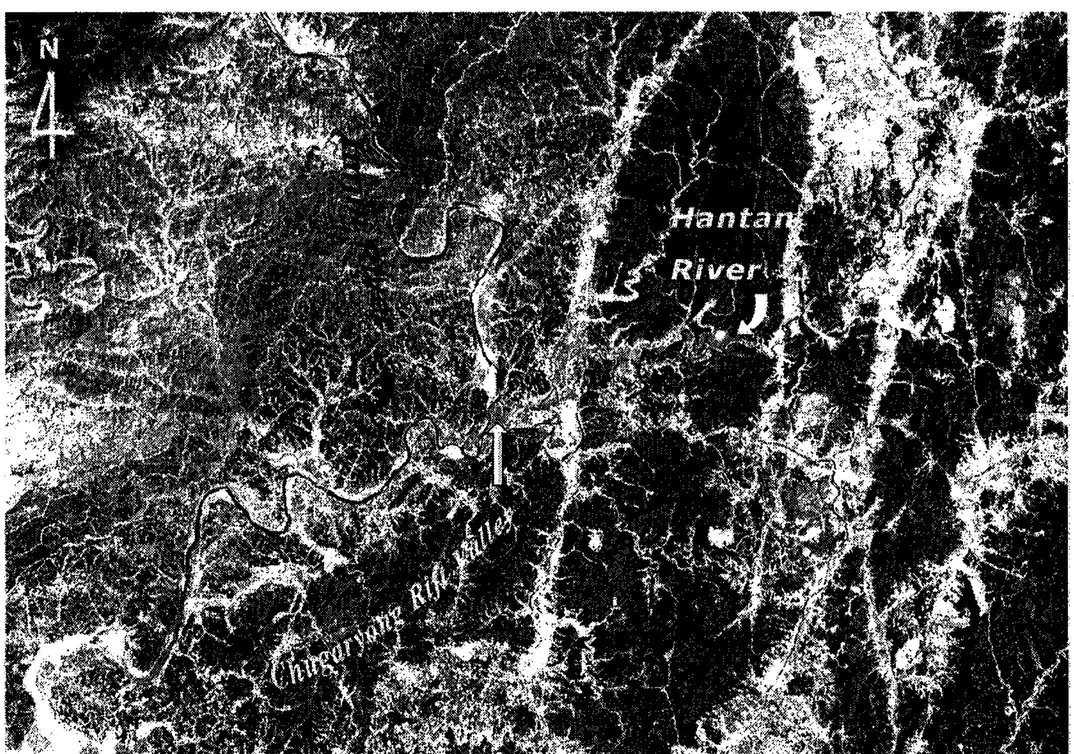


Fig. 3.3. Satellite image of the Chugaryong Rift Valley and main river channel system (Digitally compiled from *http://earth.google.com*)

B. General Stratigraphy of the CRV

The lower stratigraphic unit of the CRV is composed of Precambrian banded gneiss, partly intruded by gabbros around 1000 Mya (Kim K. H. and H. J. Lee 1994). Above this Precambrian bedrock is a series of gravel and sand layers (Fig. 3.4.), which comprises the *Baekeuri Formation*. The Baekeuri Formation consists primarily of quartzite, gneiss and granite, all of which originated from the Precambrian bedrock below (Bae 1988). Based on the particle size and the origin of its composition, the Baekeuri Formation is believed to have been formed by erosion of strongly flowing streams, especially in the midstream area of the Hantan River.

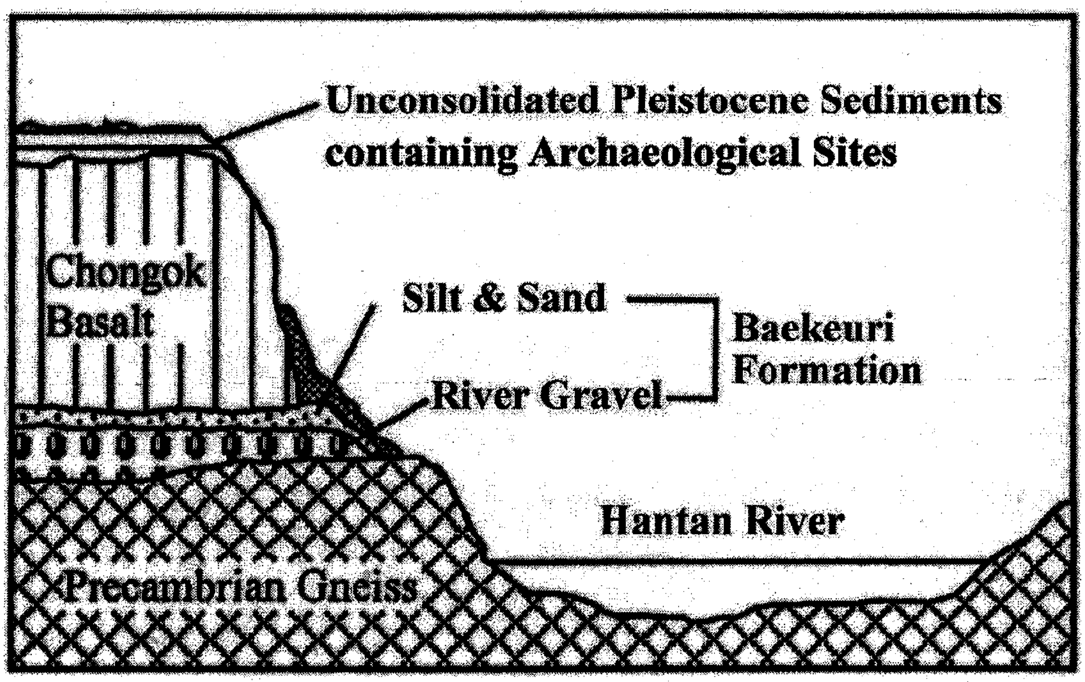


Fig. 3.4. An exemplary cross-section of the CRV
(Near Chongokni, re-drawn from Bae 1988)

The large valley of the CRV was filled with several lava flows that are dated from Late Cretaceous to the later part of Middle Pleistocene (Lee D. S. *et al.* 1983). These created a thick formation of basalt (the Chongok Basalt, Fig. 3.4.). The Chongok Basalt is usually found overlying the Baekeuri Formation and its thickness is about 10 to 20m. It has a well-developed structure of columnar joint indicating rapid cooling and evaporation. The horizontal "clinkers" which show a porous structure and a weathered part (Bae 1988) with thin filling of clastic sediments can be used as a demarcating joint for discriminating individual lava flows from each other. The number of lava flows is estimated to be more than three and, possibly, up to as many as eleven (Lee D. S. *et al.* 1983).

C. Volcanic Activity in the CRV

Several volcanic outlets are distributed along the fault line of the CRV. The *Ap* Mountain, located *ca* 3km south from Pyonggang County, and another volcanic mountain near the Gumbullang Station of northern Kangwon Province are two candidates for the direct origin of the Chongok Basalt (Lee, D. S. *et al.* 1983: 30) based on the similarity of alkaline olivine components within the basalt rock formation. It is believed that the configuration of a lava flow is almost identical to that of a hydraulic flow because the lava flows follow the narrow trough gutters distributed in the CRV, in the same way as stream water follows the fluvial channels.

However, even though lava flows covered much of the CRV, their maximum stretch did not reach within the downstream or the far-upstream area of the Imjin River, the two opposite extremities of the total channel system. In these marginal areas, stepwise river terraces formed by uninterrupted fluvial actions survived and the slope-wash deposits from surrounding hillsides were accumulated (Yi 1996). For example, the "Jangsanri Terrace," (Yi 2004a) which is located in the downstream part of the Imjin River, was formed before the volcanic eruption and the outcrops do not contain any signature of direct volcanic activity (Yi

1996, 2004b; Yi, Y. I. Lee, and J. W. Kim 2004).

3. Geological Sequence after the Volcanic Eruption

A. Temporal Suspension of Channel Flows

After the volcanic eruption, the lava flow was abruptly cooled by land drainage water and this produced an uneven lava floor along the original river channel trajectories. When the cooling process was terminated, the basalt bedrock became a "lava dam." The deposits formed behind this dam area are mainly composed of very fine, water-logged clay sediments with the characteristics of lacustrine layers (Lee, M. B. *et al.* 2001; Yi 1989). This clay sediment made by the "palaeolake" is observed in the small trough channels such as the Chatan (Lee M. B. *et al.* 2001) and the Yeongpyong Stream (Yi 1989) where discharging energy of suspended water flow is nearly zero (Fig. 3.5.).

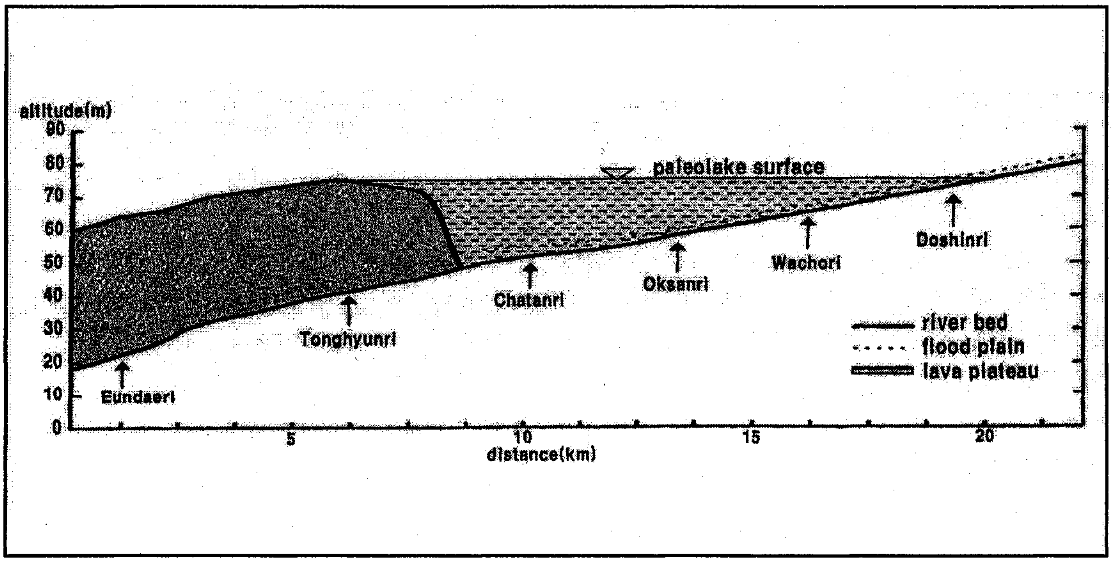


Fig. 3.5. Longitudinal profile of the Chatan Stream with heights of floodplain and palaeolake surface from present river bed (From Lee, M. B. *et al.* 2001: 362)

In contrast, the large main channel of the Imjin and Hantan River has survived in the form of a divergent multi-channel system with reduced discharge capacity that accelerated its flow velocity. As individual channels were enlarged by the cutting of the stream bed, small divergent flows continually converged and the multi-channel system gradually developed into a large stabilized channel, thereby finally recovering the energy level of the original flow before the sequence of the volcanic eruptions.

B. Rejuvenation of Channel Action and Formation of Archaeological Assemblages

Most of the archaeological horizons are distributed within the silty clay layers above the lava flow and these post-volcanic deposits were accumulated by the fluvial action of the rejuvenated Imjin and Hantan River. When the river flow was fully recovered, this cut down through the river bed and finally exposed a vertically fluted basalt cliff. During down-cutting of the river bed, the silt-clay deposits were continually accumulated at the channel margins and formed a thick layer of floodplain sediments near the current river channel. Since the volcanic eruptions had entirely terminated, this floodplain area became an ideal place for hominin occupation.

C. Problematics in the Chronology of the IHRA

The majority of the archaeological horizons is distributed within the upper part of floodplain sediments, the reddish brown silty clay layer, which forms generally a 4-7m thick stratum on top of the basalt bedrock. The age of the archaeological horizon is usually established by estimating the initial date of the reddish brown silty clay layer; and this age estimation is determined by the calculation of the elapsed time since the terminal lava flow constituted the top of the basalt bedrock, which is roughly synchronous with the duration of channel rejuvenation.

In sum, the chronological framework of the IHRA is largely based on the timeline of the fluvial actions in the CRV. Therefore, as a first step, it is important to ensure that dating of the archaeological assemblages be based upon good geological chronometric data as well as an adequate general reconstruction of the CRV terrain. Due to the lack of direct referent dates, however, the reliability of the dating of the IHRA assemblage is still controversial and any explanation on its formation processes can be regarded as only tentative. It would not be inaccurate to assert that the age determination of the IHRA archaeological horizon is very much contingent upon the proxy data, and that a valid approximate date is extremely hard to establish.

Since the discovery of the Chongokni site, the IHRA has been central in a vigorous debate among local archaeologists as well as with foreign researchers. Sometimes these debates have been emotional; often methodological pitfalls have marred the understanding of the "archaeological facts." Therefore, before discussing the chronology of the IHRA assemblages, it might be useful to briefly review the research history and the development of the relevant discussions.

(3) Research History of the IHRA: Issues and Debates

The research history of the IHRA can be divided into three periods: the Formative, the Competitive, and the Integrative Periods, based on the major issues, research trends, and technical methods. The initial time set of this research history can be designated as the first excavation of the Chongokni site in 1979.

1. Formative Period (1979- 1989): the "*Age of the Innocence*"

A. The Incipient Phase of the Korean Palaeolithic Research

The discovery of the Chongokni site boosted public attention and produced a strategy-based archaeological research style among Korean archaeologists. Before Chongokni, the study of the Palaeolithic period in Korea was directed toward the reconstruction of Palaeolithic "culture." The notion of culture used at this time, however, had no archaeological significance. For archaeology, a culture is specific to a given spatial and temporal unit and is focused on describing the material content of the assemblage left by the past people who produced and used it (*see* Trigger 1989). Indeed, the term was originally used merely to identify and associate the archaeological evidence with assumed human activities. Such terms as "Palaeolithic culture" and "cultural originality" gained currency among researchers without any serious concern for significance in understanding cultures. It was this academic milieu that set Korean archaeology toward simple identification and classification of "impressive" artifacts.

However, as a result of finding a possible handaxe at the Chongokni site (Bowen 1978), the research of the IHRA made a breakthrough. Up until then, local archaeologists tended toward interpreting the archaeological data in a hyper-romantic style. This style was prevalent in Korean archaeology, often exacerbated "by the idiosyncratic understanding and personalities of individual archaeologists" (Trigger 1995: 266). They tended to generate "fancy stories" (*e.g.* Sohn 1972; Lee, Y. J. 1976, 1982) from the finding of some artifacts, creating "fairy tales" (*e.g.* Sohn 1973; Lee Y. J. 1979) about the mental ability of hominins who performed "sagas" (*e.g.* Lee Y. J. 1983) of hunting and butchering. It is, therefore, not an exaggeration to state that scientific forms of analytical methodology and inter-disciplinary research did not emerge in Korean Palaeolithic archaeology until the research at the Chongokni site was initiated in 1979. In this sense, the first period of the IHRA research history can be entitled as the "Age of Innocence." Korean archaeology has now started on a new road by explaining the factual evidence based on the scientific approach.

B. First Excavation of Chongokni and its Results

The Chongokni site was first excavated in 1979 and five additional excavation sessions followed afterward until 1982 (Bae 2002). At the time of first discovery, the Acheulian-like handaxe was a huge issue and somewhat exaggerated as conclusive counter-evidence against the Movius' hypothesis (1944) and this led to an unfounded age estimation of 0.3 Mya simply based on its similarity to that of the classic Acheulian industry (Kim, W. Y. and Chung 1979). J. D. Clark (1982), however, remarked that it was "similar to Sangoan of Africa, but less sophisticated."

The first report of six excavation sessions (Kim, W. Y. and Bae 1983) was published in 1983. It includes the important background research findings such as a geological analysis of the site area (Park D. W. 1983), pollen analysis (Chang 1983), regional survey and identification of other adjacent sites. The estimated age (younger than 0.27 Mya, Kojima 1983: 587) of Chongokni is based on the K-Ar date of the basalt bedrock (0.108±0.158 Mya, *ibid*: 587). In addition to this, Yi and Clark (1983) published a seminal work criticizing Movius' opinion of the East Asian Lower Palaeolithic and its implication for hominin "cultural retardation" (Movius 1949: 411).

C. Initial Debate between Yi and Bae

However, Yi (1986, 1989) later gave up the idea that the Chongokni and other IHRA archaeological assemblages are typical Lower Palaeolithic types. Yi's macro-scaled regional study, based on the strict "actualistic" approach and schematic framework of Asian Pleistocene chronostratigraphy, reconstructed the process of geomorphological development and systematically demonstrated the overall sedimentary environment of IHRA deposits.

He hypothesized (1989: 143- 58) that, after a lava dam blocked the entire drainage system, a thick deposit of lacustrine layer accumulated until the suspended river channel was finally breached and the river flow resumed. He also postulated that the time between the suspension and rejuvenation of channel flow was quite long, and that the earliest date of the fluvial deposit can be estimated from the date of the lacustrine layers. A TL date of 45.4±5 Kya (Yi 1989: 148) was acquired from the thick stratum of grayish lake deposit located near the Youngpyong Stream, suggesting that the Chongokni assemblage was formed during the cold phase of Upper Pleistocene (OIS 4). If valid, Yi's hypothesis on the geological processes of the IHRA and the age of fluvial deposit entails that hominin occupation did not occur until the Upper Pleistocene. His argument has generated a debate over the correlation of the technological level of the lithic assemblage with its actual age.

Around this time, Bae (1988) presented another perspective on the formation process of the Chongokni assemblage. Unlike Yi's approach, he took a localized rather than a regionalized perspective and focused on the site area of the Chongokni site relying on the empirical data emerging out of his full-scale excavation work starting in 1979. Bae's (1988) assumption is that there was no serious time-gap between suspension and rejuvenation of the Hantan River, and that the lacustrine sediments around the lava dam were not universally distributed in the main channel stream area. Therefore, he did not accept Yi's hypothesis on the development of a full-scaled lava dam. He added that the fluvial deposit, the reddish brown silty clay layer which contains the archaeological horizons, began its accumulation not long after the volcanic eruption. The approximate date of the archaeological horizon can be established by the direct age of the basalt bedrock, and by the correlation of different-colored sediments and wedge-shaped cracks with the Pleistocene climatic fluctuations. The reddish brown layer was formed during the warm, humid period of the Middle Pleistocene, almost the same date as the earlier warm episode of the Biwa lake core data in central Japan (Bae 1988: 146). In these terms, then, the age estimate of archaeological horizon is about 0.21-0.30 Mya (Bae 1988: 147) based on the new K-Ar dates of 0.6231±0.18 Mya of basalt, dated by the Berkeley Geochronology Center (Bae 1988: 459).

As a result of their research, there came a full debate on the formation process of the Chongokni site and the IHRA with special concern focused on the age of the archaeological horizons. In a sense, the debate between Yi and Bae was, in the history of Korean Palaeolithic research, a first close-encounter of two positions, both based on the scientific approach combined with their own research styles. Parallel to this, the temporal/cultural significance of the IHRA handaxe came to face a dilemma: was it an extension of the Acheulian or was it an independent and spontaneous emergence in East Asia? It should not be a surprise to note that due to the unreliability of the chronometric dating methods and to the limited range of the field research, the two extreme dates and their related interpretations stimulated re-examination and modification relying on additional fieldwork and new dating methods.

2. Competitive Period (1989- 1999): the "*Sturm und Drang*"

A. Accumulation of Fieldwork Data

The IHRA has become a critical area in the fields of archaeology, geology and geography because of its unique cultural and natural attributes. The lively debate on the age and formation process of the IHRA assemblages resulted in three research trends: 1) vigorous field research at a regional scale, 2) the participation of diverse specialists from other related disciplines, and 3) the accumulation and distribution of data and findings by active archaeological and geological publication.

In essence, this period can be characterized as endeavoring to better understand the IHRA using various approaches. However, this period was still partially trial-and-error and general agreement on the age and formation process of the archaeological horizons was still to be achieved. It is appropriate to summarize the research style of this period as the "Sturm und Drang" because two extreme viewpoints on the formation process were independently pursued, each establishing its respective supporting evidence and both the fieldwork and the establishment of chronology were carried out in a highly competitive atmosphere.

The most notable product of this period is the significant increase of field research results. Official or unofficial survey and excavations were undertaken by various institutions and archaeological investigations were published of almost thirty sessions. Additional sites were discovered and excavated across the whole area of the IHRA: the sites of Keumpari (Bae *et al.* 1999), Namkyeri (Choi M. J. 1991, 1994), Juwolri/Kawolri (Yi 1996; Yi and K. D. Lee 1993), and Wondangri (Choi M. J. 1997). Likewise, the Chongokni site was excavated several more times (Bae 1989, 1994; Bae and Ko 1993; Bae *et al.* 1996) and the discussion of the age and characteristics of the IHRA assemblages was presented by various sources (Bae 1992a, 1992b, 1995a, 1995b; Chung 1996; Yoo 1997; Yi 1996, 1999).

B. Diversification of Perspectives

Since Yi and Bae initiated the issue of the IHRA formation processes, consideration of the stratigraphic units and the various agents that contributed to the production and transformation of the archaeological horizons came to be an important research topic. Bae (1989) first noticed the sequential wedge-shaped cracks within the sediments. Since the cracks usually develop under a cold and dry climate environment, the crack horizon can be a marker of fragipans which were formed under the mild influence of continental periglacial climate. He also pointed out that these two horizons of fragipans were probably formed in a swamp area suggesting that they can be utilized as a chronological index correlated with the record of the Pleistocene climate change (Bae 1988: 184).

Yi and K. D. Lee (1993) argued against Bae's opinion, claiming that the multiple crack horizons cannot be correlated with the climatic deterioration over such a long time scale. Since the cracks are generally formed in a short time span, their development phase cannot be a marker for such a long interval as a glacial/interglacial cycle. Although the general features are highly indicative of a cold and dry environment, the granular texture of the silty clay sediments and the highly water-saturated particles can create enough surface tension to cause major cracks during a very short period of dry conditions.

Relevant to this, Yi (1996) warned against an optimistic and simplistic perspective for understanding the general formation processes of the IHRA, arguing that the fluvial sedimentary conditions such as that of the IHRA would rarely make a "sealed-in living floor (Yi 1996:142)." A synchronicity of all the evidence of hominin occupation cannot be ensured and a single chronometric date without an appropriate context will have a limited explicability for the chronological framework. He asserted that the "complex sedimentary condition of the IHRA cannot but allow the data to be capitalized in a very rough scale," which makes any chronostratigraphic correlation extremely difficult (Yi 1996: 142).

Yi's emphasis on the limitation of the data for the chronological framework led to a new perspective: the formation of archaeological horizons should be understood in a long term basis. Regarding this, Bae *et al.* (1995) identified during the 11th campaign of excavation at the Chongokni site that the total lithic assemblage of the IHRA can be divided into at least two horizontal strata (the lower and upper). However, the upper stratum was significantly affected by post-depositional deformation through the activity of rodents and earthworms. Therefore the time-gap between the upper and lower horizon is still in question even though their difference in depth is as much as 2m (Bae *et al.* 1995.: 83).

C. Publication of Initial OSL Dates and Discovery of the AT Particles

Yi (1996) published several new OSL dates from various locations in the IHRA (Table 3.1.). The OSL dating method utilizes the amount of luminescence emitted from inorganic minerals (mostly quartz) exposed to the flux of nuclear radiation from surrounding sediments (Choi J. H. *et al.* 2004). Samples were extracted either from the bottom of the reddish brown silty clay layer or from the top of the yellowish brown silty sand layer, with the purpose of dating the initial age of archaeological horizons. Although the reliability of the result is vulnerable to the technical limitation of the OSL method (Stokes 1992), Samples Nos. 1, 3, 5, and 9 suggest that the reddish brown silty clay layer was deposited during the earlier half of the Upper Pleistocene.

In addition to the OSL dates, the Aira-Tanzawa tephra (AT) was retrieved from the infilling sediments of the upper crack (Yi, Soda, and Arai 1999). The AT originated from Kyushu Island of Japan, and was originally estimated to be 24 Kya (Yi, Soda and Arai 1999). It is widely used as a temporal marker for the chronostratigraphy of Upper Pleistocene sediments in East Asia. Since most archaeological assemblages are positioned below the upper crack which is filled with grayish silty clay-sized fine particles deposited under a deoxidizing environment of dry and cold climate (possibly OIS 2; Yi 1999), the horizon of AT particles can be regarded as the chronological upper limit of the archaeological horizons.

No.	Sampling Location	Age Result	Remark
1	Uppermost of Silt/Sand Layer from an outcrop at Jangpari	73.8 ± 14 Kya	Close vicinity to Keumpari Site.
2	Uppermost of Silt/Sand Layer from an outcrop at Kawolri	No result.	Contaminated sample, possibly exposed to the daylights
3	Bottom of Pit A at Kawolri Site (1993's excavation Campaign, Yi and K. D. Lee 1993)	120 ± 24 Kya	
4	Upper crack of outcrop at Kawolri	235 ±16 Kya	Overestimated date, possibly from unbleached quartz particles.
5	Bottom of Pit A at Juwolri Site (1993's Campaign, Yi and K. D. Lee 1993)	116 ± 7.3 Kya	
6	Bottom of yellowish brown silt/sand layer from an outcrop at Chongokni	No result	Contaminated sample, possibly exposed to the daylights
7	Upper crack from an outcrop at Chongokni	29.4 ± 1.9 Kya	AT (Aira-Tanzawa) tephra retrieved (*see* Yi, Soda, and Arai 1999)
8	Silt/sand layer from an outcrop at Baekeuri	No result	Contaminated sample, possibly exposed to the daylights
9	Uppermost from the lacustrine layer at Yangmunri	72.5 ± 6.2 Kya	Previously dated *ca* 45 Kya by TL dating (Yi 1989)

Table 3.1. OSL dates of various locations in the IHRA (Dated by Luminescence Laboratory at University of Wales, Aberystwyth, U. K., 1996, quoted from Yi 1996: 153)

3. Integrative Period (1999-present) : the "*Connaissance de la Longue Durée*"

A. Expansion of Temporal Range

After some new dates were published and the conceptualization on the timescale of the formation process changed, the research of the IHRA entered a new era. The debate on the age of archaeological horizons has now progressed, using a more integrative perspective having various alternative approaches with special reference to the sedimentary mechanism. In particular, following the Fujimura scandal in Japan in 2000, many Japanese archaeologists and other related specialists who are interested in the development of pre-Upper Palaeolithic technology have actively participated in field researches in the IHRA (*e.g.* Danhara 2001, 2003; Naruse 2003; Nagatomo *et al.* 2004).

Summarizing the research trend of this period, the "Connaissance de la Longue durée" will be an appropriate label because the seemingly homogeneous assemblages must now be explained in terms of evolutionary change (Clark and Lindly 1991; Jelinek 1994; Kuhn 1995). The most noteworthy aspect of this period is that the temporal range of the IHRA archaeological horizons is significantly expanded. The earliest known archaeological evidence of the Jangsanri site (Yi 2004a, 2004b) was discovered and excavated in the lower region of the Imjin River, while a typical Upper Palaeolithic assemblage of the Janghungri site (Choi, B. K. *et al.* 2001) was discovered in the far upper region of the Hantan River. These two spatial and chronological extremes suggest that hominins first entered the IHRA before the volcanic eruptions and they continued to occupy the area until after the AT horizon, at which time full-fledged modern sapiens appeared, making and using such typical terminal Palaeolithic tools as microblades and microcores.

B. Application of New Dating Methods

Technical developments of dating methods have also occurred. The advanced OSL and IRSL (Infra-Red Stimulated Luminescence, Balescu *et al.* 2001) methods have been applied directly to measure the age of the sediments while a new calibrated age of the AT tephra has been published (ca 26- 29 Kya, Machida and Arai 2003). When Yi's initial OSL dates were obtained, the reliability of these techniques was still at the initial level and most of his results were provisional. However, several developments in the OSL dating technique have been made since then (*e.g.* Bailey, Smith and Rhodes 1997; Murray and Wintle 2001; Stokes, Bray, and Blum 2001). For example, such high-resolution methods as SAR (single-aliquot regenerative-dose) have been introduced and widely applied. The SAR method provides with good results and its dating limits can be extended beyond those of the AMS dating method (Murray and Wintle 2000).

The IRSL dating method is a more powerful version of TL dating. It measures the ratio of paleodose to the annual dose of luminescence captured in clastic minerals. Since the IRSL technique can even measure the amount of luminescence emitted either by a thermal or optical stimulation of the infra-red rays, this dating method can be an alternative source for dating the sediments in direct contact with the lava flow. In addition, it also efficiently measures quartz particles exposed to the wave of far infra-red rays included in normal daylight (Balescu *et al.* 2001).

Until recently, the date of the AT was taken to be 24.720± 290 Kya based on the AMS dating method. However, several earlier chronometric dates have been published and the zone of AT concentration is now estimated to be up to 31 Kya (at the border between OIS 2 and 3 of the GISP2 core data; Machida and Arai 2003). Currently some authors use the fixed age of over 29 Kya, (*e.g.* Chun, Ikehara, and Han 2004; Okuno 2002) while others use an average age of 28 Kya (*e.g.* Hyodo 1999; Ikawa-Smith 2004). Although these new dates of the AT must still be examined completely in the future, the provisional age now tends to be set around 26- 29 Kya (Machida and Arai 2003: 67).

C. Synthesis of Various Approaches

Thanks to these advanced methods, more reliable chronometric dates of newly discovered archaeological sites have been ensured: *e.g.* the Jangsanri site (*ca* 0.23- 0.22 Mya based on IRSL dating; Yi 2004a, 2004b) and the Janghungri site (*ca* 24.2 Kya by AMS dating; Choi, B. K. *et al.* 2001). The final report (Bae *et al.* 1999) of four excavations at the Keumpari site was published. Also recent discoveries of the Hoengsanri site (Bae *et al.* 2004) and other neighboring localities have furnished good data to investigate the characteristics of the lithic assemblages in the upper Imjin River area. In addition, as a salvage program for a large portion of the preservation, the Chongokni site was excavated (Bae *et al.* 2001) with the purpose of delineating the extent of the site area. As a result of this excavation, the artifactual distribution of the Chongokni area has been well-documented. Furthermore, new dating of the basalt bedrock (0.51±0.07 Mya; Danhara 2001: 287) by fission track dating has been accomplished.

In 2002 and 2003, in order to synthesize research results and to direct a new multidisciplinary approach to the study of the IHRA, two international conferences were held on the issue of the chronology and lithic industry of the IHRA. Controversial issues were re-examined and new interpretations of formation processes were presented within a broader perspective (*e.g.* Bae 2002; Chung 2002; Danhara 2003; Danhara *et al.* 2002; Naruse *et al.* 2003; Yi 2002). Among various approaches and achievements, worth mentioning are the new chronometric dates of the Chongok Basalt, the discovery of K-Tz tephras (Kikai Tozurahara, *ca* 95- 90 Kya; Danhara *et al.* 2002, Fig. 6.1.), and the correlation of the loess/paleosol sequence with the OIS (Naruse *et al.* 2003) from the E55S20 pit of the Chongokni site.

Danhara *et al.* (2002) estimated the age of the archaeological horizon at the Chongokni site to be 0.3 Mya, based on new chronometric dates using fission-track and K-Ar dating (Table 3.2.). They assumed the sediment accumulated at a steady rate and that the thickness of the deposit was directly proportional to the time span between basalt bedrock and the lowest archaeological horizon. Their age estimation is partly supported by the discovery of the K-Tz tephra from the second wedge crack and the correlation of the OIS with the fluctuation of magnetic susceptibility in the sediments.

No.	Sample Code	Location /Area	Source	Formation	Dating Methods	Age (Mya)	Remarks
1	2001032592	Chongokni/A1	Silt	Baekeuri	Fission Track dating (ED1 method)	**0.51±0.07**	Weighted mean
2	2001061802-1	Chongokni/A1	Silt	Baekeuri		**0.51±0.07**	Weighted mean
3	2001061802-2	Chongokni/A1	Silt	Baekeuri		47.8±4.0	Overestimated
4	2001061802-3	Chongokni/A1	Silt	Baekeuri		94.3±8.1	Overestimated
5	2001061801	Chongokni/A3	Matrix	Baekeuri		21.6±1.8	Overestimated
6	2001032501	Chongokni/A4	Basalt	Chongok Basalt, Top		N/A	No zircon crystals extracted
7	2001061701	Eundaeri/B1	Gravel	Baekeuri		104.3±9.0	Overestimated
8	2001061702	Eundaeri/B1	Matrix	Baekeuri		90.3±7.0	Overestimated
9	2001061704	Eundaeri/B2	Clay	Baekeuri		99.0±14.0	Overestimated
10	2001032401	Kungpeongri/C	Burnt soil	Baekeuri		96.0±14.0	Overestimated
11	2001032402	Kungpeongri/C	Basalt	Chongok Basalt		1.05±15.2	Overestimated
12	S37-822	Chongokni/A2	Basalt	Chongok Basalt	K/Ar dating	**0.49±0.05**	Plagioclase, highly magnetic minerals excluded
13	S37-825	Eundaeri/B1	Basalt	Chongok Basalt		**0.50±0.03**	
14	S37-823	Eundaeri/B2	Basalt	Chongok Basalt		**0.16±0.25**	
15	S37-827	Chongokni/A2	Basalt	Chongok Basalt	K/Ar dating	**0.85±0.03**	Whole Rock, highly magnetic minerals excluded
16	S37-824	Eundaeri/B1	Basalt	Chongok Basalt		**0.57±0.03**	
17	S37-826	Eundaeri/B2	Basalt	Chongok Basalt		**0.18±0.02**	

Table 3.2. Fission Track and K-Ar dates from the IHRA.
(Dated by Kyoto Fission Track Co. quoted from Danhara *et al.* 2002)

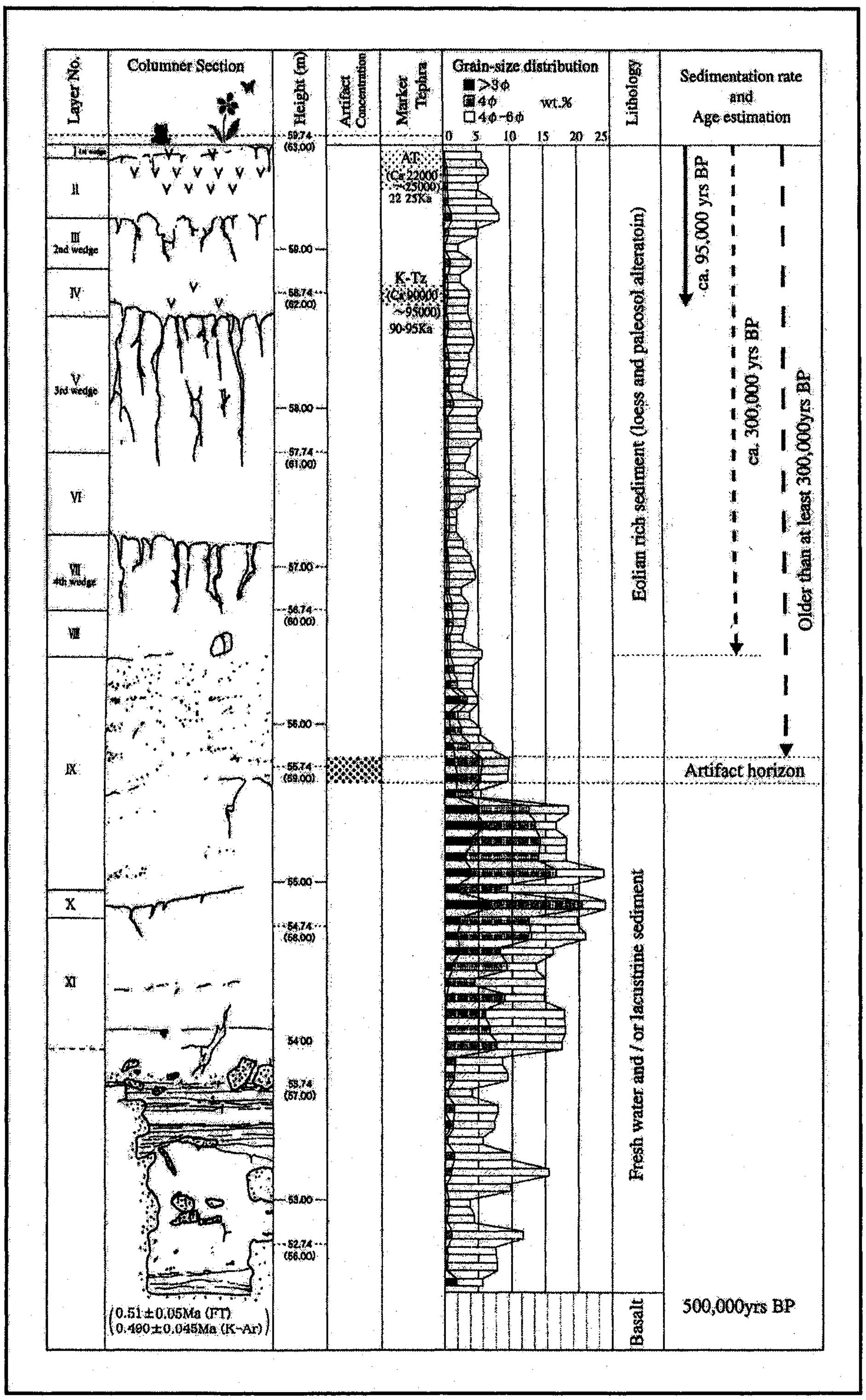


Fig. 3.6. Chronostratigraphy of E55S20-IV Pit at Chongokni (From Danhara *et al.* 2002:106)

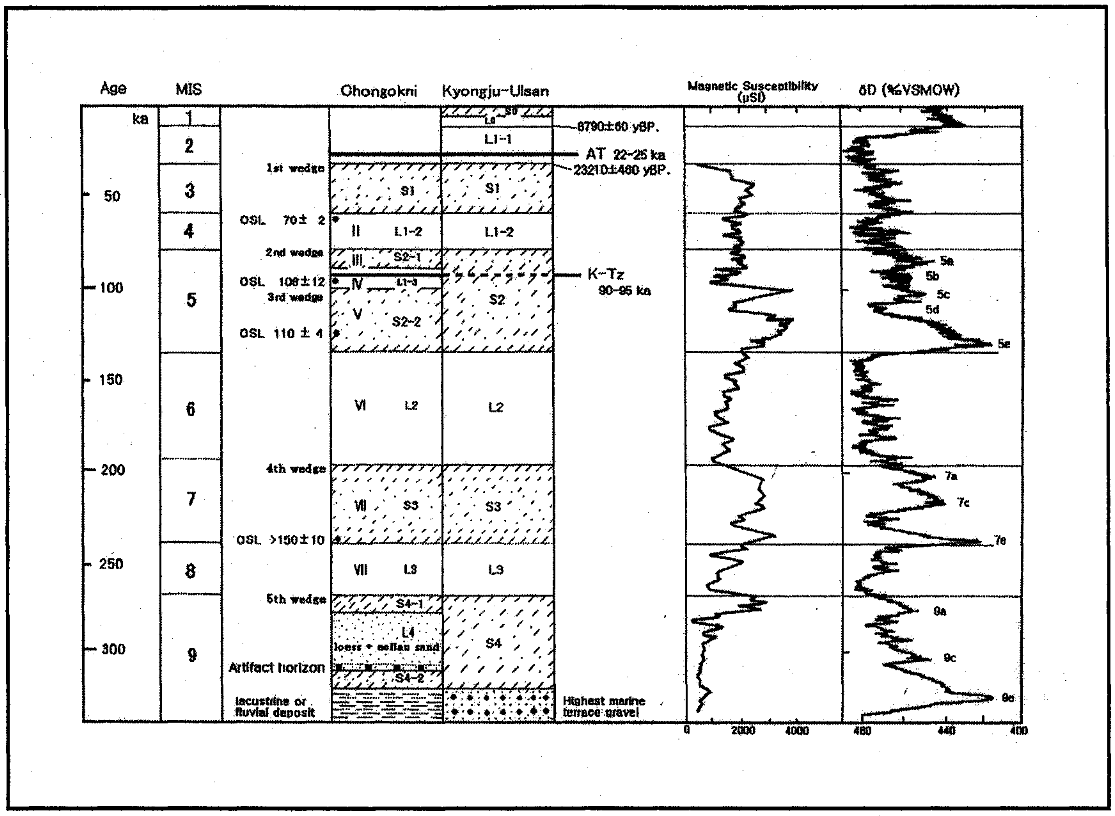


Fig. 3.7. Loess/paleosol sequence, OSL dates and magnetic susceptibility values of E55S20-IV Pit at Chongokni correlated with OIS sequence (From Naruse *et al.*: 153)

Relevant to this new age estimation, the analysis of the paleosol/loess sequence observed in the IHRA sediments was presented. Naruse *et al.* (2003) argued that the reddish brown silty clay layers of Chongokni where the artifact horizon is located were accumulated as a result of altering loess/paleosol sediments. They divided the whole cross-section of reddish brown silty clay layers into 12 subunits of loess and paleosol, and correlated each subunit with OIS from 9 to 3, until reaching just below the upper crack where the AT tephras are usually found (Fig. 3.7.). As supporting data to this, a series of four new OSL dates and the K-Ar and fission track dates of Danhara *et al.* (2002) were suggested a primary ages, and the estimated age of the archaeological horizon was set at 0.3 Mya of OIS 9, almost the same as that of Danhara *et al.* (2002).

4. A Critical Review of Current Research

A. Problems on the Assumption of Constant Sedimentation

A very recent article (Matsufuji *et al.* 2005) has combined the results of the research of both Danhara *et al.* (2002) and Naruse *et al.* (2003) while appending some new data on the discovery of β-quartz from another column of the E22S50-IV pit at the Chongokni site (Hwang 2003). At a superficial glance, this work seems to resolve a number of old research problems, and to "finalize" the debate over the age and the formation process of the IHRA. While their multidisciplinary endeavor toward this single issue is praiseworthy, the plausibility of its conclusion needs to be closely examined. Leaving aside the most recent chronometric dates and their multi-dimensional attempts to obtain the reliable age estimate, the "comprehensive" approach of Matsufuji *et al.* (2005) has several problems and leaves much to be desired.

First, their assumption that the thickness of the deposit between the basalt bedrock and the archaeological horizon is directly proportional to the time lapsed is very questionable considering the sedimentary environment of the Chongokni area. If the dating of the archaeological horizon is to be estimated in this way, the rate of sedimentation must be constant, and the structure and soil morphology must be homogeneous across the whole cross-section. Unfortunately, however, this is by no means the case. The stratigraphy of Chongokni is not that of deep-sea core sediments and the alternating loess/paleosol sequence strongly contradicts this assumption.

B. The Authenticity of the K-Tz Tephra

Another problem on the discovery of arguable K-Tz tephra is worth mentioning. As Machida and Arai (2003: 74- 75) noted, the chemical compositions of the K-Tz and of the AT are closely similar while the refractive indexes of quartz particles are slightly different. In addition, the Korean Peninsula is definitely far outside the maximum distribution range of the K-Tz (Fig. 3.8.) which is largely limited to only Kyushu, the southern Kanto and the Chubu area of the Japanese Archipelago. Of course, the possibility that the K-Tz tephra may be discovered beyond the maximum distribution range cannot be excluded, and some promising examples have been identified in the Shandong Peninsula of mainland China (Eden *et al.* 1996). Nevertheless, it should be noted that miniscule volcanic glass shards cannot be directly identified with the K-Tz distribution. Accordingly, there could be other sources responsible for these Chinese volcanic glass shards, for example, "from Russian Kamchatka or from the Phillipines" (Eden *et al.* 1996).

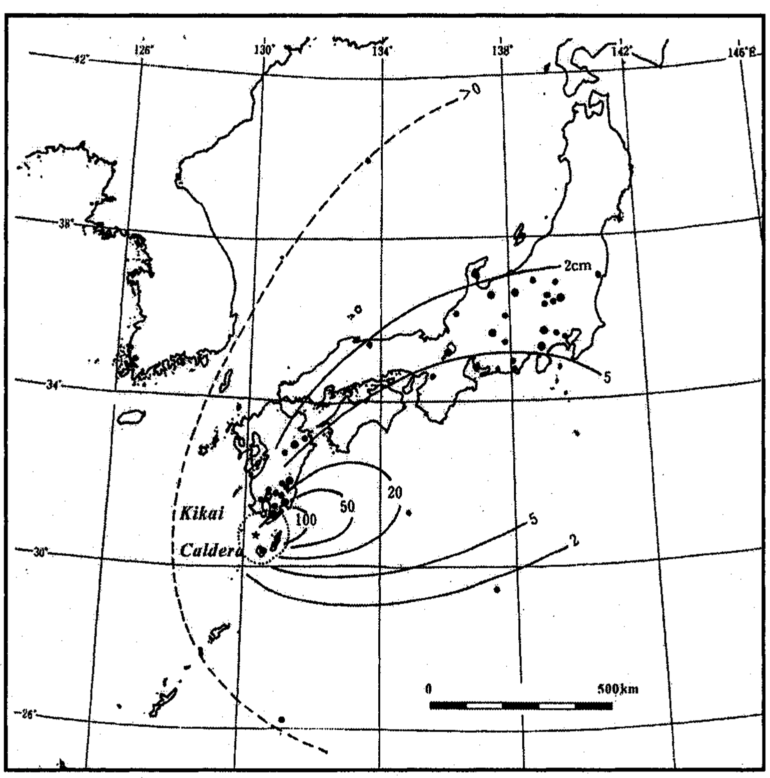


Fig. 3.8. Distribution range of K-Tz tephra (From Machida and Arai 2003: 75)

Danhara *et al.* (2002) discovered only two fragments of K-Tz tephra particles from the lower crack of the Chongokni cross-section (Fig. 3.6.). Their refractive index is approximately 1500 which is almost identical to that of the AT particles discovered from the upper crack. Only β-quartz, which is a unique mineral to the K-Tz tephra, has been suggested as a discriminator to differentiate samples of the K-Tz from the AT tephra. Considering that the K-Tz particles were completely hydrated, these tephras that were discovered at the Chongokni site can arguably be interpreted as the weathered particles of the AT which moved down from the upper crack rather than as genuine K-Tz particles because there is no conclusive evidence supporting the possibility that original K-Tz tephras from Japan reached as far west as the IHRA. Although Hwang (2003) discovered additional β-quartz particles from another column of the E55S20 Pit of the Chongokni site, the discovery of β-quartz does not at all support the argument that the K-Tz tephras have been definitely included in the sediments of Chongokni. The β-quartz is not a pedological but a mineralogical phenocryst element which tends to be pyrogenically produced by natural processes regardless of the K-Tz tephras.

C. Chronostratigraphy of the Loess/Paleosol Sequence

The correlation of the loess/paleosol sequence with the OIS sequence is also questionable. According to Naruse *et al.* (2003), their correlation is largely dependent on the proxy data from the Kyongju-Ulsan area (Fig. 3.7.), the southeastern part of the Korean Peninsula where step-wise marine terrace surfaces are clearly visible. The bottom S4 paleosol layer is estimated to be of OIS 9 data because it is distributed directly on the highest marine terrace gravel of OIS 9 (Naruse et al. 2003: 152). As briefly mentioned in chapter II discussing the problematics of the marine terrace sequence of Korea, the chronostratigraphy of the base level of the S4 paleosol layer is far from solid and its age of formation is based on nothing but simple assumption.

The location of the site area also needs to be taken into consideration. Naruse *et al.* (2003) assumed the eolian dusts were continuously blown from mainland China and accumulated in the Chongokni area starting in OIS 9. However, the site is situated adjacent to an overbank area of the Hantan River channel where fluvial sediments were primarily deposited forming a floodplain. In this case, it is rarely expected that a well-stratified, regularly alternating loess/paleosol sequence would develop during such a long period between OIS 2 and 9. Relevant to this, a recent remote sensing analysis using seismic refraction (Choi, K. H. *et al.* 2005) verified that the sediments over the basalt bedrock represent a former floodplain of the Hantan River. The velocity of the P-wave within the Chongokni sediments is identical to that of the current floodplain deposit near the Hantan River; and its measured velocity (*ca* 1800m/s) is significantly different from that of the normal loess deposit (300- 600 m/s).

Besides these methodological problems, Naruse *et al.* (2003) committed another serious mistake. The horizontal position of the artifact layer (*i. e.* the archaeological horizon of E44S20-IV Pit) needs to be adjusted. According to the original excavation report (Bae *et al.* 2001), the lowest level of the artifact layer is *ca* 55.7m amsl, which is the upper part of layer XI (the yellowish brown silt/sand layer). Usually, this level is regarded as the earliest level of archaeological horizon. However, the previous excavations suggested that the archaeological horizon below the border between the reddish brown silty clay and the yellowish brown silt/sand layer is not the primary context as a result of vertical movement of artifacts within the fluvial sediments (Bae *et al.* 1995:83, 2001: 233). Figure 3.7. demonstrates that the position of the artifact layer designated by Naruse *et al.* (2003) is far below the original horizon, at least a difference of 1.5m or more. If their artifact horizon is corrected, the estimated age of 0.3 Mya must correspondingly be subjected to serious re-examination and its real age would become far younger than this.

Whatever the reason may be for the methodological problems and for the technical error, the suggested age of the Chongokni site as estimated by Matsufuji *et al.* (2005), including the results of Danhara et al (2002), Naruse et al (2003), and Hwang (2003), is not realistic. Although their attempt to establish a solid age must be acknowledged, their result must be discarded if a better understanding of the chronostratigraphy and the formation process of the IHRA archaeological sites, is to be achieved.

(4) Summary

This chapter has covered the basic knowledge on the geographic aspects of the field area and it has illustrated the research history of the relevant topics, emphasizing controversial issues on the determination of the chronology of IHRA assemblages. The difficulty in dating the archaeological horizons lies in the nature of the temporal zone. While the age of the basalt bedrock has been estimated to be later Middle Pleistocene (*e.g.* Bae 1988; Danhara *et al.* 2002 Kojima 1983; Park, K. H. *et al.* 1995), the K-Ar dating, in itself, cannot establish high-resolution dates, nor produce statistically significant results. Furthermore, this temporal zone is beyond the coverage of AMS dating and there rarely exists unpolluted organic material suitable for ESR and/or U-series dating due to extremely bad preservation conditions. In sum, it is not an exaggeration to say that the IHRA assemblages are in a "chronometrically compromised" horizon.

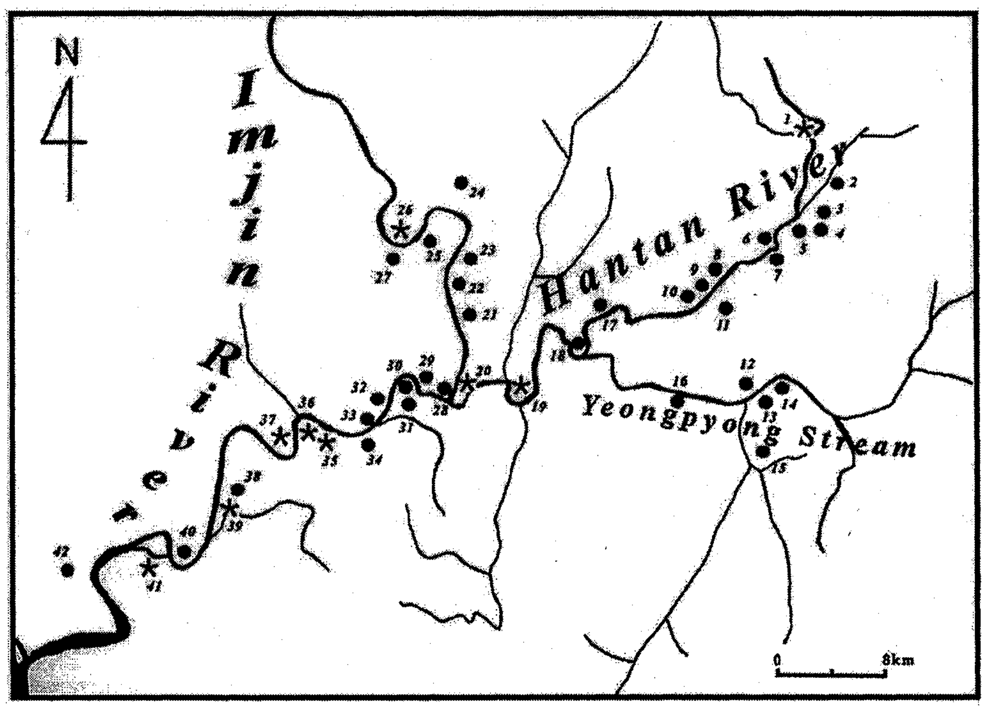
Given all these difficulties, the dating of the IHRA archaeological horizons is a most demanding task. In the course of vigorous debate and active field research, what has been attained by past research is the lesson that the age of the archaeological horizon of the IHRA is not to be determined by chronometric dating methods alone, but by the addition of a comprehensive perspective formulated as a result of region-scaled fieldworks. The next part of this thesis thus attempts to establish the new dating of the archaeological horizon and to delineate its geological formation processes based on newly acquired data from a target-oriented fieldwork.

IV. FIELDWORK DATA AND RESULTS

(1) Fieldwork Schedule and Data Acquisition

This chapter will be devoted to the introduction of various archaeological sites and their ages based on the fieldwork conducted for this thesis. A preliminary fieldwork was carried out from September 1999 to June 2000. During this time, the background work for understanding the geological and geomorphological features of the IHRA constituted the main field task. Six basalt rock samples for K-Ar dating were extracted from the Chongokni and Shindapri sites where unweathered fresh basalt nodules are available. The K-Ar dates of these samples were obtained in the first half of 2001, dated by the Geochronology Team of the Korean Basic Science Institute.

The IHRA was re-visited in February of 2003 in order to resume the main fieldwork. The first task of this fieldwork was two excavation sessions conducted in the Juwolri and Kawolri areas from March to June 2004 under the auspices of Seoul National University Museum and the Institute of Archaeology, Hanyang University, Korea. Its main objective was to observe and record the colluvial sediments distributed beyond the overbank area of the lower Imjin River, as well as to collect samples of the lithic assemblages. After the excavation of these two sites was completed in July 2003, a labwork to document and analyze the lithic assemblage from the Jangsanri site was carried out. The excavation of the Jangsanri site had been carried out by the Seoul National University Museum from October to December of 2002 and its lithic specimens were stored in the Palaeolithic Archaeology Laboratory of the same institute.



● Surveyed Location ★ Excavated Location

1. *Janghungri*
2. *Kuntanri (RockShelter)*
3. *Jipori*
4. *Jailri-Shinchon*
5. *Jailri-Palho*
6. *Sajungri-Hwajeokyeon*
7. *Woncheon*
8. *Joongri-Araesimjae*
9. *Joongri-Neulgeori*
10. *Joongri-Moonbaeteul*
11. *Daehoesanri*
12. *Shinjangri*
13. *Yangmunri*
14. *Seondongri*
15. *Keumjuri*
16. *Ogari*
17. *Komoonri*
18. *Shindapri*
19. *Chongokni*
20. *Namkyeri*
21. *Jinsangri*
22. *Samgeori*
23. *Seongokri*
24. *Samgotri*
25. *Kangnaeri*
26. *Hoengsanri*
27. *Kangseori*
28. *Dongyiri*
29. *Majeonri*
30. *Samhwari*
31. *Eoyujiri*
32. *Kumiri*
33. *Hakgokri*
34. *Yulpori*
35. *Kawolri*
36. *Juwolri*
37. *Wondangri*
38. *Jangpari*
39. *Keumpari*
40. *Dongpari*
41. *Jangsanri*
42. *Dorasanri*

Fig. 4.1. Identified archaeological locations in the IHRA

In October 2003, a joint team was organized among the members of the Palaeolithic Archaeology Laboratory and the Laboratory of Sedimentary System, Seoul National University, to conduct geological and archaeological research of the IHRA; and the fieldwork for this thesis was incorporated into the research of this team. The principal task of this team was to conduct an interdisciplinary geoarchaeological investigation at a regional scale level for reconstructing the Quaternary history of the CRV region. Its geographical focus was on the midstream region of the Hantan River and, as a result, several fission–track (FT) dates were obtained from the Chongokni area.

Later, a small-scale excavation at the Chongokni site was carried out from April to July 2004. The purpose of this excavation was to obtain uncontaminated dating samples for luminescence dating and to examine the whole sequence of fluvial deposits in the Chongokni area. In order to expose a fresh outcrop of stratigraphic column, a 4m x 20m x 8m control pit was excavated and sediment samples for OSL dating and soil analysis were collected. As a result of this excavation work, two OSL dating sequences were obtained, each of which measured by independent luminescence labs: the Geochronology Laboratory at the Korean Basic Science Institute (Yi, Y. I. Lee, and Lim 2005), and the Institute of Paleoenvironment of Chungcheong Cultural Property Foundation (Kim, M. J. 2005).

The rest of the fieldwork was devoted to the measurement and illustration of lithic specimens from the Chongokni, Juwolri and Kawolri sites with some supplementary data additionally collected from the Keumpari, Hoengsanri, and Janghungri sites. The fieldwork was completed by April of 2005, and its result was published a year after (Yi, Yoo, and D. W. Kim 2006). This chapter will introduce new chronometric dates and archaeological data acquired from the excavations of the fieldwork. Some other major sites will also be described by summarizing previous research and relevant publications.

(2) Jangsanri: the Oldest Evidence of Hominin Occupation in the IHRA

1. Chronostratigraphic context and Site Formation Process

A. Site Location and General Features

The Jangsanri site (No. 41 of Fig. 4.1.) is located near Munsan Town of Paju City (N 37° 54', E 126° 47'). Because of its closeness to the DMZ line and incomplete cartographic documentation, the topography of the Jangsanri area has been outside the focus of research until recently. It was originally discovered by a field survey team on excursion from the Seoul National University Museum in 1994. Several lithic artifacts were retrieved by surface survey about 30m above the shore land of the Imjin River (Yi 1996). Excavation was conducted from November to December 2002 by the same institute.

The site faces the Imjin River to the north and Chopyung Isle, which was formed as a result of strong down-cutting action of the meandering Imjin channel flow (Fig. 4.2.). The excavated area is at the height of 35- 40m (amsl) and is now occupied by a military guard and observatory post. The site location was also used as a small harbor with a fortification during the 15 to 19th centuries A. D., and several artifacts of that era were distributed within the disturbed topsoil layer.

B. Geomorphological Characteristics: the Oldest Terrace in the IHRA

Near the mouth of the Imjin River, the channel velocity is significantly lowered and the sizes of the transported sediments are reduced. Cobbles and pebbles with a high roundness, which is diagnostic of typical downstream river beds, are ubiquitously deposited at the overbank area. The stratigraphy of the Jangsanri site shows these geological processes very well. Since it is located at the far downstream end and away from the maximum reach of the lava flow, the undisturbed river terraces are well preserved; even the ancient terrace surface which is much older than the volcanic eruption survived as a series of pebble-dominant sediments on the surface.

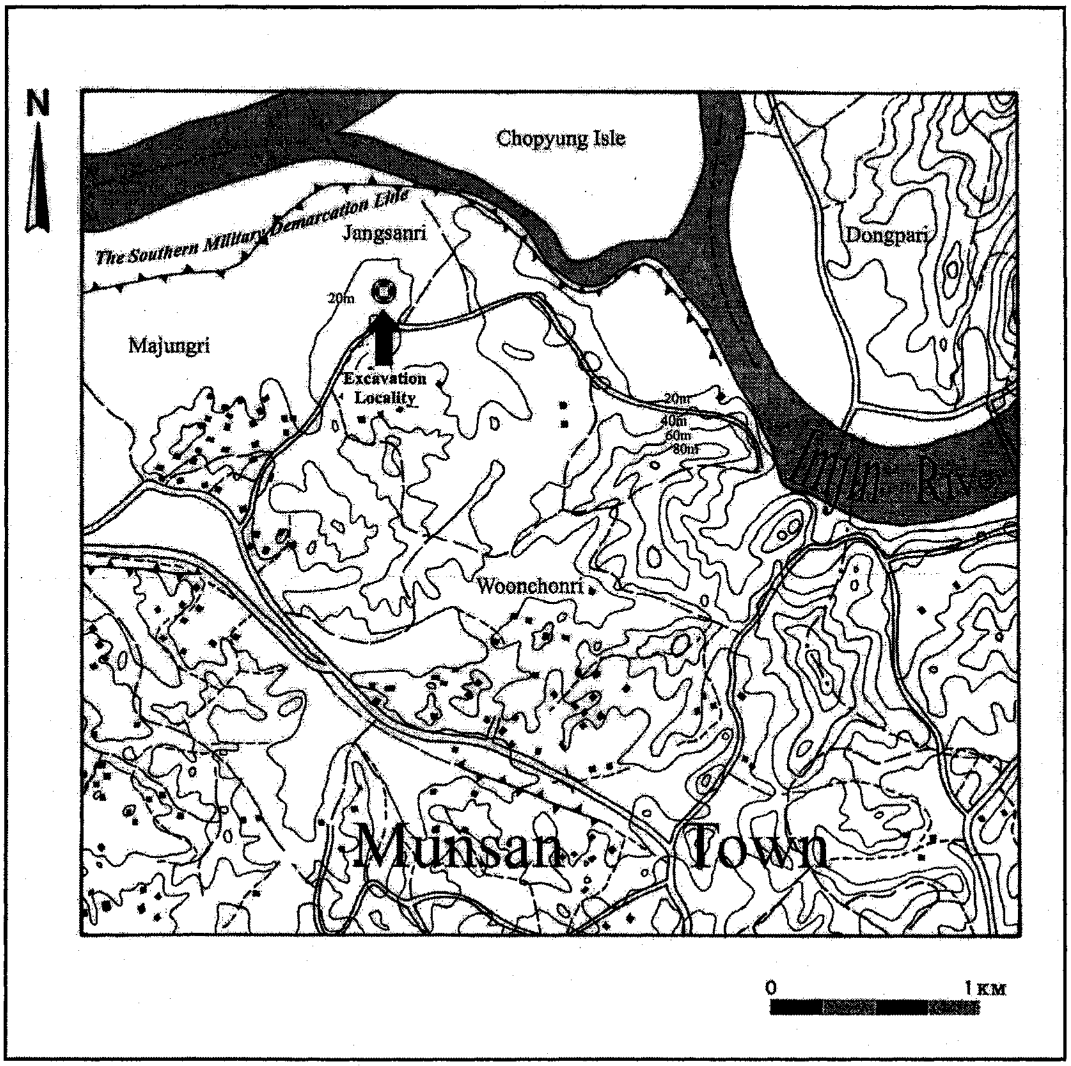


Fig. 4.2. The location and excavated spot of the Jangsanri Site
(The contour line is per every 20m of altitude)

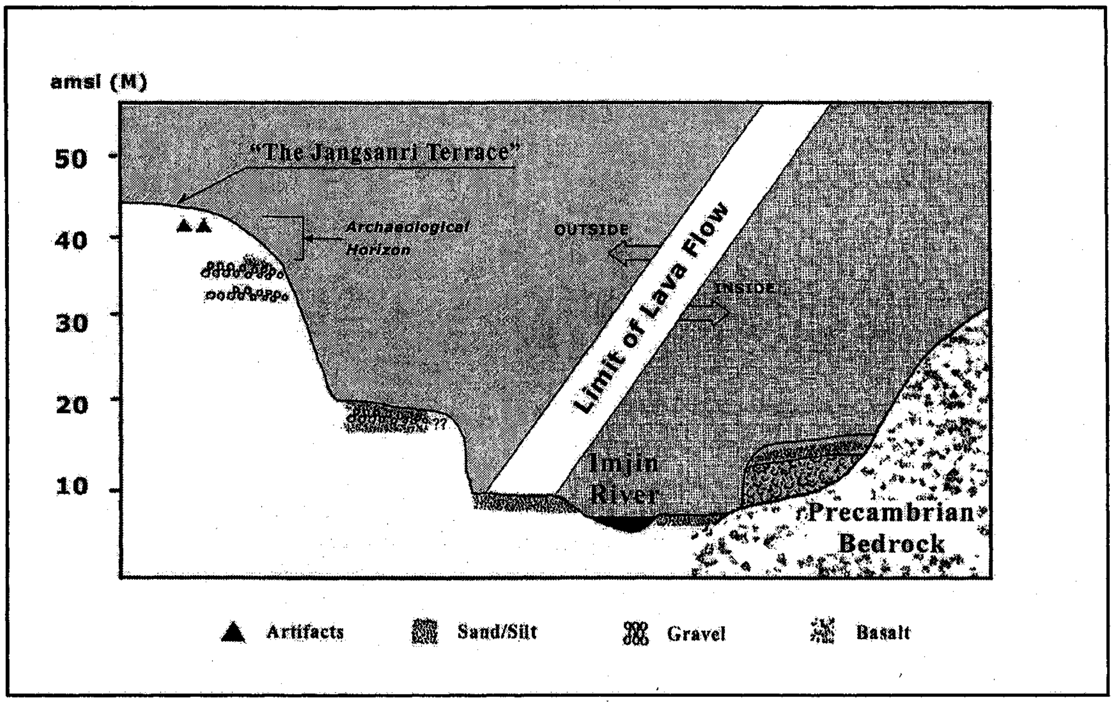


Fig. 4.3. Schematic Cross-section of the Jangsanri Topography in the context of the lava flow range (Altitudes were calibrated based on Yi 2002: 86)

After the first discovery of lithic artifacts in 1994, Yi (2002) verified that the highest terrace level (*ca* 45m amsl) is the oldest surface and arguably much older than the volcanic eruption at the middle and upper Imjin-Hantan river channel because its height is about 20 to 30m higher than the average altitude of the basalt area (Fig. 4.3.). Yi (2002) also tentatively suggested that the minimum age of the "Jangsanri Terrace" could be early Middle Pleistocene or even Lower Pleistocene based on the degree of weathering of gravels in the sediment. It was, therefore, proposed that the excavation should be conducted in this zone for the purpose of finding and identifying possibly the oldest lithic assemblage in the IHRA and also for establishing reliable chronometric dates.

C. Excavation Layout and Stratigraphy

Because the upper part of the deposits was severely disturbed by the construction of the military defense posts, the excavation pits were located where both the original stratigraphic sequence and the archaeological horizon seemed to be best preserved. Pits A, B, D, and E were positioned at the periphery of the hollow area carved for the military defense structure; Pit C is located north beyond the highest ridge of the Jangsanri Terrace (Fig. 4.4.).

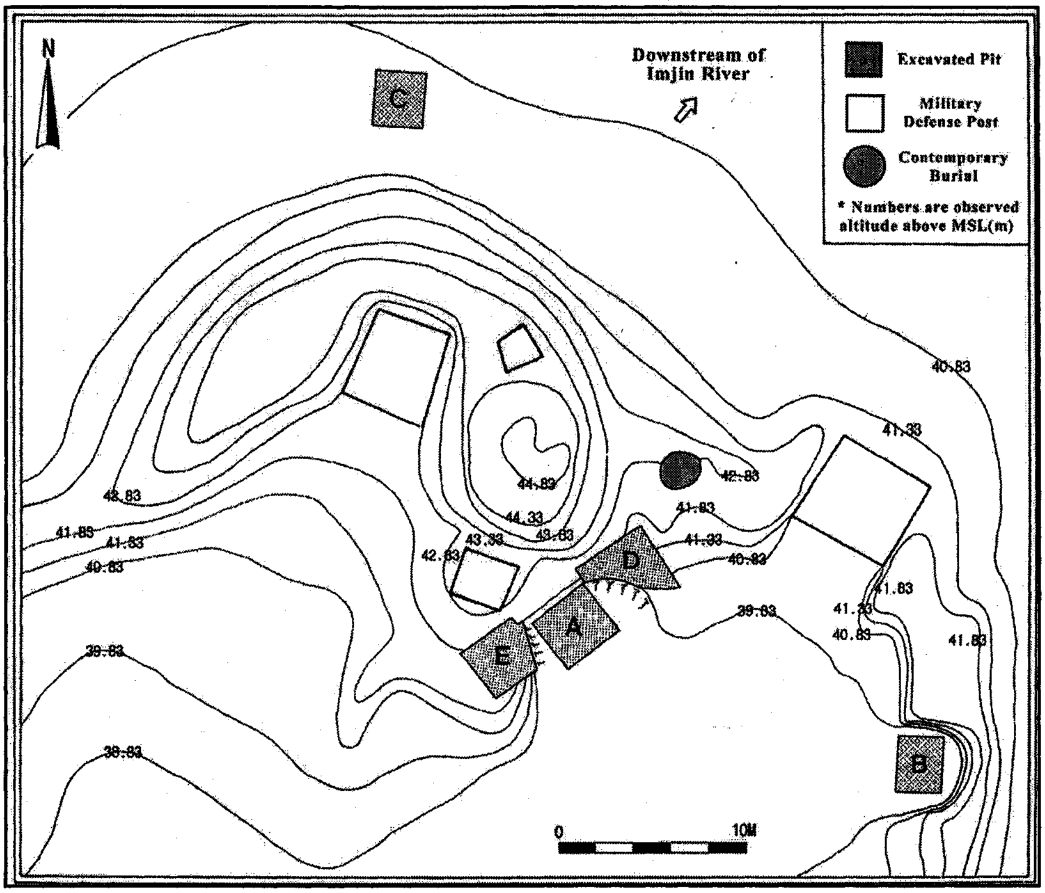


Fig. 4.4. Distribution of excavation pits at the Jangsanri site

A stratigraphic profile about 5m thick was obtained from the north wall of Pit A (Fig. 4.5.). In general, sediments were poorly sorted showing a slight tendency of fining-upward texture. The lower part was composed of largely well-rounded and strongly weathered pebbles, diagnostic of the typical river bed accumulation of water-transported gravel deposits.

This gravel deposit was interleaved with several bands of light-toned sand sediments. Above this gravel deposit, the amount and the particle size of the sands gradually decreased upward and alternating light yellowish silt bands appeared. The well-stratified bands of fining-upward sand/silt suggested that their depositional origin is the point-bar sediments that developed alongside the overbank area of the river channel (Yi 2004).

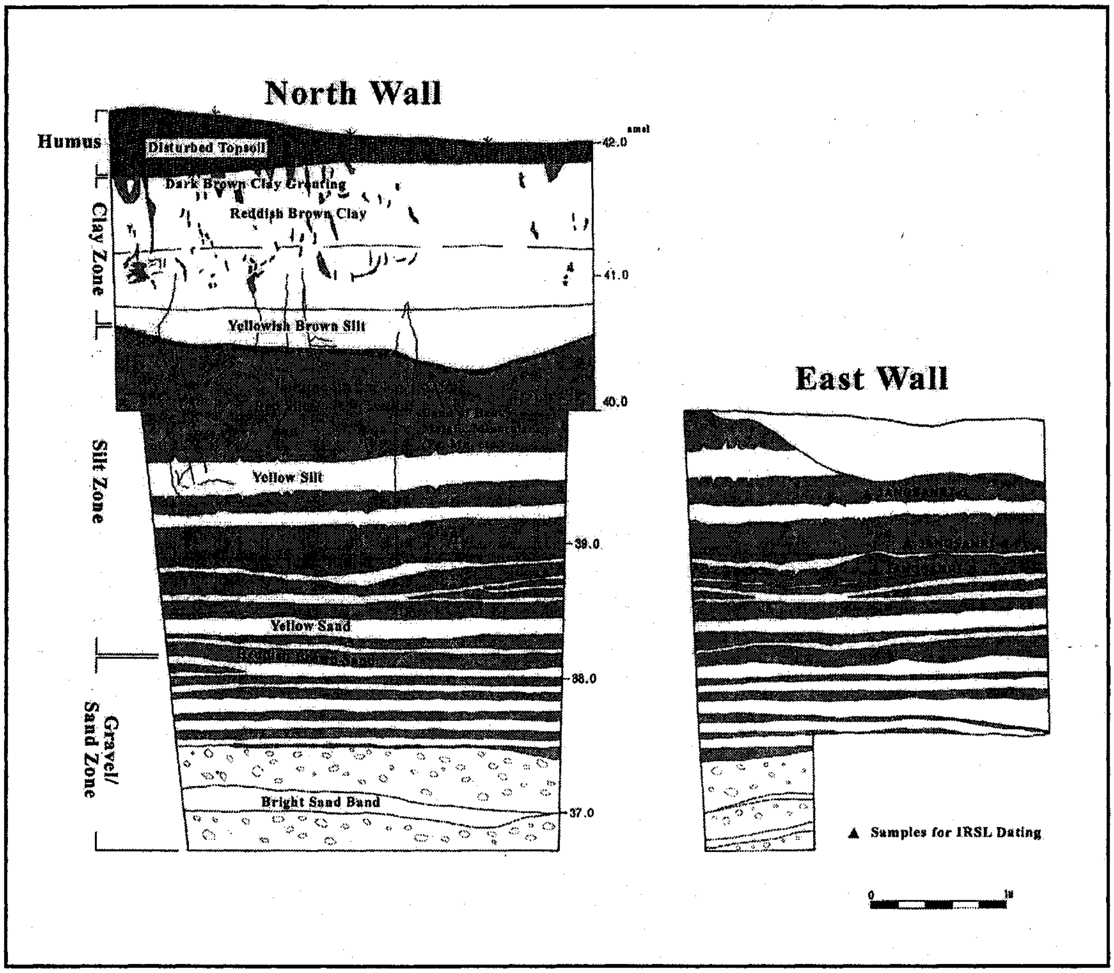


Fig. 4.5. Stratigraphic Cross-section of Pit A at the Jangsanri site

The upper part of the overall stratigraphy was demarcated from the lower part by a dark black mineral-rich band (Fig. 4.5.). This dark stratum was possibly made by the chemical breakdown of organic components originating from ancient vegetation when the top of the silt/sand deposits were exposed at the surface. In contrast to other sites in the IHRA, no cracks were observed. However, features of dark brown clay grouting were occasionally observed although their origins were not confirmed. According to the analysis of sediments of the upper part (Lee, Y. I. 2004), the velocity of water flow forming the strata of the upper part gradually was diminished and its deposition stabilized compared to the lower part.

D. Age Determination of the Jangsanri Assemblage

The Archaeological horizon is identified at the lower part of the column. The top of the red silt layer just below the dark stratum noted earlier was the zone of the most condensed artifact distribution. Excluding Pit A, which produced only four artifacts between 38.8 to 40.5 m (amsl), the majority of artifacts was closely packed within the sediments at about 40.5m and this level can be regarded as marking the primary context of hominin occupation at Jangsanri.

Sample Code	Paleodose (Gy)	Annual dose (Gy/Kya)	IRSL Dates (Kya)	Method
Jangsanri-3	1267±119	6.16±0.22	**206±21**	FG/IRSL
Jangsanri-4	1226±138	5.62±0.18	**220±26**	FG/IRSL
Jangsanri-5	1192±226	5.54±0.19	**215±41**	FG/IRSL

Table 4.1. The IRSL dates from the sediments below the archaeological horizon (Dated at the Nagatomo Laboratory of Archaeological Science, Nara University of Education, Nara, Japan, 2004)

The age of the archaeological horizon is estimated to be *ca* 23 Kya (Yi 2004a; Yi, Y. I. Lee, and J. W. Kim 2004) based on three IRSL dates acquired from the reddish brown sand bands of Pit A (Fig. 4.5.; Table 4.1.). The IRSL dates of poly-mineral fine grains were measured by the multiple aliquot additive dose method (*see* Aitken 1997) using the automated OSL/TL system (the NRL-99-OSTL system) originally designed by Nara University of Education. The Beta dose-rate was estimated with TLD powder ($CaSO_4Tm$) while the alpha dose-rate and the gamma dose-rate were calculated by the amount of U, Th and ^{40}K tracked by a gamma-ray spectrometer. Cosmic ray dose-rate is assumed to be 0.15mGy/year by Nagatomo *et al.*(2005).

While much younger than originally proposed by Yi (2002), the result of IRSL dating well-illustrates that the Jangsanri lithic assemblage was deposited during the later Middle Pleistocene. The general fining-upward tendency of sediments can be attributed to the gradual stabilization of river channel and the decrease of hydraulic energy. However, as a result of post-depositional activities such as frequent inundation and fluctuation of the stream level as well as modern day construction, the possibility cannot be excluded that more recent assemblages have been entirely destroyed.

2. General Features of the Jangsanri Lithic Assemblage

A. Raw Material Distribution and Quality

Even though its age is younger than expected, the lithic assemblage shows stylistic "antiquity." Many tools are made of pebbles and cobbles which can be easily acquired in the vicinity of the site. The majority of the raw material is by no means of good quality, but it is of sufficient quality for making heavy duty tools with simple manufacturing techniques.

The major raw materials can be classified into three rock types: quartzite, gneiss, and vein quartz. Because no lava flow reached this area, the outcrop of bedrock was easily exposed and nodules of the Precambrian gneiss are one of principal raw material resources.

The source of the quartzite is mainly large cobbles accumulated in the sediments. According to macroscopic observation, the quartzite has a very coarse texture, and the structure of the cemented particles is similar to that of a normal conglomerate and/or greywacke.

Most large tools were made with quartzite while gneiss was occasionally used. Gneiss is usually found so badly weathered that its mechanical properties are almost totally transformed from the original ones. Its hardness is seriously reduced enough to be easily fractured by simple percussion and most debitage is made of gneiss pebbles. Fine-grained vein quartz was rarely employed and only a small amount was found through surface collection.

B. Assemblage Characteristics and Basic Technology

A total of 83 lithic artifacts were retrieved of which 36 are either modified or directly utilized (see App. I). Pit D yielded the highest number of artifacts (n=65) including unmodified pebbles. Some pebbles show definite scratches and scars, possibly caused by such hominin activities as crumbling and/or scratching other materials. However, any claim that the Jangsanri assemblage represents a "pebble culture" has yet to be addressed since these few scratches and scars cannot be directly linked to direct utilization of raw pebbles by hominins.

While their function was not determined, some randomly modified manuports were also retrieved, including broken pebbles, a large pecked flat cobble, and an elongated cobble with several flake scars. The textures of pebbles and manuports are different from the clastic detritus of the underlying gravel deposits, suggesting that they were possibly imported from elsewhere to the site area for potential utilization. Considering that the total assemblage rarely has any intensively modified cores and tools, the Jangsanri hominins are believed not to have been fully aware of flake acquirement and blank utilization techniques.

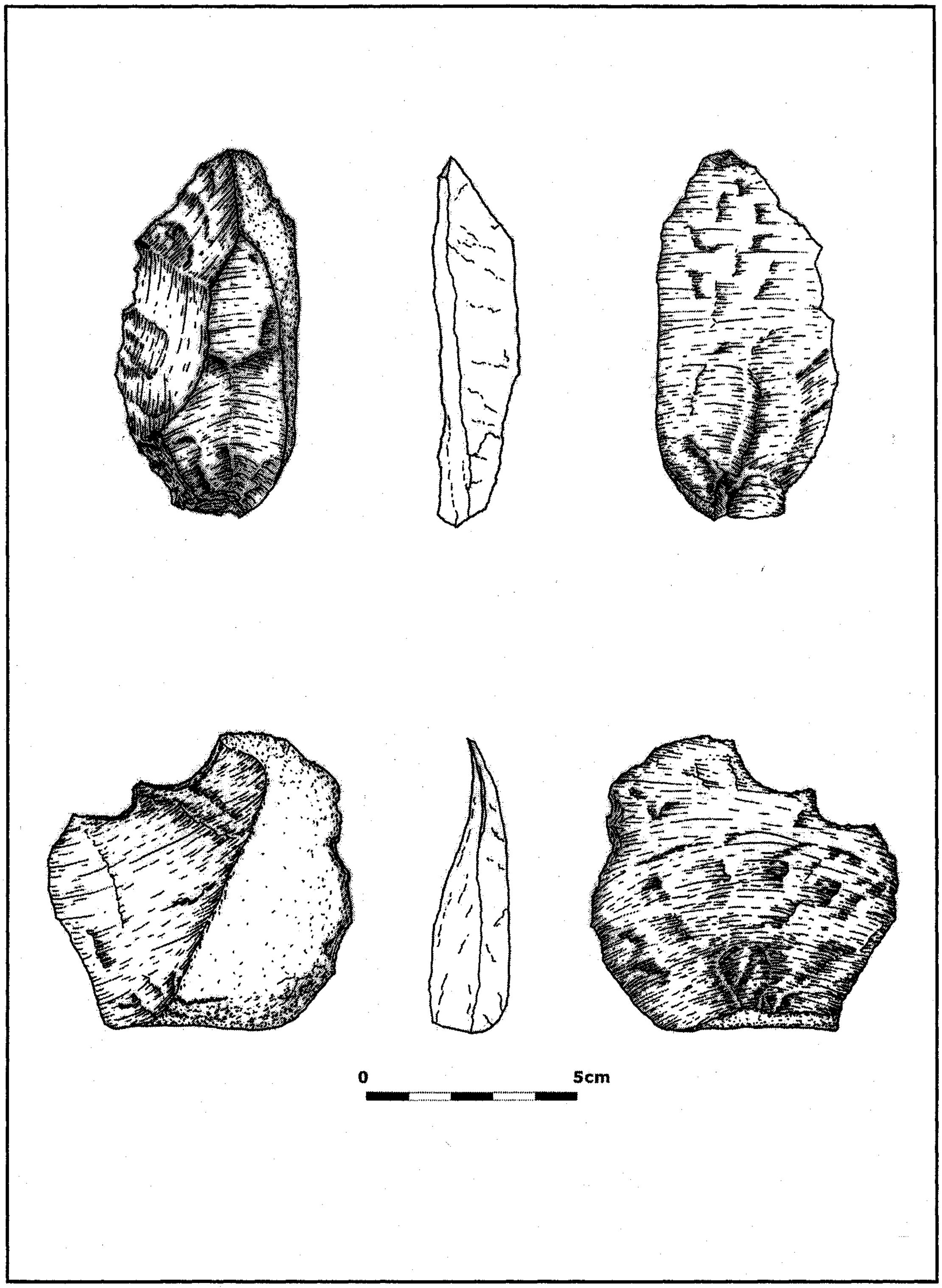


Fig. 4.6. Two small tools from the Jangsanri site
(Top: backed knife, E-1; bottom: notch, D-2)

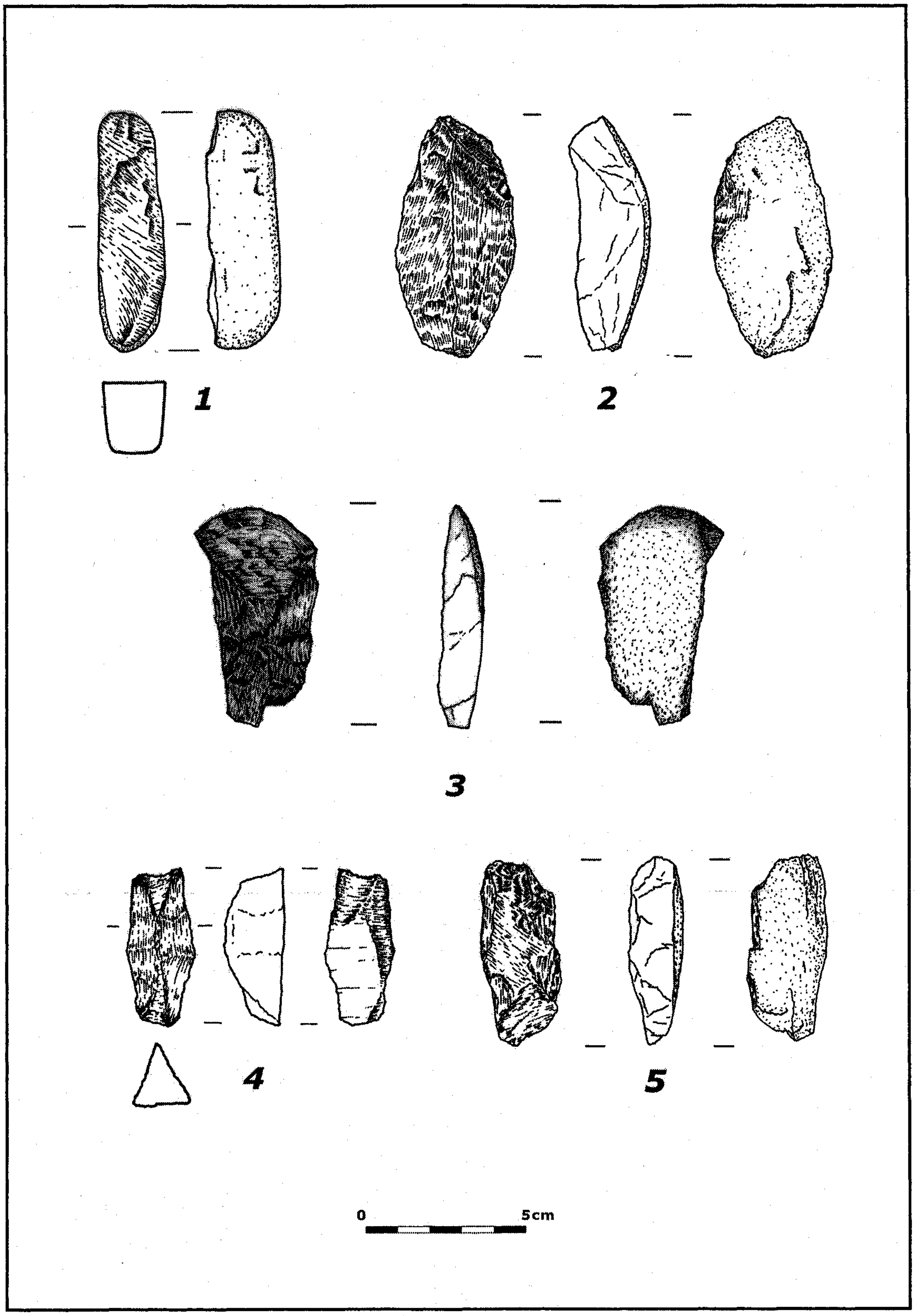


Fig. 4.7. Bipolar pieces from the Jangsanri site
(1: D-5, 2: D-35, 3: A-1, 4: D-57, 5: D-58)

Evidence of retouching was also rarely identified; some small tools show secondary modification, but the manufacturing technique employed seems to be very rudimentary since, at best, only minimal modification was performed. Just two pieces show clear evidence of modification: a naturally backed knife made with an elongated flake (Fig 4.6., #1) and a notch made by two simple Clactonian blows (Fig. 4.6., #2) based on the Bordesian typology. Other than these two types and an endscraper from the top soil, there were no distinct flake tools within the total assemblage.

The Jangsanri assemblage has a higher proportion of bipolar pieces compared to the number of normal flakes (Fig. 4.7.). Seven bipolar pieces were discovered and four of these were produced by direct "pebble-splitting percussion" (Kuhn 1995: 97). No pieces have any additional scars while some pieces have sharp edges on their margins with slightly fractured dentations. The high incidence of bipolar pieces in the debitage category indicates that a deliberate pebble-splitting technique was frequently performed in order to reduce the thickness of pebbles and to acquire naturally formed edges. In contrast, normal flakes were rarely found except for the two flake tools noted above.

Tools shaped with large cobble blanks rarely show evidence of intentional design consideration as well. Even though a large pick (Fig. 4.8.) discovered from Pit A can be regarded as a proto-type of handaxe (Yi 2004a), the original shape of the slim and ellipsoidal blank cobble was primarily responsible for its relatively elongated shape. The contribution of the manufacturer's intention to the design of overall shape seems to be minimal because its modification was performed only at the distal end of the cobble blank and most of the cobble retains unmodified cortex much like a simple chopper. Since these are characteristic of a very limited manufacturing technology, the Jangsanri assemblage is treated here as an expression of a generalized utilitarian lithic technology with no type-specific manufacturing techniques.

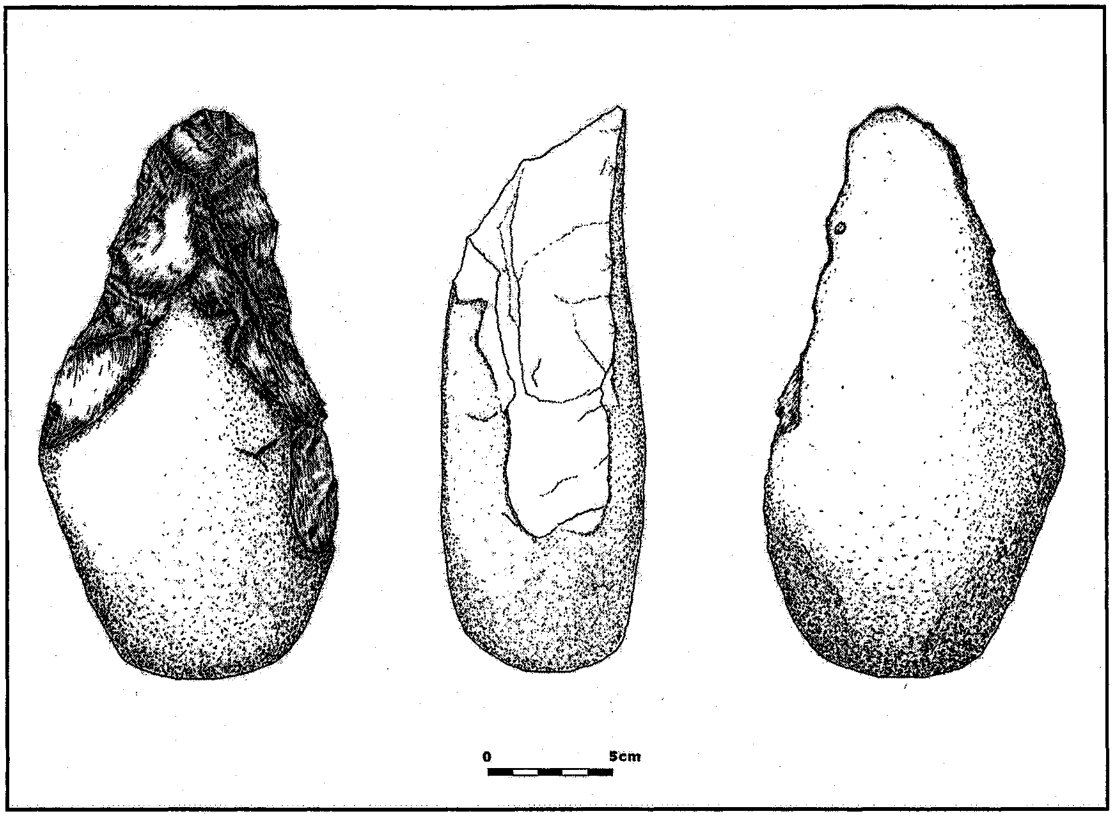


Fig. 4.8. Pick from the Pit A of the Jangsanri site

C. The Surface Collection

Several artifacts were discovered on the surface and from the top soil. An intensively reduced bipolar core (Fig. 4.9. #2) and several crude heavy-duty tools were retrieved. Of these surface collections, a conjoining handaxe (Fig. 4.9.#1) suggests that the manufacturing idea of the pointed tip and peripheral side-edges was established early in the IHRA. Although its primary context was entirely erased, this handaxe is technologically identical to other handaxes discovered elsewhere in the IHRA. Its lateral margins were simply modified by alternately detaching several flakes from either side of flat cobble to form a rhomboidal cross-section as well as forming a pointed tip. This kind of margin-shaping is prevalent in other handaxes and is one of major handaxe manufacturing techniques in the overall IHRA assemblages (*e.g.* the alternate technique; Yoo 1997).

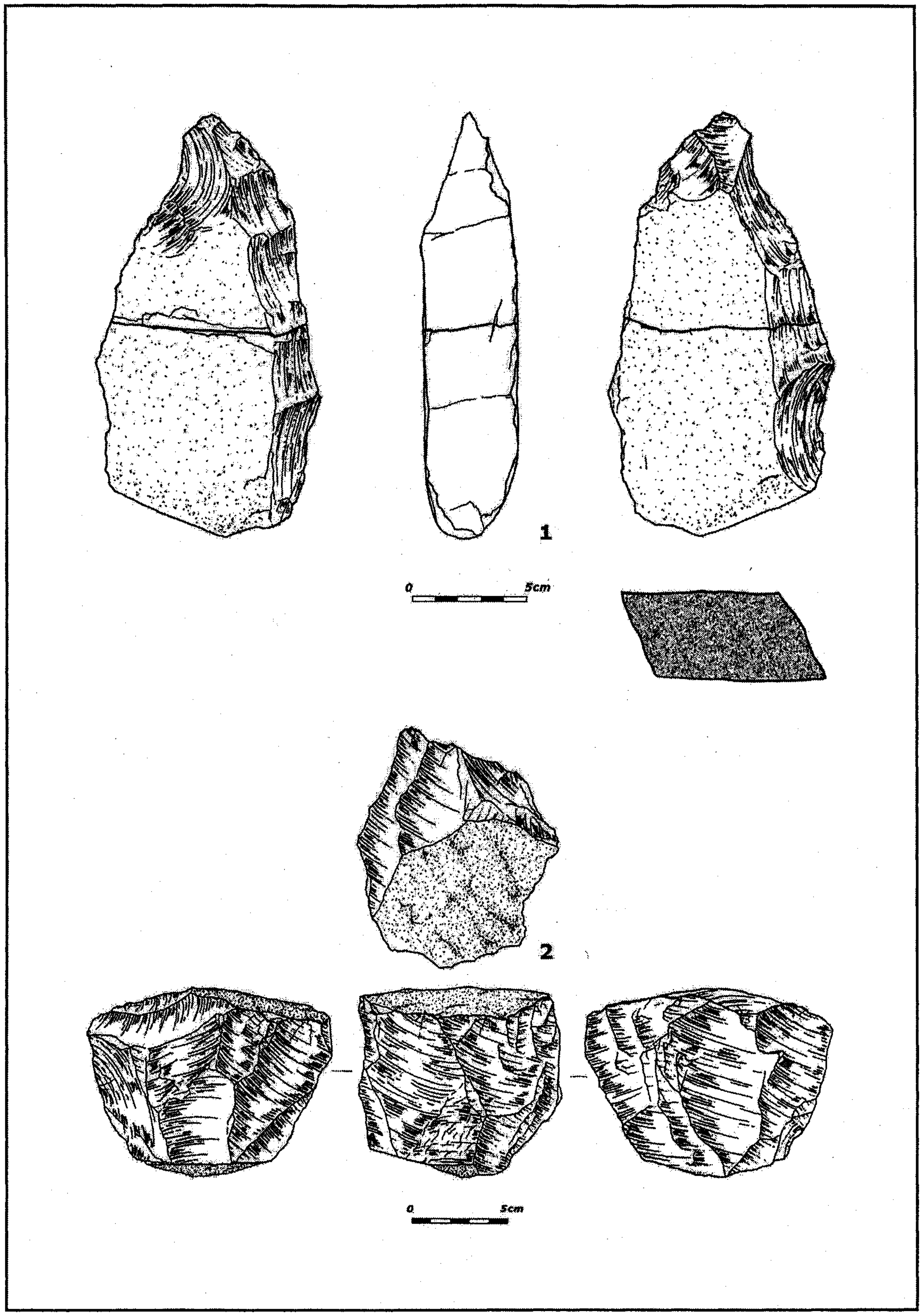


Fig. 4.9. Surface collections from the Jangsanri site
(1: handaxe, 2: tabular core, re-drawn from Yi 2002: 93- 94)

It is, however, still questionable that these surface collections belong to the same context as the original *in-situ* assemblage discovered from the lower level. Because of poor preservation, the upper part of stratigraphic column is almost entirely disturbed and some younger artifacts were possibly transported out of their original context, finally to be discovered on the surface. Compared to the original assemblage from the lower part which is older and "primitive," it can be arguably suggested that the somewhat technologically enhanced form of handaxe and highly modified bipolar core from the surface resulted from a more advanced technology that was practiced later.

(3) Juwolri and Kawolri
: the Technological Multitude

1. Site Location and Previous Research

A. Location of the Juwolri and Kawolri Sites

The Juwolri and Kawolri sites were discovered in the late 1980s, and first excavated in 1993 by archaeologists from Seoul National University (Yi and K. D. Lee 1993). These two sites are situated on the border between Yeonchon County and Paju City at the midstream turning point of the Imjin River. The site area is divided by Autoroute No. 37 into two localities: Juwolri (the west side) and Kawolri (the east side; Fig. 4.10.). The average altitude of the former is about 35m (amsl) while the latter is slightly lower because of the smoothly eastward-tilting terrain.

The site area is surrounded by low hillsides and was covered with floodplain deposits transported by the Imjin River channel flow. In contrast to the Chongokni and other sites of the upstream area, the evidence of any lava flow is almost absent. Previous excavation (Yi and K. D. Lee 1993) revealed that basalt outcrops developed only near the river channel and the debris of basaltic nodules was unevenly distributed in the site area. Considering its location, this area falls in the marginal zone of lava flow intrusion and some subsidiary clastic debris was accumulated as a result of fluvial activity.

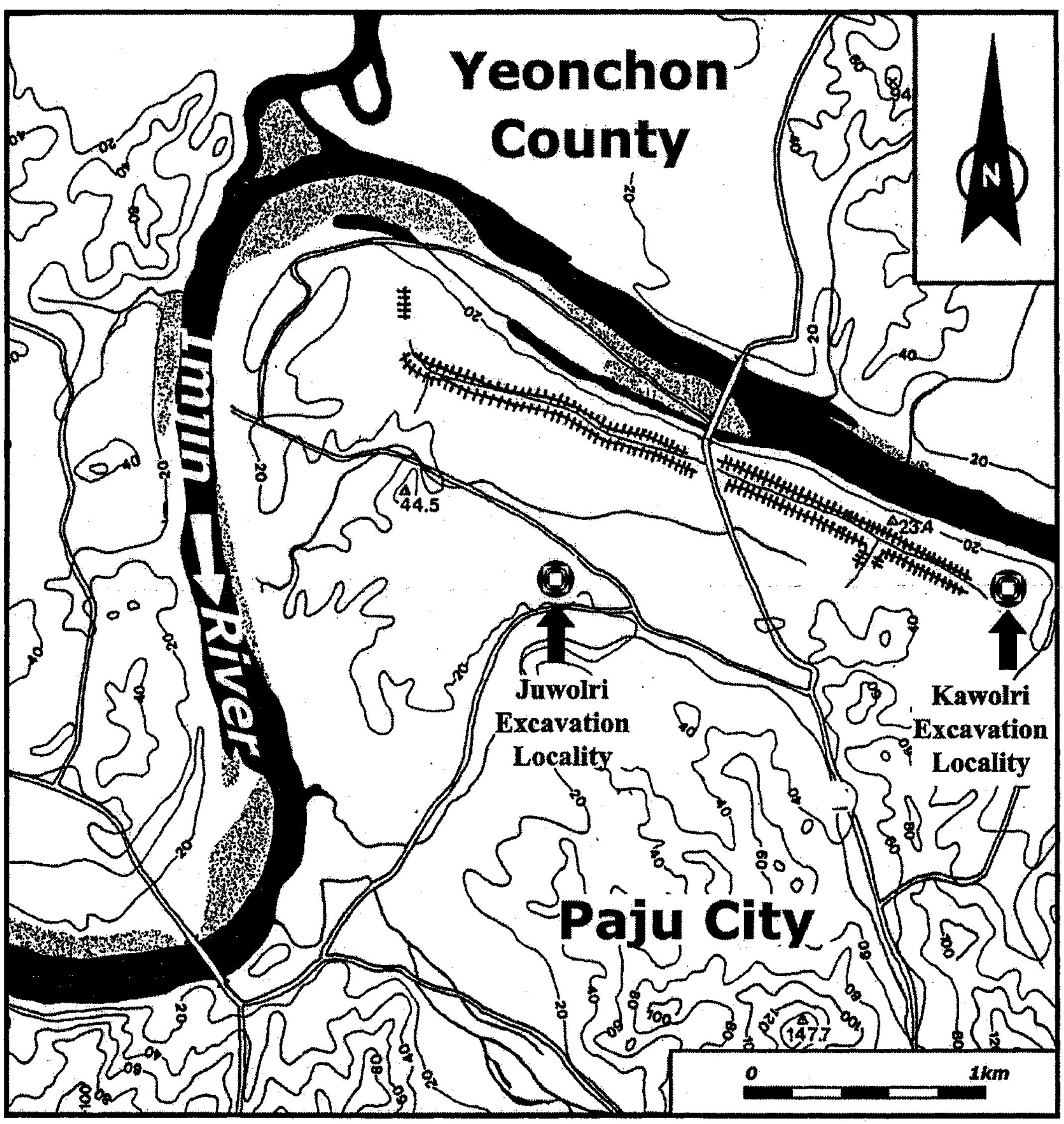


Fig. 4.10. Location of the Juwolri and Kawolri sites

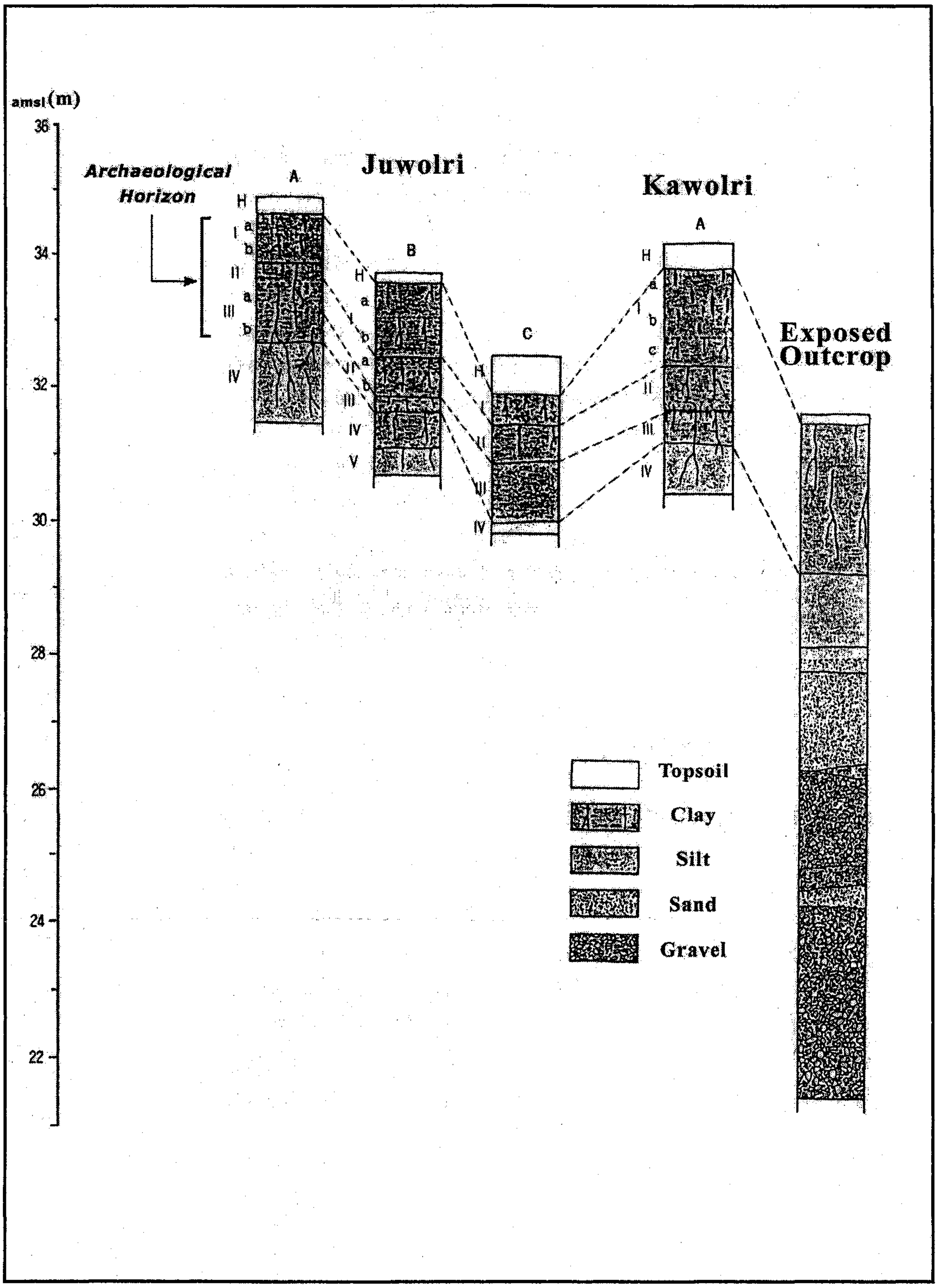


Fig. 4.11. Stratigraphic correlation of the Juwolri and Kawolri sites with a well-exposed outcrop column from vicinity (Re-drawn from Yi and K. D. Lee 1993: 16)

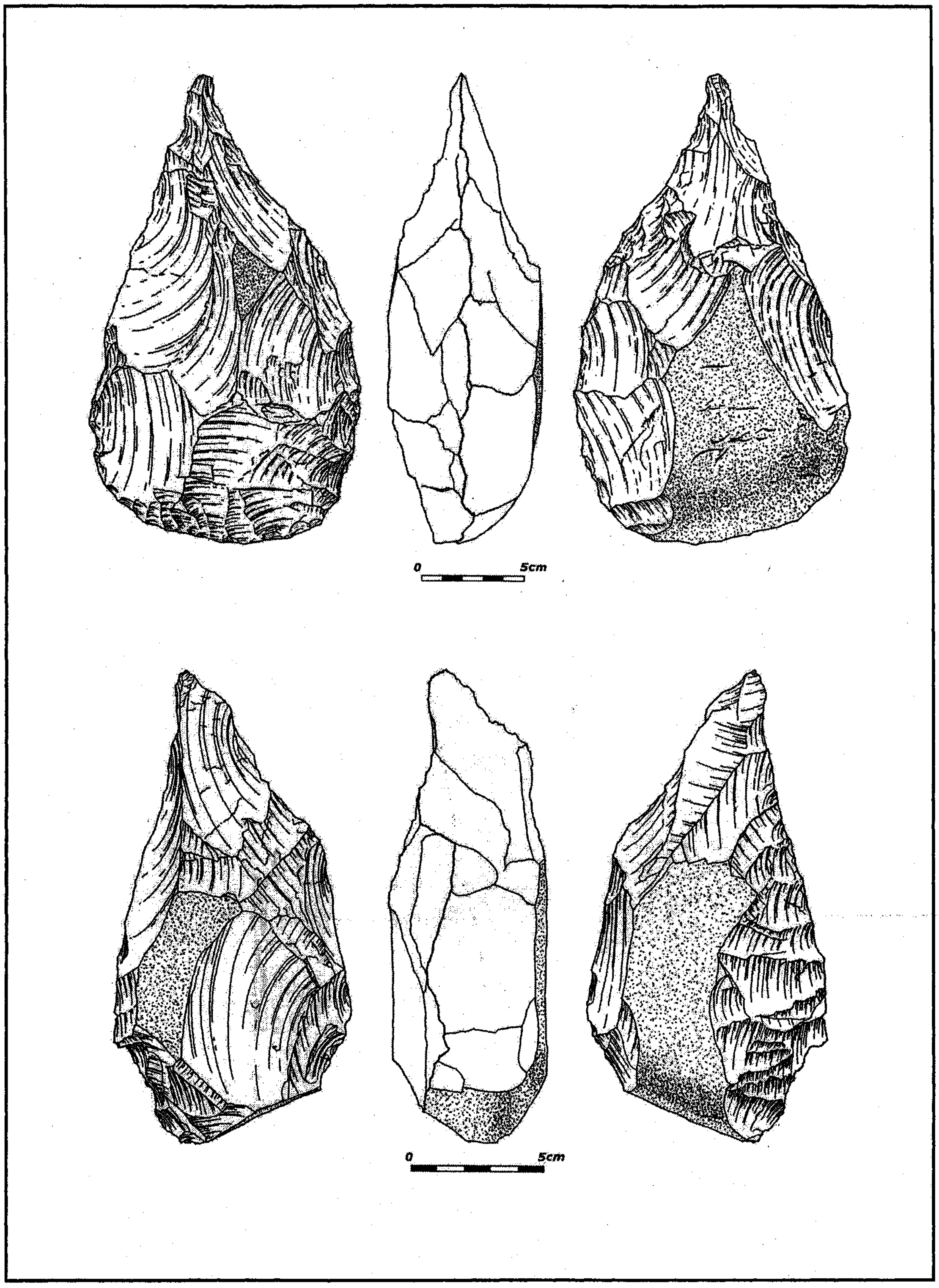


Fig. 4.12. Handaxes from the Juwolri site
(Re-drawn from Yi and K. D. Lee 1993: 25, 27)

Once the lava reached past the confluence of the Imjin and Hantan river channels, its advancing velocity was gradually slowed down because of the lower gradient of the river bed (Yi 1989, 1996). The width of the river valley expands in this section so that the lava flow did not block the entire cross-section of the valley. As a result, a large amount of clastic sediment was transported by the flooding of the saturated Imjin River channel (Yi 1996) along the marginal sides of the lava flow and finally deposited around the Juwolri and Kawolri area. Upon this, slopewash sedimentation from adjoining hillsides produced a poorly sorted sequence of intermingled colluvial deposits.

B. Previous Excavation Results

Because the area around the Juwolri and Kawolri sites has been under development since the 1970s, most of the archaeological context was badly disturbed, resulting in surface collections often outnumbering the *in situ* collections. From the excavation in 1993, Yi and K. D. Lee (1993) presented a general stratigraphic sequence of this area (Fig. 4.11.). The archaeological horizon is distributed within the reddish brown silty clay layer above the coarser yellowish brown one around 32- 34m (amsl). Except for the scattered basalt nodules at the riverbank area, direct evidence of the lava flow is not observed.

The Juwolri and Kawolri areas are one of the most handaxe-abundant locations in East Asia, and the morphological complexity of its assemblage is far superior to other known sites in this region. Apart from handaxes, small tools made of fine-grained quartz were also discovered, including a meticulously retouched tool resembling the Châtelperronian point (Fig. 4.13. #1), a canted point with ventral retouches (Fig. 4.13. #2), and several trapezoids (Fig. 4.13. #3). These small tools strongly suggest that the IHRA assemblages are not exclusively composed of large tools such as handaxes and cleavers.

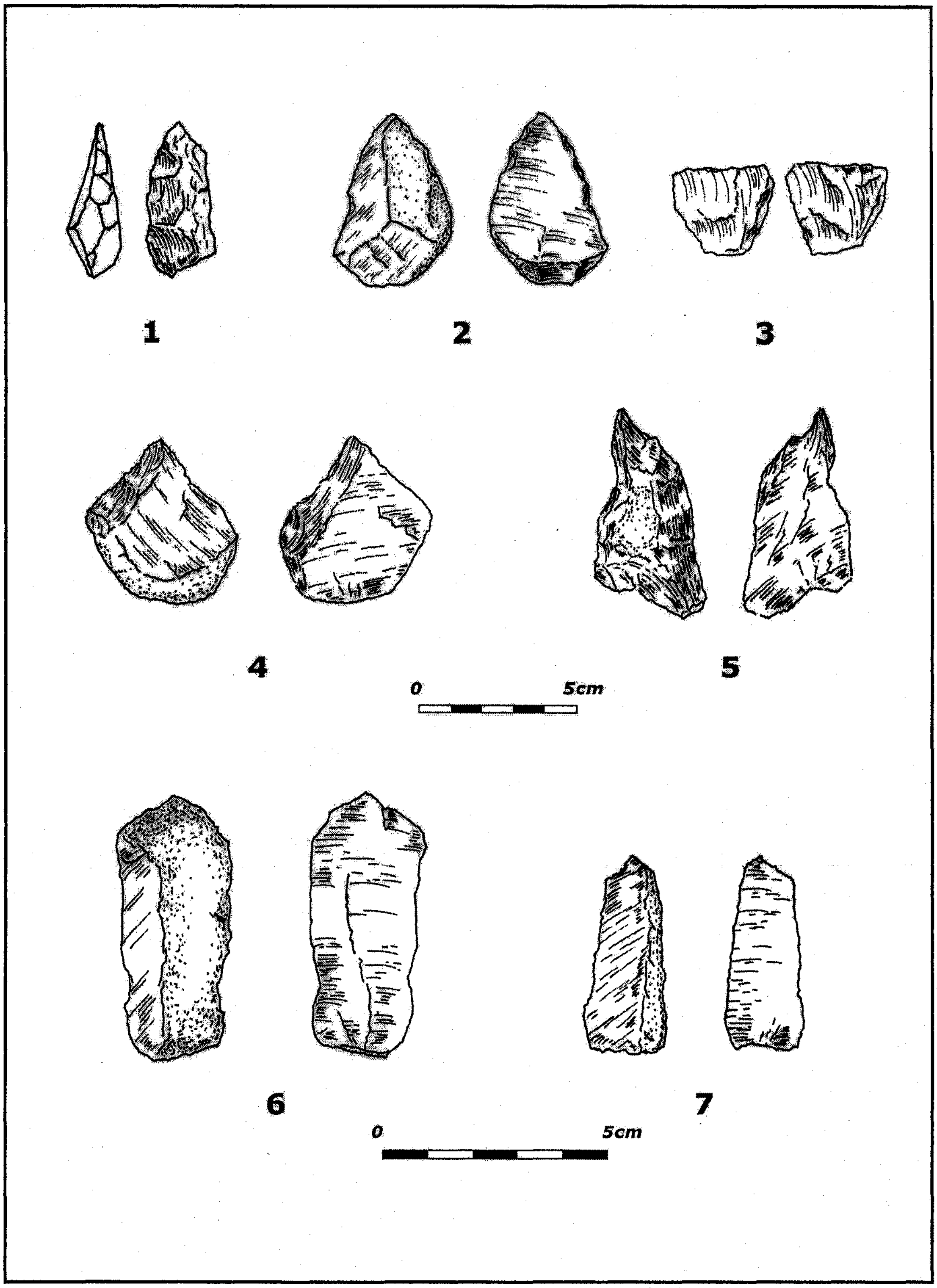


Fig. 4,13. Small tools and debitage from the Juwolri-Kawolri sites (1: backed knife; 2: canted point; 3: trapezoid; 4: notch; 5: borer; 6-7: elongated flakes)

Given these morphologically unique small tools and exceptionally delicate handaxes, it is clear that the design consideration of the Juwolri/Kawolri technology was more fully developed than those of other archaeological assemblages in the IHRA. According to the shapes of the various handaxes, a concrete plane scheme seems to have figured into their shaping techniques. In addition, the predominance of relatively fine-grained quartz and the exquisitely finished small tools suggest that some advanced technological organization was strategically maintained by the Juwolri-Kawolri hominins compared to other assemblages in the IHRA.

2. The Excavation Work and Results

A. Juwolri Excavation and Stratigraphy

The fieldwork at the Juwolri and Kawolri sites was designed to reveal any undisturbed stratigraphic sequence and to locate the original horizon of artifact concentration. The excavation area at the Juwolri site is about 2km south of the main Imjin River channel and six 4×4m grids were distributed over the downhill area avoiding the currently inhabited zone by local residents (Fig. 4.14.). Most of the original stratigraphic sequence was already destroyed by recent human activity, so that only one grid (N5E4) showed an intact geological context. This made a stratigraphic correlation across the whole excavation area impossible.

In spite of thick humus, the reddish brown silty clay layer had a set of well-developed cracks on the top. Most artifacts were retrieved from this layer above the border of the yellowish brown silt/sand layer; and this find corresponds to the previous excavation result (Yi and K. D. Lee 1993). Above the artifact horizon, a fine-grained, light-yellow layer of clay sediments covers the cracks (Fig. 4.15.). This layer is rarely found in the IHRA, and only in some of the high altitude areas of the upper Hantan River (*e.g.* the Janghungri site, see the later part of this chapter; Choi, B. K. 2001). No artifacts were found in this layer.

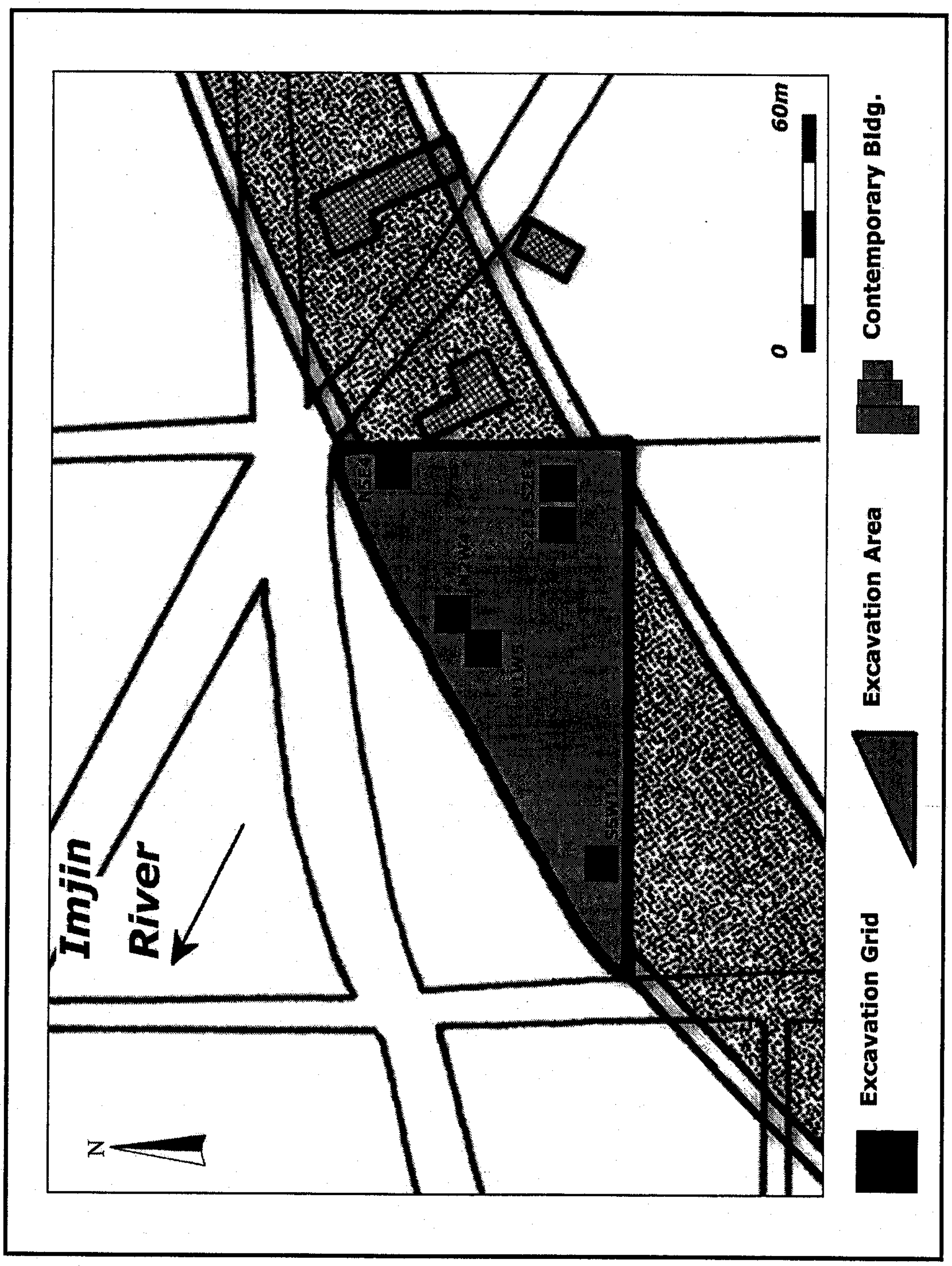


Fig. 4.14. Excavation Layout of the Juwolri site

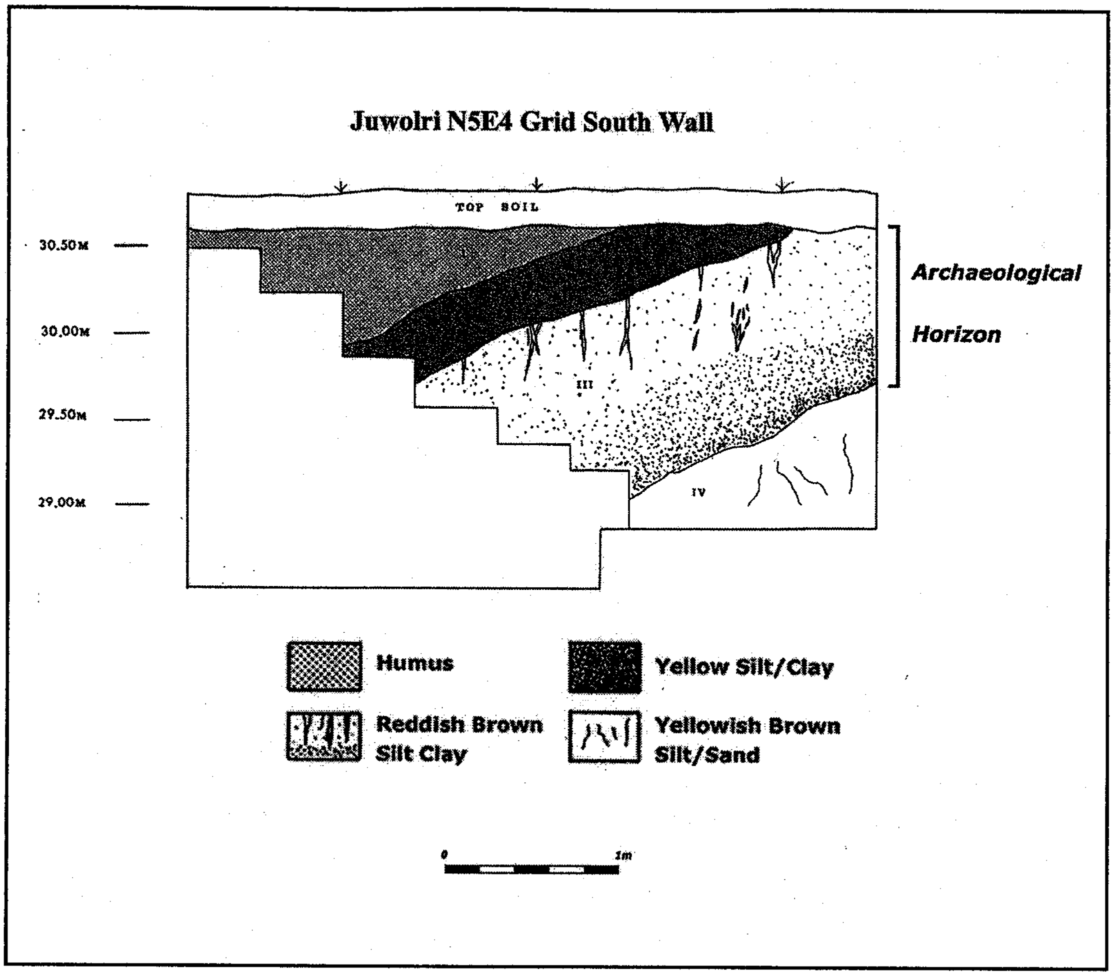


Fig. 4.15. Stratigraphy of N5E4 Grid from the Juwolri site

B. Excavation Layout, Stratigraphy and Age of the Kawolri Assemblage

The Kawolri site is about 1.2km south of the Imjin River. The main excavation area is located in the foothills of the nearby mountain. Sixteen rectangular grids were excavated but only the eastern sector of the site area yielded an undisturbed archaeological horizon: about 95% of the artifacts were discovered there (Fig. 4.16.). A 20m-long stepwise trench (TR of Fig. 4.16.) was laid along the hillside ridge to establish the stratigraphic sequence and to investigate the site formation processes. An IRSL date (51±23 Kya) was obtained from a sample at *ca* 32m (amsl) which was about 1m below the artifact concentration.

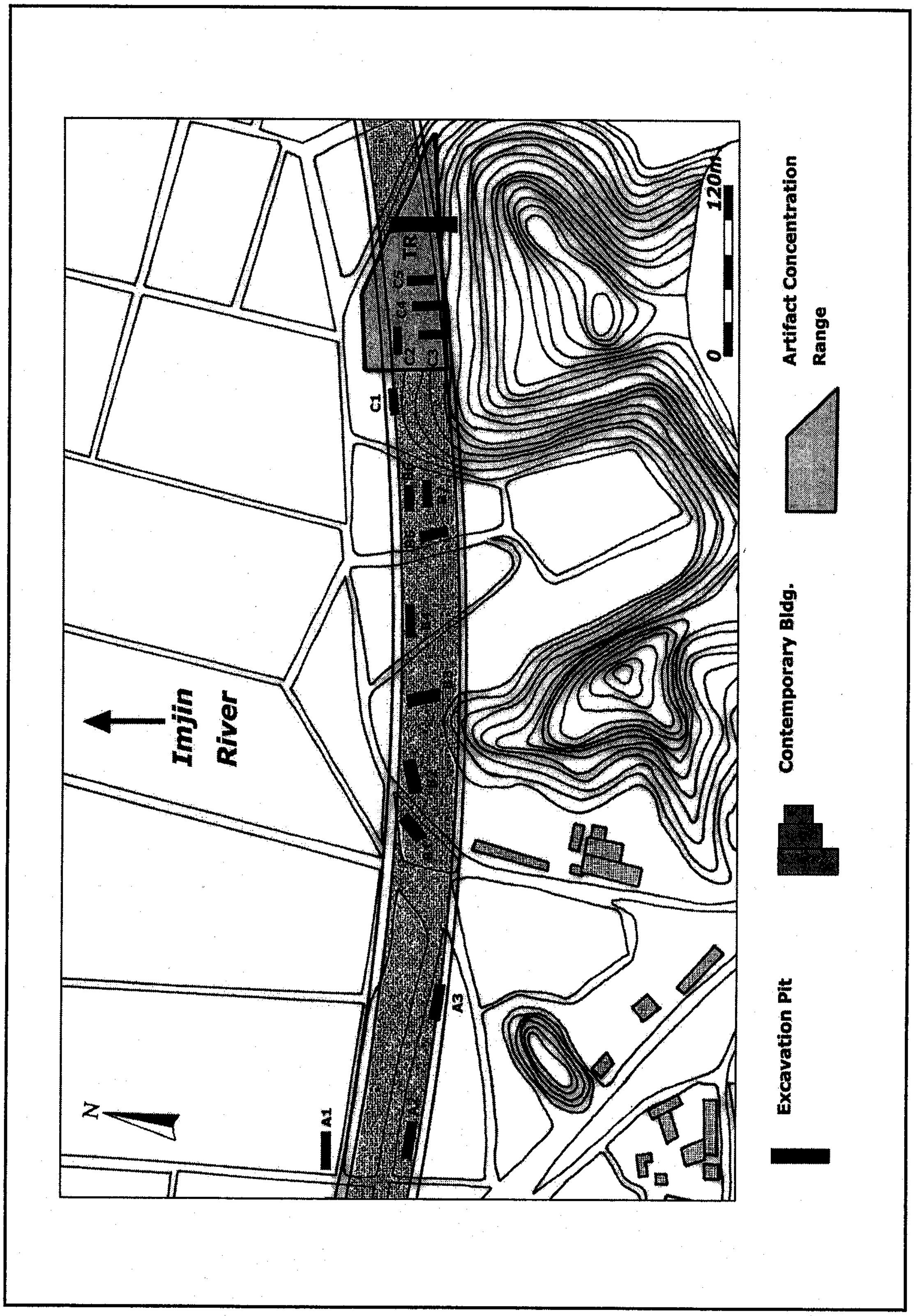


Fig. 4.16. Excavation Layout of Kawolri site

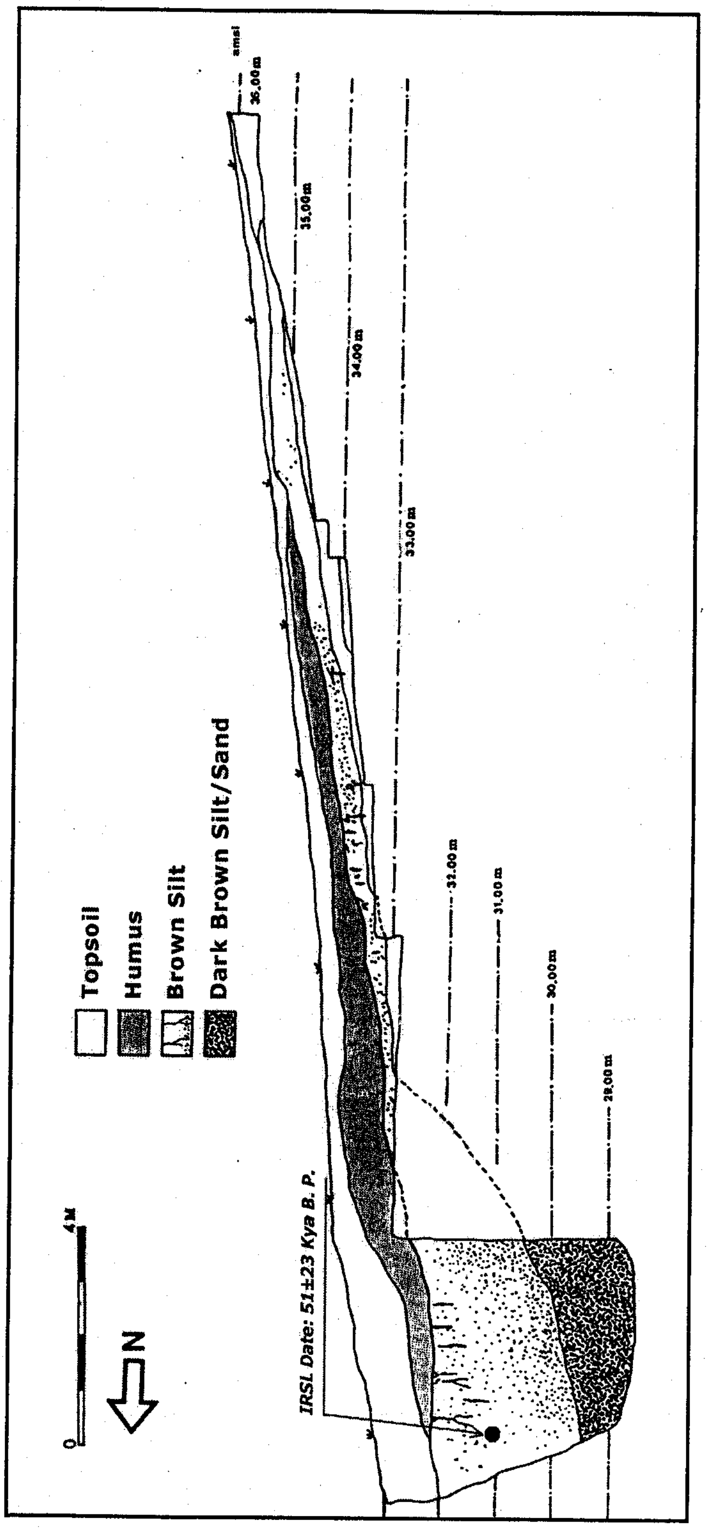


Fig. 4.17. Stratigraphy of the Kawolri Trench

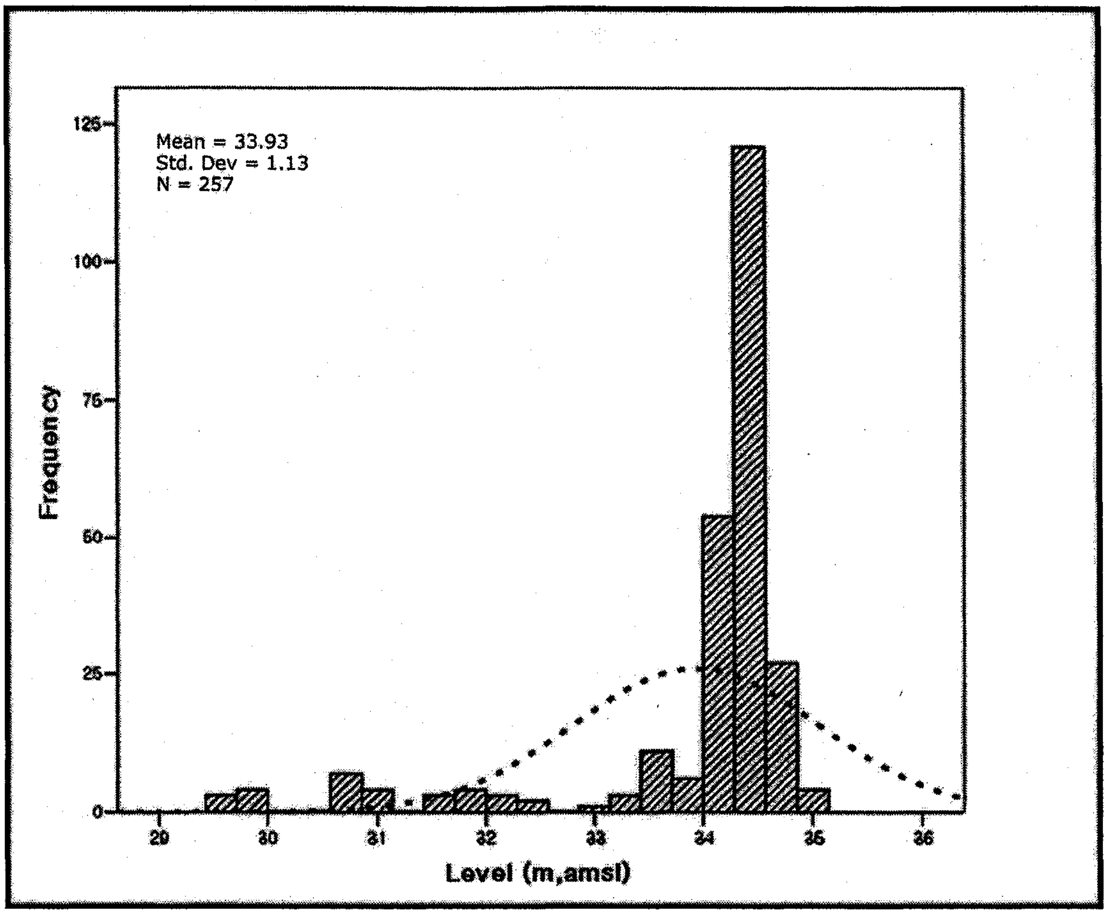


Fig. 4.18. Vertical distribution of artifacts at the Kawolri site

The stratigraphic sequence of the Kawolri site is different from those of the Juwolri and other IHRA sites. From the bottom up, there was dark brown silty sand, then brown silt, and topped with disturbed humus and topsoil (Fig. 4.17.). Because the river channel runs 1- 2 km north of the Kawolri site, the area is almost beyond the floodplain zone. In general, sediments of the site are dark-toned and saturated with decayed organic components. The particle size is relatively coarse and poorly sorted, possibly deposited as a result of slope-washing activity over the pediment. According to the characteristics of soil texture, the overall deposits were composed of weathered colluvium originating from the surrounding hills rather than of fluvial sediments.

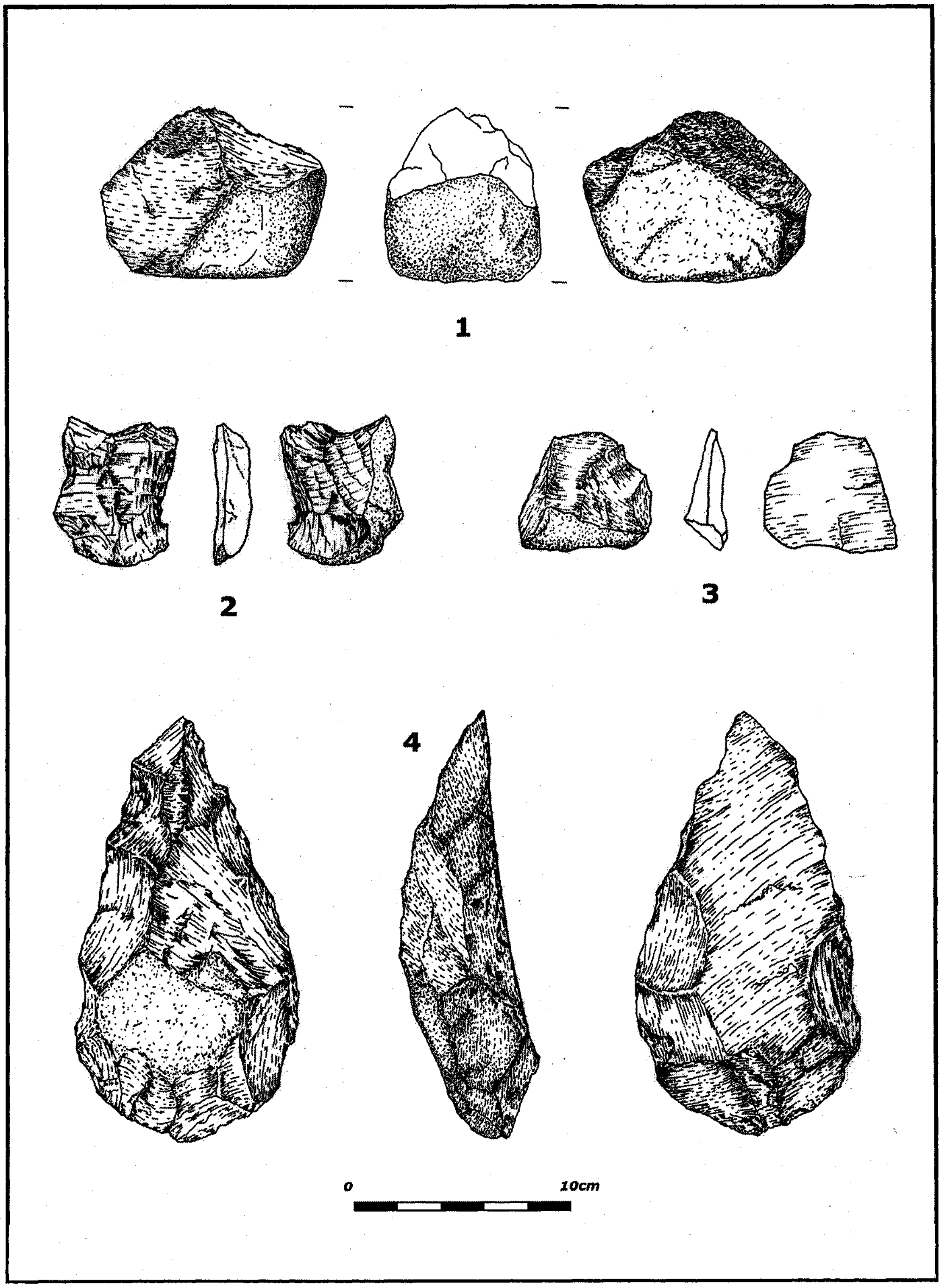


Fig. 4.19. Artifacts from the Juwolri site
(1: chopper- N2E4-1, 2: flake- S2E3-3, 3: flake- N5E4-4, 4: handaxe; S2E3- 8)

The archaeological horizon is concentrated within the brown silt layer below the crack zone. Although tilted down northward, the horizon is primarily located at the level of 34- 5m (amsl), a relatively high altitude (Fig. 4.18.). Based on the IRSL date of *ca* 51 Kya (Nagatomo *et al.* 2005), the cracks on top of the brown silt layer were probably formed during the dry and cold phase of OIS 2 (Han 2004; Yi 2000). Therefore, the age of the Kawolri assemblage is estimated to be the later part of OIS 3, possibly 30- 50 Kya. The temporal gap between the source of the IRSL sample and the archaeological horizon is not precisely known because the silt deposits between these two levels are poorly sorted and intermingled; the artifact horizon is obliquely distributed following the gradient of the hill slope as well.

3. Characteristics of Lithic Assemblages

A. Raw Material Properties and Availability

Common to the IHRA, the major raw material is quartz and quartzite. However, in contrast to the Juwolri, the Kawolri assemblage is composed exclusively of fine-grained quartz which is more advantageous for making sharp-edged debitage than the coarse-grained quartzite. This fine-grained quartz tends to fracture well, generating strong tools with reliable edges. Because it is not as easily available as the crude quartz embedded in small veins within the exposed outcrops, this fine-grained quartz was probably collected elsewhere and brought into the site area as part of a raw material utilization strategy.

Another important property of fine-grained quartz is its "anisotropic" fracture mechanics. Because of uneven heating and pressure during its lithogenesis, the SiO_2 crystals are irregularly cemented which triggers laminar splitting by a simple shear stress (Klein and

Hurlbut, Jr. 1993). This textured structure of the quartz makes it relatively easy to reduce the original nodule to make small tools of diverse shapes and sizes. For improvising small tools in immediate response to different functional needs, this anisotropic property of fine-grained quartz furnishes a selective advantage regardless of the shape and size of blanks.

B. Artifacts from the Juwolri Site

According to the excavation results, the artifacts from the Juwolri site consist of some large tools (*e.g.* choppers and a handaxe) and casually detached flakes with minimal retouches. Because of the small number of lithic artifacts (32 specimens and 3 from the surface collection), no quantitative approach to the assemblage characterization is appropriate. Although found out of its original context, a well-made handaxe (Fig. 4.19., #4) suggests a standardized manufacturing procedure and morphological design, a so-called "imposed form," had been established in the Juwolri and Kawolri area. Since most handaxes in this area had been exclusively manufactured with relatively high quality material, such as fine-grained quartz or sandstone (Yoo 1997), it can be supposed that specific rock types were selectively procured for the manufacture of certain tool types. Certainly, the quality of these selected materials is suitable for intensive shaping of such standardized tools as the handaxe.

C. Characteristics of the Kawolri Assemblage

Fourteen percent of the Kawolri assemblage (n=289) was composed of shaped tools, including choppers, a handaxe, and several distinct types of small tools made of debitage (Fig. 4.20.). Although the quantity of large tools is limited, a broken piece of handaxe shows apparently intensive shaping and bifacial trimming (Fig. 4.21., #2). The groups of small tools show diverse types, including points, rabots, and borers, as well as normal scrapers and notches. Miscellaneous types such as hammers, anvils and manuports are absent, but relatively small and heavily reduced cores are included.

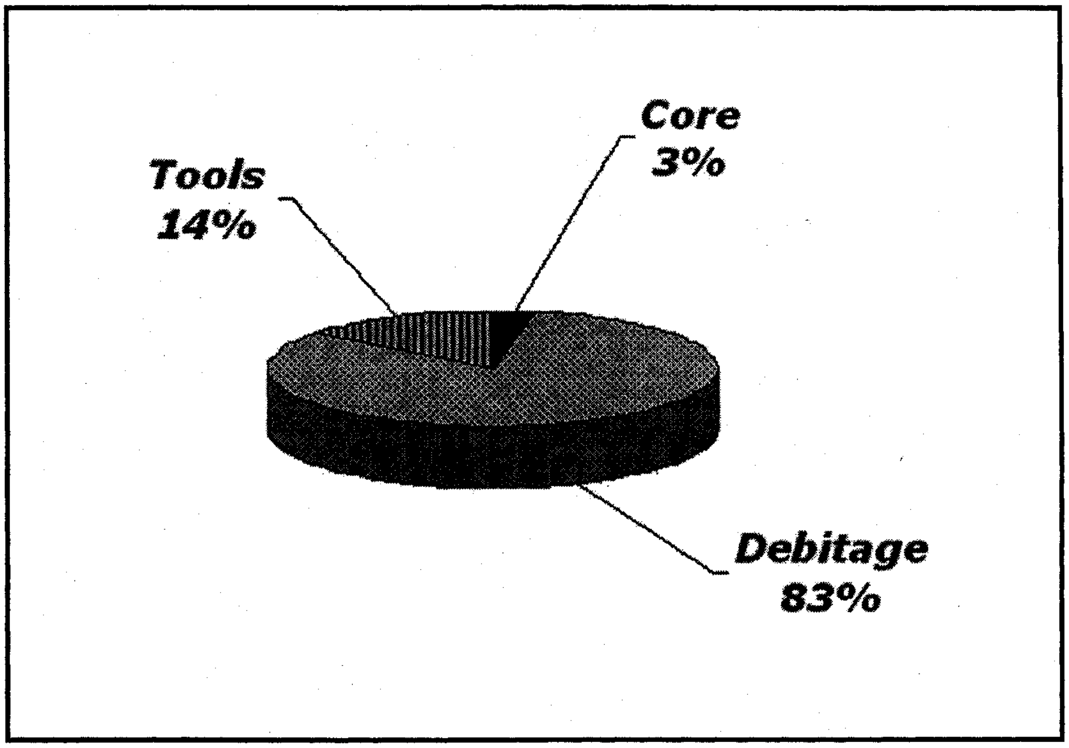


Fig. 4.20. Lithic composition of the Kawolri assemblage

Small tools are made of both irregular debitage and normal flakes. Broken parts of flakes and angular fragments were actively utilized as blanks for small tools and the breakage was possibly influenced by the intentional fracture of original flakes for acquiring suitable sizes. For example, sidescrapers are manufactured either with snapped flakes without platform (*e.g.* Fig. 4.22., #1) or with distal flake fragments (*e.g.* Fig. 4.22., #2). Some points are made by shaping the distal end of normal intact flakes (*e.g.* Fig. 4.22., #5) but others were formed by marginally re-sharpening the originally acute angular debitage (*e.g.* Fig. 4.22., #6 and #7). Likewise, trapezoids were often produced by slightly modifying or altering the lateral edges of broken flakes (*e.g.* Fig. 4.22., #8, #9, and #10).

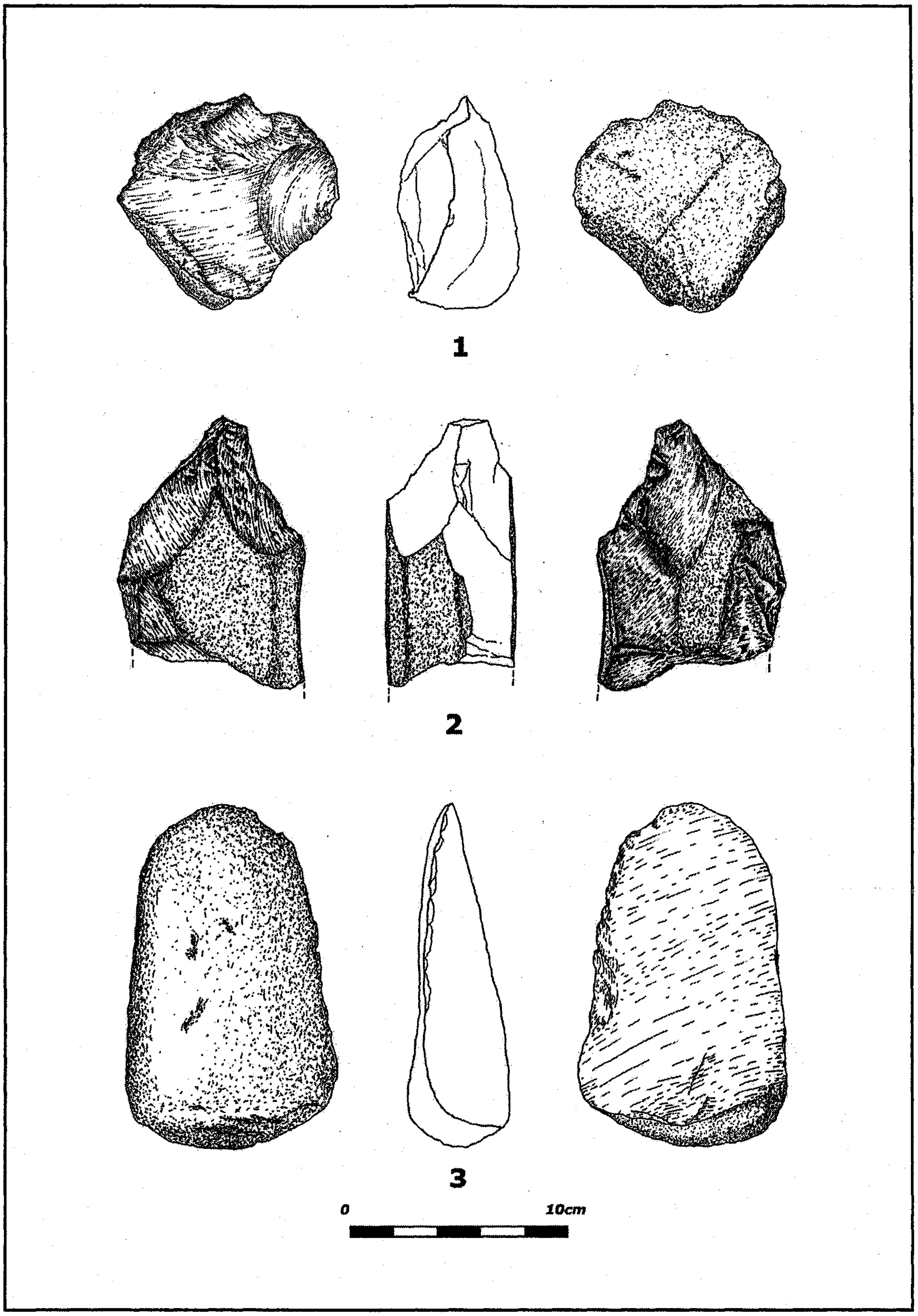


Fig. 4.21. Large Tools from the Kawolri site

(1: chopper- TR-144; 2: handaxe (broken), TR-15; 3: large Scraper, TR-44)

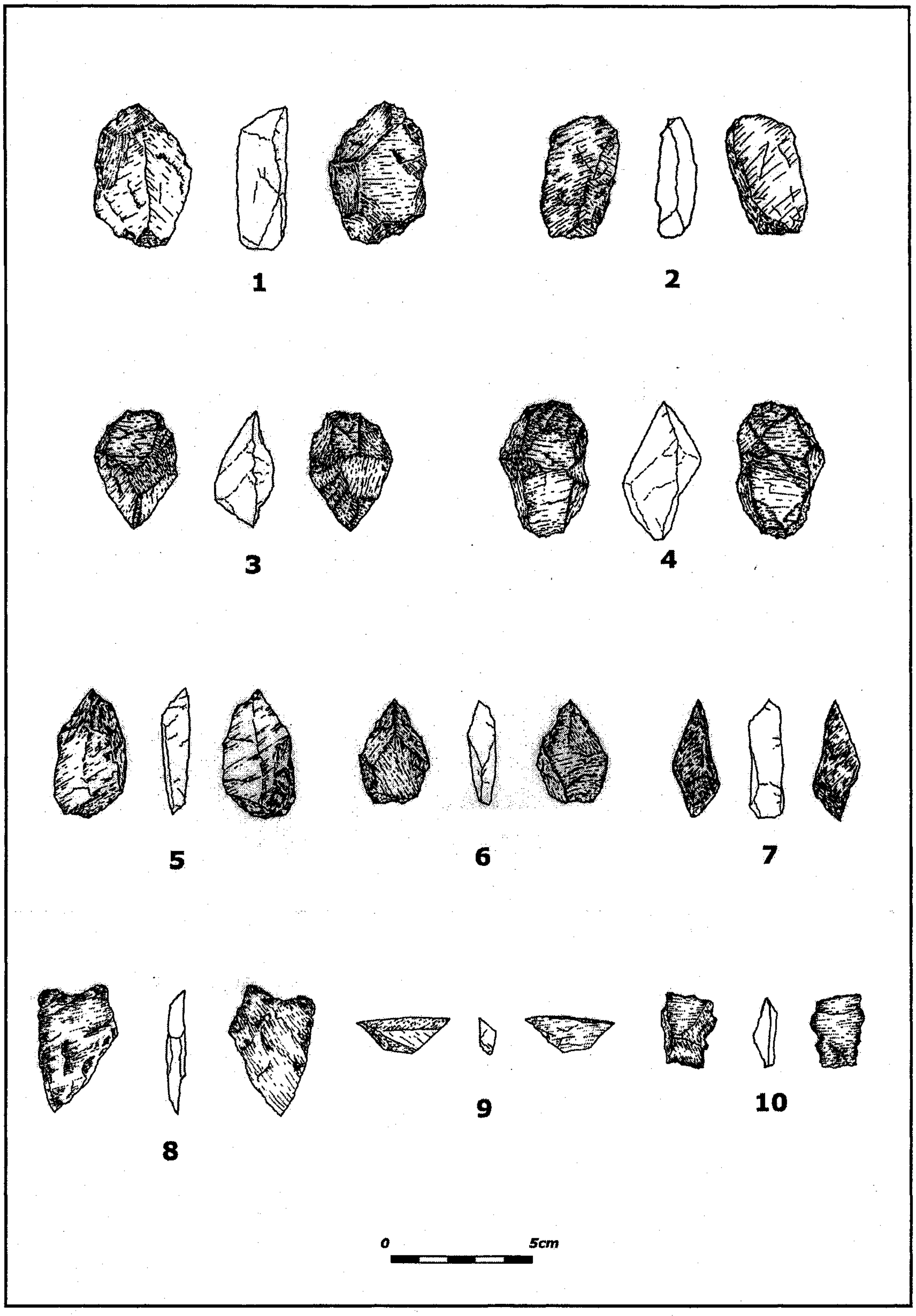


Fig. 4.22. Small tools from the Kawolri site
(1- 2: sidescraper- TR-89, 38; 3- 4: endscraper- TR-120, 81;
5- 7: point- TR-9, 13, 16; 8- 10: trapezoid- TR-10, 28, 14)

(4) The Age Determination of the Archaeological Horizons of the Midstream IHRA

1. Fieldwork Design and Strategy

In order to solve the controversy over the age of the Chongokni assemblage and the complex geological processes that occurred in the middle Hantan River, a regional field survey to collect samples for a new dating analysis was carried out. The geological processes of the IHRA that formed the context for hominin occupation can be summarized as follows.

***1) Pre-volcanic Stage*:** Before the volcanic eruption, the CRV had undergone a series of tectonic movements resulting in several fault zones. The Imjin and Hantan channel system produced some fluvial deposits represented by the Baekeuri Formation. Hominin occupation during this stage is rarely recorded except for the case from the Jangsanri site.

***2) Volcanic Stage*:** During the volcanic period, the lava flow intruded into the CRV. The main channel was transformed into multiple divergent streams over the lava floor, sustaining its flow but at a reduced rate. Some small streams were entirely blocked by the lava dam to make temporary swamps.

***3) Post-volcanic Stage*:** With the termination of volcanic activity, the river channel recovered its original discharging energy. Fluvial deposits developed around the floodplain area and the evidence of hominin occupation appeared across the whole range of the IHRA.

These three stages are the basic temporal framework for establishing the chronostratigraphy of the IHRA. The fieldwork was carried out as three tasks: 1) appropriate samples have been collected for chronometric dating before and after the volcanic eruption as well as direct samples of basalt bedrock; 2) a well-established cross-section of the entire stratigraphy of the middle Hantan River has been established; 3) the configuration and topography with the relevance to the formation of the terrain has been achieved. The sampling points and dating methods are set to be under similar conditions as those of Danhara *et al.* (2002) and Naruse *et al.* (2003) for the purpose of re-examining their problematic dating results.

2. Fission Track Dates below the Basalt

A. Gravel and Sand Sediments under the Lava Flow

In order to obtain the initial age of the lava flow, the ages of sediments directly below the basalt bed were obtained. It is widely known that before the volcanic eruption, the margins of the CRV were overlaid with various patches of gravel and sand-dominant sediments, one of which is the well-developed Baekeuri Formation distributed around the midstream Hantan River (see Ch. III, p. 50). However, no solid chronometric data of these sediments have been published with the purpose of exploring the initial age of the lava flow. Consequently, 18 samples were obtained from a well-stratified outcrop of gravel and sand sediments of fluvial origin distributed beneath the bottom of a thick lava flow. The location of the primary sampling spot is at the Chongokni site area facing the meandering channel flow of the Hantan River (the upper-left asterisk of Fig. 4.28.). These samples were processed by fission-track dating (Table 4.2.).

B. The Fission Track Dating Method

Fission-track (FT) dating is a chronometric method using tracks made by the spontaneous fission of isotopes such as ^{232}Th, ^{235}U, and ^{238}U included in silicate sediments containing apatite and zircon minerals (see Westgate *et al.* 1997 for the details on the basic principles and techniques of the fission-track dating). In order to measure the age of sediments by the FT method, the minerals must have been heated enough until previous fissions were all erased ("reset" or "totally annealed"; Fleischer, Price, and Walker 1975), usually 100°C for apatite and 240°C for zircon. The usual temperature of normal lava (above 1000°C) is believed to completely reset the minerals on the surface of sediments over which it flows. The fission tracks produced after the reset time are measured by the external detector method for dating the age of individual mineral particles (Yi, Y. I. Lee, and Lim 2005).

Out of 18 samples, only 6 had a sufficient amount of zircon to facilitate the dating (sample No. 4, 7, 10, 16, 17, and 18 of Table 4.2.). Sample No. 15 was used as a supplementary sample that was collected from the neighboring Seongokri area of Yeonchon County where another well-exposed outcrop of the basalt bed shows clear contact with the pebble-dominant sediments. The Seongokri area is the southernmost known stretch of lava flow from the upstream area of the Imjin River valley (Yi, Y. I. Lee, and J. W. Kim 2004). Sample Nos. 16 and 17 were acquired from the spot where Danhara *et al.* (2002) obtained samples to establish their dates using the FT and the K-Ar methods.

The FT dates of the samples below were acquired using the newest automatic staging system after controlled chemical processing of the raw sediment samples was done. The apparatus for measuring the track density was a Nikon Optiphot-II polarizing microscope (Yi, Y. I. Lee, and Lim 2005). Of six dates, the very old ages of Sample Nos. 17 and 18 are believed to be the result of incomplete resetting by lava heat because these samples were acquired from thin sections of lava-covered pebbles. Relevant to this, it should be noted that the reset rate is affected by the density and consolidation of clastic sediments, and that sand particles are more liable to be reset by lava heat than are any associated cobbles and pebbles.

No.	Sample Code	Sample Type	GPS Coordinates	Age (Mya)	Remark
1	031128-3	Pebble	N38° 00' 08" E127° 00' 28"	N/A	154 Kya by IRSL and 200 Kya by ESR (Nagatomo *et al.* 2005; Yi 2005)
2	031128-4	Pebble		N/A	
3	031128-5	Sand		N/A	
4	031224-1A	Sand	N38° 01' 06" E127° 04' 43"	**0.40±0.10**	Yellow sand/gravel deposit at the northeastern riverside of the Hantan River at Chongokni (Yi, Y. I. Lee, and Lim 2005)
5	031224-1B	Sand		N/A	
6	031224-1C	Sand		N/A	
7	031224-2A	Sand	N38° 01' 28" E127° 04' 43"	**0.43±0.11**	
8	031224-2B	Sand		N/A	
9	031224-2C	Sand		N/A	
10	031224-3A	Sand	N38° 01' 21" E127° 04' 36"	**0.41±0.11**	
11	031224-3B	Sand		N/A	
12	031224-3C	Sand		N/A	
13	040115-2	Pebble	N38° 01' 21" E127° 00' 26"	N/A	From Samgotri, the upstream area of the Imjin River
14	040115-3	Soil		N/A	
15	040129-1	Pebble	N38° 06' 00" E127° 01' 18"	N/A	From Seongokri, the assumed southern limit of the lava flow from upstream Imjin River valley
16	040129-3	Pebble	N38° 01' 08" E127° 08' 25"	**0.42±0.17**	From the outcrop at Baekeuri, the uppermost part of the Baekeuri Fm.
17	040225-1	Pebble	N38° 02' 32" E127° 03' 36"	> 20	Same place as the sample S37-823 of 0.50±0.03 Mya by K/Ar dating from Danhara *et al.* (2002)
18	Y-13	Pebble	N38° 02' 42" E127° 03' 29"	> 20	30m southward from Sample No. 17

Table 4.2. Fission-track dates of gravel/sand sediment below the lava flow in the IHRA (Dated by Laboratory of Sedimentary System, Seoul National University, Korea, 2005, directly quoted from Yi, Y. I. Lee, and Lim 2005)

C. Dating Results and Correlation

According to Table 4.2., three dates (Sample Nos. 4, 7, 10) from the Chongokni site show well-clustered ages. These dates are around the same age as that of the Baekeuri Formation (Sample No. 16), all of which are statistically significant at the 95% level of probability. These four FT dates directly demonstrate that the basalt bed was formed above the ancient fluvial deposit approximately *ca* 0.4 Mya. Therefore, previously published K-Ar dates of the lava flow exceeding this age need to be treated as overestimations of the actual dating, *e.g.* 0.6231±0.018 Mya by Bae (1988); 0.49±0.05, 0.50±0.03, 0.85±0.03, 0.57±0.03 Mya by Danhara *et al.* (2002) (see Samples No.12, 13, 15, 16 of Table 3.2 at Ch. III, respectively). Considering the technical limitation of the K-Ar dating method, these "older" dates are probably the result of either inappropriate sampling and/or abnormal K/Ar ratios caused by the weathering of the basalt samples (Walters 1997).

However, although closely concordant and statistically significant, these four FT dates should be only tentatively accepted as marking the initial age of lava flow. Because a single zircon particle contains only a low-density of spontaneous tracks, uncontrolled errors, proportional to the size of optically observed section, are liable to occur (Westgate *et al.* 1997). Also, because the age of the sample is quite young compared to the normal dating range of the FT method, the final result is highly dependent upon the number of spontaneous tracks; and even a single track can result in an overestimation of more than 10,000 years (Yi 2005).

Some data comparable with these FT dates are available. Choi J. H. *et al* (2004a) recently published a new isothermal TL date of 138±9 Kya (calibrated to 148±10 Kya considering the moisture quantity of samples) from the mixed sand-gravel deposits below the lava flow at the Chongokni area, the same context as the above FT dating samples. If this isothermal TL date is accepted, then the FT dates given above can be considered as a possible maximum (the oldest) age of the lava flow since uncontrolled errors (*i.e.* incomplete resetting and/or rounding-up of track measurement calculation) can increase the age readings and the resulting FT dates are vulnerable to overestimations. Taking all these circumstances into consideration, the estimated age of *ca* 0.4 Mya by FT dating can be an index for the maximum age of the lava flow.

3. K-Ar Dates of the Basalt

A. Geological Context of Lava Flow

According to the FT dates of the gravel-sand deposits, the actual age of the basalt will be younger than *ca* 0.4 Mya. The time span between the oldest and the youngest lava flow is not believed to be long because there is no evidence of stratigraphic unconformity within the basalt formation. There are only a few thin clinkers between lava flows (Yi 2004b), and these can be interpreted as the accumulation of intermingled clastic debris rather than the marker of major temporal gaps across the multiple lava flows. In addition, there is no evidence that these lava flows sequentially encroached upon the IHRA in a turbulent manner because current basalt bed appears very laminar and stable. Thus, it is hardly expected that the sequence of multiple lava flows marks an extended period of volcanic activities.

B. The K-Ar Dating Method

Six new K-Ar dates were acquired from three samples collected at the Chongokni and Shindapri areas where the original morphology of the lava flow is well-preserved and unweathered basalt rock samples are easily available. In order to ensure technical reliability, each sample was measured by two different K-Ar dating techniques: the isotope dilution method and the peak comparison method.

The isotope dilution method uses ^{38}Ar as the spike gas to measure the ratio of each isotope and it is not affected by any external factors such as the sensitivity of the measuring apparatus; but in case of young samples, especially below 1 Mya, the result tends to appear older because the absolute quantity of ^{40}Ar is extremely small (Nagao *et al.* 1996). The peak comparison method is the normal, conventional K-Ar dating which directly measures the quantity of isotopes.

No.	Sample Code	Dating Method	Age (Mya)	Remark
1	CHB1-A	Isotope dilution	0.939±0.020	From the same outcrop with S37-822 (0.49±0.05 and 0.85±0.03) of Danhara *et al.* (2002)
2	CHB1-B	Peak comparison	0.534	
3	CHB2-A	Isotope dilution	1.785±0.037	About 1m above sample No. 1 and 2
4	CHB2-B	Peak comparison	1.963	
5	SHB-A	Isotope dilution	**0.373±0.012**	Above the FT sample 2001032401 (96.0±15.2) of Danhara *et al.* (2002)
6	SHB-B	Peak comparison	**0.158**	

Table 4.3. K-Ar dates of basalt in the IHRA
(Dated by Geochronology Laboratory, Korean Basic Science Institute, Korea, 2000, quoted from Yi 2005)

As with the previous K-Ar dates (*e.g.* Kojima 1983; Bae 1988; Danhara *et al.* 2002), the results (Table 4.3.) are very confusing and even baffling. Apart from the overestimation of the dates, the range between the maximum and minimum dates is over one million years and some results are entirely inverted. Furthermore, the results of the two different methods show huge differences between each other and no specific patterns can be recognized between the age results and the methods. One could take a sarcastic position at this point and note that the results are simply more evidence that the K-Ar dates are one of the "usual suspects" responsible for the confusion and stalemate in determining the age of the IHRA archaeological horizons.

This problematic resut leads to two fundamental questions about the nature of the basalt strata and the limitation of the K-Ar dating method: 1) why are the results almost always unreliable, and 2) to what extent is the K-Ar dating reliable in determining the age of such relatively recent geological events? It is important to note that the lava flow directly and simultaneously covered the river channel, the river bed, the adjacent swamps, and the overbank area, all of which have the potential to vaporize large quantities of minerals and pyrolyzed organic materials that are critical to the ratio balance of atmospheric $^{40}Kr/^{40}Ar$. As a result of thermal transformation occurring at the hydraulic zone, large amounts of miscellaneous isotopes are usually converted to either ^{39}Ar or ^{40}Ar. Consequently, the estimated age at which the lava was cooled and consolidated into basalt rock cannot but be biased. Unfortunately, however, the relationship between the hydraulic condition of the sampling locations and the extent to which the dates are biased cannot be adequately addressed nor correlated for these conditions are unpredictable and stochastic. Therefore, it is still beyond the current capacity of the K-Ar method used in geological and archaeological research to establish the reliable ages of lava flows.

The unreliability of the dates also can be attributed to the relatively recent geological age of the basalt strata. Theoretically, the K-Ar dating method can be applied to the time beyond the coverage of ^{14}C AMS dating. Practically, however, if the events are too recent in geological time to allow the capturing and building up of enough ^{40}Ar for accurate average dating, the results can exceed or at least meet the full tolerance range of statistical errors

(Walter 1997). This tolerance range might be regarded as very minimal in a large geological time-scale of several billion years, but significantly enormous in an archaeological one which covers only a few million years at best. A method having higher resolution is certainly hoped for in the future but there is the serious constraint that the precision of the K-Ar dating is a function of the ratio of ^{40}Ar to ^{40}K remaining in a sample. As long as there is not enough argon gas in the sample, the dating result is always exposed to errors regardless of the degree of resolution of the measuring technique.

C. Re-examination of Previous K-Ar Dates

It is discouraging that currently no adequately refined dating method is available for the temporal range of the targeted lava flow and that the actual age of the basalt stratum has been able to be estimated analogically by using only "proxy" data. As noted earlier, the FT dates of the gravel and sand deposit beneath the lava flow suggests the oldest likely age (*i.e. ca*0.4 Mya; Table 4.1.) of the lava flow. According to the earlier established age of the Jangsanri Terrace (*ca* 0.23 Mya by Yi 2004a; Yi, Y. I. Lee, J. W. Kim 2004) which definitely predates the volcanic eruption, the lava flow must also be no older than this age.

Importantly, this more recent date for the Jangsanri Terrace would be consistent with the some "younger" K-Ar dates of the basalt: *e.g.* 0.108±0.158 Mya by Kojima (1983); 0.16±0.25 and 0.18±0.02 by Danhara *et al.* (2002, *i.e.* Sample Nos. 14 and 17 of Table 3.2.); 0.1384± 0.0057 and 0.1365±0.0054 Mya by Park, K. H. *et al.* (1996); and the Sample No. 6 of Table 4.3. All these dates can be taken as evidence against the "older" ages proposed by Bae (1988) and Danhara *et al.* (2002). In addition, some of these younger K-Ar dates independently correspond to the previously presented isothermal TL date of *ca* 148±10 Kya of the underlying gravel sediments (Choi, J. H. *et al.* 2004), demonstrating that the age of the basalt bed is quite younger than previously believed, and that the duration of the multiple lava flows was relatively short period compared to the entire time range of the IHRA geological history.

The approximate age of the basalt stratum, therefore, can be deduced or "squeezed" out of these correlative data and several young K-Ar dates. Notwithstanding the technical limitation of the K-Ar dating method mentioned above, the estimated age of the lava flow can be suggested as a wide range of *ca* 0.2- 0.13 Mya. This estimated range is consistent with these principles: 1) the age of the lava flow does not predate the FT and TL dates of the underlying sand-gravel sediments; 2) it is younger than three IRSL ages of the Jangsanri Terrace (see Table 4.1.). Taking this estimate as a provisional age of the lava flow, the duration of the volcanic activity is believed to fall within this time range.

4. Luminescence Dates above the Basalt Bedrock

A. Stratigraphy above the Basalt

Similar to the initial age, the terminal age of lava flow is to be determined by the date of contacting sediments on its top. Above the lava flow, however, the stratigraphic sequence is very complex and each unit was formed under the changing sedimentary conditions in the context of the rejuvenation of the Hantan River channels. The strata containing archaeological assemblages are distributed about 2-10m above the basalt bed depending on the altitude of each site location. The dates of sediments between the archaeological horizons and the basalt, therefore, can determine the duration of channel suspension (Lee, M. B. *et al.* 2001) prior to when hominin's occupation began in this area.

Sampling of an excavation profile at the Chongokni site was carried out in order to date this duration. The control pit of the 2004 excavation, which was a part of the fieldwork operation for this research, exposed a well-stratified cross-section covering the entire sequence of the IHRA deposits. The archaeological horizon was distributed at the altitude of about 58m (amsl) and the total height of the column of the stratigraphic profile was 8.5m. The control pit included almost every facies of the sedimentary environment that occurred in this area, and the stratigraphic units from bottom to top are as follows (Fig. 4.23.).

1) Basalt bed: Consolidated lava flow usually observed in the Chongokni area; partially hydrated by underground water and not suitable for the K-Ar dating method.

2) Grayish green lacustrine bed: About 30 to 50cm thick; not a regularly observed stratigraphic unit in the IHRA; often alternately interleaved with well-stratified varve-like thin bands of light yellowish brown and dark grayish green silty clay sediments.

3) Cross-bedded Coarse sand: Only observed in the river shore area; over 3m thick; prominent cross-bedding; lower part shows partly disturbed "trough cross-bedding"; upper part is well-stratified "laminar cross-bedding" with coarse sand particles coated with black-toned manganese; typical features of the point-bar deposits under high-velocity channel flow.

4) Reddish-yellowish sand: Occasionally discovered stratigraphic unit; about 1m thick; particle size is finer than the cross-bedded layer below; alternating bands of red and yellow tones; possibly deposited with transported turbidity sediments as a result of relatively rapid channel velocity.

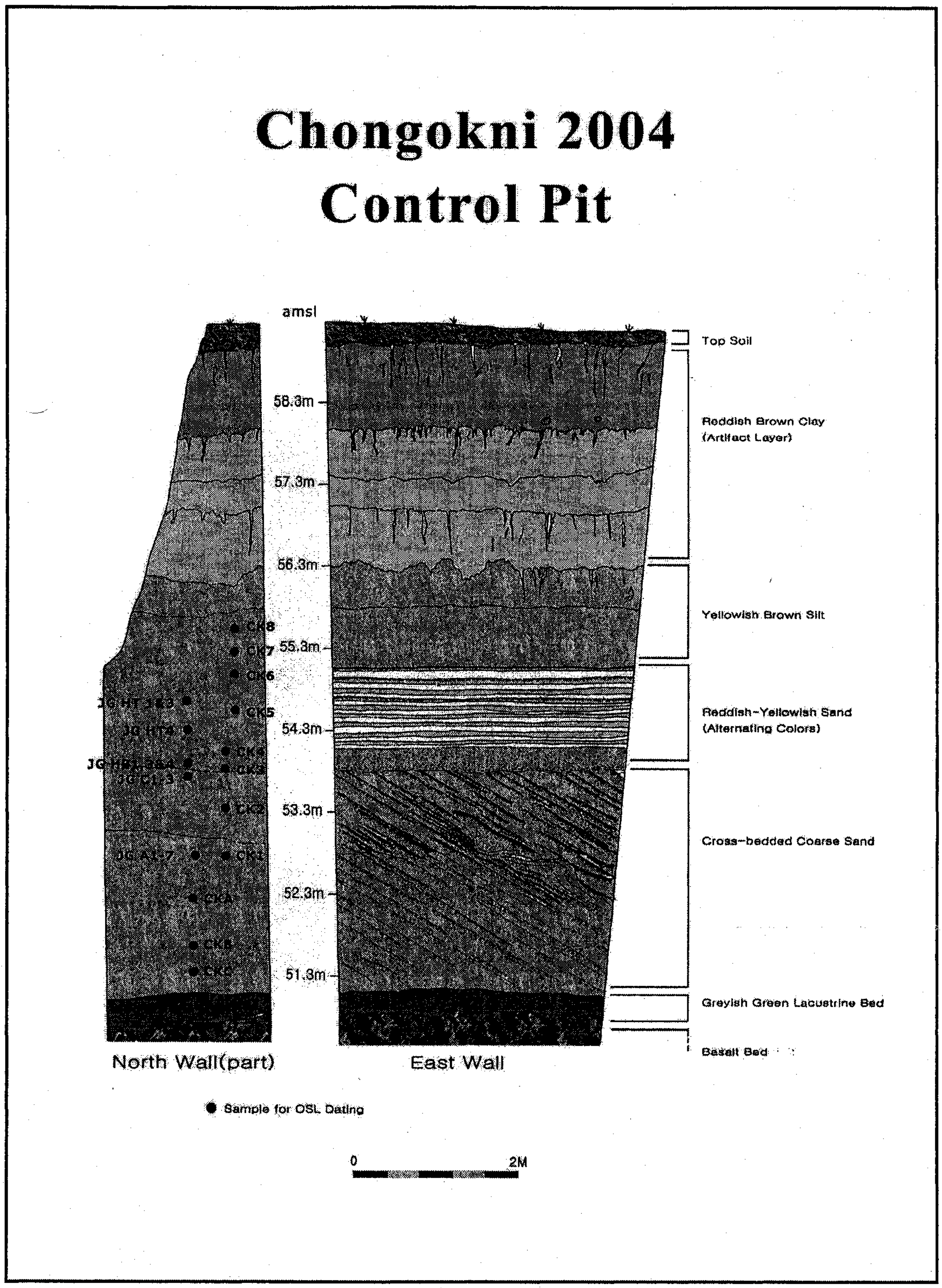


Fig. 4.23. Stratigraphic column of the Control Pit and sampling points for OSL dating at the Chongokni site (From 2004's Excavation Campaign)

5) Yellowish-brown Silty Sand: Silt-dominant layer with light yellow tone; regarded as the transitional phase from erosion to deposition environment as the channel velocity continuously decreases; deposited under floodplain conditions on the overbank area; some artifacts are discovered but considered as being transported from their original provenience, possibly as a result of post-depositional movement from the upper layers.

6) Reddish Brown Silty Clay: General color is reddish brown but interleaved by bands with yellow tones; sedimentary conditions were similar to the silt layer below but the granule size is finer and poorly sorted; at least two archaeological horizons are identified; cracks and fossilized animal burrows are often identified.

B. The OSL Dating Method

The principal method for measuring the age of sediments is the OSL dating method. Its recent technological enhancement has achieved significant refinements, sufficient in principle to measure any quartz-containing sediment (Choi, J. H., Cheong and Chang 2004). However, as is common in all chronometric methods (Walters 1997), uncontrollable and accidental errors limit its reliability. Thus, special care should be taken in the sampling and pre-lab processing, as well as caution should be taken in interpreting the dating results.

All samples were extracted at least 1m below the bottom of reddish-brown silty clay layer. The dating of the samples was carried out by the Geochronology Laboratory of the Korean Basic Science Institute, using Model. TL/OSL-DA-15 manufactured by the Risø National Laboratory of Denmark. The results (Table 4.4.) are very confusing. First, there is no pattern to the distribution of the results. The difference between the raw OSL dates and the converted dates based on the water-laid condition of the sediments revealed no sequence at all. The structure and the particle size of each stratigraphic unit indicate at least three or four different geological stages intervened between the lava flow and the initial hominin occupation. According to the dates above, however, the formation of all the stratigraphic units was completed in a very short time span, and this contradicts the well-stratified fining-upward structure of a long sedimentary sequence.

Sample Cluster	Sample Code	OSL age (Kya)	Converted Age (based on the saturated water content)	Remark
JG HT	1	54.0±2.9	57.8±3.1	Horizontal bands of medium sands
	3	40.4±3.1	48.8±3.8	
	4	46.6±3.5	48.9±3.7	
JG HB	1	38.8±5.0	42.2±5.5	Border between cross-bedding and horizontal sand bands
	3	56.2±3.0	67.5±3.6	
	4	60.4±4.0	69.1±4.5	
JG C	1	51.9±3.0	57.4±3.3	Samples obtained according to the oblique stratification of cross-bedding
	2	34.0±2.8	38.2±3.2	
	3	54.2±3.0	64.1±3.6	
JG A	1	56.4±4.8	60.9±5.1	
	2	34.0±2.8	38.2±3.2	
	3	52.3±2.9	56.7±3.2	
	4	34.9±3.6	36.9±3.8	
	5	42.3±4.5	43.6±4.7	
	6	48.7±3.5	51.5±3.7	
	7	51.0±3.1	58.0±3.5	

Table 4.4. First Sequence of OSL dates from Sediments of 2004's Chongokni Control Pit (Dated by Geochronology Laboratory, Korean Basic Science Institute, Korea, 2004, directly quoted from Yi, Lee and Lim 2005)

Sample	Sample Code	Sample Type	Age (Kya)	Remark
1	CK8	Fine sand/silt	N/A	Incomplete bleaching
2	CK7	Fine sand/silt	**60±10**	
3	CK6	Medium sand	**65±10**	
4	CK5	Medium sand	**72±9**	
5	CK4	Medium sand	**83±13**	
6	CK3	Medium sand	N/A	Incomplete bleaching
7	CK2	Medium sand	**92±8**	
8	CK1	Coarse sand	120±6	Reversed age (cross-bedded)
9	CHA	Coarse sand	**104±8**	
10	CHB	Coarse sand	127±6	Reversed age (cross-bedded)
11	CHC	Coarse sand	**113±3**	

Table 4.5. Second Sequence of OSL dates from 2004's Chongokni Control Pit (Dated by the Institute of Paleoenvironment, Chungcheong Cultural Property Foundation, Korea, 2004, quoted from Kim, M. J. 2005)

Two factors appear to explain why these OSL dates are so problematic: 1) the partial bleaching and re-bleaching of samples (Aitken 1997); 2) the hydraulic disturbance of radiogenic energy. Partial bleaching and re-bleaching are the generic pitfalls of OSL dating. Compared to eolian deposits, fluvial deposits are more liable to undergo incomplete resetting of previous luminescence build-ups, thereby causing cumulative bleaching after their sedimentation is complete (Berger 1990; Murray *et al.* 1995; Rhodes and Bailey 1997; Zhang, Zhou and Yue 2003). In these cases, the paleo- (or "equivalent" by Yi, Y. I. Lee, and

Lim 2005) dose rate of luminescence absorption when the quartz particle was last exposed to the daylight cannot be calculated. Without establishing unequivocal dose rates, the resulting dates are always older or younger than the actual age.

Another problem is the sampling condition of the sediments. The sampling location was exposed to heavy rainfall during the summer monsoon season and the cross-bedded sand layer is below the current surface of underground water. It has been suggested that the moisture content of a sample is highly critical to the quantity of radiogenic energy absorbed in the quartz particle (Choi, J. H., Cheong C. and Chang H. 2004). Water-logged samples tend to produce younger dates than expected because the annual dose rate increases as a result of hydraulic interception of radiogenic energy imbued from the surrounding sediment.

In order to minimize these two biasing factors, the outcrop was modified to ensure more controlled sampling. The underground water was completely drained using a high-power electric pump and the cross-section of the stratigraphy that had been exposed to rainfall and normal daylight was freshly scraped and polished to remove the previously contaminated surface. The actual sampling work was carried out on a dry and warm day after the summer monsoon season had completely ended.

The second result (Table 4.5.) stands in strong contrast to the first one, producing a more refined and better sequence; a reliable series of dates was finally published although two samples were partially bleached (Sample Nos. 1 and 6) and the dates of another two (Nos. 8 and 10) are inverted. The date of Sample No. 11 from the bottom is partly consistent with the young K-Ar dates of basalt bedrock (*e.g.* Sample No. 6 of Table 4.3.; No. 14 and 17 of Table 3.2), suggesting that the formation of the fluvial deposits above the basalt had begun shortly after the termination of volcanic eruption during the OIS 5e, between 132 and 115 Kya, (Shackleton *et al.* 2002; 14). No date for Sample No. 1, from the top of the yellowish brown silty sand layer, was obtained; but the date of Sample No. 2 shows that the formation of fluvial sediments continued until *ca* 60 Kya, the terminal part of OIS 4 between 74 and 59 Kya (Rutter *et al.* 2003) before the reddish brown silty clay layer started to be deposited.

C. Dating the Archaeological Horizons: an Estimate

As at the Chongokni site, most archaeological horizons, especially in the middle Hantan River, are found above the yellowish brown silty sand layer. The OSL dates presented here suggest that, after the volcanic eruption in the upper IHRA, the multiple lava flows reached this area *ca* 0.2- 0.13 Mya B. P. After a short period during which the river channel was blocked by the lava flow, the flooding resumed and the coarse-grained sediments transported by fluvial activities were cumulatively deposited up to and following hominin occupation, which was initiated after *ca* 60 Kya.

Yi (2000) hypothesizes that at least two separate artifact horizons are located below the AT level (OIS 2). The upper one was possibly formed during the OIS 3 and the lower one during the OIS 5a or warm sub-stage of OIS 3 (Yi 2000: 14). Currently available OSL dates demonstrate that all archaeological horizons were formed after the terminal OIS 4 (*ca* 60 Kya), and it can be safely supposed that the post-volcanic occupation of hominins in the IHRA took place during the earlier part of OIS 3, which consequentially supports Yi's hypothesis. Given that the general geological processes were uniform across the region of the middle Hantan River where the lava flows have entirely overlaid the ancient river channels, it can be concluded that the archaeological horizons of the group of sites situated around the confluence of the Hantan and Imjin River, (*see* Fig. 4.1.) are of the same general age period: *e.g.* Shindapri, Chongokni (Yi *et al.* 2006), Namkyeri (Choi, M. J. 1991, 1994), Samhwari (Yi 1988, 2005), and so forth.

(5) Chongokni: A Long Sequence of Hominin Technological Adaptation

1. Previous Research

A. Discovery and Location

Chongokni is the site where the first handaxe was found in Korea. It was discovered in 1978 by an American serviceman based at an adjacent USFK military camp, and he identified several handaxes that were exposed on the surface near current Chongok Town (Bowen 1979). The Chongokni site is located in the meander zone of the middle Hantan River near the confluence of the Imjin and Hantan Rivers (see Fig. 4.1.). This area is a well-developed floodplain over basalt plateau and provides a good vantage point for overviewing the general topography and the resource distribution. Previous excavations were conducted at various places in this area, and the best known parts are now preserved as a national historic park.

B. Stratigraphy and Distribution of Archaeological Horizons

Although the area displays a variable and rugged topography, its stratigraphy is generally uniform, composed of several separate layers accumulated by fluvial activity of the Hantan River. As mentioned before, most of artifacts are distributed within the reddish brown silty clay layer interleaved with several cracks (Fig. 4.24.). Below this layer lies another thick layer of coarse and light-toned yellowish brown silty sand sediments. Because of different depositional environment charged with higher fluvial energy, few artifacts are discovered from this layer; and most of them, if any, are believed to be out of their primary context.

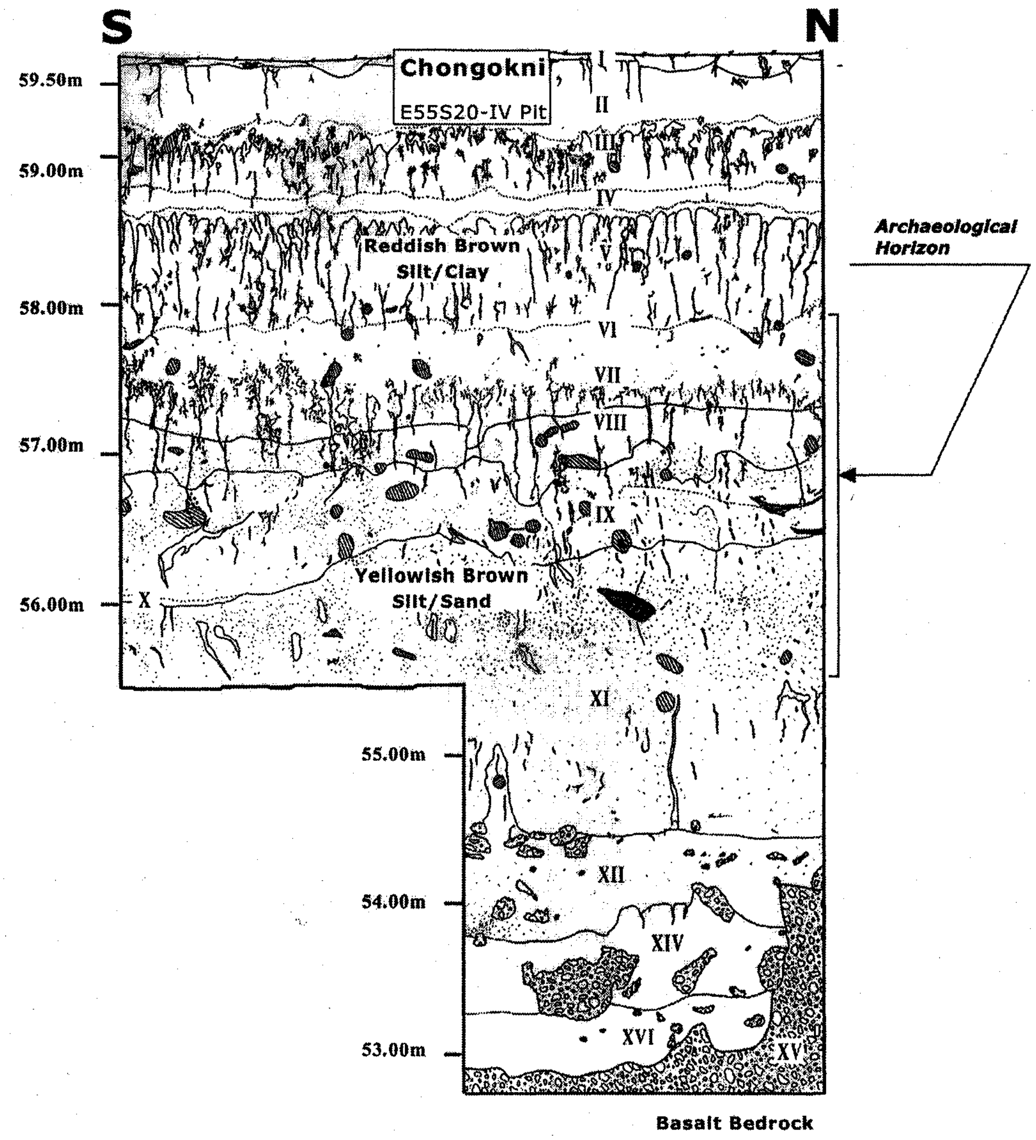


Fig. 4.24. Stratigraphy of the Chongokni Site from the Pit E55S20-IV of the 2000's Excavation Campaign

C. General Properties of the Lithic Assemblage

With rare exception, most artifacts are made of crude quartz and quartzite easily acquired from the outcrops of old bedrock and river cobbles deposited by the river flow. In addition to these principal raw material rock types, basalt and other igneous rocks are also included. Since the first handaxe was found in 1978, over 30 more handaxes have been found by official excavations and even more were retrieved by surface surveys in various sites (Fig. 4.25.). Other large tools have also been found, such as choppers, polyhedrons (Fig. 4.26.), picks, and cleavers (Fig. 4.27.). The type-composition of the Chongokni assemblage is closely similar to the African Acheulian Industry and originally this similarity led to a general view that the total assemblage of the Chongokni site can be treated as a local Lower Palaeolithic industry of East Asia which contains the handaxe (Kim, W. Y., Chung, and M. J. Choi 1981).

However, despite the resemblance of some large tools to those of the typical Acheulian industry, there is serious disagreement among local researchers about the validity of labeling of the Chongokni assemblage as "Acheulian." Some researchers (*e.g.* Chung 1996; Bae 1988, 1992) argue that handaxes from the Chongokni site are the clear evidence against Movius' attribution of the East Asian Lower Palaeolithic to the "chopper-chopping tool tradition" (Movius 1949). They believe that the primitive manufacturing technology employed by the Chongokni hominins might be regarded as parallel to other Lower Palaeolithic traditions elsewhere (Yi and Clark 1983). Nevertheless, the techniques used to form the handaxe and other heavy-duty tools are not developed along the lines of the classic Acheulian (Bae 1992, 2000), and this is due to the poor mechanical properties of the principal raw materials (*i.e.* the crude quartz and quartzite) that imposed severe limits on the shaping of the tools (Bae 1988, 1992, 1995b; J. D. Clark 1998).

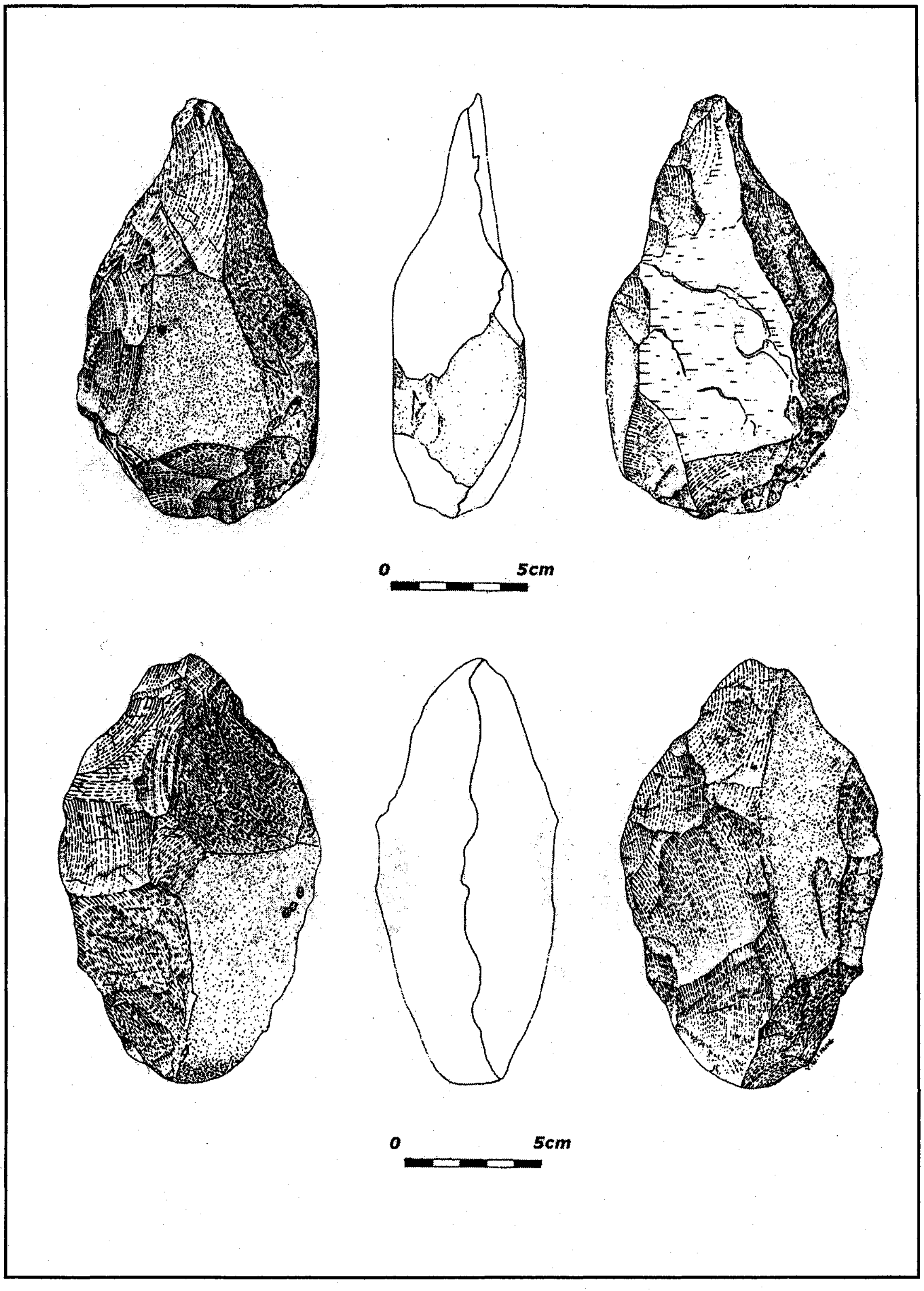


Fig. 4.25. Handaxes from the Chongokni site
(Originally drawn by Young-Hwa Chung, from Kim and Bae 1983)

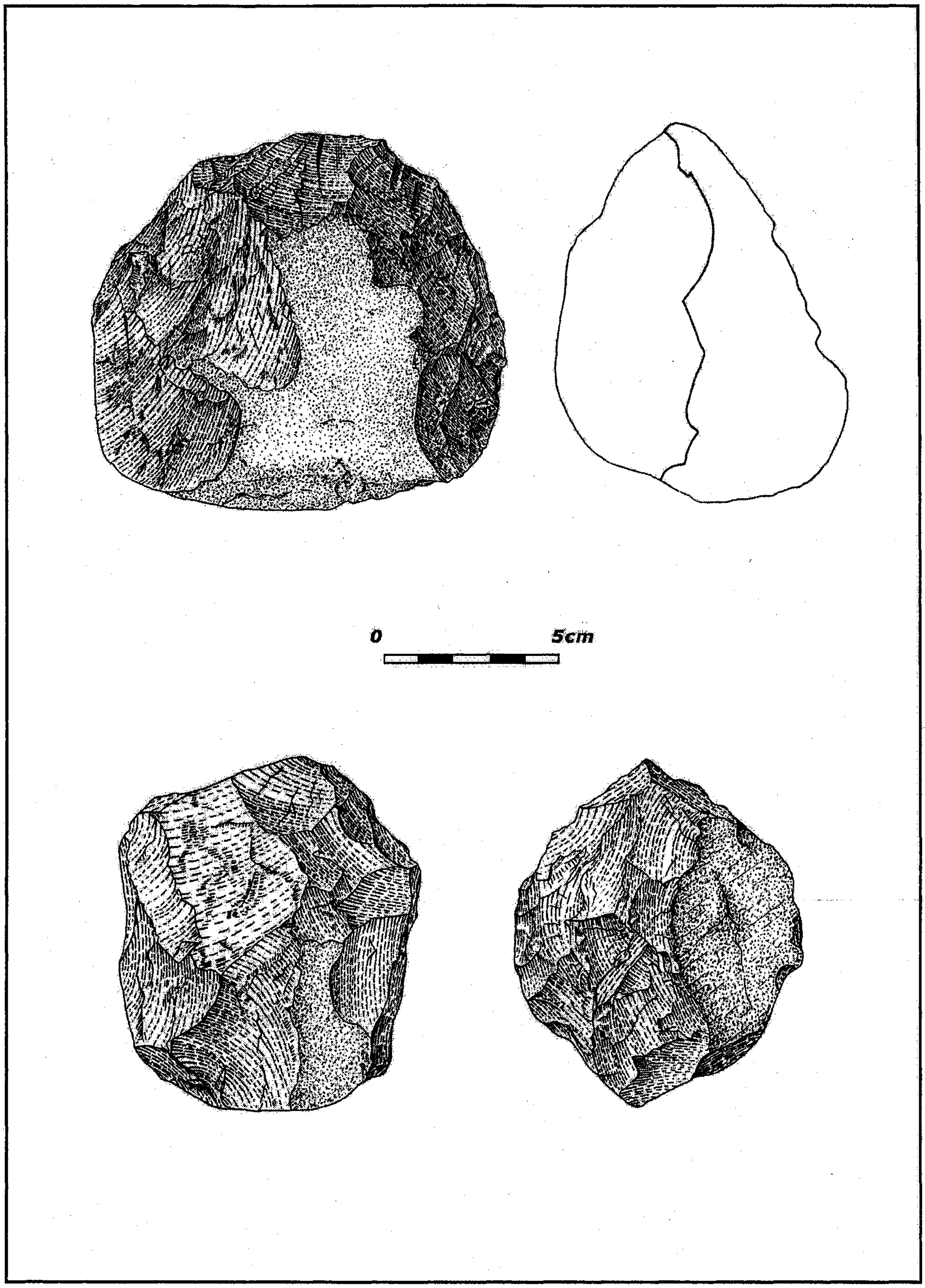


Fig. 4.26. Chopper and polyhedron from the Chongokni site (Originally drawn by Young-Hwa Chung, from Kim and Bae 1983)

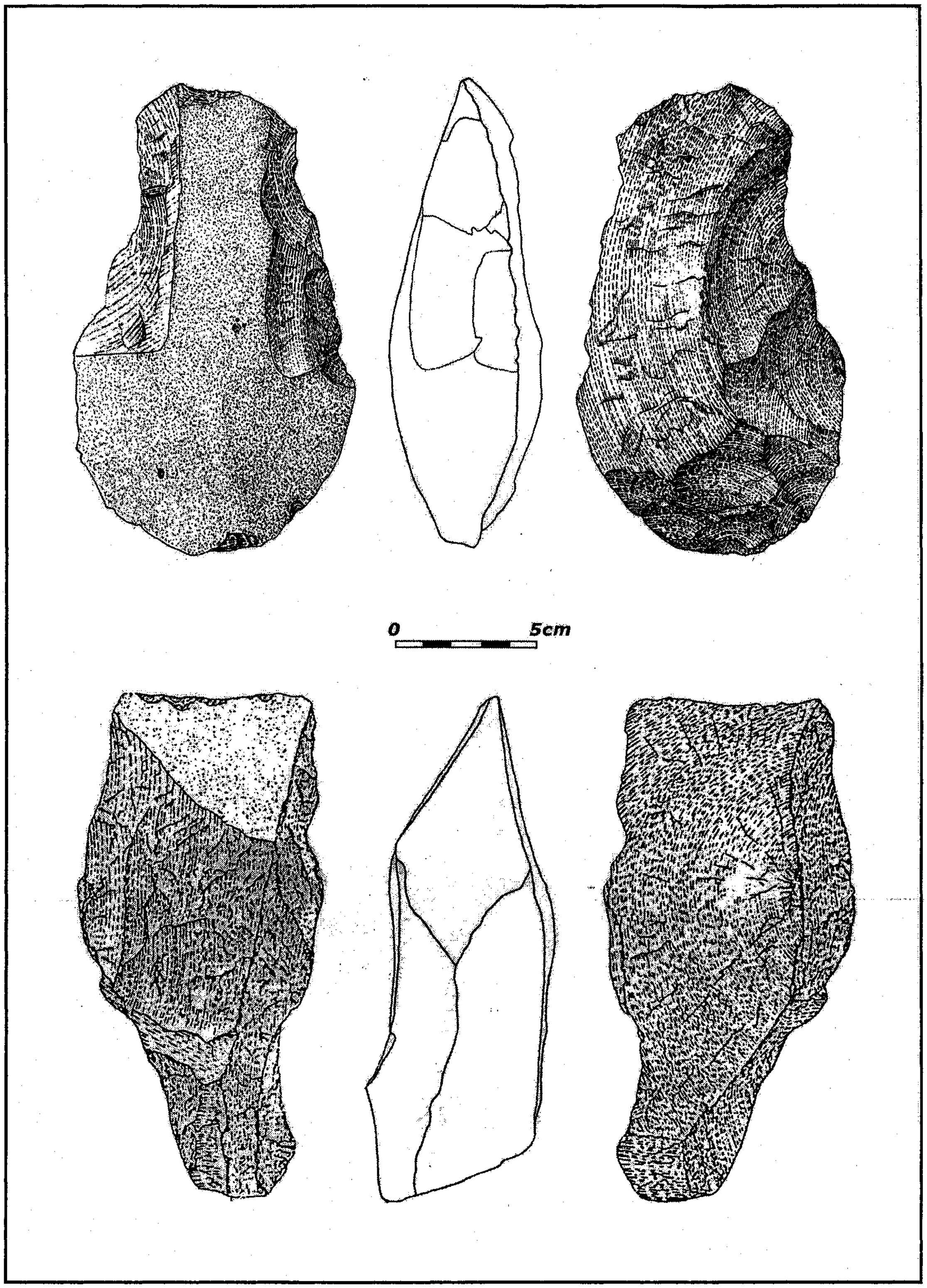


Fig. 4.27. Cleavers from the Chongokni site
(Originally drawn by Young-Hwa Chung, from Kim and Bae 1983)

Other researchers, however, claim that the morphological resemblances indicate neither contemporaneity nor technological association with the Lower Palaeolithic and/or the Acheulian industry. Yi (1989) argues that although the existence of an Acheulian-like handaxe contradicts Movius' over-simplification of East Asian Lower Palaeolithic traditions, the lithic assemblages from the Chongokni site and other forms of expedient techno-complexes in East Asia should not be understood just in terms of similarity and synchronicity to Acheulian. As presented shortly, an analysis of the handaxes (Yoo 1997) demonstrates that even if the silhouette or plane view of the IHRA handaxe is identical to the Acheulian, the blank procurement and the manufacturing procedures are not in the same technological tradition as those of the typical Acheulian handaxe manufacture.

What the "Acheulian syndrome" has generated is a general bias favoring the visually appealing handaxe. Most of former research on the Chongokni assemblage has focused on the handaxe as the dominant lithic type above others (*e.g.* Bae 1992a, 1995b; Yoo 1997), and almost every fieldwork report and descriptive work, with few exceptions, has had a strong tendency to emphasize the cultural and technological role of handaxe within the total assemblage (*e.g.* Bae *et al.* 1996; Chung 2002; Kim, W. Y. and Bae 1983; Yi and K. D. Lee 1993). Such a focus on a single tool-type can seriously distort interpreting the assemblage variability. For example, although such diverse lithic types as a centripetally detached radial core (Fig. 4.28., #1 and #2) and a few para-Levalloisian multi-ridged flakes (Fig. 4.28., #3 and #4) are included within the Chongokni assemblage, their technological implication still go largely unexplored. It is, therefore, necessary to investigate the IHRA lithic assemblage with the purpose to examine the total range of technological features. The fieldwork for this thesis was carried out at Chongokni site with a holistic approach to establish a sound framework for analysis that was free from the bias created by "spotlighting" the handaxe.

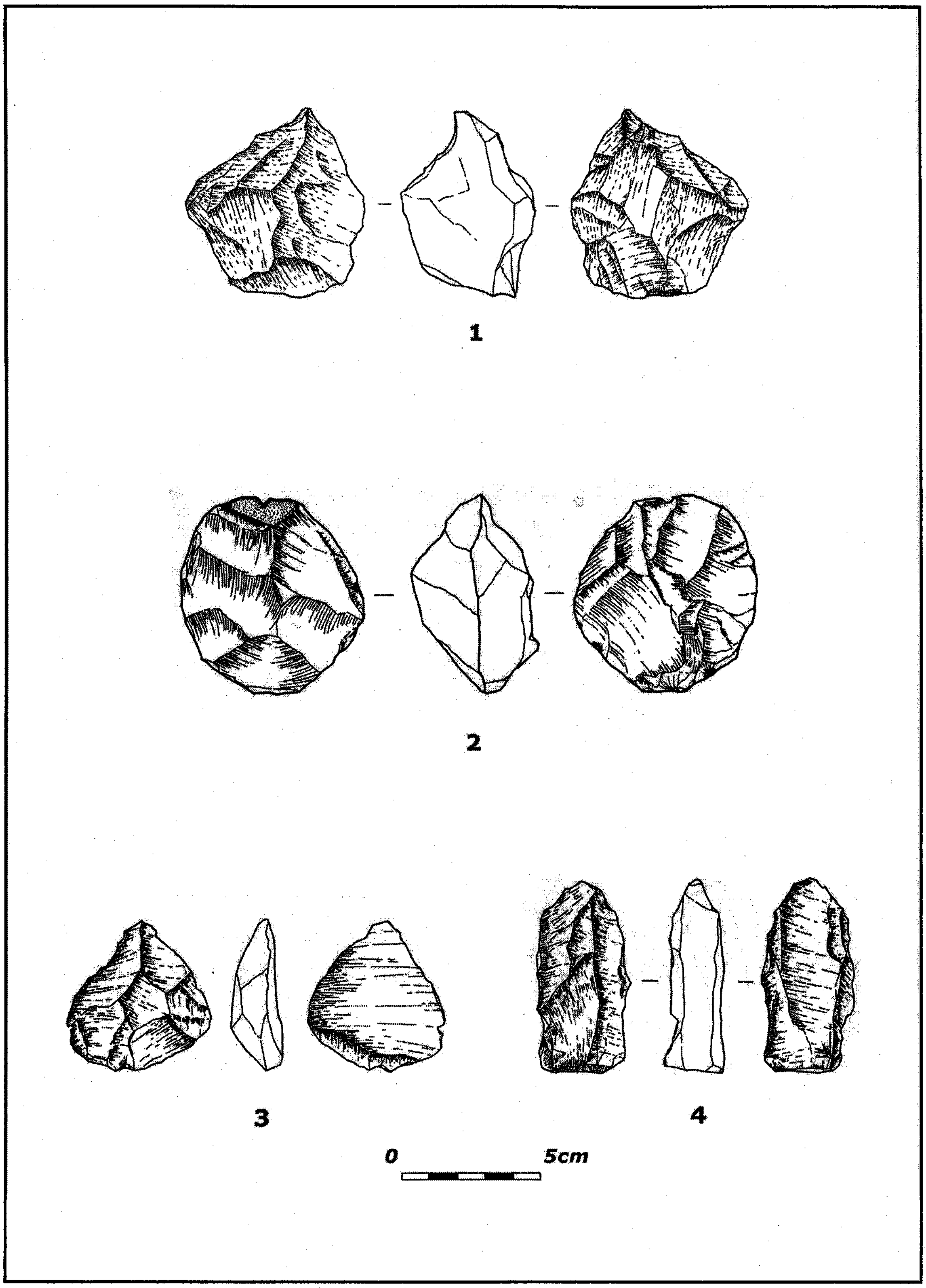


Fig. 4.28. Cores and flakes from the Chongokni site

(1-2: radial cores, 3-4: flakes with multiple ridges;

re-drawn and re-scaled from Bae *et al.* 1996: 123, 124, 128, 136)

2. Excavation Work and Results

A. Excavation Layout and Stratigraphy

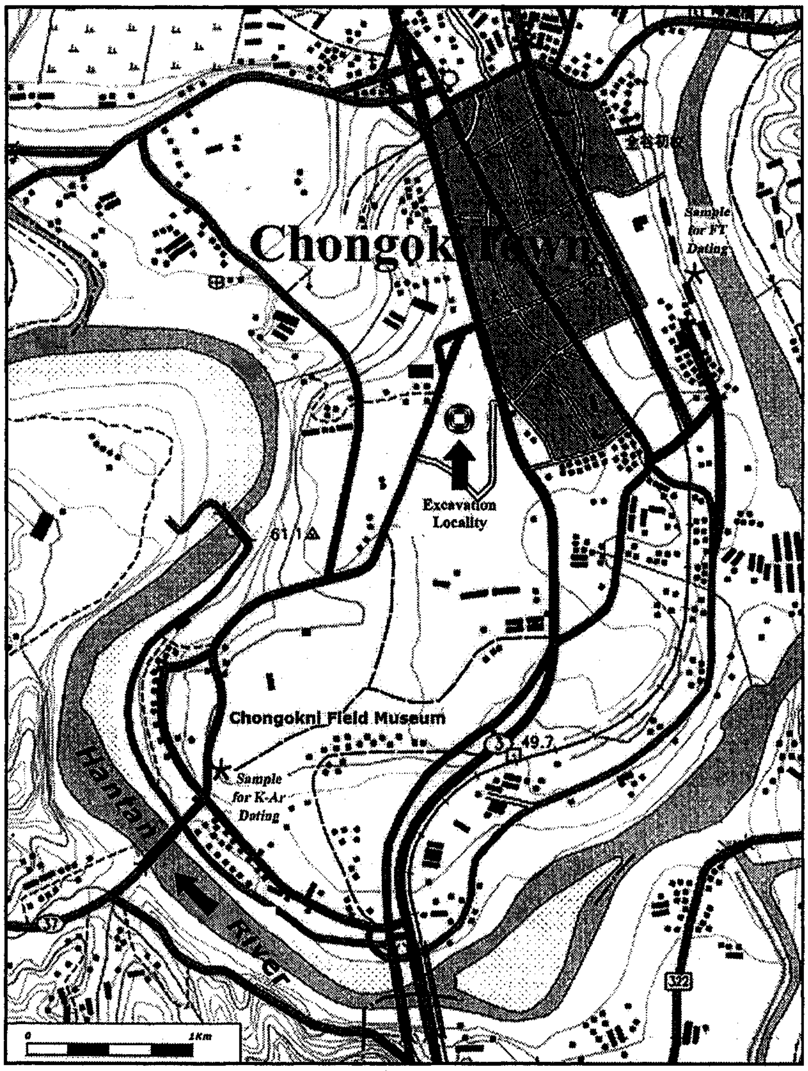


Fig. 4.29. The excavated location at the Chongokni site (Asterisks are sampling points for FT and K-Ar dating)

As mentioned before, a test excavation was carried out at the Chongokni site and samples for OSL dating were collected. The excavation locality is located in the northern half of the meander area near Chongok Town (Fig. 4.29.). This area, still yet to be fully excavated, is located about 1.3 km north of the current historical park. The Hantan River marks a deep reverse turn around the site. Since the river increased its sinuosity after re-establishing the channel activity, the site, when it was occupied by hominins, was probably located closer to the ancient riverbank and the meandering stream of the Hantan River subsequently receded southward.

A total of 13 pits (4×4m grid) and one control pit were distributed across the excavation area (Fig. 4.30.). The datum point was located at the central spot and each grid was named by the coordinate numbers of every five meters. Like most IHRA archaeological localities, this excavation area was seriously disturbed by modern human activity such as cultivation and military field training. Nevertheless, at the eastern and western extremes of site area, generally well-sorted outcrops survived and two excellent stratigraphic sequences (*i.e.* the Control Pit and the eastern wall of the N8E16 Grid) were available for excavation. The control pit was located in the southeastern sector in order to investigate the full sequence of stratigraphic units. As noted previously (Fig. 4.23.), two set of samples for OSL dating were obtained from a well-stratified sequence exposed at this control pit.

The N8E16 Grid located at the heart of floodplain zone does not show any evidence of coarse sandy deposits, indicating that the eastern part of excavation area was not seriously affected by the erosion caused by the Hantan River. The altitude of the surface is highest on the eastern part and this is the case also for the level of the basalt bed (Fig. 4.31.), thereby reinforcing the idea that fluvial activity significantly eroded the original lava flow and reduced the current level of basalt at the western end. As a result, unlike the control pit, the N8E16 Grid shows the thickest deposit of yellowish brown silty sand layer; and no traces of strong fluvial activity, such as the sand-dominant deposits with cross-beddings, are observed.

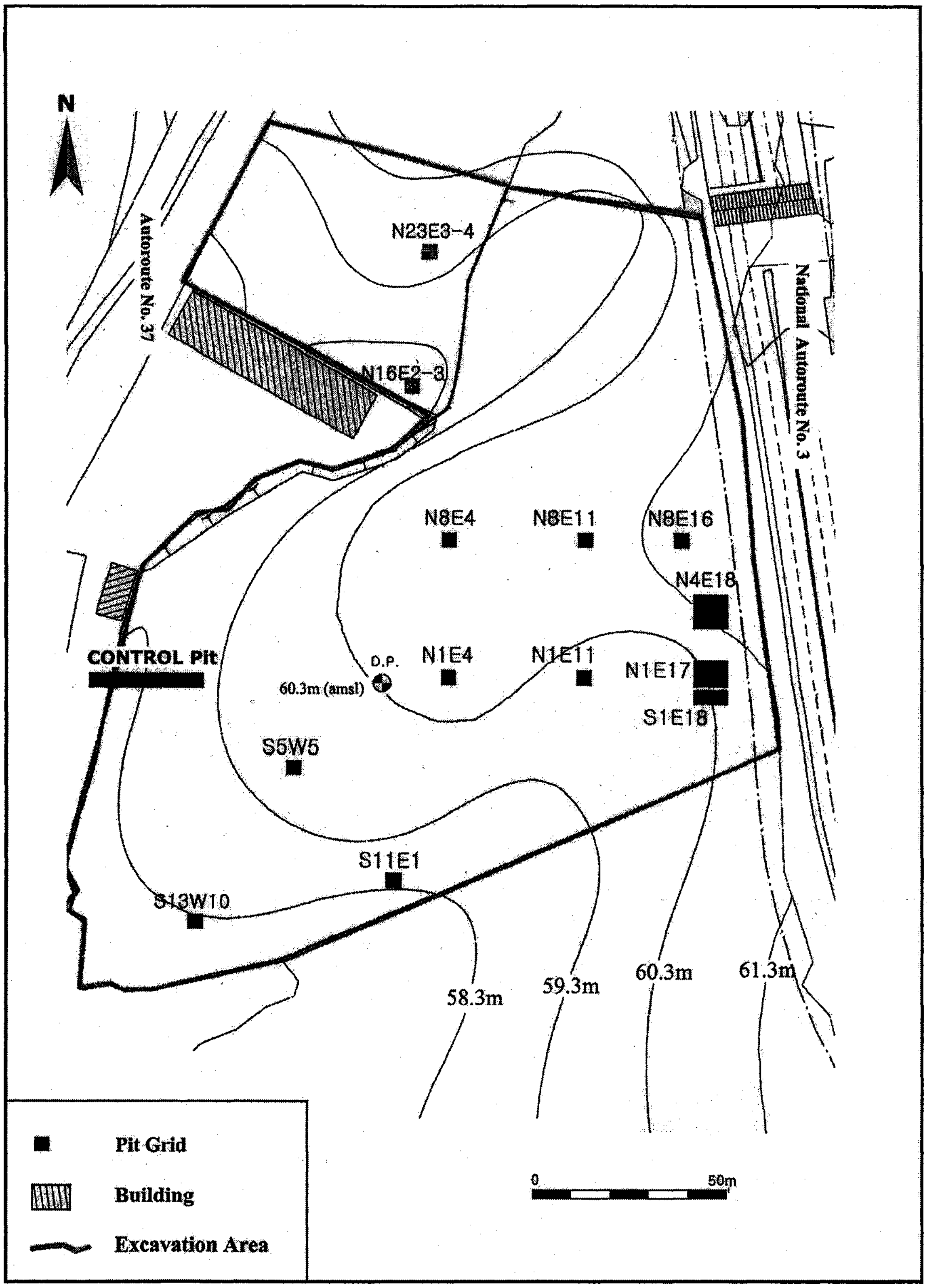


Fig. 4.30. Excavation layout of the Chongokni site

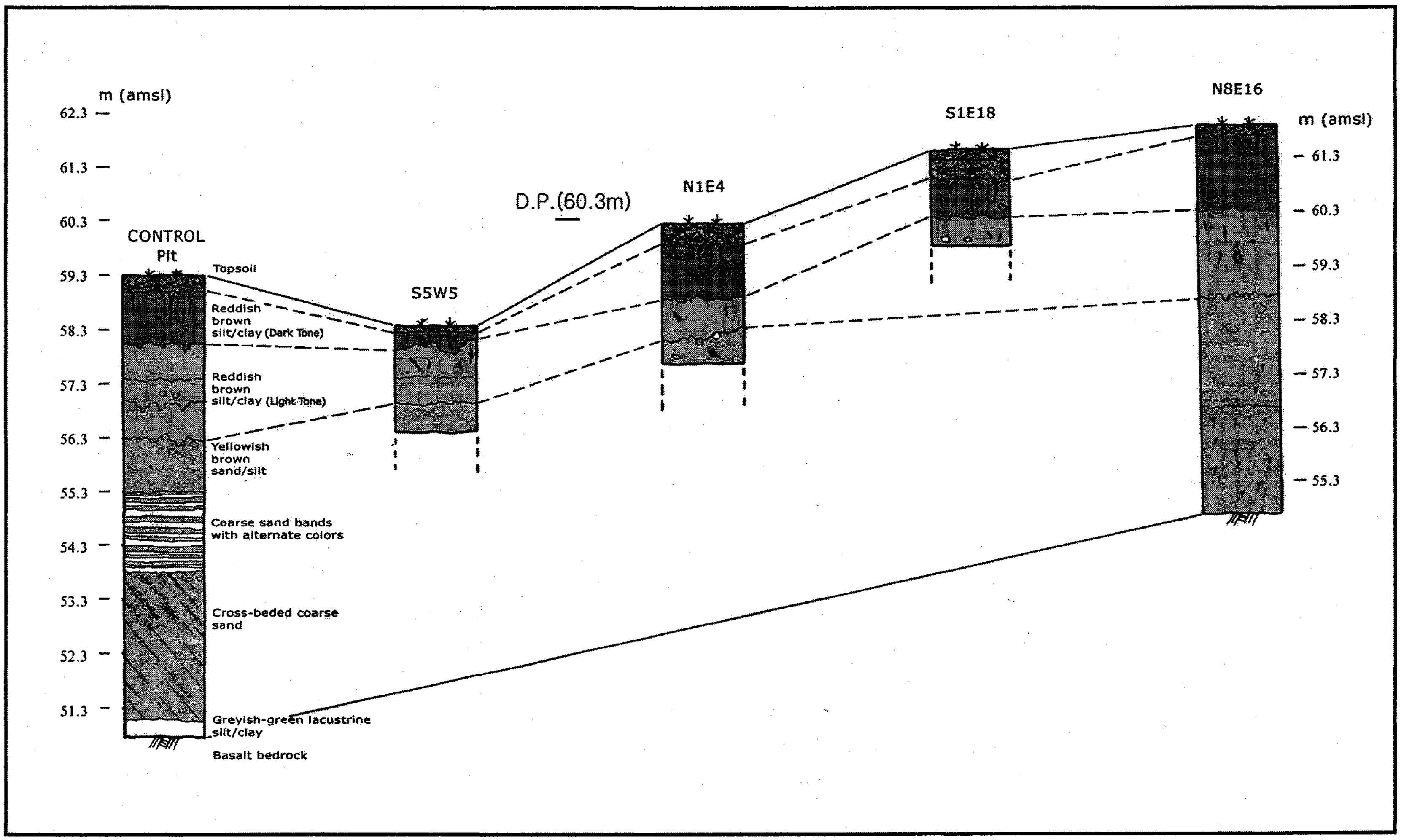


Fig. 4.31. Stratigraphic correlation of the Chongokni grid pits

B. Site Formation and Post-Depositional Transformation

Most artifacts are clustered at the *ca* 60m level (amsl, Fig. 4.32.) and almost 80% are concentrated in the eastern half of the excavation area. As discussed earlier, the initial reddish brown silty clay layer is dated *ca* 60 Kya and the age of lithic assemblage is estimated to be early OIS 3. Considering the surface level is tilted southwest and the reddish brown silty clay layer becomes thinner in the western half of the site area, it is believed that much of the upper part of archaeological horizon in the ancient river shore has been eroded away by fluvial activity.

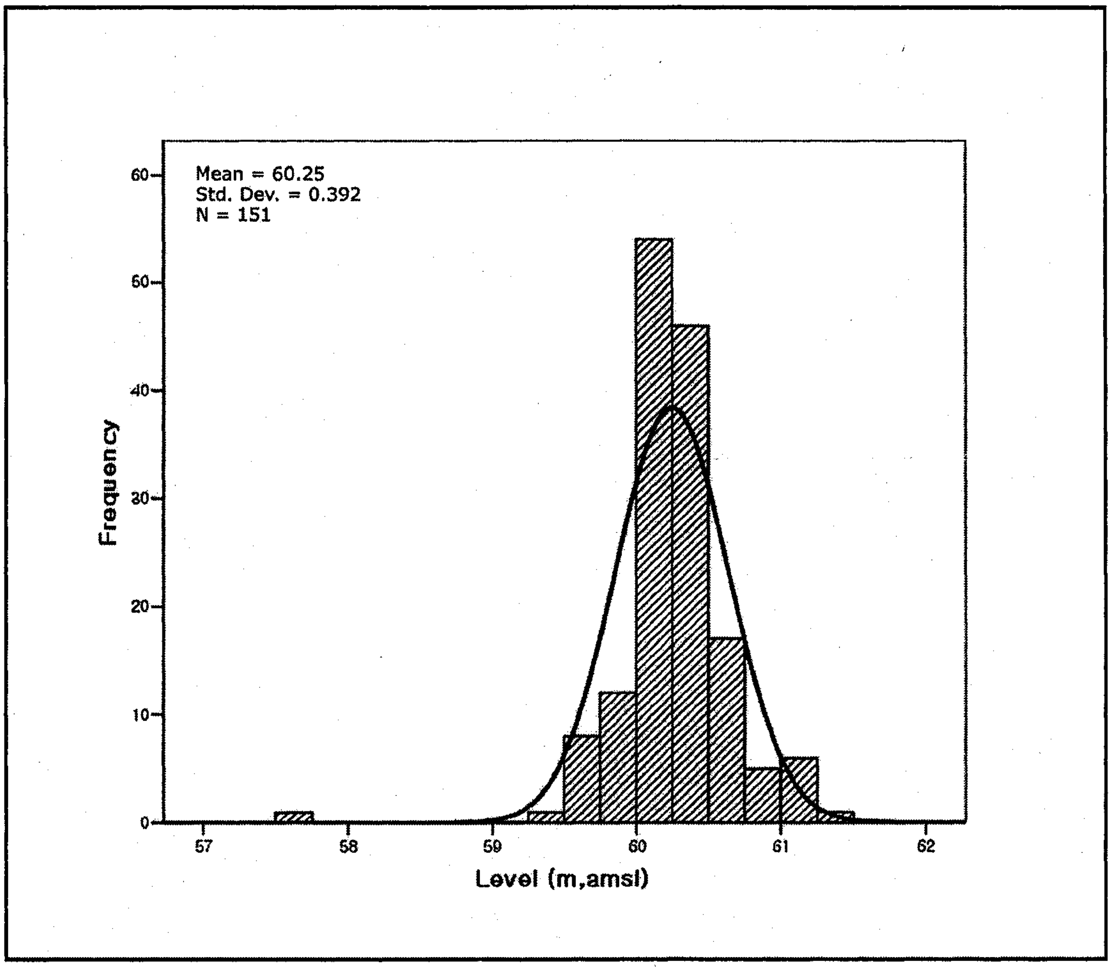


Fig. 4.32. Vertical distribution of artifacts at the Chongokni site

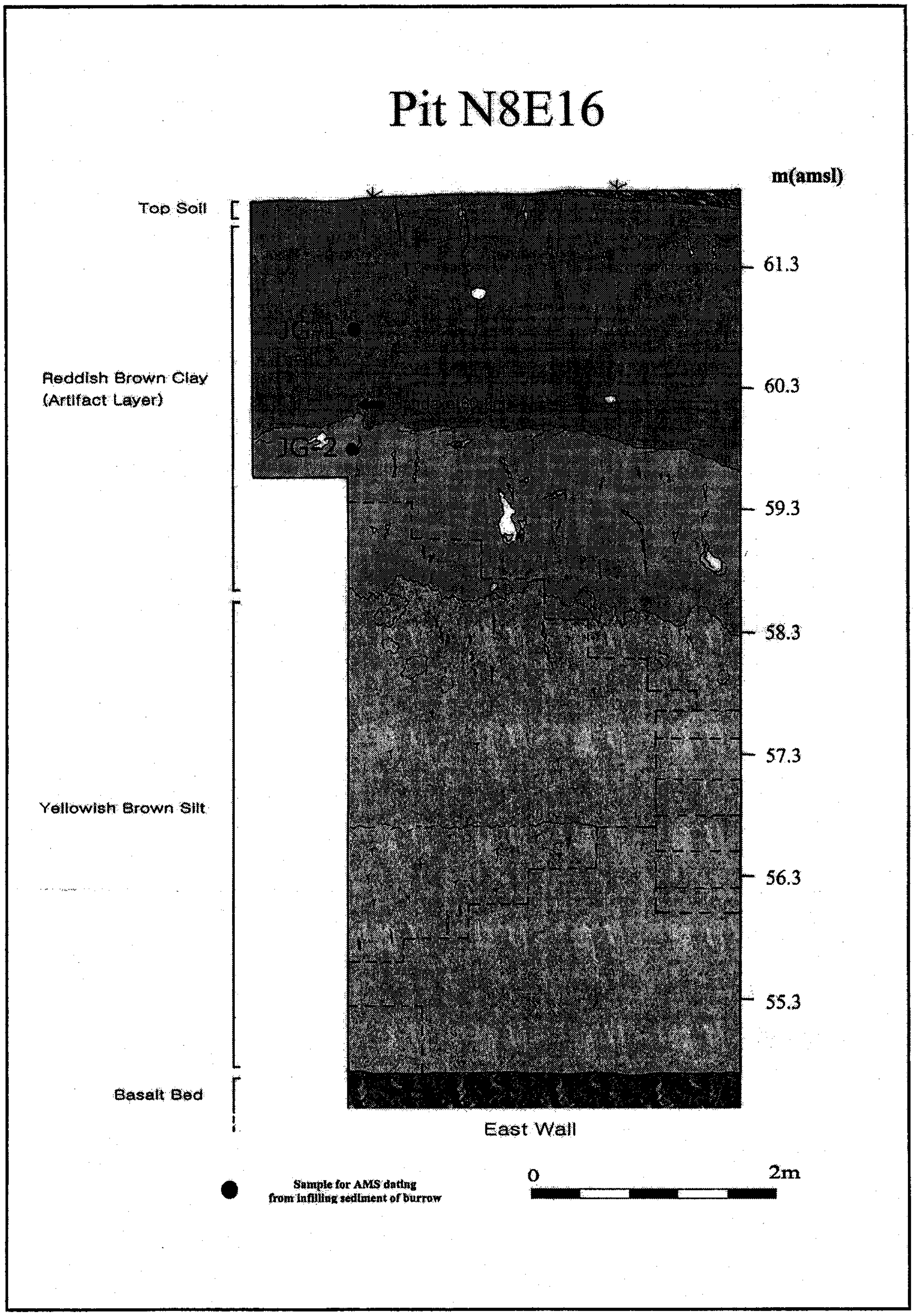


Fig. 4.33. Stratigraphy of Grid N8E16 at the Chongokni site

Another process that contributed to the post-depositional transformation is the burrowing of rodents or other subterranean animals. The excavation area provides a reticular network of trace fossils developing from 1m to 1.5m below the surface (from *ca* 62- 61.5m amsl). Previous research at the Chongokni site (*e.g.* Bae 1988; Bae *et al.* 1996) has suggested some bioturbation of the archaeological horizon by underground activities of either insects or hibernating animals. However, according to the size and morphology of the burrows and the chemical components of the infilling sediments, the principal agents of the burrowing have been revealed to be some species of rodents which contemporaneously resided with hominins during the later phase of the site formation (Lim *et al.* 2004).

Sample Code	Level (m, amsl)	AMS Date (Kya)	Remark
JG-1	60.7	**20.84±0.45**	Slightly below the top crack
JG-2	59.8	**30.49+4.76/-2.59**	Almost identical level to the artifacts

Table 4.6. AMS dates from infilling sediments of burrows at the Chongokni site (Dated by Geochron Laboratories /Krueger Enterprises, Inc., Federal Id. # 042461845)

According to Lim *et al.* (2004), these burrows were made as a result of securing the residential den rather than by foraging habits. The burrows were repetitively visited and possibly used as a semi-permanent residences, considering the diameter and the structure of the infilling sediments. Compared to surrounding sediments, the infilling sediments are more saturated with oxidized carbon and nitrogen, possibly originating from the atmosphere, but the soil texture and amount of rare elements, such as chlorite and illite, are almost identical to those of the surrounding sediments. Samples for AMS dating were extracted from two burrows at the lower and upper part of the reddish brown silty clay layer (Fig. 4.33.). Both samples were below the top crack where AT tephras are usually discovered; and the largest burrow where the sample JG-1 was extracted, considering its length and morphology, had penetrated down after the top crack had formed. Based on the dates (Table 4.6.) and the depth of penetration, it is apparent that the development of the burrows partially coincided with hominin occupation, and their AMS dates are believed to be younger than the original age of the Chongokni artifact horizon.

As exemplary evidence of the post-depositional disturbance, the burrows are believed to have played a role in the horizontal distribution of the lithic artifacts. Given that the archaeological horizon of the Chongokni site can be divided into more than two units (Bae *et al.* 1995), the post-burrow unit at the upper level was seriously damaged while the lower one remained relatively intact. As a result, most artifacts of the upper level, if any, are believed to be eliminated by the post-depositional activity such as the inundation of river channel and the burrowing of rodents. In that case, the single horizon around the 60m (amsl, see Fig. 4.31.) level which has survived from any subsequent transformation is believed to be the lowest and oldest artifact concentration formed around ca 60 Kya.

3. Assemblage Characteristics and Type-Composition

A. Raw material Availability

A total of 176 lithic artifacts were retrieved from the excavation, including 25 from the surface (see App. II). The raw material used was predominantly crude quartz and quartzite (around 90%, Fig. 4.34.) with some miscellaneous rocks such as sandstone, gneiss and basalt as well. Two specimens are made of porphyry, which is one of the commonest high-quality raw materials among local Upper Palaeolithic assemblages. Since the same type of raw material is abundant in the Upper Palaeolithic assemblage of the Janghungri site in the upper Hantan River (see the later part of this chapter; Choi, B. K. 2002), these two pieces made of porphyry are probably the remnants of more recent assemblages that were largely destroyed by post-depositional activity. Investigation by Cho *et al.*(1995) of the development of the metamorphic rock development in this area suggested that the majority of the outcrops originated from the Samgot Formation of the Yeonchon group consisting of calc-silicate and metapsammitic rocks together with amphibolite and amphibole gneiss, all of which have a similar petrogenesis as a result of large-scale Triassic metamorphism.

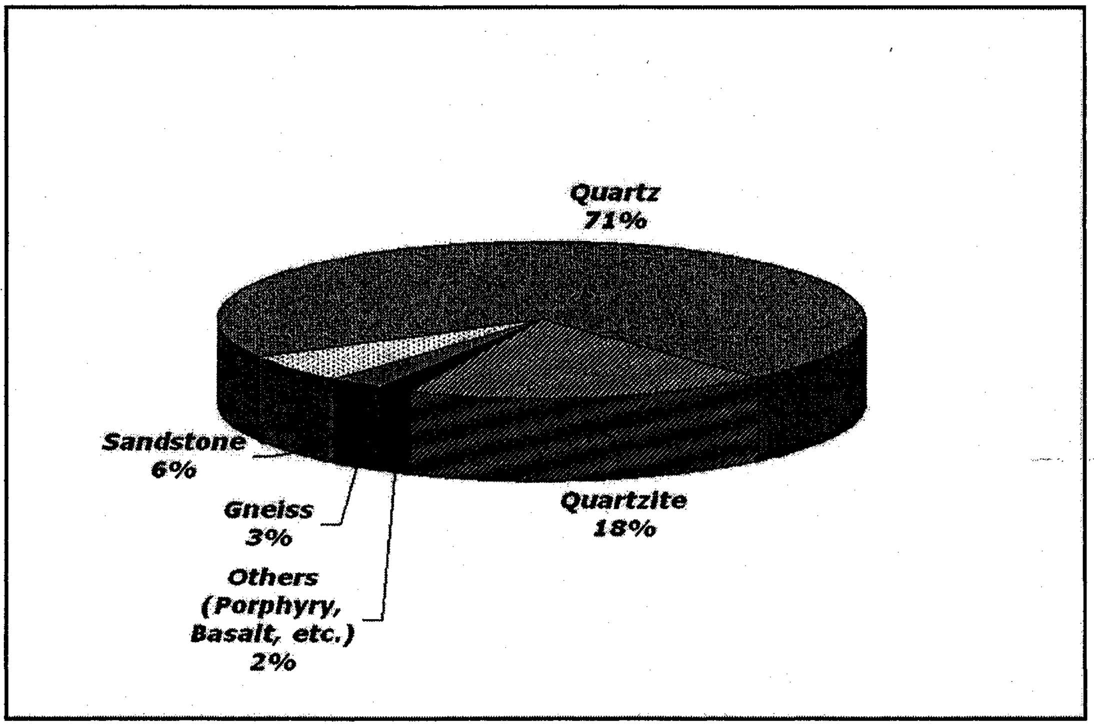


Fig. 4.34. Raw material composition of the Chongokni assemblage

Compared to the fine-grained quartz from the Kawolri site, the quality of quartz and quartzite from the Chongokni site is poor and crude, which would have made it difficult to produce the intended tools. These two rock types were probably acquired from the outcrops of the surrounding rock formation or from the river gravels. Considering their abundance and wide distribution, the quartz and quartzite employed as the principal raw material were easily procured by the Chongokni hominins.

B. Lithic Composition and Flake Morphology

Of the 176 artifacts, debitage comprises 71% while cores (n=15), tools (n=26, both large and small), and hammers (n=3) make up the rest (Fig. 4.35.). This lithic composition corresponds closely to the previous excavation results (Bae *et al.* 1996; Kim and Bae 1983; Yi 1989) which reportedly yielded about 15% in the tool category. However, if the surface collections are excluded, the assemblage from the 2004 excavation campaign has a lower frequency of cores and large tools compared to previously excavated assemblages (*e.g.* Kim, W. Y. and Bae 1983; Bae *et al.* 2001).

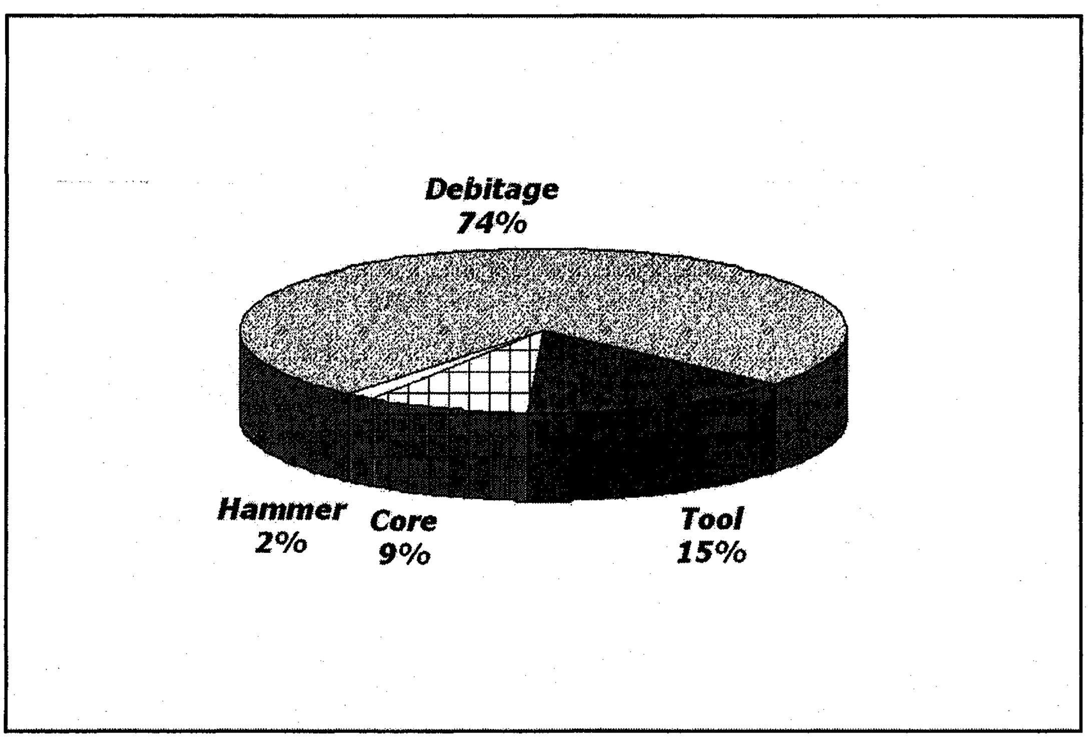


Fig. 4.35. Lithic composition of the Chongokni assemblage

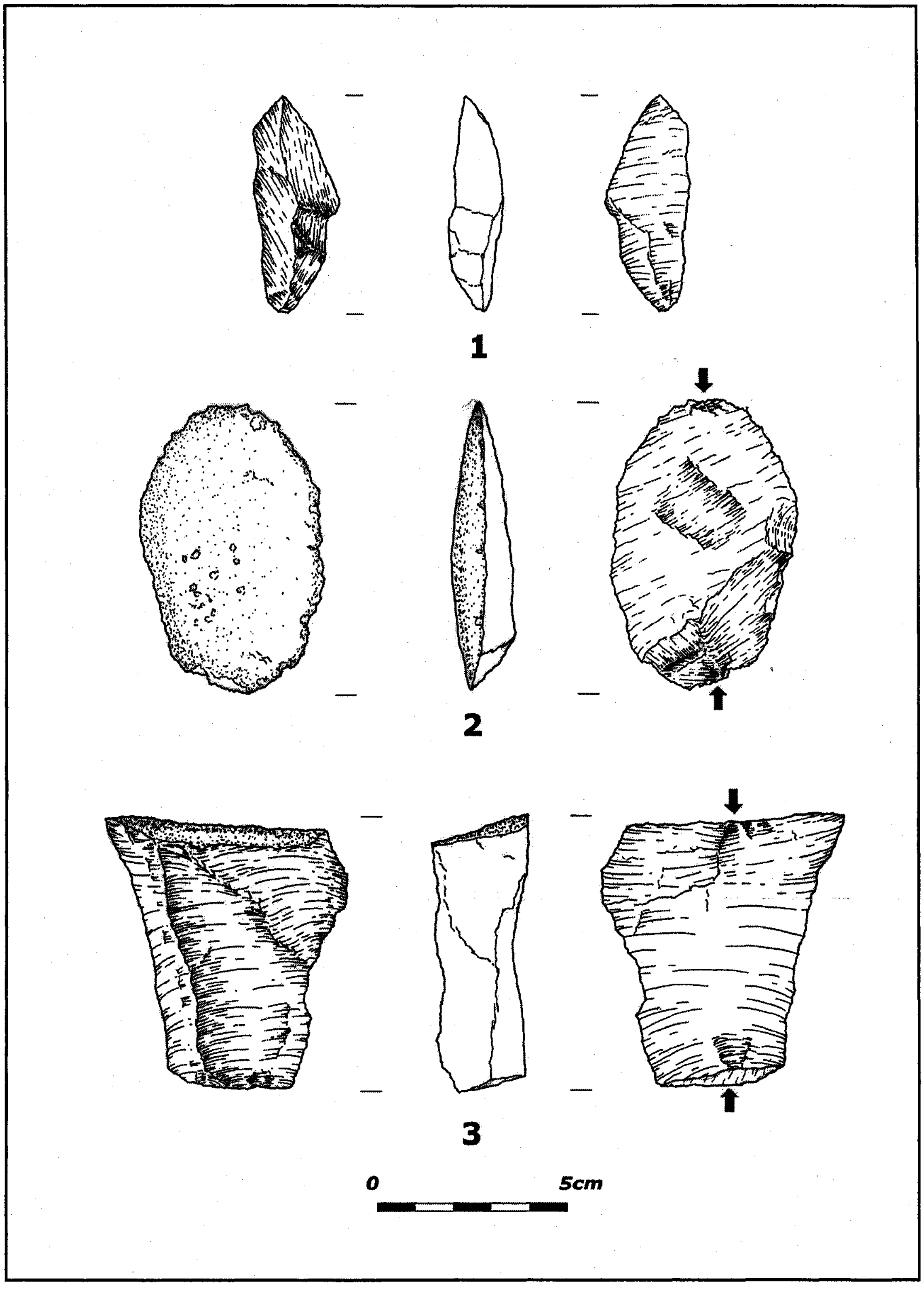


Fig. 4.36. Elongate Flake and bipolar pieces from the Chongokni site
(1: S1E18-35, 2: N1E17-1, 3: S1E18-14, arrow points indicate the direction of blow and of resilient force for bipolar percussion)

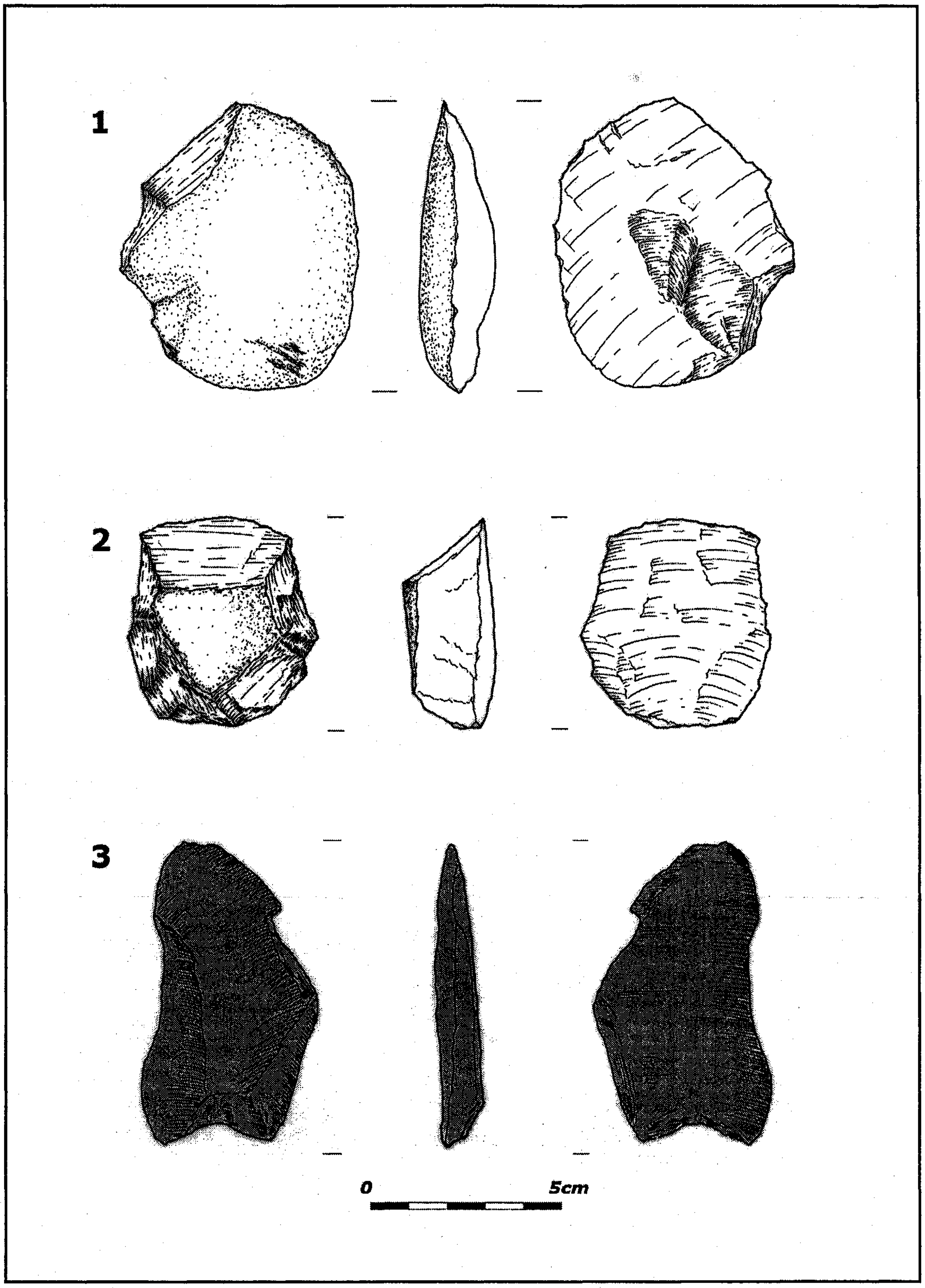


Fig. 4.37. Various flakes from the Chongokni site
(1: N1E17-3, 2: N1E17-31, 3: S1E18-24 made of porphyry)

Flakes and angular shatters (see Andrefsky 1999) make up the principal components of the debitage group while a blade-like elongated flake (Fig. 4.36. #1) and bipolar pieces (Fig. 4.36. #2 and #3) are also included. Flakes show a wide variation of size and morphology. The most frequent type is the primary flake covered with cortex without ridges on the dorsal surface (*e.g.* Fig. 4.37. #1). Some pseudo-Levallois flakes (Fig. 4.36. #2 and #3) were found but their frequency is extremely limited. The platform is rarely prepared and is mostly covered with cortex. The length/width ratio is approximately 1 (Fig. 4.38.), suggesting the principal percussion method is either the simple hard-hammer percussion or the anvil-chipping technique (Shen and Wang 2000). Such straightforward techniques tend to produce amorphous flakes without platform preparation, and the Chongokni assemblage is no exception to this.

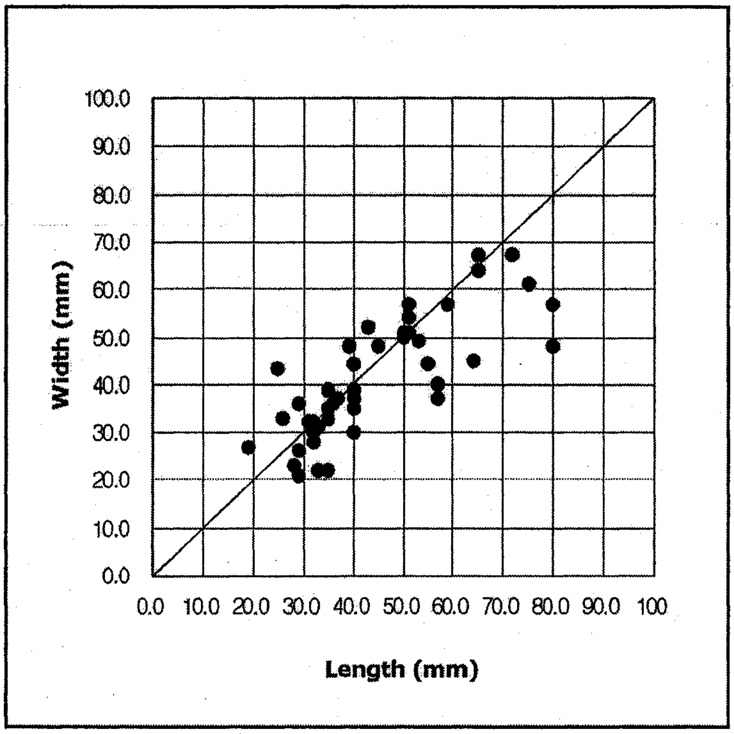


Fig. 4.38. Length-Width Scattergram of flakes from the Chongokni site (n=44)

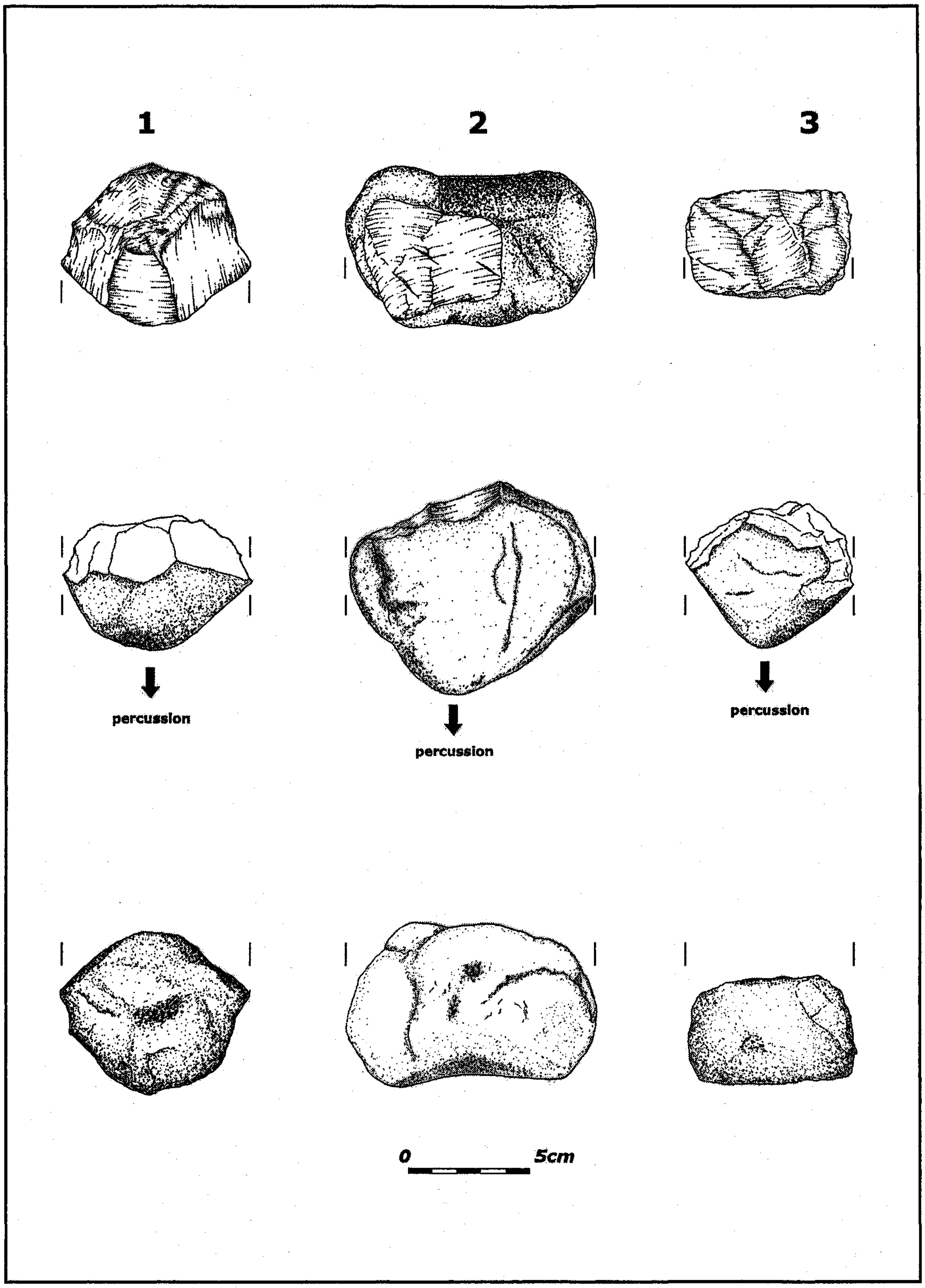


Fig. 4.39. Hammers from the Chongokni site
(1: S1E18-32, 2: S1E18-37, 3: N8E16-35,
arrow points indicate the direction of percussion for supposed use)

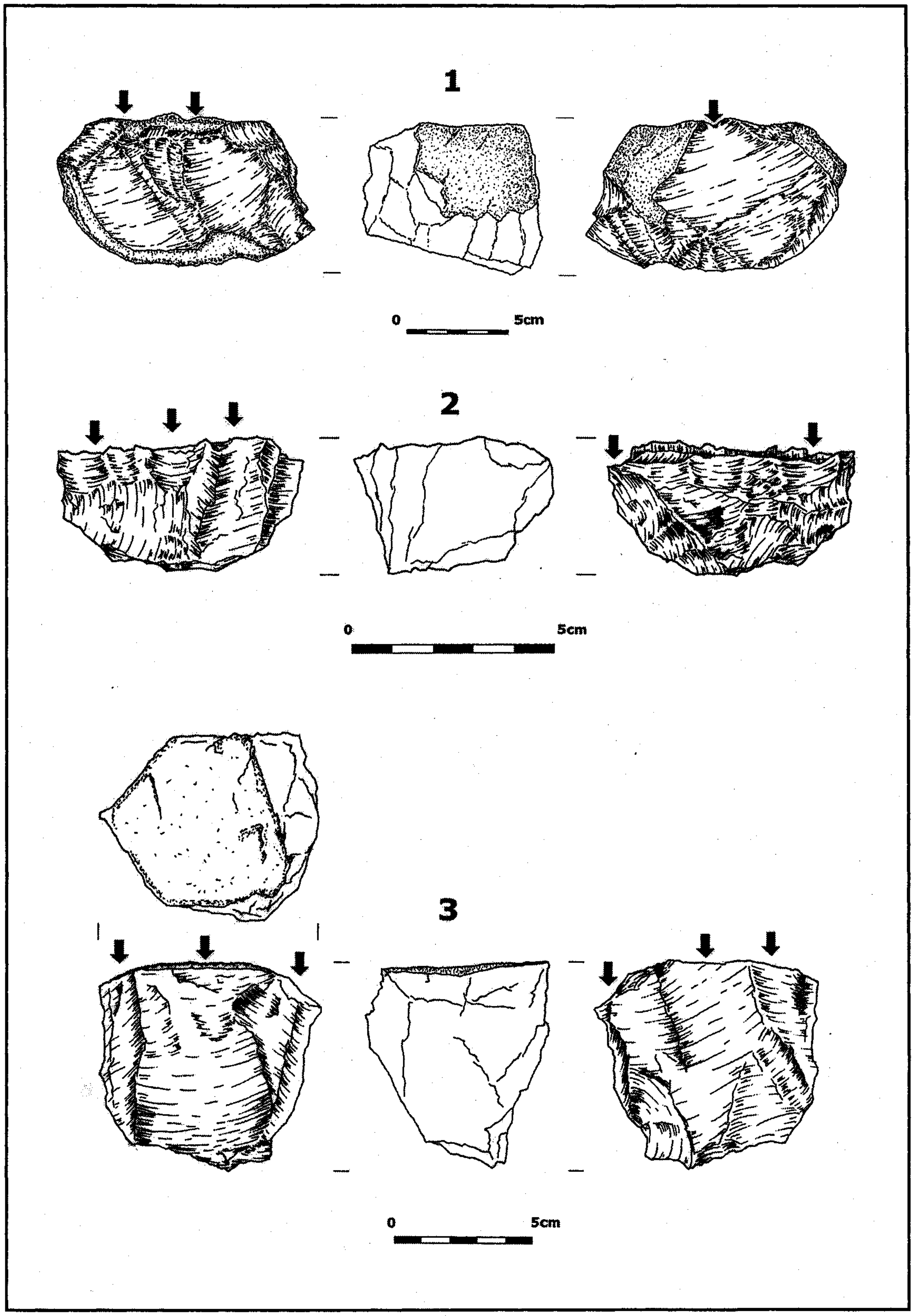


Fig. 4.40. Unidirectional cores from the Chongokni site
(1: N1E17-32, 2: N1E17-24, 3: S1E18-28)

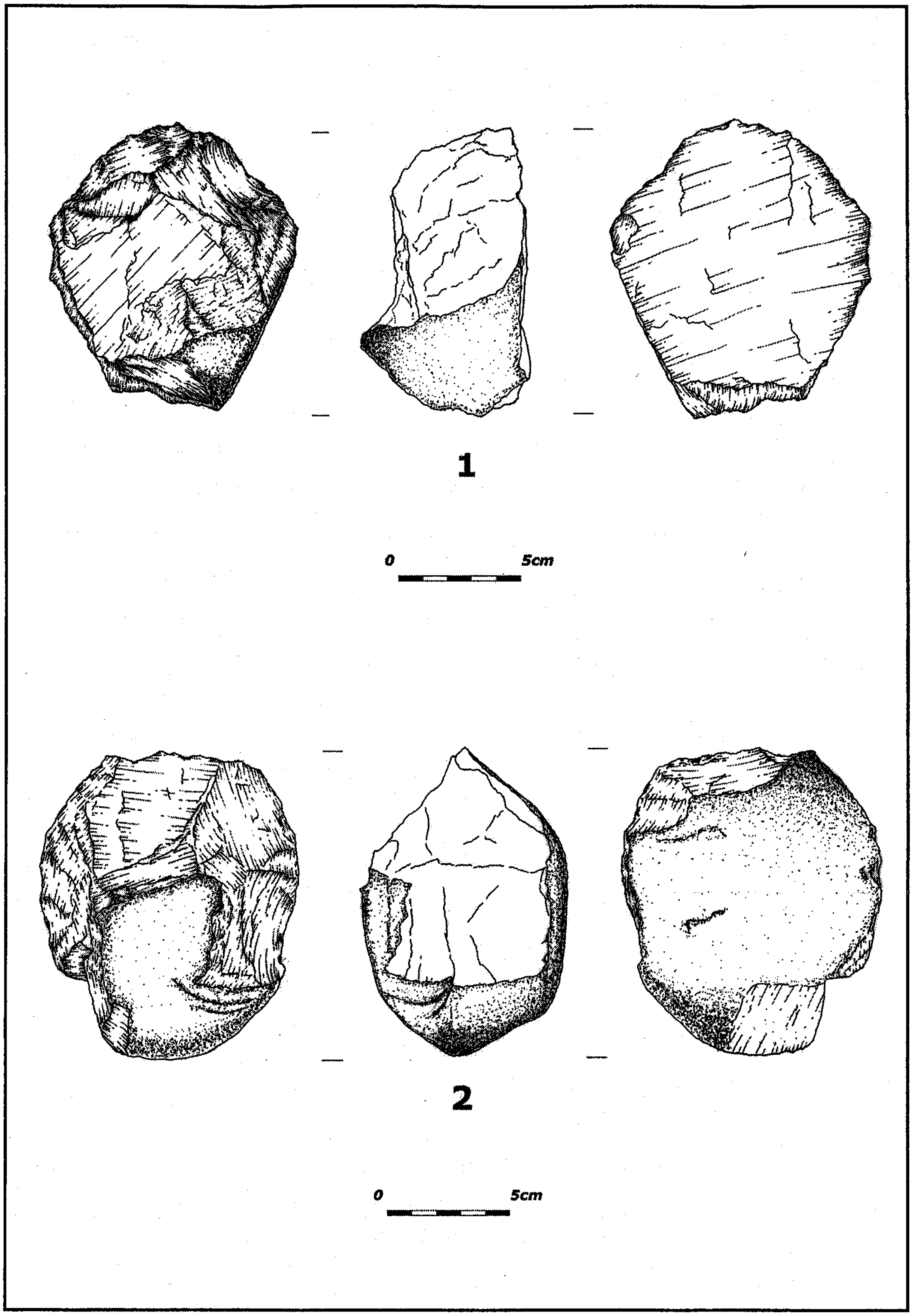


Fig. 4.41. Choppers from the Chongokni site (1: N1E4-2, 2: N4E8-4)

C. Hammerstone

Three hammers were discovered, each of which demonstrates definite percussion marks (Fig. 4.39.). The proximal ends were intensively trimmed probably for better hand-gripping and the overall sizes appear to be made for simple hand-use. The distal ends or tips of all three hammers are smoothly convergent, ideal for enhancing the accuracy of percussion blows and maximizing the striking force. Compared to the Jangsanri assemblage, the Chongokni assemblage was produced by more precisely controlled knapping using hammers; and this indicates that the development of suitable working tools resulted from the increase of manufacturing intensity as well as from the need to devise appropriate task management.

D. Cores

Cores can be divided into three types based on the orientation of flake detachment and the intensity of flake scars: unidirectional, bipolar and multidirectional. It is widely known that the Chongokni assemblage includes a high percentage of multidirectional cores. These are amorphous in form having flaking scars resulting from arbitrary orientation of the percussion blows (termed "casual core" by Bae 1988; Bae *et al.* 1995). In the assemblage from the excavation of 2004, however, the unidirectional or "tabular" core (Fig. 4.40.) is the most frequent type; at least three flakes were detached from each core and a flat, unmodified platform was positioned at the top. The intentional preparation of a striking platform is not observable but some flattening work on the platform surface with marginal modification was occasionally performed (*e.g.* Fig. 4.40. #2).

E. Large Tools

Five choppers and a handaxe comprise the category of large tools; but such types as cleavers, picks and polyhedrons, which have been usually discovered in other excavations, are not included in this assemblage. Choppers (Fig. 4.41.) are made of round or angular cobbles and their working edges are over 70°. They are usually oval in plan with a slender base, which is useful for tight gripping for heavier work.

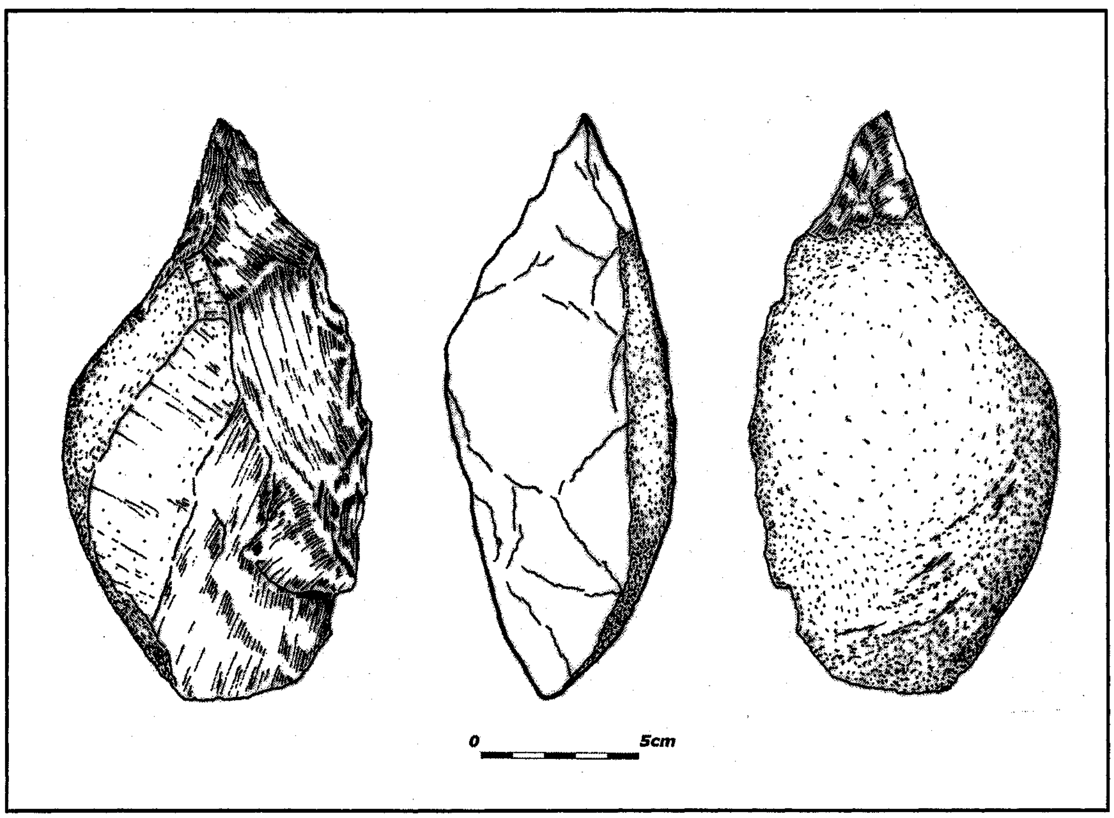


Fig. 4.42. Handaxe from the GRID S1E18-12 at the Chongokni site

A handaxe (Fig. 4.42.) discovered at the S1E18 Grid is minimally or partially bifacial with an unmodified base. Its right margin was elaborately retouched to make a convex working edge and the distal end was vertically struck to make a bifacially pointed tip. Opposite to the lateral edge, the unretouched part retains a cortical surface, indicating that an ellipsoidal cobble with a relatively convergent tip was selected as a blank for one-sided marginal retouch and the other side for an intact gripping part. The degree of shaping is very limited because minimal retouch for the single lateral edge and several simple blows for the tip were sufficient to formulate the *de facto* handaxe.

G. Small Tools

The small tools of the Chongokni assemblage have had relatively little research focus so far. The principal reason for this is the common view that the Chongokni assemblage is predominantly composed of unmodified debitage and casual cores with a few distinctive large tools. Of course, the raw material does not lend itself to careful retouch, and the Chongokni assemblage is based on such rough techniques as hard-hammer percussion and anvil-chipping. Because these techniques are liable to produce considerable amount of opportunistic debitage, the combination of crude raw material with rough manufacturing techniques hardly produces retouch-based small tools; and the deliberate utilization of flakes as blanks was consequently limited.

Nevertheless, even though their quantity is limited, small tools were also manufactured alongside the large tools and several distinct types of these small tools can be demonstrated. The principal types of small tools are scraper, notch, tranchet; and some directly utilized unmodified debitage can be also included in the tool category. The morphological variation of each type is highly dependent on the shape of the original blanks (Kuhn 1992b, 1995) and the degree of modification is less intensive compared to the typical Mousterian counterparts (see Débenath and Dibble 994; Barton 1990; Dibble 1987, 1995). As observed for the Kawolri assemblage, some Upper Palaeolithic types were also made directly from the broken pieces and angular fragments (Fig. 4.44.). The low frequency of the small tools and the narrow type variation indicate that an "imposed" small tool manufacturing technology was not prevalent among the Chongokni hominins.

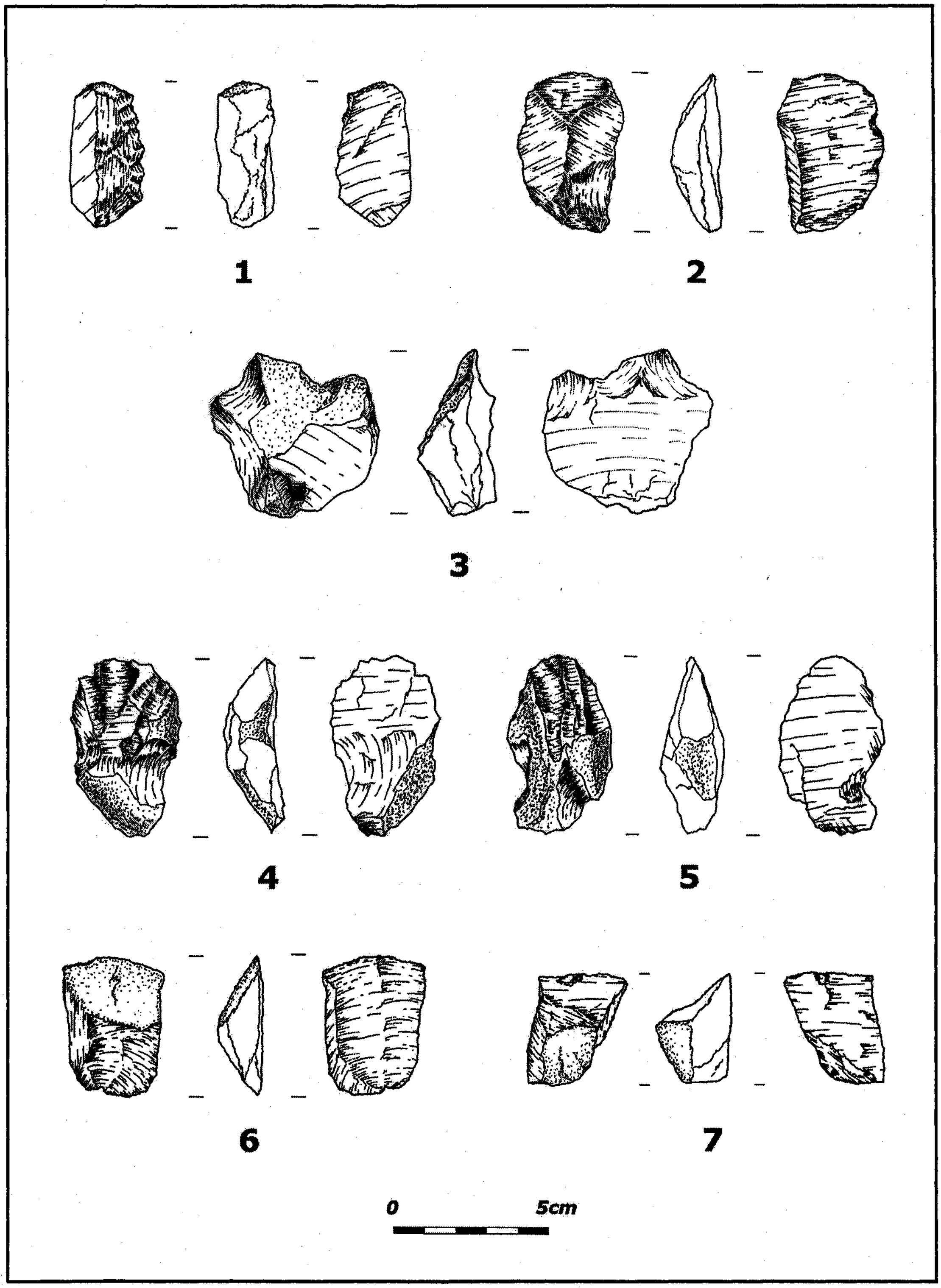


Fig. 4.43. Small tools made of flakes from the Chongokni site (1-2: sidescraper; S1E18-3, N8E11-3, 3: notch ; S1E18-33, 4-5: endscraper; N8E16-3, N8E16-9, 6-7: tranchet; N1E17-12, N1E17-23)

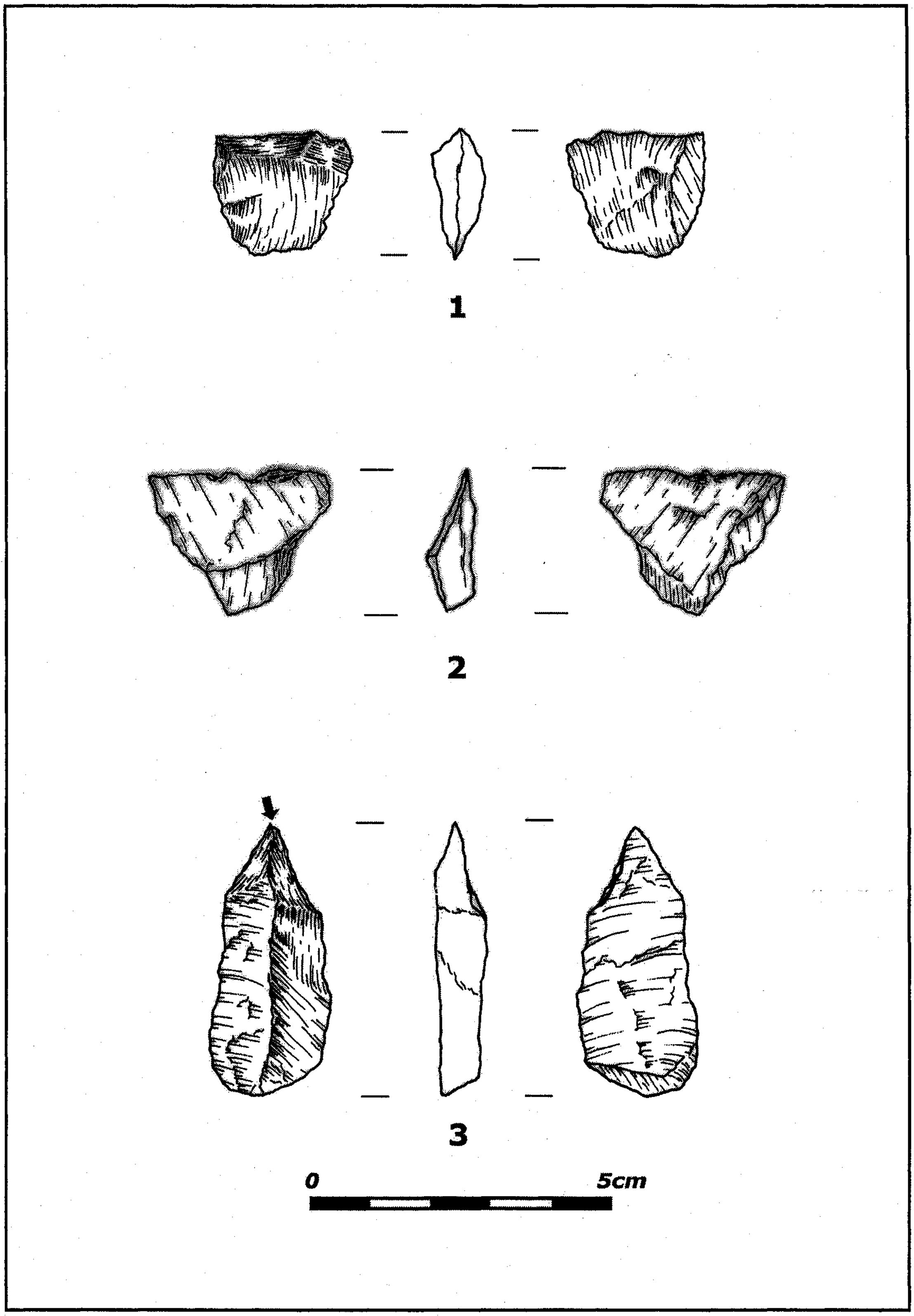


Fig. 4.44. Small tools of Upper Palaeolithic types from the Chongokni site (1-2: Trapezoid; N1E17-8, S1E18-27, 3: Point with a burin spall; N1E17-9)

(6) Other IHRA Palaeolithic Sites

1. The Keumpari Site

A. Location and Discovery

The Imjin River passes through the region of the Juwolri and Kawolri sites and then turns south. The expanded valley takes the form of a full basin which is a vast plain surrounded by low mountain hills today. The Keumpari site (No. 39 of Fig. 4.1.) is located at the river bank of this southward-flowing Imjin River channel. Since its location is very close to the current military base, the study of the surrounding terrain and the investigation of site formation processes at a macro scale are limited. As a result, the exact age of archaeological horizon is hard to ascertain.

It was originally discovered by a field survey team of the Korean National Institute of Cultural Properties with the purpose of identifying additional Palaeolithic sites in the downstream area of the Imjin River. From 1989 to 1992, four excavations were conducted and an additional salvage excavation was carried out in 2004. During the first four excavations, about 2,477 artifacts were collected and two surface level depressions which can be arguably interpreted as a hominin "living space" were discovered (Bae *et al.* 1999).

B. Stratigraphy

The Keumpari site is located in a 5- 6m thick stratified deposit over the basalt bedrock (Fig. 4.45.). Compared to the upstream area, the surface of the lava flow in this region is generally smooth and even; and sometimes exists in a densely stacked heaps of rounded basalt pebbles mixed with other clastic rocks. These basalt pebbles are well rounded and closely cemented to each other with hydrolyzed fine silts, indicating that the fluvial activity was not as turbulent as in the upriver area. The archaeological horizons are mainly distributed within the yellowish brown silty clay layer on top, but a significant amount of its upper zone was disturbed and washed away by post-depositional transformation

C. Assemblage Characteristics

The lithic type variability is almost the same as other assemblages in the IHRA. The Keumpari assemblage includes handaxe, cleaver (Fig. 4.46.), chopper and various poorly retouched small flake tools. The raw material is predominantly crude quartz and quartzite with well-cemented granular sand particles. Unlike the neighboring Juwolri and Kawolri sites, the fine-grained quartz is seldom utilized. The most frequent blanks are rounded river pebbles possibly acquired from the riverside. Small tools were made by a simple technology and the morphology of flakes is relatively wide, indicating that very dull hard-hammer was used. A few elongated flakes were found but no blade was included in the debitage group.

D. Possible Residential Site?

Two or three oval depressions with dense lithic scatters are distributed in the site area; some lithic specimens therein are conjoined with each other. Such crucial data as post holes and/or hearths which are directly indicative of dwelling locales were not found in association with either the depression or the lithic assemblages. Bae *et al.* (1999), based on the conjoining pattern of lithic fragments, postulated that the depressions were possibly used as temporary shelters for hominins while knapping the stones for tools. However, in order to decide whether the depressions were actual shelters, more analysis of the formation processes of the archaeological assemblage must be made (Bae 1998).

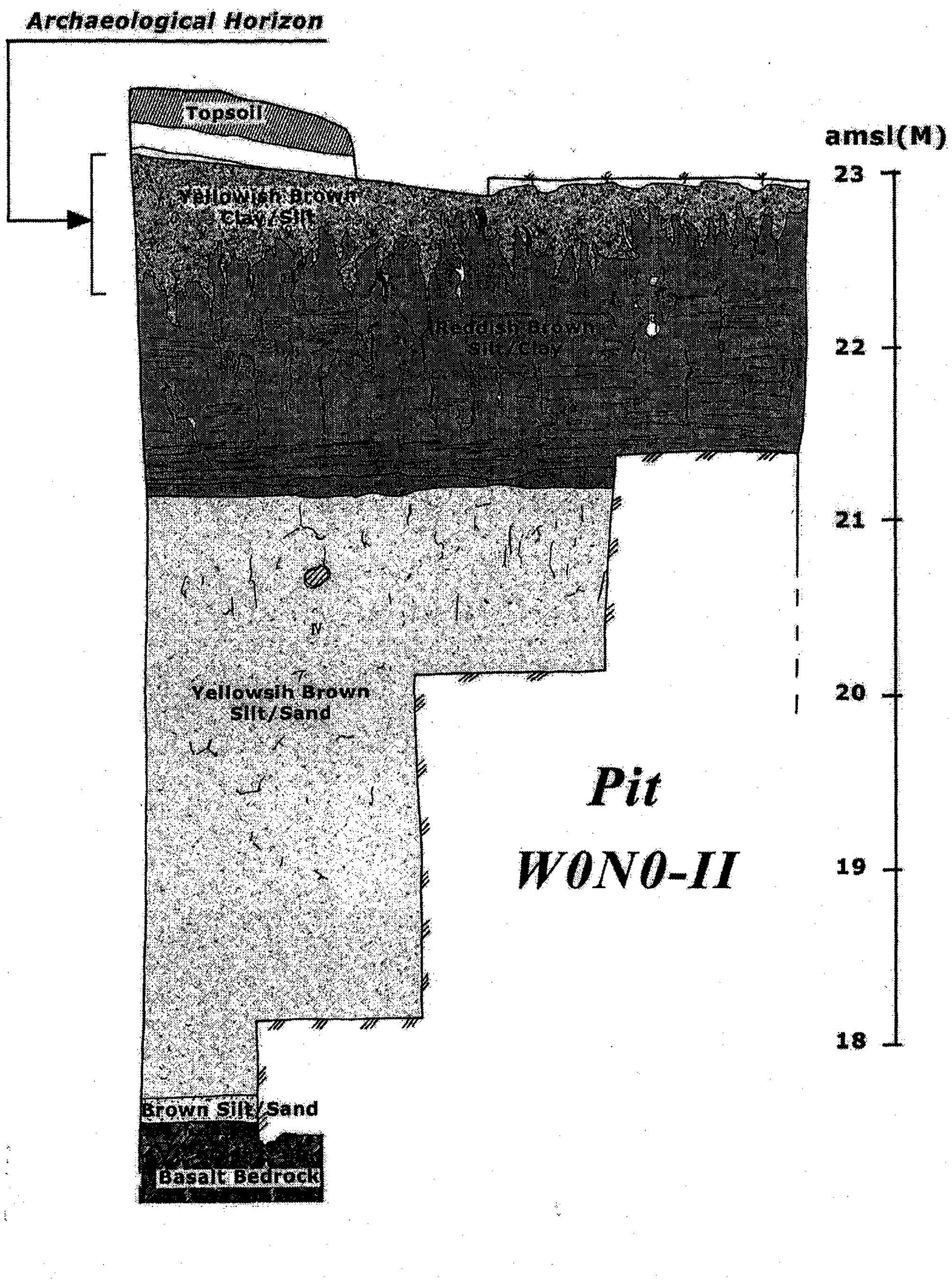


Fig. 4.45. Stratigraphy of the Keumpari site
(Re-drawn from Bae *et al.* 1999: 66)

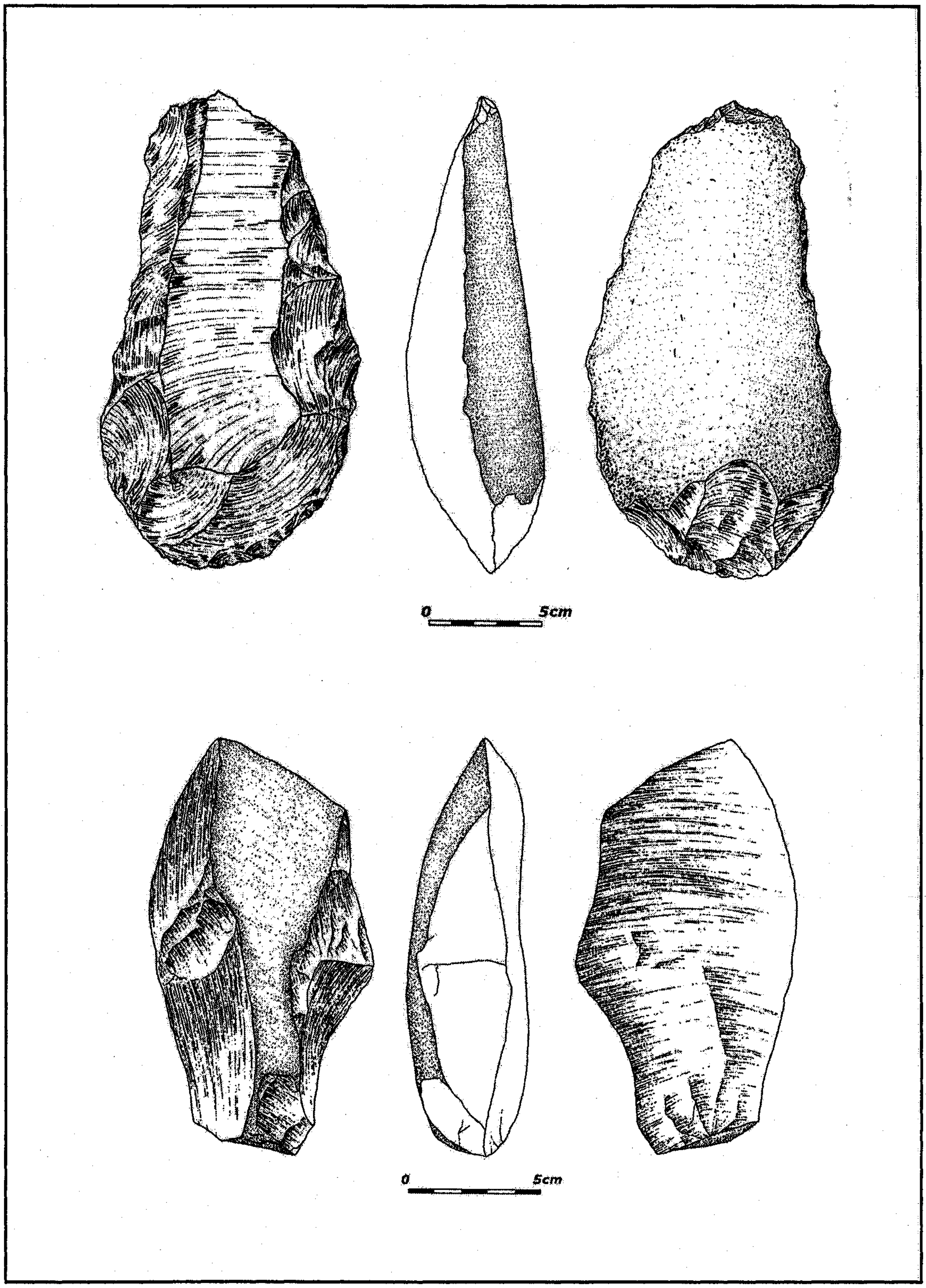


Fig. 4.46. Handaxe and cleaver from the Keumpari site

(Re-drawn from Bae *et al.* 1999: 108, 140)

E. Controversial Age

The age of the archaeological horizon at the Keumpari site is not easily determined because no reliable dating source is available. An analysis (Lim 1999) of the sediment data estimates the lowest date of the initial deposition to be about 130 Kya, which can be correlated to the OIS 5e. The accumulation of sediments continued through the LGM, according to the ice-wedge structure that developed at the top of the reddish brown silty clay layer. However, since most archaeological horizons are distributed within the layer above the wedge horizon, this age estimate is based on a simplistic correlation of ice-wedge with the LGM. Therefore, it is hard to accept this as a reliable date of the lithic assemblage and the depressions.

2. The Hoengsanri Site

A. Discovery and Location

Recently, several archaeological localities were found, along with evidence of another lava flow discovered in the upper Imjin River (Choi B. K. *et al.* 2001; Yi 2004a). This additional lava flow had erupted from the same origin as the Chongok Basalt; and is believed to have detoured along the Yeokgok Stream, a tributary sub-stream of the Imjin River, to finally have reached *ca* 7km north of the Chongok Basalt. According to geochemical analysis, this Imjin River Basalt and the more massive Chongok Basalt have close affinity in principal chemical components and rare-earth elements (Yi, Lee and Lim 2005). However, the upstream area of Imjin River did not undergo such a major transformation caused by volcanic activity as did the Hantan River area because the lava flow was not so enormous as to block the entire Imjin channel (Yi, Y. I. Lee, and J. W. Kim 2004). The Hoengsanri site is located in this area, at the southern extreme of meandering embayment of the Imjin River.

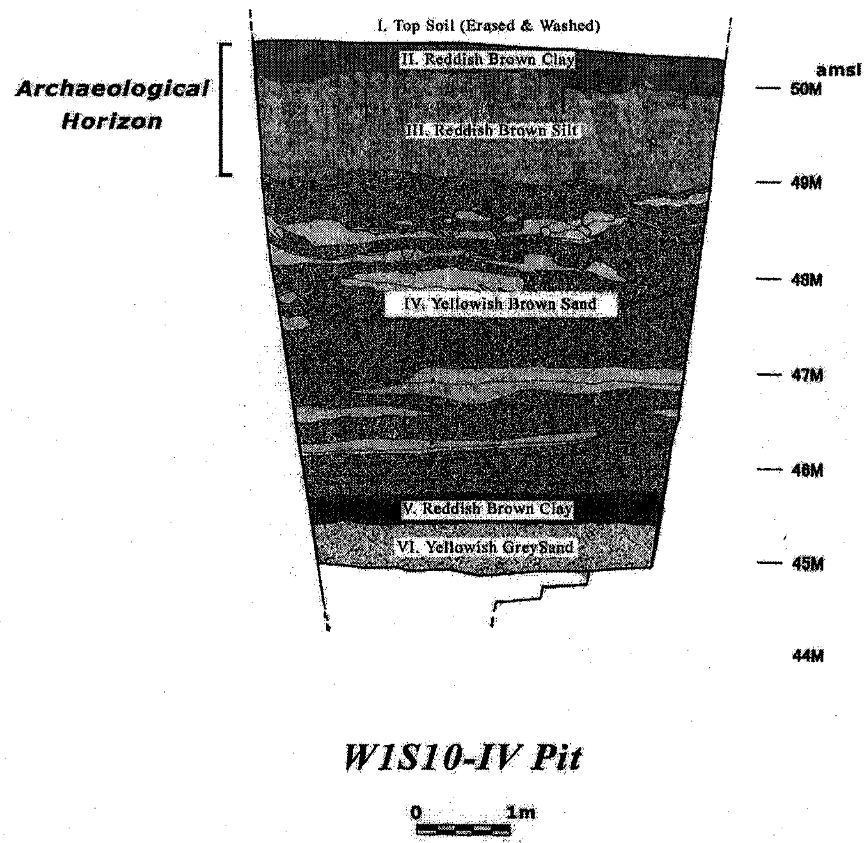


Fig. 4.47. Stratigraphy of the Hoengsanri Site
(Re-drawn from Bae *et al.* 2004)

B. Stratigraphy and Artifact Distribution

Around the excavation area, various stone artifacts are ubiquitously scattered and about ten spots show intensive artifact clusters. The site area faces the Imjin River to its south. The texture and tone of the sediment deposits are almost identical to those of other IHRA sites. Because various sedimentary environments are interrelated, the stratigraphy shows a series of complex intermingled layers which were deposited by hillside slope-wash as well as the usual flooding of the main Imjin River channel (Fig. 4.47.; Bae *et al.* 2004). Basalt is not found at the bottom of the stratigraphic column.

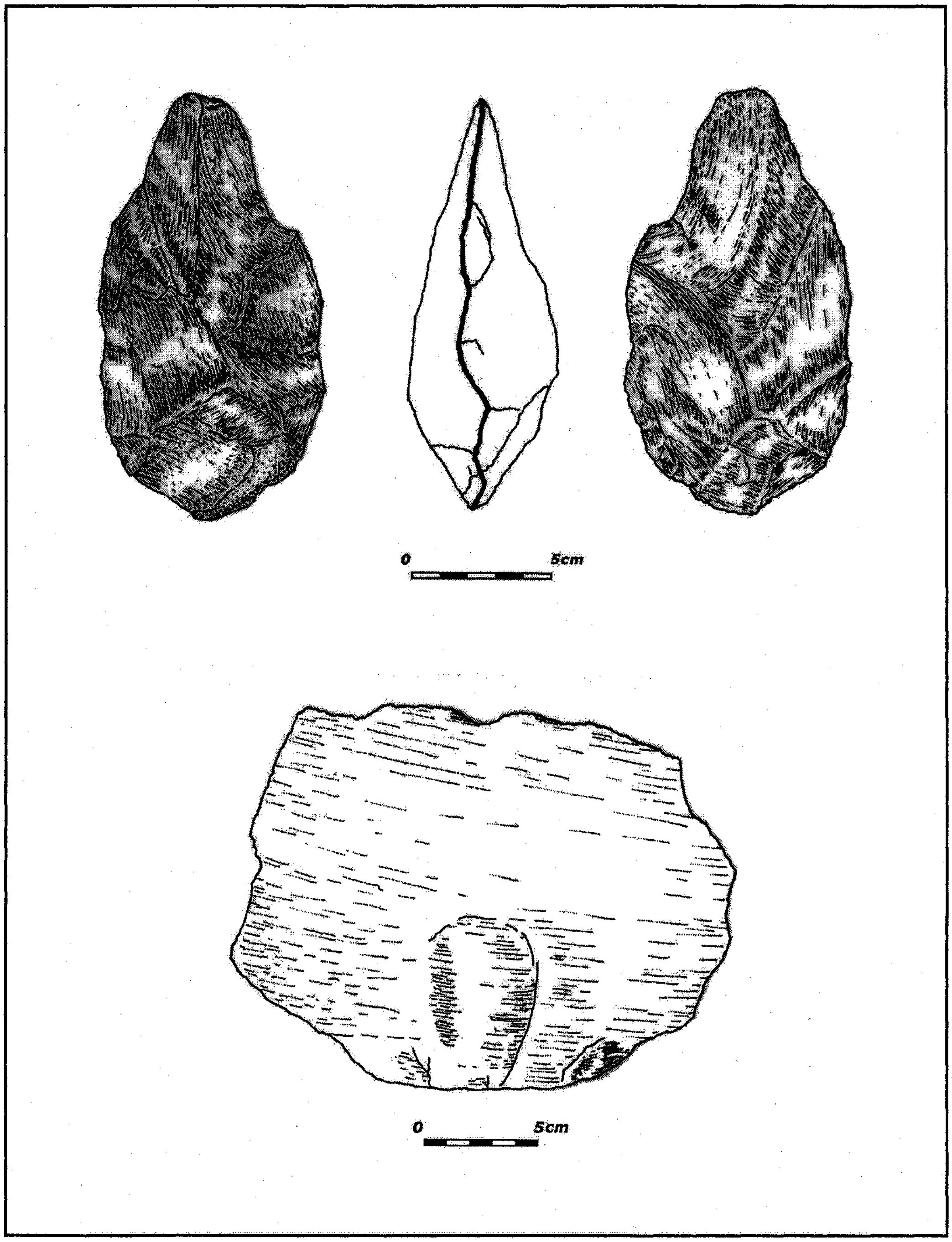


Fig. 4.48. Handaxe and huge flake from the Hoengsanri site (Drawn based on photographs from Bae *et al.* 2004)

Out of a total of 536 artifacts, about 200 were discovered *in situ* and most of these are from the two top layers: the reddish brown clay and the reddish brown silt layers. A handaxe and other heavy-duty tools (Fig. 4.48.) were discovered with casual cores and small-sized amorphous flake tools. Even though the general characteristics of the assemblage are yet to be addressed, the type-variability of the currently available assemblage appears not to be any different from other IHRA assemblages. A high proportion of basalt usage (about 17% of the *in situ* artifacts) is worth mentioning, and a small tool made of obsidian was also retrieved from the surface. The chronometric dates of lithic assemblage are yet to be published. More research is anticipated in this area.

3. The Janghungri Site

A. Location and the Stratigraphy

The Janghungri site is located in the far upstream area of the Hantan River of Cheolwon County, Kangwon Province (No. 1 of Fig. 4.1.), where the average altitude (above 165m amsl) is much higher than other IHRA sites. The archaeological horizon was discovered about 0.5- 1m below the surface. The stratigraphic sequence of the Janghungri site is divided into six units (Fig. 4.49.). Above the sandy gravel deposit of layers 5 and 6, a series of brown-toned silty clay layers is deposited, and an Upper Palaeolithic assemblage is distributed in layer 2. The AMS date (24.4±0.6 Kya) was acquired from an associated carbon sample (Choi B. K. *et al.*2001) discovered above the AT particles from the wedge-shaped crack zone. Choi B. K. *et al.* (2001) argue that the age of the Janghungri assemblage can be correlated to this AMS date although they assume the age of the microcores and microblades is slightly younger than this date.

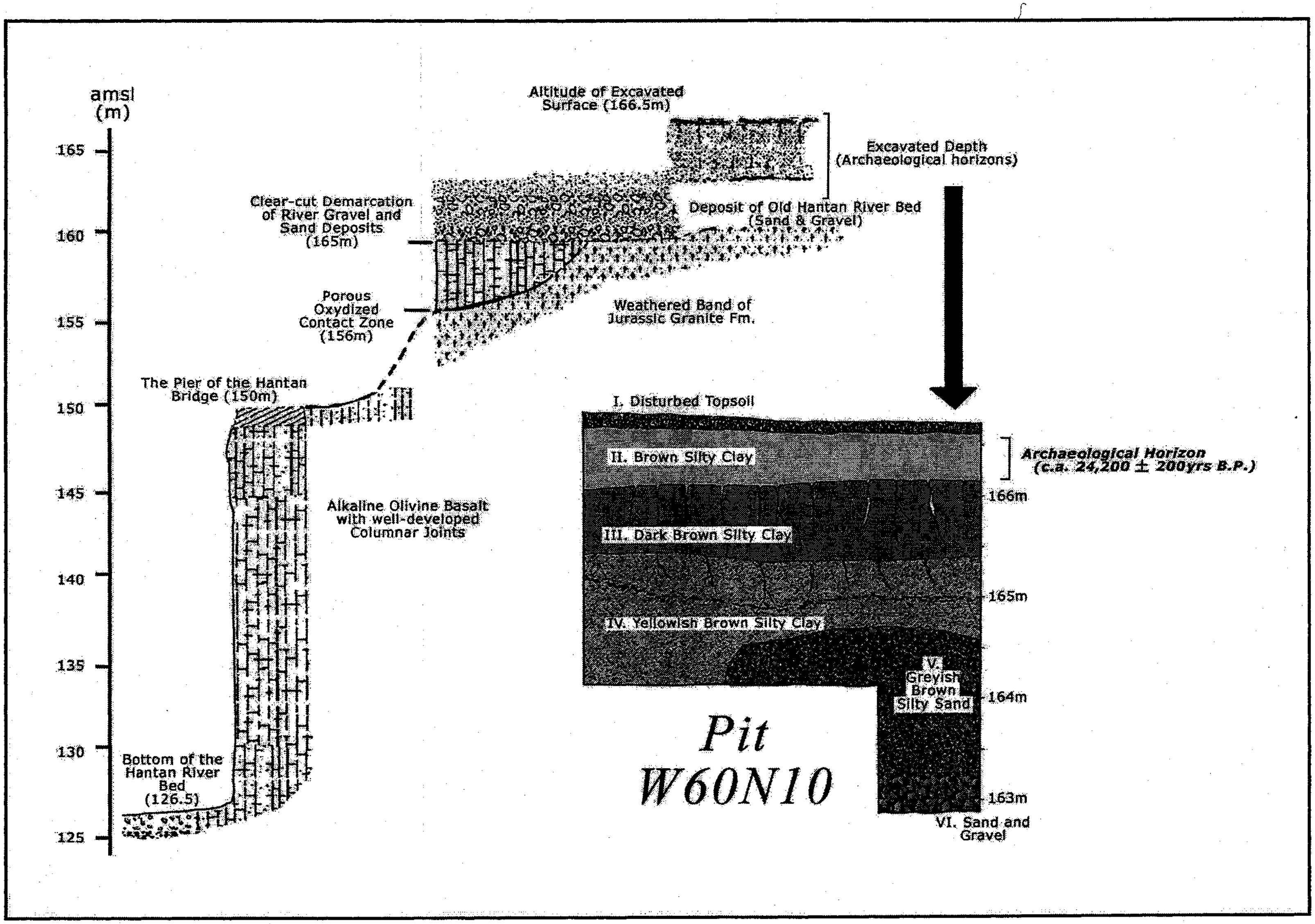


Fig. 4.49. Stratigraphy of the Janghungri Site
(Re-drawn from Choi *et al.* 2001: 171, 194)

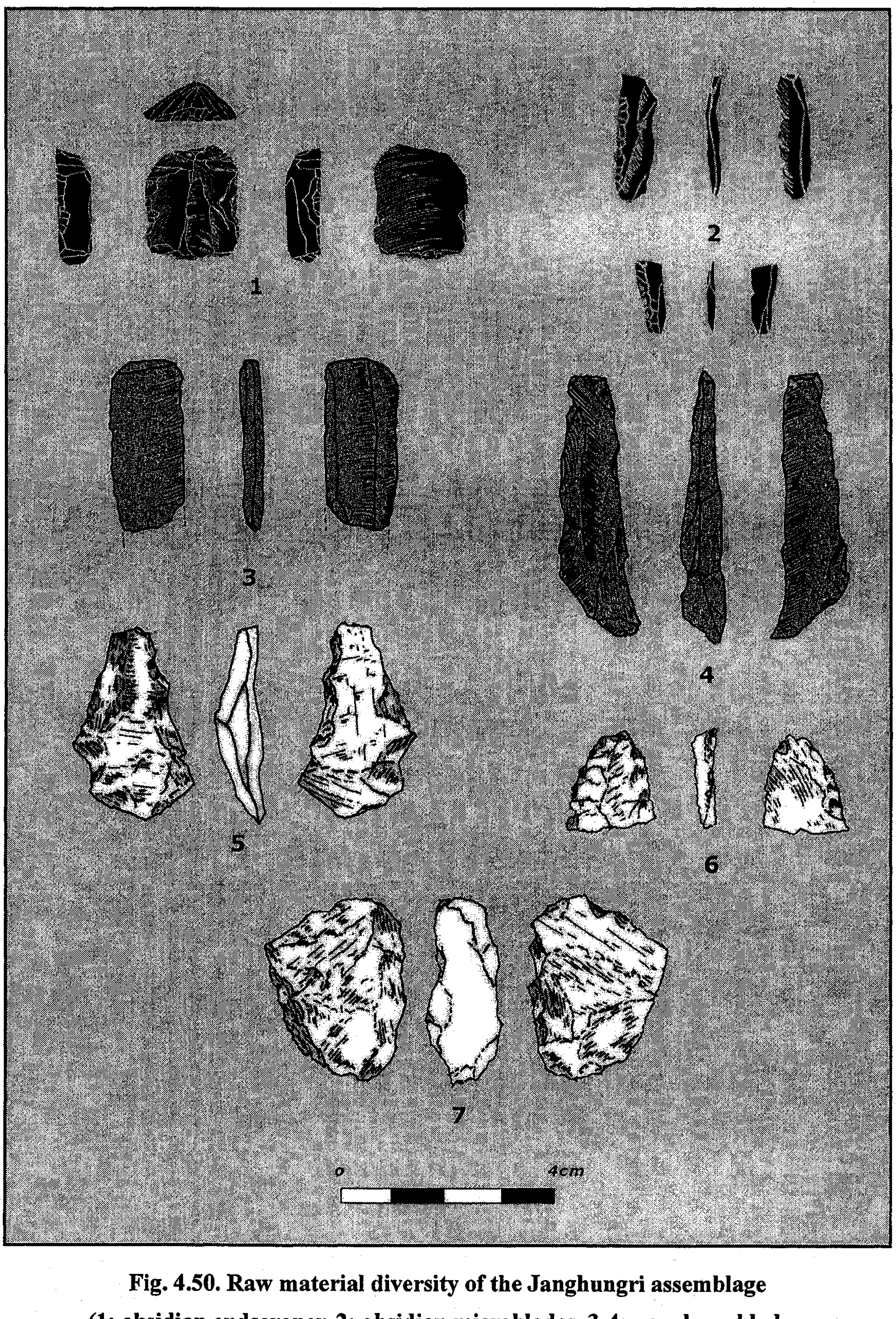


Fig. 4.50. Raw material diversity of the Janghungri assemblage
(1: obsidian endscraper, 2: obsidian microblades, 3-4: porphyry blades,
5-7: quartz sidescrapers ; re-drawn from Choi B. K. et al. 2001: 64, 68, 77)

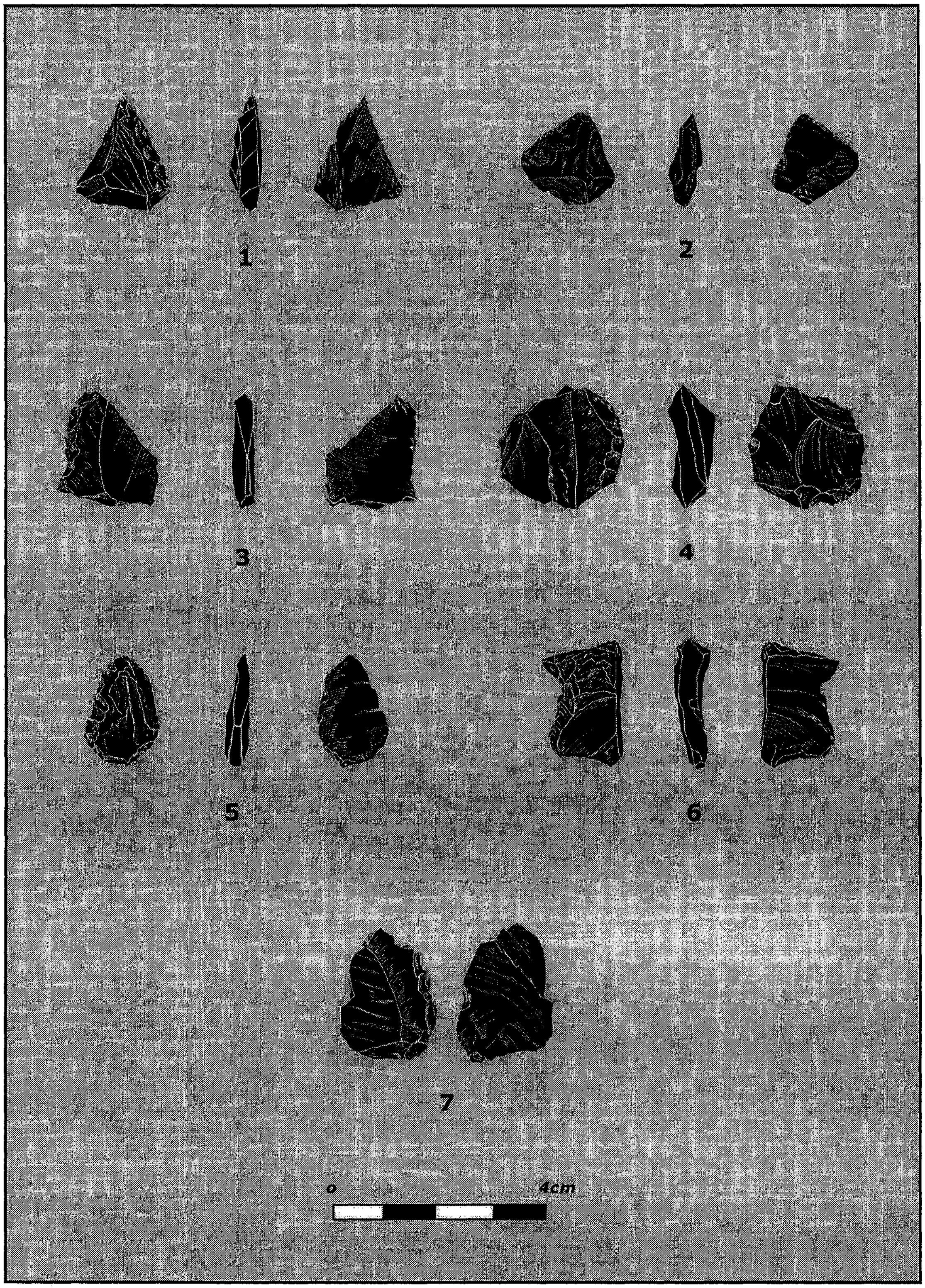


Fig. 4.51. Obsidian microliths from the Janghungri site
(Re-drawn from Choi, B. K. *et al.* 2001: 66, 68)

B. Raw Material Diversity and Assemblage Characteristics

The lithic assemblage from the Janghungri site displays features that are entirely different from those of other archaeological sites in this area. The assemblage is composed of typical Upper Palaeolithic types that are widely distributed in other part of East Asia after *ca* 35Kya (Ambiru 1997; Yi 1999). The raw materials are almost exclusively high-quality ones such as obsidian, porphyry, rhyolite, and chalcedony while some low-quality ones such as quartz and quartzite are also included (Fig. 4.50.).

Among the small tools, some new types are found, such as the flayer, the awl, and the thumbnail scraper, as well as normal sidescrapers and amorphous notches made with small flake fragments. The handaxe and other large tool types are absent, but several small choppers made of quartz are associated with the small tools. Interestingly, the frequency of blades, generally diagnostic of the global Upper Palaeolithic technologies (Bar-Yosef and Kuhn 2000), is very limited. Excluding some broken pieces and pseudo-blades with non-parallel lateral margins (Fig. 4.50. #3 and #4), the genuine blade technology is not well-documented. Indeed, rather than blades, a large amount of microblades and elongated flakes comprises the main part of the debitage group. This "unbalanced" tool characteristic of the Janghungri assemblage leaves much to be examined in the future. Similar assemblages are expected to be discovered in other parts of the IHRA.

V. THE CHARACTERISTICS OF THE IHRA LITHIC ASSEMBLAGES

(1) Problems in the Typology of the IHRA Assemblages

1. Ambiguity and Subjectivity in Typology

The previous chapter reviewed and summarized several archaeological localities in the IHRA and the lithic assemblages from these sites were introduced. Features common to these assemblages can be summarized as: 1) the IHRA lithic assemblages, excluding the Jangsanri one, were deposited after the volcanic eruption, as late as the later part of Upper Pleistocene; 2) in spite of the relatively young age, there is a considerable amount of crudely made small tools as well as some Acheulian-like large tools; 3) raw materials are predominantly low-quality while some assemblages are composed of moderate or high quality materials as demonstrated by the Kawolri and Janghungri assemblages; 4) systematic core reduction and flake acquirement strategies are not well-established, partly because of the raw material constraints and of the low degree of flake production.

It is widely acknowledged that the IHRA assemblages, in general, exhibit a narrow range of variation in tool morphology and that the diversity of technological attributes, such as the amount of retouch, the number of retouch types, and the orientation of tool edges, is apparently limited (Bae 1988, 2002; Clark, J. D. 1982; Kim, W. Y. and Chung 1979; Yi 1989, 1999). A typological characterization of such an inherently "static" assemblage tends to be intuitive and arbitrary rather than explicit and systematic. As a matter of fact, one of the most serious problems with this earlier research is that the typological systematics of the IHRA assemblage are not based on the precise classification of morphological units. For example, the handaxe in the IHRA assemblage is not a clearly defined type; rather, its definition is loosely based on the image of the Acheulian handaxe in each observer's mind. More often than not, the lack of conceptually standardized criteria for formal classification causes a superfluity of new descriptive terms even for a single type description, such as the notorious "mountain summit-like tool" for the simple pointed pick (Choi, M. J. 1991, 1994).

Since clarifying the description of artifacts by a selection of technological attributes is a subjective procedure, it would be truly said that the degree of inter-assemblage variability tends to be directly proportional to the complexity and ambiguity of typological frameworks employed for basic classification. In sum, the typology needs to be more succinct, confusion-free, and, above all, organized and consistent in linking the concepts with systematic terminologies. This goal can be achieved by three tasks: 1) some specific types should be re-defined while ambiguous and awkward expressions be minimized; 2) the attributes of each type should be technologically defined in a strict and systematic manner (Bisson 2000); 3) the denomination of each type should be based on the adequate formal assimilation. For this reason, the typological scheme for the IHRA assemblage should be revised so as to enhance communication among typologists.

2. The Clark-Kleindienst Systematics

Past research (*e.g.* Bae 1988; Yi 1989), which concentrated exclusively on the typological approach to describe and characterize the IHRA assemblages, has especially preferred the Clark-Kleindienst scheme (Clark and Kleindienst 1974). The Clark-Kleindienst scheme, compared to the Bordesian one, is clearer in terms of definition of technological nomenclatures (Yi 1989) and its simple structure of tool categories reduces ambiguity and confusion among researchers (*e.g.* "the inter-typologist variability" by Bisson 2000: 3).

Nevertheless, in spite of its succinctness and wide applicability, there are limitations to the Clark-Kleindienst scheme. Too many types are liable to be categorized into "miscellaneous" items without any specific definition. Small tools made of various kinds of blanks are especially vulnerable to being simply dismissed or lumped together as "debris" and/or "chips" because of their unstandardized morphological features. Above all, it is somewhat methodologically misleading that the Upper Pleistocene lithic assemblages of the IHRA should be classified based on the Lower Palaeolithic typological scheme that depends on the formal similarities among several large tool categories. As noted in chapter IV, overall assemblage characteristics of the Chongokni, Juwolri, Kawolri, and Keumpari sites are not clearly explained under the dogma of Clark and Kleindienst scheme because of the vast differences between the East Asian context and that of the Acheulian industries of Africa. For these reasons, the basic typological scheme of the IHRA assemblage should break with the Clark-Kleindienst scheme. Instead, it is necessary to devise a suitable systematics based on technologically defined attributes.

(2) Core Technology and Blank Acquisition

1. Core Reduction Technology

A. General Features of the IHRA Cores

In the IHRA assemblages, the frequency of cores is relatively small. Because of mechanically poor raw materials, the intensity of flake detachment from a single core is not well-documented and its general features are arbitrary rather than systematic. The platforms for primary flakes are rarely prepared and the number of detachments is directly affected by the size of flake removal and the scar patterns left by previous detachment. Three core types are recognized based on the platform characteristics and detachment patterns: 1) unidirectional, 2) bipolar, and 3) arbitrary.

B. Unidirectional Core

The unidirectional core is the most frequent type in the IHRA. This core is usually large because river cobbles were directly used without any size reduction., Typically, it has a single platform on top and the direction of flake detachments is uniformly perpendicular to the surface of the platform. A rarely modified flat cortex surface of a nodule was directly used as the platform for initial flaking coordination. The number of scars is determined by the width of the detached flakes but usually does not exceed 4. The cross-section is generally cuneiform and is somewhat similar to that of a heavy-duty tool with a transversal edge.

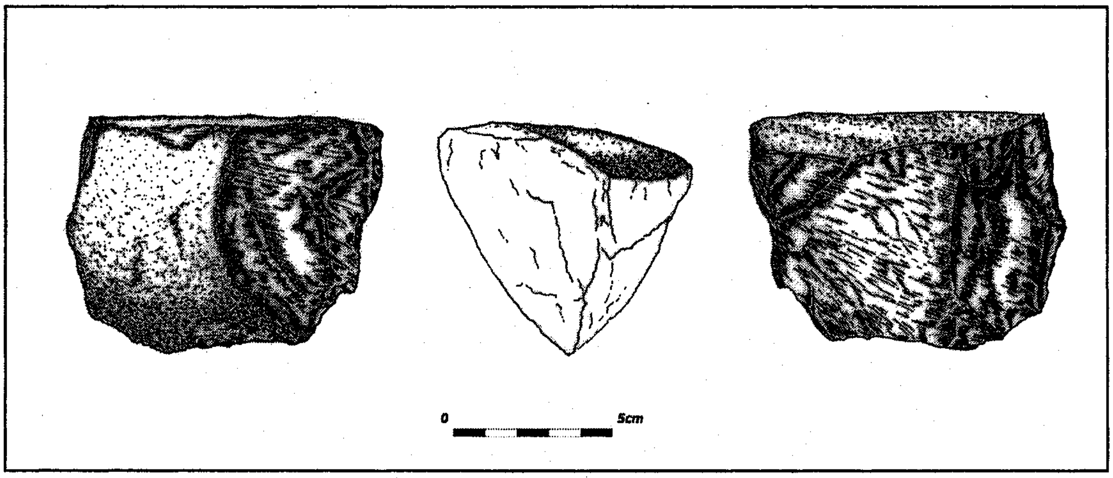


Fig. 5.1. A unidirectional core from the Jangsanri site

C. Bipolar Core

The Bipolar core has one platform on each opposite side and the flake detachments were performed from both platforms. Its unique double-sided platform morphology is attributed to the usage of originally flat nodules that had cortical flakes removed from opposite ends. Unlike the unidirectional core, the bipolar core has well-developed laminar ridges and its two platforms are more or less modified. This core is generally smaller (*i.e.* more exhausted) than unidirectional core and the size variation of flakes detached from this type is relatively low because their maximum dimension is limited by the distance between two opposite platforms.

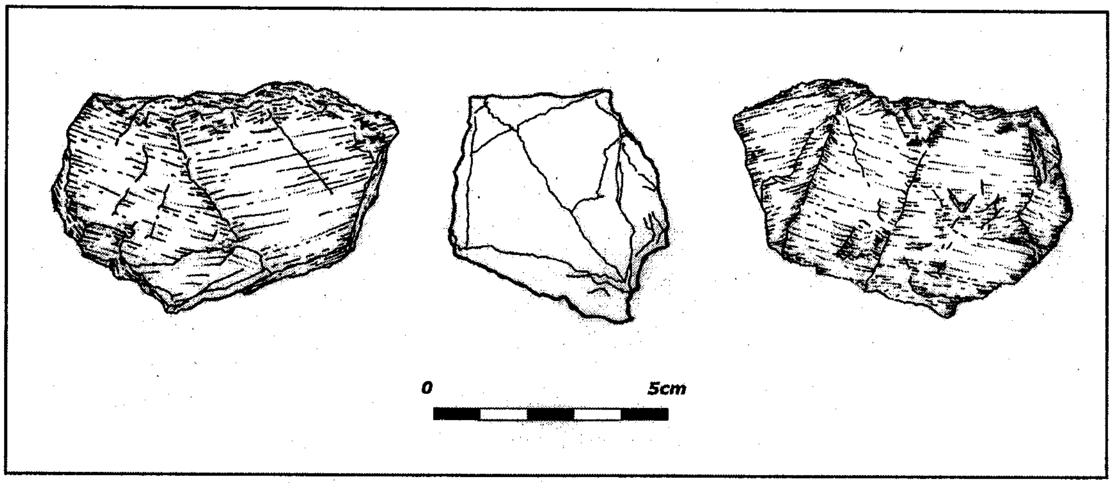


Fig. 5.2. A bipolar core from the Kawolri site

D. Arbitrary Core

The arbitrary core has no specific platform and it rarely shows any patterning of the flake scars or detachment ridges. Because of its apparently randomized reduction sequence, the number of flake removals from a single core is highly contingent on its original size; the configurations of detached flakes are arbitrary since often no traces of previous removals are seen. In some cases, a pseudo-centripetal core can be manufactured resulting from several radial detachments from the periphery of a globular nodule. Other than this case, any pattern of a flake removal sequence or of a platform preparation is hardly expected.

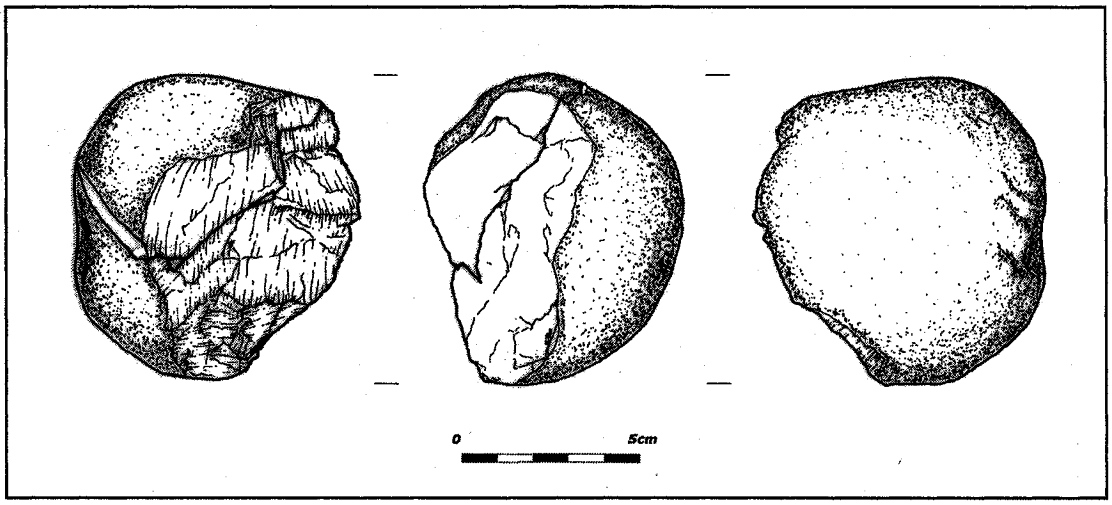


Fig. 5.3. An arbitrary core and a conjoining flake from the Chongokni site

2. Debitage Categories and their Characteristics

A. Definition of Debitage

Debitage is usually defined as an aggregation of unshaped, directly detached pieces resulting from percussion blows against another stone (Andrefsky 1998: 17). Within lithic technological organization, the term usually refers both to the results of various reduction sequences that are directly the outcome of intended tool-making and to the unwitting results of producing miscellaneous chipped items.

In the IHRA assemblage, debitage is categorized into five types; and each type is based on the mode of formation and the size: 1) flakes, 2) shatters, 3) bipolar pieces, 4) chunks, and 5) blades or their affiliates. Because it is still questionable whether some of these debitage types were directly used as tools without further modification, they are, at best, regarded as delineating possible preparation for future alteration; and their primary function is then treated as limited to being blanks for tools.

B. Flake

The flake is the principal chipped fragment resulting from percussion and/or pressure force applied to cores. It displays a distinctive platform and other mechanical properties such as a bulb of percussion, one or more flake scars, ripples, and so on (for various technological terms of flake, see Andrefsky 1998; Inizan *et al.* 1992; Kooyman 2000; Speth 1972; Whittaker 1994). In a strict typological sense, a flake should be intact, (the "complete flake" type; Sullivan and Rozen 1985), not having been damaged by subsequent fractures. Any broken or chipped flakes do not fall into this category because they might be the results of some modifying activities, whether natural or intentional.

An intact flake can serve as an excellent tool for basic tasks such as cutting, scratching, peeling and trimming other material (Inizan *et al.* 1992). It is, however, usually employed for procuring blanks that are to be retouched on their lateral and/or distal parts for manufacturing intended tools. Therefore, the flake can be regarded as a versatile initial product the function(s) of which were determined by the technical needs of hominins. It could be simply discarded, directly utilized for simple tasks without any modification. In most cases, it would be optionally modified as a durable tool blank for later utilization and/or subsequently fractured into various shatters.

C. Shatter

Compared to flakes, shatters include a wide range of chipped debitage. Andrefsky (1998: 82) noted that all detached pieces do not necessarily fracture into shapes with the recognizable dorsal and ventral surfaces of flakes. These non-flake debitage, such as blocky chunks and fractured chips, is recognized by the lack of discernible flake features, and these are called "angular shatters." In addition, he recognized that some fragments of broken and split flakes shared the same feature with normal angular shatters and called them "flake shatters" (*i.e.* debris, flake fragment, and broken flake by Sullivan and Rosen 1985).

Generally, shatters are not suitable for direct use because they hardly contain any naturally sharpened edges. For this reason, many researchers consider shatters as simply discarded pieces identical to debris. In some cases, however, they are intentionally selected as blanks to be modified for making "unorthodox" tools, especially under the situation of raw material shortage in which economizing is called for (Jeske 1989). Since the shatter, regardless of its size and shape, tends to be produced by uncontrolled percussion without a schematized blank production strategy, the use of shatters as small tool blanks can be ascribed to the recycling strategy for maximizing the available raw material.

In some cases, however, shatters are intentionally produced by reducing normal flakes. A flake can be horizontally snapped and vertically split in order to reduce the size and to enhance the total length of suitable edge. For example, a clever method is to take a flake of moderate size and split it into two long, slender spalls. This makes two blade-like laminar blanks without the additional need to make an elaborate platform or to use a delicate indirect percussion technique. Likewise, a flake can be horizontally snapped to produce a series of tiny fragments. These "broken flakes" are additionally retouched for making miniscule tools ideal for composite tools. The advantage of shatter of this type over the normal flake is its versatility. Regardless of the original size and shape, the use-life of shatter can be determined by its potential for intended tools. Its generally angular shape and volumetric convexity furnishes various potential working edges available for further modification.

D. Bipolar Piece

Usually the bipolar technique produces unique debitage. Most researchers use the term "bipolar flakes" (*e.g.* Andrefsky 1998; Kobayashi 1975) without discriminating them from normal flakes. In a sense, the bipolar flake can be regarded as being identical to normal flakes, except that it takes a special method and manual device to produce them. When a bipolar flake is to be produced from a small pebble, the primary splitting stress is the resilient force of the Hertzian wave (*see* Kobayashi 1975; Speth 1972) reflected against a hard material. This reflected force produces a vertical crack dividing the pebble, and a great deal of pressure, proportional to the length of the pebble and to its mechanical strength, should then be applied at the top. In this case, the pebble should be place with its longitudinal axis perpendicular to the surface of the anvil, say a flat rock. This procedure requires a more labor-intensive strategy than the normal percussion flaking.

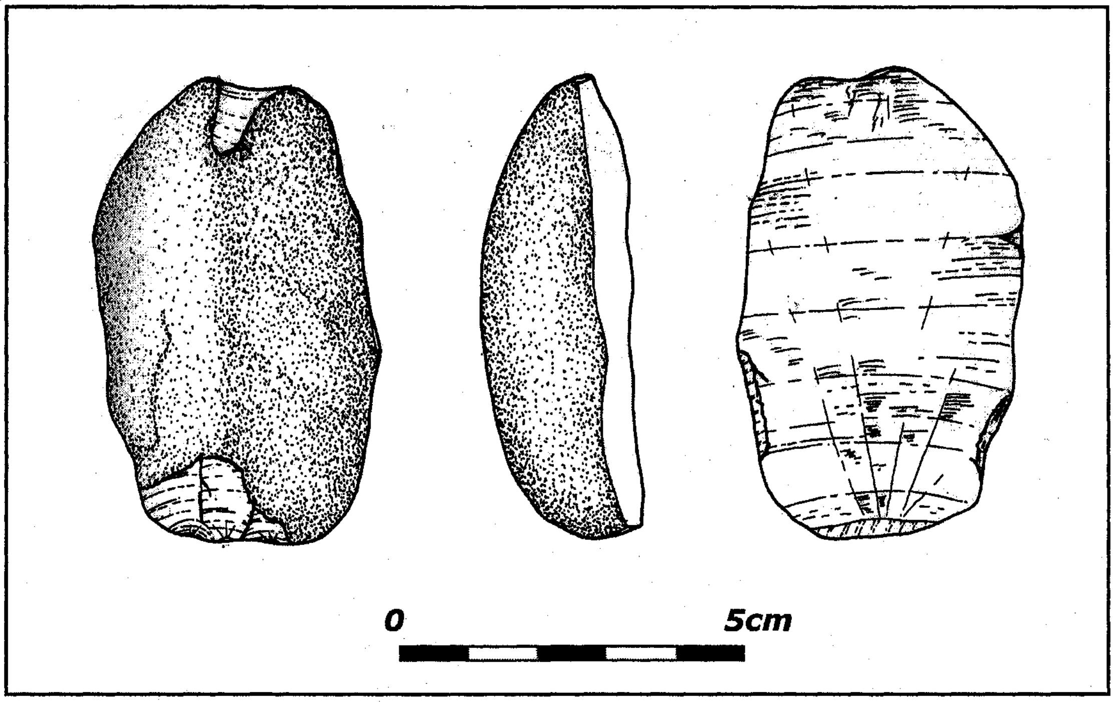


Fig. 5.4. A bipolar piece from the Keumpari site

From this, it is appropriate to use the term "bipolar piece" rather than "bipolar flake" in order to distinguish it technologically from the normal flake. The general features of a bipolar piece can be summarized as: 1) a (usually) diminutive bulb of percussion; 2) no distinct flat surface indicating a striking platform (Kuhn 1995); and 3) the traces of initial fracture (*e.g.* the "compression rings"; Andrefsky 1998: 121) occasionally appearing at both extremes of the longitudinal axis. It has been suggested that the bipolar technique usually was employed when the size of the available raw material was very minimal (*e.g.* small pebbles along river shore; Jeske and Lurie 1993; Kuhn 1995; Parry and Kelly 1987), or when any chipped stone tools were necessary for plant resource utilization (Shott 1994).

E. Chunk

In spite of being loosely defined, this term has been frequently used by several researchers (*e.g.* Bae 1988, 1994, 1995a; Choi, M. J. 1991, 1997). In a strict semantics, it refers to blocky and/or lumpy stones but actual usage of this term is confined to the large shatter, as large as the usual river boulders (10- 20cm in their maximum dimensions).

A chunk can be defined metrically rather than technologically as any piece of debitage larger than 10cm in its maximum dimension. The index of "10cm" is somewhat arbitrary but it implicates what the average individual hominin hand can "tightly grasp." Its large size and percussion technique can be contextually delineated. In order to create a chunk, there must be enough striking distance and a great deal of mass to break a large nodule into smaller pieces. For example, flakes larger than 10cm can be categorized into "chunks" based on the fact that large flakes are rarely acquired by normal free-hand hard-hammer percussion but by some other heavy-duty techniques such as throwing or by the "anvil-percussion method" (Shen and Wang 2000).

For this reason, the term "flake" should be strictly limited to small pieces less than 10cm in diameter. For hominins to produce chunks, they should either slam the nodule against a hard anvil or use an extremely heavy hammer grasped with both hands. In either case, the labor input and principles of fracture mechanism are totally different from normal hammer percussion, which requires one hand grasping a hammer and the other vising a core. Chunks, along with cobbles of adequate size, are used as blanks for producing large tools such as a handaxe, a cleaver, and a pick.

F. Blade or Blade-like Debitage

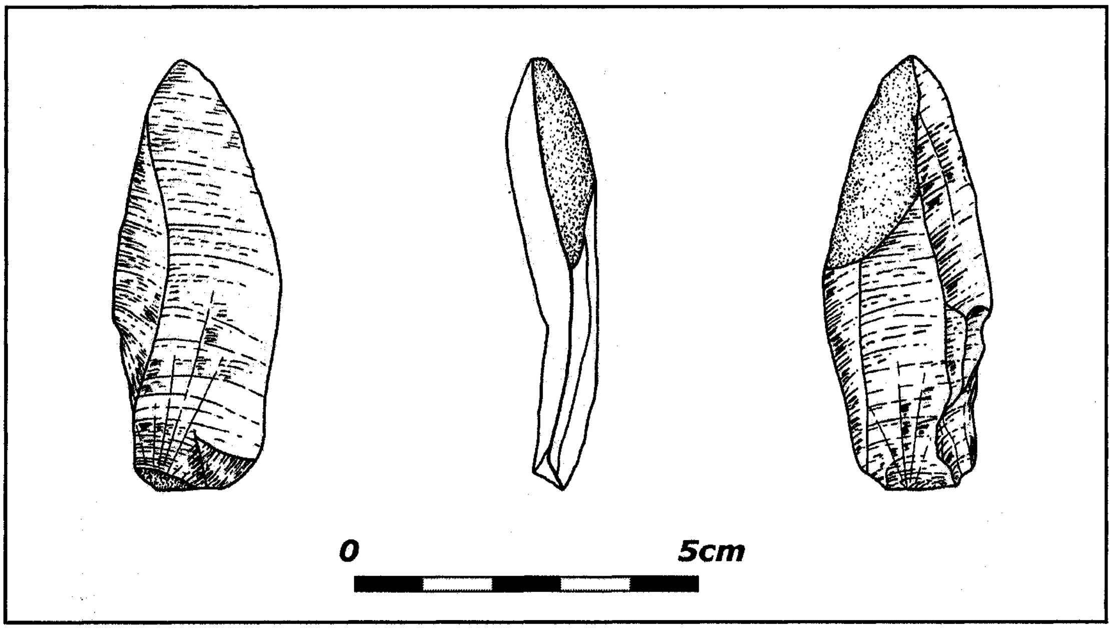


Fig. 5.5. A blade-like elongated flake from Keumpari

This category literally refers to the elongated flake with two parallel lateral margins. Its occurrence in the total IHRA assemblage is very limited, and the length/width ratio is usually less than 4. It is believed that these elongated and parallel-margined flakes are occasionally produced when a well-controlled striking blow was applied to a moderately prepared platform. This is rarely witnessed, suggesting that a "laminar technology" was not prevalent across the total assemblage of the IHRA (Bar-Yosef and Kuhn 1999: 323).

Since the production of blades is associated with a highly schematized core reduction technology, the low frequency of blades in the IHRA assemblage can explain the absence of well-prepared platform modification such as those associated with the techniques of prismatic and/or Levalloisian cores (see Kuhn 1995 for the manufacture and utilization of these cores from the Pontinian assemblages). In rare cases, slender bipolar blade-like forms can be acquired by splitting long and ellipsoidal pebbles; and a pair of elongated spalls is produced by vertically cutting through a normal flake. Those two "unconventional" debitages can substitute for the laminar blanks, and are occasionally observed in the IHRA assemblage.

(3) Tool Types and Manufacturing Procedures

1. The Large Tool Category

A. Large Tool Types of the IHRA Assemblage

Tools are usually made with special design considerations guided by assumed functions for achieving specific tasks (Hayden *et al.* 1996; Nelson 1991). Based on their overall size, tools can be divided into two groups-large and small- and each group has diverse formal types based on the shape of the original blanks and the pattern of modification.

Large tools include core tools made of cobbles and chunks. They are generally over 10cm in their maximum dimension. In the IHRA, the frequency of each type varies from site to site and the formal variation is heavily dependent on the characteristics of the locally available raw materials. Common types across the overall local assemblages include: choppers, picks, handaxes, cleavers, and some irregularly shaped tools such as polyhedrons and large scrapers (see Ch. IV for various large tools from the IHRA).

B. The Chopper

The Chopper is the most frequently found large tool type made in the IHRA assemblage. It is made from a round cobble and/or an angular chunk (*e.g.* Fig. 4.40. in Ch. IV). Because of its formal simplicity and irregular morphology, the chopper is usually regarded as identical to a casual core. It has an obtuse working edge (usually transversal) on the side opposite to the assumed grasping side, and the edge is unifacially modified. Some bifacial choppers, the "chopping-tools" defined by Movius (1944), have been also found.

C. The Pick

Compared to the chopper, the pick has a pointed tip on the distal extreme of the longitudinal axis (*e.g.* Fig. 4.8. in Ch. IV). It is usually made of an ellipsoid cobble; but some crude chunks are also employed. The cross-section of the tip is usually triangular. Except for its elongated and pointed shape, the general manufacturing procedure is identical to that of the chopper.

D. Handaxe

While some have suggested the IHRA handaxe is equivalent to the classic Acheulian handaxe, its morphology is very crude and lacks elaborate formal delicacy. Regardless of morphological variation, the IHRA handaxes commonly have two intensively modified convergent lateral edges. In most cases, the handaxes of the IHRA are not well-trimmed and large areas of cortex are left unmodified. Bifacial flaking is performed in a limited basis and, when noted, this is concentrated at the distal end of the longitudinal axis (*see* Bae 1983, Bae *et al.* 1999; Kim, W. Y. and Bae 1983; Yoo 1997).

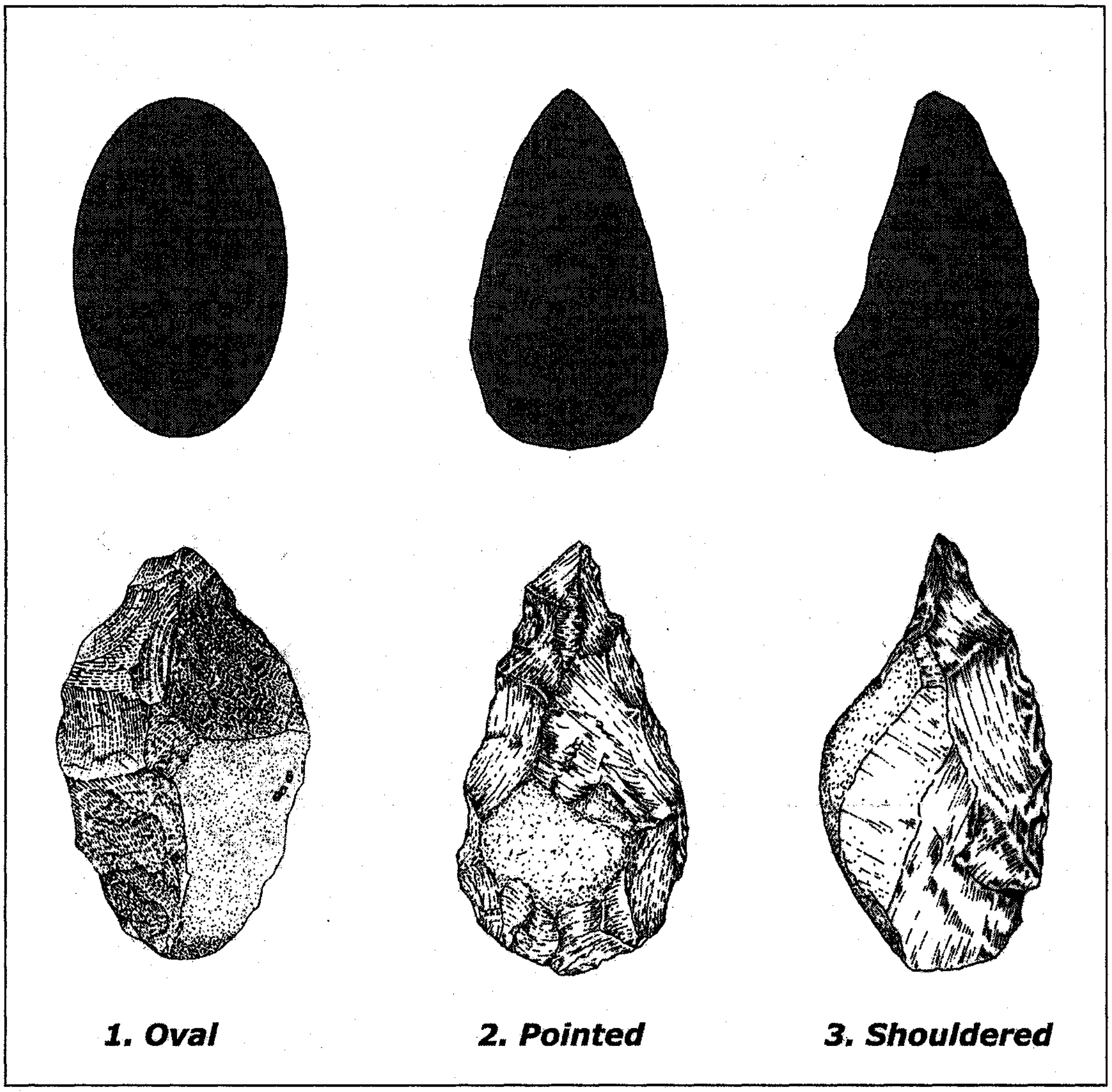


Fig. 5.6. Three formal variations of handaxe in the IHRA assemblages

Yoo (1997) observed that a specialized technique for producing blanks was employed in order to facilitate the overall shaping of the handaxe. When a large chunk was struck off from the corner of a large angular nodule, it forms a roughly triangular shape having two converging lateral edges which could then be advantageously used to produce a handaxe by applying a few simple additional shaping blows. The formal variation of the handaxe includes three major subtypes: oval, pointed, and shouldered (Fig. 5.6.). Insofar as these handaxes are designed for multifunctional use, it is hardly expected that this formal variation reflects any functional specialization and/or stylistic distinction that have temporal or spatial diagnostic significance.

E. The Cleaver

Combined with the handaxe, the cleaver served as a good *fossile directeur* for assimilating the IHRA assemblage with the Acheulian industry. In general, however, the cleaver is rarely found in the IHRA assemblage compared to the handaxe. It is generally produced with a chunk having a large transversal natural edge (*e.g.* Fig. 4.26. and Fig. 4.45 in Ch. IV). The lateral edge is minimally modified and the distal end, in most cases, is usually maintained with the original configuration of its blank chunk. Because its form is strongly influenced by the shape of the blank, formal variation is very wide and cannot be based on fixed formal attributes. Because of the simple procedures for its manufacturing and of its scarcity in the total assemblage, the cleaver might be regarded as a result of minimal shaping in preparation for manufacturing other large tools, such as handaxe and large scraper.

F. The Polyhedron

This type of artifact is a more-or-less round tool without sharp edges, produced as a result of multidimensional flaking (*e.g.* Fig. 4.25. in Ch. IV). Its size is about the same as the chopper, and usually it is regarded as a heavy-duty tool that was overworked or was worn down by intensive use (Bae 1988). While its possible function as a bola stone was proposed by some experimental work (Han 1996), it is often associated with a large amount of debitage, suggesting that it was the exhausted final form of an arbitrary multidirectional core or a worn-out hammer stone (Schick and Toth 1994).

G. The Large Scraper

Alternatively termed as a "heavy-duty scraper (Bae 1988, 1994)," this type, usually made of a huge flake, is a tool with simple retouch on its lateral or distal side (*e.g.* Fig. 4.21. in Ch. IV). Other than simple retouch, it rarely demonstrates any distinctive technological features. As with the cleaver, this type is sometimes regarded as a pre-form before substantial flaking was performed for the purpose of making other large tools. Compared to the chopper made of a cobble or an angular chunk, this type is characterized by more acute lateral edges and scalar retouches without any large flaking scars.

H. Other Types

Kim W. Y. and Bae (1983) and Yi and K. D. Lee (1993) originally included another type of tool in the large tool category- the "knife"- defined in terms of the type list of the Clark-Kleindienst scheme. As Yi (1988: 192) admitted, this type can be generally regarded as a subtype of and/or a deformed result of a handaxe or a large scraper. Alternatively, it can be treated as the result of stopping midway in the reduction sequence of some large tools. Since the so-called knife of the IHRA assemblage is usually defined as a "large tool with a single lateral cutting edge and a dull back on the opposite side" (Yi and K. D. Lee 1993), this type is safely incorporated in the large scraper group.

In addition, Yi (1988) referred to the "discoid" and the "core scraper" as minor types among the IHRA large tools. As far as the total IHRA assemblage is concerned, there exists no clear evidence of these types. Instead, some cores and choppers having unique forms can be arguably placed in this group. In sum, it cannot but be denied that the large tool category of the IHRA assemblage includes almost every "type" found in the Afro-Acheulian industries.

2. The Small Tool Category

A. Type-Variation of Small Tools

Because of unstandardized blank morphology and retouching techniques, the attributes of small tools from the IHRA are very few. These just include 1) the position of retouches on blanks (*e.g.* sidescraper and endscraper), 2) the types of working edges (*e.g.* unmodified natural edges, retouched, and dented), and 3) the general plane view of the tool shape.

Several names of types were borrowed from Bordes' typological scheme (Bordes 1961; Débenath and Dibble 1994) based on the perceived similarities between the IHRA small tools and those of the European Mousterian assemblages. However, the Bordesian scheme has been criticized for its lack of consistency and extreme biasing of certain attributes (Bisson 2000; Débenath and Dibble 1994). Furthermore, it should be emphasized that the IHRA assemblage does not include the whole type list of Bordesian scheme. Therefore, the basic framework of the Bordesian scheme will not be directly applied; instead, some definitions of its classic types will be modified and new types will be added when necessary.

B. The Sidescraper

Unlike the Mousterian assemblage, the IHRA assemblage shows very limited scraper diversity. The scrapers are not intensively retouched and the retouched edge covers a very limited part. Double-edged and/or convergent forms are extremely rare and the retouch scars cover either the dorsal or the ventral surface. The term "sidescraper," therefore, simply refers to a small tool which has some retouched edges on either side of the lateral margins parallel to its longitudinal axis.

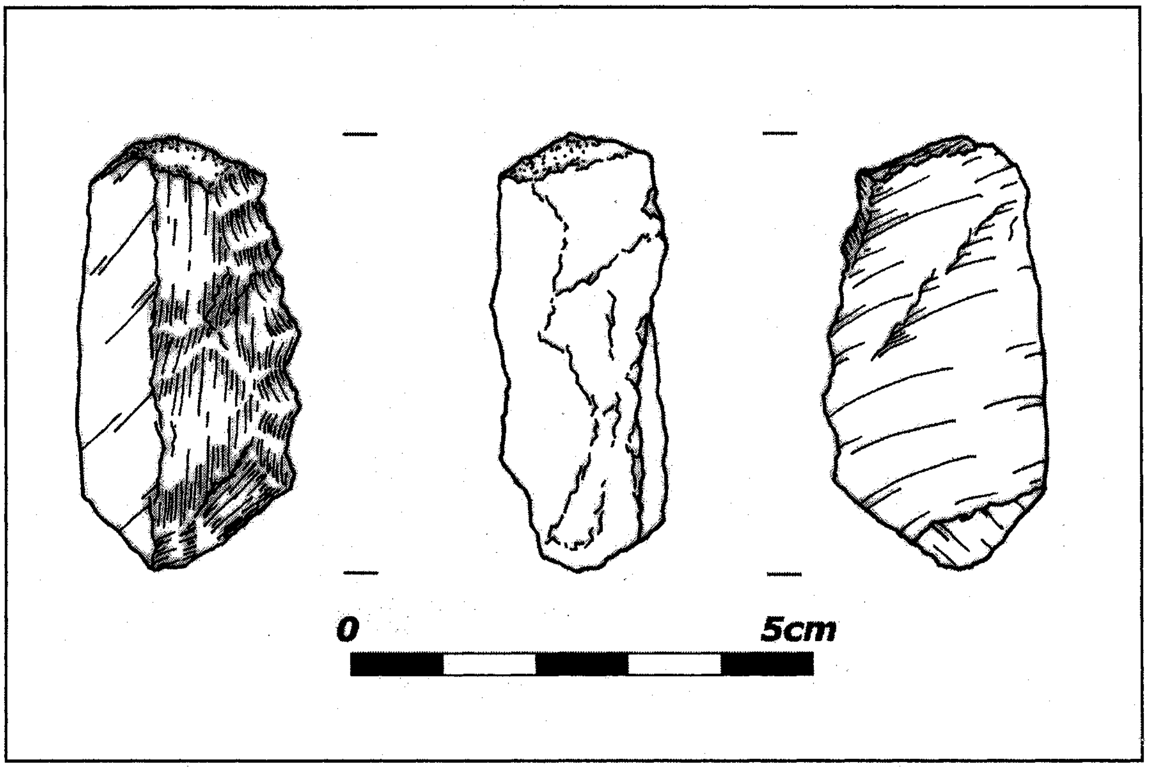


Fig. 5.7. Sidescraper from the Chongokni Grid S1E18

C. The Endscraper

The endscraper has a retouched margin on its distal end. It is usually made from a small flake, but some broken shatter is very widely used for blanks. Like the sidescraper, the amount of retouched edge is very limited and the edge angle is usually over 45°, which is not suitable for general scraping tasks. In a sense, it would be more convenient to figuratively term this type as "scrubber" or "abrader," the direct equivalent of the Bordesian "grattoir."

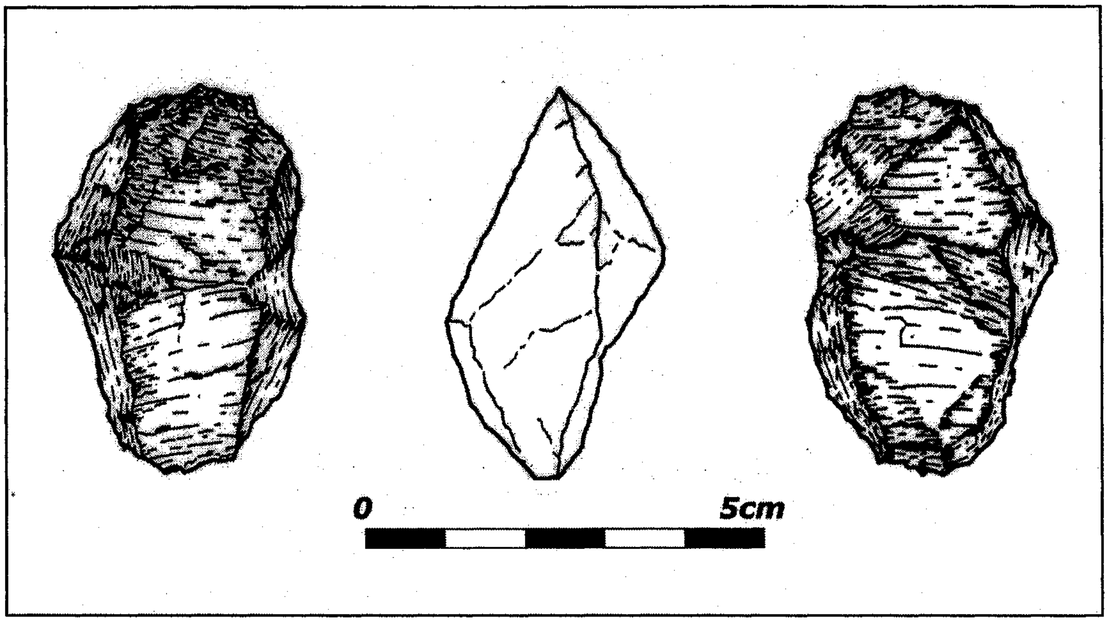


Fig. 5.8. Endscraper from the Kawolri Trench

D. The Point

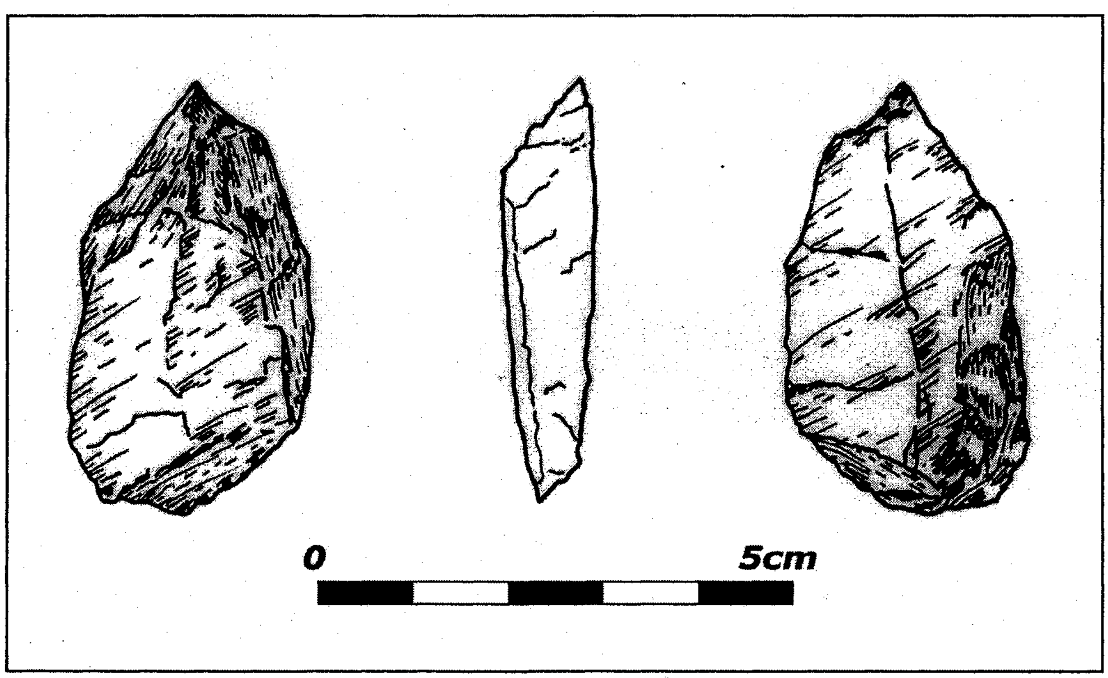


Fig. 5.9. Point from the Kawolri Trench

Compared to the Mousterian point, this type is morphologically unrefined and its proximal end is not sufficiently slim as to be suitable for hafting. Except for the pointed tip, this type shares no common features with the Mousterian point. The lateral margins are very slightly retouched and the usual tip angle is above 45°. The shape of the point is heavily dependant on its original blank, and it is highly unlikely that this morphologically unrefined type was deliberately shaped to be used as a strategically effective hunting weapon.

E. Notch

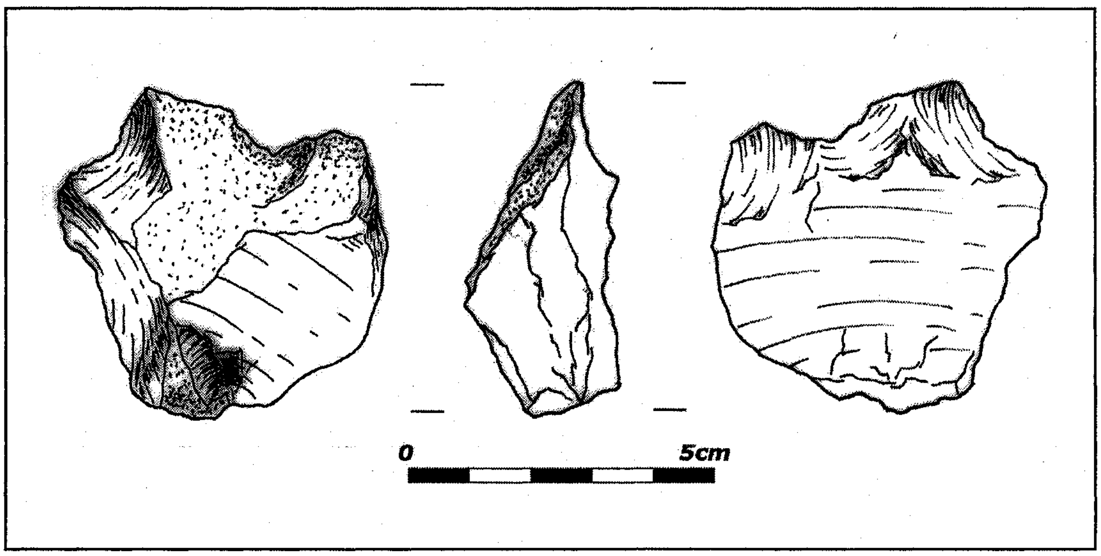


Fig. 5.10. Notch from the Chongokni Grid S1E18

Because of the strong crystalline structure of quartz and quartzite, a big dent is liable to be produced even by a simple percussion. The notch is made of amorphous flakes and shatters. The position of its concave working edge on the blank is arbitrary. Unlike Mousterian notches, the IHRA notches are similar in form to the Clactonian notches, showing no sequences of contiguous removals (*see* Débenath and Dibble 1994).

F. The Tranchet

The tranchet is one of the most frequently found of the small tool types in the IHRA assemblage. It can be regarded as a miniature cleaver; since they share the same stylistic traits. A linear natural edge perpendicular to the longitudinal axis is positioned at the distal end, and the lateral margins are slightly trimmed for grasping. The distal edge has some bruised usewear, possibly resulting from abrasion and/or pecking.

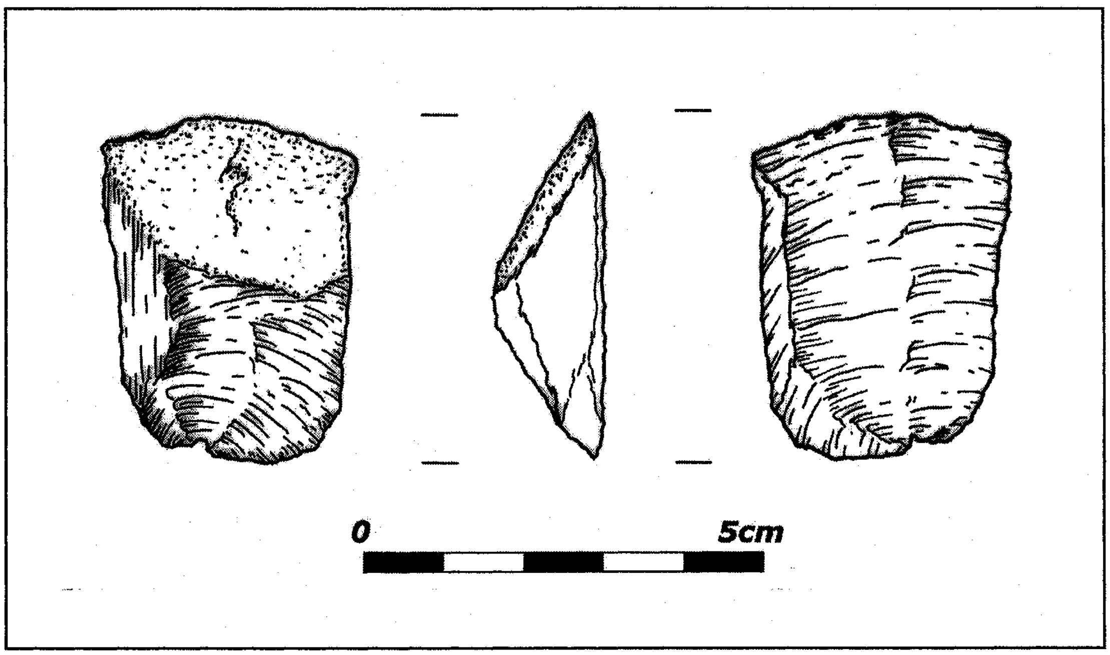


Fig. 5.11. Tranchet from the Chongokni Grid N1E17

G. Borer

By removing some marginal parts, a protrusion can be formed on the distal end of a blank, thereby producing a borer. This tool type is marginal within the small tool category, and can be regarded as a specially designed tool for perforating or piercing soft organic materials. The protruding end usually has abrasions but it is not intensive, certainly not as much as the typical Mousterian perçoir.

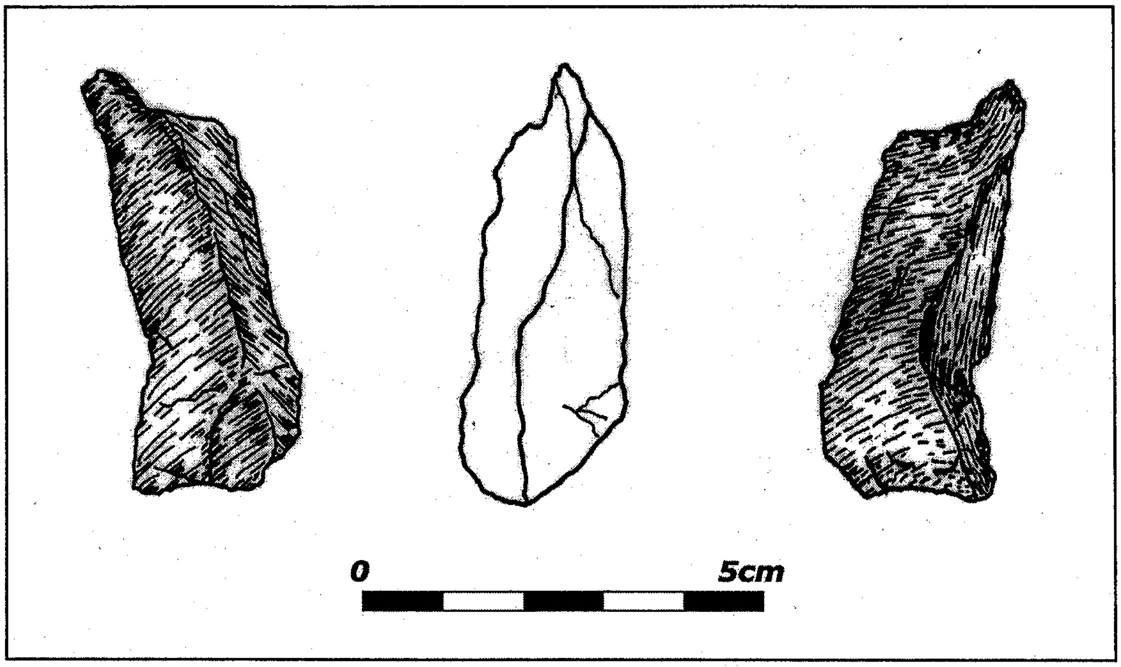


Fig. 5.12. Borer from the Kawolri Trench

H. The Rabot

Although very rare in the European Middle Palaeolithic, the rabot is often encountered in East Asian assemblage of any age. It is usually manufactured from a large block of shatter or a thick flake. While morphologically very similar to the push-plane from the Sangoan industry (McBrearty 1988; Phillipson 1985), it is rather larger and the retouching intensity on the terminal end is less prominent.

Because of its well-developed transverse edge and relatively heavy weight, the rabot can serve as a good implement for tasks such as simple wooden work and/or crumbling of plants for food-processing. Following Bae's (1988) hypothesis that the edible plant resources would be important for the daily consumption by the IHRA hominins, the assumed function of the rabot can be postulated as enabling the processing of plant resources procured by the labor-intensive foraging subsistence practices of the IHRA hominins. Microscopic analysis of the rabot to establish its usewear would be a very promising method to test this hypothesis.

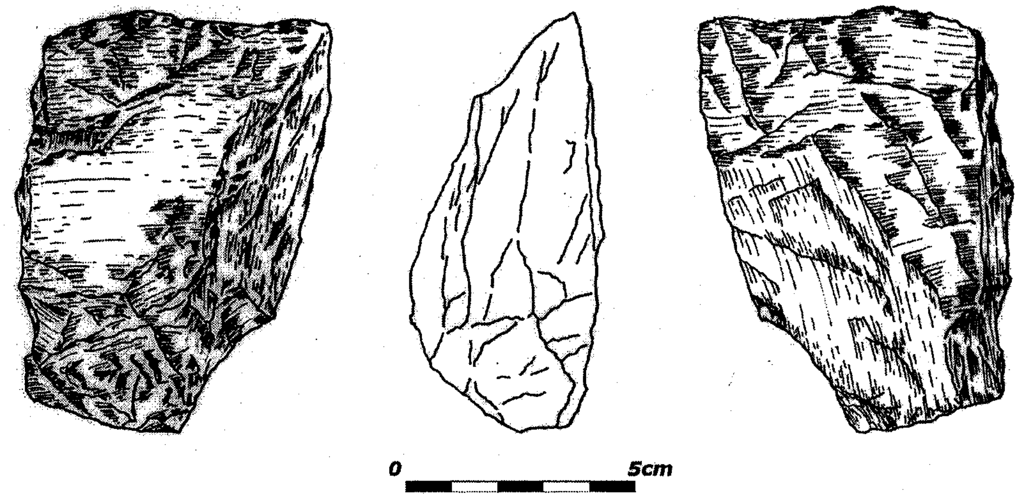


Fig. 5.13. Rabot from the Kawolri Trench

I. Upper Palaeolithic Tool Types

In the IHRA assemblage, some tiny tools diagnostic of a typical Upper Palaeolithic technology has been occasionally found. Several burin-like tools made of elongated flakes, reminiscent of the knife tools of the Japanese Upper Palaeolithic (Akazawa *et al.* 1980; Ambiru 1997), have been discovered. In addition, trapezoids (*e.g.* Fig. 4.43. in Ch. IV) and delicately retouched pieces made of fine-grained quartz, which are frequently discovered in local Korean Upper Palaeolithic sites as well as some transitional assemblages elsewhere (Yoo 2003), have been found in the IHRA.

In a strict sense, these Upper Palaeolithic types are believed to have been produced by an expedient-oriented method of blank utilization rather than have resulted from any shared technological tradition. These types have been predominantly discovered in the upper zone of the archaeological horizon or sometimes they have been retrieved from the disturbed top layer also often associated with such high-quality raw material as rhyolite and obsidian, the same rock type of the Janghungri Upper Palaeolithic assemblage (Choi, B. K. *et al.* 2001). While it is still premature to conclude that there was a process of technological innovation marking the emergence of more advanced types, these types manifesting Upper Palaeolithic-like attributes can be interpreted as the precursors of several different technological tendencies that occurred later in the IHRA.

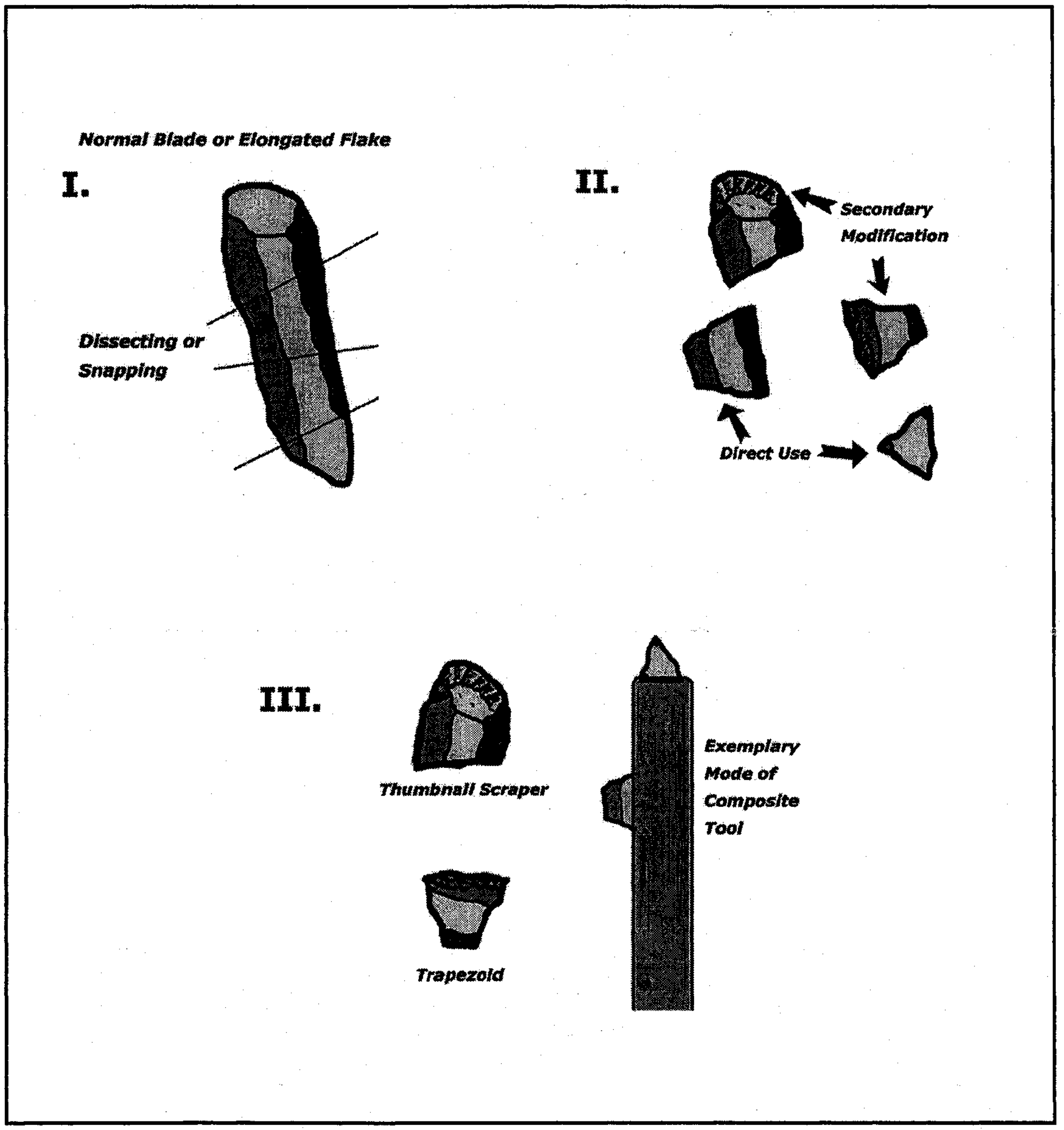


Fig. 5.14. Schematic Sequence of various microliths out of single laminar blank

(4) Components of the IHRA Lithic Assemblage

1. Raw Material Procurement

A. Correlation of Raw Material Properties and Technological Solutions

The availability and quality of raw material can be an important criterion for measuring the efficacy of the technological organization (Andrefsky 1998; Bamforth 1986; Brantingham 2000), as well as for characterizing the planning depth involved in the intentional production of tools (Hayden *et al.* 1996; Kuhn 1991; Odell 1996). Bamforth (1986), for example, argues that tool curation, maintenance and recycling are largely contingent upon raw material scarcity while others (*e.g.* Nelson 1991; Parry and Kelly 1987; Shott 1986) alternatively emphasize the transportable size of raw material package used in the hunter-gatherer's mobility strategies.

Aside from the quantity of available raw materials, Andrefsky (1994, 1998) correlated the quality of raw material with two conceptual modes of tool manufacture: the "formal" and the "informal" tools. He recognized that an intensive modification of blanks by elaborate tool shaping (*i.e.* the formal tools) generally occurred in association with high-quality raw material while unsystematic and less-exhaustive modification (*i.e.* informal tools) was usually associated with the low-quality raw material.

When the relationship between raw material and technology is concerned, it would appear that the IHRA assemblage is an output of an inefficient technological solution largely constrained by raw material limitation. In essence, low-quality material is less advantageous than high-quality when it relates to producing stylistically standardized tools and the large size of the river cobbles utilized for primary raw material is inadequate for making light and versatile mobile toolkits (Kuhn1995; Rolland and Dibble 1990).

It should be emphasized, however, that some low-quality material can be selectively advantageous over seemingly high-quality material when the latter is not easily available in the site area. For example, since quartz and quartzite, two of the materials most favored by the IHRA hominins, commonly have a large crystalline structure, natural edges can be easily created by means of several simple blows. In addition, most metamorphic rock formations in the IHRA contain vein quartz; its large quantity and easy accessibility reduce the manufacturer's work load by economizing procurement time and labor cost (Jeske 1989). Mechanically, quartz and quartzite are tough and solid enough so that they are useful for most daily provisional work. Even though they have only rough edges, a simple but durable workability can be ensured without the additional cost of applying delicate retouch.

Given these advantages of quartz and quartzite, there is no need to expend time and labor procuring non-local high-quality materials. Because good accessibility and great abundance compensate for their low quality, instant tools easily manufactured with these two rocks can suffice for most daily work, dispensing with the high-quality material. Therefore, the technology of the IHRA can be characterized as "improvised," "immediate," and "accommodating," given the context of raw material utilization. As demonstrated in the assemblages of the Chongokni, Hoengsanri and Janghungri sites (see Ch. IV), such high-quality materials as rhyolite and obsidian were locally available in the vicinity of the volcanic area as well. But except for the case of the Janghungri site, the occurrence of these materials in the IHRA assemblage is very limited. Because of scarcity and high energy-cost for acquisition, these high-quality materials are not believed to have been actively procured and utilized in spite of their excellent mechanical properties. Priority was given to quartz and quartzite, and the disadvantages arising from their poor quality was overcome by their abundance and feasibility for easily producing instant, ready-to-use tools.

The morphological crudeness of the general tool categories in the IHRA assemblage, thus, can be interpreted as a result of a "regressive" technological solution by rejecting the production of highly advanced, stylistically distinct formal tools. For the IHRA hominins, making formal tools with exotic high-quality materials requiring exquisite retouch would appear to have been a sort of "luxurious" technology with "much pain, no gain." In spite of their mechanical disadvantage, quartz and quartzite are nonetheless reliable and efficient *objets de vertu* that were regularly sought for as principal raw materials. Therefore, Andrefsky's (1998) argument that crude tool morphology and under-developed stylistic variation are unavoidable results of "expedient" technology constrained by the quantity (abundance) and quality (mechanical poorness) of low-quality raw material should be critically re-examined. More often than not, the reason for the lack of formal tools without distinct stylistic variation within a specific technological organization is because they "need not" be produced rather than because they "can not" be achieved.

B. Raw Material Size and Percussion Techniques

Because most IHRA sites are located near the river bank area, the primary sources for blanks were the large river cobbles and small pebbles (see App. V for the definition of clastic sediments and their size specifications). The principal techniques applied for producing blanks using these raw material packages are very simple and elementary. Flakes and other types of debitage rarely exhibit a patterning of scars or deliberate platform preparation. Considering the unusually large quantity of smashed cobbles and amorphous angular fragments found in the site area, it can be inferred that a certain nodule of appropriate size was desired. In order to attain this desired size, very large cobbles were fractured on location and the smaller pieces were selectively exported for additional flaking or else taken off-site for later tool-making.

Large flat or blocky cobbles were often collected and directly reduced in size to produce blanks for tool-making (Schick and Toth 1994). Because their flat surfaces could serve as a good striking platform for initial flaking, simple but appropriate knapping can easily produce a desirable size, as well as a number of subsidiary flakes that would be optionally used as blanks for small tools. For reducing the overall size of a large cobble, a simple throwing and/or anvil technique was easily applied for rough fracturing. Of course, this rough form of reduction has low predictability of adequate percussion, and tends to produce a large amount of irregular debitage with no evidences of systematic flake removals.

Relevant to this, Shen and Wang (2000) conducted an experimental test for the purpose of verifying the principal technique of the lithic assemblage from the Longyadong Cave site of mainland China, a quartz-dominant, crudely modified Lower Palaeolithic industry. They demonstrated that a loosely controlled technique such as "direct anvil-percussion method" can be very useful for simple knapping of a flat cobble to reduce its size. They also showed by experiment that even small flakes in considerable quantity can be efficiently produced by this technique, thereby not needing to apply the freehand core-and-hard hammer percussion method. Because of the unlimited abundance of raw material, little planning depth or economizing consideration was required. As demonstrated by Shen and Wang (2000) above, one of the best technological solutions for this situation is to somewhat arbitrarily fracture large nodules against a fixed anvil. The dominance of large unidirectional cores with flat cortical platforms illustrates that the use of anvil-based percussion was likely employed for initial size reduction.

The claim that anvils were used is partly supported by the bipolar pieces that were found even in the earliest assemblage of the Jangsanri site. Without the use of an anvil, the bipolar pieces cannot be made. It is, therefore, suggested that the anvil was a major "apparatus" used in the production line of the IHRA lithic "craft shop" for modifying both large cobbles and small pebbles into useful "semi-finished goods." Unfortunately, however, the probability of finding an intact anvil as a specialized lithic manufacturing device is very low since its survival among other lithic categories is barely expected. Rapid reduction of the anvil to rubbles would have been normal, and almost any flat nodule of sufficient size and bulk might have been employed as an instant anvil.

In contrast to the use of the anvil, direct manipulation of a core using the free-hand, hard-hammer technique seems to have played a comparatively minor role in producing blanks. Because most unmodified raw material packages are quite large, it is hardly expected that the IHRA hominins were such skilled and ambidextrous knappers as to easily handle heavy nodules with a single hand while grasping a hammer with the other one. Considering the weight and size of the nodules prior to initial reduction, it would be a major challenge for the IHRA hominins to perform the freehand hard-hammer percussion with ease. As such, the major purpose of this technique is possibly limited to retouching relatively small-sized blanks.

2. Modifying the Unmodified

A. The Question of Unmodified Debitage

The IHRA assemblage includes a wide array of unmodified pieces and it was suggested that some of these were possibly utilized as simple functional tools (Bae 1988: 211). Unretouched or minimally retouched pieces are effective tools in terms of low investment of time and energy insofar as suitable size and appropriate shape are ensured for the intended function.

However, unretouched pieces are limited to a narrow range of tasks because raw edges are fragile and easily damaged in use, resulting in short use life (Cowans 1994).

It is a subjective exercise to attempt a systematic classification of the unmodified debitage pieces. First of all, there is no *a priori* standard to determine whether a single unmodified piece was intentionally produced and used to the same extent as definitely modified tools. Nevertheless, it is also questionable to regard all unmodified pieces as secondary byproducts and/or discarded items. This dilemma concerning the "functionality" of unmodified debitage pieces is a constant problem when it comes to dealing with the IHRA assemblage; this assemblage shows a low diversity of attribute combinations and a limited range of morphological variation. As a result, only a tiny part of the total assemblage that has any hint of intended modification is tentatively taken for as manifesting a technology, while the vast majority of unmodified debitage pieces are lumped into the "waste products" category without any further consideration. This is unfortunate since it may have eliminated an important source of behavioral evidence.

B. Functional Modes of Unmodified Debitage Pieces

If all or most debitage is to be regarded as waste products and having no function, then a pressing question should be answered: Why was it produced in such a huge amount? It is not acceptable to claim that the IHRA hominins painstakingly manufactured their intended tools without regard to the large quantity of residual fragments they were producing. It is equally implausible to postulate that they were too clumsy to attain their goals in a satisfactory manner without numerous trial-and-error attempts, thereby unwittingly producing this large quantity of wastes. It is also not reasonable to claim that only the "advanced" tools that the hominins elaborately manufactured by an extremely long reduction sequence could be responsible for this large amount of byproducts. If these three possibilities are declined, then it can be suggested that many of the unmodified debitage pieces are "NOT" simply wasted products, but, in some cases, might be intentionally produced for both potential and actual usage.

Nevertheless, how these unmodified debitage pieces were used is not clear. Given the absence of raw material shortage, it is most likely that a certain amount of unmodified pieces was directly utilized for certain tasks, such as skinning and fleshing the animal resources (Schick and Toth 1994), without any prior or further modification. However, given the contrary, that is, under the conditions of raw material shortage, it is more likely that the majority of unmodified pieces was saved for blanks being intensively modified later until they were finally transformed into unusable material, the exhausted waste (*see* Andrefsky 1998; Kooyman 2000). It is, therefore, a plausible idea that the debitage has very flexible functions affected by the raw material availability.

3. Reduction Sequence as a Process of Size Selection

A. Size as an Implicative Variable

Size is a major factor determining the whole reduction sequence of raw material utilization (Dibble 1995; Kuhn 1995) and it is also very crucial for designing tool shapes and dimensions. Assuming that hominins have no accumulated empirical knowledge on the quality of raw materials, the primary criterion is to decide useful raw material is the size of available nodules. A decision-making is instantly discharged based on the size, and is followed by the labor cost for transportation and by the initial plan for reducing the size. For the technological concerns, the duration for manufacturing (*i.e.* time-budgets for making intended tool; Shott 1986; Torrence 1989b) and the productivity of cores (*i.e.* amount of extracted blanks from a single core; Jeske 1989) are directly proportional to the size of the raw material; but it is in inverse proportion to the portability and maneuverability that are constrained by nodule size.

The size of lithic artifacts is highly affected by four factors: 1) the physical capacity of individual hominins who transport, manufacture, and use; 2) the geological context of the raw material packages, 3) the amount of risk involved in maintaining the technological organization (Torrence 1989b: 61), and 4) the mental templates and/or "imposed forms", if any, shared by the members of local groups (see Bisson 2001 for the case of the Neanderthals). In essence, it can be argued that, regardless of the lithic categories (*i.e.* debitage and tools), the size and formal dimension of lithic artifacts are contingent on the specific external constraints governing the overall assemblage formation. These constraints implicate the individual (*e.g.* physical capacity of a hominin to carry and manipulate stones for processing them), the environmental (*e.g.* the geological formation of nodules available for raw material blanks), and the technological (*e.g.* manufacturing procedures and mode of modification for intended final tools) conditions, respectively.

B. Determination of an Ideal Size for Small Tools

Because the average size of directly accessible surface nodules in the IHRA is generally large, several steps are required to select the appropriate size for the desired tools. First, a choice can be made in terms of the primary technique that can be used for producing basic blanks, regardless of whether for small or large tools. If a nodule is too large to remove moderately small flakes, it is directly broken and/or smashed into a smaller size. For this purpose, simply hurling or breaking a large nodule against a sort of anvil is performed to produce randomly sized amorphous chunks and various subsidiary shatters. Platform preparation and direction of percussion are uncontrolled and the pattern of fracture is unpredictable so that it is seldom regulated

After large nodules are reduced, smaller debitage is produced by additional percussion. Normal flakes and fragmented shatters are two main products from this work and subsequently they are modified into retouched tools. There is plenty of unretouched debitage regardless of the general forms and shapes of edges. Compared to Mousterian scrapers (Bisson 2001; Rolland and Dibble 1990; Kuhn 1995), the majority of these unmodified debitage pieces is believed to have been intended as the final forms of the "tools" and were actively used as for simple daily tasks by the IHRA hominins. These features indicate that the "utilized pieces," which directly originated from the unmodified debitage pieces, were possibly the primary goal the IHRA hominins wanted to attain, since the retouch was minimally performed for the purpose of creating valid working edges. The formal and/or functional index for selecting debitage as instant tools would be, 1) the existence of naturally sharpened edges, like the acute lateral and/or distal ends of flakes, 2) the appropriate size ideal for adequate gripping, and 3) the durability for recurrent uses. If a certain debitage piece could satisfy these three conditions, hominins would not have been required to modify it.

In this regard, the heavily retouched tools in the IHRA assemblage can be interpreted as somewhat difficult items to be intensively produced. For example, facing an emergency such as unexpected raw material shortage and time constraints, the previously retouched tools were optionally selected as "re-cycled blanks" for coping with immediate tasks without re-procuring the fresh new debitage. The very limited frequency of small tools in the overall assemblage composition can be a direct reflection of this pattern of lithic utilization. In conclusion, the wide variation in the retouch orientation and the extremely low frequency of specially designed small tools suggest that the IHRA hominins had the lower level of any conceptualized idea to intentionally modify tools, and even less intention to generate so-called "imposed forms" (*see* Bisson 2001; Chase 1991; Mellars 1989).

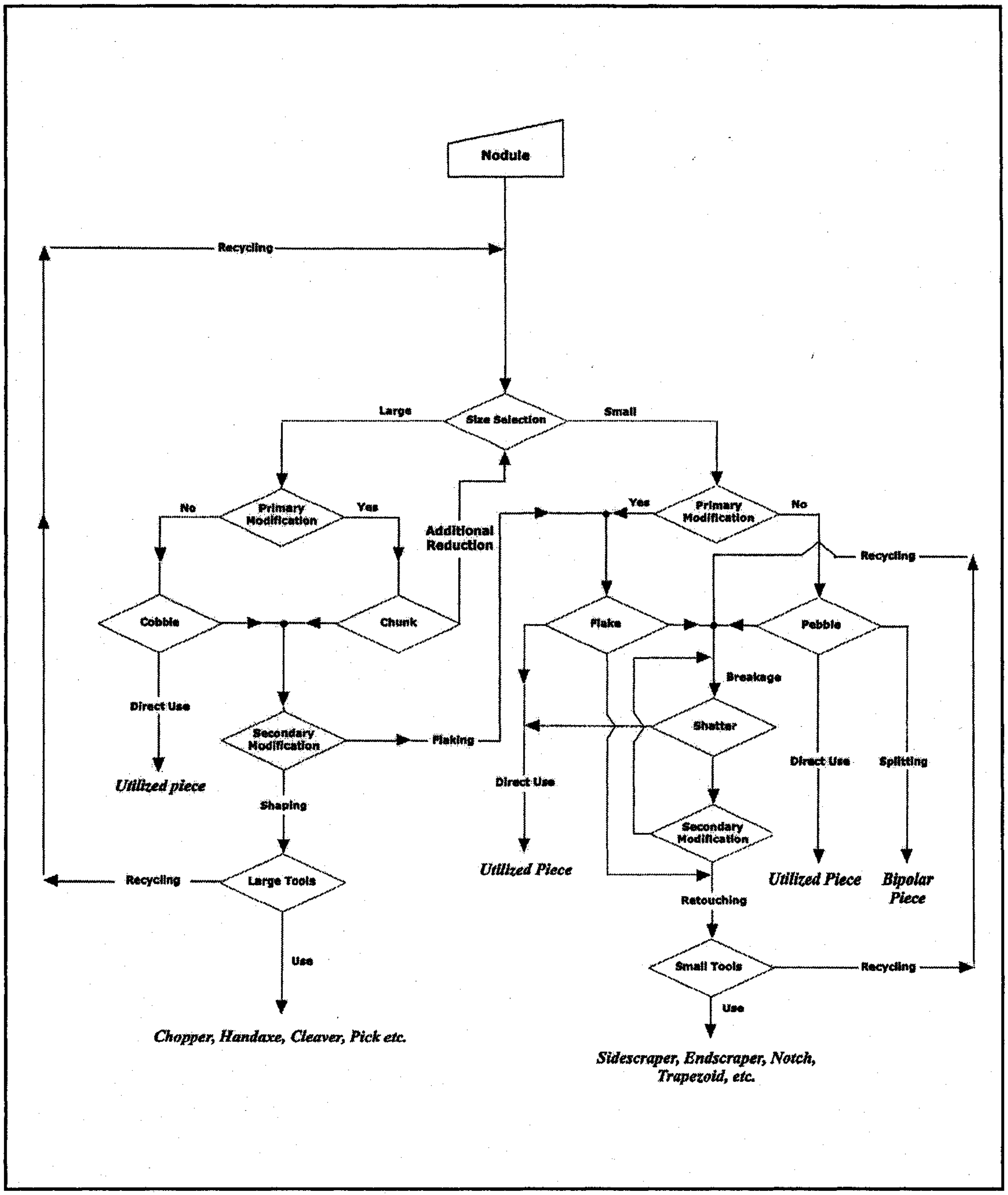


Fig. 5.15. Schematic flowchart of the selection processes in the IHRA lithic technology

C. Large Tools and the Handaxe

The abundance of crude-but-reliable raw material in the vicinity allows direct use of unmodified debitage and the possibility of recycling it by means of recurrent use was not so high. However, the manufacture of large tools made of cobbles and chunks entailed a different technological context. As exhibited in the assemblage composition of the Jangsanri assemblage, the manufacture of large tools was initiated earlier than the flake-dominant assemblages of the Chongokni and Kawolri sites. In addition, the so-called "tradition" (Bar-Yosef 2005: 312) of manufacturing handaxes continued until small tools came to be more widely accepted in the IHRA.

The existence of the handaxe and other large tools of the IHRA assemblage until relatively younger age plagued the proponents of "East Asian Acheulian handaxe" who tended to place them in the Lower Palaeolithic period, arguing that the IHRA handaxes were the temporal and technological equivalents of the Acheulian industry of Africa (*e.g.* Choi, M. J. 1991, 1994; Chung 2002). However, it is evident that the IHRA handaxe and other "Acheulian-like" large tools are far from the result of any "cultural" influences of Acheulian, nor the result of any direct population movement of hominins who had the practice of manufacturing handaxes. In addition, the differences between typical Acheulian handaxe and the IHRA handaxe have been argued by several authors (*e.g.* Bae 1992, 1995b, Yi 1989; Yoo 1997). As illustrated in Fig. 5.15, the manufacturing sequence of large tools was separated from the sequence of small tools and other miscellaneous debitage as early as from the first stage of size selection procedure. While the small tools resulted from apparently an "expedient" (Binford 1979) technology, the large tools are believed to be based on a target-oriented technology, directly associated with the instrumental requirement of heavy-duty tasks. Concerning this, some functional uniqueness of handaxe must be examined in the context of its formal variation and several roles it might played.

4. The Enigmatic "Young" Handaxe in the IHRA

A. Three Perspectives on the Role of the Handaxe

Considering its morphology and the energy consumed for its manufacture, the IHRA handaxe is seemingly an over-designed item, possibly devised for some special tasks other than being used as a simple bifacial core (Davidson and Noble 1995). It is self-evident that small tools made of amorphous flakes and shatters are functionally limited and unsuitable for major battering tasks. In this case, more reliable and versatile tools are required to serve the major part of daily work (Shott 1986: 19; Nelson 1991: 70); and this kind of tool should be durable so as to resist the physical stress of recurrent use.

However, as Isaac (1977a, 1977b) specifically noted, great cautiousness is required to carry out the "exegesis of stone artifacts" (Isaac 1977a: 207). A simple functional assumption for the role of IHRA handaxe requires detailed technological analysis as well as supportive archaeological evidence. As suggested by several authors (*e.g.* Davidson and Noble 1995, McPherron 2003, Wynn 1995, 2002), the handaxe and its form implies several different possibilities. 1) It might be a bifacial core that has been exhaustively knapped (Davidson and Noble 1995; Clark, G. A. and J. Riel-Salvatore 2005); or 2) its formal variation could be the direct result of different degrees of re-sharpening (McPherron 2000, 2003); or 3) it could be a materialistic mode for conveying the encoded messages (Wynn 2002), a primitive form of symbolic communication by hominins.

These three possibilities commonly cast a fundamental question in examining the nature of the IHRA handaxe: can one of these three arguments be directly applied to any handaxe from any assemblage of any time? In response, it is less than likely for the handaxe in the IHRA. First of all, the reduction technology manifested in the IHRA is too simple and rudimentary to create such a formally refined and intensively modified core. The intensive reduction of a single core requires high-cost, arduous labor. In reality, such core reduction has rarely been identified in the IHRA and the raw material quality of the handaxe is not exceptionally excellent so that it was worth intensively exploiting and resulted in such an heavily reduced form.

Likewise, the differential reduction model is also not applicable to the IHRA handaxes. In the case of Acheulian handaxe, the intensity of resharpening clearly entailed the strong intention of hominins to maintain the peripheral edges by resharpening it. It is instigated by hominins' spontaneous reaction to the damaged/dulled working edges and also by strong anxiety for "renovating" the shape and edge angles. However, the majority of the IHRA handaxes were made by several simple flake removals and the bifacial shaping was very limited. As an apparently expedient tool, extending or "resuscitating" its tool-use-life was not worth it, given the amount of labor it would require. The three formal variations of the IHRA handaxes identified earlier (Fig. 5.6.) might be the result of the morphological deformation constrained by the original shapes of the blanks. For example, the oval handaxe was usually made of a round cobble, and a large amount of cortex was left because of the large platform angle of the original cobble blank. The pointed handaxe was frequently made of a semi-triangular chunk detached from a corner of a large angular nodule (Yoo 1997); while the shouldered handaxe was usually an asymmetrically finished variant of the pointed form, probably resulting from poorly controlled knapping by clumsy percussion and a limited hand grip.

The symbolic communication hypothesis of the handaxe cannot be tested with the

IHRA data. Certainly, some primitive types of communication system might have existed (Byers 1999; Gamble 1998, 1999) and the manufacturing procedure of handaxe should be the output of an accumulation of such an information exchange among the IHRA hominins. However, if the IHRA handaxe was made and used in the context of modulating the expression, transmission, and acceptance of encoded messages, then the so-called "stylistic variation" should be embedded (see Binford 1989; Close 1979; Sackett 1977, 1982; Wiessner 1979; Wobst 1977 for various definitions of style and their applications); and some set of beliefs, values and templates for action (*i.e.* the "structure" enabling and constraining the human agency; Hopkinson and White 2005; Dobres 2005) on the individual level should be predestined to be activated within the materialistic culture. At least, this assumption for the materialistic "appropriation" of handaxe as a medium for the encoded symbolic message is hardly indicated by the simple and rough nature of the IHRA assemblage characteristics.

B. Reliance on the Handaxe as an "Important Tool": a Hypothesis

The IHRA handaxe can be described as a combined form of pick, large scraper and chopper, having a pointed tip and strong lateral edges (Yoo 1997). This formal and functional integrity would be useful for a variety of daily tasks, especially wood working and digging, as well as being ideal for the utilization of plant resources (Bae 1988). In fact, one of the major functions of the IHRA handaxe may have been to maximize procuring the edible components of plants: for example, stripping tress and branch of edible bark, extracting underground tubers, and "harvesting" ubiquitous wild plants (*see* Clark 1970 and Hayden 1979 for the notions of handaxe for woodworking; Schick and Toth 1994 for the examples of modern aborigines).

Of course, the IHRA hominins were not pure vegetarians and some scavenging and/or rudimentary hunting was possibly carried out "with or without" specially designed tools. The problem is that evidence for these behaviors has not survived; but what can be postulated is that these kinds of activities performed with the handaxe are not time-specific and may have persisted for a long time from the initial hominin occupation of the IHRA. The utilization of plant resources combined with the exploitation of some animal resources may have been the primary *modus vivendi* of hominins, identical to the general provisioning strategy of other hunter-gatherers elsewhere and in different times: for example, the modern Australian aborigines (Collier 1989), the European hominins (Gamble 1986), the early African hominins (Isaac 1969; Phillipson 1985), and even other East Asian hominins (Barnes 1993; Pope 1992).

The explanation for the chronological "longevity" of the IHRA handaxe relates to its functional integrity and greater effectiveness over other tools. A single handaxe is quite massive, has an effective pointed tip, and has well-established edges. Other large tools have only one or two of these technical elements. Because of its great functional integrity, the handaxe enables every possible task to be performed with enhanced efficiency. This "total-packaged" task inventory, combined with its far-heavier weight than small tools, would be the great advantages of handaxe, especially for the task managements of daily life. A single handaxe can serve for almost every menial task and its moderately large size can be exploited for the heavier tasks than can be managed by small tools.

Because of these simple but reliable advantages, the handaxe is believed to have been exclusively favored and did not require any substitute for a long period. The IHRA hominins devised the handaxe in the course of manufacturing their casual tools for daily tasks. In contrast to other tool types, the morphological uniqueness of handaxe was possibly influenced by the multitude of assumed functions that were performed by a single tool type. In spite of its low frequency in the total assemblage, the technological efficiency of a single handaxe may have excelled the sum of the other miscellaneous tool types such as simple choppers and several flake-based small tools. The "functional superiority" of the handaxe is closely affiliated with its "morphological prominence" and this implies a more tightly imposed "technological awareness" for manufacturing it. This technological awareness was liable to be adhered to by hominins to maintain the stable production of handaxe, and also to be shared and transmitted within the community. As a result, a so-called "tradition" of manufacturing handaxe would have been formulated among local hominins, and this tradition would have become somewhat widely spread out across the IHRA, thereby persisting for a considerably long time. The tradition of manufacturing the handaxe will be discussed again in the final chapter.

VI. THE VARIABILITY OF THE IHRA LITHIC TECHNOLOGICAL ORGANIZATION

(1) Introduction

As demonstrated in the previous chapter, the IHRA assemblage can be summarized as a crude quartz/quartzite-based local pre-Upper Palaeolithic industry, contemporaneous with the Mousterian/Middle Stone Age of Europe and Africa. In this chapter, however, any implication that the IHRA was a type of East Asian Middle Palaeolithic or other specific period will be avoided because no such claim can be validly made for now with regard to any local East Asian assemblage (Gao and Norton 2001; Ikawa-Smith 1978; Qiu 1985; Yoo 1997). Even the term "Middle Palaeolithic" is still problematic when applied at the global level (*see* Bar-Yosef 2005; Clark 1993; Clark and Lindley 1991; Kleindienst 2005).

With this in mind, this chapter will focus on the investigation of the diachronic technological changes carried out by the hominins who resided in different localities and at different times in the IHRA. As the first step to this end, a comparative analysis of the lithic assemblages will be presented with the purpose of documenting the changes in strategic responses as these relate to the availability of the raw material. In order to investigate the assemblage variability at the site level, three lithic assemblages from fieldwork conducted at the Jangsanri, Chongokni and Kawolri sites, plus one Upper Palaeolithic assemblage from the Janghungri site will be quantitatively analyzed and the results will be discussed. Because the direct access to the data of the Kawolri and Hoengsanri sites (see Ch. IV) was compromised, these two assemblages will not be covered in this analysis.

(2) Background and Data Structure

1. Hypothesis on the Change of Lithic Technology

A. The Change of Raw Material Economy

Jeske (1989: 36) has argued that residential mobility is the most efficient strategy in an environment characterized by "patchiness" of resource distribution such that resource availability varies through time and space. Currently, the archaeological data set of the IHRA does not allow an empirically firm reconstruction of local hunter-gatherer mobility and resource utilization pattern. Nevertheless, it is expected that the IHRA hominins were largely dependent on a high mobility strategy because the diversity and quantity of available resources in this area seasonally fluctuated to a significant degree (Bae 1988).

The provisioning strategies of mobile hunter-gatherers have implications for lithic raw material selection and procurement. Because the abundance and quality of raw material varies from site to site, the procurement patterns of blank and tool modification correspondingly change. In addition, as more specialized tasks are required to gain resources that have restricted availability, the shift from low to high-quality raw material, in order to produce functionally more effective toolkits, seems to be inevitable although the reliance on the low-quality material has persisted for a considerably long time.

B. Raw Material Shift: from Low- to High-Quality

As mentioned in the previous chapter, low-quality materials such as quartz and quartzite have several advantages over high-quality ones. But it cannot be denied that they also have obvious disadvantages for producing small and delicate tools. As information on lithic manufacturing is upgraded and the "mental template" of the optimally designed toolkits substantiated (Bleed 1986), low-quality material will not be seen as affordable to meet the needs for manufacturing small and formally effective tools such as hunting weapons. Because low-quality materials tend to produce a large amount of wastes that are not recyclable, this might become a serious disadvantage for economizing usable resources (Jeske 1989; Torrence 1989). This disadvantage can no more be tolerated when a highly intensive survival strategy is demanded under such harsh climate conditions as those of the terminal Upper Pleistocene where available food resources were significantly reduced (*see* Dong 1991; Han 2002; Yi 1999, 2000). If the cost for procuring high-quality material can be rewarded by manufacturing sufficient amount of formally more effective tools indispensable for coping with the increasing frequency of high-risks (*e.g.* the "lithic demand" by Luedke 1984: 67), the pattern of raw material utilization will be eventually changed from easily acquired low-quality to superior ones, even though the latter have a more limited distribution.

As mentioned in the chapter II, the East Asian Pleistocene climate and biomass reached their minimum during the LGM and the loess-like eolian deposits accumulated in the upper cracks in the IHRA, diagnostic of cold and dry climate ("severe climate condition" by Yi 1999: 119), suggest a similar environmental condition was prevalent during the final phase of the Upper Pleistocene, ca 25 Kya by the date of associated AT particles (Yi 1999: 119). Under the conditions of deteriorating environment, one of the most likely strategic changes required for reducing risk would be to adopt the use of new high-quality raw material that can be utilized in a more effective and intensive manner.

C. *Increasing Efficiency: Model of Maximum Tool Utilization*

Efficiency can be defined as the capacity to maximize output and minimize input, and

Christensen (1982: 421) suggested the simple input-to-output ratio can be an index to assess the efficiency of a given production system. When the high-quality raw material is to be exploited in spite of its high procurement cost, a mobile group will employ economizing strategies in consuming raw material by devising a new tool-making technology (Hayden 1989; Jeske 1989). In a lithic technological context, efficiency can be measured by the ratio of tools extracted from a given quantity of available raw material.

Substantial gains in strategies for utilizing raw material for producing lithic tools hinge on two technological solutions: 1) the augmentation of the flake removals from a single core, and 2) the expansion of the tool class spectrum. First, since wasteful expenditure of costly raw material easily leads to its depletion, the "stingy" consumption of a limited amount of the available nodules will become a selective solution for minimizing the risk of a raw material deficiency. This economizing pattern of core reduction technology involves the exhaustive use of the available platform thereby increasing the amount of flake removals from a single core (Jeske 1989). Added to this are the higher frequency of small-sized cores, the general reduction of platform size and the increase of flake ridges on a single core.

The expansion of the tool class spectrum and the increase of tool morphology diversity result from utilizing more varied forms of blanks, as well as by recurrently rejuvenating the edges in order to produce greater formal variation in the tool use-life (see Dibble 1987, 1995; Rolland and Dibble 1990). Sullivan and Rozen (1985: 757) proposed that high percentages of complete flakes and debris are produced by simple core reduction while high percentages of shatters (*i.e.* broken flakes and flake fragments) indicate the recurrent use of blanks. If tool production increases in total system, the production rate of shatters tends to increase proportionally; and the potential use of shatters as subsequent blanks also increases in a positive feedback loop.

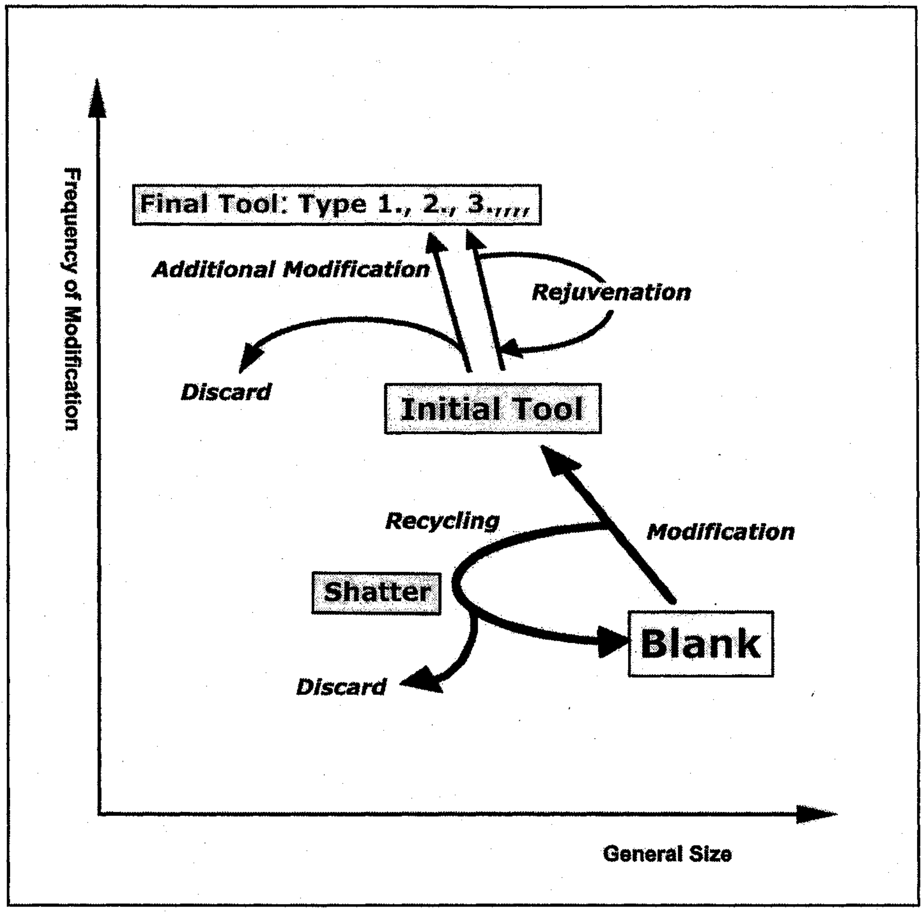


Fig. 6.1. Model of tool modification
under the background of efficient utilization of high-quality raw material

Fig. 6.1. conceptually summarizes a general mode of tool production when strict efficiency is exercised. In order to maximize the number of retouched tools, the number of initial tools should reach its maximum and associated shatters and/or debris should be thoroughly recycled for further modification. Consequently, the quantity of recycled blanks increases, and the second cycle of tool production generates a greatly enhanced potential for maximum blank utilization. This recurrent recycling of available blanks takes place when the costs for raw material procurement escalate under conditions of harsher environments.

After the initial stage of tool making is complete, the second stage is set: the rejuvenation of established tools. This includes re-sharpening (*see* Dibble 1984, 1987, 1995;

Kuhn 1992, 1995), and the "deformation" and/or "deconstruction" of the original morphology in order to obtain suitable striking angles for additional modification. The complexity of assemblage composition, thus, is determined by the complexity of these two-staged cycles.

The expected consequences from these recurrent procedures can be summarized as follows: 1) generally reduced dimensions of tools and debitage due to intensive recycling; 2) wider range of size distribution due to prolonged use-life of toolkits (Hayden 1989), 3) higher variability of tool types due to maximization of useful working edges (Nelson 1991; Shott 1986: 19) , 4) steeper angle of retouched edges due to recurrent rejuvenation (Kuhn 1992b, 1995), and, as a matter of course, 5) higher frequency of amorphous shatters/debris (for basic patterns of flake breakages, see Sullivan and Rozen 1995; other factors was suggested by Amick and Mauldin 1997; also see Shelly 1990).

D. Standardization: an Objectively Discernible Feature?

Another technological solution that can be anticipated under risky environmental conditions is the selection for standardization. With restricted high-quality raw materials, the morphology of tools tends to be standardized due to highly systematic reduction sequences, and enhanced precision in manufacturing the intended toolkits (Jeske 1989). Standardization has a close relation to the efficiency of a technology. For example, the most efficient way of mass-producing the blanks is sequentially detaching the blades from a well-prepared prismatic core, and the formal uniformity and technological consistency of blade production is one of the most successful economizing strategies attained in the Upper Palaeolithic (*see* Mellars 1989, 1996; *but* Bar-Yosef and Kuhn 1999; Marks *et al.* 2001).

In a strict sense, however, the concept of standardization should entail the active mental embedment of concrete configurations that can be encoded, transmitted and replicated. Chase (1991) called to attention to three levels of empirically cognized standardization: 1) symbolic, 2) imposed, and 3) accidental. He also demonstrated that standardization can be the unwitting result of functional and technological factors (the "accidental" level), and is not necessarily intervened by the symbolization of cognized objects. At Chase's "accidental" level, such technological variables as raw material, blank morphology, tool function, and the dynamics of mobility usually determine (or control) the pattern that can be objectively perceived (Monnier 2005; Newell *et al.* 2003). At its best, standardization is construed as a converging tendency of formal variation toward an intra-type consistency which can be habitually practiced at the level of the individual, and then unwittingly emulated, thereby becoming "traditionalized" at the group level.

Unfortunately, given the current status of the lithic data, it is strongly believed that the standardization cannot be demonstrated in the IHRA assemblages by means of the current analytical tools. Rather, delineating the strong "patterning" in the variable distribution and/or "high kurtosis" in the statistical description can be an alternative but more actually achievable in exploring the formal standardization of lithic tool types. In this regard, explaining the standardization in the evolutionary context of lithic technological organization will not be intended in this analysis.

2. Basic Data Set and Some Considerations

A. Sampling Problems

For the purpose of investigating the diachronic changes in the lithic assemblages, the inter-site variability of raw material utilization, blank acquirement and tool production will be explored. Because the IHRA sites are palimpsests of deposits of various hominin activities (Isaac 1981; Stern 1993; for the detailed definition of the palimpsest deposits, see Horsfeld 2005) and their geochronology is at a level of coarse-resolution, the inter-site variability of these sites will have a very limited relevance. It is, therefore, better to give a special emphasis to assessing the basic data set and inductively inferring the knowledge that can be demonstrated by the assemblage characteristics.

In order to investigate the temporal trajectory of technological development, what is essential is the solid chronometric dates of well-contextualized archaeological horizons. Fortunately, three sites in which adequate fieldwork was carried out currently have firm chronometric dates measured by various methods (see Ch. IV); and the geological context of each assemblage is well-documented. In spite of these advantages, however, the inherent sampling biases (Shennan 1988) could not be overcome because the majority of lithic artifacts were discovered out of context (Shott 2000: 725) and the sampling size of certain assemblages was too small to be adequately quantified for analysis. Since sampling size at the statistically significant level ought to be at least thirty (N=30), the entire assemblage of the Juwolri site (N=29, excluding the surface collection) and the surface collections from each site are excluded. In addition, because of the small size of the Jangsanri assemblage, this will also be excluded from the analysis of small tools and blanks.

B. The Janghungri Assemblage

Although the actual excavation was not included in the fieldwork for this thesis, the partial assemblage of the Janghungri site (Choi, B. K. *et al.*2001) was incorporated into the analysis. The official excavation report was recently published and a total of 664 artifacts were retrieved out of 22 (10 x 10m) square pits and 9 extended rectangular pits (5 x 10m). The assemblage (N=95) from Grid W80S10, which has a solid AMS date, was selected for analysis. The Janghungri assemblage is predominantly composed of Upper Palaeolithic artifacts, and their typological nomenclature is different from that of other assemblages. Admittedly, the basic data set covered in the analysis is the secondary data acquired from the published report and only a small part of the total assemblage was observed before the report was published.

Considering its limited accessibility, the Janghungri data will be used only for comparative purposes. The data from the published report will be selectively analyzed and only nominal (*e.g.* raw material type) and ratio (*e.g.* length, width, thickness, and weight) scale variables will be considered. The artifact list of the Janghungri site was presented by the original excavators (Choi, B. K. *et al.* 2001; see App. IV). Several unprecedented tool types (*e.g.* flayer, awl, pecker, plane, arrow point, *etc.*) and different debitage categories (*e.g. blade, blank and chip*) from other IHRA assemblages are included in this list. As such, the definition and description of the Janghungri small tool types and their significance are not covered in detail for this analysis because investigating changes in the typological variation of small tools is not the research focus for this analysis.

Nevertheless, some modification of debitage categories is unavoidable. The original excavators regarded seemingly unfinished, slightly modified tools as "blanks" and several broken blades as identical to normal undamaged blades. For consistency of data structure, what they termed as "blanks" were all converted into "amorphous tools" and the broken blades, if the length/width ratio was not greater than two based on the published measurements, were regarded as normal "shatters." Chips which have no discernible flake features were automatically renamed as shatters considering their identical characteristics to each other. As a result, 2 blanks, 1 broken blade, and 30 chips named in the original sample were changed into other lithic categories in the following analysis. Table 6.1. summarizes the number of artifacts to be analyzed from each site. The associated chronometric dates and their dating method are arranged in chronologically ascending order.

Location	No. of artifacts to be analyzed	Age and applied dating Method
Janghungri (GRID W80S10)	95	***24.4±0.6 Kya*** by AMS dating
Kawolri (Trench)	229	***younger than 50 Kya*** by IRSL dating
Chongokni	151	***ca 60 Kya*** by OSL dating
Jangsanri	39	***ca 210 Kya*** by IRSL dating

Table. 6.1. Sample sizes and chronometric dates of four assemblages to be analyzed

(3) Change of Raw Material Utilization

1. Raw Material Categorization

The raw materials available in the IHRA can be divided into several types according to the conventional rock classification. These types are very common in other parts of the Korean Peninsula and also widely distributed in East Asia (*e.g.* Shen and Wang 2000; Han 1990, 1996; Movius 1949; Qiu 1985). The most frequently used raw material is siliceous metamorphic rocks such as quartz and quartzite; but sedimentary and exotic cryptocrystalline rocks (*e.g.* jasper, rock glass, rhyolite, *etc*) are also sporadically discovered in various localities. Because general mineral-petrological classification is not easily applied in the analysis, rock types need to be categorized according to ordinal-scaled variables.

Three categories of raw material quality can be suggested based on their crystalline features and fracture mechanics: 1) low-, 2) medium-, and 3) high-quality. Low-quality materials mainly exist as river cobbles widely distributed in the IHRA. They include basalt, igneous metamorphic rocks such as gneiss and granite, and some siliceous rocks such as granular quartz and several varieties of quartzite. Their mechanical quality is determined by their coarsely foliated mineral habits showing massive and granular crystalline structure (Klein and Hurlbut 1985). Impurities are randomly distributed within the structure and their outcrops tend to be easily fractured when they were exposed to severe weathering by fluvial condition. The granular quartz and quartzite are usually acquired from the riverbank area while basalt and gneiss are from slightly more elevated slopes.

Medium-quality materials include fine-grained vein quartz , and sandstone. Contrasting to granular quartz, fine quartz is characterized by its relatively uniform crystalline structure and finer silicate particles; but it also has various impurities and irregular crevices often developed within the crystalline structure. These crevices make its outcrop vulnerable to serious weathering and re-crystallization of silicate particles is often developed. Sandstone is a quasi-metamorphic sedimentary rock regarded as a proto-type of quartzite. Its degree of cementation and re-crystallization of silicate particles is relatively low (Klein and Hurlbut 1985) compared to fully metamorphosed quartzite. Sandstone is usually acquired from the same context as quartzite; and fine quartz is encountered on a more limited basis, often associated with metapsammitic outcrops of the Samgot Formation (Cho, M. S. *et al.* 1995).

High-quality materials include various rocks of microcrystalline structure (Luedke 1992). In the IHRA, porphyry and rhyolite are the most commonly found high-quality rocks. They are based on silica, with low iron and magnesium content (Klein and Hurlbut 1985). Rhyolite is an extrusive igneous rock and is easily polymerized to become viscous lava; and if rhyolite cools so quickly that crystallization does not occur, it abruptly consolidates and transforms into obsidian. Compared to porphyry and rhyolite, obsidian is rarely formed; it usually exists as globular boulders within the igneous matrix near volcanic outlets. It is, therefore, likely that the energy cost for procuring these high-quality materials in the IHRA was considerable, largely affected not by the distance from the quarry but by the physical effort to "browse-and-pluck" the nodules exposed in the ground mass and volcanic outcrops.

2. Raw Material Variability at the Site Level

Rock Types		*Basalt*	*Gneiss*	*Quartzite*	*Granular Quartz*	*Sand-stone*	*Fine Quartz*	*Obsidian*	*Porphyry*	*Others*	*TOTAL*
Jangsanri	OF	0	19	15	5	0	0	0	0	0	39
	P/A	0	0.49	0.13	0.38	0	0	0	0	0	100
	EF	0.00	1.67	3.72	10.32	0.99	17.6	4.17	0.38	0.08	39
Chongokni	OF	1	3	30	91	10	14	0	2	0	151
	P/A	0.01	0.02	0.2	0.60	0.07	0.09	0	0.01	0	100
	EF	3.4	6.46	14.39	39.95	3.82	68.16	16.16	1.47	0.29	151
Kawolri	OF	0	0	3	40	2	184	0	0	0	229
	P/A	0	0	0.01	0.17	0.02	0.8	0	0	0	1
	EF	0.45	9.8	21.83	60.59	5.79	103.36	24.5	2.23	0.45	229
Janghungri	OF	0	0	1	0	1	34	55	3	1	95
	P/A	0	0	0.01	0	0.01	0.36	0.58	0.03	0.01	1
	EF	0.18	4.07	9.06	25.14	2.4	42.88	10.17	0.92	0.18	95
TOTAL		1	22	49	136	13	232	55	5	1	514

Table 6.2. Contingency table between sites and rock types used for raw material

Table 6.2. summarizes eight rock types used for raw material in the assemblages of the four IHRA sites. The variable "OF" is the observed frequency of a single rock type, and the "P/A" is the rate of the rock type in a single assemblage. Other than these eight types, only one

exceptional specimen, made of chalcedony, was discovered at the Janghungri site. It was placed in the group of "others." While not included in this analysis, the Janghungri site yielded some more high-quality materials such as jasper and rock crystal (Choi, B. K. *et al.* 2001).

Based on Table 6.2., a chi-square ($\chi 2$=766.8496, *see* Shennan 1988) was calculated for the observed frequencies (OF) and the expected frequencies (EF). Statistically (95% level of significance), it is clear that some raw materials were exclusively used in specific sites. However, this simple result does not inform the strength of the relationship between sites and rock types, nor does it demonstrate the way the quality of rocks and chronologically different sites were significantly associated. Therefore, for the purpose of illustrating the relative frequency of each rock type in each assemblage, and *pour l'hommage à F. Bordes*, a cumulative frequency graph was drawn (Fig. 6.2.).

Unlike the Bordesian approach (*see* Bisson 2000; Débenath and Dibble 1994), the horizontal axis of the graph is directly progressive (*i.e.* the low-quality material is situated on the left while the high-quality one right). However, it should also be noted that the quality of each rock type is not numerically defined and no index is available. The sequential rank of rock types by quality should be treated as simply an ordinal and not a scalar differentiation. Fig. 6.2. clearly demonstrates that four assemblages show a strong differentiation of raw material distribution. The Jangsanri and Chongokni assemblages are principally composed of such crude low-quality materials as gneiss, quartzite, and granular quartz while the Kawolri and Janghungri assemblages have higher frequencies of refined materials such as fine quartz and obsidian. Fig. 6.2. also illustrates that all the assemblages show, with no exception, a drastic increase of a specific rock type and this can be identified as the representative raw material signature for an individual site.

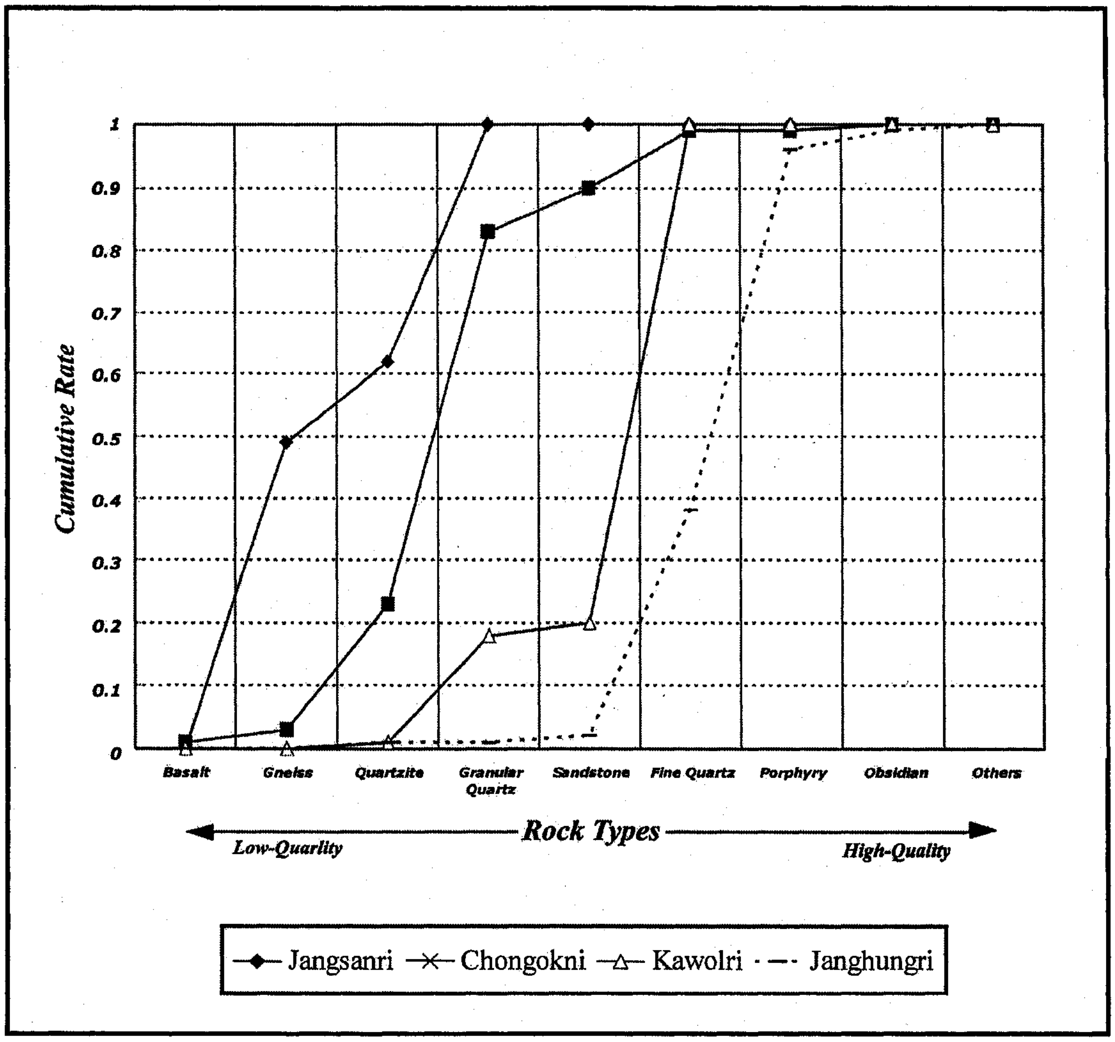


Fig. 6.2. Cumulative frequency rate of rock types in the four IHRA assemblages

Analogous to the Mousterian debates, this inter-site variability of raw material distribution can be interpreted in several ways: 1) the diversity in resource management ability resulting from physical and mental difference among hominins at the species level; 2) the uneven distribution of raw materials as a result of complex geological processes in the IHRA; 3) the difference in hominin land use patterns influenced by seasonal migration or the "logistical movement" of provisioning (Binford 1978). Because some raw materials are distributed sporadically and the distance between quarry and site area cannot be determined directly, the variation of raw material distribution at the site level will be a combined result of both the procurement and transportation of the raw material conditioned by hominin technological needs for making the intended tools. Interpretation in relation to the assemblage characteristics of each site follows below.

3. Raw Material Utilization Patterns

Raw Material Category		*Low*	*Medium*	*High*	*TOTAL*
Jangsanri	Frequency.	39	0	0	39
	Rate	1	0	0	1
Chongokni	Frequency.	125	24	2	151
	Rate	0.8278146	0.1589404	0.013245	1
Kawolri	Frequency.	43	186	0	229
	Rate	0.1877729	0.8122271	0	1
Janghungri	Frequency.	1	35	59	95
	Rate	0.0105263	0.3684211	0.6210526	1

Table 6.3. Contingency table between sites and raw material categories

The eight rock types above can be re-classified into three raw material categories based on their mechanical properties and accessibility. As indicated in the cumulative graph of Fig. 6.2., each of the four archaeological sites has its own raw material utilization pattern, as well as having a particular material at an extremely high frequency. Table 6.3. displays frequency and rate of the raw material categories in each site. The type "others" was included in the high-quality category because only one rock type, the chalcedony, falls in this category. Chalcedony is, with rare exceptions, a highly valued material that furnishes excellent workability to be intensively utilized for highly advanced tool making (Kooyman 2000;

Luedke 1992). While the quality of an individual rock type tends to be affected by its unique petrogenesis according to its location and geological context, the variants of a single rock type are not assumed to have so wide quality variation as to be separately categorized.

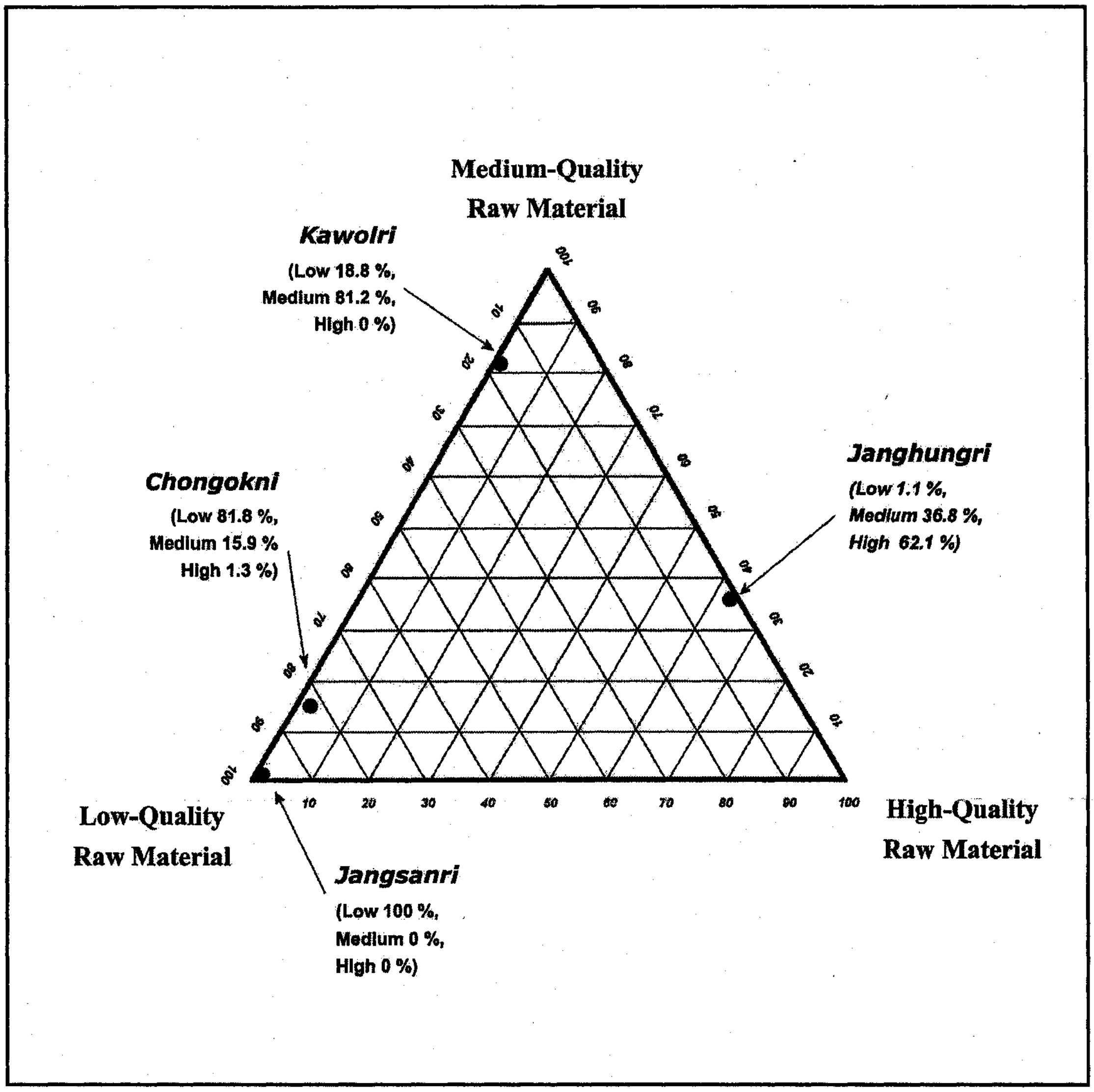


Fig. 6.3. A triangular diagram of raw material composition of the four IHRA sites

Table 6.3 and Fig. 6.3. illustrate respectively 1) the raw material composition of each sites and 2) the mutual similarity/difference of assemblage characteristics based on the quality variation. In summary, the oldest IHRA assemblage, which is from the Jangsanri site, is composed, with no exception, of very crude and mechanically poor-quality materials. This predominance of low-quality is sustained and "stagnated" in the Chongokni assemblage. However the relatively more recent assemblage from the Kawolri site is principally composed of medium-quality materials. Finally, the adoption of local high-quality raw material evidently took place when the Upper Palaeolithic assemblage of the Janghungri site was produced.

It is noteworthy that each of the four assemblages shows a bias towards exclusively depending on a single category of raw material and that no evidence or trace of combined utilization of different raw materials is observed. For example, the Kawolri assemblage is characterized by the predominance of medium quality material, although such low-quality material nodules as quartzite and granular quartz are abundant at the vicinity of site area. The ratio of fine quartz to granular quartz is over 4 (*see* Table 6.2.), partly suggesting that the Kawolri hominins were capable of discriminating the mechanical advantages and disadvantages among the quartz group. However, even though the result clearly shows four assemblages are mutually exclusive in terms of raw material preferences, it still needs a suitable explanation to argue that the IHRA hominins were extremely selective in the choice of raw material and that this selectivity is well-documented in the chronological sequence.

The site locations can be used as an alternative explanation for the distinctive interassemblage variability of raw material utilization since each site has a very unique geology. For example, the Jangsanri site is located far downstream on the Imjin River where large-sized conglomerates are ubiquitously scattered. Its site area was never encroached by the lava flows, *ca* 0.2- 0.13 Mya (see Ch. 4, and also Yi 2002, 2004a, 2005), and the outcrops of the original matrix of the Kyounggi metamorphic massif (Cho, M. S. *et al.* 1995; Lee, K. *et al.* 1987)), where gneiss and heavily weathered quartzite cobbles are abundant, was the principal quarry for raw material acquisition.

The contexts of the Chongokni and Kawolri sites can be evaluated in the same manner. Compared to the Chongokni site, the Kawolri site is situated on the low-slope pediment remote from the channel flow, where access to the nodules of unweathered solid quartz is very convenient. As a result, the Kawolri hominins benefited from more advantageous quality of fine quartz distributed in the area of fully exposed outcrops of vein quartz. On the contrary, however, the site catchment area of the Chongokni site was almost entirely overlain by lava flows. The only available quarries in the vicinity were several small patches (*e.g.* the Baekeuri Formation; Yi 1989, 2005) of quartzite and crude quartz from river cobbles. This limitation of suitable raw materials might have imposed a narrow selection range that can be used as a partial explanation for the poor quality of raw materials in the Chongokni assemblage.

(4) The Analysis of Lithic Artifacts and its Result

1. Basic Analytical Modules and Tools

A. Significance of Size as an Artifact Variable

The mobility and land-use pattern of hunter-gatherers has been a core issue for archaeologists. Up to now, many conceptual frameworks and related methodologies have been devised and applied for interpreting the patterns and the dynamics of hunter-gatherer provisioning strategies (*e.g.* Binford 1979, 1980; Binford, L., and J. O'Connell 1984; Kelly 1988, 1992; Kuhn 1994, 1995; Morrow 2001; Nelson 1991). However, it is discouraging and frustrating that the reconstruction of mobility at the macro-scale is still largely intuitive

(Close 2000: 51; Kelly 1992). The demonstration of mobility patterns and their effects on the lithic technology can be achieved by correlating evidence concerning 1) the procurement of raw material sources (*e.g.* Kelly 1988, Marrol 1999), 2) special design considerations of lithic tools (*e.g.* Bleed 1986; Hayden *et al.* 1996; Nelson 1991), 3) the degree and intensity of the tool modification sequence (*e.g.* Barton 1990; Rolland and Dibble 1990), and 4) the "size-effect" for transportation of tools (Kuhn 1994, 1995).

In a sense, Binford's (1980, 1982) model of "residential and logistical mobility" is still regarded as ideal for archaeological observation and verification. Relevant to this model is the axiomatic-like assumption that the prehistoric hunter-gatherer technological strategy was basically buttressed by effective mobility planning for the feasibility of required tasks. It is not an overstatement to claim that current lithic technological study is entirely devoid of exploratory models that can contribute to discriminating the mobility for procuring and transporting raw materials from the general logistic movement for hunting and gathering, while some attempts were welcomingly made by Barton (1990), Hayden *et al* (1996), Kuhn (1994, 1995), Nelson (1991), Rolland and Dibble (1990), and so on. Given this limitation, a more rigorous methodology need to be sought dealing with the IHRA, the one of apparently crude and stylistically unvaried local East Asian Palaeolithic assemblages.

The importance of size for mobile toolkits has been effectively illustrated elsewhere (*e.g.* Kuhn 1995), and the transportation and portability of raw materials have been dealt with under the research of site formation processes (*e.g.* Féblot-Augustins 1993; Mallol 1999; Schick 1987). In the same vein, the pattern of transportation and modification of lithic artifacts can be investigated in this research, with special emphasis on size as an important variable. The primary task of this analysis is to characterize the size distribution among the lithic artifacts within the assemblage, and to examine the patterns in terms of the dynamics of lithic manufacture and discard. This is an attempt to furnish a general model for recognizing the patterns of lithic artifact distribution; and it can be combined with other empirical models on hunter-gatherer mobility patterns as well as with those of the intra-site variability of lithic scatter patterns.

B. Operational Definition of Size and Other Metrical Variables

As demonstrated in chapter V, the structure of the IHRA assemblage is highly contingent upon the selection of the suitable size of working pieces for modification and utilization. Although commonly used, size is a vague and ambiguous variable of lithic artifacts. Size is a complex and integrative term encompassing any measurable variables such as length, width, thickness, weight, density, and so on. However, in terms of objectivity, size is not a scaled index that can be directly used to determine the quantitative difference of lithic components.

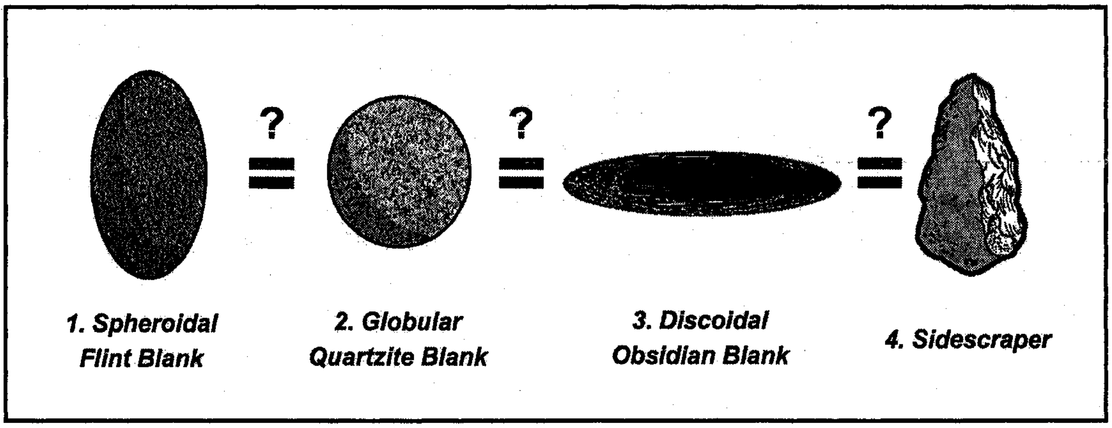


Fig. 6.4. A schematic comparison of different lithic components

As a practical example, the size of three rounded forms of blanks and a sidescraper with different volumetric dimensions can be regarded as the same or inherently different according to observer's point of view (Fig. 6.4.). From the geometrical view (*e.g.* the normal planar perspective), the discoidal blank is the largest; but by the quantum view (*e.g.* the combination of density and mass of raw material), the obsidian blank is the smallest or lightest. In the collective perspective, four components above have, 1) exactly the same, or 2) moderately similar, or 3) undetectably different sizes. From the selective perspective, each of these four components has its own physical basis for being designated as the "largest." This ambiguity originates from the conceptual pitfall of size in itself, and its fuzzy definition in the metric scale is attributed to the absence of selecting suitable dimensions.

The ambiguity of size as a concept to characterize the quantitative properties of artifacts is accentuated when dealing with the actual lithic specimens. In order to circumvent this ambiguity, some one-dimensional metric attributes are selectively chosen to compare the size of each component; but none of them can be a full descriptive index that can appropriately discriminate the absolute size among the components. It is, therefore, necessary to devise a new formula that can express the size in a useful manner; and the size should be operationally defined in these terms in order to minimize ambiguity.

In general, the lithic size is optically recognized and its measurement is contextually formulated by the identification of its morphology. The image that triggers the "size-awareness" is projected in one-sided planar form, and is then mentally processed to be transformed into the memory as an afterimage, thereby formulating the abstract idea of the "general size." Because this idea is not fully convertible into metric data, the ambiguity and vagueness occur from the remainder of the abstractness of the memorized image which is devoid of digitized scale. Therefore, the only way to minimize this ambiguity and vagueness is to capture the planar form using a metrically definable index. In order to demonstrate the size in a linear mode, the plane size (**P**) is expressed as an equation of two combined variables: length (**L**) and width (**W**). The formula for calculation is expressed below, and this generates **P** as a diagonal line traversing the maximum length and the maximum width, and it is calculated as the square root of the sum of L^2 and W^2 (Fig. 6.5.).

$$P = \sqrt{(L^2 + W^2)}$$

In the same manner, the "volumetric size (**V**)" can be calculated by adding the component of thickness (**T**).

$$V = \sqrt{(L^2 + W^2 + T^2)}$$

It can be illustrated as another diagonal line between two opposite vertexes of an ideal rectangular cube enclosing the lithic artifact. The implication of volumetric size is that it can be a parametric index for actual portability and utility of lithic artifacts combined with the weight. If a raw material package is not very heavy but is quite voluminous (*i.e.* "bulky") to transport, it will be probably discarded untouched at its original provenience or else immediately reduced to an "affordable" (i.*e.* portable or "non-bulky") size. In contrast, if a lithic tool is too small to sustain the inertia for subsequent use and modification, this small item will be either discarded or combined with other materials into composite tool to compensate for the size loss. Fig. 6.5. is the illustration of both plane size and volumetric size operationally defined. These two defined sizes can be regarded as the quantitative conversion of both the geometrical image and manually grasped bulk size of a lithic artifact. Their dimensions are identical to such indices as length, width, and thickness, each of which is commonly used for measuring only one-dimensional size.

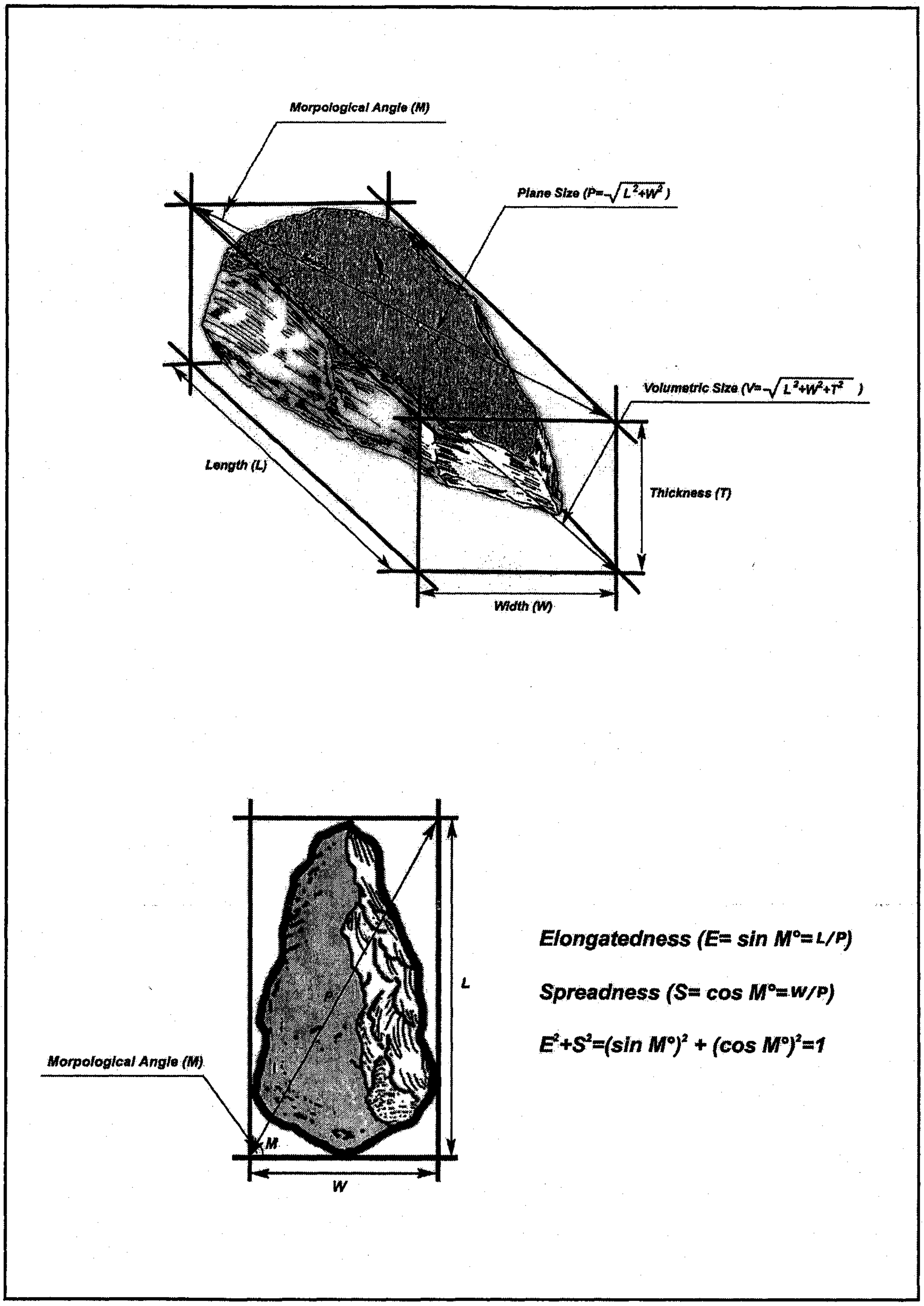


Fig. 6.5. Measurement of operationally defined lithic dimensions

Using these two defined indices, additional variables can be explored and defined. First of all, the "morphological angle" (**M**) can be defined as the angle between the vectors of width and plane size. Most metrical approaches to lithic artifacts have concentrated on the linear scales while the angular scale has been rarely used. In a geometric sense, however, the index that can determine the most realistic formal "impression" and the mental description of shape is the angular variable rather than the linear dimensions of artifacts. For example, a handaxe of 12(L) x 6(W) size is two times smaller than the one with 24(L) x 12(W); but the shapes of two handaxes are identically cognized by observers. This results from the fact that these two handaxes have the same morphological angles and the ratio of length-to-plane size is identical to each other.

Because the morphological angle is not easily measured by direct observation of artifacts, a precise illustration of a lithic specimen with a fixed orientation is mandatory. By calculating the morphological angle, two indices are additionally defined (see Fig. 6.5.): "elongatedness" and "spreadness." Elongatedness (**E**) is defined as the extent to which an artifact is estimated to be elongated, and can be rephrased as the "degree to which the perceived length of an object contributed to the judgment on how longitudinally slender its overall shape is." Spreadness (**S**) is defined as the extent of "stockiness" and also rephrased as the "degree to which the perceived width of an item contributes to the assessment of how horizontally expanded the general shape is." Because the elongatedness and spreadness are two mutually inter-related variables, their values are contingent on each other and determined by a single morphological angle. The calculation for elongatedness/spreadness, thus, can be expressed as a trigonometric function, and converted into a series of simpler formulae below. These calculations meet the basic principle that elongatedness and spreadness must be based on a ratio scale ($0 \leq sin, cos \leq 1$); and their variation offset each other ($sin^2 + cos^2 = 1$).

$$E = \sin M° = L/P \qquad S = \cos M° = W/P \qquad E^* = \sqrt{(1 - S^2)}$$

vice versa for **S because **sin²+ cos²=1***

Because the morphological angle is the most important parameter in these calculations, it should be circumscribed in more strict manner. More often than not, the shapes of lithic artifacts are differently recognized according to their orientation, and the measurement of dimensions is highly contingent on how the artifacts are placed and oriented. Fig. 6.6. is an exemplary illustration of four Middle/Upper Palaeolithic tools with the same morphological angles. It is evident that these four tools might be recognized to have different elongatedness and spreadness by the optical illusion if not having a fixed orientation. In order to minimize such confusion, the orientation of lithic artifact should strictly follow a standard of consistency. It is recommended that the standard orientation should be parallel to the direction of percussion. When shatters without distinct platform features are to be measured, they should be oriented parallel to their axis of maximum length.

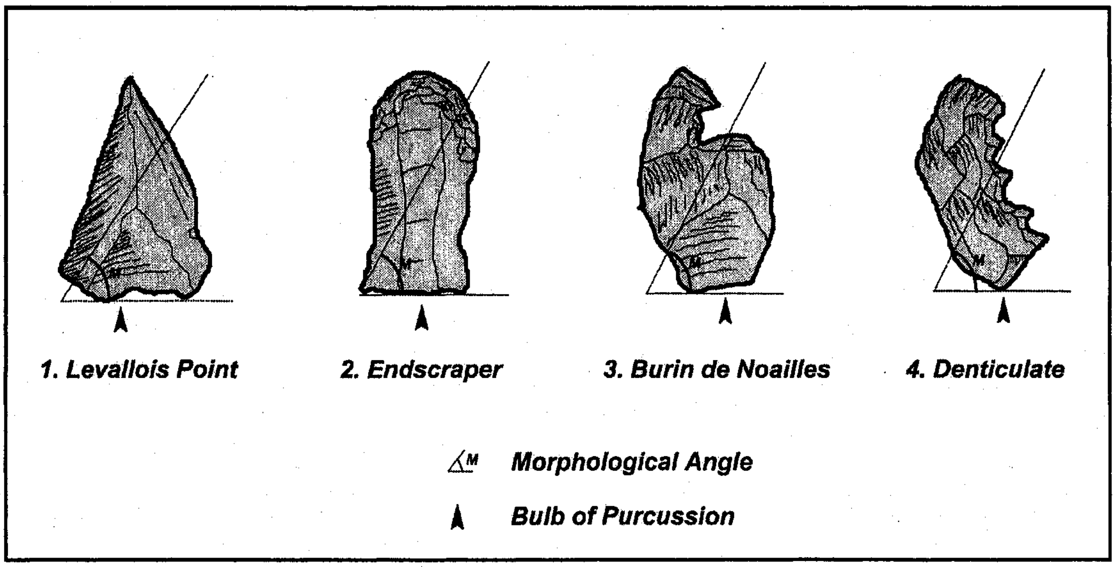


Fig. 6.6. A set of small flake tools with the same morphological angles

C. Rank Sequence and Distribution Patterns of Variables

After the variables of lithic data are operationally defined and measured, they are statistically processed for the delineating of patterns. Because the data structure of the IHRA assemblage is very scattered and inconsistent, the basic approach is grounded on the "exploratory data analysis" (EDA; Clark, G. A. 1982: 248). EDA is an empirical approach based on observation and evaluation of a primary data set in a collective manner. Its goal is to remove, if possible, misleading factors from the data structure beforehand. It is usually applied when the data structure is discursive and any stochastic approach is not facilitated, especially when the "confirmative data analysis" (CDA; Clark, G. A. 1982: 250) is particularly dependent upon the assumption of a normal distribution.

The basic EDA method that will be adopted here for the analysis is the "rank sequence" technique (*see* Yoo 1997). This technique is a very simple but powerful solution because the nominal data (*i.e.* the variables of lithic artifacts) can be directly converted to the ordinal data (i.e. the rank in the assemblage), and its processing of the data is not based on the assumption that the population of the total assemblage is a normally distributed group (*i.e.* the Gaussian distribution). This technique is principally dependent on the visual method (*see* Clark, G. A. 1982: 250), the rank curve, and its interpretation is entirely up to the judgment of observers. Because this technique does not directly process the value of variable but "deciphers" the formal variation of a continuous linear curve, the variables can be converted into different scales (*e.g.* logs, roots; Clark, G. A.; 251) in order to more effectively express the patterns.

The analysis of the relationship between rank and variable was originally developed in geography and actively adapted in archaeology for investigating settlement patterns; *e.g.* "the rank-size distribution analysis" (Falconer and Savage 1995; Liu 1996). While an initial analysis of the IHRA handaxe was attempted in this way (Yoo 1997), the rank sequence technique has yet to be applied to the analysis of artifact classes largely because of the difficulty in selecting appropriate metrical variables. The procedure for this technique has three steps: 1) re-arrange the group members in a descending order (downward) of a specific variable; 2) re-name the members from the highest to the lowest rank, for example, the lowest rank number (n=1) has the highest value of variable, and *vice versa*; 3) coordinate the rank and the value by drawing a unilinear curve (*i.e.* the rank curve), the horizontal axis is the rank sequence of members and the vertical axis is the value of the variables.

Deciphering the curvature of rank curve and transforming the result into archaeological interpretation are dependant on the nature of the variables and the expression of patterns. In order to "read" the distribution patterns of the variables, some rules override for deciphering the rank curves. Because the variables are re-arranged in a descending order, the rank curve is always illustrated as a continuous slope of declination (or declivity); and if a specific value of variable (***V***) can be determined by a functional equation of rank (***R***), the declination (***D***) of the curve is theoretically calculated by the differential value of that equation, which is always equal to or less than 0.

$$D = dV/dR \leq 0$$

The rank curve is generally illustrated by the combination of slopes and plateaus its partial ranges show their own differential array of sequential values. If the slope shows high declination ($D \leq -1$), the values abruptly decrease and the difference between neighboring ranks is relatively large; in contrast, if the declination is slight ($-1 \leq D \leq 0$), the values decrease more smoothly and the differences among the neighboring ranks become small (Fig. 6.7.).

The plateau is a flat section of a rank curve and the value of the longest plateau usually coincides with the mode value of the total group. A certain range of ranks is contiguously concentrated around a single specific value and the declination within this range is near 0 ($dT/dR \approx 0$).

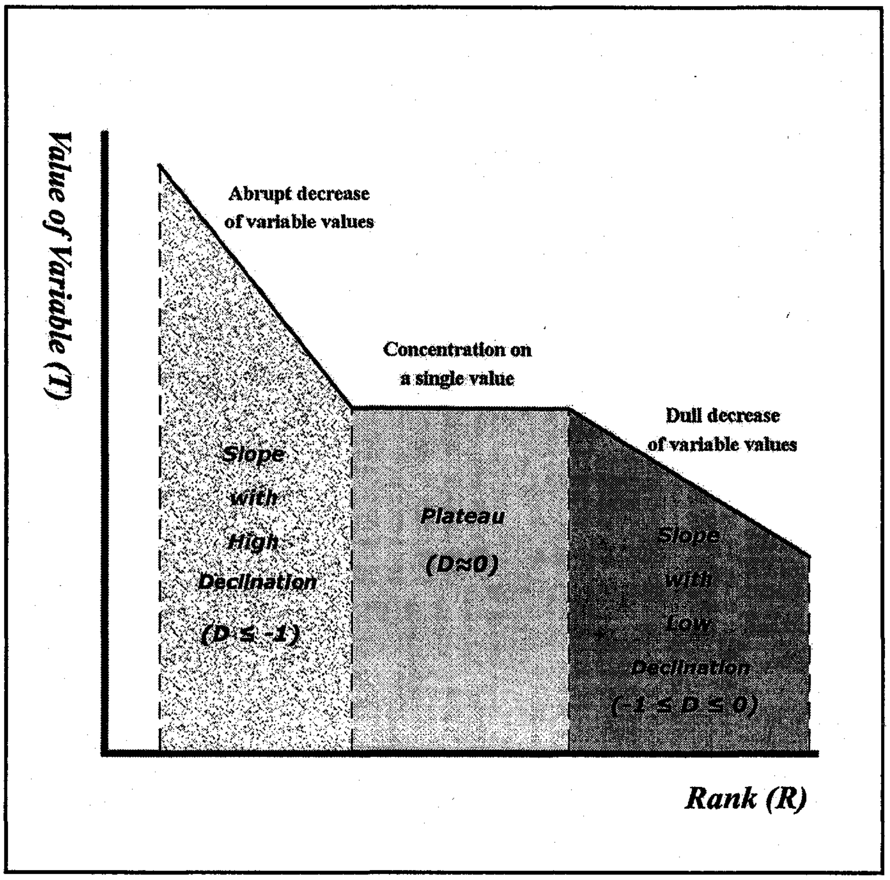


Fig. 6.7. A configuration of rank curve composed of three different ranges of declination

2. The Variability in the Lithic Size Distribution

A. Correlating the Size Distribution Patterns with the Site Formation Patterns

Taking size as a variable, the pattern of rank sequences can be regarded as a deformed mode of reduction sequences because the size distribution of the lithic artifacts in a site, incorporating all categories of tools and debitage, presupposes the continuum from raw material acquirement to reduction to final discard. In a sense, the rank curve can be interpreted as a presentation of the site formation process under a specific situation. For example, if a lithic artifact is produced in a quarry, exported to a residential site, used and recycled in a butchering site, discarded at a hunting site when was found inside the game animal, its size would have been gradually reduced by each stage and the corresponding size distribution at each site would be differently patterned. Of course, it should be noted that the manufacturers and users of this artifact were members of a mobile hunter-gatherer group.

The distribution of lithic size can be divided into six patterns (Fig. 6.7.) according to the shape of rank curve. The scenario and description of each pattern is entirely based on the widely accepted concepts and terminologies that have been suggested by past and current research on hunter-gatherer land use patterns and on the hominin lithic utilization technology as a provisioning strategy (*e.g.* Andrefsky 1998; Binford 1980, 1982; Barton 1991; Cowans 1999; Dibble 1995; Hayden *et al.* 1996; Kelly 1995; Kuhn 1994, 1995). This correlation excludes any post-depositional transformation and assumes that no unexpected factors interfered with the original size distribution and assemblage characteristics.

1) Pattern I (the Large-Size-Dominant Pattern): This pattern is characterized by an abundance of large size and abrupt decrease in medium and small size. It is considered as the result of "primitive" techniques such as throwing and/or anvil-percussion method, both of which tend to produce massive chunks and irregularly fractured flakes and chips. It is usually expected at the quarry site of low-quality material in the form of huge nodules and boulder-sized blanks. It has both large cores and large tools made with minimal modification and rare retouch, indicating that tool-making was carried out "*in situ*," possibly used and discarded on the spot. Intensive re-use of existing tools was scarcely taken into consideration. It can also be considered as a cache of bulky raw material packages which will be subsequently reduced so as to be transported for further use elsewhere.

2) Pattern II (the Bimodal Pattern): This pattern is characterized by the absence of medium-sized lithic artifacts. It is considered to be the result of carrying away the medium artifacts which may have been modified and used elsewhere. It is expected at a quarry site having high- or medium-quality raw material because moderate size will be selectively taken out, while the large size will be reserved for later visits. The debitage of small size would simply be neglected and/or discarded. It is also expected at a butchery site having large tools for heavy-duty works such as bone-crushing and dismembering, while small tools for marginally performed details such as skinning, fleshing and filleting. It usually includes some large cores, irregularly broken chunks with steep angles which are not suitable for additional flaking, and small pieces directly used without significant retouch.

3) Pattern III (the Palimpsest Pattern): This pattern is characterized by the generally uniform mixture of all size categories and it is the most frequently encountered archaeological situation. It is considered to be the result of recurrent use of a place generating a palimpsest site formation where a random mixture of several patterns takes place. Otherwise, it can be interpreted as a living space and/or a residential camp where all possible activities, including tool-making, food-processing, exchange of information and caching of raw material, take place cumulatively. It is composed of various tools, debitage pieces, cores, and some miscellaneous categories such as hammers and/or anvils.

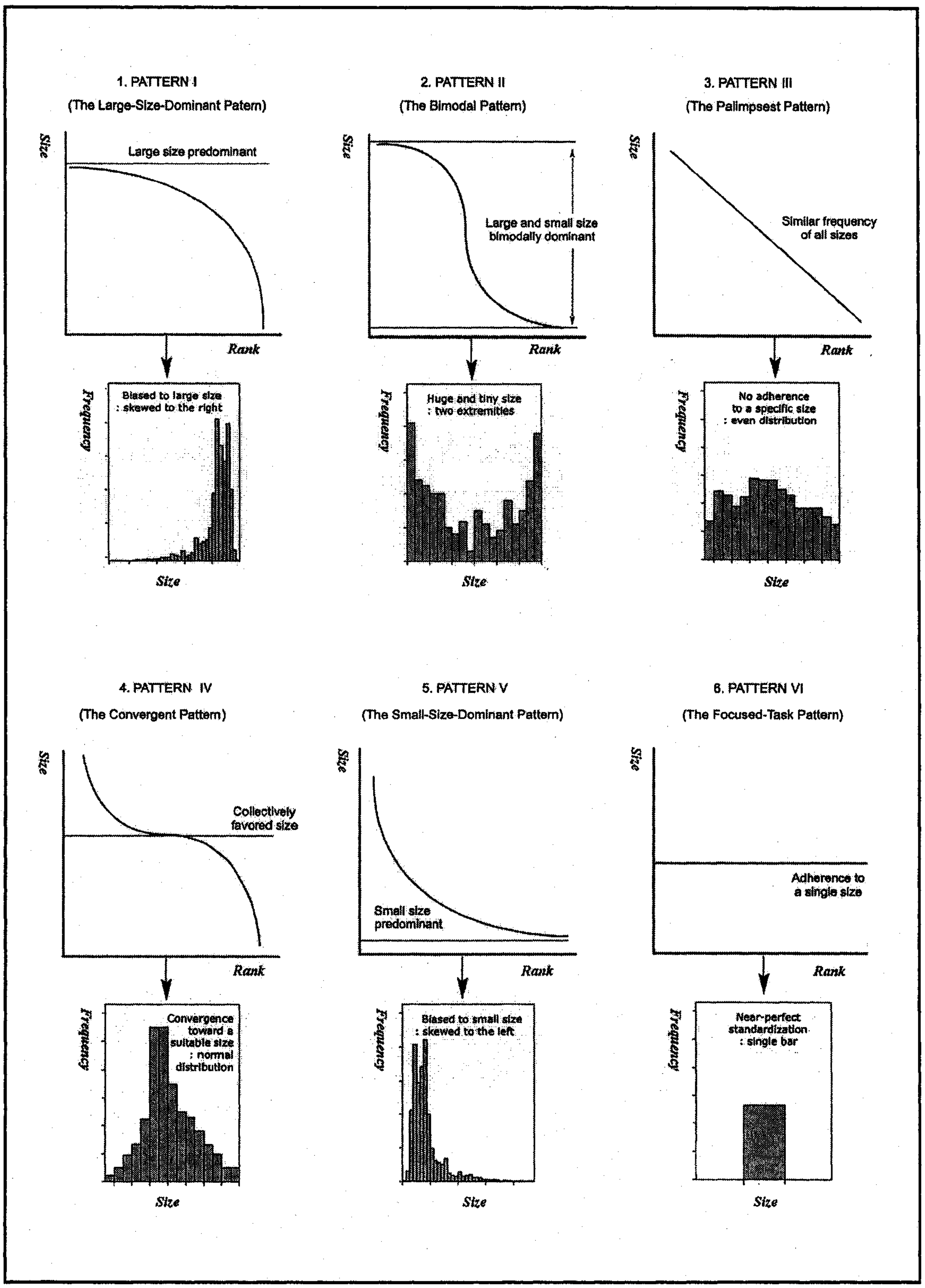


Fig. 6.8. Rank curves and corresponding histograms for six patterns of lithic size distribution

4) Pattern IV (the Convergent Pattern): This pattern is characterized by the dominance of a certain size and the rank curve has a distinct plateau. It is also characterized by the high-frequency of a specific tool type because its manufacturing technique is often typified and the resulting products tend to converge around a fixed size. It can be expected to occur simultaneously with the bimodal pattern, with some distance between each other when lithic artifacts of moderate size are selectively or favorably exported from the quarry and discarded in the site area. It is expected in a hominin group which has some degree of imposed form and/or "standardized" tool-making tradition that is shared, transmitted, and maintained among group members. This pattern also can be a result of a brief visit by a special task group such as hunters armed with projectile points and mobile toolkits. Finally, it is usually composed of highly formalized tools and very specialized cores like Levalloisian and/or prismatic ones because the sizes of flakes removed from such cores are almost homogeneous.

5) Pattern V (the Small-Size-Dominant Pattern): This pattern, contrary to Pattern I, is characterized by the abundance of small sized tools and debitage. It is considered a result of a highly precise percussion technique such as the pressure flaking and the use of the punch. It can be expected at a workshop or logistic camp site which produces large amounts of small debitage and intensively reduced formal tools. It also can be expected at a quarry of high-quality raw material far from any residential camp, where intensive reduction of cores is carried out for returning as many blanks as possible to the main camp. It is usually composed of small and highly modified tools as marked by a relatively low frequency of intact pieces because available debitage will be thoroughly modified and utilized until finally exhausted, strongly suggesting an "economizing strategy."

6) Pattern VI (the Focused-Task Pattern): This pattern is characterized by the dominance of a single size and can be figuratively entitled as a "Fordism" of lithic manufacture. It is rarely encountered, especially during the Old World Pleistocene. When encountered, it is usually the result of highly redundant situation such as a mass-killing where plenty of highly standardized hunting tools, such as the Folsom point, are associated with animal carcasses. It is also expected where specialized raw material and lithic weaponry exchange occurred such as in the Mayan territory. Otherwise it is a very rare pattern and scarcely generated unless a single individual or even a small group of skillful hominins recurrently replicate the same type of tool of uniform size.

As summarized in Fig. 6.8., each pattern can be expressed either as a linear curve or a straight line. Each pattern is accompanied by a corresponding histogram if a sample group has an adequate size and its population entails a normal distribution. In most cases, however, these patterns may not be clearly displayed because the fidelity of original patterns will be undermined by various external factors and post-depositional interference. Therefore, the interpretation of patterns and their correlation with actual assemblages need to be considered in the context of the geological records and sampling conditions of the assemblages.

B. The Formation of Lithic Assemblages

As mentioned above, the general size distribution of lithic artifacts can contribute to the recognition of the fundamental factors administering the site formation process. Using operationally defined variables of size, all lithic artifacts from a single assemblage can be expressed in a linear mode and the pattern of their distribution can be explored. In order to perform such tasks, suitable variables should be selected beforehand.

Size of raw material is a critical factor for mobile hunter-gatherers who must transport and reduce the raw material for making tools. The primary limiting constraint is hominin physical capacity to grasp and manipulate the load and this regulates the suitable size and weight of selected materials. If a raw material package is too heavy, it must be either modified on the spot, or fractured into smaller pieces to enhance portability. The portability (**P**) of a single piece of lithic material is conceptually determined by a schematic equation with six parameters as below.

$$\mathbf{P} = f \; (\textit{Volume, Weight, Quality}) + g \; (\textit{Necessity, Availability, Workability})$$

The f is an imaginary function of the physical property of a lithic artifact that is untransformed while g is the contextual potentials which varies conditionally according to the assumed behavior and technology of the artifact users. There are three variables governed by this function of contextual potentials that a lithic artifact should fulfill: the necessity, availability, and workability. Of these three parameters, the necessity is a functional requirement that a lithic artifact should suffice, the availability relates with its "*status quo* suitability" for a specific targeted task, and the workability is its applicability under given situation. To illustrate how the above equation applies, assume that a juvenile hominin must carry sufficient stone tools to hunt a medium-sized aurochs. In ideal terms, the event should progress as follows.

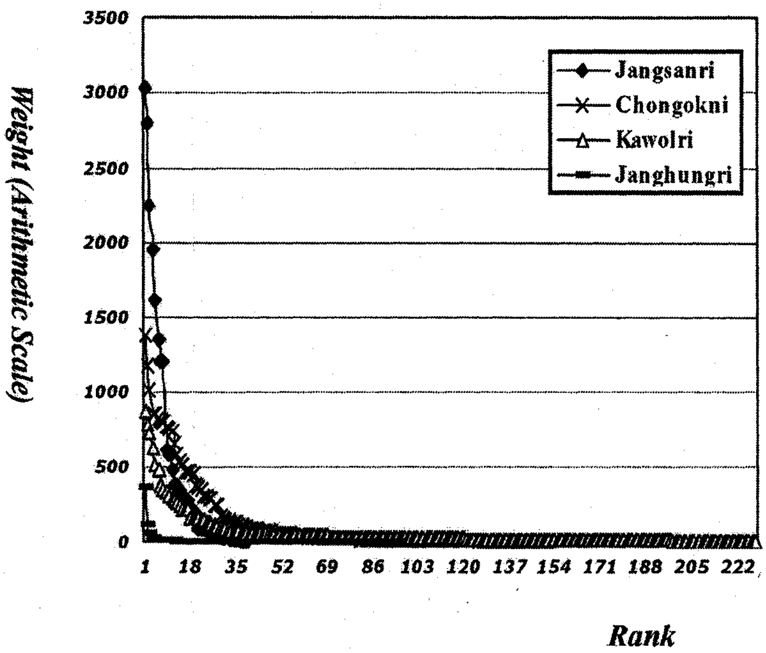
> *Deciding what kind of gear he should take from his arsenal today, he considered everything that he could. Since he was still not in his prime, he could not carry heavy-duty tools because they are too big (volume) and heavy (weight) for him. A*

medium-sized Solutrean point had been heavily weathered and too fragile (quality) for hunting a large aurochs. A flint Levalloisian core was useless (necessity) for hunting game. A used but sizable projectile point was already broken (availability) and no others were left. A bola stone requires some skills that he, as a novice, did not have (workability).

He decided to carry five Mousterian points for hunting, one sidescraper for skinning, one denticulate for tendon-removing, and three backed knives for filleting. He thought some heavy-duty tools for dismembering should be instantly manufactured and discarded on the butchering spot because they were too heavy to bring back together with his original ten tools and a big haunch of the aurochs.

He lost two Mousterian points while hunting the aurochs, and the serration of the denticulate wore down from processing the carcass. On his way back, he discovered a fist-sized obsidian pebble, a valuable item too good to be left behind. He carried that pebble in his mouth while the haunch of aurochs on his right shoulder, and the backed knife and the rest of points in his left hand. One of these points will be modified into a denticulate that will replace his loss today. It was a jaw-dropping lucky day for him!

In summary of this fictitious situation, excluding the potential (***g***) which cannot be directly verified by the materialistic evidence, the most important physical properties of lithic artifacts for determining portability would be the volume and weight. Therefore, with the aid of six different patterns of relationship between the size and rank, the distribution of weight and volumetric size can indicate how the production and transportation of lithic artifacts were carried out in terms of site formation processes.



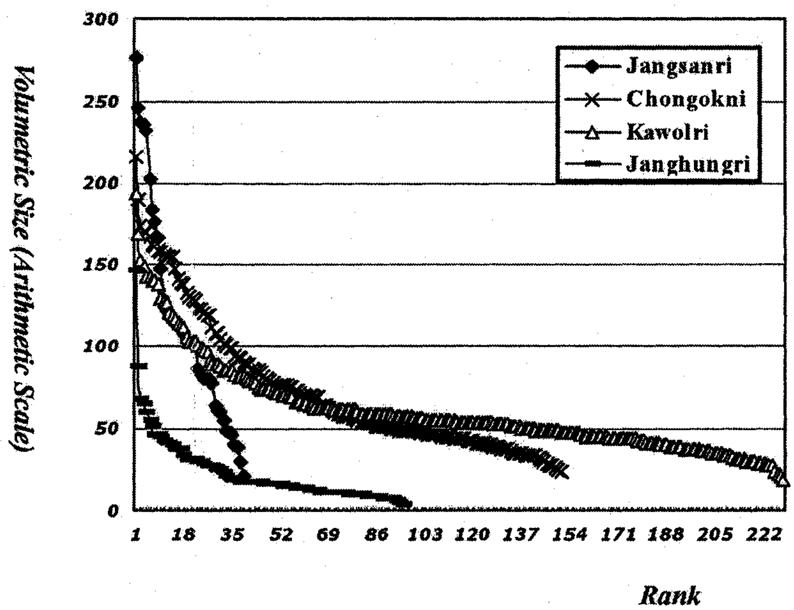


Fig. 6.9. Rank sequence of weight (W) and volumetric size (V)

for the four IHRA assemblages

C. Size Distribution Variability of the IHRA Assemblages

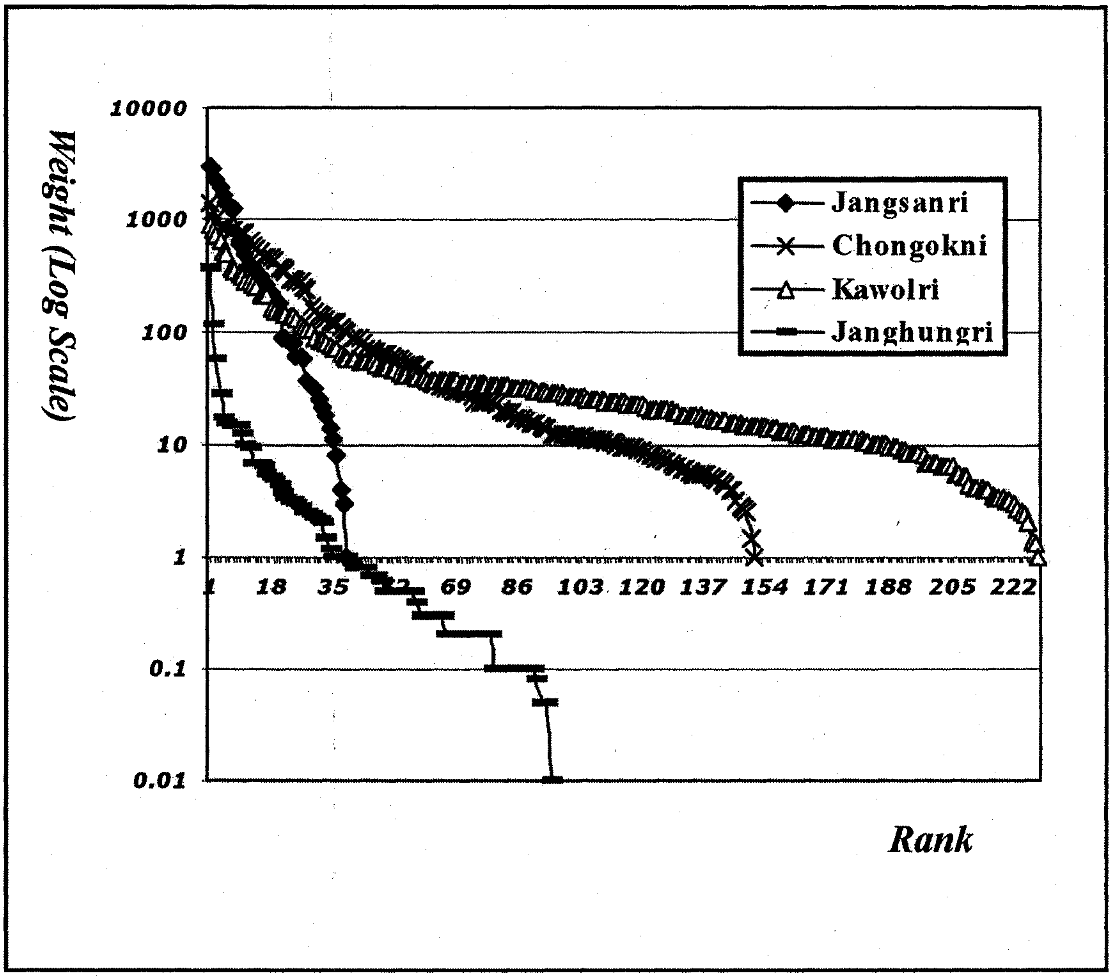


Fig. 6.10 Rank sequence of weight (log scale) for the four IHRA assemblages

Fig. 6.9. summarizes the general distribution patterns of weights and volumetric sizes of all lithic types from four selected IHRA sites. Because four assemblages are simultaneously plotted in a single coordinate and the rank numbers are different for each, the total range of variable tends to be too wide and the scale of each curve is so constricted as not to express their inherent patterns. To circumvent this problem, the variables need to be converted to a more suitable scale. In order to compare the shapes of rank curves, the constricted correlation

between ranks and variables can be easily spread-out and illustrated in a panoramic view by taking alternative values. As a result, the values of weight and volumetric size are converted into log scaled values and their rank curves are correspondingly re-drawn (Fig. 6.10. and 6.11).

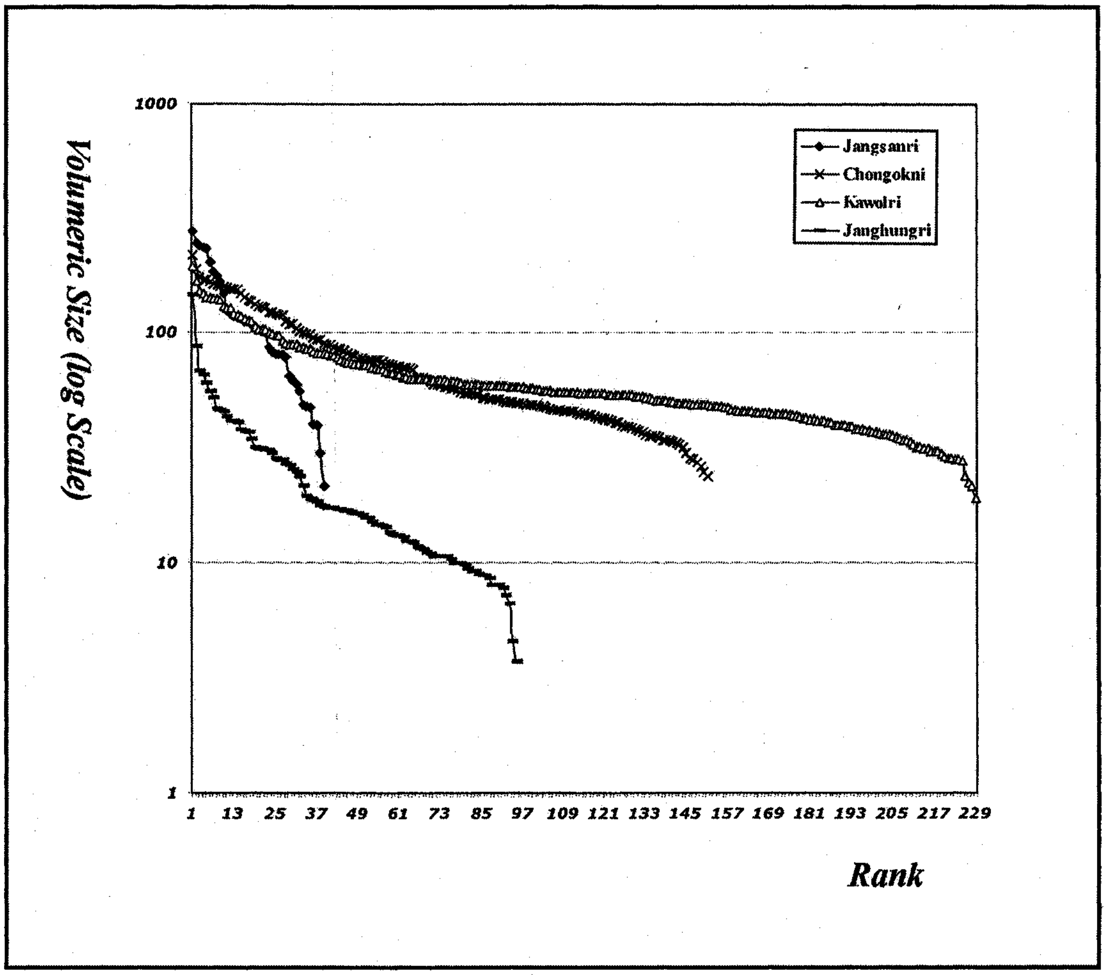


Fig. 6.11. Rank sequence of volumetric size (log scale) for the four IHRA assemblages

Excluding the unusually low values of the five lowest ranks (below the 86th), it is clear that the rank curves of both weight and volumetric size for the Janghungri assemblage have neither a plateaus nor inflection points while their declination is smooth and gentle.

From this, the Janghungri assemblage can be regarded as a typical Pattern V (the Small-Size-Dominant Pattern) characterized by the predominance of small pieces such as microblades and tiny retouched tools. On the other hand, the rank curves of weight and volumetric size for the Jangsanri assemblage show a rather abrupt declination and their curvature is similar to that of the Pattern I (the Large-Size-Dominant Pattern). As briefly summarized in the description of the fieldwork data (see Ch. IV), the majority of the Jangsanri assemblage consists of large tools and chunks as well as unmodified cobbles and pebbles (see App. V, for the classification of sediments size and terminologies). The extremely low frequency of small-sized artifacts and the predominance of huge manuports and tools contribute to the steepness of its rank curve.

Compared to the Janghungri and Jangsanri assemblages, the curves of the Chongokni and Kawolri sites are somewhat straight, both in weight and volume. They identically demonstrate the slightly skewed Pattern III (the Palimpsest Pattern). Following the expected scenarios of the Pattern III above, both sites are believed either to have been recurrently used by hominins on innumerable visits, or else to have been used as places where the simultaneous manufacture of lithic artifacts of diverse sizes was carried out.

D. Assemblage Characteristics and Site Use Patterns

Only three cores were discovered at the Jangsanri site and some of them did not even originate from the primary context (Yi 2004a, 2004b). The extremely low frequency of core implies that the blank acquirement technology of the Jangsanri lithic assemblage was not based on the "conjugate" of core and flake. A possible explanation for this unusually crude and puzzling assemblage is that the technology of the Jangsanri hominins was not, in a strict sense, a strategy-based one but was composed of loosely imprinted simple methods for reducing the original size of procured nodules.

Circumstantial evidence in support of this claim is the relatively high frequency of bipolar pieces. The bipolar pieces of the Jangsanri site are, without exception, made by vertically splitting fist-sized pebbles. If successfully split, two mirror-image pieces are usually produced (Kuhn 1995: 97) and usable peripheral natural edges are obtained. However, it is strongly suggested that the bipolar pieces from the Jangsanri site did not result from a planned technology because the size and fracture pattern are very different from piece to piece and their circumferential edges are usually over 50°, which is too dull to be directly used as suitable edges.

Summarizing all this indirect evidence and the actual age, the Jangsanri assemblage was principally formed by one of the most "primitive" hominin groups in the IHRA. Apparently they did not have any systematic blank production technology using the normal core-and-flake removal technique. The Jangsanri hominins were only capable of reducing the original size of nodules using such rudimentary techniques as anvil-percussion method (Shen and Wang 2000). Bipolar pieces and amorphous flakes, which were acquired from simple fracturing against a anvil, played a significant role in furnishing more or less useful natural edges; this kind of technological organization does not require any planning either for the procurement of suitable raw material or any shaping and retouching of debitage for more refined tools. In conclusion, it would appear that the Jangsanri site was not a habitually used place because the characteristics of its lithic assemblage can be generated without targeted behaviors which usually take place in a specialized camp or a residential shelter.

In contrast, it is possible that Chongokni and Kawolri sites were used as multipurpose living places. They are enclosed by meandering streams, one of the conditions ideal for creating a natural "territoriality" (Kelly 1995: 163). The assemblages of both the

Chongokni and Kawolri sites contain a relatively high diversity of tool types and other miscellaneous lithic categories such as hammers, cores, irregularly fractured debitage, and chunks predominantly used as blanks for large tools. The combination of both large and small tools, and the association of different lithic categories which are located at the two extremities of the reduction sequence (see Fig. 5.15 in Ch. V.) reflect almost every possible activity involved with lithic manufacture.

These two assemblages commonly have handaxes in relatively higher frequencies compared to other localities. Although embedded in the technological organization of a hominin group, because the handaxe is the result of an emulated manufacturing technique (the "individualized mimic constructs" by McNabb *et al*. 2004: 667), the idea of its formality can be transmitted by propagation and dissemination in the course of unlimited "fission and fusion" of local population. In this sense, the area of the Chongokni and Kawolri sites were part of a fairly populated area where various task-oriented activities of the IHRA hominins were liable to occur while taking advantage of the main river channel as a great opportunity to travel through the territory (Gamble 1986; 32- 53).

3. Modes of Blank Utilization and Small Tool Manufacture

A. Blank Utilization Patterns

The IHRA assemblage contains numerous small tools and unmodified flakes. Considering the flakes were utilized as principal blanks for small tools, the ratio of small tools to flakes will reflect the hominin intention to produce regular tools with retouched edges and trimmed parts for gripping. Because small tools are reduced from flake blanks, their general size is smaller than normal flakes and the relative position of the small tool rank curve tends to be below that of the flakes. If these tools are further modified and edges are continuously rejuvenated for recurrent use, the size distribution pattern is correspondingly changed.

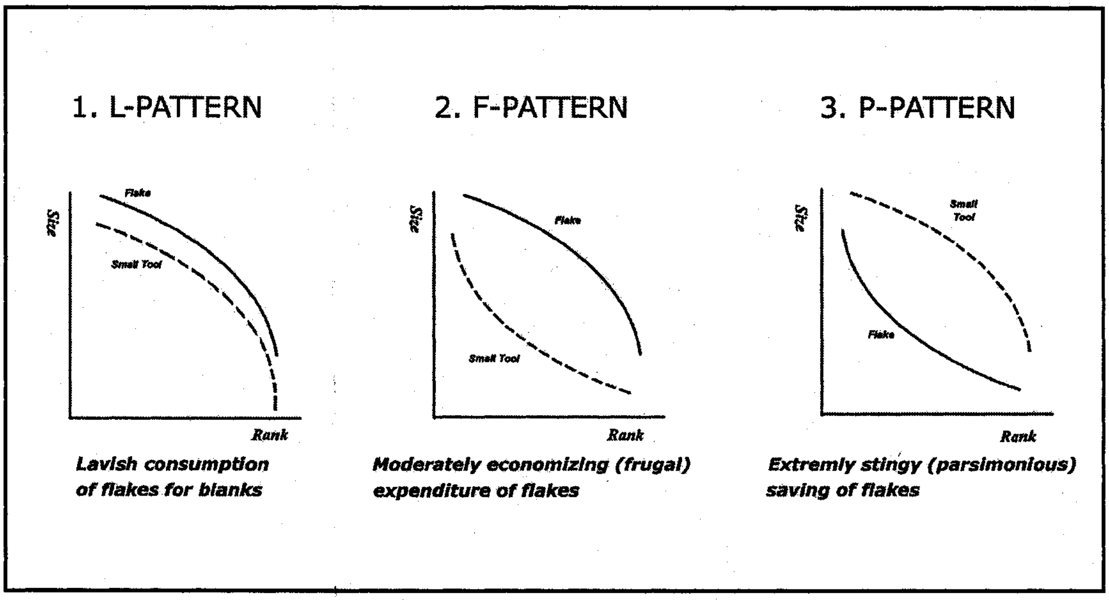


Fig. 6.12. Three patterns of blank utilization

Fig. 6.12. demonstrates three patterns of flake utilization. The first pattern is expected when the majority of flakes are used as blanks on a regular basis. Flakes are casually produced and "extravagantly spent" as blanks in order to maximize the tool-manufacturing rate. The rank curves of both flakes and small tools are similar and their general distribution fits either uniform or large-size dominant pattern. In this case, as many available flakes as possible were directly used for tool making without any thought for "saving plan." Therefore, as a paired pattern, these two curves can be entitled as the "L-Pattern" taking the initial of the "Lavish Consumption."

The second pattern is expected when flakes are produced in the same way as the L-Pattern while "ready-made" tools are more intensively reduced for re-sharpening their dull edges. Because it is "easier to recycle the once modified tools than to restart the initial modification" with fresh flakes (Dibble 1995: 332), the size reduction of small tools is accelerated while the original size of flakes remains largely unchanged effectively acting as a reserve for future use. In this case, because heavily reduced tools tend to be manufactured in a large quantity, the rank curve of small tools becomes a small size-dominant pattern and can be entitled as the "F-Pattern" from the initial of the "Frugal Expenditure."

The third pattern is expected when flakes and small tools are concurrently reduced. Almost entire flakes are reduced to small tools regardless of their size; and the small tools are subsequently recycled until they become completely unusable in size. The remaining flakes are usually microdebitage and tiny debris produced while retouching and/or trimming, followed by casual discard. As a result, the flake rank curve is placed below that of the small tools and usually displays a small-size-dominant pattern. The sizes of small tools are evenly distributed or larger sizes are slightly dominant because too small-sized tools are rarely produced unless they are originally designed to be hafted or used as components of composite tools. Because of its "austere thriftiness" for consuming available blanks and maximizing the frequency of recycling, this pattern of blank utilization can be labeled as the "P-Pattern," taking the initial of "Parsimonious Saving" of blanks.

B. Variability of Flake-Small Tool Size Distribution across the IHRA assemblages

The three patterns of blank utilization outlined above are useful when analyzing formally crude assemblages without having or using a systematic typology of tool classes. Taking the plane size as variable, three pairs of rank curves for flakes and small tools from the Chongokni, Kawolri, and Janghungri sites were plotted, as illustrated in Fig. 6.13. The Jangsanri assemblage was excluded because it has only two flakes and two small tools.

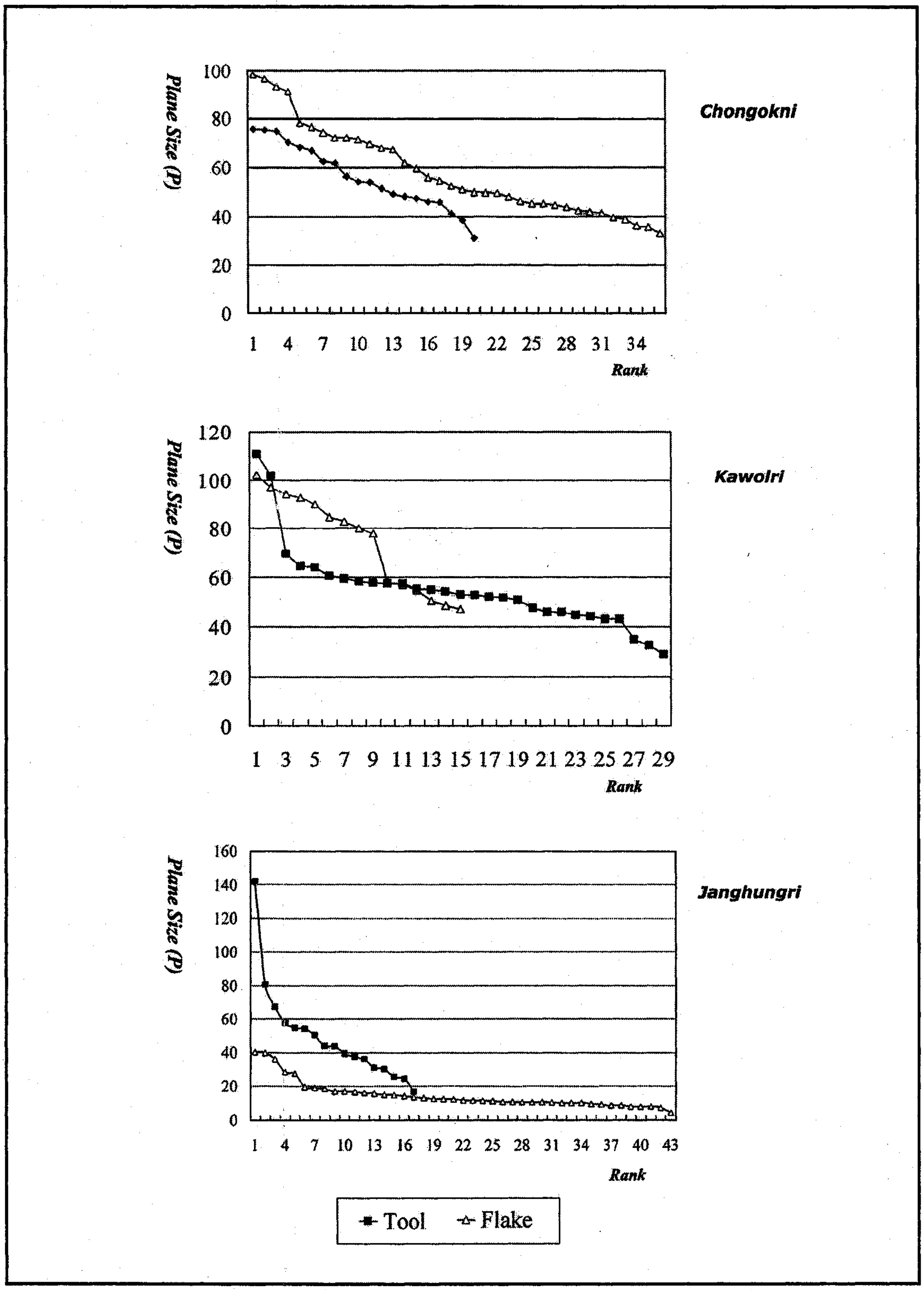


Fig. 6.13. Plane size distributions of flakes and small tools from three IHRA assemblages

Both the Chongokni and Janghungri assemblages show typical examples of the F-Pattern and P-Pattern respectively; however, the rank curves of the Kawolri assemblage requires some additional interpretation. For the Kawolri assemblage, the two highest ranks of the tool sequence have exceptionally large sizes and these two "huge" small tools are rabots, both of which are made of unusually large blocky shatters. If these two rabots are excluded, the rank curve of the small tools becomes a rather semi-straight line with low declination. This is strongly suggestive of a uniform distribution in sizes but the majority of small tools is distributed within the range between the plane size values of 40 and 60 (mm).

The rank curves of the flakes and of the small tools from the Kawolri site intersect each other at the 9th rank. The plane size of flake at this rank is abruptly reduced and its rank curve is located below than that of the small tools. Two interrelated hypothetical interpretations can be made about this unusual pattern of blank utilization within the Kawolri assemblage: 1) since the débitage components of the Kawolri assemblage are principally composed of shatters (over 90%), the original flakes might have been either snapped or split into smaller shatters and the "intact" flakes became fewer; 2) small tools were produced as a result of retouching shatters which did not have useful edges, while flakes were directly used as "utilized pieces." This would have been possible because the medium-quality raw material of the Kawolri site could have been used for producing thin and acute natural edges which would have been more effective than retouched tools. These two hypotheses suggest that the small tools and flakes of the Kawolri assemblage are not strongly related, and that the blanks of small tools did not necessarily originate from normal flakes.

Except for the Kawolri case, both the Chongokni and Janghungri assemblages show well-established typical patterns. The Chongokni assemblage, which is older than and technologically underdeveloped compared to the Janghungri assemblage, shows a perfect example of the L-Pattern. Because of the abundance of low-quality material in the vicinity, the Chongokni hominins did not stick to the exploitation of previously made tools but procured new, fresh flakes to produce their needed tools. Compared to the Kawolri assemblage, it has a relatively higher frequency of both cores (see Fig. 4.34. and 4.20. in Ch. IV) and the small tool types with distinct flake features (*i.e.* the complete platform and intact ripples on the ventral side). The Chongokni assemblage generally contains more retouched tools marking less prominent edge-resharpening; and their edge angles are generally lower than those of the Kawolri retouched tools, which indicates that their degree of rejuvenation was comparatively less intensive (for the principles of rejuvenation, *see* Kuhn 1990, 1995).

In contrast, the Upper Palaeolithic assemblage of the Janghungri site was exclusively dependent upon high-quality raw materials, and shows a typical P-Pattern with a slightly skewed tool rank curve. This indicates that the Janghungri hominins were desperately pressed to utilize all available sizes. If an unusually large tool is excluded, the rank curve of its small tools conforms to a uniform distribution, corresponding well to the basic assumption of the P-Pattern. The average size of the flakes is smaller than 20mm and its rank curve displays a small-size-dominant pattern, which partly suggests that the tiny flakes of the Janghungri assemblage consist of the microdebitage produced by manufacturing small tools and/or preparing the platforms of the microcores that were frequently encountered within the assemblage (Choi, B. K. *et al.* 2001).

4. Modes of Retouching and Change of Blank Morphology

A. Elongatedness of Flakes and Small Tools

The variable "elongatedness" is an index to explain the effective production of blanks and the general shape of the retouched tools. For example, the blade which shows significant elongatedness, can be treated as a sort of *fossile directeur* of Upper Palaeolithic technology (Bordes 1969; Mellars 1989; Bar-Yosef and Kuhn 1999), and the emergence of the blade technology is also interpreted as the marker of the Upper Palaeolithic in East Asia (*see* Barnes 1993: 58), as well as in Korea (Han 2003; Yi 1999; Yoo 2003).

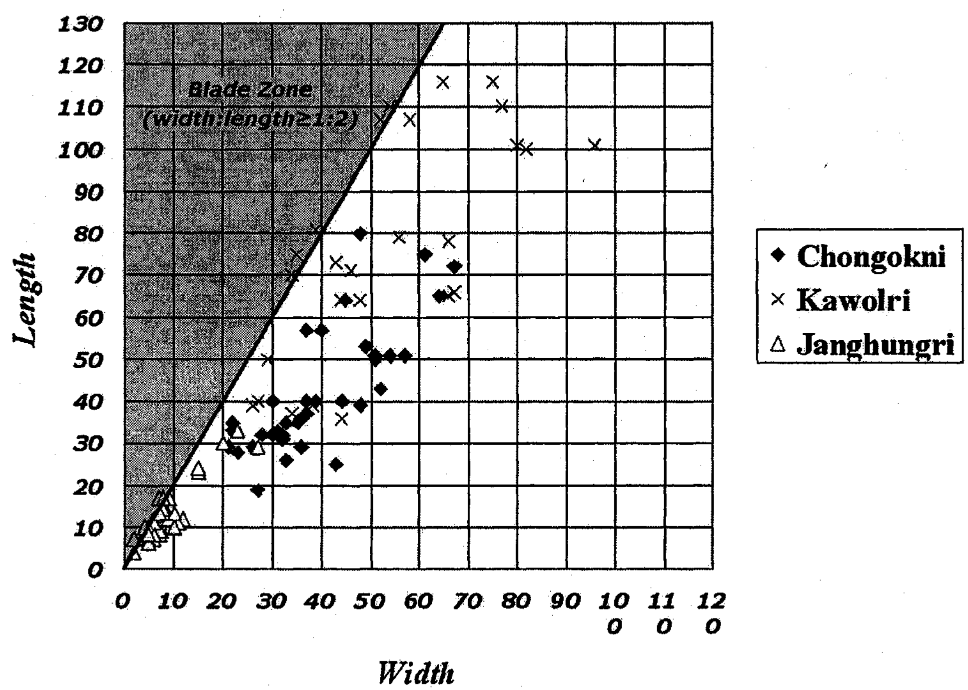


Fig. 6.14. Scattergram of blank dimensions from three IHRA assemblages

In a strict sense, however, the blade technology is not well represented in the overall IHRA assemblage. Excluding the oldest Jangsanri assemblage, some of the younger assemblages, such as those of the Chongokni, Kawolri, and Keumpari sites, are almost entirely devoid of genuine blades. Instead, there is the rare occurrence of long and slender flakes. Even in the Janghungri assemblage, according to the published data (Choi, B. K. *et al.* 2001), the majority of blades are actually microblades; and the frequency of the normal-sized blade is very low and, when found, it is rather amorphous and very thick. Fig. 6.14. is a scattergram of flake dimensions (width-length) from the Chongokni, Kawolri and Janghungri sites. According to this scattergram, the Upper Palaeolithic assemblage of the Janghungri site displays a ratio not so different from that of the antedating Chongokni and Kawolri assemblages. The only discernible difference is that the Janghungri flakes are generally smaller and their distribution is more concentrated. It is also clearly shown that none of these three assemblages has a distinct cluster of flakes included in the blade zone.

However, using the rank curve of the elongatedness, the inter-site variability of flake/small tool dimensions becomes more evident. Fig. 6.15 illustrates the combined sequence of elongatedness for blanks (*i.e.* flake and blade) and small tools from each of the three assemblages. The elevation of the rank curve demonstrates the general level of elongatedness for each assemblage. While the declinations of the three sequences are similar to each other, the level of the Janghungri assemblage is the highest in each rank and the difference is augmented as rank increases. It is widely accepted that a blade is defined by a length/width ratio higher than 2 (but "some prefer 2.5 or even 4"; Bar-Yosef and Kuhn 1999: 324); and if this ratio is converted into the elongatedness, the threshold value for blade is about 0.895 ($2/\sqrt{5} \approx \sin 63.5° \approx 0.895$). Conversely, if the ratio is lower than 0.5, it is called a transverse or "side-blow" (Barnes 1993:60) flake and its threshold value of elongatedness is likewise calculated as 0.447 ($1/\sqrt{5} \approx \sin 26.5° \approx 0.447$). One of techniques regularly used to produce the transverse flake is to sequentially "slice-off" a specially prepared flat core, and this method was technologically traditionalized, especially, in southwestern Japan (*i.e.* the Setouchi technique; Akazawa *et al.* 1980: 23; Imamura 1996; Inizan *et al.* 1992).

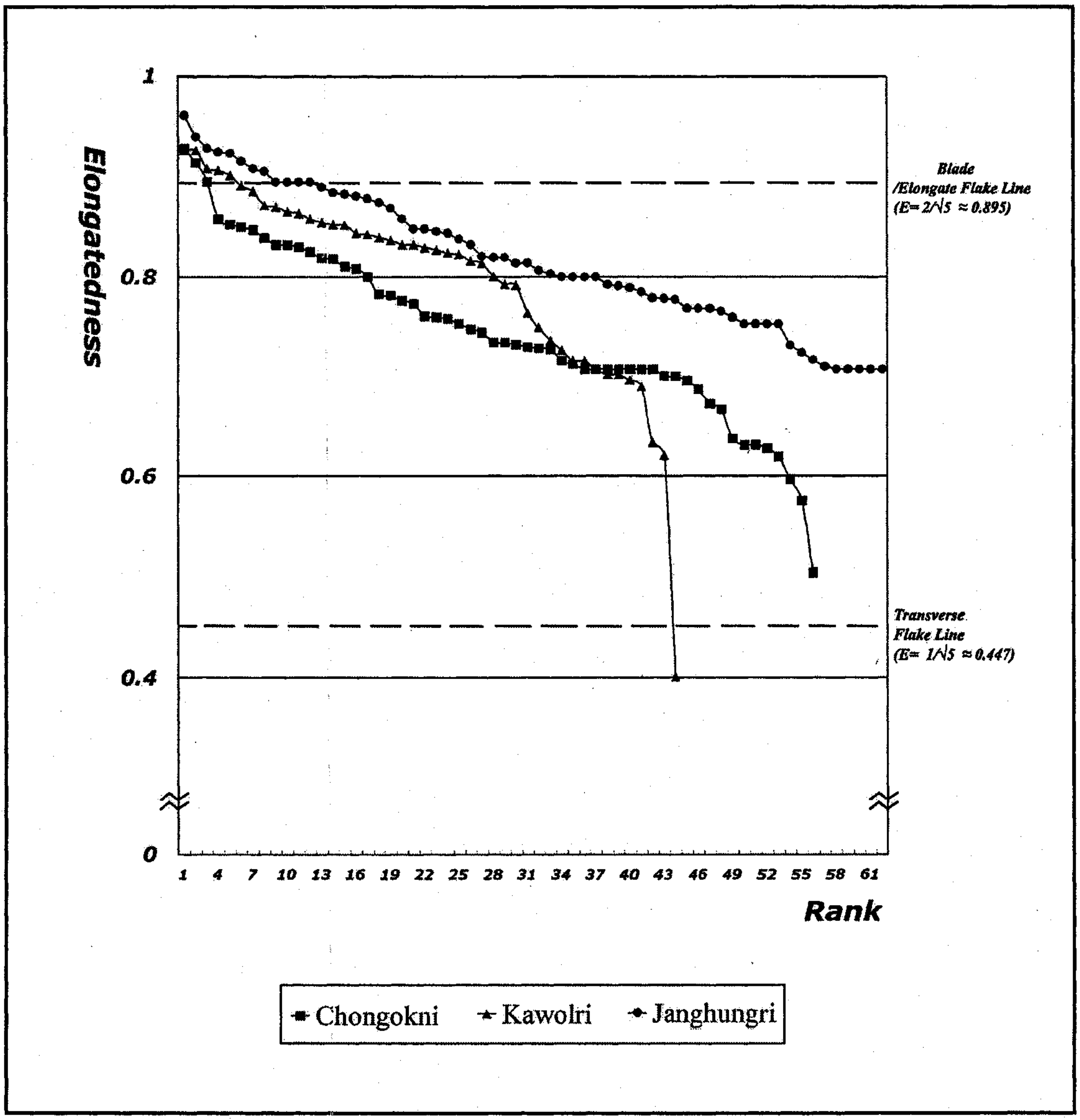


Fig. 6.15 Rank sequences of elongatedness for combined flakes and small tools from three IHRA sites

As observed from Fig. 6.15., the majority of flakes and small tools falls between the blade and transverse flake lines. Of course, several values are positioned above the blade line; but these are not considered classic blades because all specimens from the Janghungri are microblades/bladelets ("the maximum width is generally set between 1 and 1.5cm" by Bar-Yosef and Kuhn 1999: 323), and, in the Chongokni and Kawolri assemblages, these are either relatively slim flakes or bipolar pieces split from longitudinal pebbles. From this, it can be safely concluded that, although the elongatedness of both the flakes and the small tools increases from the chronologically older to the younger assemblages, the blade was not commonly included in the IHRA, even in the Upper Palaeolithic assemblage of the Janghungri site while some longitudinal and/or elongated flakes and bipolar pieces were opportunistically produced. Therefore, the blade line above needs to be re-described as the "blade/elongated flake line."

B. The Direction of Retouch: Lateral or Distal

The near absence of any authentic blades in the IHRA made from the intensive utilization of specially prepared cores is another question that should be substantially examined in the future. However, some initial explanation can be advanced by investigating the small tool manufacturing patterns with particular attention to the direction of retouch. If the blade was produced but its length was significantly reduced by horizontal modification, then the low frequency of the blade type in the assemblage would be offset by the higher frequency of retouched tools made with blade blanks.

In order to test this hypothesis, the elongatedness of both blanks and tools needs to be separately correlated, and a pair of curves is drawn on a single coordinate. Given the assumption that flakes and blades are chosen as tool blanks on a regular basis, four patterns can be determined by the positions and intersections of the two curves (Fig. 6.16.). Even though the shape of each curve will be different based on the distribution pattern of the elongatedness, the general configuration of the combined pattern will not be significantly different from these four patterns. The basic assumption for these patterns is that a blank will be either horizontally or vertically retouched and its elongatedness correspondingly decreases or increases according to the degree of reduction either at the distal or at the lateral margin.

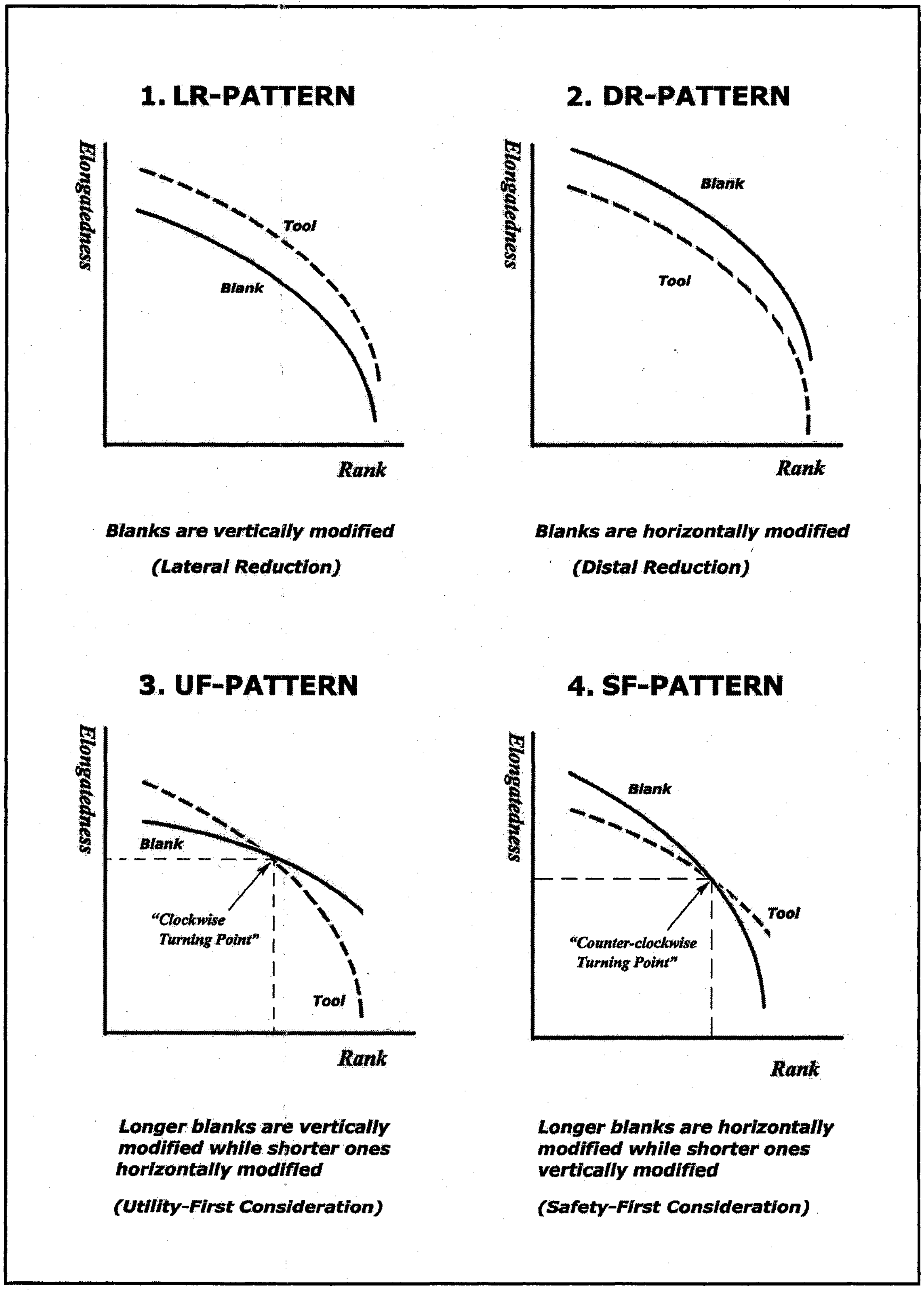


Fig. 6.16. Four patterns of blank reduction based on its elongatedness

1) LR-Pattern (the Dominance of the Lateral Reduction): The blank is generally reduced perpendicular to the longitudinal axis and the retouch is applied vertically (retouched edge is parallel to the longitudinal axis). The lateral margin receives the most intensive modification while the distal end becomes convergent or oblique (Dibble 1995: 318) or remains largely unchanged. The width of the resultant tool is necessarily smaller than the original blank but the length is at best minimally reduced. The elongatedness of the tool is higher than that of the blanks and the rank curves are generally parallel or converging downward. The sidescraper made of a normal flake is a typical example of this pattern..

2) DR-Pattern (the Dominance of the Distal Reduction): The blank is generally reduced parallel to the longitudinal axis and the retouch is applied horizontally (retouched edge is perpendicular to the longitudinal axis). The distal end receives the most intensive modification while the lateral margins are left relatively intact. The length of the resultant tool tends to be shorter than the original blank and the elongatedness of the tool is lower than that of the blank. As a result, their rank curves generally parallel to each other. The endscraper made of a blade or an elongated flake is the typical product for this pattern.

3) UF-Pattern (the Utility-First Consideration): The longer blanks are reduced laterally while shorter and/or wider ones are horizontally reduced because "the focus of use and maintenance will be on the longest edge" (Dibble 1995: 321) in order to maximize the utilized part of the blank. After reaching the critical width, the retouching tends to be switched to the distal end ("transversely retouched" by Dibble 1995: 317) and the blank is turned clockwise if the knapper is right-handed and the thick platform is not retouched. The critical width is determined by the increase of the edge thickness as well as by some consideration on the “self-defense” to avoid bruising the knapper’s hand. The burin is the typical example of this pattern because lateral retouch is initialized and the burin spall is detached from the distal margin afterward (Inizan *et al.* 1992: 70).

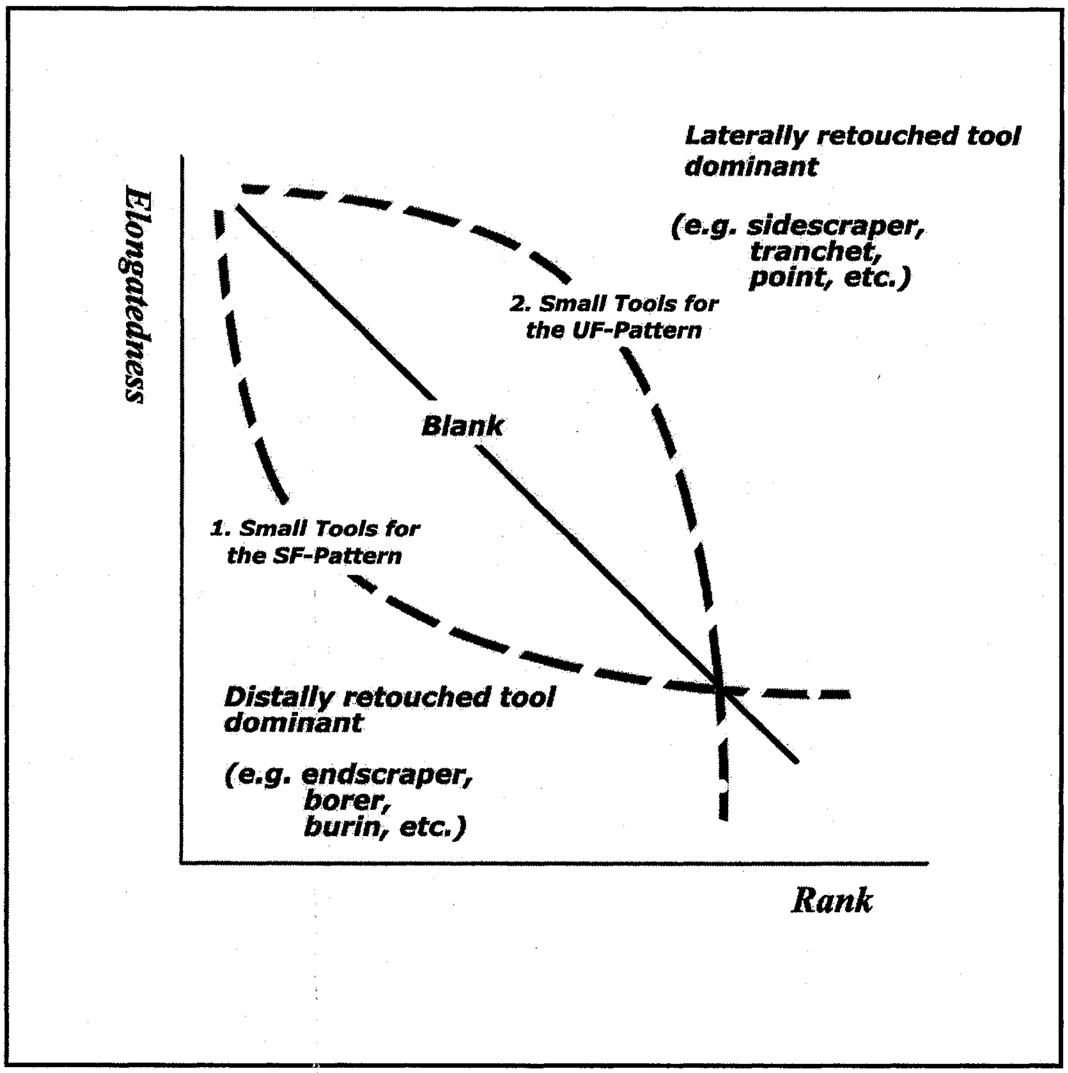


Fig. 6.17. The correlation of the UF-Pattern and the SF-Pattern pattern with associated small tools

4) SF-Pattern (the Safety-First Consideration): The longer blanks are reduced distally because of their excellent leverage for grasping; but shorter and/or wider blanks are laterally reduced in order to maximize the retaining inertia and to keep the knapper's hand from being injured by the percussion blows. As the distally reduced blank reaches its critical length for further removal, it tends to be turned counter-clockwise for lateral reduction afterward if the knapper is right-handed and the right margin is retouched first. The reduction process continues or is repeated until the length of the blank reaches the point at which the safety of the knapper's hand is compromised or until the edge thickness (*e.g.* the "Reduction Index" by Kuhn 1990: 587) is too large to be further retouched.

Of the UF- and SF-Patterns, the crossing of the rank curves is affected by the shape of the tool curve rather than by that of the blank curve (Fig. 6.17.). Supposing a straight line indicates the rank sequence of blank elongatedness, the assemblage that has a majority of distally retouched tools tends to show a high frequency of such types as endscraper, borer, and burin; and the shape of its rank curve will be a steep declination with a lower plateau. In contrast, the assemblage with the dominance of laterally retouched tools would have an abundance of sidescraper, tranchet, and point; and its rank curve would be a steep declination with a higher plateau.

It should be noted that the representative tool types of each pattern are respectively identical to the western European Middle and Upper Palaeolithic tool types (Débenath and Dibble 1994). However, these two patterns are not exclusively related to the chronological sequence of the lithic technology, nor to any differences in mental capacity between the Neanderthals and modern humans. The determination of the initial retouching direction is purely entailed by the technological requirements to produce suitable tools. As a matter of fact, the distally retouched types above are mostly made from blades. Their narrow and slim form promotes avoidance of lateral retouch while preferably encouraging initial retouch at the distal end. Thus, any implication that this pattern of retouch might have been closely related to the development of hominin planning depth and mental involvement, particularly the "self-awareness" mediating the active avoidance of injury while manufacturing lithic tools, must be supported by additional independent evidence.

C. Variability of Retouching Patterns across the IHRA Assemblages

Fig. 6.18 demonstrates three pairs of rank curves for blanks and small tools from the Chongokni, Kawolri, and Janghungri sites. The Kawolri assemblage shows a typical LR-Pattern while the Janghungri assemblage displays a DR-Pattern. Significantly, the rank curves of the small tools of the Janghungri and Kawolri assemblages both have flat plateaus, suggesting the exercise of a preference for a certain value of the elongatedness of the small tools. Particularly intriguing is the fact that the plateau of the Kawolri small tool sequence, hovering around 0.85, can be transformed into an approximation of the "Golden Ratio (φ)" ($\varphi \approx 1.618$, the elongatedness of the Golden Ratio is calculated as $1.618/\sqrt{(1+1.618^2)} \approx 0.85$).

The intersecting rank curves of the Chongokni assemblage is regarded as a plausible display of the UF-Pattern. Around 0.73 of the elongatedness value, two curves cross each other suggesting that relatively slender blanks were retouched from lateral margins while blanks wider than the elongatedness of 0.73 are horizontally modified from the distal ends. The five tools falling below 0.73 (*i.e.* the ranks lower than 16^{th}) are three trapezoids and two notches. This is consistent with the assumption that the distally retouched tools display lower elongatedness. The trapezoids are usually made by snapping flakes and their working edges are usually formed along the longest horizontal margins (see Fig. 5.12. in Ch. V. for the formation of trapezoid). Likewise, the two notches are manufactured by making dents along the distal ends of flakes and they were all made on the wider and amorphous flakes.

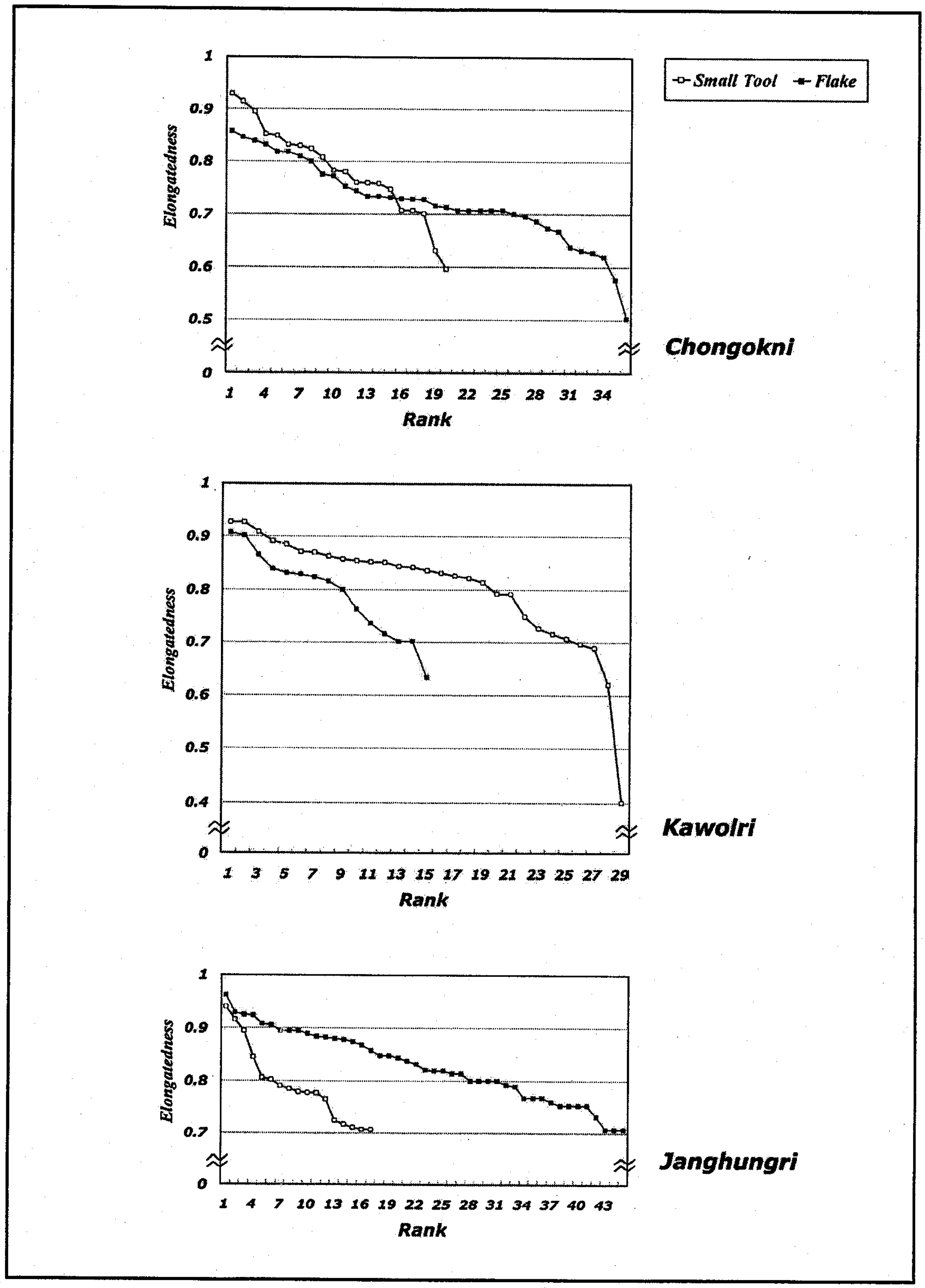


Fig. 6.18. Rank sequences of the elongatedness for separate blanks and small tools from three IHRA sites

The typical LR-Pattern of the Kawolri assemblage is an example of well-established technique for blank utilization. Comparing the two rank curves, the declination of the tool rank curve is significantly lower while its overall elevation is higher than that of the blank rank curve, excluding two specimens having exceptionally low elongatedness values: a small sidescraper and a trapezoid (see the specimen No. Tr-008 and 028 in App. III). The pattern of the Kawolri assemblage can be interpreted to support the claim that the hominins exclusively concentrated on lateral retouching until the general configuration of all the small tools converged to a certain point at which their elongatedness was similar regardless of their type. It is not a coincidence that the converging value of elongatedness approximately corresponds to the Golden Ratio which can be regarded either as a geometric "norm" shared among the Kawolri tools makers, or as an unwitting outcome of commonly achieving similar objective purposes.

The distal reduction pattern of the Janghungri assemblage partially explains why it lacks normal blades. As illustrated from the pattern of the plane size distribution, the Janghungri technology is based on the recycling and stringent utilization of previously made tools. This strategy does not require a steady supply of fresh blanks or such a highly systematic blade production technique as the use of prismatic cores (Bar-Yosef and Kuhn 1999). Therefore, the Janghungri assemblage did not entail any specialized large core reduction technique, except for the production of microblade and microcore (Fisher 2006). Moreover, its DR-Pattern of small tool manufacture involved the horizontal retouching of moderately elongated blanks. For this reason, any "laminar features" or traces of "longitude" of the original blanks would be unlikely to survive. In this regard, the Janghungri assemblage raises a significant question: should the Upper Palaeolithic technology be exclusively ascribed to the emergence of the blade technology?

(5) Discussions on the Change of Lithic Technology

1. Change of Raw Material Selection Strategy

A. Difference in the Rock Type Variation

From the distribution of rock types employed for raw material, eight types are observed to be differentially utilized at the site level. The inter-site diversity of the distribution pattern is influenced by the differential availability of each type, and by the different lithogeneses of rock types. For example, the Jangsanri site is located on the lower Imjin River where relatively large rounded cobbles are dominant. These cobbles were transported from the midstream area by fluvial activity that ground the stones into rounded shapes. These rounded cobbles were continuously abraded by the strong channel flow (Yi 2004) and were further eroded by post-depositional weathering processes. In contrast to this, the quartz from the area of the Janghungri site conserved its original properties and its degree of weathering was not as intense as that at the Jangsanri site.

The variation of the raw material making up the Chongokni and Kawolri assemblages has to be explained in more detail. These sites are located midway in the river system and mechanical properties of the rock in both sites were not much different. In addition, even the different patterning of rock type distribution is not believed to reflect any significant differentiation in the raw material utilization strategy because the frequently utilized types (*e.g.* quartz and quartzite) were predominant in both assemblages. If the quartz is not divided into two subgroups (*i.e.* granular and fine quartz), the ranges of rock types in both assemblages are almost the same each other, and the cumulative frequency curves do not show any significant difference.

However, the differences in the pattern of the rock type composition can be also explained by those two subgroups. In contrast to the Chongokni, the Kawolri assemblage is over 80% composed of fine quartz. Using a modified equation (Pielou's 1966: 136; Chatters 1987: 363) for measuring the evenness (E) of an array of items ($E= -\sum [(n/N)\cdot \log(n/N)/\log T]$, where, n=number of each rock type, N= total number, T= number of rock types), the rock types of the Kawolri assemblage has a 41.7% evenness index (n is respectively 2, 3, 40, 184 for sandstone, quartzite, granular quartz, and fine quartz; see App. III for details), while the Chongokni assemblage has a 54.7% (n is respectively 1, 3, 30, 91, 10, 14, 2 for basalt, gneiss, quartzite, granular quartz, sandstone, fine quartz, and porphyry; see App. II for details). In addition to its lower index of evenness, the lower number of its rock types suggests that more intensive utilization of fine quartz was carried out for producing the Kawolri assemblage, and that the Kawolri hominins had a basic comprehension of the technical values of distinguishing fine quartz from granular quartz. Therefore, it can be concluded that the difference in rock combination between the Chongokni and Kawolri assemblages possibly stemmed from the differentiated selection ability of hominin groups for acquiring their raw material.

This argument is also supported by the rock type combination displayed by the Juwolri assemblage. While it was not included in the analysis because of its small sample size, the Juwolri assemblage that was retrieved in the close vicinity of the Kawolri site is predominantly composed of quartzite and granular quartz, very similar to the Chongokni assemblage (see App. III). Given that the Kawolri and Juwolri hominins occupied the same region, it is likely that both hominin groups were exposed to the same range of raw materials. However, the marked contrast in the rock type composition between these two neighboring sites suggests that the two hominin groups did not share their raw material procurement practices; and it follows that the Kawolri hominins were more aware of the importance of the qualitative difference among the range of quartz variants, and selectively procured the fine quartz that was mechanically superior.

B. Shift of Raw Material Quality

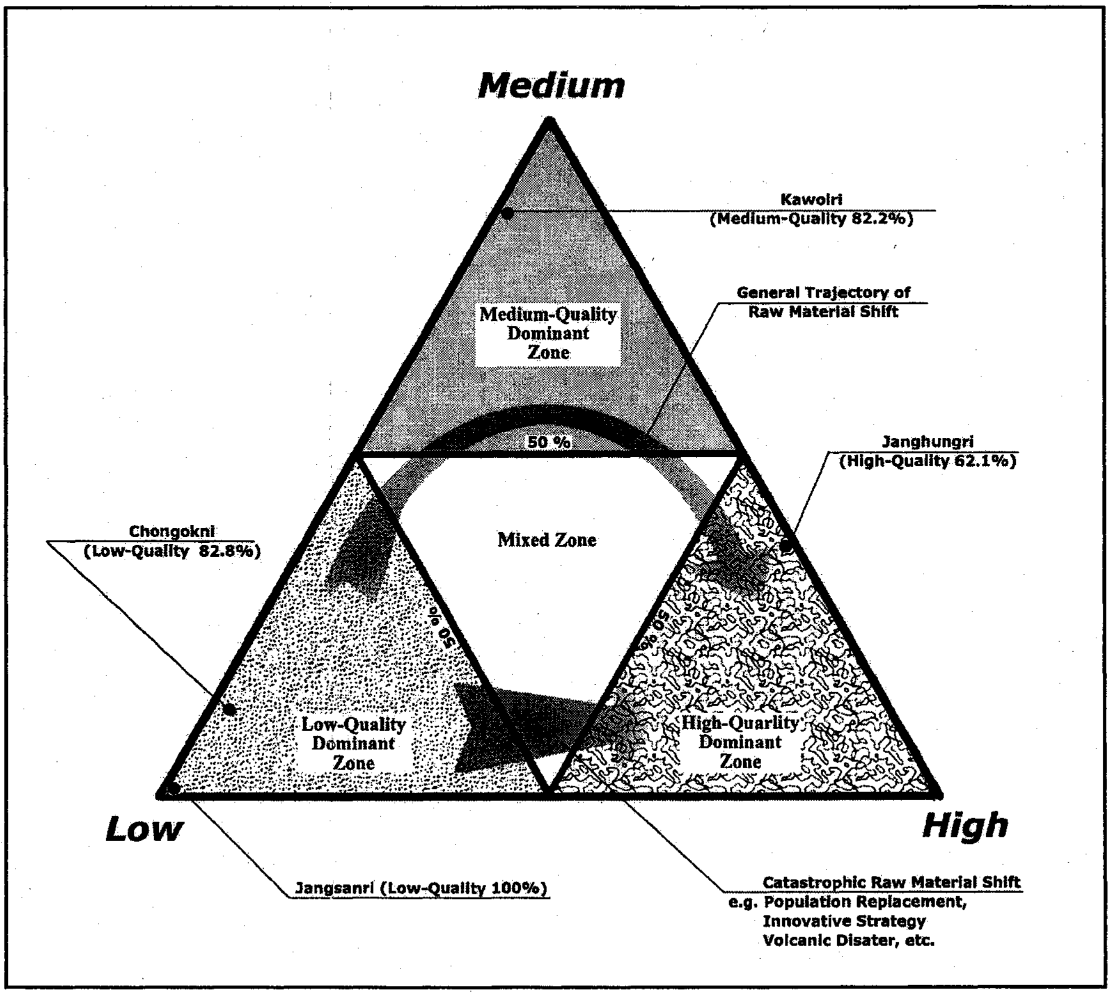


Fig. 6.19. A model of raw material selection shift in the IHRA

In order to demonstrate the temporal change of raw material utilization patterns, another triangular diagram needs to be drawn (Fig. 6.19.), incorporating several modifications. Its central part can be designated as the "mixed zone" where three categories of raw material quality are almost evenly distributed. The boundaries demarcating this mixed zone from the other three zones are arbitrarily drawn at 50% in order to make all four zones identical in size. Using the chronometric dates (Table 6.1.) of the four sites, the development of hominin selection capacity can be mapped on this triangle and it is expected that a trajectory of change will be shown from lower to medium to high-quality raw material. This trajectory is expressed in the diagram by the broad arrow in the form of a hyperbolic curve.

The provenience of each rock type is not well-documented in the IHRA since quartz, quartzite and sandstone are ubiquitously distributed in the entire area while volcanic-based high-quality raw materials have a more limited distribution. However, regardless of unspecified proveniences of raw materials, it is evident, by Fig. 6.19., that the quality of the lithic raw material generally shifted from low to high. The Jangsanri assemblage of the late Middle Pleistocene, which is the earliest, is composed entirely of low-quality material while the Janghungri assemblage of late Upper Pleistocene, the most recent one, is predominantly composed of high-quality material.

As shown by the differences between the Chongokni and Kawolri assemblages, the shift from low to medium quality material suggests the development of hominin "selection capacity." Distinguishing granular quartz and fine quartz is a complex, not a simple, process mediated by the development of hominin comprehension of the natural environment. This process involves the accumulation of experience-based knowledge about the quality and source location of different raw materials. The entrenching of habit (*i.e.* "habitual practice"; Hopkins and White 2005:20) would ensure concentrating on the better raw material. The development of the hominin capacity to select for the qualitative nature of the raw material can be defined as the "increase of discriminatory judgment"; the diversity of raw material quality must be separately understood, be reified in order to embody the quality-specification, and be memorized to capitalize on the advantages of using raw materials of better qualities. The IHRA hominins could then accelerate this process by means of numerous trial-and error experiments so as to accommodate their tool-making activity to the raw material constraints (*see* Jelinek 1994; Jeske 1989; McNabb *et al.* 2004).

C. Hypotheses on the Catastrophic Raw Material Shift

It can be suggested that two modes of raw material shift may have occurred in the IHRA: 1) a general or gradual shift, and 2) a catastrophic or "big-bang" shift. A general shift takes the sequence of low-medium-high quality, expressed as the hyperbolic curve in the triangular diagram above. In contrast, a catastrophic mode is a direct shift from low to high without an interim stage, expressed as the short horizontal arrow in Fig. 6.19. A catastrophic shift occurs on a small scale, locally rather than regionally. When a volcanic explosion suddenly brakes out, igneous rock is newly formed and the rapid cooling of the magma creates different minerals in the form of veins, exemplified by the formation of obsidian veins. This phenomenon is quite expected on sites at the vicinity of volcanic outlet, (see Lee, D. S. et al. 1983; Lee, K. et al. 1987; Yi 2005, for the evidence of multiple volcanisms in the IHRA) and the Janghungri assemblage can be suggested as a result of being in a volcanic zone.

Two other hypothetical explanations for a catastrophic shift can be made relating to hominin occupations: 1) an innovation in lithic technology, and 2) a large-scaled population replacement in the IHRA. Innovation is the process of inventing, testing and putting into practice a new method and/or device (Fitzhugh 2001: 128). If a group depending on low-quality raw materials succeeds in devising a new tool-making technology, and this technology cannot be effectively maintained by low-quality ones (Hayden 1989; Jeske 1989), a "radical" change of raw material quality is imperative and the energy cost for acquiring high-quality material significantly increases. To compensate for the high energy-cost for the procurement of high-quality material, the utility of raw material tends to shift from an expedient to an economizing mode and the intensity of tool modification increases while tool size reduces.

The population replacement hypothesis implicates global change, especially relating to the emergence of the modern human species (Clark, J. D. 1992; Clark, G. A. 1992; Mellars 1989). If a new hominin group with totally different raw material utilization strategies rapidly migrated into the IHRA, a catastrophic mode of raw material shift would occur and all the related changes in the technological organization necessarily take place. Assuming that the population pressure in the continental East Asia during the terminal Upper Pleistocene (see Ch. II) was critical and that a large-scale migration of wide-spread hominin groups was mandatory, the population replacement can be provisionally accepted as an explanation for the catastrophic raw material shift. However, since the archaeological data set of the IHRA contains no hominin fossil record, the question whether these new population groups were anatomically different from and genetically indifferent to the indigenous group is still pending. Therefore, further discussion of this issue must be suspended until the discovery of well-preserved hominin fossils directly associated with the lithic assemblages.

2. The Change of Tool Making Strategies

A. Decrease of Artifact Size and Increase of Tool-type Diversity

From the analysis of the size distribution for each site, it was demonstrated that the Jangsanri and the Janghungri assemblages show Pattern I and Pattern V respectively (see p. 243- 5).

The Jangsanri assemblage, except for several bipolar pieces, is composed of large tools such as choppers and a pick, as well as quite large irregular chunks and manuports. In contrast, the Janghungri assemblage is principally composed of small retouched tools made of tiny flakes and shatters. It is not surprising that the size of lithic artifacts has a general tendency to be reduced through time. The reduction of size is a global phenomenon (Torrence 2002), and the IHRA is no exception.

The Chongokni and the Kawolri assemblages commonly show the Pattern III, the Palimpsest Pattern, characterized by a relatively uniform distribution of both small- and large-sized artifacts. Chronologically, these two assemblages are located between the Jangsanri and the Janghungri assemblages and might be considered marking an "intermediate" stage between the large and the small size-dominant technologies. However, a simple comparison of assemblages based only on the size distribution cannot explain the temporal dynamics of the basic manufacturing technologies. As demonstrated in Fig. 6.1., the size reduction of lithic artifacts is contingent upon the interaction between the raw material availability and the degree of modification as well as the frequency of recycling. In addition, according to the debitage patterns, these two assemblages are characterized by the adoption of the direct hammer technique, a more precise and controllable percussion method than the simple anvil-percussion technique.

Combined with the increase of "discretion" (*i.e.* the increase of discriminatory judgment; see p. 267) in the raw material selection, the enhanced precision of percussion necessarily led to greater "regulation" of debitage sizes and shapes as determined by the intentions of the producers. More regulated manufacturing output emerged when hominins became endowed with greater discriminatory ability of selectively producing their tools. As a result, the ranges of sizes and forms of debitage, either as blank or as debris, became more controlled. Since the final forms of tools were influenced by the original forms of their blanks (Kuhn 1992b) and the intensity of retouch performed (Dibble 1984, 1987, 1995), the resultant tools show a wider range of variation, both in types and dimensions regardless of their assumed functions. In these terms, Pattern III of the Chongokni and Kawolri assemblages which include a relatively higher number of small-sized artifacts than the Jangsanri assemblage can be attributed to the increased capacity of hominins to produce a wider range of tools and debitage. This capacity also contributed to the higher type-variability both in the small tool and large tool categories.

The variability of size distribution and type composition at the site level was also affected by the hominin land use pattern. As mentioned before, the Chongokni and the Kawolri assemblages include the handaxe. This specific tool type is suggestive of a diverse network of hominin information exchange by which manufacturing techniques and ideas of general tool morphology were shared. This kind of strategic interaction among hominins is usually associated with a wider territory of cohabitation (*see* Gamble 1998, 1999). Hence, the manufacture of a morphologically integrated form, represented by the handaxe, was replicated accompanied by miscellaneous forms of debitage and small tools when the mobile hominin groups regularly visited this territory. However, the Pattern III for the Chongokni and Kawolri assemblages is insufficient for clarifying the exact pattern of hominin land use. Therefore, determining the function of these two site areas must be supported by substantial evidence reflecting hominin residential mobility as well as their strategy of land use for special purposes.

B. Blank Utilization and the Retouch Intensity

As demonstrated in chapter V, the frequency of small tools in the IHRA assemblage is very low and their retouch pattern is arbitrary rather than highly systematized in terms of shaping and edging procedures. Given that the functional efficacy of small tools is not seriously different from that of the unmodified debitage having sharp natural edges, the retouch added to the blanks can be regarded as optional shaping and trimming for facilitating the utilization of these natural edges.

In regard to this, the distributions of plane size and elongatedness for the Chongokni flakes and small tools implicate how the blanks were utilized by the local hominins. Combining the patterns for both distributions, the L-Pattern of blank utilization and the UF-Pattern of the retouch direction can be summarized as the simple direct use of flakes as blanks without further consideration. Overall flakes were generally transformed into small tools while longer flakes were often retouched along the lateral margin and shorter ones horizontally retouched. Following Dibble's (1995) reduction model putting a priority on the longest margin for initiating retouch, a rule of blank retouch can be applied to the Chongokni assemblage: the longitudinal flakes tend to be laterally retouched while the transverse ones horizontally retouched. However, this rule does not fit the Kawolri and the Janghungri assemblages. They show clear LR-Pattern and DR-Pattern, respectively, regardless of the change of elongatedness.

This dualistic retouch direction in the Chongokni assemblage can be accounted for either as "ambivalence" on determining the desired orientation of blank utilization or as "flexibility and versatility" in responding to the ongoing changes in blank size and shape. The latter reflects the increase of "manipulatability" in coping with the size limitation of blanks under more advanced technological organization; while the former reflect low adaptive capacity, probably an under-establishment of the technological norms, as a result of less-developed conceptualization of the steps involved in shaping the tool morphology and in retouching the functional edges.

Assuming that the extent to which the technological norms are imposed becomes more stringent with time, the dualistic direction of retouch in the Chongokni assemblage can be interpreted as the result of the hominin ambivalence toward determining the retouch orientation compared to the more recent assemblages (*i.e.* the Kawolri and the Janghungri assemblages) which are characterized by showing uninterrupted uniform direction of retouch. The technological norms for procuring blanks and for utilizing them can also be detected by the distribution of plane sizes. Unlike the uniform distribution of the sizes of the Chongokni small tools (*see* Fig. 6.13.), the sizes of the Kawolri small tools clearly converge toward a fixed value, between 40 and 60 (mm). As mentioned earlier (see p. 251), the blank utilization of the Kawolri assemblage is not highly contingent on the direct exploitation of flakes but on the shatters derived from these flakes. Even though the distribution of shatter sizes might be more random because of the uncontrolled nature of arbitrary fracturing, the resultant small tools show a rather strong consistency in plane size between the value of 40 and 60 (mm). This "convergence" is also observed for the distribution pattern of the elongatedness. The rank curve for the elongatedness of the Kawolri small tools has a remarkable clear plateau around the value of 0.85, the Golden Ratio.

If this converging tendency in the distribution of plane size and elongatedness can be regarded as the manifestation of a conceptualized standard delineating the desired form (see Monnier 2005 for the concept of standard in relation to the notion of the mental template), it can be safely concluded that the extent to which it is imposed on the planning and execution of the strategic blank utilization is higher in the Kawolri assemblage than it is in the Chongokni assemblage. Therefore, the difference in the lithic technological organization of the Chongokni and Kawolri sites becomes even more evident from the procurement and modification of blanks, as well as from the raw material utilization patterns.

3. Changing Hominin Behavioral Patterns during the Upper Pleistocene of the IHRA

From the results of the chronometric dating of the assemblages and of their analyses, it is more than evident that the technological organization of the IHRA experienced "directional" changes in the selection of raw material, the inventory of lithic types, and the procurement and utilization of blanks. These directional changes can be summarized as follows.

1) The raw material utilization pattern shifted from the arbitrary use of crude low-quality ones, such as gneiss, basalt, and quartzite, to the consistent dependence on the exotic high-quality cryptocrystalline rocks. This shift in quality of raw materials reflects increasing discriminatory judgment of hominins in the selection of better raw material, a discretion that favored the technological efficiency of the end product.

2) The type variability significantly increased from the earliest period, represented by the Jangsanri assemblage, to the Upper Palaeolithic period, represented by the Janghungri assemblage. The distinctive handaxe type was established in the Chongokni and Kawolri assemblages, while various small tool types "recursively" (Shea 2005: 194) emerged and then disappeared within these assemblages.

3) The dominant size-class of lithic artifacts reduced from the large to the smaller sizes. The high-frequency of huge cobble-based lithics generally decreased, while the use of flakes and

shatters for small tool blanks increased. After the shift in the quality of raw materials occurred, the majority of tools and blanks came to be based on small fragments and microblades without any distinct use of normal blades.

4) The blank utilization pattern changed from a lucrative to a frugal pattern, and finally to the parsimonious pattern. Flakes of the Chongokni assemblage came to be modified and transformed into small tools on a relatively regular basis; but the small tools of the Kawolri assemblage came to be made of secondarily fractured or "unorthodox" blanks selected from shatters such as snapped and/or split flakes. The intensity of the economizing strategy in the use of available blanks was directly proportional to the quality of raw materials and to the energy cost expended for acquiring them.

5) The utilization of blanks for tool making was changed from the dominance of non-retouched bipolar pieces of the Jangsanri assemblage, to the utility-first pattern of the Chongokni assemblage, to the lateral reduction pattern of the Kawolri assemblage, and finally to the distal reduction of the Janghungri assemblage. The tendency across these patterns reflects the shift from the ambivalence to the convergence of behavioral orientation. This tendency is believed to have been determined by the degree to which the technological norms were developed and applied to produce desired tools.

The view has been widely accepted (Bae 1988; Yi 1989) and is still pervasive in the literature (Yi 2000, 2002, 2005a) that the general features of the IHRA industry were homogeneous and static across the individual assemblages for a considerably long period. However, this is a seriously biased view arising largely from emphasizing the handaxe and treating it incorrectly as a *fossile directeur*. As demonstrated earlier, the temporal changes reflected in the four IHRA assemblages were evinced by the pronounced "directedness" of the unique technological solutions used by each hominin group that occupied these sites. This directional change is analogous and partly "synchronous" with the progressive tendency toward "behavioral modernity" (Bar-Yosef 2005; Chase 1991; Clark 1992; Klein 2001; Mellars 1989, 1996; Shea 2005; Stringer 1989, 1990).

Even though it takes more than the change of lithic technology to attest to the dynamics of behavioral patterns, the distinct assemblage variability of lithic manufacturing strategies at the site level strongly suggests that the IHRA hominins are not correctly attributed to being an entirely "lethargic" and/or "nonchalant" species unable to deliberately modify and innovate their technological repertoires to accommodate to external physical conditions. For example, they were selectively able to minimize the energy input for procuring raw material by concentrating on the abundant low-quality materials. Also they were able to shift to high-quality ones with their enhanced discriminatory control over the mechanical properties of various rock types. This allowed them to compromise with the shortage of high-cost raw material by reducing the general size of blanks and by increasing the degree of recycling them. Along with this, they were capable of changing the direction of retouch in response to the size and elongatedness of the available blanks.

It is further possible that the capacity of IHRA hominins to modify their behaviors in relation to changing environmental constraints was related to slowly changing mental capacities that were realized as changing general attitude toward tool production. The attitude of the IHRA hominins was gradually changed as their external condition, such as increasing environmental stress, constrained their selection of technology and augmented their reliance on the lithic tools. As a result, their behaviors based on their attitude were changed to more consideration on making suitable, target-oriented specialized tools as well as enhancing the degree of blank utilization. This behavioral change was evoked by the shift from "easy-going, relaxed, and nonchalant" to the "careful, thoughtful, and planning" attitude toward the manufacture and maintenance of lithic tools. Initially, the attitude toward tool production might be characterized as expedient in that economizing of labor costs was forefronted. Slowly emerging, however, may have been an attitude that treated tools as part of the satisfaction of the intention as well as the goals they served to achieve. An attitude of this type might deserve being termed "reflective."

In essence, insofar as the accommodation to the external constraints by the IHRA hominins is concerned, their attitude, the principles and motives of their voluntary behaviors, might have been slowly changed from the less self-perceptive mode that encouraged low standards of self-satisfaction to the more reflective mode enabling them to actively modify their survival strategies. With this change in the mode of attitude, the IHRA hominins became more aware of the complexities of the external world, such as the resource seasonality and patchiness, the quantitative and qualitative properties of the lithic raw material, the feasibility of specific manufacturing techniques, and so on. As a result, the IHRA hominins slowly came to adjust their attitude in response to the deteriorating environmental and materialistic context. This promotes the possibility that the forms of tools were assessed in terms of their being instrumental to serve in achieving specific goals by the hominins as active producers and users.

Therefore, the apparently static and remarkably mundane nature of the lithic assemblages in the pre-Upper Palaeolithic of the IHRA, somewhat similar, for example, to "the Mousterian Stasis" as postulated by Kuhn (2005: 109), can be characterized as a long-term series of the slow-paced changes cumulatively brought about by the adaptive mapping of an expedient, minimally responsive technology to a changing environment. The rather rapid technological changes marking the emergence of the Upper Palaeolithic can be accounted for, therefore, as the emergence out of this "hard-boiled," rather pre-reflective expediency-based attitude into the "high-tensioned" vigilantly reflective mode, possibly triggered by serious subsistence crises caused by the environmental deterioration during the LGM. The emergence of the Upper Palaeolithic technology in the IHRA, therefore, is postulated to be the result of this radical change in hominin mentality, and was probably somewhat synchronous across the Pleistocene population dispersal in East Asia – a claim, of course, that goes well beyond the data of this thesis.

VII. THE LONG-TERM CHANGE OF THE IHRA TECHNOLOGICAL ORGANIZATION : A CONCLUSION

(1) The Pleistocene History of the IHRA

1. Time-scale and the Evolution of Fluvial System

A. Understanding "la longue durée"

Across the research history of the IHRA, many attempts have been made to elucidate the large-scale dynamics of relating the environmental changes and hominin activity. It must be admitted, however, that unreliable data and a lax academic attitude toward tackling this problem have brought about a plethora of unfounded claims. In this conclusion, an attempt to break through this stalemate will be made by using the results outlined in the previous chapters. The final step of this study, therefore, is to establish a temporal framework that can be adequate for advancing the understanding of the IHRA, and hopefully to help the cultural and technological correlation with other local East Asian Palaeolithic assemblages. What is needed for this purpose is a theoretical consideration on the concept of time, chronology, and temporal scope of observation (Hodder 1987).

Ferdinand Braudel (1972, 1980), the champion of the *Annales*, scaled time of the past into a "Trinitarian" hierarchical chain of rhythms (Smith 1992: 25; Fletcher 1992: 37): long-term geographic or environmental structures (*la longue durée*), medium-term socio-political cycle (*conjuncture*), and short-term socio-political events (*l'historie événementielle*). In his multi-dimensional time-scale, physical or material factors that operate over long periods of time act as constraints on human behavior (Knapp 1992: 6). Unlike environmental determinism, Braudel's approach to the understanding of *la longue durée* is based on the perspective of "macro-history" as more than human ecology incorporating the geological, biological, environmental and social interrelationships. Although an integrative entity embracing events of short duration, *la longue durée* is not influenced by the pulse of short-termed events. Rather it constitutes the structure of human relationships with the external constraints, where "constant repetition and ever-recurring cycles" in which "all change is slow" are activated (Braudel 1972: 20).

Braudel's *la longue durée* can be used as an effective framework for delineating the dynamics of the Pleistocene landscape and of the interaction of hominins with their external world. Relevant to this, Butzer (1982) proposed another scheme, roughly analogous to the Braudelian one, which is composed of three modes of adaptation defined in terms of time scale: 1) the "adaptive adjustments" directed to solve the social and economic problems in the short term; 2) the medium-termed "adaptive modifications" involving "substantial revision of adaptive strategies within the context of a viable and persistent adaptive system" (Butzer 1982: 290), mode of which is exemplified by the "Upper Palaeolithic Revolution" (Gilman 1984); 3) finally, the long-termed "adaptive transformation" realized as the gradual change of technological systems by incorporating a multitude of different adaptive modes (Smith 1992: 25).

While more specific and practical for explaining the dynamics of long-term Pleistocene history, Butzer's scheme puts too much emphasis on environmental stress to address the full range of relationships between human populations and their natural world

(Smith 1992). In Butzer's terms, the strategic behaviors of hominins who were the active actors responsible for the cultural transformation of materials during the Pleistocene are treated as "predestined" by being deterministically regulated by the external constraints. Braudel's original *longue durée,* although not covering the "very remote period" such as the Pleistocene, does not exclude the relevance of intentional forms of human (or hominin) intervention in the natural and social processes that operate at different temporal rhythms. These forms can be technological innovation based on the creativity (Hodder 1998; Mitchen 1998), development of social networking (Mithen 1990; Gamble 1998, 1999), and new ways of information exchange, including social learning (McNabb 2004; Mithen 1996).

B. Landscape and Geological Time-scale

An interpretation of the IHRA geological processes requires understanding of the landscape as the "natural background" (Knapp and Ashmore 1999: 5- 8) where a wide variety of cultural and technological activities of its occupants took place. This interpretation begins with the assumption that the principal actors of the IHRA are the hominin population who were responsible for the production of the lithic assemblages. The landscape was perceptually constituted by these actors and their practice was structured therein (Giddens 1984: 2; Hopkins and White 2005: 16). While behavior can be understood as the ecological and technological engagement hominins have with their environment, practice is understood as mediated by their cultural knowledge and know-how performed in terms of these social contexts (Gamble and Porr 2005: 8). Hence, as an individual agent, the hominin engages with the natural and social world by behaving through the mediation of the culture; and transforms this engagement with a practice that generates changes in the socio-natural world. A hominin as an individual actor performing a practice, which is enacted within the background of physical world as its context, actively engages with the natural environment; and this engagement subsequently necessitates further actions and reactions.

As has been demonstrated by previous research (*e.g.* Yi 1996; Yi *et al.*2004), it is widely accepted that the IHRA hominins were not immigrants but resided in the basin area of the CRV (see Ch. II) from the later Part of the Middle Pleistocene (*i.e. ca* 0.23 Mya, according to the maximum age of the Jangsanri Terrace, see Ch. IV). This can lead to the view that the IHRA lithic assemblage was a reflection of structured practices and that these practices had been routinely and "spontaneously repeated" on a daily basis (Hopkins and White 2005: 18). However, these practices should not be treated as "a predestine phase of actions and fates" (Gamble 1993: 19). Instead, they should have been generated by hominins through their ongoing perceptual experiencing of the world that they occupied.

To trace the long-term Pleistocene history in the context of the changing IHRA landscape, the stratigraphic units need to be related to the levels of geological activities along with different time-scales. Until now, the problem of addressing the chronology of the IHRA has been principally influenced by the biases of viewpoints on different geological time-scales Different modules were persuasively applied to generate "plausible" ages while often supported by wildly misleading interpretations of the geological record based on the expanding of the ranges of "digitized metrical data," for example, of calculated chronometric ages, the level of archaeological horizon, the frequency of tephra particles, the number of lava flows, the number of river terraces and its correlations, and so forth.

Using the concept of *la longue durée,* each of the different time-scales of the IHRA geological processes can be evaluated. It is unequivocal that one of the major components of the IHRA landscape is the Imjin-Hantan River and the complex history of its channel system. This channel system has continuously evolved at different time scales, thereby changing its configuration and drainage. No doubt it was differently perceived by the occupants in that area over these different times. Relating to this, Vandenbergh (1995: 632) has stressed three time-scales with respect to the development of the channel system and the relationship between the river dynamics and other accompanying physical factors.

1) One-hundred-thousand year unit (100,000 yrs): The fluvial evolution is climatically contingent and affected by tectonic dynamics. The correlation between glacial/interglacial cycles with the change in the tones of sediments in the Chongokni stratigraphy can be a typical example of this time-scale (Bae 1988).

2) Ten-thousand year unit (10,000 yrs): The fluvial action is determined by vegetation, soil cohesion and run-offs, while short unstable phases alternate with long periods of inactivity. The correlation of isotope stages with the changes in soil texture and with alternating color bands is based on this time-scale (*e.g.* Naruse *et al.* 2003; Yi 2000).

3) One- thousand year unit (1,000 yrs): The fluvial change is dependent upon the intrinsic evolution of the channel system and inundation, as well as other transforming agents. Changes in soil morphology, appearance of surface features and weathering effects within a single stratigraphic unit is based on this time-scale.

Out of these three stepwise time-scale units, the difference between a 100,000 year unit and a 10,000 year unit is the key point of discrepancy among different viewpoints on the formation of fluvial sediments in the IHRA. This is largely responsible for the confusion on the age of the IHRA assemblages interpreted with the chronometric dates because, as illustrated in the Ch. III and Ch. IV, the resolutions of the applied dating techniques are very low and the interpretations of the geological formation processes tend to hinge on the different time scales these dates are calculated of. In order to avoid this confusion, the 1,000 year time-scale unit needs to be applied to the elucidation of the evolution of the Imjin-Hantan River channel system as well as the practices of hominins that occupied that system.

C. Evolution of Channel Systems in the IHRA

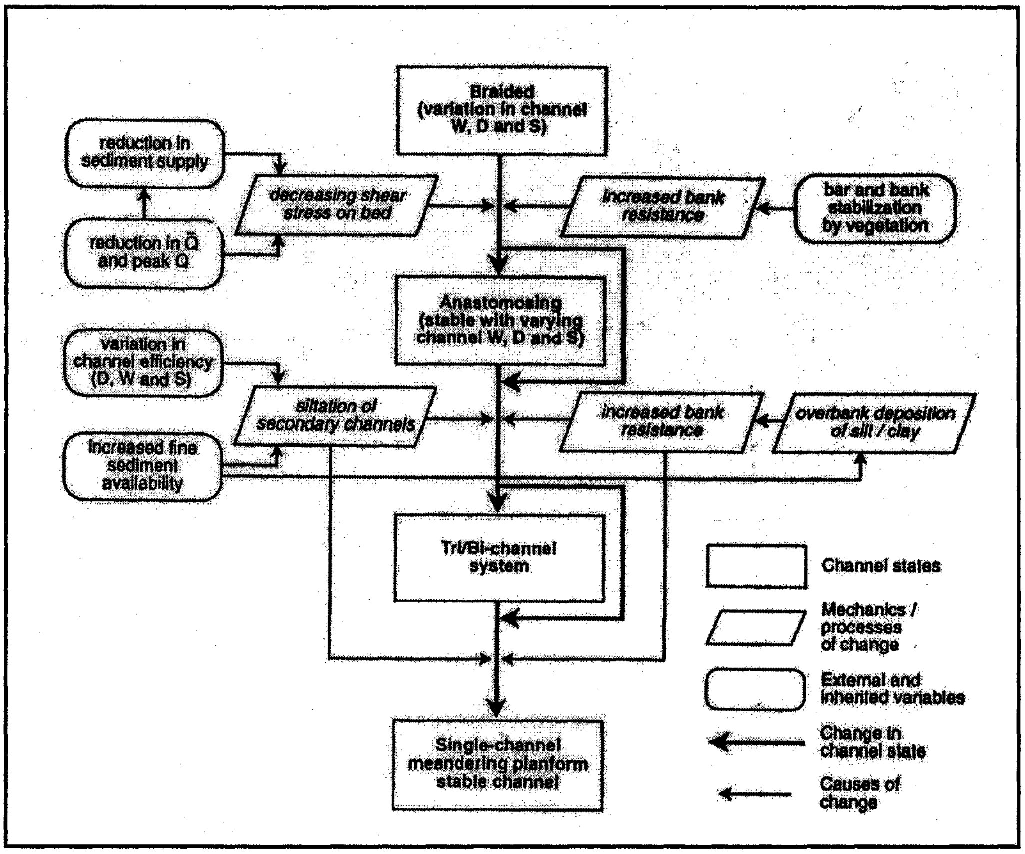


Fig. 7.1. Evolutionary model of a general channel flow (from Brown 1997: 24)

The evolution of a channel system is a time-dependent function of hydraulic dynamics and a circulating process of non-reversible change (Brown 1999: 76). The fluvial channel tends to maintain its stability to the degree that the discharging flow is balanced with the incoming flow, and this tendency toward the stability is termed "channel equilibrium" (Rapp and Hill 1997). If this equilibrium is broken, the channel current rapidly reacts by eroding and flooding until the original stable status is recovered. Brown (1999: 24) demonstrates this process with special reference to different channel configuration and changing mechanics (Fig. 7.1.). Based on the hydraulic forces and the morphology of diverging channels, his model summarizes four stages of channel evolution: 1) braided, 2) anastomosing, 3) tri/bi channel and 4) single channel. Since the Imjin-Hantan River system can be considered a normal fluvial channel, a catastrophic interception of lava flow will force it to undergo all four stages of Brown's model. This is because the huge lava dam blocked the ancient channel, forcing the initiation of the process as if it were a new channel.

The channel-system-based landscape is a basis for understanding how the individual hominins selectively cognized the external world as the principal water-supply source and the habitat for exploitable plant and animal resources, as well as being a possible route for ranging beyond the territorial limits of their everyday provisioning tasks. The general process of geomorphological transformation and the consequential impact on hominin perception of the landscape will be examined using both the 10,000 and 1,000 time-scale units. What follows is a narrative on the hominin practices in the context of the natural environment and the mediation of their survival strategies. This narrative is based on the six-phased schematic change of the landscape in the IHRA. The time-table for each of these phases is based upon the chronometric dates that were obtained from the fieldwork (see Ch. IV). This sequence of phases includes 1) the pre-volcanic phase, 2) the lava flow phase, 3) the initial braided stream phase, 4) the intermediate anastomosing system phase, 5) the single channel down-cutting phase, and 6) the final stabilized phase.

2. Six Phases of Geological Process in the IHRA

A. Phase 1 (before ca 0.20 Mya)

The original terrain of the CRV was very rugged and uneven. The ancient river channel developed across this narrow valley and its channel configuration was determined by multidirectional troughs of the CRV. As water descended along the steep gradient of the troughs, its velocity became rapid. The main stream channel was continuously cut down toward the bottom, and the trough expanded to maintain the equilibrium in its energy current of flow discharge (Rapp and Hill 1997). The high-velocity of the water flow through the channel transported boulders and organic debris from the hillside, generating much frictional drag. When the velocity of water was decreased, a thick deposit of cobbles and gravels (*e.g.* the Baekeuri Formation) was accumulated on both sides of the channel. A stepwise series of river terrace surfaces developed as a result of the fluctuation of channel surface and/or of the tectonic upheavals of the river bed (Fig. 7.2.).

The hominin occupation seems to be minimal during this phase. Only the Jangsanri Terrace surface preserves a handful of lithic artifacts, and other locations do not have any *in situ* artifact concentrations. The upper region of the Imjin River shows a similar river terrace sequence (Yi 2004a; Yi, Lee, and Kim 2004) but currently no unequivocal evidence of hominin residency has been reported. The altitude of the Jangsanri site makes it an excellent vantage point for viewing the entire shore area of the Imjin River. The density of artifact distribution and the intensity of raw material utilization appear to be very limited. This indicates that the frequency of site formation was extremely low. Therefore, interaction among local hominins was probably scarce.

The Jangsanri hominins are not believed to have had any habitually practised technology such as basic flaking techniques performed by free-hand hammering. They did not have any cognized standard for selectively identifying the properties of rock types. As a result, the diversity of assemblage variation was extremely low and the raw material utilization was entirely based on the memory of previously "fractured" nodules which could have barely specified what sizes and what forms of cortex on cobbles/pebbles would have made them worth targeting for the next fracture.

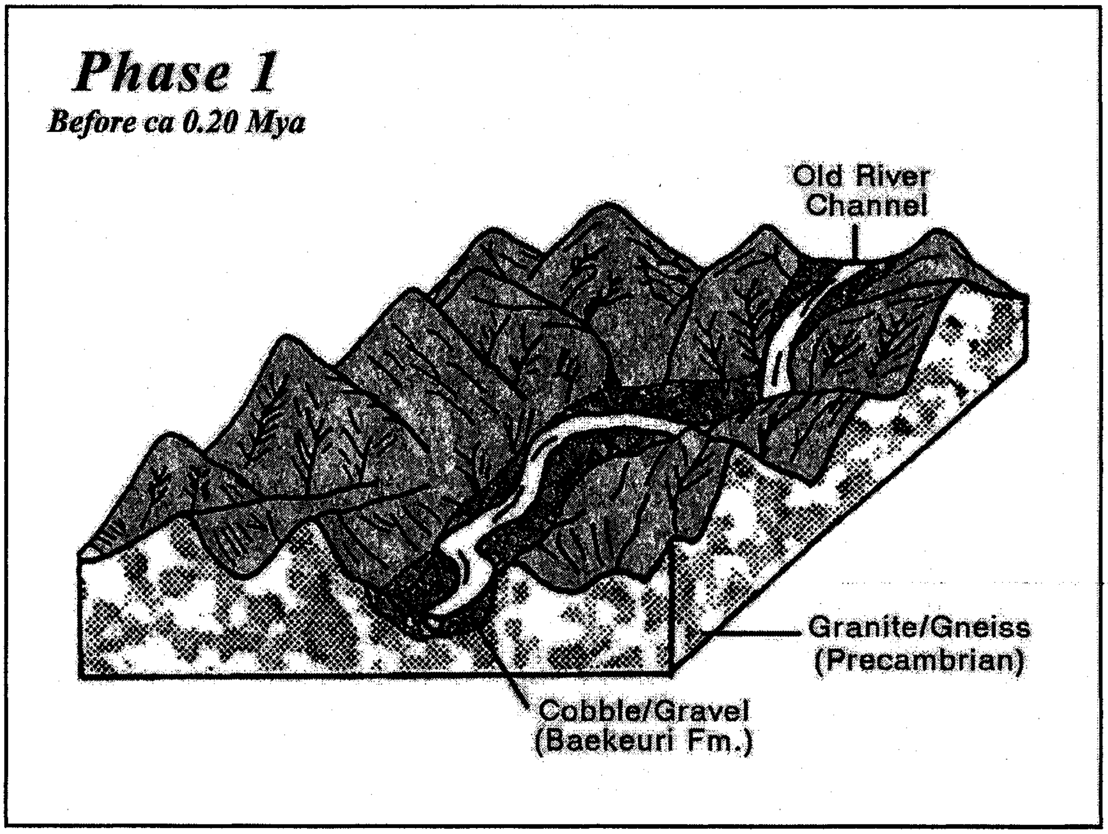


Fig. 7.2. Schematic illustration of Phase 1

B. Phase 2 (ca 0.20- 0.13 Mya)

The accumulation of clastic cobble and gravel deposits was covered by a huge lava flow that formed a temporary lava dam intercepting the flow of water in the old channel. The maximum age of the lava flow based on the FT dates of the contacting layer composed of sand and pebble was about 0.4 Mya. But according to the several K-Ar dates and the sequence of OSL dates summarized earlier, the estimated age is about 0.2- 0.13 Mya. (see Ch. IV). The number of lava flows was probably more than one, but the exact number has been still unknown (Yi 2005). After the volcanic activity was terminated, the lava cooled and solidified into the basalt formation. All exposed archaeological evidence, if any, was incinerated and, in any case, it was totally overlain by this basalt. The morphology of the lava flow was determined by the very irregularity of the existing terrain at that time, and by the rapid cooling process caused by the channel water. As a result, the surface of cooled lava flow became very irregular and randomly uneven (Fig. 7.3.).

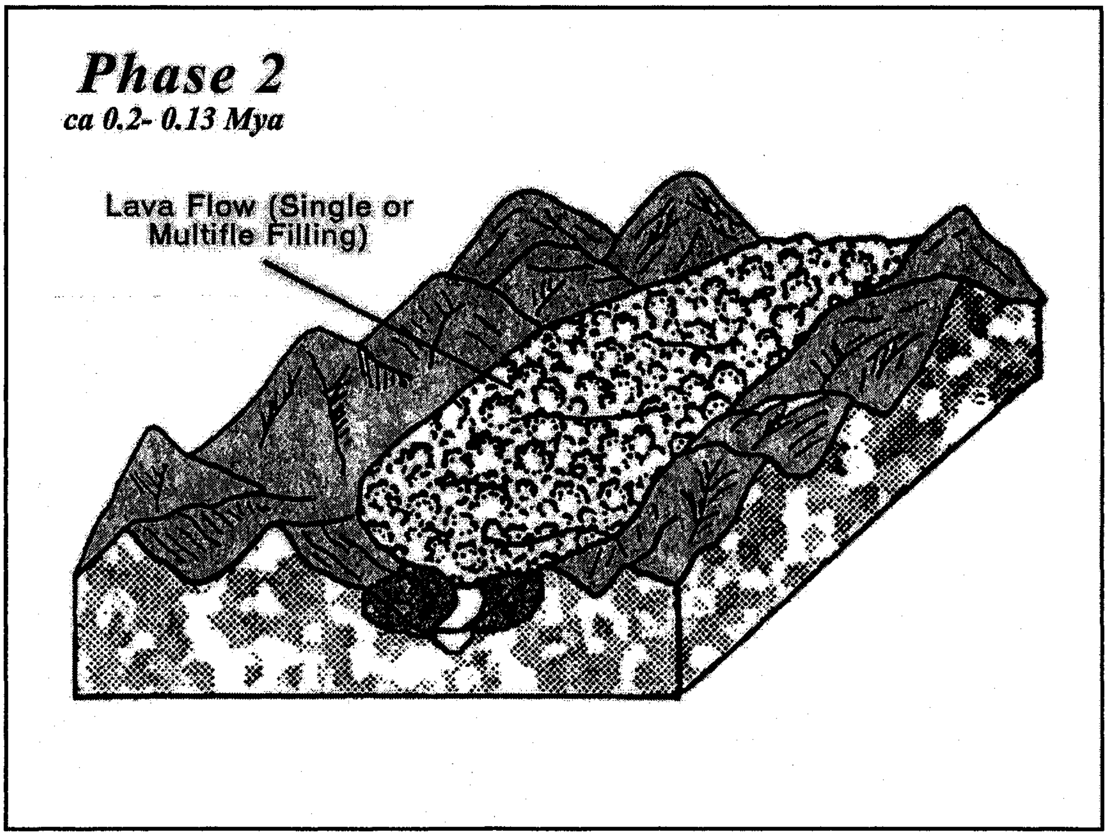


Fig. 7.3. Schematic illustration of Phase 2

Hominin occupation was only possible beyond the margin of the lava flow. However, the Jangsanri area was still probably occupied while the middle and upper region of the valley was subjected to this volcanic "bombardment." Not only the Jangsanri area, but also some locations in the lower region of the Imjin River could also have been occupied, probably above the lava flow in the heavily forested pediment of the adjoining hills where colluvial sediments continued to be deposited. Because a vast area of the IHRA was usurped by lava, hominin residential shelters would have been located at more elevated level. Hominins were compelled to move to the forested uphill zone from the lowland and also spread to the region of the upper CRV. The direction of population migration was likely influenced by the scattered distribution of water resource left by the differential cooling of the lava flow.

It can also be hypothesized that these major landscape changes stimulated new task-oriented strategies to emerge, including the development of systematic technology as part of the daily life of hominins. The production of durable lithic tools became more efficient and this type of technological adaptation was repetitively practised. However, the need to locate residential shelters in the highland area was extremely disadvantageous because the daily cycle of descending and ascending the hills, both for procuring lithic raw material and for foraging under conditions of resource instability, caused high energy costs. As a result, finding the evidence of regular hominin occupation sites in the landscape, contemporaneous with the lava flow, is highly problematic.

C. Phase 3 (ca 130- 120 Kya)

Because the old channel system was mostly covered and the new riverbed was elevated by cooled lava, a steeper gradient accelerated the rapidity of erosion. The main channel became dissected into numerous small branches and each separate branch channel had no fixed drainage configuration because it randomly flowed over the basalt (Fig. 7.4.).

The increased net sum of energy in this wider system of channels on a steeper gradient of the elevated riverbed produced vigorous turbulent flows. As a result, a highly charged braided system of channels filled by rapid and turbulent water developed and this caused significant lateral cutting of the basalt surface. Large-sized debris from the basalt was transported in a saltatory movement through the force of rapid drainage. The indenting actions of these turbulent surface flows started to carry out a new channel configuration and some pockets of locked water, formed in the depression of the uneven basalt bed, subsequently developed into ephemeral swamps

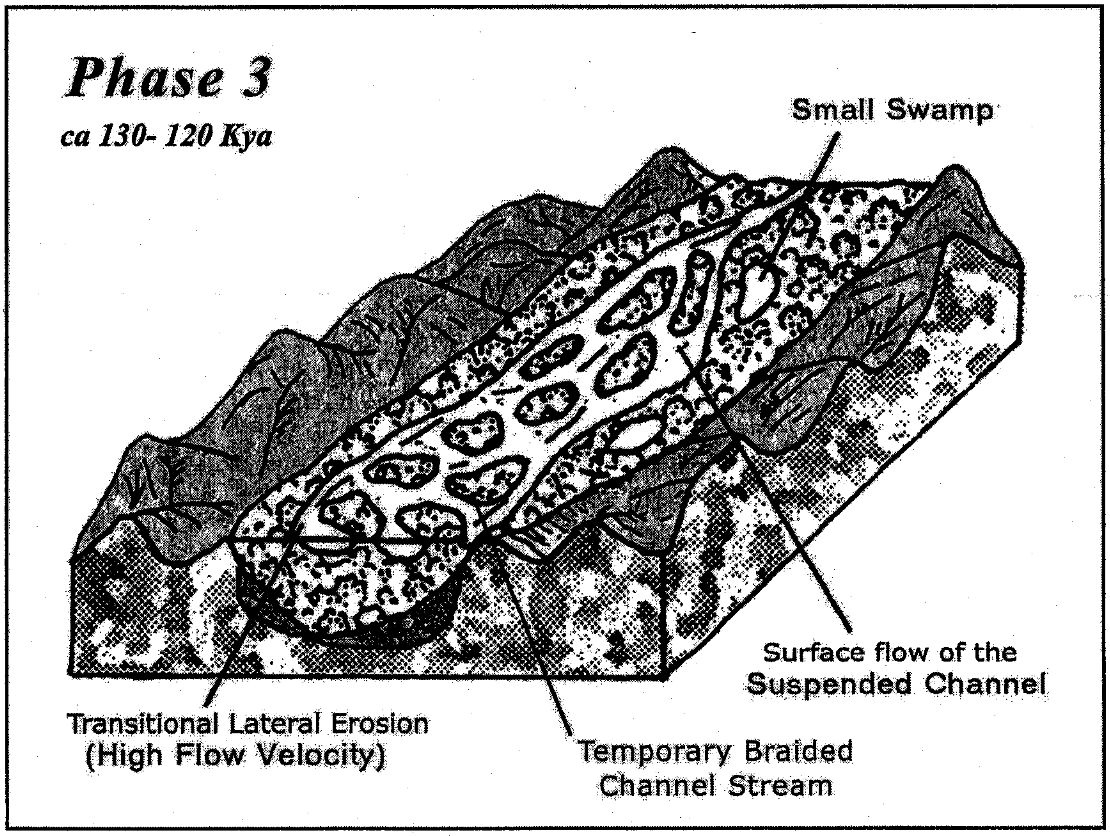


Fig. 7.4. Schematic illustration of Phase 3

The length of this phase was determined by the OSL dates of the samples from the bottom of the coarse sand layer at the Chongokni site (*i.e.* Sample Nos. 10 and 11 of Table 4.5.; see also Fig. 4.23. at Ch. IV). Archaeological evidence was very scarce during this phase. Although the environment around the river channel was fairly beneficial to hominins, the drainage flow was very strong and the randomly directed channels generated extremely unfavorable condition for preserving artifacts and fossil remains. The terminal region of the lava flow in the lower Imjin River, which includes the Juwolri, the Kawolri and the Keumpari sites, was probably under relatively more favorable environmental conditions than other locations since the small amount of lava flow made some areas available as hominin habitats. Therefore, it is postulated that the occupational history was somewhat older in the lower river valleys than in the highly charged middle and upper regions.

As a result, a group and/or several groups of hominins became concentrated around such well-positioned locations as the Juwolri and the Kawolri sites where overall distribution of resources from the riverside with the woodland hills was consistent. Within this area, some raw materials were newly encountered that became more actively utilized while an elementary ability of selective procurement developed among the hominin groups. The mechanism of basic lithic fracture was noticed, memorized, and socially incorporated, and transmitted (Mithen 1996). However, strongly supportive archaeological evidence is not guaranteed since hominin practices of tool manufacture were still rudimentary, and apparently failed to formulate any patterned remains.

D. Phase 4 (*ca 120- 60 Kya*)

As a result of lateral cutting, the braided streams gradually became merged and developed into a more stabilized anastomosing channel system. The erosion of the old basalt bed significantly advanced and the configuration of the new channel became more prominent. Semi-permanent isles started to emerge within the channel. The sinuosity gradually increased in order to dissipate the discharging force of river flow, and its velocity became slower (Rapp and Hill 1998). Point-bar deposits which contain basalt debris and angular coarse sands from the hillsides of the adjacent valleys were formed at the margin and the cross-sections of these deposits usually show a well-stratified cross-bedding.

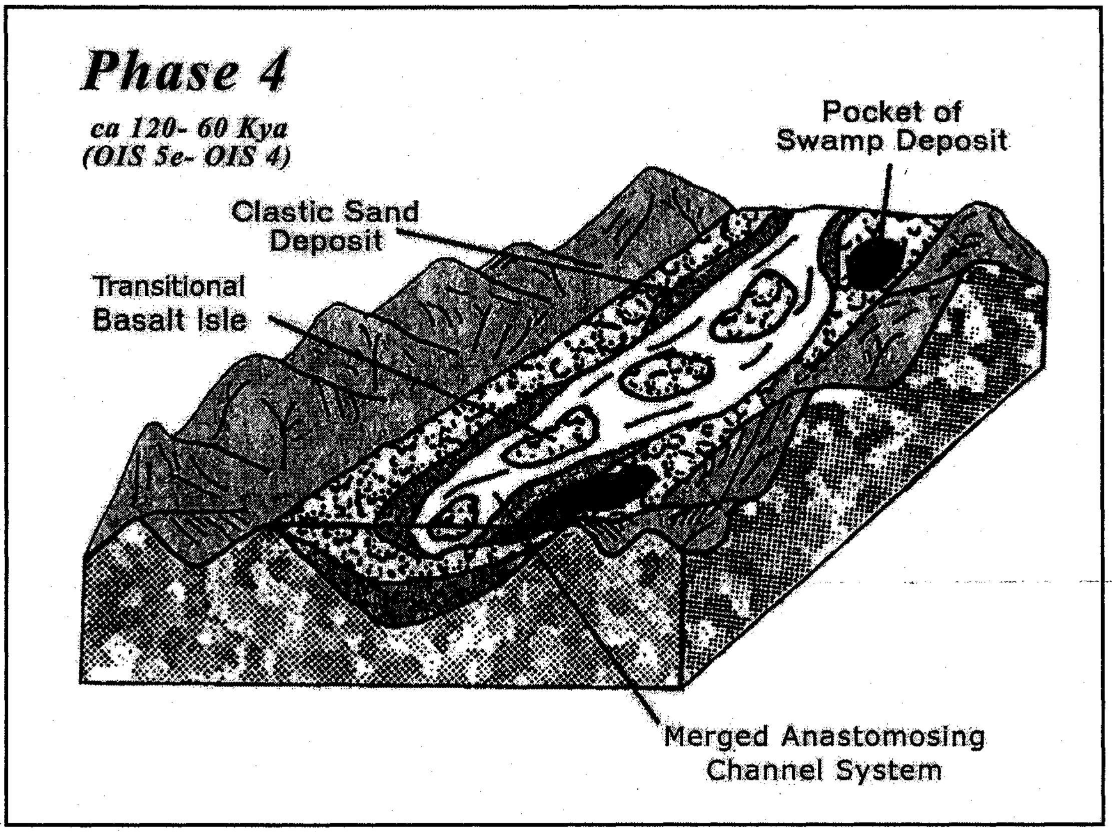


Fig. 7.5. Schematic illustration of Phase 4

As the anastomosing system was laterally enlarged and the discharging capacity increase, the channel configuration developed into a meandering stream. Channel velocity decreased even more and the quantity of deposited sediments dramatically increased. The particle sizes of sediment were gradually reduced from sand to silt, and the discharging water hydrated and/or hydrolyzed the soluble minerals while the ionized chemical components were washed away. As a result, light-toned silt sediments were deposited over the cross-bedded sand layer. The time span of Phase 4 during which the sand and silt layers were deposited is from *ca* 120 to 60 Kya based on the sequence of OSL dates (*i.e.* from Sample No. 2 to No. 9 of Table 4.5), which can be correlated to the OIS 5e to the OIS 4.

Still archaeological evidence is rarely found for this phase. Some artifacts have been discovered within the yellowish brown silt area at the Chongokni site (Bae 1988; Bae *et al.* 1995); but they are not believed to be in their original context because artifact concentrations that were found are randomly distributed. The development of point-bar sediments and hydrated light-toned particles commonly indicate that the site area was located in close proximity to the frequently inundated riverside area and, therefore, the lithic artifacts would have been quite liable to be transported by the drainage wash-off.

It is believed that hominins pursued the typical lifestyle of hunter-gatherers. Their provisioning would have been, supposedly, based on the accessibility of plant resources and small-game hunting or scavenging, all of which were based on the labor-intensive foraging strategy. The existence of a local social network can be hypothesized. Following the complete termination of volcanic activity, the accessible area in the landscape significantly increased and the primary territory for foraging activity became limited to the area below the ridge of hills because moving upland on an everyday-basis was not cost-effective in an "already-stabilized" environment (Yoo 1997). The hominin migration routes are expected to be centripetal toward some wide-open regions where a good view of the overall terrain would be ensured because such surveillance was a critical tactic for effective survival. Since the current terrain is generally identical to that of Phase 4, the Chongokni, Juwolri, Kawolri, Keumpari and Janghungri sites might be considered as the ideal "residential places" because of good accessibility to constant water resources and a rich woodland-based biomass.

E. Phase 5 (ca 60- 20 Kya)

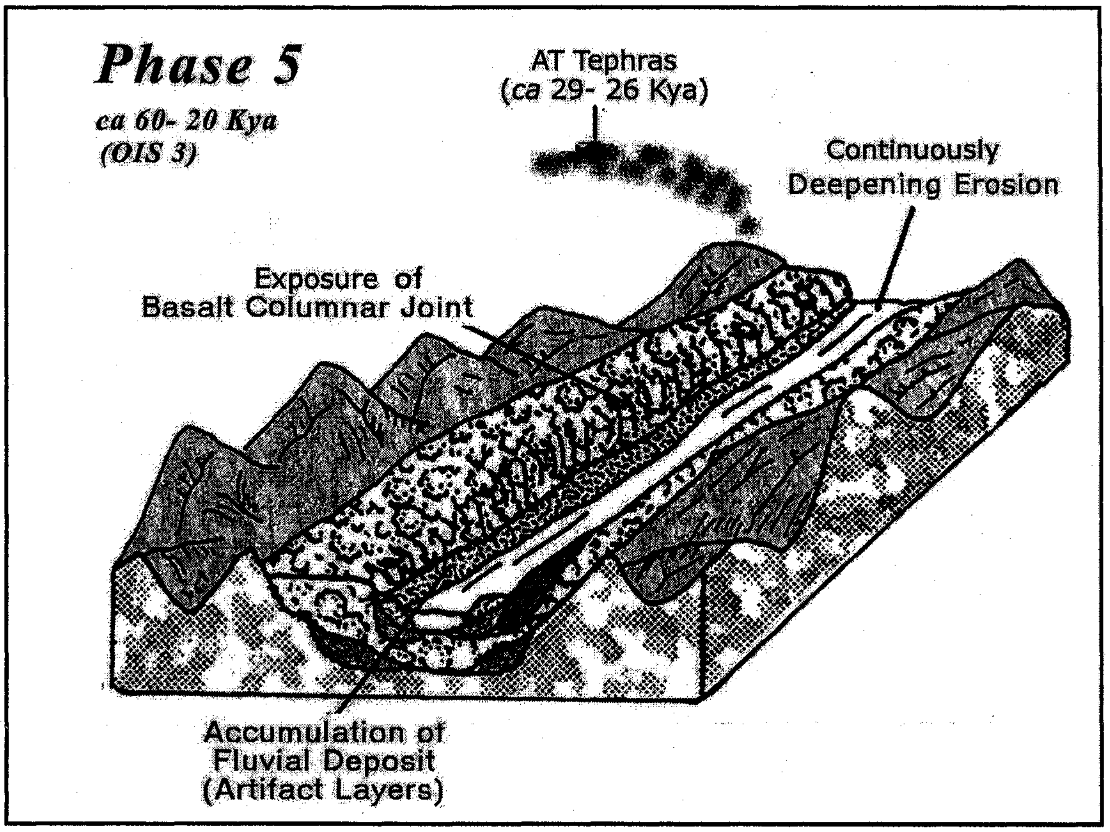


Fig. 7.6. Schematic illustration of Phase 5

As the meandering process of the river channel was intensified, the discharging energy became lower and the riverbanks gradually regressed. Under these less-turbulent depositional conditions, finer sediments were deposited at the overbank area. The river finally recovered its original level of discharging energy and the expanded magnitude of the river channel increased the down-cutting of the riverbed. Consequently, the riverbed was slowly lowered and the basalt bed became entirely exposed. As a result of a decreased flow speed, silt- and clay-dominant sediments were accumulated and some floodplains came to be highly populated beyond the riverbank.

The initial age of the silty clay layers slightly postdates the youngest OSL date of Table 4.5. The OIS 3 roughly corresponds to the temporal range when the reddish brown silty clay deposit was accumulated. While the temperature was slightly lowered compared to Phase 4 (Yi 2000), the moderately mild climate accelerated the oxidization of the ferrous minerals in the sediments. Consequently, their general tone and hue became reddish and darker than the underling silty sand layers. With the approach of the dry and cold period around the terminal OIS 3, the wedge-shaped cracks developed and the AT tephras from Kyushu of the Japanese Archipelago were blown to the IHRA.

A relatively mild temperature and stabilized floodplain would be the ideal condition for hominins to intensively occupy the IHRA. The time and duration of occupation are different from one residential locus to another. However, the tight distribution of archaeological horizons within the sediments and the rapid increase of site numbers imply that the hominins occupied the IHRA within a relatively short-time span and the intensity of land use was accelerated until every suitable location was fully populated. The distance among sites became shorter, sufficient to make casual contacts happen frequently. Such frequent interaction promoted the sharing and transferring of the lithic technology. For example, the manufacture of the handaxe, which possibly originated as a result of this regularized interaction to meet the common functional needs for sharing the habitats within the same landscape, was widely propagated across the whole range of the IHRA. Accordingly, it is likely that its basic design elements were solidly "institutionalized" as hominin interrelationship escalated and the frequency of producing the handaxe increased. Its manufacturing techniques were imitated, socially learned from generation to generation, and finally established as a local "tradition" (McNabb 2004; Mithen 1996).

Even though the lithic assemblage is generally dependent on the locally unique raw materials, similar tool types were prevalent across the several locations. For example, the Chongokni hominins were dependent on crude quartz and quartzite and those of the Kawolri site predominantly used the medium-quality materials that were abundant within its territory, such as fine quartz. However, these two assemblages commonly include small tools such as sidescrapers, endscrapers, tranchets, notchs, and so on, as well as sharing such "stereotyped" large tools as the chopper and the handaxe. In particular, these assemblages show clear inter-site variability in terms of the patterns by which flake blanks were transformed into intended tools. Both the Chongokni and Kawolri assemblages were basically dependent on their own unique blank reduction patterns- the SF-Pattern and LR-Pattern respectively (see Ch. VI). This "pattern-ization" is believed to reflect the change of the habitual practices of local hominins who shared a tendency for producing technological items accommodated to the constraints of raw material quality and availability.

F. Phase 6 (after ca 20 Kya)

As the cold and dry OIS 2 approached, the sediments became weathered, transformed by such natural processes as dehydration, bioturbation and cryoturbation. The typical layer associated with the OIS 2 is the light grayish silty clay sediment infilling and overlying the upper crack zone. Its structure and soil profile is different from normal fluvial sediments, and it was possibly formed by the accumulation of eolian dusts blown by a strong continental air stream from the inland regions of China (Yi 2000). No artifacts have been discovered from this layer; but AT particles accumulated at the terminal OIS 3 have been frequently recovered.

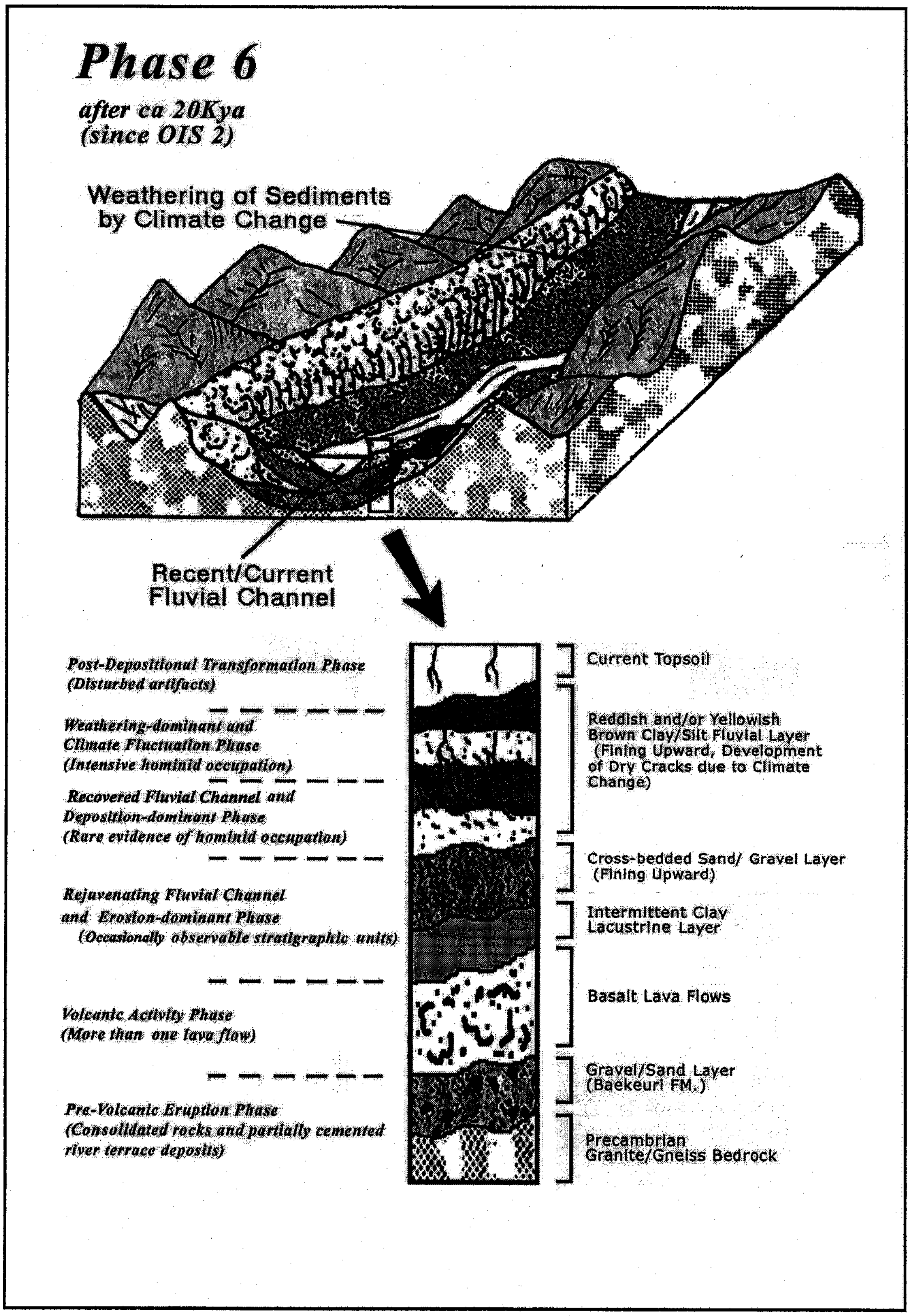


Fig. 7. Schematic illustration of Phase 6
and currently observed stratigraphic cross-section in the IHRA

The layers above this upper crack zone are not well-preserved in this area. Most of them were disturbed by various forms of bioturbation (Bae 1988; Lim *et al.* 2005) and they were washed off by post-Pleistocene flooding. Although archaeological evidence is scarce, hominin occupation continued until the terminal Pleistocene. Based on the assumption (Yi 1999: 120) that the IHRA was like a "no man's land" during the OIS 2, it can be hypothesized that the overall biomass was seriously reduced and the adjacent floodplain area became sterile as the river level was lowered and the climate became cold and dry.

Except for the Janghungri site which yielded an exceptionally well-preserved Upper Palaeolithic assemblage above the AT horizon (Choi, B. K. 2001), only minimal quantities of Upper Palaeolithic artifacts have been discovered at several different sites. The procurement of plant resources was extremely limited and animal exploitation was hard to imagine, given the unsystematic lithic technology for effective hunting. The local population size has possibly been reduced and strategies for survival in extreme environmental conditions became indispensable. One technological solution to this stress was to change the quality of raw material by selecting technologically reliable micro-crystalline rocks. Most high-quality rocks available in this area are igneous metamorphic types such as obsidian, porphyry and vitrified quartz crystal. It is highly probable that their quarries were found in the vicinity of crater and the outcrops of intrusive plutonic rocks.

The systematic utilization of these high-quality raw materials was increasingly required. One of the pivotal technological solutions was to produce more refined tools. A sort of technological leap occurred, marked by the major shift of raw material selection. Associated with this shift was the intensification of modified small tools, which was itself an economizing strategy to increase the efficient use of the high-quality raw material. As a result, the production of more intensively modified small tools and economizing strategy of available high-quality material were eventually practised, manifesting more vigilant attitudes, among hominins. This shift in raw material quality, a hallmark of the Upper Palaeolithic, would have promoted several corresponding activities, such as scheduled migration and more patterned land-use (*see* Barton *et al.* 2004; Cowans 1999; Kuhn 1991, 1992a; Mellars 1989). As a result, the maximum range of hominin mobility would have greatly increased and mutual cooperation and/or conflict would probably have emerged in order to cope with the competition that the greater mobility had encouraged.

The area of ideal habitats was largely limited to small patchy spots, most of which tended to be located adjacent to available quarries. As a result, the site distribution pattern was changed from being "uniform and sparse" to "clustered and dense." No evidence of systematic animal resource utilization has been recovered so far. The lithic technology, as represented by the Janghungri assemblage, was based on the high-quality raw material but the acceptance of such highly systematic technological components as the prismatic core and blade technique has not been well-demonstrated. Compared to the preceding assemblages, the sizes of retouched pieces are significantly smaller, implicating the practice of a strict economizing strategy (*i.e.* the P-Pattern, see Ch. VI) of raw material utilization. Apart from this economizing of raw material, the Janghungri assemblage does not show any distinct "conventional" Upper Palaeolithic hallmarks, such as the dominance of blade tools or conceptually embedded artistic activities. This may be partially explained by the possibility that the practices of the Janghungri hominins were differently structured so that they did not tend to embody the same level of technological and cultural traits as found in other Upper Palaeolithic traditions of the Old World.

Based simply on the observable archaeological data and the current chronological framework, it can be concluded that the evolution of the lithic technology in the IHRA was in the same tempo with the changing of the Pleistocene environment. The relatively warm and mild conditions before the OIS 3 were correlated with non-schematic and poorly conceptualized technology. This continued for a quite long time until the "stressful" conditions of the OIS 2 necessitated a prompt technological response marked by an abrupt change in the quality of raw material, correlated with an equally rapid development of highly operational small tools like microblades and microcores. However, the dynamics of the emergence of Upper Palaeolithic in the IHRA are yet to be elucidated because the data available for this are too limited and fragmentary. The detailed chronological framework for delineating lithic technological evolution is still at the level of speculation. More relevant archaeological and geological data must be accumulated and appropriate analytical research tool be devised in order for this issue to be substantially explored and examined.

(2) Some Considerations for Future Research

1. The IHRA Industry: a Local Tradition of the East Asian Palaeolithic?

As demonstrated in Ch. II, the environment of East Asia from the later part of the Middle Pleistocene to its termination was generally stable; the climate condition was relatively milder than in the western part of the Eurasian continent. With the beginning of the Upper Pleistocene, the temperature was slowly reduced (Tong and Shao 1991) but the number of sites increased, suggesting that the population density of the East Asian Upper Pleistocene was gradually accelerated despite the reduction in biomass and productivity. Under these conditions, optimization of resource utilization can be hypothesized as having occurred.

The emergence of the IHRA handaxe can be interpreted in this context. If a certain tool offers eminent efficacy and suitability for various tasks, the reliance on this tool will be so enormous that it might not be either replaced by something else or discarded in the absence of more effective alternatives. Adherence to a single tool type and a conservative attitude toward an established technology can be defined as the basis for a tradition, and the IHRA handaxe can be regarded as a major component of one of the East Asian local traditions prior to the Upper Palaeolithic (see Ikawa-Smith 1978), as has been adequately termed the "Chongoknian" Industry or technocomplex (Bae 1992a).

The distribution of the Chongoknian Industry is reportedly limited to the current midwestern part of the Korean Peninsula. However, it includes an exceptionally elaborate handaxe accompanied by other ancillary lithic types consisting of expediently shaped large tools and irregularly retouched small tool types. A change in the Chongoknian Industry is principally marked by the emergences of small tools while the traditionalized manufacturing technique of the handaxe continued to be maintained and solidly constituted the practices of the IHRA hominins. Relevant to this, Bar-Yosef (2005: 312) recently noted that "if (*successful*) artifacts were instrumental for the physical survival of the group, keeping the tradition was imperative." He added by saying that "once successful, the imposed technical knowledge had to be taught again and again as the only socially accepted way of making stone tools." In terms of his remark on the Palaeolithic traditions of the Old World before the Upper Palaeolithic, the Chongoknian Industry can be taken either as circumstantial evidence of a local East Asian Pleistocene material culture or as an example of the "tradition of the non-Acheulian handaxe in the East Asia." In either case, establishing the Chongoknian Industry in this way can eventually emancipate itself from the "Dogma of the Acheulian," allowing it to be understood as one of the technological traditions free of the "Movius'

Legacy."

The IHRA is not an isolated case. Evidence of the long-term continuity of a seemingly simple but reliable tool type has been witnessed in other parts of the Old World, especially associated with woodland habitats and the intensive use of plant resources, such as the large cutting tools and handaxe of Sangoan industry (*e.g.* McBrearty 1995; Phillipson 1985; Tryon 2006). This has also been observed in the Pleistocene lithic records of the southeastern Asia from the Anyathian Culture of the Lower Palaeolithic (*e.g.* the "handadze" and the "proto-handaxe"; Movius 1944) to the Hoabihnian of the terminal Pleistocene, both of which include simply modified but exceptionally distinct large tools with crude raw material (also the handadze which is morphologically identical to that of the Anyathian; Yi *et al.* 2005).

2. The Problem of the "Middle Palaeolithic" in the East Asia

On earlier in this study (see p. 207), it was noted that the term "Middle Palaeolithic" and other chrono-specific terminology for this period would be avoided in reference to the IHRA assemblages. It is now appropriate to clearly address this term and to suggest that this avoidance should be reconsidered, not only for the IHRA but for the prehistory of East Asia in general. According to the analyses of the four IHRA assemblages, a progressive trend in the development of lithic technological organization has been revealed to have occurred. This trend was manifested in 1) the progressive selection of raw material suitable for lithic tool production, 2) the development of more efficient methods for production and utilization of blanks, and 3) the increase in diversity of tool-types. This trend was directly correlated with the tripartite chronological division of the Lower-Middle-Upper Palaeolithic sequence which is most widely accepted among Palaeolithic researchers arguing for unified usage of terms for the Palaeolithic sequence at the global level (see Bar-Yosef 2005: 307).

In terms of the ages of the individual assemblages, the Jangsanri assemblage displays typical attributes of the Lower Palaeolithic technological organization. In equivalent terms, the Chongokni and Kawolri assemblages locally represent the attributes of the Middle Palaeolithic. Finally, the Janghungri assemblage is, with no doubt, one of the East Asian local Upper Palaeolithic assemblages. This sequence is supported because their chronostratigraphic positions clearly correspond with the conventional Old World Palaeolithic sequence, and their technological characteristics show mutually exclusive contrasts (Schick and Toth 2001; Gamble 1986, 1993; Klein 2001; see Qiu 1985 for the chronological definition of Chinese Middle Palaeolithic; also see McBrearty and Brooks 2000 for some innovative notions on the temporal division of Palaeolithic sequence and associated fossil record).

Unfortunately, however, this fit of the data to the established Palaeolithic scheme gives little reason for confidence when applying it to East Asian data because the scheme, in itself, is epistemologically not well-founded. The definition and perception of time is closely tied to the nature of a given research tradition (Chazan 1995; Ramenofsky 1998). Time itself is a continuum which can be infinitely divided and this "infinite divisibility" (Ramenofsky 1998: 77) allows arbitrary demarcations and innumerous subdivisions. The detailed and precise segmenting of time has been the most fundamental challenge and even the major purpose of archaeology during the era of the culture-historical doctrine in archaeological history (Trigger 1989). For example, the original two divisions (Lower and Upper) of the French Dordogne Palaeolithic period made by Lartet and de Mortillet during the late 19th century (Chazan 1995; Sackett 1981, 1991; Trigger 1989) was subsequently further segmented by the discovery of sites supporting the formation of the Châtellperonean and

Gravettian; and de Mortillet's "Mousterian industry/culture (*Époque de Moustiers*)" was separated and deemed to be an independent chronological division, which transformed the Mousterian into a conceptual equivalent to the "general" Middle Palaeolithic.

The origin of the Middle Palaeolithic as a chronological term is very vague. Prior to de Mortillet's (1872; Chazan 1995) definition of the Mousterian concept, it was treated as a subdivision of the Palaeolithic period defined by the presence of only stone tools (*"paléolithique avec instruments uniquement en pierre taillée"*; Chazan 1995: 460), thereby antedating *Magdalenien*, the combination of stone and bone tools. Neither Levalloisian elements nor Neanderthal fossils were included in *"le Mousterien"* by de Mortillet. Identifying the Middle Palaeolithic as equivalent to the Mousterian possibly derived from a series of discoveries of Neanderthal fossils in the valley of the Vézére River from 1908 to 1914 (Stringer and Gamble 1993) which occurred following the first discovery of a Levallios core from Levallois-Perret suburb of Paris in the late 19th century (Sackett 1991). Although, ironically in retrospect, neither Lartet nor de Mortillet believed this local chronological framework was applicable elsewhere, the transformation of the Mousterian into the Middle Palaeolithic division clearly reflects its change of role from being a local descriptive term to a universal term applied to the chronology of the Old World Palaeolithic.

The difficulty in establishing the Middle Palaeolithic as a chronologically solid division also lies in its intrinsic nature. Unlike the Lower and Upper division, the Middle Palaeolithic requires two demarcating borders and its chronological position is frequently altered as those borders are changed by new discoveries of older or younger assemblages. Thus, the *"raison d'être"* of the Middle Palaeolithic is contingently determined by the gap between the Lower and Upper rather than being independently substantiated so as to distinguish itself as autonomous from the preceding and succeeding neighboring divisions.

As a result, unless distinct features are detected that clearly demarcate a middle period, the basic tripartite chronological framework, when applied at regional level, is always liable to be reduced to either a Lower/Upper or an Early/Late scheme, by discarding the Middle.

For this reason, recent recommendations to withdraw the term "Middle" from the East Asian Palaeolithic chronology (*e.g.* Gao and Norton 2001; Lee H. W. 2001) are not at all different from an earlier proposal made about three decades ago (Ikawa-Smith 1978). Unlike the Mousterian in general, the East Asian assemblages of the lower part of the Upper Pleistocene, which used to be termed "conditional Middle Palaeolithic" by Qiu (1985), do not have any chrono-specific lithic types such as Levalloisian elements and the associated hominin fossils are not contemporaneous counterparts of the Neanderthals (Gao and Norton 2001). The problems of the Middle Palaeolithic are not limited only to East Asia. As mentioned above, the conceptual looseness and epistemological confusion has brought about the ambiguity of the Middle Palaeolithic as a universally accepted term (Kleindienst 2005; Bar-Yosef 2005).

Narrowing the geographical scope just to the IHRA, the handaxe might be accepted as a sort of type-fossil to define the local Middle Palaeolithic. However, the intermediate level of technology between Lower and Upper Palaeolithic is still far from being established because the ages of the Chongokni and Kawolri assemblages do not suggest any hints of either lower or upper limits of a local Middle Palaeolithic. Nonetheless, it should be specially emphasized that any "hesitation" in applying the term "Middle Palaeolithic" to these assemblages does not automatically lead to "confidence" in abandoning this possiblity. Reliable chronometric dates of new discoveries will no doubt contribute to drawing meaningful demarcating lines separating the Middle from the Lower and Upper Palaeolithic in the continuum of the Pleistocene time.

3. Theoretical Consideration for the Expanded Palaeolithic World: a Closing Remark

A recent publication (Gamble 2004) dedicated to honoring a prominent senior archaeologist borrowed its principal tenet from a subfield of archaeology other than Palaeolithic by stressing the notion of "praxis" (*i.e.* the unity of theory and practice by a very simplistic definition) of Palaeolithic archaeology. It (Gamble 2004: 25) also insists that Palaeolithic archaeology should explore the social structural nature of the Pleistocene hominins groups that made up the "Palaeolithic society" (*see* Gamble 1999). This call to broaden the research goals of Palaeolithic archaeology may be a precursor enabling us to conjecture what the very fascinating topics of future doctoral theses in Palaeolithic archaeology would be.

As Trigger (1998: 1) clearly articulated, "archaeology is the only discipline that seeks to study human behavior and thought without having any direct contact with either." Of course, Trigger's claim does not mean to give up on reconstructing the non-materialistic facets of a prehistoric people, nor intended it to constrain the freedom of research interest in this dissection. The possibility of reconciliation between processual and post-processual camps (Trigger 1991, 1998) is now penetrating even the Palaeolithic field. Too much dependence on the theory itself while neglecting the tangible patterns has been a critical weakness of the different post-processual camps. Such neglect makes their endeavor to actively reconstruct the non-materialistic features of the "Palaeolithic world" seem implausible. An integrative and/or synthetic perspective can allow Palaeolithic archaeology to attain a realistic appraisal while limiting the tendency found in the post-processual camps to treat human agency in overly relativistic and idealistic terms. Furthermore, an integrative approach should also overcome the overt reliance of processual camp on the "behaviorism" based on the neoevolutionism and positivism.

With respect to the balance between these two extreme epistemological points of view (*i.e.* the positivistic and the idealistic), Trigger (1998) advocated the adaptation of "a materialist ontology and a realist epistemology" which he claimed is the only way to attain "an archaeology that is more complete and less biased." The realist epistemology embraces "the study of processes and emergent properties as well as of what can be observed directly" and treats "mind, senses, and external reality in an interrelated fashion" (Trigger 1998: 23). While his providing of a realist epistemology as the "ONLY" way is a preoccupation that must await the future theoretical development of archaeology, the notion that reality is externally perceived archaeological phenomena promotes the integrative approach to the Palaeolithic world. The general theory that enables the understanding of this Palaeolithic world to be substantiated is composed of the balanced perspectives of post-processual approach. This general theory is buttressed by the solid processual approach which produces sound middle-range theories. However, this general set of ancillary themes, although derived from other disciplines such as philosophy, sociology, and psychology, should be based on the appropriate epistemological background oriented toward the archaeological reality, and be practised by objectively describing and analyzing the existing material data.

As an example of following the pathway of the integrative approach suggested above, this study has attempted to furnish an example of how the Palaeolithic world can be understood through the interpretation of the lithic data. In keeping with this attempt, chapter II introduced the macro-scaled temporal and spatial background of the IHRA assemblages. Chapter III delineated the problems to be solved and reviewed the research history of the IHRA for the purpose of evaluating what was done and what should be resolved through this study. As a preliminary work in recognizing data limitations and how these constrain explicability, chapter IV was devoted to the publishing new chronometric dates and the documentation of lithic artifacts from several IHRA sites. Chapter V was a general description of the typological variation in the IHRA lithic assemblage as well as summarizing the investigation of the characteristics of the assemblage and the manufacturing techniques. Chapter VI presented several explanatory models serving to reveal the dynamics underlying the variability of lithic assemblage. It also demonstrated several factors responsible for the temporal change of the IHRA technological organization. As the final task, chapter VII has attempted to understand the IHRA hominin practices within the landscape over the long term time-scale.

As a result of this integrative approach, a new chronological framework of the IHRA assemblages was established and the geological context was systematically reconstructed. A lithic typology of small tools, a category of tools that has been out of research focus for decades, was proposed and the inter-site variability of assemblage characteristics was investigated in terms of raw material utilization and the temporal changes in the technological organization. Based on this temporal framework and the dynamics of change, the long-term Pleistocene history of the IHRA could be narrated and the practices of hominins in the landscape be illustrated. What was gained from this approach is the idea that the level of knowledge induced from archaeological data is highly contingent on which perspectives the researchers have; and it can be confidently addressed that even apparently crude and technologically under-developed lithic assemblages can be meaningfully interpreted as long as sound methodologies and appropriate theoretical frameworks are adopted.

However, the level of accomplishment in the research of the IHRA is still far from satisfactory; and the resulting interpretation that this thesis has presented is based on a small portion of the entire IHRA assemblage. Many major issues were not covered because of the limited data and only minimal implication was drawn because of the limited pages of this thesis. Maintaining objectivity in describing the static data, explaining the dynamic patterns, and interpreting the underlying meanings are among the most important but most easily forgotten goals in the Palaeolithic archaeology; and that is why I deliberately refrained from using one of the most frequently used English words until this sentence. This is the tern "I." As a final note, it would be appropriate for me to quote directly from Trigger's (1998: 27) "testament" for a better tomorrow in archaeology.

> *The greatest obstacle to making progress in archaeology is complacency. Without the ability to imagine alternative explanations, archaeology languishes. On the other hand, without the opportunity and determination to test ideas, imagination is of little value.*

APPENDIX I.

LITHIC SPECIMEN LIST FROM JANGSANRI SITE

(1) Modified/Utilized Specimen

Spec. No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Level (m, amsl)	Rock Type	Lithic Type
Surface-1	164	122	40	779	N/A	quartzite	Large Scraper
Surface-2	110.5	76	75.5	636	N/A	quartzite	Core
Surface-3	119.5	111.5	86	1501	N/A	quartz	Polyhedron
Topsoil-1	180	127	75.5	1947	N/A	gneiss	Chopper
Topsoil-2	75	62	52.5	272	N/A	quartz	Core
Topsoil-3	43	40	19	31	N/A	quartz	Endscraper
A-1	68.5	38	15.5	38	38.85	quartzite	Bipolar Piece
A-2	232.5	121.5	86	2798	39.59	quartzite	Pick
A-3	216	72	68	1615	39.57	gneiss	Core
B-1	72	30	26	82	39.43	quartzite	Bipolar Piece
D-1	33.5	18.5	8	4	41.35	quartzite	Shatter
D-2	74.5	67.5	23	89	41.37	quartzite	Notch
D-3-1	87.5	61.5	30	183	41.71	gneiss	Bipolar Piece
D-3-2	63	39	22.5	61	41.71	gneiss	Bipolar Piece
D-5	73.5	23	21	58	40.81	gneiss	Bipolar Piece
D-7	140.5	92	76	1212	40.76	quartzite	Chopper
D-9	34.5	32.5	9.5	11	40.75	gneiss	Shatter
D-12	24.5	15	8	3	40.79	quartz	Shatter
D-14	92	63.5	35	317	40.79	gneiss	Chopper

D-17	71	56.5	41	201	40.8	quartzite	Modified manuport
D-19	34.5	28	14.5	14	40.77	quartzite	Shatter
D-21	57	50.5	24	89	41.5	quartzite	Hammer stone
D-25	136	83.5	75	1212	40.85	quartzite	Chopper
D-26	35.5	26	19	22	40.85	quartzite	Shatter
D-27	183.5	137	60.5	2250	41.56	gneiss	Modified manuport
D-31	196.5	121.5	83.5	3033	40.74	gneiss	Modified manuport
D-34	144	127.5	64.5	1354	40.78	gneiss	Modified manuport
D-35	74.5	35.5	23	62	40.81	quartzite	Bipolar Piece
D-36	93	59.5	50	372	41	gneiss	Chopper
D-40	79	65.5	51	232	40.77	quartzite	Chopper
D-43	75.5	61	46	271	40.76	gneiss	Modified manuport
D-49	12.5	91	46	589	40.76	gneiss	Modified manuport
D-54	50	25.5	19.5	25	40.76	quartz	Flake
D-57	48	21	18.5	18	40.75	gneiss	Bipolar Piece
D-58	57	23.5	17.5	34	40.72	gneiss	Bipolar Piece
D-61	114.5	83	43	487	40.7	gneiss	Bipolar Piece
E-1	88.5	42.5	21.5	80	41.2	quartzite	Naturally backed knife
E-4	81.5	61.5	53.5	356	40.65	gneiss	Modified manuport
E-5	18	11.5	3.5	1	40.53	gneiss	Shatter
E-6	29	25	11.5	8	40.52	quartz	Modified manuport
E-11	124.5	103	39	618	40.49	quartzite	Chopper
E-12	85	73.5	53	385	40.37	gneiss	Modified manuport

(2) Imported Pebbles

Spec No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Level (m, amsl)	Rock Type
A-4	107	106.5	96.5	1349	40.59	gneiss
D-4	145	85	71	1131	40.76	gneiss

D-6	31	28.5	23	30	40.77	gneiss
D-8	151.5	105	71	1569	40.72	gneiss
D-10	53	51.5	39	135	41.35	gneiss
D-11	40	31	18.5	31	40.84	quartzite
D-13	107	99	84.5	991	40.78	quartzite
D-15	151	111	95.5	2198	40.83	gneiss
D-16	69	62	35	182	40.86	gneiss
D-18	17	15.5	10.5	4	40.8	quartzite
D-20	119.5	109	56.5	916	41.15	gneiss
D-22	16.5	14	11	4	41.21	quartzite
D-23	17	12.5	8.5	2	41.05	quartzite
D-24	155.5	126	82.5	1943	40.96	quartzite
D-28	15	94	48.5	754	40.79	gneiss
D-29	120.5	81.5	59	1012	40.74	quartzite
D-30	156	133	82.5	1973	40.73	quartzite
D-32	160	100	55.5	1251	40.74	gneiss
D-33	145.5	129.5	83	1872	40.8	gneiss
D-37	116.5	77.5	69	1118	40.75	quartzite
D-38	115.5	101.5	57	754	40.77	gneiss
D-39	115.5	75	60	747	40.75	gneiss
D-41	138	86.5	67	1013	40.73	gneiss
D-42	34.5	18	14.5	12	40.76	gneiss
D-44	20.5	20.5	20.5	11	40.76	quartzite
D-45	91.5	57.5	40	297	40.74	gneiss
D-46	18.5	17	13.5	6	40.75	quartzite
D-47	83	67	61	443	40.73	quartzite
D-48	25	17.5	14.5	9	40.76	quartzite
D-50	168	82.5	61.5	1212	40.77	gneiss
D-51	22	19	12	8	40.78	quartzite
D-52	54	49	18.5	82	40.73	gneiss
D-53	141	116	94.5	1769	40.73	quartzite
D-55	28	22	14.5	12	40.84	gneiss
D-56	35.5	22.5	15.5	16	40.77	quartzite
D-59	124.5	117.5	65.5	1009	40.62	quartzite
D-60	53.5	39	31	74	40.71	gneiss
D-62	60.5	41.5	14.5	50	40.72	gneiss

D-63	88.5	66.5	37.5	212	40.54	quartzite
D-64	143	97.5	76.5	1485	40.54	quartzite
E-2	78.5	69	51.5	367	41.5	gneiss
E-3	59	28	10.5	29	41.03	gneiss
E-7	16	12	8.5	2	40.41	gneiss
E-8	72	48.5	43	186	40.39	gneiss
E-9	25.5	18	11.5	7	40.34	quartzite
E-10	189.5	103.5	66	1852	40.5	gneiss
E-13	106	95	69	845	40.32	gneiss
E-14	81.5	75.5	50	465	40.56	quartzite

APPENDIX II.

LITHIC SPECIMEN LIST

FROM CHONGOKNI SITE

Spec. No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Level (m, amsl)	Rock Type	Lithic Type
N1E17-01	77.0	49.0	17.0	59.9	61.2	Quartzite	Bipolar Piece
N1E17-02	32.0	22.0	12.0	6.9	60.2	Granular Quartz	Shatter
N1E17-03	75.0	61.0	20.0	90.8	60.2	Quartzite	Flake
N1E17-04	26.0	32.0	6.0	5.0	60.2	Fine Quartz	Trapezoid
N1E17-05	41.0	35.0	9.0	9.3	60.4	Fine Quartz	Utilized piece
N1E17-06	24.0	21.0	15.0	6.2	60.5	Granular Quartz	Shatter
N1E17-07	24.0	18.0	10.0	4.0	60.5	Quartzite	Shatter
N1E17-08	22.0	22.0	10.0	4.0	60.2	Granular Quartz	Trapezoid
N1E17-09	45.0	20.0	8.0	7.1	60.1	Granular Quartz	Point
N1E17-10	35.0	35.0	14.0	16.3	60.2	Granular Quartz	Flake
N1E17-11	32.0	18.0	11.0	5.2	60.2	Granular Quartz	Shatter
N1E17-12	44.0	35.0	19.0	27.7	60.2	Granular Quartz	Utilized piece
N1E17-13	54.0	37.0	32.0	73.6	60.3	Granular Quartz	Shatter
N1E17-14	33.0	31.0	16.0	15.2	60.2	Granular Quartz	Shatter
N1E17-15	32.0	30.0	11.0	11.6	60.3	Granular Quartz	Flake
N1E17-16	27.0	17.0	15.0	9.6	60.3	Granular Quartz	Shatter
N1E17-17	29.0	36.0	12.0	9.5	60.5	Fine Quartz	Flake
N1E17-18	22.0	27.0	9.0	6.4	60.5	Granular Quartz	Shatter
N1E17-19	32.0	28.0	11.0	7.5	60.2	Granular Quartz	Flake
N1E17-20	36.0	31.0	11.0	11.7	60.3	Granular Quartz	Tranchet
N1E17-21	40.0	30.0	11.0	17.6	60.3	Granular Quartz	Flake
N1E17-22	51.0	51.0	19.0	66.0	60.3	Granular Quartz	Flake
N1E17-23	36.0	32.0	24.0	24.0	60.2	Granular Quartz	Tranchet

N1E17-24	34.0	64.0	51.0	124.1	60.2	Granular Quartz	Core
N1E17-25	57.0	40.0	21.0	53.4	60.2	Granular Quartz	Flake
N1E17-26	39.0	48.0	15.0	24.6	60.2	Quartzite	Flake
N1E17-27	45.0	30.0	19.0	27.3	60.3	Quartzite	Sidescraper
N1E17-28	38.0	25.0	21.0	15.4	60.3	Granular Quartz	Shatter
N1E17-29	37.0	27.0	16.0	17.7	60.2	Fine Quartz	Utilized piece
N1E17-30	30.0	16.0	15.0	5.5	60.2	Quartzite	Shatter
N1E17-31	53.0	49.0	23.0	66.7	60.2	Quartzite	Flake
N1E17-32	75.0	136.0	77.0	1022.7	60.2	Quartzite	Core
N1E17-33	28.0	23.0	10.0	5.5	60.3	Granular Quartz	Flake
N1E17-34	26.0	18.0	12.0	6.0	60.2	Granular Quartz	Shatter
N1E17-35	43.0	52.0	16.0	37.5	60.3	Quartzite	Flake
N1E17-36	105.0	82.0	87.0	764.6	60.1	Granular Quartz	Chopper
N1E17-37	20.0	38.0	11.0	10.3	60.2	Granular Quartz	Shatter
N1E17-38	25.0	24.0	17.0	10.7	60.2	Granular Quartz	Shatter
N1E17-39	112.0	98.0	51.0	576.9	60.2	Granular Quartz	Chunk
N1E17-40	36.0	32.0	23.0	23.6	60.3	Granular Quartz	Shatter
N1E17-41	110.0	100.0	77.0	857.7	60.2	Granular Quartz	Cobble
N1E17-42	109.0	72.0	69.0	466.1	60.2	Sandstone	Cobble
N1E17-43	40.0	17.0	15.0	8.0	60.1	Granular Quartz	Shatter
N1E17-44	40.0	37.0	14.0	18.8	60.1	Granular Quartz	Flake
N1E4-01	50.0	46.0	33.0	91.4	59.3	Granular Quartz	Core
N1E4-02	97.0	112.0	66.0	808.7	60.3	Granular Quartz	Chopper
N8E11-01	35.0	30.0	16.0	10.9	59.9	Fine Quartz	Trapezoid
N8E11-02	42.0	58.0	26.0	64.0	59.9	Granular Quartz	Core
N8E11-03	51.0	35.0	15.0	24.4	59.6	Quartzite	Sidescraper
N8E11-04	85.0	45.0	38.0	131.1	59.6	Granular Quartz	Chunk
N8E16-01	72.0	67.0	25.0	114.6	60.6	Fine Quartz	Flake
N8E16-02	89.0	65.0	45.0	369.3	60.7	Granular Quartz	Cobble
N8E16-03	58.0	36.0	17.0	33.0	60.6	Quartzite	Endscraper
N8E16-04	37.0	28.0	21.0	19.8	60.6	Granular Quartz	Shatter
N8E16-05	38.0	62.0	50.0	102.6	60.6	Granular Quartz	Core
N8E16-06	64.0	45.0	33.0	81.0	60.5	Quartzite	Flake
N8E16-07	18.0	36.0	20.0	12.5	60.5	Granular Quartz	Shatter
N8E16-08	117.0	83.0	59.0	650.0	60.2	Granular Quartz	Cobble
N8E16-09	57.0	35.0	19.0	32.3	60.2	Quartzite	Endscraper

N8E16-10	55.0	44.0	28.0	58.9	60.8	Fine Quartz	Sidescraper
N8E16-11	55.0	83.0	50.0	244.5	60.2	Granular Quartz	Core
N8E16-12	50.0	26.0	19.0	29.4	60.4	Granular Quartz	Shatter
N8E16-13	51.0	57.0	26.0	87.7	60.4	Granular Quartz	Flake
N8E16-14	98.0	80.0	53.0	356.3	60.2	Quartzite	Core
N8E16-15	31.0	32.0	10.0	11.2	60.9	Granular Quartz	Flake
N8E16-16	32.0	32.0	17.0	11.9	60.1	Granular Quartz	Shatter
N8E16-17	59.0	44.0	22.0	52.2	61.0	Granular Quartz	Shatter
N8E16-18	50.0	67.0	41.0	170.7	60.4	Granular Quartz	Core
N8E16-19	35.0	33.0	16.0	20.0	60.4	Granular Quartz	Flake
N8E16-20	106.0	99.0	53.0	744.4	60.0	Quartzite	Chopper
N8E16-21	26.0	33.0	10.0	7.5	60.3	Quartzite	Flake
N8E16-22	70.0	28.0	26.0	63.5	60.3	Quartzite	Borer
N8E16-23	57.0	30.0	23.0	47.1	61.4	Granular Quartz	Shatter
N8E16-24	35.0	22.0	14.0	10.1	60.3	Granular Quartz	Flake
N8E16-25	28.0	28.0	14.0	11.0	60.4	Granular Quartz	Shatter
N8E16-26	30.0	33.0	11.0	12.6	60.4	Quartzite	Shatter
N8E16-27	12.0	10.0	18.0	1.0	60.3	Granular Quartz	Shatter
N8E16-28	19.0	27.0	11.0	5.7	60.4	Fine Quartz	Flake
N8E16-29	36.0	19.0	9.0	7.9	60.2	Granular Quartz	Shatter
N8E16-30	40.0	44.0	19.0	35.7	60.4	Granular Quartz	Flake
N8E16-31	26.0	18.0	10.0	4.3	60.3	Granular Quartz	Shatter
N8E16-32	122.0	85.0	62.0	776.4	60.4	Sandstone	Cobble
N8E16-33	23.0	13.0	10.0	3.2	60.4	Granular Quartz	Shatter
N8E16-34	30.0	28.0	12.0	9.4	60.6	Granular Quartz	Shatter
N8E16-35	65.0	74.0	44.0	286.9	60.3	Granular Quartz	Hammer
N8E16-36	36.0	20.0	18.0	11.3	60.3	Granular Quartz	Shatter
N8E16-37	22.0	13.0	5.0	1.5	60.3	Granular Quartz	Shatter
N8E16-38	29.0	55.0	35.0	66.7	60.4	Granular Quartz	Shatter
N8E16-39	20.0	15.0	11.0	2.8	60.4	Granular Quartz	Shatter
N8E16-40	22.0	41.0	15.0	13.7	60.4	Granular Quartz	Shatter
N8E16-41	29.0	25.0	17.0	8.8	60.4	Granular Quartz	Shatter
N8E16-42	38.0	38.0	21.0	32.0	60.3	Quartzite	Cobble
N8E16-43	22.0	15.0	14.0	5.0	60.2	Granular Quartz	Shatter
N8E16-44	27.0	23.0	16.0	9.6	60.4	Granular Quartz	Shatter
N8E16-45	22.0	20.0	16.0	7.1	59.9	Granular Quartz	Shatter

N8E16-46	32.0	28.0	25.0	29.9	59.8	Granular Quartz	Core
N8E16-47	32.0	32.0	14.0	14.9	59.7	Fine Quartz	Flake
N8E16-48	38.0	20.0	14.0	11.7	60.9	Granular Quartz	Shatter
N8E4-01	71.0	38.0	27.0	50.7	59.6	Quartzite	Bipolar Piece
N8E4-02	52.0	35.0	31.0	50.6	59.5	Granular Quartz	Notch
N8E4-03	40.0	39.0	12.0	24.4	59.5	Granular Quartz	Flake
N8E4-04	130.0	108.0	86.0	1382.5	59.5	Granular Quartz	Chopper
S1E18-01	57.0	37.0	19.0	46.8	60.5	Granular Quartz	Flake
S1E18-02	35.0	28.0	18.0	19.6	60.1	Granular Quartz	Shatter
S1E18-03	46.0	23.0	16.0	22.5	60.2	Fine Quartz	Sidescraper
S1E18-04	73.0	40.0	33.0	125.0	60.0	Granular Quartz	Chunk
S1E18-05	34.0	33.0	21.0	23.5	60.0	Granular Quartz	Shatter
S1E18-06	33.0	31.0	10.0	10.9	60.3	Quartzite	Flake
S1E18-07	45.0	37.0	18.0	34.1	60.8	Granular Quartz	Shatter
S1E18-08	29.0	26.0	11.0	8.6	60.6	Fine Quartz	Flake
S1E18-09	29.0	21.0	9.0	5.4	60.2	Granular Quartz	Flake
S1E18-10	18.0	14.0	10.0	2.6	60.3	Granular Quartz	Shatter
S1E18-11	37.0	37.0	12.0	13.8	60.2	Granular Quartz	Flake
S1E18-12	184.0	95.0	64.0	1174.1	60.2	Quartzite	Handaxe
S1E18-13	37.0	25.0	14.0	10.7	60.4	Gneiss	Shatter
S1E18-14	72.0	64.0	25.0	104.6	60.4	Quartzite	Bipolar Piece
S1E18-15	27.0	16.0	16.0	5.5	60.4	Granular Quartz	Shatter
S1E18-16	50.0	51.0	26.0	56.4	60.3	Granular Quartz	Flake
S1E18-17	102.0	65.0	47.0	289.1	60.3	Sandstone	Cobble
S1E18-18	75.0	73.0	25.0	157.7	60.2	Quartzite	Chunk
S1E18-19	103.0	102.0	89.0	817.6	60.2	Sandstone	Chunk
S1E18-20	105.0	95.0	62.0	542.2	60.2	Porphyry	Cobble
S1E18-21	56.0	53.0	38.0	122.1	60.2	Granular Quartz	Core
S1E18-22	104.0	78.0	47.0	464.4	60.0	Quartzite	Chopper
S1E18-23	95.0	74.0	43.0	376.9	60.5	Sandstone	Cobble
S1E18-24	80.0	48.0	10.0	36.2	61.0	Porphyry	Flake
S1E18-25	30.0	25.0	12.0	12.3	61.0	Gneiss	Cobble
S1E18-26	100.0	62.0	19.0	139.0	61.0	Basalt	Chunk
S1E18-27	23.0	31.0	8.0	4.7	61.0	Granular Quartz	Trapezoid
S1E18-28	79.0	80.0	62.0	463.2	60.4	Quartzite	Core
S1E18-29	36.0	36.0	16.0	27.6	60.8	Granular Quartz	Flake

S1E18-30	110.0	105.0	75.0	838.4	60.3	Sandstone	Cobble
S1E18-31	33.0	22.0	18.0	11.9	60.5	Granular Quartz	Flake
S1E18-32	58.0	82.0	70.0	305.3	60.5	Quartzite	Hammer
S1E18-33	53.0	53.0	24.0	12.2	59.8	Quartzite	Notch
S1E18-34	28.0	15.0	10.0	5.5	59.9	Granular Quartz	Shatter
S1E18-35	58.0	22.0	12.0	12.2	60.0	Quartzite	Blade
S1E18-36	51.0	54.0	20.0	50.0	60.1	Granular Quartz	Flake
S1E18-37	93.0	107.0	67.0	866.5	59.9	Granular Quartz	Hammer
S1E18-38	83.0	75.0	51.0	300.0	60.0	Sandstone	Shatter
S1E18-39	109.0	71.0	55.0	512.9	60.1	Sandstone	Cobble
S1E18-40	53.0	54.0	35.0	71.3	60.1	Fine Quartz	Notch
S1E18-41	88.0	81.0	58.0	451.6	59.8	Fine Quartz	Core
S1E18-42	65.0	64.0	37.0	148.9	59.8	Granular Quartz	Flake
S1E18-43	39.0	26.0	17.0	15.5	60.2	Sandstone	Shatter
S1E18-44	42.0	35.0	21.0	29.2	59.7	Granular Quartz	Shatter
S1E18-45	26.0	18.0	12.0	6.3	59.8	Gneiss	Cobble
S1E18-46	25.0	43.0	11.0	9.2	59.8	Quartzite	Flake
S1E18-47	91.0	65.0	45.0	247.7	59.8	Sandstone	Cobble
S1E18-48	20.0	17.0	10.0	2.7	60.2	Fine Quartz	Shatter
S5W5-01	45.0	31.0	15.0	16.9	57.6	Granular Quartz	Shatter
SUR-01	34.0	32.0	10.0	10.1	Surface	Granular Quartz	Shatter
SUR-02	50.0	34.0	22.0	35.6	Surface	Quartzite	Shatter
SUR-03	31.0	18.0	15.0	10.9	Surface	Fine Quartz	Shatter
SUR-04	50.0	50.0	14.0	41.6	Surface	Granular Quartz	Flake
SUR-05	35.0	39.0	15.0	22.5	Surface	Granular Quartz	Flake
SUR-06	35.0	25.0	12.0	10.5	Surface	Granular Quartz	Shatter
SUR-07	65.0	67.0	29.0	130.5	Surface	Fine Quartz	Flake
SUR-08	113.0	60.0	38.0	290.7	Surface	Granular Quartz	Chunk
SUR-09	55.0	44.0	15.0	32.4	Surface	Granular Quartz	Flake
SUR-10	80.0	48.0	44.0	130.6	Surface	Gneiss	Shatter
SUR-11	85.0	65.0	41.0	183.0	Surface	Granular Quartz	Chunk
SUR-12	40.0	60.0	42.0	97.6	Surface	Granular Quartz	Core
SUR-13	40.0	26.0	13.0	13.2	Surface	Granular Quartz	Shatter
SUR-14	37.0	25.0	10.0	7.5	Surface	Fine Quartz	Shatter
SUR-15	21.0	35.0	13.0	11.9	Surface	Granular Quartz	Shatter
SUR-16	45.0	48.0	16.0	35.1	Surface	Quartzite	Flake

SUR-17	59.0	57.0	13.0	40.1	Surface	Granular Quartz	Flake
SUR-18	63.0	40.0	35.0	83.0	Surface	Granular Quartz	Shatter
SUR-19	35.0	19.0	12.0	6.0	Surface	Granular Quartz	Shatter
SUR-20	142.0	88.0	57.0	868.0	Surface	Granular Quartz	Chunk
SUR-21	72.0	70.0	31.0	126.5	Surface	Quartzite	Chunk
SUR-22	80.0	57.0	25.0	163.0	Surface	Fine Quartz	Flake
SUR-23	57.0	90.0	68.0	448.0	Surface	Granular Quartz	Core
SUR-24	140.0	155.0	105.0	2438.9	Surface	Quartzite	Core
SUR-25	40.0	35.0	13.0	18.5	Surface	Granular Quartz	Flake

APPENDIX III.

LITHIC SPECIMEN LIST

FROM JUWOLRI/KAWOLRI SITE

(1) Lithic Specimens from Juwolri

Spec. No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Level (m, amsl)	Rock Type	Lithic Type
SUR-1	250	172	93	4700	N/A	Quartzite	Core
SUR-2	81	58	30	141.5	N/A	Quartzite	Notch
SUR-3	119	100	65	781.3	N/A	Quartzite	Chopper
S2E3-1	140	121	56	235.6	N/A	Granular Quartz	Core
S2E3-2	61	84	34	155.7	N/A	Granular Quartz	Core
S2E3-3	46	38	12	21.9	N/A	Granular Quartz	Flake
S2E3-4	68	39	22	61.5	N/A	Granular Quartz	Shatter
S2E3-5	86	43	22	94.3	N/A	Quartzite	Shatter
S2E3-6	109	76	39	373.4	N/A	Fine Quartz	Chunk
S2E3-7	70	90	80	507.6	N/A	Fine Quartz	Core
S2E3-8	192	104	59	1097.9	N/A	Quartzite	Handaxe
S2E4-1	67	62	20	65.2	N/A	Fine Quartz	Flake
S2E4-2	80	35	18	61.7	N/A	Quartzite	Shatter
S2E4-3	52	33	25	58.5	N/A	Granular Quartz	Shatter
S2E4-4	90	75	49	278	N/A	Fine Quartz	Core
N2W4-1	72	91	65	481.8	N/A	Quartzite	Chopper
N5E4-1	35	38	22	24	28.6	Granular Quartz	Flake
N5E4-2	119	93	37	581.9	28.7	Quartzite	Cobble
N5E4-3	77	72	11	64.1	29.1	gneiss	Shatter

N5E4-4	41	42	14	23.5	29.3	Quartzite	Flake
N5E4-5	31	39	7	8.4	29.8	Granular Quartz	Flake
N5E4-6	62	41	28	70.1	29.3	Fine Quartz	Notch
N5E4-7	82	91	41	204.9	29.6	Quartzite	Flake
N5E4-8	32	52	10	15.6	30	Granular Quartz	Utilized Piece
N5E4-9	40	62	21	46.8	29.3	Quartzite	Flake
N5E4-10	44	30	12	11.6	29.3	Granular Quartz	Utilized Piece
N5E4-11	38	18	18	12	29.6	Granular Quartz	Utilized Piece
N5E4-12	51	52	23	64.7	29.3	Fine Quartz	Flake
N5E4-13	92	71	65	312.5	30.4	Quartzite	Core
N5E4-14	66	54	34	116.2	30.2	Fine Quartz	Shatter
N5E4-15	25	17	7	3.4	30.3	Granular Quartz	Flake
N5E4-16	92	80	37	334.2	30.1	Fine Quartz	Rabot

(2) Lithic Specimens from Kawolri

Spec. No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Level (m, amsl)	Raw Material	Lithic Type
Tr-1	58	38	26	49.5	34.1	Fine Quartz	Point
Tr-2	39	39	26	24.6	34.3	Fine Quartz	Point
Tr-3	39	22	16	15.5	34.2	Fine Quartz	Sidescraper
Tr-4	50	32	16	33.8	34	Fine Quartz	Tranchet
Tr-5	20	21	9	4.2	34.2	Fine Quartz	Trapezoid
Tr-6	43	38	14	18.4	34.5	Fine Quartz	Endscraper
Tr-7	32	33	13	17.1	34.7	Fine Quartz	Utilized Piece \
Tr-8	34	43	13	25.6	34.2	Fine Quartz	Sidescraper
Tr-9	44	25	9	13.2	34.6	Fine Quartz	Point
Tr-10	46	28	8	11.3	34.5	Fine Quartz	Trapezoid
Tr-11	50	28	20	28	34.3	Fine Quartz	Shatter
Tr-12	41	24	9	10.3	34.5	Fine Quartz	Endscraper

Tr-13	35	25	10	8.6	34.1	Granular Quartz	Point
Tr-14	26	20	7	4	34.6	Fine Quartz	Trapezoid
Tr-15	128	90	62	730.9	34.3	Quartzite	Handaxe
Tr-16	39	18	14	8.6	34.3	Fine Quartz	Point
Tr-17	43	34	19	32.3	34.7	Granular Quartz	Shatter
Tr-18	61	30	27	43	34.5	Fine Quartz	Shatter
Tr-19	48	34	19	38	34.1	Fine Quartz	Shatter
Tr-20	59	24	15	18.6	34.2	Fine Quartz	Borer
Tr-21	26	19	17	9.9	34.6	Granular Quartz	Shatter
Tr-22	45	27	18	14.7	34.5	Fine Quartz	Point
Tr-23	32	21	13	11.1	34.3	Fine Quartz	Shatter
Tr-24	54	22	20	26.5	34.3	Granular Quartz	borer
Tr-25	34	19	13	9	34.6	Fine Quartz	Shatter
Tr-26	36	23	20	20.1	34.2	Fine Quartz	Shatter
Tr-27	41	40	11	20.2	34.3	Fine Quartz	Tranchet
Tr-28	14	32	7	3.3	34.2	Granular Quartz	Trapezoid
Tr-29	21	18	7	3	34.6	Fine Quartz	Shatter
Tr-30	47	24	11	11.3	34.5	Granular Quartz	Sidescraper
Tr-31	74	70	27	155.5	34.5	Fine Quartz	Notch
Tr-32	43	21	15	16.6	34.3	Fine Quartz	Shatter
Tr-33	91	63	43	309.3	34.2	Fine Quartz	Rabot
Tr-34	47	32	16	27.2	34.5	Fine Quartz	Shatter
Tr-35	110	54	40	286.1	34.3	Granular Quartz	Chunk
Tr-36	101	80	49	486.7	34.3	Fine Quartz	Chunk
Tr-37	57	72	45	213.7	34.6	Fine Quartz	Core
Tr-38	44	27	14	18	34.2	Fine Quartz	Sidescraper
Tr-39	68	65	40	217	34.6	Granular Quartz	Shatter
Tr-40	116	65	42	265.5	34.3	Fine Quartz	Chunk
Tr-41	57	85	48	218.6	34	Fine Quartz	Core
Tr-42	100	82	59	506.5	34.1	Fine Quartz	Chunk
Tr-43	110	77	41	357.2	34.2	Granular Quartz	Chunk
Tr-44	160	95	52	872.3	34.2	Quartzite	Large scraper
Tr-45	55	50	41	115.7	34.3	Fine Quartz	Shatter
Tr-46	66	67	30	146.3	34.5	Fine Quartz	Flake
Tr-47	36	44	13	24.1	34.3	Fine Quartz	Flake
Tr-48	43	39	20	36.7	34.2	Fine Quartz	Shatter

Tr-49	43	33	24	25.9	34.5	Fine Quartz	Shatter
Tr-50	70	34	27	36.5	34.6	Fine Quartz	Chunk
Tr-51	64	44	36	106.5	34.6	Granular Quartz	Flake
Tr-52	64	48	37	109.8	34.5	Fine Quartz	Flake
Tr-53	107	58	38	248.2	34.7	Fine Quartz	Chunk
Tr-54	78	66	56	282.6	34.1	Fine Quartz	Flake
Tr-55	48	32	7	11	34.3	Fine Quartz	Endscraper
Tr-56	116	75	55	632.3	34.5	Granular Quartz	Chunk
Tr-57	79	56	24	140.8	34.5	Fine Quartz	Flake
Tr-58	89	55	45	164.6	34.1	Fine Quartz	Shatter
Tr-59	42	38	15	26.9	34.6	sandstone	Shatter
Tr-60	65	66	26	138	34.5	Fine Quartz	Flake
Tr-61	107	52	17	133.5	34.3	Fine Quartz	Chunk
Tr-62	58	54	15	80	34.7	Fine Quartz	Shatter
Tr-63	81	39	16	73	34.7	Fine Quartz	Flake
Tr-64	47	31	24	39.8	34.5	Fine Quartz	Shatter
Tr-65	55	31	19	32.1	34.5	Granular Quartz	Shatter
Tr-66	50	29	19	29	34.6	Fine Quartz	Flake
Tr-67	37	34	21	29.1	34.3	Fine Quartz	Flake
Tr-68	75	40	25	89	34.3	Fine Quartz	Shatter
Tr-69	55	46	39	103.8	34.6	Fine Quartz	Shatter
Tr-70	73	43	47	157	34.5	Fine Quartz	Chunk
Tr-71	54	29	16	33.5	34.2	Fine Quartz	Shatter
Tr-72	41	35	22	26.6	34.1	Granular Quartz	Shatter
Tr-73	39	20	14	12.1	34.3	Fine Quartz	Shatter
Tr-74	41	28	17	25.7	34.1	Fine Quartz	Shatter
Tr-75	75	35	29	84.1	34.5	Fine Quartz	Flake
Tr-76	36	24	15	18.5	34.4	Granular Quartz	Shatter
Tr-77	50	30	23	36.2	34.3	Fine Quartz	Shatter
Tr-78	39	40	14	28.7	34.2	Fine Quartz	Shatter
Tr-79	71	46	13	59.6	34.5	Fine Quartz	Flake
Tr-80	29	45	22	33.2	34.6	Fine Quartz	Core
Tr-81	44	28	24	38	34.3	Fine Quartz	Endscraper
Tr-82	57	40	17	46.5	34.2	Granular Quartz	Shatter
Tr-83	66	34	26	53.3	34.3	Fine Quartz	Shatter
Tr-84	76	43	18	74.8	34.5	Fine Quartz	Shatter

Tr-85	70	29	16	41.6	34.6	Fine Quartz	Shatter
Tr-86	36	30	17	24.5	34.6	Fine Quartz	Shatter
Tr-87	37	31	24	34.8	34.5	Fine Quartz	Shatter
Tr-88	45	37	22	53.7	34.5	Fine Quartz	Shatter
Tr-89	50	34	17	33.3	34.2	Granular Quartz	Sidescraper
Tr-90	56	34	21	41.3	34.3	Fine Quartz	Shatter
Tr-91	35	34	21	36.1	34.5	Fine Quartz	Shatter
Tr-92	50	26	28	35.6	34.2	Fine Quartz	Shatter
Tr-93	57	30	25	37.9	34.2	Fine Quartz	Point
Tr-94	39	38	15	34.1	34.1	Fine Quartz	Flake
Tr-95	36	27	19	19.9	34.5	Granular Quartz	Shatter
Tr-96	44	28	22	38.9	34.6	Fine Quartz	Shatter
Tr-97	50	37	24	48.3	34.2	Fine Quartz	Shatter
Tr-98	35	24	15	16.7	34.5	Fine Quartz	Shatter
Tr-99	30	27	16	15.7	34.3	Fine Quartz	Shatter
Tr-100	51	36	18	46.5	34.4	Fine Quartz	Shatter
Tr-101	46	29	18	27.3	34.3	Granular Quartz	Shatter
Tr-102	46	31	21	41.2	34.2	Fine Quartz	Shatter
Tr-103	46	20	22	23	34.3	Fine Quartz	Shatter
Tr-104	62	30	13	29.9	34.5	Fine Quartz	Shatter
Tr-105	36	29	26	31	34.2	Fine Quartz	Shatter
Tr-106	40	27	11	14.2	34.5	Fine Quartz	Flake
Tr-107	37	29	26	34.3	34.3	Fine Quartz	Shatter
Tr-108	56	28	10	22.2	34.3	Fine Quartz	Shatter
Tr-109	40	29	22	30.7	34.2	Fine Quartz	Shatter
Tr-110	39	25	19	26.2	34.6	Granular Quartz	Shatter
Tr-111	45	29	23	29.2	34.7	Fine Quartz	Shatter
Tr-112	38	30	20	23.5	34.2	Fine Quartz	Shatter
Tr-113	40	29	20	24.3	34.3	Fine Quartz	Shatter
Tr-114	32	25	19	22.5	34.2	Fine Quartz	Shatter
Tr-115	38	30	23	38	34.5	Fine Quartz	Shatter
Tr-116	41	30	25	37.9	34.4	Granular Quartz	Shatter
Tr-17	70	34	23	71.6	34.1	Fine Quartz	Shatter
Tr-118	56	32	27	52.7	34	Fine Quartz	Shatter
Tr-119	51	48	14	55.2	34.2	Fine Quartz	Shatter
Tr-120	35	27	19	19.7	34.3	Fine Quartz	Endscraper

Tr-121	31	24	21	18.5	34.2	Fine Quartz	Shatter
Tr-122	30	20	15	11.2	34.5	Fine Quartz	Shatter
Tr-123	27	25	7	5.5	34.5	Fine Quartz	Shatter
Tr-124	45	35	13	25.3	34.6	Granular Quartz	Shatter
Tr-125	30	25	14	11.1	34.5	Fine Quartz	Shatter
Tr-126	63	30	16	35.1	34.2	Fine Quartz	Shatter
Tr-127	40	33	20	32.5	34.1	Fine Quartz	Shatter
Tr-128	70	31	24	58.8	34.8	Fine Quartz	Shatter
Tr-129	49	18	16	13.1	34.5	Fine Quartz	Shatter
Tr-130	41	30	14	20.5	34.5	Fine Quartz	Shatter
Tr-131	50	50	26	84.5	34.2	Fine Quartz	Shatter
Tr-132	101	45	12	65.5	34.3	sandstone	Shatter
Tr-133	26	25	12	6.3	34.3	Fine Quartz	Shatter
Tr-134	39	26	13	14.8	34.5	Granular Quartz	Flake
Tr-135	50	30	21	37.6	34.2	Fine Quartz	Shatter
Tr-136	35	23	14	13.1	34.1	Fine Quartz	Shatter
Tr-137	37	35	18	31.3	34.1	Fine Quartz	Shatter
Tr-138	40	25	18	20.9	34.6	Fine Quartz	Shatter
Tr-139	50	41	14	35.2	34.5	Fine Quartz	Shatter
Tr-140	36	28	17	27.9	34.5	Fine Quartz	Shatter
Tr-141	47	23	10	12.6	34.2	Granular Quartz	Shatter
Tr-142	22	21	7	3.6	34.5	Fine Quartz	Shatter
Tr-143	25	22	12	9.3	34.3	Fine Quartz	Shatter
Tr-144	103	94	63	790.7	34.3	Quartzite	Chopper
Tr-145	40	38	21	42.4	34.5	Fine Quartz	Shatter
Tr-146	48	20	12	14.7	34.4	Fine Quartz	Shatter
Tr-147	45	27	22	18.7	34.6	Fine Quartz	Shatter
Tr-148	48	20	13	13.2	34.5	Fine Quartz	Shatter
Tr-149	30	28	16	16.7	34.5	Granular Quartz	Shatter
Tr-150	39	24	11	11.2	34.5	Fine Quartz	Sidescraper
Tr-151	45	30	11	22.6	34.2	Fine Quartz	Shatter
Tr-152	29	18	18	9	34.1	Fine Quartz	Shatter
Tr-153	46	17	13	14.4	34.5	Fine Quartz	Shatter
Tr-154	39	26	13	20	34.6	Fine Quartz	Shatter
Tr-155	48	31	18	19.9	34.3	Fine Quartz	Shatter
Tr-156	46	24	18	21.2	34.3	Fine Quartz	Shatter

Tr-157	31	18	16	12.7	34.2	Fine Quartz	Shatter
Tr-158	43	27	19	34.5	34	Granular Quartz	Shatter
Tr-159	35	33	23	32.2	34	Fine Quartz	Shatter
Tr-160	34	32	9	10.4	34.2	Fine Quartz	Shatter
Tr-161	28	25	19	14.9	34.1	Fine Quartz	Shatter
Tr-162	38	18	17	14.2	34.5	Fine Quartz	Shatter
Tr-163	34	35	25	33.8	34.6	Fine Quartz	Shatter
Tr-164	34	23	15	12.5	34.5	Fine Quartz	Shatter
Tr-165	26	24	13	11.8	34.2	Fine Quartz	Shatter
Tr-166	36	31	13	15.2	34.5	Fine Quartz	Shatter
Tr-167	28	18	17	10	34.2	Granular Quartz	Shatter
Tr-168	44	26	19	25.8	34.3	Fine Quartz	Shatter
Tr-169	25	16	7	2.7	34.3	Fine Quartz	Shatter
Tr-170	29	26	21	14.9	34.1	Fine Quartz	Shatter
Tr-171	40	19	10	9.8	34.1	Fine Quartz	Shatter
Tr-172	36	27	18	16.1	34.5	Fine Quartz	Shatter
Tr-173	41	21	21	17.5	34.6	Fine Quartz	Shatter
Tr-174	36	31	20	23.4	34.5	Fine Quartz	Shatter
Tr-175	26	22	11	6.7	34.5	Granular Quartz	Shatter
Tr-176	36	20	13	9.8	34.6	Fine Quartz	Shatter
Tr-177	26	14	11	4	34.2	Fine Quartz	Shatter
Tr-178	42	33	12	19.8	34.5	Granular Quartz	Shatter
Tr-179	21	18	3	1.4	34.3	Fine Quartz	Shatter
Tr-180	27	22	12	7	34.6	Granular Quartz	Shatter
Tr-181	40	21	16	12.1	34.5	Fine Quartz	Shatter
Tr-182	38	24	18	15.1	34.2	Fine Quartz	Shatter
Tr-183	22	20	11	6.5	34.3	Fine Quartz	Shatter
Tr-184	36	22	24	23.2	34.6	Granular Quartz	Shatter
Tr-185	23	17	8	3.1	34.2	Fine Quartz	Shatter
Tr-186	41	32	9	17.7	34.1	Granular Quartz	Shatter
Tr-187	28	21	18	11.8	34.1	Fine Quartz	Shatter
Tr-188	30	19	10	5.2	34.5	Fine Quartz	Shatter
Tr-189	34	21	20	11.9	34.6	Fine Quartz	Shatter
Tr-190	30	27	14	12.6	34.5	Fine Quartz	Shatter
Tr-191	25	12	8	2.5	34.7	Fine Quartz	Shatter
Tr-192	23	21	9	4.3	34.2	Fine Quartz	Shatter

Tr-193	37	20	14	10.1	34.3	Granular Quartz	Shatter
Tr-194	30	25	13	13	34.5	Fine Quartz	Shatter
Tr-195	33	21	14	8.7	34.3	Fine Quartz	Shatter
Tr-196	34	23	16	11	34.2	Fine Quartz	Shatter
Tr-197	31	21	15	9.7	34.2	Granular Quartz	Shatter
Tr-198	33	24	16	15	34.1	Fine Quartz	Shatter
Tr-199	28	24	13	11.2	34.2	Granular Quartz	Shatter
Tr-200	37	19	7	6.6	34.3	Granular Quartz	Shatter
Tr-201	16	14	4	1	34.2	Fine Quartz	Shatter
Tr-202	17	14	9	3.1	34.2	Granular Quartz	Shatter
Tr-203	15	12	11	2	34.3	Fine Quartz	Shatter
Tr-204	26	15	9	4.2	34.2	Fine Quartz	Shatter
Tr-205	23	14	8	3.4	34.6	Fine Quartz	Shatter
Tr-206	26	14	7	4.1	34.5	Fine Quartz	Shatter
Tr-207	31	17	13	6.8	34.6	Fine Quartz	Shatter
Tr-208	30	20	20	13.6	34.3	Granular Quartz	Shatter
Tr-209	31	22	11	9.3	34.2	Fine Quartz	Shatter
Tr-210	24	24	11	6.4	34.2	Granular Quartz	Shatter
Tr-211	28	17	11	5.6	34.1	Fine Quartz	Shatter
Tr-212	23	22	12	6.8	34.1	Fine Quartz	Shatter
Tr-213	19	16	14	5.3	34.2	Fine Quartz	Shatter
Tr-214	23	21	16	8.4	34.1	Fine Quartz	Shatter
Tr-215	13	12	7	1.3	34	Fine Quartz	Shatter
Tr-216	29	16	7	3.3	34.2	Fine Quartz	Shatter
Tr-217	20	17	8	2.4	34.2	Fine Quartz	Shatter
Tr-218	96	73	38	330.9	34.1	Granular Quartz	Shatter
Tr-219	70	42	23	54.2	34.1	Fine Quartz	Shatter
Tr-220	50	46	25	57.2	34.2	Granular Quartz	Shatter
Tr-221	62	35	18	49.8	34.5	Fine Quartz	Shatter
Tr-222	53	41	32	54.2	34.6	Fine Quartz	Shatter
Tr-223	72	65	32	156.4	34.7	Fine Quartz	Shatter
Tr-224	55	51	25	58.3	34.2	Fine Quartz	Shatter
Tr-225	40	37	30	36.7	34.5	Fine Quartz	Shatter
Tr-226	52	26	22	38.6	34.3	Fine Quartz	Shatter
Tr-227	40	35	24	29.7	34.3	Fine Quartz	Shatter
Tr-228	31	31	9	7.9	34.1	Fine Quartz	Shatter

Tr-229	101	96	30	380.4	34.1	Fine Quartz	Chunk
A1-1	20	15	4	1	33.8	Fine Quartz	Shatter
A1-2	88	58	25	156.1	33.7	Quartzite	Sidescraper
A1-3	27	20	17	9	33.8	Fine Quartz	Shatter
B2-1	95	95	59	654.5	34	Quartzite	Chopper
B3-1	55	45	41	79.2	33.8	Quartzite	Core
B3-2	45	30	23	42.5	33.9	Granular Quartz	Shatter
B3-3	37	34	24	36.4	33.9	Quartzite	Shatter
B3-4	47	30	22	36.7	33.6	Fine Quartz	Core
B3-5	37	32	17	20.6	33.8	Quartzite	Flake
B3-6	35	16	19	5	33.7	Fine Quartz	Shatter
C1-1	32	18	13	6.2	33.8	vein crystal	Sidescraper
C4-1	42	33	15	27.7	33.7	Fine Quartz	Sidescraper
C4-2	42	33	20	26.6	33.9	Fine Quartz	Shatter
C4-3	37	42	15	16.4	34	Granular Quartz	Utilized Piece
C4-4	51	45	19	33	33.7	gneiss	Shatter
C4-5	90	80	68	682.2	33.8	Quartzite	Core
C4-6	32	20	18	8.6	33.7	Fine Quartz	Shatter
C5-1	87	40	29	151.1	34	Fine Quartz	Flake
C5-2	42	41	29	53.5	33.8	Fine Quartz	Shatter
C5-3	47	24	19	17.7	33.8	Fine Quartz	Shatter
C5-4	24	22	20	14.3	33.9	Granular Quartz	Shatter
C5-5	22	28	9	2.1	33.8	Fine Quartz	Shatter
C5-6	35	22	18	15.7	33.9	Granular Quartz	Shatter
C5-7	32	13	9	3.7	33.7	Fine Quartz	Shatter
C5-8	50	82	46	185.9	33.7	Quartzite	Core
C5-9	58	61	57	189	33.8	Granular Quartz	Core
C5-10	60	65	24	97.1	33.9	Granular Quartz	Shatter
C5-11	36	23	16	17	33.9	Fine Quartz	Shatter

APPENDIX IV.

LITHIC SPECIMEN LIST*

FROM GRID W80S10 OF JANGHUNGRI SITE

*** Re-arranged from the Original Publication (Choi, B. K. *et al.* 2001)**

**** Lithic types are converted to more suitable nomenclatures in the actual analysis**

Spec. No.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Raw Material	Lithic Type
W80S10-1	6	5	2	0.1	Obsidian	Flake
W80S10-2	15	8	2	0.3	Obsidian	Flake
W80S10-3	25.5	10	14.1	2.9	Obsidian	Core
W80S10-4	8	6	1.4	0.1	Obsidian	Flake
W80S10-5	21.4	21.2	5.2	2.5	Obsidian	Sidescraper
W80S10-6	19	15	5	1.2	Jasper	Flayer
W80S10-7	11	7	2	0.2	Obsidian	Flake
W80S10-8	9	7.5	1.6	0.2	Obsidian	Flake
W80S10-9	11	11	3	0.2	Obsidian	Flake
W80S10-10	24.1	19.4	6.4	2.4	Obsidian	Sidescraper
W80S10-11	28.1	22.7	7.9	5.3	Obsidian	Sidescraper
W80S10-12	12	6	2.5	0.2	Obsidian	Flake
W80S10-13	14	8	1.4	0.1	Obsidian	Flake
W80S10-14	8	6	1	0.1	Obsidian	Flake
W80S10-15	7	6	1	0.5	Obsidian	Flake
W80S10-16	17	8	1.5	0.2	Obsidian	Flake
W80S10-17	3	2	1	0.1	Obsidian	Chip**
W80S10-18	10	10	1.6	0.2	Obsidian	Flake
W80S10-19	10	8	4	0.3	Obsidian	Chip**
W80S10-20	8	3.7	0.7	0.08	Obsidian	Blade

W80S10-21	10	8	3	0.2	Obsidian	Chip**
W80S10-22	8	5	3	0.1	Obsidian	Chip**
W80S10-23	7	5	1	0.5	Obsidian	Flake
W80S10-24	10	6	1	1	Obsidian	Flake
W80S10-25	7	5	2	0.5	Obsidian	Flake
W80S10-26	10	7	2.5	0.2	Obsidian	Flake
W80S10-27	12	5	1	0.05	Obsidian	Blade
W80S10-28	8	7	2	0.1	Obsidian	Flake
W80S10-29	12	9	2	0.2	Obsidian	Flake
W80S10-30	4	2	1	0.05	Obsidian	Flake
W80S10-31	8	5	0.6	0.05	Obsidian	Flake
W80S10-32	13	9	6	0.7	Obsidian	Chip**
W80S10-33	8	4	1	0.5	Obsidian	Chip**
W80S10-34	7	6	1	0.3	Obsidian	Chip**
W80S10-35	10	7	1	0.3	Obsidian	Flake
W80S10-36	9	7	1	0.2	Obsidian	Flake
W80S10-37	30	22	3.6	1.5	Obsidian	Denticulate
W80S10-38	6	3	1	0.1	Obsidian	Chip**
W80S10-39	13	10	1	0.4	Obsidian	Flake
W80S10-40	8	7	2	0.3	Obsidian	Flake
W80S10-41	7	3.6	1.6	0.5	Obsidian	Flake
W80S10-42	17	7	5	1	Obsidian	Flake
W80S10-43	11	6	1	1	Obsidian	Flake
W80S10-44	8.8	6	1.3	1	Obsidian	Blade**
W80S10-45	13	7	1	3	Obsidian	Flake
W80S10-46	24	15	2.5	5	Obsidian	Flake
W80S10-47	15.7	5.7	2.2	2	Obsidian	Sidescraper
W80S10-48	7	2	0.5	0.01	Obsidian	Flake
W80S10-49	10	5	1	0.1	Obsidian	Flake
W80S10-50	9	5	1.5	0.8	Obsidian	Flake
W80S10-51	6	5	2	0.3	Obsidian	Chip**
W80S10-52	6	5	1	0.1	Obsidian	Flake
W80S10-53	18	18	9	2.5	Obsidian	Sidescraper
W80S10-54	8	7	3	0.2	Obsidian	Flake
W80S10-55	8	6	1	0.1	Obsidian	Flake
W80S10-56	10	4	1	0.1	Obsidian	Flake

W80S10-57	103	98	35	367	Sandstone	Point
W80S10-58	60	30	10	15.5	Porphyry	Sidescraper
W80S10-59	36	35	11	14.5	Quartzite	Sidescraper
W80S10-60	31	31	11	12.7	Fine Quartz	Sidescraper
W80S10-61	50	22	10	14.7	Fine Quartz	Sidescraper
W80S10-62	31	24	9	6.8	Fine Quartz	Flayer
W80S10-63	68	43	34	120	Fine Quartz	Blank
W80S10-64	35	26	15	17.5	Fine Quartz	Sidescraper
W80S10-65	44	37	31	59	Fine Quartz	Sidescraper
W80S10-66	42	34	27	29	Fine Quartz	Blank
W80S10-67	8	7	2	0.2	Fine Quartz	Flake
W80S10-68	30	20	12	9.7	Fine Quartz	Flake
W80S10-69	17	9	4	0.6	Fine Quartz	Flake
W80S10-70	12	12	3.3	0.5	Fine Quartz	Flake
W80S10-71	33	23	9	6.5	Fine Quartz	Flake
W80S10-72	23	15	5	7	Porphyry	Flake
W80S10-73	29	27	10	7	Porphyry	Flake
W80S10-74	13	12	6	1	Fine Quartz	Chip**
W80S10-75	15	4	3	0.2	Fine Quartz	Chip**
W80S10-76	14	10	5	0.8	Fine Quartz	Chip**
W80S10-77	21	12	11	5.4	Fine Quartz	Chip**
W80S10-78	26	15	8	3.3	Fine Quartz	Chip**
W80S10-79	11	7	7	0.7	Fine Quartz	Chip**
W80S10-80	14	9	5.5	0.8	Fine Quartz	Chip**
W80S10-81	15	8	3	0.5	Fine Quartz	Chip**
W80S10-82	28	18	8	4.5	Fine Quartz	Chip**
W80S10-83	30	26	15	10	Fine Quartz	Chip**
W80S10-84	39	20	14	15	Fine Quartz	Chip**
W80S10-85	14	7	5	0.7	Fine Quartz	Chip**
W80S10-86	25	13	10	3.2	Fine Quartz	Chip**
W80S10-87	10	10	3	0.5	Fine Quartz	Chip**
W80S10-88	12	11	5	0.8	Fine Quartz	Chip**
W80S10-89	18	13	8	2.3	Fine Quartz	Chip**
W80S10-90	18	10	6	0.9	Fine Quartz	Chip**
W80S10-91	22	15	8	3.8	Fine Quartz	Chip**
W80S10-92	25	17	7	3.2	Fine Quartz	Chip**

W80S10-93	11	13	3.5	0.5	Fine Quartz	Chip**
W80S10-94	18	17	5	2.1	Fine Quartz	Chip**
W80S10-95	12	11	3	0.3	Fine Quartz	Chip**

APPENDIX V.
TERMS AND SIZES FOR CLASTIC ROCKS AND SEDIMENTS

	Name	Millimeters	Micrometers	Φ
GRAVEL		4,096		−12
	Boulder			
		256		−8
	Cobble			
		64		−6
	Pebble			
		4		−2
	Granule			
		2		−1
SAND	Very coarse sand			
		1		0
	Coarse sand			
		0.5	500	1
	Medium sand			
		0.25	250	2
	Fine sand			
		0.125	125	3
	Very fine sand			
		0.062	62	4
MUD	Coarse silt			
		0.031	31	5
	Medium silt			
		0.016	16	6
	Fine silt			
		0.008	8	7
	Very fine silt			
		0.004	4	8
	Clay			

After Klein and Hurlbut (1985). The Φ scale is a transformation based on a logarithmic scale ($\Phi = -\log_2 S$, where S is grain size in millimeters)

APPENDIX VI.
SUMMARY IN KOREAN

유용욱
(캐나다 맥길대학 인류학과)

본 논문은 캐나다 맥길 대학에 박사학위 청구 논문으로 제출된 연구로서, 한반도 중서부 지역 임진-한탄강 유역 구석기 공작의 장기간에 걸친 기술 조직의 변천을 고찰하고자 한다. 이 지역은 지난 78년에 경기도 연천군 전곡리의 발견을 필두로 하여, 아프리카 아슐리안 공작과 유사한 형태의 석기군이 대량으로 발견되서 국제적인 주목을 지속적으로 받아 왔지만 석기군의 연대에 대한 논란 및 석기군의 구체적인 성격과 그 발달 과정에 대한 탐구가 본격적으로 이루어지지 않은 아쉬움이 지속되어야만 했었다. 이러한 상황에 대해 본 논문은 기존 연구를 종합하고 아울러 답보 상태에 머무르고 있는 석기군의 연대 및 그 성격과, 유물군 사이에서 보이는 상호 변이의 시간상 전개 과정을 살펴보고자 하는데 그 목적을 두고 있다.

II장에서는 임진-한탄강 유역 구석기 공작의 기본적인 시공간적 배경에 해당하는 중기 홍적세부터 후기 홍적세 말기까지 동아시아의 전반적인 환경변화를 조망하고 있으며 아울러서 한반도 내에서 그 동안 축적된 홍적세 환경 연구를 요약하고 있다. 동아시아 중기 홍적세 이후의 환경은 구대륙 다른 지역과 마찬가지로 뚜렷한 온난-한냉의 주기가 반복되지만, 대체적으로 후기 홍적세 말기의 마지막빙하극성기까지 기후와 생물상의 쇠락이 관찰되고 있다. 그리고 이러한 점진적인 환경 변화에 수반되는 석기군의 양상은 동시기의 다른 지역에 해당하는 네안데르탈인의 무스테리안 공작과는 차별되는 변화를 보이는 것으로 가설을 세울 수가 있다. 한반도의 홍적세 연구는 기존 연구자들의 보수 민족주

의적 시각 및 자료에 대한 순진한 접근으로 인하여 아직까지 객관적인 해석이 미흡한 실정이다. 그러나 비록 단편적이고 요약이 힘든 산만한 자료의 성격 속에서 그 일반적인 경향을 찾을 수는 있는데, 한반도는 적어도 중기 홍적세의 후반부 이후부터 고인류의 점거가 이루어졌다는 증거가 현재까지 축적되어 있는 상태이며 식물자료나 동물자료를 통해서 볼 때 고인류의 점거 당시 한반도의 환경은 소위 빙하환경과도 같이 현재와 급격한 차이를 보이지는 않았던 것으로 짐작할 수 있다.

III장에서는 본 연구의 구체적인 현지조사 대상에 해당하는 임진-한탄강 유역의 지질사를 개관하고 아울러 그 동안 진행되어 온 연구들에 대한 학사적 조망을 하고 있다. 임진-한탄강 유역은 하계망의 부분에 따라 상호 다른 지형영력을 보여주고 있지만 대체적으로 선캠브리아기의 기반암 형성을 거치고 고하계망이 완성된 상태에서 홍적세 기간 동안 수차례에 거친 화산활동의 결과로 인하여 용암대지가 형성된 것으로 요약할 수 있다. 유적의 연대와 관련해서 가장 논란이 많은 부분은 바로 용암대지의 형성 연대에 해당하며, 이러한 연대 문제와 관련해서 지금까지 진행되어 온 논쟁들을 검토하고 각각의 주장을 다시 한번 재음미 하였다. 구체적으로, 지난 30년 동안 진행되어 온 임진-한탄강 구석기 연구에 대한 학사를 정리하면서 그 시대 구분을 크게 3단계로 제시하였다. 그리고 가장 최근의 연대 측정 및 임진-한탄강 유역의 지질사 복원에 해당하는 소위 30만년전 설에 대해, 자료 해석의 불완전함과 퇴적 형성과정에 대한 종합적 이해의 결여에 근거해서 비판을 하였으며 새로운 대안적 해석의 필요성을 제기하였다.

IV장에서는 이러한 필요성에 입각해서 본 논문의 집필 과정에서 실시된 야외 조사의 과정과 결과를 보고하고 있다. 우선 2002년에 발굴된 임진강 하류의 장산리 유적, 2003년에 한양대 문화재연구소와 서울대 박물관이 조사한 주월리/가월리 유적의 발굴 과정과 출토유물을 소개하고 있다. 그리고 2003년 말에서 2004년까지 서울대학교 지구시스템학부 퇴적학 실험실과 고고미술사학과 구석기 고고학 실험실이 공동으로 실시한 임진-한탄강 유역의 종합적 지형 조사와 절대 연대 측정을 상술하며, 이러한 과정에서 이루어

진 2004년도 전곡리 농협부지 유적의 발굴 과정 및 출토 유물들을 개관하였다. 마지막으로 직접적인 발굴조사가 이루어지지는 않았지만 본 논문에서 참고자료로 다루게 될 파주 금파리 유적과 연천 횡산리 유적 및 철원 장흥리 유적에 대한 기본적인 정보들을 소개하였다.

본 현지조사 과정에서 새롭게 채취된 샘플의 다양한 방식의 연대 측정에 기반하여 임진-한탄강 유역의 전반적인 연대폭을 설정할 수가 있었다. 일단 가장 오래된 연대 중에 하나에 해당하는 장산리 단구면의 경우 IRSL 연대 측정치를 통해서 대략 중기 홍적세 후반에 해당하는 23만년전의 연대가 얻어 졌다. 한탄강 유역 현무암반의 시초 연대를 탐구하기 위해 측정된 모래자갈층의 피션트랙 연대는 약 40만년전, 그리고 현무암반의 포타슘-아르곤 연대는 많은 문제를 안고 있음에도 불구하고 장산리 단구의 연대보다는 낮을 것이라는 전제와 기존 측정치의 재활용도를 검토해서 약 20- 13만년전의 연대를 추정할 수 있었다. 이러한 연대 추정치는 현무암반 퇴적층 상부의 하상퇴적층에서 얻어진 일련의 OSL연대군을 통해 납득할만한 수준의 신뢰를 가질 수 있으며 최종적으로 유물군이 집중적으로 발견되는 적갈색 점토층 최하부의 연대는 약 6만년에 해당한다는 증거를 얻을 수 있었다. 따라서 임진-한탄강 유역의 각 층서 단위는 대부분 후기 홍적세에 형성된 것으로 결론을 내릴 수 있으며 전곡리를 비롯한 임진-한탄강 중류역의 유적은 대략 OIS 3기에 해당한다는 것을 밝혀낼 수 있었다.

V장에서는 이러한 후기 홍적세 시기의 유물군에 해당하는 임진-한탄강 유역의 전반적인 석기군의 성격을 고찰하고 있다. 기존의 클라크-클라인디엔스트 방식의 형식분류 체계의 문제점을 지적하고 아울러 지금까지 대형 석기에 대한 연구성향의 집착으로 인하여 상대적으로 등한시되던 소형석기의 형식분류를 제시하였다. 대체적으로 이 지역의 석기군은 형식분류상에서 나타나는 변이폭이 적고 또 도구석기의 빈도가 낮아서 일괄적으로 공통적인 성격을 보유하는 것으로 인식이 되어왔지만 기본적인 석재의 구성이나 도구 석기의 원석으로 사용되던 박편 및 석괴, 그리고 석핵의 가공 수준에서 상호 간에 미

약하나마 차이를 보이는 것을 알 수 있다.

석기의 제작과정에서 일차적인 기준으로 인식되는 속성은 바로 고인류가 직접적으로 가공할 수 있는 역량을 반영하는 석기의 크기에 해당한다는 것을 알 수 있으며, 이러한 크기를 선택하는 과정에서 다양한 형태의 석기가 파생되는 것을 박리과정의 복원을 통해서 밝혀낼 수가 있었다. 한편 비교적 늦은 시기임에도 불구하고 주먹도끼가 잔존하는 요인에 대해서 기존에 제시된 주먹도끼의 기능 및 형태변이에 대한 다양한 해석들을 검토하였다. 결론적으로 임진-한탄강 유역의 주먹도끼는 동물자원보다는 식물자원에 더 큰 기반을 두고 있는 삼림지역의 생계경제에 비교적 적합한 선택적 우위를 점하는 특징이 있으며, 도구로서의 집약적 활용도가 높기 때문에 대체할만한 석기의 필요성이 부과되지 않아서 상당히 긴 시간 동안 그 생명력을 유지할 수 있다는 가설을 제시할 수 있었다.

VI장은 본 논문의 핵심적인 부분으로서, V장에서 제시한 미약하게나마 각 유적의 유물간에 보이던 변이를 구체적으로 입증하고 유물군의 시간적 변화에 대한 설명을 시도하는데 그 목적을 두고 있다. IV장에서 얻어진 절대 연대 측정치에 의거해서 시기적인 차이가 명백한 장산리, 전곡리, 가월리 유적의 석기군과 아울러 후기 구석기 유물군과의 비교를 위해서 장흥리 유적의 유물을 주 분석 대상에 포함하였다. 형태 변이가 뚜렷하지 않고 가공 방식이 불확실한 석기들의 변화과정을 추적하기 위해서 석기 형식 및 가공 방식에 좌우되지 않는 변수들인 입체크기, 평면크기, 세장도 등을 조작적으로 정의하였다. 구체적인 분석틀은 탐구적 자료 분석의 한 예인 서열 배치법을 선택하였으며 서열 배치법으로 그려지는 곡선의 형태 및 상호 관계를 통해서 석기의 크기 분포 및 세장도 분포의 몇가지 패턴을 설정할 수 있었다. 그리고 이러한 패턴에 기반해서 각 유물군 간에 차이를 규명하고 그러한 차이에 대한 설명을 시도하였다. 분석 결과를 통해, 임진-한탄강 유역의 석기군은 가시적인 현상인 형식간의 조합이나 석기 형태 면에서는 상호 동일한 수준으로 인지가 되지만 오히려 석기 제작을 직접적으로 반영하는 원석의 활용 및 도구 석기의 제작 패턴에서는 뚜렷한 시간적 변이를 보이는 것을 알 수 있었다. 특히 장산리의 조잡하면

서 지극히 일차적인 석기 가공 방식부터 전곡리와 주월리를 거치면서 후기 구석기의 장흥리에 이르기까지 석기 기술 조직의 진화에서 모종의 방향성이 발견되었다. 그리고 이러한 방향성은 석재의 질적 향상을 반영하며 동시에 고인류가 분별력과 집중력을 가지는 행위 양상의 변화를 통해서 이루어진 결과로 결론을 내릴 수가 있었다.

VII장은 본 논문의 결론이자 임진-한탄강 유역의 홍적세 역사에 대한 요약에 해당한다. 비교적 긴 시간 동안 이 지역에서 이루어진 지형 발달과 고인류의 행위 양식의 연관을 조망하기 위해서 브로델의 장기지속이라는 개념을 차용하였으며, 고인류의 점거 기간 동안 이루어진 다양한 지형 발달의 역동성을 화산활동 및 하계망 양상의 변화를 기준으로 해서 경관고고학적인 접근을 시도하였다. 이를 통해서 고인류의 대지 이용 양상 및 이에 수반하는 석기 제작 기술의 변화에 대한 거시적인 관점과 시간적 맥락을 확보할 수 있었다. 그리고 이러한 관점의 보완 및 본 연구에서 자료의 한계와 기타 여건으로 다루지 못한 여러가지 문제점들은 차후의 연구를 통해서 보완되어야 할 것이라고 진단을 내렸다.

BIBLIOGRAPHY

Aitken, M. J.

1997 Luminescence Dating. In *Chronometric Dating in Archaeology*, edited by R. E. Taylor and M. J. Aitken, pp.183- 216, Plenum Press, New York.

Akazawa, T., S. Oda, and I. Yamanaka

1980 *The Japanese Palaeolithic: a Techno-Typological Study*. Rippu-Shobo, Tokyo.

Ambiru, M.

1997 Upper Palaeolithic Culture in Japan and East Asia. *The Quaternary Research (Daiyonki Kenkyu)* 36(5): 347-9. (In Japanese)

Amick, D. S. and R. P. Mauldin

1997 Effects of raw material on flake breakage patterns. *Lithic Technology* 22(1): 19- 32.

Andrefsky, W. Jr.

1994 Raw-material availability and the organization of technology. *American Antiquity* 59(1): 21-34

1998 *Lithics- Macroscopic Approaches to Analysis*. Cambridge University Press, Cambridge.

Bae, Kidong

1983 On the characteristics of handaxes from Chongokni. *The Ancient Culture (Komunhwa)* 22: 1-23 (In Korean)

1988 *The Significance of the Chongokni Stone Industry in the Tradition of the Palaeolithic Culture in East Asia.* Unpublished PhD Dissertation. University of California. Berkeley.

1989 *Excavation Report of Chongokni (Campaign in 1986)*. Museum of Seoul National University, Seoul. (In Korean)

1992a Palaeolithic tradition of East Asia: Chongoknian. In *Proceedings of 1st International Symposium on Cultural Properties*. pp. 193-211, National Institute of Cultural Properties of Korea, Seoul.

1992b Palaeolithic Period. In *Retrospect and Prospect of Korean Prehistoric Archaeology* edited by Mongryong Choi. pp. 9- 75. Kachi Publishing, Co., Seoul. (In Korean)

1994 Excavation report of Locality 5. Chongokni (Campaign in 1991). In *Palaeolithic Excavation of Bosung and Hantan River*. edited by Y. Whang, M. Choi, and K.

Bae. pp. 235- 86. Institute of Cultural Properties, Seoul. (In Korean)

1995a Formation process of Chongokni and problems of understanding the cultural traditions. In *Commemorative Bulletin of Dr. Jungki Kim's Sexagenarian*. pp. 400-18, Committee of Monograph Publication, Seoul. (In Korean)

1995b Study of handaxe industry in Hantan-Imjin River Region. In *Ancient Culture of Asia- Commemorative Monograph of Dr. Yonghoon Whang's Retirement*. pp. 25-39. Hakyeon Munhwasa, Seoul. (In Korean)

2000 Comparative Archaeology in Prehistoric Culture in East Asia and East Africa. *Journal of the Korean Archaeological Society* 43: 1-39. (In Korean with English summary).

2002 Chongokni Palaeolithic site: Current Understandings. In *Palaeolithic Archaeology in Northeast Asia.* edited by Kidong Bae, pp. 55- 75, Institute of Cultural Properties in Hanyang University, Yeoncheon. (In Korean with English summary)

Bae, Kidong and Jaewon Ko

1993 *Excavation Report of Chongokni (Campaign in 1992)*. Dept. of Anthropology, Hanyang University and Yeonchon County. Yeonchon. (In Korean)

Bae, Kidong *et al.*

1996 *Report of Excavation of the Chongokni Palaeolithic Site 1994-'95*. Dept. of Anthropology, Hanyang University and Yeonchon County. Yeonchon. (In Korean)

1999 *The Keumpari Palaeolithic Site Report of Excavations in 1989~ 1992*. Korean National Research Institute of Cultural Properties, Seoul. (In Korean)

2001 *The Chongok Palaeolithic Site- report of Test-Pits Excavation, 2000- 2001.* The Institute of Cultural Properties of Hanyang University, Yeoncheon. (In Korean)

2004 Guidebook for Field Excavation Colloquium of Hoengsanri Palaeolithic Site. Institute of Cultural Properties in Hanyang University, Ansan (In Korean)

Bailey, R. M., B. W. Smith, and E. J. Rhodes

1997 Partial bleaching and the decay form characteristics of quartz OSL. *Radiation Measurements* 27: 12- 36.

Balescu, S. *et al.*

2001 IRSL dating of Middle Pleistocene interglacial sediments from southern Quebec (Canada) using multiple and single grain aliquots. *Quaternary Science Reviews* 20: 821- 4

Bamforth, D. B.

1986 Technological efficiency and tool curation. *American Antiquity* 51(1): 38-50.

Bar-Yosef, O.

2002 The Upper Paleolithic revolution. *Annual Review of Anthropology* 31: 363- 93.

2005 Between observations and models: an eclectic view of Middle Paleolithic Archaeology. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 305- 323, Springer Press, New York.

Bar-Yosef, O., and S. L. Kuhn

1999 The Big Deal about Blades: Laminar Technologies and Human Evolution. *American Anthropologist* 101(2): 322- 38

Barham, L. S. and L. Smart

1996 An early date for the Middle Stone Age of central Zambia. *Journal of Human Evolution* 30: 287- 90.

Barnes, G. L.

1993 *The Rise of Civilization in East Asia: the Archaeology of China, Korea and Japan.* Thames and Hudson, London.

Barton, C. M.

1990 Beyond style and function: a view from the Middle Palaeolithic. *American Anthropologist* 92(1): 57-72.

1991a Retouched tools, fact or fiction? Paradigms for interpreting Palaeolithic chipped stone. In *Perspectives on the Past.* edited by G. A. Clark. pp. 143-63. University of Pennsylvania Press. Philadelphia.

1991b Technological organization and hunter-gatherer land use: a California example. *American Antiquity* 56: 216- 34.

Barton, C. M. *et al.*

2004 Long-term socioecology and contingent landscapes. *Journal of Archaeological Method and Theory* 11(3): 253- 94.

Bartz, P. M.

1972 *South Korea.* Clarendon Press. Oxford.

Berger, G. W.

1990 Effectiveness of natural zeroing of the thermoluminescence in sediments. *Journal of Geophysical Research* 95: 375- 97.

Binford, L. R.

1972 Contemporary model building: paradigms and the current state of Palaeolithic research. In *Models in Archaeology.* edited by D. L. Clarke. pp. 109-66. Methuen. London.

1973 Interassemblage variability- the Mousterian and the "functional' argument. In *The Explanation of Culture Change*, edited by C. Renfrew, pp. 227- 54, Duckworth, London.

1979 Organization and formation process: looking at curated technologies. *Journal of*

Anthropological Research 35: 255-73.
1980 Willow smoke and dogs' tail: hunter-gatherer settlement systems and archaeological site formation. *American Antiquity* 45(1): 4- 20
1982 The archaeology of place. *Journal of Anthropological Archaeology* 1: 5- 31.
1983 *In Pursuit of the Past.* Thames and Hudson. London.
1989 Styles of style. *Journal of Anthropological Archaeology* 8: 51- 67.

Binford, L. R., and S. R. Binford
1966 A preliminary analysis of functional variability in the Mousterian of Levallois facies. *American Anthropologist* 68(2): 238- 95.

Binford, L., and J. O'Connell
1984 An Alyawara day: the stone quarry. *Journal of Anthropological Research* 40: 406-32.

Bisson, M. S.
1990 Lithic reduction sequences as an aid to the analysis of Late Stone Age quartz assemblages from Luano Spring, Chingola, Zambia. *African Archaeological Review* 8: 103-38.
2000 Nineteenth century tools for twenty-first century archaeology? Why the Middle Palaeolithic typology of Francois Bordes must be replaced. *Journal of Archaeological Method and Theory* 7(1): 1- 48.
2001 Interview with a Neanderthal: an experimental approach for reconstructing scraper production rules, and their implications for imposed form in Middle Palaeolithic tools. *Cambridge Archaeological Journal* 11(2): 165- 84.

Bleed, P.
1986 The optimal design of hunting weapons: maintainability or reliability. *American Antiquity* 51(4): 737- 47.

Boëda, E., J. –M. Geneste and L. Meignen
1990 Identification de chaînes opératoires lithiques du Paléolithique ancient et moyen. *Paléo* 2: 43- 80.

Bordes, F.
1961 *Typologie du Paleolithique ancien et moyen*. Delmars, Bordeaux.
1969 Reflections on typology and techniques in the Palaeolithic. *Arctic Anthropology* 6: 1- 29.

Bordes, F., and D. de Sonneville-Bordes
1970 The significance of variability in Palaeolithic assemblages. *World Archaeology* 2(1): 61- 73.

Bowen, G.

1978 Report on the stone tools from Chongokni. *Jindan Review of History (Jin Dan Hak Bo)* 46/47: 48- 55.

Brown, A. C.

1997 *Alluvial geoarchaeology- Floodplain Archaeology and Environmental Change.* Cambridge University Press, Cambridge.

Bradbury, A. P., and P. J. Carr

1991 Flake typologies and alternative approaches: an experimental assessment. *Lithic Technology* 20(2): 100-15.

Bradley, B. A.

1975 Lithic reduction sequences: A glossary and discussion. In *Lithic Technology*, edited by E. H. Swanson, pp. 5-14. Mouton. The Hague.

Bradley, B. A., and Y. Giria

1992 Concepts of the technological analysis of flaked stone: a case study from the high arctic. *Lithic Technology* 21(1): 23-39.

Brantingham, P. J.

1998 Mobility, competition, and Plio-Pleistocene hominid foraging groups. *Journal of Archaeological Method and Theory* 5(1): 57- 98.

Brantingham, P. J. *et al.*

2000 Raw material quality and prepared core technology in Northeast Asia. Journal of *Archaeological Science* 27: 255- 271.

Braudel, F.

1972 The Mediterranean and the Mediterranean World in the Age of Philip II (vol. 1). Harper and Row, New York.

1980 History and the social sciences: the *longue durée.* In *On History*, pp. 25- 54. University of Chicago Press, Chicago.

Butcher, K. W.

1982 *Archaeology as Human Ecology: Method and Theory for a Contextual Approach.* Cambridge University Press, Cambridge.

Byers, A. M.

1999 Communication and material culture: Pleistocene Tools as Action Cues. *Cambridge Archaeological Journal* 9(1): 23- 41.

Chang, Namki

1983 Biiological environment of the Chongokni Palaeolithic site. In *Chongokni,* pp. 563-576, National Institute of Cultural Properties of Korea, Seoul. (In Korean)

Chappell, J., and N. J. Shackleton

1986 Oxygen isotopes and sea level. *Nature* 324: 137- 40.

Chase, P. G.

1991 Symbols and Paleolithic artifacts style, standardization, and the imposition of arbitrary form. *Journal of Anthropological Archaeology* 10: 193- 214.

Chazan, M.

1995 Conceptions of time and the development of Paleolithic chronology. *American Anthropologist* 97(3): 457- 67.

Chatters, J. C.

1987 Hunter-gatherer adaptations and assemblage structure. *Journal of Anthropological Archaeology* 6: 336- 375.

Cheong, C. S. *et al.*

2002 Optical dating of the last interglacial marine terrace deposits in southeastern Korean peninsula. In *Proceedings of the 10th International Conference on Luminescence and Electron Spin Resonance Dating*, pp. 92, University of Nevada, Reno.

Choi, Bok Kyu *et al.*

2001 *The Janghung-ri Palaeolithic Site.* Institute of Kangwon Archaeology. Chuncheon (In Korean)

Choi, Jeong Heon *et al.*

2003a Luminiscence dating of well-sorted marine terrace sediments on the southeastern coast of Korea. *Quaternary Science Reviews* 22: 407- 21.

2003b The resolution of stratigraphic inconsistency in the luminescence ages of marine terrace sediments from Korea. *Quaternary Science Reviews* 22: 1201- 6.

2004a Age estimate of the Chongok Basalt with Luminescence dating: preliminary result. In *Proceedings of Annual Joint Conference,* pp. 7- 9, Petrological Society and Mineralogical Society of Korea, Cheongju.

2004b Principles of quartz OSL dating and its geological applications. *Journal of the Geological Society of Korea* 40(4): 567- 83.

Choi, Kwang-Hee, Jong-Wook Kim and Kennedy Munykwa

2005 Shallow subsurface investigation in the Chongokni Area, Korea, using the seismic refraction method. *Journal of the Korean Geomorphological association* 12: 39- 50.

Choi, Moo-Jang

1991 *Excavation Report of Namkyeri Palaeolithic Site.* National Institute of Cultural Properties of Korea, Seoul. (In Korean)

1994 Report on the 2nd Excavation of Namkyeri Palaeolithic Site. In *Palaeolithic Excavation of Bosung and Hantan River*. edited by Y. Whang, M. Choi, and K.

Bae. pp. 63- 234, Institute of Cultural Properties, Seoul. (In Korean)

1997 *Report on the Excavation of the Palaeolithic site at Wondangri, Jangnam-mien, Yeoncheon County, Kyonggi Province.* Kon-Kuk University Museum, Seoul. (In Korean)

Chowdhury, M. E. K, et al.

2001 Eolian Dust Deposition in the Last Glacial Stage (43- 12ka) in Tanigumi Moor, Gifu Prefecture, Central Japan. *The Quaternary Research (Daiyonki Kenkyu)* 40(3): 211-8.

Christensen, A. L.

1982 Maximizing clarity in economic terminology. *American Antiquity 47*(4): 419- 26.

Chun, Jong-Hwa, K. Ikehara, and Sang-Joon Han

2004 Evidence in Ulleung Basin sediment cores for a termination II (Penultimate deglaciation) eruption of the Aso-3 tephra. *The Quaternary Research (Daiyonki Kenkyu)* 43(2): 99- 112.

Chung, Young-Hwa

1996 Problems of studies of North Korean Palaeolithic cave sites. In *Proceedings of International Symposium on the Palaeolithic Cave Sites and Culture in Northeast Asia.* edited by Yung-Jo Lee. pp. 23- 37, Chungbuk National University Museum, Cheongju. (In Korean)

2002 Current issues and problems in Korean Palaeolithic research. In *Palaeolithic Archaeology in Northeast Asia.* edited by Kidong Bae, pp. 13- 29, Institute of Cultural Properties in Hanyang University, Yeoncheon. (In with English Korean summary)

Clark, G. A.

1982 Quantifying archaeological research. In *Advances in Archaeological Method and Theory, vol. 5*, edited by M. B. Schiffer, pp.217- 73, Academic Press, New York. .

1989 Romancing the Stones: Biases, Style and Lithics at La Riera, In *Alternative Approaches to Lithic Analysis*, edited by D. Henry and G. Odell, pp. 27- 50, Archaeological Papers of the American Anthropological Association No. 1

1992 Continuity or replacement? Putting modern human origins in an evolutionary context. In *The Middle Palaeolithic: Adaptation, Behavior and Variability*, edited by H. L. Dibble, and P. Mellars, pp. 183- 206, The University Museum of University of Pennsylvania, Philadelphia.

Clark, G. A. and J. M. Lindley

1989 The case for continuity: observations on the biocultural transition in Europe and western Asia. In *The Human Revolution: Behavioral and Biological Perspectives* *on the Origins of Modern Humans*, edited by P. Mellars and C. Stringer, pp. 626-76, Edinburgh University Press, Edinburgh.

1991 Paradigmatic biases and Palaeolithic research traditions. *Current Anthropology* 32: 577-87.

Clark, G. A. and J. Riel-Salvatore

2005 Observations on Systematics in Paleolithic Archaeology. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 29- 56, Springer Press, New York.

Clark, J. D.

1982 Report on the visit to Palaeolithic site in Korea. *The Cultural Properties (Munhwajae)* 15: 134- 40.

1992 African and Asian perspectives on the origins of modern humans. *Philosophical Transactions of Royal Society* B. 337: 201-15.

1998 The Early Palaeolithic of the eastern region of the Old World in comparison to the West. In *Early Human Behavior in Global Context – The Rise and Diversity of the Lower Palaeolithic Record*, edited by M. Petraglia and R. Korisettar, Routledge, London.

Clark, J. D., and M. Kleindienst

1974 The Stone Age cultural sequence: terminology, typology and raw material. In *Kalambo Falls. Vol. II.* edited by J. D. Clark *et al.* pp. 77- 106, Cambridge, Cambridge University Press.

Close, A. E.

1979 The identification of style in lithic artifacts. *World Archaeology* 10(2): 223- 37.

2000 Reconstructing movement in prehistory. *Journal of Archaeological Method and Theory* 7(1): 49- 77.

Collier, S.

1989 The influence of economic behavior and environment upon robusticity of the post-cranial skeleton: a comparison of Australian Aborigines and other populations. *Archaeology of Oceania* 24: 17- 30

Cowans, F. L.

1999 Making sense of flake scatters: lithic technological strategies and mobility. *American Antiquity* 64(4): 593- 607

Danhara, T.

2001 Testing age determination of the Chongok Basalt: approach by FT dating method. In *The Chongok Palaeolithic Site- report of Test-Pits Excavation, 2000- 2001,* edited by Kidong Bae *et al.* pp. 286- 288, The Institute of Cultural Properties of

Hanyang University, Yeoncheon.

2003 Tephrochronology of Quaternary sediments in the Korean Peninsula- Applications, significance, and future possibilities. In *Geological Formation of the Chongokni Palaeolithic Site and Palaeolithic Archaeology in East Asia.* edited by Kidong Bae *et al.*, pp. 125- 34, Yeoncheon County and the Institute of Cultural Properties of Hanyang University, Yeonchon.

Danhara *et al.*

2002 What is the real age of the Chongokni Palaeolithic site? In *Palaeolithic Archaeology in Northeast Asia.* edited by Kidong Bae, pp. 77- 116, Institute of Cultural Properties in Hanyang University, Yeoncheon. (In with English Korean summary)

Davidson, I. and W. Noble

1993 Tools and Language in Human Evolution. In *Tools, Language and Cognition.* edited by K. Gibson and T. Ingold, pp. 363-388, Cambridge University Press, New York:

Débenath, A., and H. Dibble

1994 *Handbook of Palaeolithic Archaeology vol. 1: The Lower and Middle Palaeolithic of Europe.* University of Pennsylvania Museum Press. Philadelphia.

Delagnes and L. Meignen

2005 Diversity of lithic production systems during the Middle Paleolithic in France. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 85- 107, Springer Press, New York.

Dibble, H. L.

1984 Interpreting typological variation of Middle Palaeolithic scrapers: Function, Style, or Sequence of Reduction? *Journal of Field Archaeology* 11(3); 431-6

1987 The interpretation of Middle Palaeolithic scraper morphology. *American Antiquity* 52(1): 109-17

1995 Middle Palaeolithic scraper reduction: background, clarification, and review of the evidence to date. *Journal of Archaeological Method and Theory* 2(4): 299- 368.

Ding, Zhongli

1991 Pedostratigraphy of Chinese loess and Quaternary climatic Fluctuation. In *Quaternary Geology and Environment in China*, edited by Liu Tungsheng, pp. 168- 172, Science Press, Beijing.

Dobres, M. A.

2000 *Technology and Social Agency.* Blackwell, Oxford.

Dobres, M. A. and C. R. Hoffman

1994 Social agency and the dynamics of prehistoric technology. *Journal of Archaeological method and Theory* 1(3): 211- 58.

Eden, D. N. *et al.*

1996 Volcanic glass found in late quaternary Chinese loess: a pointer for future studies?. *Quaternary International* 34-36: 107-11.

Falconer, S. E. and S. H. Savage

1995 Heartlands and hinterlands: Alternative trajectories of early urbanization in Mesopotamia and the southern Levant. *American Antiquity* 60(1): 37- 58.

Feblot-Augustins, J.

1993 Mobility strategies in the Late Middle Palaeolithic of Central Europe and Western Europe: elements of stability and variability. *Journal of Anthropological Archaeology* 12: 211- 65.

Fisher, L. E.

2006 Blades and microliths: Changing contexts of tool production from Magdalenian to Early Mesolithic in southern Germany. *Journal of Anthropological Archaeology* 25: 226- 38.

Fitzhugh, B.

2001 Risk and invention in human technological evolution. *Journal of Anthropological Archaeology* 20: 125- 67.

Fleischer, R. L., P. B. Price, and R. M. Walker

1975 *Nuclear Tracks in Solids: Principles and Applications.* University of California Press, Berkeley.

Fletcher, R.

1992 Time perspectivism, *Annales*, and the potential of archaeology. In *Archaeology, Annales and Ethnohistory,* edited by A. Bernard Knapp, pp. 35- 49, Cambridge Univ. Press: Cambridge.

Gamble, C.

1986 *The Palaeolithic Settlement of Europe.* Cambridge University Press, Cambridge.

1993 *Timewalkers: the Prehistory of Global Colonization.* Harvard University Press. Cambridge.

1996 Making tracks: hominid networks and the evolution of the social landscape. In *The Archaeology of Human Ancestry: Power, Sex, and Tradition*, edited by J. Steele and S. Shennan, pp. 253- 277. Routledge, London.

1998 Palaeolithic society and the release from proximity: a network approach to intimate relations. *World Archaeology* 29(3): 426- 49.

1999 *The Palaeolithic Societies of Europe.* Cambridge University Press, Cambridge.

2004 Social Archaeology and the Unfinished Business of the Paleolithic. In *Explaining Social Change: studies in Honour of Colin Renfrew.* edited by J. Cherry, C. Scarre, and S. Shennan, pp. 7- 26. McDonald Institute for Archaeological Research. Cambridge.

Gamble, C. and G. Marshall

2001 The shape of handaxes, the structure of the Acheulian world. In *A Very Remote Period Indeed- Papers on the Palaeolithic Presented to Derek Roe.* edited by S. Milliken and J. Cook, pp.19- 27, Oxbow Books, Oxford.

Gamble, C. and M. Porr

2005 From empty spaces to lived lives: Exploring the individual in the Palaeolithic. In *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic Landscapes, Locales and Artifacts.* edited by C. Gamble and M. Porr, pp. 1- 12, Routledge, London.

Gao, X. and C. J. Norton

2001 A critique of the Chinese 'Middle Palaeolithic.' *Antiquity* 76: 397- 412.

Giddens, A.

1984 *The Constitution of Society- Outline of the Theory of Structuration.* Polity Press, Cambridge.

Gilman, A.

1984 Explaining the Upper Palaeolithic Revolution. In *Marxist Perspectives in Archaeology*, edited by M. Spriggs, pp. 115- 26. Cambridge University Press, Cambridge.

Gravina, B.

2004 Agency, technology, and the 'Muddle in the Middle': the case of the Middle Palaeolithic. In *Agency Uncovered: Archaeological Perspectives on Social Agency, Power, and being Human.* edited by A. Gardner, pp. 66- 78. UCL Press, London.

Guillou, H., Garcia, M.O., and Turpin, L.,

1997 Unspiked K-Ar dating of young volcanic rocks from Loihi and Pitcairn hot spot sea mounts. *Journal of Volcanology and Geothermal Research* 78: 239-249.

Han, Chang-Gyun

1990 *Prehistoric Archaeology of North Korea(Ed.).* Baeksan Munhwasa. Seoul. (In Korean)

1996 The Byeongsanri prehistoric site. *Prehistoric Culture (Seonsa Munhwa)* 4: 31- 54. (In Korean)

2003 On the problems of the dates of Korean Palaeolithic sites. *Journal of the Korean Palaeolithic Society* 7: 1- 39.

Hayden, B. N.

1979 *Palaeolithic Reflections: Lithic Technology and Ethnographic Excavation among Australian Aborigines.* New Jersey: Humanities Press Inc, New Jersey.

1989 From chopper to celt: the evolution of resharpening techniques. In *Time, Energy, and Stone Tools*, edited by R. Torrence, pp. 7- 16, Cambridge University Press, Cambridge

Hayden, B., N. Franco, and J. Spafford

1996 Evaluating lithic strategies and design criteria. In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by G. H. Odell, pp. 9- 49, Plenum Press, New York.

Hodder, I.

1987 The contribution of the long term. In *Archaeology as Long-Term History*. edited by I. Hodder, pp. 1- 8, Cambridge University Press, Cambridge.

1998 Creative thought: a long-term perspective. In *Creativity in Human Evolution and Prehistory*. edited by S. Mithen, pp. 61- 77, Routledge, London.

Hopkinson, T., and M. J. White

2005 The Acheulian and the handaxe: structure and agency in the Palaeolithic. In *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic Landscapes, Locales and Artifacts*. edited by C. Gamble and M. Porr, pp. 13- 28, Routledge, London.

Hosfield, R. T.

2005 Individuals among palimpsest data: fluvial landscapes in Southern England. In *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic Landscapes, Locales and Artifacts*. edited by C. Gamble and M. Porr, pp. 220- 43, Routledge, London.

Hosfield, R. T. and J. C. Chambers

2005 Pleistocene geochronologies for fluvial sedimentary sequences: an archaeologist's perspective. *Journal of Quaternary Science* 20(3): 285- 96.

Hovers, E., and A. Belfer-Cohen

2005 "Now You See it, Now You Don't"- Modern human behavior in the Middle Palaeolithic. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 295- 304, Springer Press, New York.

Hovers, E., and S. L. Kuhn (eds.)

2005 *Transitions before the Transition*. Springer Press, New York.

Hwang, Sohee

2003 Tephra analysis of EssS20-IV pit at Chongokni, Korea. In *Palaeolithic Archaeology in Northeast Asia*. edited by Kidong Bae, pp. 75- 76, Institute of

Cultural Properties in Hanyang University, Yeoncheon. (In Korean with English summary)

Hyodo, Masayuki

1999 Recent progress in paleomagnetic and rock-magnetic studies of the Quaternary in Japan. *The Quaternary Research (Daiyonki Kenkyu)* 38(3): 202- 8.

Ikawa-Smith, F.

1978 Introduction: The Early Palaeolithic tradition of East Asia. In *Early Palaeolithic in South and East Asia*, edited by F. Ikawa-Smith, pp. 1-11. Mouton, The Hague.

1999 Construction of national identity and origins in East Asia: a comparative perspective. *Antiquity* 73: 626- 9.

2004 Humans along the Pacific margin of northeast Asia before the Last Glacial Maximum. In *Entering America: Northeast Asia and Beringia before the Last Glacial Maximum.* edited by D. B. Madsen, pp. 285- 309, The University of Utah Press, Salt Lake City.

Imamura, K.

1996 *Prehistoric Japan*, University of Hawaii Press, Honolulu

Inizan, M. L., H. Roche and J. Tixier

1992 *Technology of Knapped Stone*. CREP, Meudon.

Isaac, G. LL.

1969 Studies of Early Culture in East Africa. *World Archaeology* 1:1-28.

1977a *Olorgesailie: Archeological Studies of a Middle Pleistocene Lake Basin in Kenya.* The University of Chicago Press, Chicago.

1977b Squeezing blood from stones. In *Stone Tools as Cultural Markers: Change, Evolution and Complexity*, pp. 5- 12, edited by R. V. S. Wright, Australian Institute of Aboriginal Studies, Canberra

1981 Towards the interpretation of occupation debris: some experiments and observation. In *The Archaeology of Human Origins: Papers by Glynn Isaac*, edited by B. Isaac, pp. 191- 205, Cambridge University Press, Cambridge.

Jelinek, A. J.

1994 Hominids, energy, environment, and behavior in the Late Pleistocene. In *Origins of Anatomically Modern Humans*, edited by M. H. Nitecki and D. V. Nitecki, Plenum Press, New York.

Jeske, R.

1989 Economics in raw material use by prehistoric hunter-gatherers. In *Time, Energy, and Stone Tools*, edited by R. Torrence, pp. 34- 45, Cambridge University Press, Cambridge

Jeske, R. J., and R. Lurte

1993 The archaeological visibility of bipolar technology: an example from the Koster Site. *Midcontinental Journal of Archaeology* 18: 131- 60

Jia, Lanpo and Weiwen Huang

1985 On the recognition of China's Palaeolithic Cultural Traditions. In *Paleoanthropology and Palaeolithic Archaeology in the People's Republic of China.* edited by R. Wu and J. W. Olsen, pp. 259- 265, Academic Press, New York.

Jochim, M. A.

1998 *A Hunter-Gatherer Landscape: Southwest Germany in the Late Paleolithic and Mesolithic.* Plenum Press, New York.

Keats, S. G.

1997 Analyzing modern Human Origins in China. In *Conceptual Issues in Modern Human Origins Research.* edited by G. A. Clark and C. M. Willermet. pp. 283- 94, Aldine de Gruyter, New York.

Kelly, R. L.

1988 The three side of a biface. American Antiquity 53(4):717- 34

1992 Modility/sedentism: concepts, archaeological measures, and effects. *Annual Review of Anthropology* 21: 43- 66.

1995 *The Foraging Spectrum: diversity in hunter-gatherer lifeways.* Smithsonian Institution Press. Washington D. C.

Kim, Bok Chul *et al.*

2004 Paleomagnetic and soil chemical studies on the Quaternary paleosol around the Hantan River. *Economic Environmental Geology of Korea* 37(3): 325- 334.

Kim, Ju-Yong, Dong-Young Lee and Sung-Kil Choi

1998 A research on Pleistocene stratigraphy: an Overview. *The Korean Journal of Quaternary Research* 12: 77- 87. (In Korean)

Kim, Ju-Yong *et al.*

2003 Landscape, stratigraphy, and material contexts of prehistory archaeological sites in Hantan River valleys of Korea in special comparison with the Suyanggae Palaeolithic Site. In *Geological Formation of the Chongokni Palaeolithic Site and Palaeolithic Archaeology in East Asia.* edited by Kidong Bae *et al.*, pp. 55- 62, Yeoncheon County and the Institute of Cultural Properties of Hanyang University, Yeonchon.

Kim, Kwang Ho and Moo-Young Song

1995 Structure and physical properties of the mid-west crust of Korea: Paleomagnetism of the Cretaceous volcanic rocks in Jeongog (Chonkok)-Yeoncheon area. *Journal of Korean Earth Science Society* 16(1): 65- 73.

Kim, Kyu Han and Hyun Joo Lee

1994 Geochemistry and K-Ar age of Gabbroic rocks in the Konamsan area of Yeonchon Province, South Korea. *Economic Environmental Geology of Korea* 27(1): 29- 39.

Kim, Myoung-Jin

2005 OSL dating of Palaeolithic sediments at Chongokni, Yeoncheon. In *Report of 2004's Excavation Campaign at Chongokni.* edited by Yi, Seonbok, Yongwook Yoo, and Dongwan Kim, Seoul National University Museum, Seoul. (In Press)

Kim, Shin-Kyu *et al.*

1985 *Report on the Excavation Works in the vicinity of Pyongyang City.* Vol. 14 of The Excavation Report Series, Institute of Archaeology of North Korea, Pyongyang.

Kim, Wonyong and Kidong Bae

1983 Excavation of the Chongokni site: 1979- 1983. In *Chongokni,* pp. 1- 158, National Institute of Cultural Properties of Korea, Seoul. (In Korean)

Kim, Wonyong and Young-Hwa Chung

1979 Preliminary repot on the Chongokni Acheulian Industry. *Jindan Review of History (Jin Dan Hak Bo)* 46/47: 7- 47.

Kim, Wonyong, Young-Hwa Chung and Moo-Jang Choi

1981 *Study of Korean Palaeolithic Culture*. Korean Institute of Humanistic Study, Seoul (In Korean)

Klein, R.

2001 Fully modern humans. In *Archaeology at the Millennium.* edited by G. M. Feinman, and T. D. Price, pp. 109- 135; Kluwer Academic/Plenum Publishers, New York.

Klein, C. and C. S. Hurlbut, Jr.

1985 *Manual of Mineralogy (21st Ed.)*. John Wiley & Sons, Inc. New York.

Kleindienst, M. R.

2005 On naming Things- Behavioral Changes in the Later Middle to Earlier Late Pleistocene, Viewed from the Eastern Sahara. In *Transitions before the Transition,* edited by E. Hovers and S. L. Kuhn, pp. 13- 28, Springer Press, New York.

Knapp, A. B.

1992 Archaeology and Annales : time, space and change. In *Archaeology, Annales and Ethnohistory,* edited by A. Bernard Knapp, pp. 1-21, Cambridge Univ. Press: Cambridge.

Knapp, A. B., and W. Ashmore

1999 Archaeological Landscapes: Constructed, Conceptualized, Ideational. In *Archaeologies of Landscape*, edited by W. Ashmore and A. B. Knapp, pp. 1- 31, Blackwell, Malden.

Kobayashi, H.

1975 The experimental study of bipolar flakes. In *Lithic Technology- Making and Using Stone Tools.* edited by E. Swanson, pp. 115- 27, Mouton, The Hague.

Kojima, M.

1983 Dating of the basalt from the Chongokni Palaeolithic site. In *Chongokni,* pp. 586-588, National Institute of Cultural Properties of Korea, Seoul. (In Japanese)

Koto, B.

1903 An orographic sketch of Korea. *Journal of College of Science in the Imperial University of Tokyo*, vol. 19, Art. I. (In Japanese)

Kooyman, B.

2000 *Understanding Stone Tools and Archaeological Sites.* University of New Mexico Press, Albuquerque

Kukla, G. J. et al.

2002 Last Interglacial Climates. *Quaternary Research* 59:2- 13

Kuhn, S. L.

1990 A geometric index of reduction for unifacial stone tools. *Journal of Archaeological Science* 17(4): 583- 593.

1991 Unpacking reduction: lithic raw-material economy in the Mousterian of West-Central Italy. *Journal of Anthropological Archaeology* 10: 76- 106.

1992a On planning and curated technologies in the Middle Paleolithic. *Journal of Anthropological Research* 48: 185- 214.

1992b Blank form and reduction as determinants of Mousterian scraper morphology. *American Antiquity 57(1)*: 115- 28.

1994 A formal approach to the design and assembly of mobile toolkits. *American Antiquity* 59: 426- 42/

1995 *Mousterian Lithic Technology: an Ecological Perspective.* Princeton University Press, Princeton.

2005 Trajectories of Change in the Middle Paleolithic of Italy. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 109- 547, Springer Press, New York.

Kwon, Hyeok-jae

1987 *The Geography of Korea.* Beobmunsa, Seoul. (In Korean)

Kwon, Haksoo

1996 Quantitative analysis of *Cervus* bones from Turubong Chonyogul Cave. In *Proceedings of International Symposium on the Palaeolithic Cave Sites and Culture in Northeast Asia.* edited by Yung-Jo Lee. pp. 99- 106, Chungbuk National University Museum, Cheongju. (In Korean)

1998 Analysis of assemblage composition of animal bones from palaeolithic sites: principles and application. *Journal of the Korean Archaeological Society* 38: 1- 25. (In Korean)

Lee, Dai Sung, Ki Ju Ryu, and Gwang Ho Kim

1983 Geotectonic interpretation of Chugaryong Rift Valley, Korea. *Journal of Geological Society of Korea* 19(1): 19- 38.

Lee, Hyeong Woo

2001 The Palaeolithic industries in Korea: chronology and related new find-spots. In *A Very Remote Period Indeed- Papers on the Palaeolithic Presented to Derek Roe.* edited by S. Milliken and J. Cook, pp.133- 7, Oxbow Books, Oxford.

Lee, Kiehwa, Byung Doo Kwon, and Tae Woo Chang

1987 Seismicity of the Korean Peninsula: 3. Seismicity of the Kyeonggi Massif. *Journal of the Geological Society of Korea* 23(3): 257- 76.

Lee, Dong-Young

1987a Preliminary Study of Quaternary Deposits in Korea and first approximation of their lithostratigraphical position. In *Geobound* edited by Vrije Universiteit van Brussel, pp. 27- 40. Brussel.

1987b Stratigraphical research of the Quaternary deposits in the Korean Peninsula. *The Korean Journal of Quaternary Research 1*: 3- 20.

1990 Palaeoenvironmental implication of the Quaternary gravel sequence on the basis of gravel shape. *The Korean Journal of Quaternary Research 4*: 41- 57.

1997 Present state of coastal development in the Korean Peninsula. In *Sustainable Development and Geohazards in the Coastal Areas of East and Southeast Asia*, edited by Korea Institute of Geology, Mining and Materials, pp. 93- 100, Seoul.

Lee, Dong-Young and Ju-Yong Kim

1990 Geological excursion for Quaternary terrace deposits and their stratigraphy along the East Coast of the Korean Peninsula. In *Proceedings of International Symposium on the Quaternary Natures.* edited by Koran Society of Geology and Korean Institute of Geology, Mining, and Materials, pp. 1- 33, Seoul.

Lee, Dong-Young, Ju-Yong Kim and Chang-Kyun Han

1993 Field excursion for Quaternary terrace and palaeolithic sites in Han River area and the Eastern Coastal Area. In *Bulletin on the Second Field Excursion of the*

Quaternary Working Group in Korea. pp. 1- 21, Seoul.

Lee, Min-Boo *et al.*

2001 Analysis of depositional environment of confluent alluvial fan in Yeonchon Fault Area of Chugaryong Rift Valley. *Journal of Geological Society of Korea* 37(3): 345- 64.

Lee, Yong-Il

2004 Sediments of Jangsanri Site. In *Jangsan-ri: A Lower Palaeolithic Site in Paju, Korea.* edited by Seonbok Yi, Seoul National University Museum, Seoul. (In Korean)

Lee, Yong-Il and Seonbok Yi

2002 Characteristics of Pyongchangni Palaeolithic site paleosols: implication for archaeological application. *Journal of the Geological Society of Korea* 38 (3): 471-487.

Lee, Youn Soo, Kyung Duk Min, and Jae Ha Hwang

2001 The geodynamic evolution of the Chugaryeong fault Valley in a viewpoint of palaeomagnetism. *Economic Environmental Geology of Korea* 34(6): 555- 71.

Lee, Yung-Jo

1976 Some examples of newly discovered artifacts from Palaeolithic tradition. *Journal of Baeksan Academy (Baek San Hak Bo)*20: 5- 66. (In Korean)

1978 Pattern of Korean prehistoric arts. *Ancient Culture (Ko Mun Hwa)* 16: 2- 11. (In Korean)

1979 An approach to the Human Face Sculpture of the prehistoric period. *Journal of the UNESCO Korean Committee* 19(5): 33- 38

1983 A study on the reconstruction of Palaeolithic society at Turubong Cave No.2. *The Study of the Korean History 42 (Han Kuk Sa Yeon Gu)*: 1- 36.

Lemonnier, P.

1986 The study of material culture today: toward an anthropology of technical systems. *Journal of Anthropological Archaeology* 5: 147- 86.

Lim, Hyoun-Soo *et al.*

2004 A preliminary study of large burrows at Jeongok and Naju palaeolithic sites, Korea. *Journal of Geological Society of Korea* 40(4): 559- 66.

Liu, Li

1996 Settlement patterns, chiefdom variability, and the development of early states in north China. *Journal of Anthropological Archaeology* 15(2): 237- 88.

Luedtke, B.

1978 Chert sources and trace-element analysis. *American Antiquity* 43(3): 413-23.

1979 The identification of sources of chert artifacts. *American Antiquity* 44(4): 744-56.

1984 Lithic material demand and quarry production In *Prehistoric Quarries and Lithic Production,* edited by J. E. Ericsson and B. A. Purdy, pp. 65- 76, Cambridge University Press, Cambridge.

1992 *An Archaeologist's Guide to Chert and Flint*. University of California Press, Los Angeles

Machida, H.

1999 Quaternary widespread tephra catalog in and around Japan. *The Quaternary Research (Daiyonki Kenkyu)* 38(3): 194- 201

Machida H. and F. Arai

2003 *A New Atlas of Tephras: the Japanese Archipelago and its vicinity*. University of Tokyo Press. Tokyo. (In Japanese)

Marks, A. E. *et al.*

2001 Tool standardization in the Middle and Upper Palaeolithic: a closer look. *Cambridge Archaeological Journal* 11: 17- 44.

Matsufuji, K., *et al.*

2005 New progress of studies at the Chongokni Palaeolithic Site, Korea: Korea-Japan Cooperative Project in 2001- 2004. *Palaeolithic Archaeology (Kyuseki Kogugaku)* 66: 1- 16. (In Japanese)

Mallol, C.

1999 The selection of lithic raw materials in the Lower and Middle Pleistocene levels TG6 and TD10A of Gran Dolina (Sierra de Atapuerca, Burgos, Spain). *Journal of Anthropological Research* 55: 384- 405

McBrearty, S.

1988 The Sangoan-Lupemban and Middle Stone Age sequence at the Muguruk site, western Kenya. *World Archaeology* 19: 288- 420.

McBrearty, S. and A. S. Brooks

2000 The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution* 39(5): 453- 563.

McBrearty, S. and C. Tyron

2005 From Acheulian to Middle Stone Age in the Kapthurin Formation, Kenya. In *Transitions before the Transition,* edited by E. Hovers and S. L. Kuhn, pp. 257- 77, Springer Press, New York.

McNabb, J., F. Binyon, and L. Hazelwood

2004 The Large Cutting Tools from the South African Acheulian and the Question of Social Traditions. *Current Anthropology* 45(5): 653- 77.

McPherron, S. P.

2000 Handaxes as a measure of the mental capabilities of early hominids. *Journal of Archaeological Science* 27: 655- 63.

2003 Technological and Typological Variability in the Bifaces from Tabun Cave, Israel. In *Multiple Approaches to the Study of Bifacial Technologies*. edited by M. Soressi and H. L. Dibble, pp. 55-76, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia.

Mellars, P.

1989 Major issues in the emergence of modern humans. Current Anthropology 30: 349-85.

1996 *The Neanderthal Legacy.* Princeton University Press, Princeton.

Mithen, S.

1990 *Thoughtful Foragers.* Cambridge University Press. Cambridge.

1996 Social learning and cultural tradition. In *The Archaeology of Human Ancestry: Power, Sex, and Tradition*, edited by J. Steele and S. Shennan, pp. 207- 229. Routledge, London.

1998 A creative explosion? Theory of mind, language and the disembodied mind of the Upper Palaeolithic. In *Creativity in Human Evolution and Prehistory.* edited by S. Mithen, pp. 165- 191, Routledge, London.

Meignen, L. *et al.*

2005 Middle Paleolithic settlement patterns in the Levant. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 149- 169, Springer Press, New York.

Morris, J.

2004 'Agency' theory applied: a study of later prehistoric lithic assemblages from Northwest Pakistan. In *Agency Uncovered: Archaeological Perspectives on Social Agency, Power, and being Human.* edited by A. Gardner, pp. 51- 63. UCL Press, London.

Morrow, J. E.

1997 End scraper morphology and use-life: an approach for studying paleoindian lithic technology and mobility. *Lithic Technology* 22(1): 70- 85.

Monnier, G.

2005 Testing retouched flake tool standardization during the Middle Paleolithic. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 57- 81, Springer Press, New York.

Movius, H. L. Jr.

1944 *Early Man and Pleistocene Stratigraphy in Southern and Eastern Asia.* Papers of the Peabody Museum of American Archaeology and Ethnology. vol. 19(5), Harvard University, Cambridge.

1949 *The Lower Palaeolithic Cultures of Southern and Eastern Asia.* Transactions of the American Philosophical Society N. S. 38: 329- 420.

1978 Southern and East Asia; Conclusions. In *Early Palaeolithic in South and East Asia,* edited by F. Ikawa-Smith. pp. 351-6. Mouton. The Hague.

Murray, A. S. and A. G. Wintle

2000 Luminiscence dating of quartz using an improved single-aliquot regenerative-dose protocol. *Radiation Measurements* 32: 57- 73.

Murray, A. S., J. M. Olley, and G. C. Caitcheon

1995 Measurement of equivalent doses in quartz from contemporary water-lain sediment using optically stimulated luminescence, *Quaternary Science Reviews* 14: 365- 71.

Nagao, K., Ogata, A., Miura, Y.N., and Yamaguchi, K.,

1996 Ar isotope analysis for K-Ar dating using two modified-VG5400 mass spectrometer- 1: isotope dilution method. *Journal of Mass Spectrometry Society of Japan* 44: 39-61.

Nagatomo, Tsuneto *et al.*

2005 Luminiscence dating of the basalt plateau at the Imjin/Hantan River of Korea and the reconstruction of the formation process of Palaeolithic sites. In *Proceedings of 22nd Annual Conference.* pp. 42- 45. The Japanese Society of Archaeological Science (Nippon Bunkazai Kagakukai), Tokyo.

Naruse, T.

1998 Eolian dust deposition and the monsoon changes during the Last Glacial age in Japan. *The Quaternary Research (Daiyonki Kenkyu)* 37(3): 189- 97.

2003 Loess-paleosol sequence in the Chongokni palaeolithic site. In *Geological Formation of the Chongokni Palaeolithic Site and Palaeolithic Archaeology in East Asia.* edited by Kidong Bae *et al.*, pp. 143- 56, Yeoncheon County and the Institute of Cultural Properties of Hanyang University, Yeonchon.

Nash, S.

1996 Is Curation a useful heuristic? In *Stone Tools: Theoretical Insights into Human Prehistory,* edited by G. H. Odell, pp. 81- 100, Plenum Press, New York.

Nelson, M. C.

1991 The Study of Technological Organization. In *Archaeological method and Theory, vol. 3.* edited by m. B. Schiffer, pp. 57- 100, University of Arizona Press, Tucson.

Newell, A. *et al.*

2003 Deformation modeling: a methodology for the analysis of handaxe morphology and variability. In *Multiple Approaches to the Study of Bifacial Technologies*. edited by M. Soressi and H. L. Dibble, pp. 193- 208, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia.

Norton, C. J.

2000 The current state of Korean paleoanthropology. *Journal of Human Evolution* 38: 803- 25.

Odell, G. H.

1981 The morphological express at Function Junction: search for meaning in lithic tool types. *Journal of Anthropological Research* 37: 319- 42.

1996 Economizing behavior and the concept of "curation." In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by G. H. Odell, pp. 51- 80, Plenum Press, New York.

Olley, J. M., A. S. Murray, and R. G. Roberts

1996 The effect of disequilibrium in the uranium and thorium decay chains on burial dose rates in fluvial sediments. *Quaternary Science Reviews* 15: 751- 60.

Okuno, M.

2002 Chronology of Tephra Layers in Southern Kyushu, SW Japan, for the Last 30,000 Years. *The Quaternary Research (Daiyonki Kenkyu)* 41(4): 225- 36. (In Japanese)

Otte, M.

2003 The pitfalls of using bifaces as cultural markers. In *Multiple Approaches to the Study of Bifacial Technologies*. edited by M. Soressi and H. L. Dibble, pp. 183- 192, University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia.

Pai, Hyung Il

1994 The politics of Korea's past: the legacy of Japanese colonial archaeology in the Korean Peninsula, *East Asian History* 7: 25- 48.

Park, Dong-Won

1983 Palaeoenvironment of the Palaeolithic site at Chongokni: the analysis of the soil properties. In *Chongokni,* pp. 517- 30, National Institute of Cultural Properties of Korea, Seoul. (In Korean)

Park, Kye-Hun *et al.*

1996 *Study on the microcomposition of terrestrial and marine samples and it structural analysis. vol. 1*, Korean Basic Science Institute, Daejeon. (In Korean)

Park, Seon-Ju and Eun-Kyong Lee

2003 Hominids of the Korean Peninsula. *Journal of the Korean Palaeolithic Society* 7:

41- 51.

Parry, W. J., and R. Kelly

1987 Expedient core technology and sedentism. In *The Organization of Core Technology*, edited by J. K. Johnson and C. A. Morrow, pp. 285- 304, Westview Press, Boulder, Colorado.

Phillipson, D. W.

1985 *African Archaeology* (2nd eds), University of Cambridge, Cambridge.

Pielou, E. C.

1966 The measurement of diversity in different types of biological collections. *Journal of Theoretical Ecology* 13: 131- 44.

Pope, G. G.

1992 Replacement versus regional continuous models: the Palaeobehavioral and fossil evidence. In *The Evolution and Dispersal of Modern Humans in Asia*, edited by T. Akazawa, K. Aoki, and T. Kimura, pp. 3-14. Hokusen-sha, Tokyo.

1997 Palaeoanthropological research traditions in the Far East. In *Conceptual Issues in Modern Human Origins Research,* edited by G. A. Clark and C. M. Willermet, pp. 269- 83, Aldine de Gruyter, New York.

Pu, Qingyu

1991 Quaternary glaciers in China In *The Quaternary of China*, edited by Zonghu Zhang, pp. 240-74, China Ocean Press, Beijing

Qi, Guoqin

1991 Pleistocene human environment in North China. *The Quaternary Research (Daiyonki Kenkyu)* 28(4): 327- 36

Qiu, Zhonglang

1985 The Middle Palaeolithic of China. In *Paleoanthropology and Palaeolithic Archaeology in the People's Republic of China.* edited by R. Wu and J. W. Olsen, pp. 187- 210, Academic Press, New York.

Ramenofsky, A. F.

1998 The illusion of time. In *Unit issues in Archaeology: Measuring Time, Space, and Material.* edited by A. F. Ramenofsky and A. Steffen, pp. 74- 84, The University of Utah Press, Salt Lake City.

Rapp, G. Jr. and C. Hill

1998 *Geoarchaeology- The Earth-Science Approach to Archaeological Interpretation.* Yale University Press, New Haven.

Rhodes, E. J. and L. Pownall

1994 Zeroing of the OSL signal in quartz from young glaciofluvial sediments. *Radiation*

Measurements 23: 581- 5.

Rhodes, E. J., and R. M. Bailey

1997 Thermal transfer effects observed in the luminescence of quartz from recent glaciofluvial sediments. *Quaternary Science Reviews* 16: 291- 8.

Ricklis, R. A., and K. A. Cox

1993 Examining lithic technological organization as a dynamic cultural subsystem: the advantages of an explicitly spatial approach. *American Antiquity* 59(3): 426-42.

Roberts, H. M. and G. A. T. Duller

2004 Standardized growth curve for optical dating of sediment using multiple-grain aliquots. *Radiation Measurements* 38: 241- 52.

Rolland, N.

1990 Middle Palaeolithic socio-economic formations in western Eurasia: an exploratory survey. In *The Emergence of Modern Humans- An Archaeological Perspectives*, edited by P. Mellars, pp. 347-88, Edinburgh University Press, Edinburgh.

1999 The "Movius Line": Myth or Reality? In *Proceedings of Symposium to Commemorate the 80's Birthday Celebrations of Professor Chosuke Serizawa- World Views on the Early and Middle Paleolithic in Japan*, pp. 201-214, Sendai Fukushi University, Sendai.

2001 The initial peopling of Eurasia and the early occupation of Europe in its Afro-Asian context: major issues and current perspectives. In *A Very Remote Period Indeed- Papers on the Palaeolithic Presented to Derek Roe.* edited by S. Milliken and J. Cook, pp.78- 94, Oxbow Books, Oxford.

Rolland, N., and H. Dibble

1990 A new synthesis of Middle Palaeolithic variability. *American Antiquity* 55(3): 480-99.

Ronen, A.

1992 The emergence of blade technology: cultural affinities. In *The Evolution and Dispersal of Modern Humans in Asia*, edited by T. Akazawa, K. Aoki, and T. Kimura, pp. 401- 13. Hokusen-sha, Tokyo.

Rutter, N. W., *et al.*

2003 Correlation and interpretation of paleosols and loess across European Russia and Asia over the last interglacial-glacial cycle. *Quaternary Research* 60: 101-9.

Sackett, J. R.

1977 The Meaning of style in archaeology: a general model. *American Antiquity* 42(2): 369- 80.

1981 From de Mortillet to Bordes: a century of French Paleolithic research. In *Towards* *a History of Archaeology*. edited by G. Daniel, pp. 85- 99, Thames and Hudson, London.

1982 Approaches to style in lithic archaeology. *Journal of Anthropological Archaeology* 1: 59- 112.

1991 Straight archaeology French Style: the Phylogenetic paradigm in historical perspective. In *Perspectives on the Past*. edited by G. A. Clark, pp. 109- 40. University of Pennsylvania Press, Philadelphia.

Shackleton, N. J. *et al.*

2002 The classic marine isotope substage 5e. *Quaternary Research* 58: 14- 6.

Shelly, P. H.

1990 Variation in lithic assemblages: an experiment. *Journal of Field Archaeology* 17: 187- 93.

Shen, C. and S. Wang

2000 A preliminary study of the anvil-chipping technique: experiments and evaluation. *Lithic Technology* 25(2): 81- 100.

Shi, Yafeng

1991 Glaciers and glacial geomorphology in China. In *Quaternary Geology and Environment in China*, edited by T. Liu, pp. 16- 27, Science Press, Beijing.

Schick, K.D.

1987 Modeling the formation of Early Stone Age artifact concentrations. *Journal of Human Evolution* 16: 789- 807.

Schick, K.D. and N. Toth

1994 *Making Silent Stones Speak: Human Evolution and the Dawn of Technology*. Touchstones, New York. +

2001 Paleoanthropology at the Millennium. In *Archaeology at the Millennium*. edited by G. M. Feinman, and T. D. Price, pp. 39- 108; Kluwer Academic/Plenum Publishers, New York.

Shea, J. J.

2005 The Middle paleolithic of the Levant. In *Transitions before the Transition*, edited by E. Hovers and S. L. Kuhn, pp. 189- 211, Springer Press, New York.

Shennan, S.

1988 *Quantifying Archaeology*. Edinburgh University Press, Edinburgh.

Sheppard P. J. and M. R. Kleindienst

1996 Technological change in the Earlier and Middle Stone Age of Kalambo Falls, Zambia. *African Archaeological Review* 13(3): 171- 96.

Shin, Jae-Bong *et al.*

2004 Study on the loess-paleosol stratigraphy of Quaternary unconsolidated sediments at E55S20-IV pit of Chongokni Palaeolithic site. *Journal of Geological Society of Korea* 40(4): 369- 81.

Shott, M. J.

1986 Technological organization and settlement mobility: an ethnographic examination. *Journal of Anthropological Research* 42: 15- 52.

1989a Bipolar industries: Ethnographic Evidence and archaeological implications. *North American Archaeology* 10: 1- 24.

1989b On Tool-class use lives and the formation of archaeological assemblages. *American Antiquity* 54: 9- 30.

1994 Size and form in the analysis of flake debris: review and recent approaches. *Journal of Archaeological method and Theory* 1: 69- 110.

2000 The Quantification Problem in Stone-tool Assemblages. *American Antiquity* 65(4): 725- 38.

Smith, M. E.

1992 Braudel's temporal rhythms and chronology theory in archaeology. In *Archaeology, Annales and Ethnohistory,* edited by A. Bernard Knapp, pp. 23- 49, Cambridge Univ. Press: Cambridge.

Sohn, Pow-Key

1967 Stratigraphy of the Sokchangni Palaeolithic site. *Journal of History (Yuk Sa Hak Bo)* 35/36: 1- 23. (In Korean)

1972 Lower and Middle Palaeolithic cultural layers in Sokchangni. *The Study of the Korean History 5 (Han Kuk Sa Yeon Gu)*: 1- 46.

1973 An Upper Palaeolithic camp dwelling at Sokchangni. *The Study of the Korean History 9 (Han Kuk Sa Yeon Gu)*: 15- 57.

1978 The Early Palaeolithic industries of Sokchangni, Korea. In *Early Palaeolithic in South and East Asia,* edited by F. Ikawa-Smith, pp. 233- 45, Mouton, The Hague.

1990 *Palaeolithic Cultures in Korea and Manchuria.* Korea Institute of Prehistory, Seoul.

Soh, Chil-Sub

1980 Geotectonics of East Asia and the Korean Peninsula. In *Korean Geography vol. 1*, pp. 143- 147. KNGI (Korean National Geographic Information Institute), Seoul. (In Korean)

Speth, J.

1972 The mechanical basis of percussion flaking. *American Antiquity* 37(1): 34- 60.

Steffen, A., E. J. Skinner, and P. W. Ainsworth

1998 A view to the core: technological units and debitage analysis. In *Unit issues in Archaeology: Measuring Time, Space, and Material.* edited by A. F. Ramenofsky and A. Steffen, pp. 131- 46, The University of Utah Press, Salt Lake City.

Steiger, R.H., and E. Jager

1977 Convention on the use of decay constants in geo- and cosmochronology. *Earth Planetary Science Letter* 36: 359-362.

Stern, N

1993 The structure of the Lower Pleistocene Archaeological Record: A case study from the Koobi Fora Formation. *Current Anthropology* 34(2): 201- 25.

Stokes, S.

1992 Optical dating of young (modern) sediments using quartz: results from a selection of depositional environments. *Quaternary Science Reviews* 11: 153- 9.

Stokes, S., H. E. Bray, and M. D. Blum

2001 Optical resetting in large drainage basins: tests of zeroing assumptions using single-aliquot procedures. *Quaternary Science Reviews* 20: 879- 85.

Stringer, C. B.

1989 Documenting the origin of modern humans. In *The Emergence of Modern Humans*, edited by E. Trinkaus, pp. 67- 96, Cambridge University Press, Cambridge.

1990 The emergence of modern humans. *Scientific American* 263(6): 98-104.

Stringer, C., and C. Gamble

1993 In Search of the Neanderthals. Thames and Hudson, London.

Sullivan, A. P., and K. C. Rozen

1985 Debitage analysis and archaeological interpretation. *American Antiquity* 50(4): 755- 79.

Stringer, C. B. and C. Gamble

1993 *In Search of the Neanderthals.* Thames and Hudson, London.

Tada, R.

1991 Late Quaternary paleoceanography of the Japan Sea: An update. *The Quaternary Research (Daiyonki Kenkyu)* 38(3): 216- 22

Thomas, P. J., A. S. Murray, and P. Sandgren

2003 Age limit and age underestimation using different OSL signals from lacustrine quartz and polymineral fine grains. *Quaternary Science Review* 22(3): 1139- 43.

Tong, G. and Shixiong Shao

1991 Evolution of Quaternary Climate, In *The Quaternary of China*, edited by Zhang Zonghu, pp.42- 76, China Ocean Press, Beijing.

Torrence, R.

1989a Tools as optimal solution. In *Time, Energy, and Stone Tools*, edited by R. Torrence, pp. 1- 6, Cambridge University Press, Cambridge.

1989b Re-tooling towards a behavioral theory of stone tools. In *Time, Energy, and Stone Tools*, edited by R. Torrence, pp. 57- 66, Cambridge University Press, Cambridge.

2002 Thinking big about small tools. In *Thinking Small: Global perspectives on Microlithization.* edited by G. Elston and S. L. Kuhn. Pp. 179- 90, Archaeological papers of the American Anthropological Association. 12, Washington D. C.

Trigger, B. G.

1978 *Time and Traditions.* Columbia University Press. New York.

1989 *A History of Archaeological Thought*. Cambridge University Press. Cambridge.

1995 Romanticism, Nationalism and Archaeology. In *Nationalism, Politics and the Practice of Archaeology,* edited by P. H. Kohl and C. Fawcett, pp. 263- 79, Cambridge University Press, Cambridge.

1991 Constraint and Freedom: a new synthesis for archaeological explanation. *American Anthropologist* 93(6): 551- 69.

1998 Archaeology and epistemology: Dialogues across the Darwinian Chasm. *American Journal of Archaeology* 102: 1- 34.

Tryon, C. A.

2006 "Early" Middle Stone Age Lithic Technology of the Kapthurin Formation (Kenya). *Current Anthropology* 47 (2): 367– 75

Vandenburgh J.

1995 Timescales, climate and river development. *Quaternary Science Reviews* 14: 631- 8.

2002 The relation between climate and river processes, landforms and deposits during the Quaternary. *Quaternary International* 91: 17- 23.

2003 Climate forcing of fluvial system development: an evolution of ideas. *Quaternary Science Reviews* 22: 2053- 60.

Walter, R. C.

1997 Potassium-Argon/Argon-Argon Dating Methods. In *Chronometric Dating in Archaeology*, edited by R. E. Taylor and M. J. Aitken, pp.97- 126, Plenum Press, New York.

Watanabe, M., and K. Sakagami

1999 Recent pedological approach to reconstruction of the Quaternary Environment in Japan and East Asia. *The Quaternary Research (Daiyonki Kenkyu)* 38(3): 244-52

Wee, Soo-Min

1996 Geochemical characteristics of the Quaternary Jeongok (Chongok) Basalt in

Chugaryong Rift Valley, Mid-Korean Peninsula. *Economic Environmental Geology of Korea* 29(2): 171- 82.

Westgate, J., A. Sandhu, and P. Shane

1997 Fission-Track Dating. In *Chronometric Dating in Archaeology*, edited by R. E. Taylor and M. J. Aitken, pp.127- 157, Plenum Press, New York.

Whittaker, J. C.

1994 *Flintknapping- Making and Understanding Stone Tools.* University of Texas Press, Austin.

Wiessner, P.

1983 Style and social information in Kalahari San projectile points. *American Antiquity* 48(2): 253- 75.

Wobst, M.

1977 Stylistic behavior and information exchange. In *Papers for the director: Research essays in honor of James B. Griffin*, edited by C. E. Cleland, pp. 317- 42. Academic Press, New York.

Wu, Xinzhi and Wu Maolin

1985 Early Homo sapiens in China. In *Paleoanthropology and Palaeolithic Archaeology in the People's Republic of China.* edited by R. Wu and J. W. Olsen, pp. 91-106, Academic Press, New York.

Wynn, T.

1995 Handaxe enigmas. World Archaeology 27(1): 10- 24

2002 Archaeology and Cognitive Evolution. *Behavioral and Brain Science* 25(3):389-402.

Yerkes, R. W., and P. N. Kardulias

1993 Recent developments in the analysis of lithic artifacts. *Journal of Archaeological Research* 1(2): 89- 119.

Yi, Seonbok

1983 Geoarchaeology of Chongokni, Korea. In *Chongokni.* edited by W. Kim. pp. 577-85. Institute of Cultural Properties, Seoul.

1986 *Lower and Middle Palaeolithic of Northeast Asia: A Geoarchaeological Review.* Unpublished Ph.D. Dissertation. Arizona State University. Tempe.

1987 New Palaeolithic localities in Korea. In *Commemorative Bulletin of Dr. Pow-Key Sohn's Retirement Vol.1.* pp. 97-115, Seoul. (In Korean)

1989 *The Study of Northeast Asian Palaeolithic.* Seoul National University Press, Seoul (In Korean)

1996 Chronostratigraphy of Palaeolithic occurrences in the Imjin Basin. *Journal of the*

Korean Archaeological Society 34: 135- 60. (In Korean)

1999 The temporal change of Korean Palaeolithic industry. In *Proceedings of Symposium to Commemorate the 80's Birthday Celebrations of Professor Chosuke Serizawa- World Views on the Early and Middle Paleolithic in Japan*, pp. 115-120, Sendai Fukushi University, Sendai.

2000 For chronology and stratigraphy of Korean Palaeolithic. *Journal of the Korean Archaeological Society* 42: 1-22. (In Korean with English summary)

2002 A Lower Pleistocene- Early Middle Pleistocene Palaeolithic locality in the Imjin River Basin- preliminary report. In *Palaeolithic Archaeology in Northeast Asia.* edited by Kidong Bae, pp. 199- 208, Institute of Cultural Properties in Hanyang University, Yeoncheon. (In English with Korean summary)

2004a *Jangsan-ri: A Lower Palaeolithic Site in Paju, Korea.* Seoul National University Museum, Seoul. (In Korean)

2004b The Jangsan-ri Terrace and lava deposit in the upstream areas of the Imjin River. *Journal of the Geomorphological Association of Korea* 11(1): 1- 14. (In Korean)

2005 New Data on the formation of the basalt plain in the Imjin River Basin. *Journal of the Geomorphological Association of Korea* 12(3): 21- 38. (In Korean)

Yi, Seonbok and G. A. Clark

1983 Observation on the Lower Palaeolithic of Northeast Asia. *Current Anthropology* 24(2): 181-202.

Yi, Seonbok and Kyodong Lee

1993 *Excavation Report of Juwolri/Kawolri Palaeolithic Site*. Dept. of Archaeology and Art History, Seoul National University, Seoul (In Korean)

Yi, Seonbok, T. Soda and F. Arai

1998 New discovery of Aira-Tn ash (AT) in Korea, *Journal of the Korean Geographical Society* 33(3): 447- 54.

Yi, Seonbok, Yong-Il Lee, and Hyonsoo Lim

2005 *A Preliminary Study on the Geological Background of the Formation Process of Imjin Basin Palaeolithic Sites.* vol. I., Seoul National University Museum, Seoul.

Yi, Seonbok, Yong-Il Lee, and Jong-Wook Kim

2004 The Jangsanri Terrace and lava deposit in the upstream area of the Imjin River. *Journal of the Geomorphological Association of Korea* 11(1): 1- 14.

Yi, Seonbok, Yongwook Yoo, and Dongwan Kim

2006 *Excavation Report at Chongokni (aka Jeongok ACF) Site and its Vicinity.* Seoul National University Museum and Jeongok Agricultural Cooperative Federation, Seoul.

Yi, Seonbok *et al.*

2005 On the Hoabihnian Lithic Industry. *Journal of the Korean Archaeological Society* 57: 1- 34. (In Korean)

Yoshinaga, S.

1996 Fluctuation of fine quartz accumulation rate of the "Kanto loam" indicating Northwest Winter Monsoon intensity since the last glacial age. *The Quaternary Research (Daiyonki Kenkyu)* 35(2): 87- 98. (In Japanese with English Abstract))

Yoo, Yongwook

1997 On the characteristics of Handaxes from Imjin-Hantan Riverine Area. *Journal of the Korean Archaeological Society* 36: 147-80. (In Korean with English Abstract)

2003 Rethinking of quartz as raw material: examples from Pyongchangni site. In *Geological Formation of the Chongokni Palaeolithic Site and Palaeolithic Archaeology in East Asia.* edited by Kidong Bae *et al.*, pp. 55- 62, Yeoncheon County and the Institute of Cultural Properties of Hanyang University, Yeonchon. (In Korean with English Abstract)

Yoon, Soon-Ock *et el.*

2005 Environmental change and agricultural activities during the Late Holocene in Geumcheon-ri, Milyang City, Korea. *Journal of the Korean Archaeological Society* 56: 27-48. (In Korean with English Abstract)

Yu, G., Bin Xue and Sumin Wang

2002 Reconstruction of Asian palaeomonsoon Patterns in China over the Last 40kyrs: A Synthesis. *The Quaternary Research (Daiyonki Kenkyu)* 41(1): 23- 33.

Zhang, Zonghu, Zhiyi Zhang and Yunsheng Wang

1991 Loess in China. In *The Quaternary of China*, edited by Zonghu Zhang, pp. 459-507, China Ocean Press, Beijing

Zhang, J., L. Zhou, and S. Yue

2003 Dating fluvial sediments by optically stimulated luminescence: selection of equivalent doses for age calculation. *Quaternary Science Reviews* 22: 1123- 9.