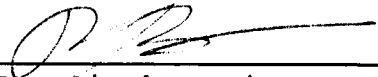


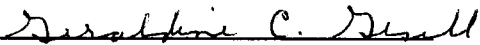
To the Graduate Council:

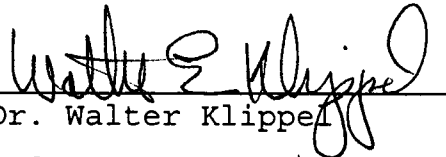
I am submitting herewith a dissertation written by Maureen A. Hays entitled "A Functional Analysis Of The Magdalenian Assemblage From Grotte XVI (Dordogne, France)". I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

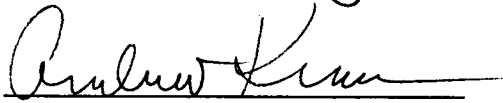

Dr. Jan Simek, Major Professor

We have read this dissertation
and recommend its acceptance:


Dr. Jefferson Chapman


Dr. Geraldine Gesell


Dr. Walter Klippel


Dr. Andrew Kramer

Accepted for the Council:


Associate Vice Chancellor and
Dean of The Graduate School

**A Functional Analysis Of The Magdalenian Assemblage
From Grotte XVI (Dordogne, France)**

A Dissertation
Presented for the
Doctor of Philosophy
The University of Tennessee, Knoxville

Maureen A. Hays
May 1998

ACKNOWLEDGMENTS

This doctorate could not have been completed without the guidance and support of so many people. I can only begin to express the great appreciation I have for each of them here. I would like to thank the members of my committee, Drs. Jefferson Chapman, Geraldine Gesell, Walter Klippel and Andrew Kramer, for their time and efforts in reading and commenting on my dissertation. More than anyone else, Drs. Jan Simek and Jean-Philippe Rigaud have shaped my academic and professional career. To them I owe a deep debt of gratitude.

I would also like to recognize Dr. Lawrence Keeley. Without his instruction and patience in teaching to me the methods he developed in microwear analysis, this research could never have been conducted. Also acknowledged here are the University of Tennessee, The Institute de Quaternaire, Universitaire de Bordeaux, The Oakridge National Laboratory and Adirondack Community College for providing equipment and technical support without which my research would have been sorely limited.

To those old friends and new that have provided encouragement and support through the years I am eternally

grateful. I am especially thankful for the support Nikki, Julia, and Mary have provided me over many summers in France. Marie, Sarah and Renee, you have been there from beginning to end. Thank you for giving me the strength to see this through.

Lastly, I would like to thank my family.

ABSTRACT

This dissertation applies the methods developed in high magnification microwear analysis to an archaeological assemblage. This archaeological assemblage comes from the intact Magdalenian deposits from Grotte XVI, a stratified cave site in Dordogne, France. Through analogy, using experimentally produced and used tools, functional interpretations can be made concerning the Magdalenian occupation of the cave. This dissertation integrates previous analyses of the lithic and faunal materials from Grotte XVI with both spatial and functional analyses to allow for a synthetic explanation of site systematics.

This study describes the uppermost, intact deposits from Couche 0 dating to the Magdalenian occupation of Grotte XVI. By integrating the existing analyses of the faunal assemblage, stone tool typology, technology, and raw material analyses, and artifact spatial distributions with functional analyses a picture of Grotte XVI as a short term, specialized site used by small, mobile task groups emerges. This interpretation implies that use of Grotte XVI during the Magdalenian was part of a larger, logistically organized collector land use strategy.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION.....	1
II. THEORETICAL FOUNDATIONS.....	13
Theoretical Framework.....	13
The Magdalenian.....	25
Microwear in the Magdalenian.....	38
Models for Grotte XVI.....	47
III. METHODOLOGICAL CONSIDERATIONS.....	53
The Nature of Microwear.....	53
Methods Specific to This Study.....	75
IV. THE GROTTÉ XVI COLLECTION.....	105
History of the Excavation.....	105
The Magdalenian Deposit.....	108
Excavation Methods.....	110
The Grotte XVI Magdalenian Collection.....	112
V. RESULTS AND INTERPRETATIONS.....	139
Introduction.....	139
Microwear Results.....	140
Chi-Square.....	163
Spatial Results.....	175
Models.....	181
Comparison to Other Magdalenian Sites.....	190
VI. CONCLUSIONS.....	195
BIBLIOGRAPHY.....	200
APPENDIX.....	217
VITA.....	226

LIST OF TABLES

TABLE	PAGE
1. Test for Independence Between Raw material and Type.....	124
2. Test for Independence Between Type and Technological Phase.....	129
3. Test for Independence Between Raw Material and Technological Phase.....	131
4. Test for Independence Between Action and Raw Material.....	166
5. Test for Independence Between Material and Raw Material.....	167
6. Test for Independence Between Action and Technological Phase.....	169
7. Test for Independence Between Material Worked and Technological Phase.....	170
8. Test for Independence Between Action and Type...	172
9. Test for Independence Between Material Worked and Type.....	174
A-A. Results of Blind Tests.....	218
A-C. Raw Data Counts.....	223

LIST OF FIGURES

FIGURE	PAGE
1. Location of the Grotte XVI in the Le Conte Cliffs Near Cenac-et-St. Julien in Dordogne France.....	4
2. Variables Recorded During Analysis.....	86
3. Upper Paleolithic Typology.....	88
4. Types of Damage Scars Produced During Use.....	91
5. Location of the Grotte XVI in the Le Conte Cliffs Near Cenac-et-St. Julien in Dordogne France.....	106
6. Plan of the Interior of Grotte XVI.....	109
7. Log (%SSE) for All Artifacts.....	114
8. Plan Map of All Artifacts with 2 Cluster Kmeans Solution.....	115
9. Lithic Assemblage Composition.....	117
10. Comparison of Assemblage Typology Between Cluster 1 and Cluster 2.....	118
11. Comparison of Common Tool Types Between Cluster 1 and Cluster 2.....	120
12. Assemblage Raw Material.....	122
13. Comparison of Raw Material Between Cluster 1 and Cluster 2.....	126

FIGURE	PAGE
14. Assemblage Technological Phases.....	128
15. Comparison of Technological Phases Between Cluster 1 and Cluster 2.....	132
16. Animal Taxa in Assemblage.....	134
17. Comparison of Animal Taxa Between Cluster 1 and Cluster 2.....	135
18. Comparison of Uncommon Taxa Between Cluster 1 and Cluster 2.....	136
19. Comparison of Reindeer Anatomy Between Cluster 1 and Cluster 2.....	137
20. Used Tools According to Action.....	151
21. Used Tools According to Material Worked.....	153
22. Used Tools According to Activity.....	154
23. Used Microliths According to Action.....	156
24. Used Microliths According to Material Worked....	157
25. Used Microliths According to Activity.....	159
26. Used Debitage According to Action.....	160
27. Used Debitage According to Material Worked.....	162
28. Used Debitage According to Activity.....	164
29. Comparison of Action Between Cluster 1 and Cluster 2.....	177

FIGURE	PAGE
30. Comparison of Material Worked Between Cluster 1 and Cluster 2.....	179
31. Comparison of Activities Between Cluster 1 and Cluster 2.....	180
A-B. Microwear.....	219

I. INTRODUCTION

This dissertation represents an attempt to apply the methods developed in high magnification microwear analysis to an archaeological assemblage. This archaeological assemblage comes from the intact Magdalenian deposits from Grotte XVI, a stratified cave site in Dordogne, France. Through analogy, using experimentally produced and used tools, functional interpretations will be made concerning the Magdalenian occupation of the cave. It is also my objective to integrate previous analyses of the lithic and faunal materials with both spatial and functional analyses to allow for a more synthetic explanation of site systematics.

In order to address site function during the Magdalenian, microwear methods for the analysis of chipped stone tools were chosen. Chipped stone tools often comprise the bulk of the archaeological record. This is because, due to a combination of site formation processes, lithic implements are often the only materials that remain as an indication of cultural activities that took place prehistorically. Because cultural mechanisms are frequently

inferred from stone tools, considerable attention has been given to their analysis. Studies have focused on many aspects of the lithic record including style, technology, and one of the most commonly discussed areas of lithic analysis, function. Functional studies have been conducted on several scales throughout the years. The earliest studies focused on macroscopic morphological traits and types. Most recently however, functional studies have developed and utilized methods that focus on microscopic evidence for use. The work of Semenov (1964), and Keeley (1980) both defined, as well as applied, the methods for high-magnification microwear analysis; the work of Tringham (et al. 1974) and Odell (1977) were pioneering in low-magnification microwear analysis.

Methodological investigations into the defining characteristics of function on the microscopic level begun by Semenov, Keeley, Tringham and Odell launched other microwear studies that, not only built upon their methodological works but, also went on to apply their findings to archaeological materials throughout the Old and New World (Anderson 1979, 1980; Beyries 1989; Del Bene 1979; Kooyman; Shea 1988). These studies continued to strengthen

the support for microwear as a legitimate method of functional analysis, while they began to build a data base for functional studies. For some while, microwear studies focused on strengthening and refining methods of interpretation through experimentation and "blind tests" to prove the reliability of the interpreter.

Once microwear analysts had established that patterns could be recognized in experimentally used tools and that from those patterns functional interpretations could be made, they moved toward application and refinement of the methods. The following research is one such study that attempts to apply the findings of experimental microwear studies to archaeological materials. This research specifically involves an intensive functional analysis of the Magdalenian lithic assemblage from the cave site "Grotte XVI", located in the Le Conte Cliffs, Dordogne, France (Figure 1). The intention of this functional analysis was to allow for the reconstruction of the principal economic activities and their organization during the Magdalenian at Grotte XVI. One hundred percent of the formal tool types, which include 478 microliths, were analyzed along with a large percentage of the debitage. The methods employed were

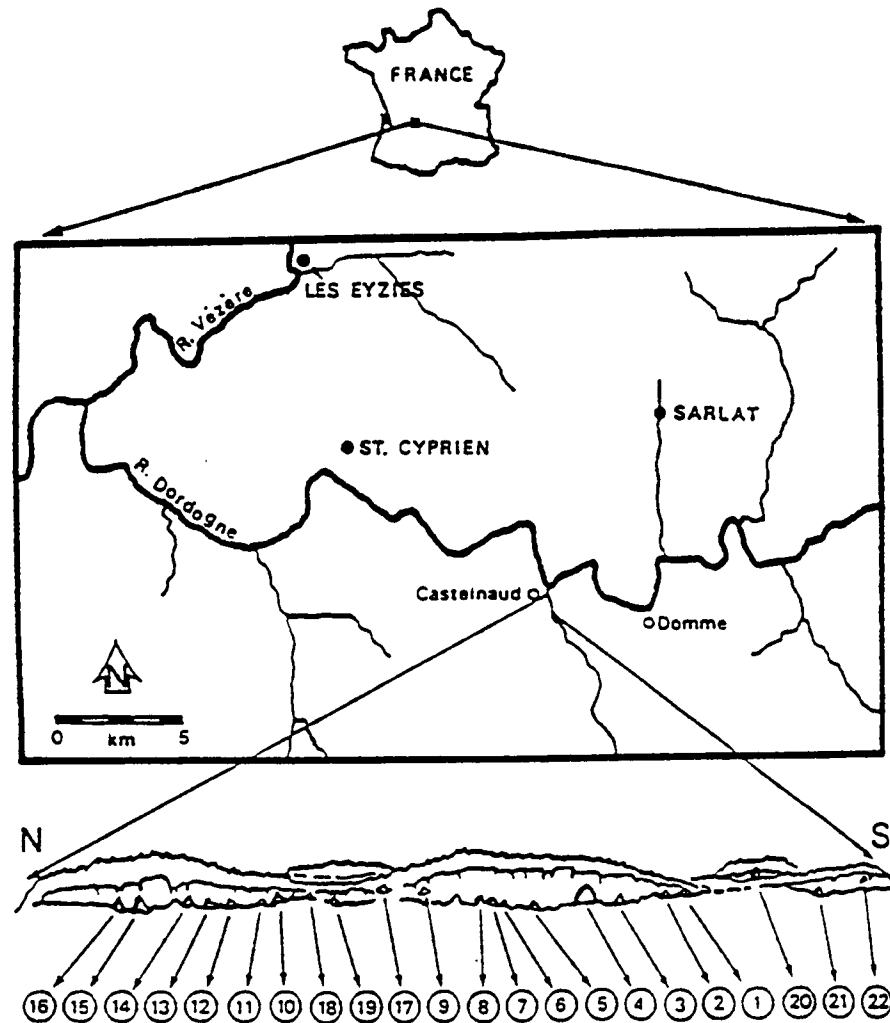


Figure 1. Location Of The Grotte XVI In The Le Conte Cliffs Near Cenac-et-St. Julien In Dordogne, France (after Rigaud, Simek, and Ge 1995)
Note: the numbers represent individual caves.

those developed for high-magnification microwear analysis as defined by Keeley (1980).

This study concentrates on describing the uppermost, intact deposits from Couche 0 dating to the Magdalenian occupation of Grotte XVI. The existing analyses of the faunal assemblage, stone tool typology, technology, raw material analyses, and artifact spatial distributions are integrated with functional analyses. From this analysis a picture of Grotte XVI as a short term, specialized site used by small, mobile task groups emerges. This interpretation implies that use of Grotte XVI during the Magdalenian was part of a larger, logistically organized collector land use strategy.

This dissertation has been divided into four main sections with an introduction and conclusions. The four primary sections are: "Theoretical Foundations", "Methodological Considerations", "The Grotte XVI Collection", and "Results and Interpretations".

The first section entitled "Theoretical Foundations" presents the theoretical framework upon which the dissertation research was based. Chapter II outlines the basic premises of systems theory and the *chaîne opératoire*

approach to lithic analysis. These two theoretical bodies lay the groundwork for the research to follow. When considering function, and more precisely the functional interpretation of stone tools, it is necessary to view these functional interpretations as just one aspect in a larger cultural system. Function needs to be considered not just in its most immediate role as it interacts with raw material choice, typology and technology, but also as part of a broader system that involves movement on the landscape along with economic and subsistence strategies. For this reason, Chapter II, in addition to laying out the theoretical foundations for the research, also presents an overview of the cultural period investigated, the Magdalenian. The Magdalenian, the last of the Upper Paleolithic cultural complexes dating from about 18,000 to 10,000 years ago, has been written about extensively. For that reason its description in chapter II is cursory with regards to an overall definition, description of settlement patterns, subsistence and technology. However, detailed descriptions of the Magdalenian are presented in regards to other analyses into the function of stone tools through the use of microwear techniques. Details of the microwear research

conducted at Pincevent, Verberie, Rascano, Cassagros, and Abri Dufour are given and their interpretation presented.

Having laid out the theoretical and cultural context for the research, the last section in Chapter II uses this information to develop models to be tested for the Magdalenian from Grotte XVI. Models based on ethnographic research, hunter-gatherer studies, and pattern recognition in spatial analysis are used to provide broad models for subsistence strategies implemented at the Grotte XVI. On a more specific level, previous research on the Magdalenian, as well as previous research at Grotte XVI, are also used to aid in the development of models. These will then form the basis for research into function.

To investigate site function at the Grotte XVI various methods were deliberated. Chapter III, "Methodological Considerations", describes those methods. The chapter opens with a historical overview detailing the development of various methods in microwear analysis. These methods include, but are not limited to, low magnification, SEM analysis of residues, and high magnification analysis of micro-polishes. Having presented an overview of the differing methods and a justification for the use of high

magnification in this study, the chapter goes on to address several debates within the discipline concerning the formation of the polish itself. Is its development contingent upon the presence of a "silica gel", or does the polish form as the result of abrasion? In addition, the process by which the tool is treated and cleaned prior to viewing is also open to debate. The use of chemical versus non-chemical cleaning methods is considered.

Those debates aside, microwear analysis has been accused of being a rather subjective endeavor (Grace 1996) that involves a "eye to brain" pattern recognition. For this reason both description of the blind tests that have been conducted and their results are considered. Finally the limitations to the method itself are presented.

Following the historical overview of microwear methods and debates, the methods specifically used in this study are outlined and defined. First and foremost was the construction of an experimental program to simulate prehistoric activities in the laboratory. The experimentally produced damage was evaluated and used to understand the patterns associated with different motions and contact materials. "Blind tests" were then used to test

my proficiency in identification of wear traces and the results of this are described.

In this section on "Methodological Considerations" relevant terms and variables are defined. Through a combination of data collected from the experimental program and a search through the literature, various attributes were assembled that work in combination to define function. These attributes are described and then used to show how they define motions and contact materials. Motions are divided into the categories projection, cutting, scraping, graving and boring. The contact materials are meat, hide, vegetal material, wood, bone and antler. These are then combined to define activities. In addition, natural processes that might alter or imitate usewear are discussed.

The final section of Chapter III reviews the statistical tests used to aid in interpretation of the collected data. Two main statistical means are used to analyze the data. First the Chi-square test for independence is reviewed in terms of its merits as a method for looking at the correlation between raw material and type, type and technological phase, and raw material and technological phase. Chi-square tests are also used to

investigate the relationship between function and raw material, technological phase and typology.

Besides looking at the relationship between particular aspects of the tools, spatial analysis is also used to define activity areas at the Grotte XVI. K-means, a non hierarchical clustering analysis, was applied to the point provenience data. The last section of Chapter III describes this statistical method of spatial analysis.

Chapter IV, "The Grotte XVI Collection", presents a historical overview of the excavations. The chapter locates Grotte XVI in both space and time while also briefly describing the geology of the Magdalenian deposits. The excavation and curation methods used at the site are detailed. Based on the geological data from the site, and the excavation and curation methods, justification is made for the use of the Magdalenian materials for microwear analysis. One hundred percent of the Magdalenian deposits have been excavated from the site and all the materials have been processed, curated, and analyzed. The faunal materials have been analyzed by Delpech (1987). The raw material, typology and technology have been investigated by Chadelle (1983) and Marino (1996) and the spatial dimensions of the

artifacts combined with these analyses are presented by Rigaud, Simek and myself (in press). These findings are briefly presented in Chapter IV so that they may later be integrated with the functional analyses.

In Chapter V, "Results and Interpretations", the data collected from the analyses of the lithic material are described and an attempt is made to interpret the findings with regards to the models presented in Chapter II. First, the results of the microscopic analyses are presented. The microwear damage that was recorded is described by functional category. Next, Chi-square analyses are presented to investigate the relationship between function and typology, raw material, and technology. These relationships are explored in terms of both contact material and physical motion. Once the wear patterns and their relationship in the broader realm of the assemblage have been presented, these are integrated with the cartographic proveniences of the artifacts to explore the spatial dimension of function. From this, activity areas are

interpreted.

The "Interpretations" section of this chapter not only works to interpret Grotte XVI on an intra-site level, but also on an inter-site level. I strive to place Grotte XVI within a broader hunter-gatherer system and integrate the Grotte XVI data with that of other Magdalenian sites that have been analyzed functionally.

Chapter VI's conclusions summarize the results of the study as it relates to the broader archaeological literature. Also, incorporated into Chapter VI are suggestions for further research.

II. THEORETICAL FOUNDATIONS

1. Theoretical Framework

One of the most difficult tasks archaeologists face is to take the data amassed from excavations and make behavioral interpretations of that static archaeological record. With the archaeological record now being in the present we have only at our disposal tools from the present to aid in making those behavioral interpretations. No matter how good those tools are, they suffer from the fact that they are at best analogic. Theoretical models of hunter gatherer behavioral patterning have been built based on ethnographic and experimental data. These will be presented in the following chapter and used to build models for this study.

The theoretical framework upon which the models for this dissertation are based is a fairly simple one. It finds its roots in systems theory, a theoretical framework that views behavior as a system of interactive parts that make up the whole (Clarke 1968). In order to specifically investigate the role function plays in the behavioral

system, this dissertation address two main areas. First is function and its integration into the *chaîne opératoire* of stone tools. Ethnographic studies are used to build models of site function and land use patterns within this system. In conjunction with this, previous studies of the Magdalenian and more specifically usewear studies of lithic assemblages will be used in building functional models for the Magdalenian of Grotte XVI. Secondly, models for the spatial distribution of artifacts, and more precisely activity areas, will be developed by using ethnographic investigations into artifact distributions and spatial information from previously analyzed Magdalenian sites where usewear studies have been conducted.

David Clarke (1968) proposed a systemic view of human culture looking at process and change. This systemic view looks at the subsystems of human culture (material culture, economics, religion, social dogma) as being an integrated whole. They do not operate independently but rather as a unit, and changes in one subsystem effect the other subsystems. The system strives to maintain equilibrium in the presence of environmental pressure. There is input to the system from external forces. There is also output which

is the action of the system on the environment.

Stone tool studies that emphasize function sometimes operate in a subsystem realm. They focus primarily on the function of the tool at the exclusion of its role throughout the system. That a human used this tool, and that the exact use of this tool is only a small part of a functioning cultural system, is often lost in a very narrow view of function, usually within one subsystem of human culture. This systemic view of human culture is used to expand and enhance archaeological studies of tool function by looking at how functional input and output within subsystems will effect other subsystems as they operate as a whole (Grace 1996; Inizan et al. 1992).

When considering the interplay of subsystems within a cultural system looking at stone tool function, this can be viewed on a regional level (Keeley 1988; Odell 1985; Shea 1988) or a site specific level (Kooyman 1992; Moss 1986, 1987a). On the regional level there have been ethnographic studies that investigate land use patterns and the decision making process that dictates site location and ultimately site function (Binford 1978; Kent 1991). On the more site specific level, ethnographic studies have been used to model

technological, functional and spatial dimensions of the cultural system (Gargett and Hayden 1991; Yellen 1977).

Binford's (1978) work is a good example for it attempts to formulate settlement system models for hunter-gatherer land use patterns and site formation. Binford (1980) synthesizes work by Lee and De Vore (1976) on the !Kung San of the Kalahari desert and work by Campbell (1968) and himself (1978) on the Nunamiut Eskimo of Alaska. He uses ethnographic data on these two groups to formulate and define two different types of settlement systems: foragers and collectors. He also defines different types of sites that will be associated with each system.

The forager system is a simple one that sees the bulk of the resources gathered daily within a reasonable radius from the base camp. Foragers set out from the base camp each day to gather resources and at the end of the day they return to that same base camp. If there is resource stress the response is to move the base camp to a new source of available resources. In this system the base camp is the central unit and it is moved several times a year as the resources dictate (Binford 1980).

In contrast to a foraging system, a collector system

has work parties that leave the base camp to collect specialized resources but do not necessarily return to the base within the same day. Because of this, there are several other types of sites that are associated with the collector system. These sites are specialized task oriented sites and are occupied over a generally short term. Sites such as hunting camps and lithic retooling stations are examples of these specialized locales. A collector system involves careful planning and preparation. Once the task is completed, caches of resources are made and what is needed is taken back to the base camp. While groups utilizing a collector system are still mobile, there is less of a need for a large number of moves during the year because the resources are brought to the base camp.

Each of these systems implies a different use of the landscape. While they represent extremes, in reality groups may employ a combination of strategies. While this is interesting in and of itself, each of these systems with their differing sites has this reflected in both artifacts present at the site and artifact distributions.

Attempts have been made to derive from ethnographic observations a series of spatial patterns in artifact

distributions that define site function. Yellen's (1977) work with the !Kung San explores the spatial patterning of artifact distributions present at a forager site. Because the settlement system's central unit is the base camp, the artifact accumulations will reflect a long term use of the site. Yellen found that there were essentially two distinct artifact areas at !Kung San sites. The first is a location of general activity around a central hearth with an artifact concentration to the side of the hearth. This artifact area is a dump where the refuse from the activities are deposited. The artifacts within this area will be a representative mix of the general activities performed in and around the central hearth. A second type of area of artifact concentration is located away from the main living area. These areas are where one specific activity takes place that may require open space or a locale away from the base camp. In these deposits the artifacts are not mixed like the area around the central hearth but rather are specific and reflect the activity at hand.

On the other end of the continuum lies the spatial patterns associated with a collector system as deduced by Binford in his studies of the Nunamiut (1978). The basic

pattern as defined by Yellen persists at the base camp. Binford further considers the nature of the means by which the artifacts were deposited. He sees that smaller artifacts are deposited where they were used while larger artifacts are tossed away. Still, the pattern of a mixed assemblage near to the central hearth at the base camp remains. The peripheral areas at the base camp are activity specific. Binford (1978, 1980) believes that at a base camp the signature of these peripheral sites may not be very strong because the activity is not repeated. For this reason there is little accumulation of artifacts. Activity specific sites resulting from specialized task groups sent out from the base camp may, because of their activity specific nature, look similar to the peripheral areas at the base camp. However, if these specialized camps were the site of repeated use then their signature of artifact patterning should be stronger than that of the base camp peripheral areas.

Additional work has been done by Gargett and Hayden (1991) on site structure and sharing among the aboriginal Australians. The main contribution of this study has been to identify intact households through their spatial

organization. They believe that this can then be used to interpret economic patterns at prehistoric sites.

Kent (1991) has presented data on mobility strategies and site structure. She looks at site mobility as being linked to more than ecological factors. Site structure is investigated as it relates to "anticipated" group mobility. Here, it is the length of time that people expect to occupy the site, rather than the actual time spent at the site, that influences the site structure. This implies a great deal of planning. She looks at site size as being a standard variable with anticipated length of stay. When site size is correlated with length of anticipated stay the results are interesting. No matter what the number of people occupying a site, from 4 to 25, the ratio of meters per person was the same. When the anticipated length of the stay was less than 3 months the meters squared per person was less than 32.9 square meters. On the far end of the spectrum when the anticipated length of the stay was more than 6 months the ratio was 66 meters squared per person. She also assessed storage areas. There were no formal storage areas for sites with an anticipated short term occupation. Also, there tended to be more investment into

hut structure and the number of huts with an anticipated long term stay. All of this information may be helpful when building models for site structure in the Paleolithic. If in the Paleolithic we are seeing a shift toward a collector subsistence system which requires a great deal more logistical planning, then investigations into the link between site structure and "anticipated" length of the stay could be critical. Because more than one type of site is seen in a collector system (Binford 1980), these sites and their structure should reflect planning and an "anticipated" length of stay.

While ethnographers have amassed data pertaining to settlement systems and artifact distributions across sites, experimental archaeology has begun to provide insight into the factors that affect where, when, and how a tool was used and later incorporated into the archaeological record. Keeley (1991:258) considers the factors that might influence tool disposal such as clean up and tossing, tool placement in relation to the duration of the sites occupation and timing between the occupations, and lastly, how retooling of hafted tools will effect artifact placement and distribution. As illustrated through ethnographic data

(Binford 1978, Yellen 1977) the size of the tool plays a role in whether the tool will be deposited at or near its locus of use. Smaller pieces are generally deposited nearer to where they were used than larger tools which are likely to be tossed away. Small pieces may be such artifacts as resharpening flakes or spalls, broken fragments or most importantly pieces that were once hafted as part of composite tools. Secondly, cleanup plays a major factor in the deposit and redeposit of tools. Ethnographic studies show that in areas of domestic use clean up is more intense so that tools are generally in a location of secondary deposit. This in combination with the length of time the site is occupied may influence tool location. Longer term sites will suffer from more cleanup and therefore the activities will be homogenized in a central rubbish heap. Tool placement in shorter term occupations may more likely be deposited where used (Yellen 1977). Keeley (1991) gives greatest attention to the factors that are involved in the deposition of hafted tools. He states that hafted tools are those most likely to be curated and therefore their use may not reflect an activity occurring where they were deposited. "Problems arise because once hafted tools accumulate where

they were replaced in hafts, not necessarily where they were used" (1991:259). These data combined with ethnographic data can aid in the interpretation of site function.

Ethno and experimental archaeology provide archaeologists with a behavioral context upon which to base interpretations of the archaeological record. However, this is not to say that the data collected through these observations should serve as a strict one to one interpretive tool. Rather, they should be used as hypothesis building tools.

One way of tying this all together theoretically is to synthesize this data using the *chaine operateire* concept (Grace 1996; Inizan et al. 1992; Leroi-Gourhan 1943). The *chaine operateire*, or as it is translated, the operational sequence (Inizan et al. 1992), investigates the life history of a stone tool. This concept was first introduced by Leroi-Gourhan(1943) and has been applied by numerous archaeologists to date (eg. Chadelle 1983; Geneste 1985; Grace 1996; Marino 1996). This life history includes four main phases from raw material procurement, to technological production, to use and then to the final discard and incorporation of the artifact into the archaeological

record.

Accepting that in each stage, people have choices to make, these choices reflect behavior and traditions of the group (Bar-Yosef et al. 1992). All too often archaeologists, when utilizing the *chain operatoire* concept, concentrate on the technological aspect of it at the expense of the functional role. By omitting the functional aspect, the primary purpose for the production of the implement is disregarded. By considering function in the *chaîne operatoire* as well as raw material choices, technology and typology we may be able to look at the relationship between these phases in the sequence and find that for example the intended use of the tool may effect the choice in raw material or technology. From this, site function may be assessed and interpretations may be made in order to investigate subsistence strategies. It is also helpful to ascertain the interdependence of the variables in the phases of the *chaîne operatoire*. For example, by looking at the relationship between typology and function, the traditional assumptions about stone tool use might be challenged.

By integrating the *chain operatoire* approach with

ethnographic data gathered to produce models of subsistence systems and artifact spatial patterning we can begin to develop models for site function at the Grotte XVI. However, although this may allow us to build general models to be tested, there is an additional body of data that will allow the shaping of models more specific to the Grotte XVI itself. Given that model building is essentially a dialogue between building hypotheses and data collection (Tringham 1978), the Magdalenian will be discussed below.

2. The Magdalenian

Definition

The Magdalenian is the last of the Upper Paleolithic techno-cultural complexes spanning the time period of the last interglacial from about 18,000- 10,000 years ago. The initial Magdalenian sees its roots in a climatically cold and dry period progressing to a warm, humid period (Clottes 1987, Laville et al. 1980). The rest of the Magdalenian fluctuates between these two extremes. The initial Magdalenian, or Badegoulian (Laville et al. 1980), is limited geographically to areas mostly in the Perigord and

does not seem to cross the Garrone River (Cheynier 1949). During the later stage of the Magdalenian there seems to be an expansion of territory into other areas that were previously occupied by Solutrean cultures. This may be attributed to population expansion during the later time period (Strauss 1983).

The Magdalenian is generally defined as being lamellar in form, having a predominance of burins, raclettes (tools with invasive retouch in geometric forms), bladelets, microliths forming composite tools and a strong bone/antler industry implementing the splinter and grove technique (Hemingway 1980). The Magdalenian was first defined by Breuil (1912) as having six stages (I-VI). The diagnostic tool in each of these stages was either bone point types for stages I-III, or harpoon types in stages IV-VI with pseudo harpoons first appearing in stage IV evolving to full harpoons with barbs on one side in stage V and barbs on two sides in the final stage VI of the Magdalenian (Julien 1987). Later Capitan and Peyrony (1928), with refinement by de Sonneville-Bordes & Perot (1963, 1973, 1987), used the finer-scaled excavations at Laugerie Haute and La Madeleine to distinguish the six stages of the Magdalenian using stone

tool assemblages. They saw the Magdalenian being divided basically into a lower (I-III) and an Upper (IV-VI) Magdalenian.

Rigaud (Laville et al. 1980) has probably done the most interesting work at trying to discern the origins of the Magdalenian. Unfortunately, when the cultural periods preceding the Magdalenian are examined, there are few similarities between the Solutrean and the Magdalenian. Rigaud sees the division of Upper and Lower Magdalenian coming a bit earlier. With the discovery of a Magdalenian 0 level at Laugerie Haute, Rigaud groups Magdalenian 0 and I into the Badegoulian and Magdalenian II-VI into the Upper Magdalenian. The Badegoulian seems to have a different source than the upper stages of the later Magdalenian. Stages II-VI have fewer tools on flakes, as well as many specialized tools, for example, beak truncation burins, Tayjet points and Laugerie Basse points and a plethora of microliths. Retouch on the blades and points is more similar to the Gravettian or the Perigordian. Rigaud (1980) even goes so far as to say that the later stages of the Magdalenian exhibit a "schizophrenic" quality.

From work mostly at Laugerie Haute and La Madeleine,

Laville, Rigaud and Sackett (1980) have defined the sequence of the Magdalenian. Magdalenian 0-III are well-represented at Laugerie Haute with stages IV-VI at La Madeleine. A problematic site is the site of Le Flageolet. From the traditional systematic view the assemblage at Le Flageolet falls into stage V. This is problematic because it is contemporary with stage III at Laugerie Haute both in the pollen profiles and dates of about 15,000 years ago. In trying to explain this, the assemblages without harpoons would look very much like stage II or III. Possibly many sites without good bone preservation may be misclassified. But, the issue here is whether one tries to explain why Le Flageolet is problematic or whether one questions the systematics of the typology for the whole Magdalenian.

Rigaud (1980) suggests, based on the "schizophrenic" quality of the Magdalenian and the problematic nature of Le Flageolet, that there might not be such a straight-forward evolutionary succession. He thinks that the variability that is seen is related to activity. As a whole the Magdalenian is a very homogeneous complex. The variability in the proportion of tools is generally attributed to differing activities.

Subsistence

In general during the Magdalenian we see both subsistence strategies and the use of particular resources changing (Audouze and Enloe 1991; Bahn 1977; Burke 1992; Conkey 1978; Legall 1992; Strauss 1987c). As for food procurement during the Magdalenian, they are exploiting a wide range of food products. While there is a concentration on reindeer in some areas (Bahn 1983), ibex (Strauss 1987c) and horse are being exploited in others. In addition we also begin to see a concentration on the use of birds, marine resources and the harvesting of fish such as salmon (Legall 1992).

Subsistence strategies themselves during the Magdalenian are evolving from those in the previous stages of the Upper Paleolithic and are intrinsically linked with land use patterns discussed below. Basic hunter-gatherer subsistence economy as modeled by Jochim (1976) views subsistence strategy as the result of three interlinked components; resource use schedule, site placement, and demographic arrangement. These components all come into play when investigating the culture of the Magdalenian.

Resource use scheduling takes into account the process

by which the decision is made as to what resources should be used and when. Linked to resource use scheduling is the decision as to where to place the sites. Based on the type of resource and the carrying capacity of the area, demographics need also be considered. This dictates the demographic decisions as to how many people can, or should, be designated for resource procurement.

It would appear that during the Magdalenian a transition occurred from a predominantly-forager model to essentially a collector model of subsistence settlement system. As a result, there is less movement of the base camp, and this may account for the large aggregation sites that begin to appear in the Magdalenian. Another result of this strategy is that on the landscape, in addition to seeing home base camps and locations of gathering, there are also sites used as field camps and caches of resources.

Audouze and Enloe (1991) propose several subsistence strategies based on location on the landscape and abundance of resources. The first are sites located near rivers with low quantities but very diverse fauna. These are also sites of intense stone tool production, and include sites like Etiolles (Pigeot 1987, 1990). The second model is one where

sites are also located near rivers; however, there is a concentration on one species of animal, such as reindeer, and many tools. These are represented by the sites of Pincevent (Leroi-Gourhan and Brezillion 1966) and Verberie (Audouze 1986). The last subsistence model proposed is one where sites are located on the edge of the plateau with many different faunal species present and many tools (Audouze and Enloe 1991). They propose the first and last models to be summer and winter encampments while the second model represents an autumn occupation. These three models paint a picture of a changing subsistence strategy with seasonal task oriented encampments.

Land use Patterns

When regarding subsistence strategies, location on the landscape cannot be ignored. Land use patterns during the Magdalenian should be contemplated both in regards to subsistence and economic strategies, and demographics. Land use patterns come into debate when considering whether Magdalenian peoples were following the large game herds, or were logistically placing their sites near to migration paths, or if there was even limited domestication of reindeer. Bahn (1977, 1978, 1982, 1983) is a proponent of

the herd following model along with the idea that these hunters and gatherers were treating some deer as domestic animals. He cites engravings at La Mache of horses and deer with what appears to be ropes around their necks. In addition, he sees evidence of animals with broken bones that should have been weeded out of the herd living several years with what he thinks is nurturing human intervention.

Delpech (1978) and White (1987) disagree with the domestication idea and cite other reasons an animal might have lived after having a broken bone. They also take a further look at the engravings and show that there are lines similar to the ones that Bahn interpreted as rope but they are associated with wild bison images.

The Herd Following Model

Burke (1992), PikeTey (1990), White (1989), Conkey (1980), and Strauss (1991, 1987a) support a model that would have sites being placed logistically to intercept herds on their migrations. Strauss's work at La Riera shows an exploitation of ibex and the utilization of marine resources. Straus (1987c) has also noted that these sites associated with ibex hunting are specialized for that purpose. Ibex hunting is never associated with multi-

purpose or long term sites. The sites are short term and task oriented.

White's (1989) work on land use patterns in the Perigord shows that there were a preference for south-facing caves and rock shelters and a selection for sites that were at fords in rivers where both humans and herds could cross. White (1989), Conkey (1980) and Strauss (1987c) propose that there were smaller camps that could support about 35 people and larger aggregation sites that could support up to 100 people at a time. These aggregation sites are almost always in an area that would see a lot of animal traffic and areas where people would pull together for the harvesting of resources like salmon.

Schmider's (1982, 1987, 1990) work in the Paris river Basin also supports an interpretation that sees Magdalenian peoples utilizing a collector strategy. While it is easy to locate large aggregation sites in southern France due to the abundance of caves and rock shelters, this is not the case in the Paris basin. Schmider sees this area as one for the passage and exchange of information and resources. In an area lacking natural shelters, the Magdalenian people had to adapt. Here most sites are short-term, and activity-related

either to the procurement of lithic resources or at herd crossings.

Strauss (1987a) goes further to suggest that people were becoming slightly territorial during the Magdalenian. He has looked at land use pattern in Cantabria, Spain and has noted that there are clusters of habitation sites in association with large art sites like Altamira. There is no geological reason why there should be voids in the habitation of land. There are caves, they have been surveyed, and there is no evidence of extensive habitation. These art sites seem to be on the outskirts of habitation areas, possibly marking a boundary.

Technologies

In defining the Magdalenian it is painfully obvious that although an amalgamation of a number of cultural attributes, the basis of the Magdalenian rests in its technologies. There are a number of technologies that see their florescence during the Magdalenian period. These fall into several categories; bone, stone, and art, which indeed bridges both stone and bone technologies in addition to its own unique expression.

Bone technology during the Magdalenian is both

functional and expressional. The atlatl is in full use during the Magdalenian as a hunting technology (Camps-Fabrer 1974). Not only are these atlatls an innovative functional advancement but, they are works of expressive art carved from bone and antler. Along with the production of bone technologies for hunting comes the production of harpoons and fish hooks (Julien 1987). Beyond hunting technology, the use of bone and antler for the production of needles for making tailored clothing is evidenced by the hundreds of needles found throughout Magdalenian sites (Camps-Fabrer 1974).

Stone tool technology during the Magdalenian concentrates on the production of tools made on blades. For the most part, it is dominated by burins, raclettes and microliths for the production of composite tools. There is also evidence for craft specialization in stone tool production. Work by Pigeot (1987, 1990) at Etjolles with refitting has lead to the interpretation of craft specialization at the site. The raw material at Etjolles is very difficult to work. Therefore, only experts are able to work it with any proficiency. It would appear that based on both refitting studies and technological studies there was a

hierarchy of flint knapping at Etiolles. This hierarchy is reflected in site organization. The best flint knappers seem to have been knapping in the center of the camp nearest to the hearth. The next level of skill seems to be on the periphery of the area, with the complete novices on the outskirts of the camp working very poor quality material. With the complete novices there seems to be a haphazardness to their knapping. With the intermediate knappers, there is a knowledge of the technology but one can see that there are technical difficulties. This evidence supports the idea that there is an apprenticeship taking place because the stages of discovery technologically that should come between a complete novice and the second stage are not present.

Much has been written on the interpretation of the symbolic representations. In fact there are probably as many interpretations as there are those to make the interpretation! Fewer people have investigated the technology that goes into the art's production. Clottes is one of those people. Clottes (1993) has analyzed the composition of the paints that were used in the caves. Through grain size analysis, trace element analysis and X-ray analysis he has found that there were several different

formulas being used. In some, the binder is just water while others use animal fat. Using trace element analysis he has even been able to determine that, though the same formula was used, the artist had to stop mid way through the painting and mix another batch of paint. He has also been able to determine that certain formulas were used in the lower Magdalenian while others were used in the Upper Magdalenian. This, in the long run, may act as a fossil director and help aid in solving the problem of chronology as well as number of artists involved in the production of the paintings.

Conclusions

During the Magdalenian we see technological advances and innovations in many different areas of the culture. Stone tool technology, food procurement, land use patterns and the production of art all lend support to the idea that the Magdalenian was a culture whose population was growing and whose culture was rapidly changing.

3. Microwear in the Magdalenian

Having discussed the Magdalenian in terms of its changing technologies and subsistence systems, at this juncture it seems necessary to examine several of the principle Magdalenian sites that have been the focus of usewear studies. Microwear analysis of Magdalenian assemblages have been few. This is potentially a reflection of one, or a number of the following elements: the number of sites suitable for analysis, the number of people employing microwear techniques in their studies, the richness of Magdalenian sites, and the time-consuming nature of microwear analysis. Therefore, the studies that have been conducted thus far are either limited in sample size or focused on a small portion of the site.

The analysts most widely published on their work in microwear of Magdalenian assemblages are Keeley (1988), Moss (1983a, 1986a, 1987a), Plisson (1983), Vaughan (1981, 1985b), Symens (1986), and Akoshima (1993). Each of these will be discussed in regards to microwear evidence and their resulting interpretation of site function. All of the studies to be discussed are conducted using the high-

magnification method (Keeley 1980) due to the excellent preservation of the stone tools at these sites.

Pincevent

Extensive research into the investigation of function has been conducted by Moss (1983a, 1986a, 1987a, Moss and Newcomer 1982) at the open air site of Pincevent in the Paris Basin. The tools are in excellent condition and Moss here elects for cleaning the tools solely in soapy water rather than traditional chemical means. Her studies support the hypothesis proposed by Leroi-Gourhan and Brezillian (1966, 1972) that views the two hearths at Pincevent as being separate, either temporally or spatially. Moss' work, along with Plisson's (1983), has shown that one of the hearths seems to have a high proportion of hide working tools (she is not sure if they are from dry hide working or fresh hide working) in an other stained area. The other hearth has a high proportion of bone/antler working tools assumedly associated with the retooling of microlith composite tools.

The microliths do not show many wear traces. The pointed microliths show evidence of impact and striations suggestive of hafting while the non-pointed microliths show

evidence of hafting and some evidence of contact with meat or hide. However, in terms of activity, given the nature of microliths and the retooling that is taking place at these temporary camps, the location of the microliths is only indicative of the activity of retooling, nothing else.

Another fine example of analyses conducted on the Magdalenian assemblage from Pincevent is the work by Cahen, Karlin, Keeley and Van Noten (1979). This study both examines the assemblage for function combines microwear analysis with extensive refitting. The refitting analysis revealed that tools of the same morphological type were all knapped from the same core. The microwear analysis indicated that these tools were all used for the same purpose. The combined data allowed the conclusion that there may have been a single activity episode taking place at the site that involved both the manufacture and use of a limited number of tools (Cahen et al. 1979).

Thus far, the microwear analysis at Pincevent indicates a short term occupation or occupations. The microwear analysis suggests that the activities at the site were restricted to hide processing and the retooling of composite tools. These activities are interpreted through the

presence of hide working polish on tools associated with an other stained hearth area (other has been shown to be used in stages of hide processing (Plisson 1983)) and bone and antler polish from retooling of composite tools. These two activities are isolated in space and associated each with individual hearths.

Verberie

Three Magdalenian sites, Verberie in the Paris Basin, and Rascano and El Juyo in Cantabria were analyzed functionally and typologically by Keeley (1988). His aim was to identify variability in site functions. Based on proportions of bone working to hide working and dry hide working to fresh hide working, he formulates interpretations of site function as either base camps or temporary hunting/retooling camps.

Verberie is located in northern France on the Oise River (Audouze 1986). Verberie is an open air site not unlike the site of Pincevent discussed earlier. The layout of the site consists of several hearths with knapping debris scattered around them. Verberie dates by thermoluminescence to 13,300 B.P. late in the Magdalenian. The faunal assemblage, also similar to Pincevent, is dominated by

reindeer. This combined with its position on the Oise River has lead to the interpretation of the site as a temporary hunting camp for the interception of migrating reindeer (Audouze 1986).

An investigation of function was undertaken by Keeley (1988) with the intention of integrating the resulting information with both typological and technological analyses. It should be noted that Keeley's stratified random sample of lithic material from Verberie included 100% of the retouched tools and a sample of the unretouched material totaling 1100 artifacts. In the tool action category, microwear evidence shows that the motions boring and graving were dominant (60%). Cutting and scraping account each for about 10% of the tools and another 20% of the analyzed tools were as projectiles. As for the materials being worked at Verberie, the working of bone and antler by far overshadows the assemblage at 56%. Hide working accounts for another 10% of the materials worked at the site. In a summary of the activities interpreted for the retouched tools at Verberie, boring bone/antler and graving bone/antler account for 50% of the activities with

another 18% of the assemblage used as projectiles (Keeley 1988).

Symens (1986) has also conducted analysis at Verberie. His findings agree with those of Keeley's. Along with a high proportion of usewear indicative of bone/antler working he finds a certain amount of meat cutting along with some fresh hide working.

Both Keeley's and Symens' analysis of the material from Verberie support the interpretation that Verberie was a short term specialized hunting camp. Activities focusing on bone and antler work for the retooling of composite tools and evidence for the early stages of hide processing, support this interpretation.

Rascano

Another Magdalenian site, Rascano, is located in Cantabria, Spain very near to the coast. It differs from the two sites previously described in that it is a cave site and not an open air occupation. Though Rascano differs from Pincevent and Verberie in its location, there are functional similarities between the sites as supported by the microwear analyses.

The site of Rascano has also been analyzed by Keeley

(1988). The sample from Rascano was not a random sample but rather a selection of retouched tools gathered by a graduate student. The sample consists of 100 tools distributed throughout the upper paleolithic typology.

At Rascano, Keeley found evidence for a limited number of activities. In his microwear analysis he found traces of bone/antler polish on burin nibs as well as on the edges of the burins for scraping and graving bone/antler. Bone and antler polish accounts for 39% of all the materials worked. At Rascano, graving and boring account for 45% of the motions. Cutting and scraping are represented by 31% of the tools analyzed while 22% of the tools were used as projectiles. He also found traces of hide polish(17%) on scrapers. He again found a very high proportion of bone/antler working tools to hide working tools and a high proportion of fresh hide to dry hide working tools as he did at Verberie. Though there was a limited number of bone artifacts at the site, it led him to conclude that Rascano, like Verberie, represented the typical Magdalenian pattern of a temporary hunting camp where there was a great deal of retooling for composite tools and evidence for the initial processing of fresh hides from the hunt.

El Juyo

El Juyo, like Rascano, is a cave site located in Cantabria also not far from the coast. Unlike Rascano, however, El Juyo shows a different pattern of functional variation allowing for quite a different interpretation of site use.

At El Juyo, approximately 43% of the tool motions can be ascribed to cutting and scraping while only 26% can be attributed to graving and boring. The materials being worked were diverse and distributed rather evenly over the categories bone/antler, meat, and hide.

El Juyo has a high ratio of dry hide to fresh hide working and a low bone/antler working ratio. This, along with a broader range of activities over potentially a longer period of time, led Keeley (1988) to conclude that El Juyo was a base camp rather than a temporary hunting station.

Cassagros

Vaughan (1981,1985) analyzed a Lower Magdalenian assemblage from the cave site of Cassagros in southwestern France. The assemblage was excavated from a distinctive ocher-stained Magdalenian level. The sample included 532 retouched and unretouched flints which represents 100% of

the excavated flints from the site. He concluded that, though there was evidence for the working of antler, bone and wood, the dominant activity at Cassagros was the preparation of both dry and fresh hides (60% of the tools). The presence of antler and bone polish on some of the stone tools is interpreted as evidence for the production of hide working tools made from those materials.

Though no quantitative analysis of spatial patterning was performed, the overall pattern of artifact distribution indicates that the principal tool use activity took place in the first chamber of the cave near a hearth. These tools distributed around the central hearth had the remains of red ocher adhering to the edges. Vaughan proposes that during the winter months hides were processed around the central hearth inside of the cave for both light as well as warmth.

Abri Dufour

Akoshima's (1994) dissertation analysis of Abri Dufour is entirely inconclusive. Akoshima found that the assemblage was too patinated for usewear studies.

Conclusion

During the Magdalenian we begin to see changes in technologies and subsistence strategies. Evidence for the

support of this is seen in the artifacts, site placement and spatial analysis and content of archaeological sites. Specialized analyses into stone tool function through microwear research at Pincevent, Verberie, Rascano, and El Juyo have also contributed to the ever expanding data base supporting these interpretations of Magdalenian culture.

4. Models for Grotte XVI

Data have been discussed concerning ethnographic and experimental observations used in building models of hunter-gather systematics. These models investigate land use patterns, site organization and artifact distributions across the site. Here these models will be used in combination with data collected from Magdalenian sites to formulate models specific to Grotte XVI.

Based on ethnographic observations, groups that employ a forager system should be represented in the archaeological record by one type of site, a base camp. At such a base camp, tool assemblages should be general, not specialized, and as a result, microwear evidence should point to general domestic activities. Away from the base camp are of

peripheral activities. Tools from these peripheral assemblages will be specialized and task specific; however, in the archaeological record the signature will be very slightly because these activities are not repeated.

Groups that employ a collector subsistence system have base camps represented in the artifact assemblage similarly to that of a forager camp. In addition, however, as a part of the system they have specialized task oriented sites away from the base camp. These task oriented-sites while similar to the peripheral sites at a forager camp are first, nowhere near the camp and second, defined by a very strong signature in the archaeological record due to repeated visitations (Binford 1978). These specialized task oriented sites will not only have specialized tools but these tools will also be correlated with specialized usewear.

Spatially, artifacts from a forager camp should be in a redeposited refuse area to one side of a central hearth and, as a result of this, the function of the site will be homogenized. Though functions may still be determined through microwear analysis, activity areas can not be defined because of the redeposited context. However, work by both Binford (1978) and Keeley (1991) supports the

hypothesis that smaller artifacts have a higher likelihood of being deposited where they were used. These materials at a forager base camp would be indicative of activity areas. These pieces, resharpening flakes and pieces of broken tools, are also the materials least likely to show evidence of microwear damage. Microliths from hafted composite tools, on the other hand, would show evidence of use. They are not deposited where they were used rather where they were they were hafted or rehafted (Keeley 1991).

Spatially, artifacts from a collector base camp should also be in a redeposited refuse area to one side of a central hearth just as they are in a forager base camp and, as a result, of this the function of the site will be homogenized (Binford 1978). Where function may be both determined and non homogenized is at specialized task camps. Here because of the temporary nature of the camp, the site is less susceptible to the general cleanup and redeposition of artifacts in a central rubbish pile. Rather, artifacts have a higher probability of being deposited where they were used. Therefore, activity areas may be present and capable of being determined through usewear analysis. It is here at these specialized sites that Keeley's (1991, 1982) work on

hafted tools becomes important. Being both small and hafted, the probability of their being deposited where they were worked on is very high. Their function most probably should not be used to define an activity area but rather by implication, to provide evidence of the retooling process. Consequently, because they were once hafted there should be microwear evidence of the production of bone and antler hafts on other tools nearby.

By definition, a forager system requires little logistical planning. Given that planning is at a minimum, Kent's (1991) model involving the correlation between the "anticipated length of stay" and site structure would not apply. If planning is at a minimum, then the length of stay in one place would not be anticipated and therefore would not determine site size (Kent 1991).

A collector system requires a great deal of logistical planning. Therefore, there should be a strong relationship between typology, technology, raw material and function. If there is planning then Kent's (1991) model correlating site size with the "anticipated" length of stay at the site location may be applied. These task-oriented sites are assumed to be short term. If the group anticipates a short

term stay then sites should be no larger than 33 square meters per person (Kent 1991).

Earlier, I discussed the *chaine operatoire* approach to lithic artifact analysis. This theoretical framework positions a tool in its place in the operational sequence. It investigates the life history of the tool. Often the sequence from raw material procurement, to production, to use, to discard is seen as linear and the tools' position within the sequence is assessed. However, if this sequence is not considered linear but rather a series of loops where one decision may effect one or more of the other stages, then we can investigate relationships between the operational sequences. Because analyses have already been conducted into the technology, typology and raw material at the Grotte XVI, these data may be used to model function at the site. If there are feedback loops between the separate phases then, there should be a strong relationship between function and each of those phases. There are local and non local materials present at the site. If there were logistical planning involved, as would be suggested by a collector model, then functions related to the pre-planned tasks should be correlated with specialized tools made of

exotic materials curated and brought to the site for a specific purpose. On the other hand, wear as the result of unplanned or expedient tasks should be associated with tools made from local materials. If there is a relationship between the decision making process involved in the selection of particular tool types or technological phases and function, then usewear should reflect a strong correlation with specialized tasks. The last phase in the use life of the stone tool is its final discard and incorporation into the archaeological record. This could present the strongest relationship yet. If the position of the stone tool within the site has an operational feedback with function, then activity areas will be present at the site and these activity areas will be separated in space at the site.

These are just some of the models that will be tested at the Grotte XVI. Each model relates to the role site function plays in a hunter-gatherer system. Investigation into these models and site function is accomplished through microwear analysis of the stone artifacts from the Magdalenian assemblage. These methods are the focus of the next chapter.

III. METHODOLOGICAL CONSIDERATIONS

1. The Nature of Microwear

Introduction

Functional analyses are very important in gaining an understanding of archaeological materials. While typological analyses may aid us in identifying the cultural/temporal origins of the lithic materials, and technological analyses can tell us how the tools were produced, functional analyses can reveal to archaeologists what activities were taking place at a site and thus expand our insight into the role of the tool in the *chaîne opératoire*.

When a tool is used, microscopic wear traces form on the edges. These traces can show not only *that* the tool was used, but also, *how* the tool was used (to cut, scrape, bore or grave) and on what material it was used (wood, bone, hide, plant material), allowing for functional interpretations to be made about the site. From this, activity areas within a site may be defined and sites may be compared based on what activities were taking place. This

chapter outlines the historical development of microwear analysis. In so doing, the methods used in microwear studies will be discussed, along with the primary experimental works. Theories on how and why wear develops will also be presented. Lastly, justification will be made for the methods used in this dissertation research.

Historical Development

With the publication of Prehistoric Technology (Semenov 1964), a plenitude of microwear studies were launched. These studies not only used, but also refined the methods of analysis Semenov developed. At present, microwear analysts fall into three methodological camps; low-magnification, residue analysis using scanning electron microscopy (SEM), and high-magnification.

The first group (Frison 1968; Lawrence 1977; Odell 1975, 1977, 1981; Odell and Odell-Vereecken 1980; Rosenfeld 1971; Shea 1988, 1989, 1990; Tringham et al. 1974) employs low magnifications (up to 100X) using stereomicroscopes. The analysis is concerned primarily with the evaluation of edge damage in the form of micro-scarring. The second group (Anderson-Gerfaud 1980, 1986; Fullagar 1991; Kooyman 1992; Mansur-Franchomme 1983) concentrates on the analysis of

prehistoric residues on, or incorporated into, the edge of the stone tool using SEM with magnifications exceeding 500X. The third group (Akoshima 1993; Anderson-Gerfaud 1979, 1990; Beyries 1989; Cahen and Keeley 1980; Juel-Jensen 1988; Keeley 1974, 1980, 1982, 1988; Moss 1983, 1986a, 1987a; Symens 1986; Vaughan 1981, 1985b) uses a binocular microscope with an incident-light attachment, employing a range of magnifications (up to 500X) in light-field illumination. This method concentrates primarily on the assessment and interpretation of edge polishes and striations. Which of these methods produces the most reliable, quantifiable and verifiable data is debated and its application dependant upon the collection to be observed. Each of these methods will be discussed along with critical experimental studies and blind tests.

Low Magnification

The low-magnification approach to microwear analysis was pioneered by the work of Ruth Tringham (et al. 1974) and George Odell (1977, Odell and Odell-Vereecken 1980). These seminal studies have inspired additional studies like those of Shea (1988, 1989, 1990) on Mousterian assemblages. In general this technique microscopically scans a utilized edge

of an implement at magnifications between 10 and 20x to locate the damage. Once the damage has been located, the patterns are assessed and interpreted at a magnification between 20 and 80x.

It has been noted that scarring usually appears before any other type of wear; in addition, scarring seems to be more resistant to post depositional alteration than micropolishes (Odell 1977). For this reason low-magnification views and assesses use damage in the form of scar patterns, edge rounding, and striations with scar patterns forming the bulk of the interpretive material. This scarring, the tiny chips removed from the edge of a tool under the pressure caused by utilization, is important in defining the function for which that implement was used. Low-magnification analysis is the most expedient of the methods used in microwear analysis. The preparation for the lithics is simple. Generally sample preparation need only involve washing with soap and water. Microscopic analysis time per piece usually takes between 3-5 minutes (Tringham et al. 1974, Odell 1977).

Early experiments investigating stone tool function were uncontrolled and unsystematic. The studies focused

primarily on the efficiency of the stone tool as it was used to replicate "prehistoric tasks". In order to accomplish this, generally early experimentation involved the replication of a stone tool type and its application to the completion of a "prehistoric task" (Curwen 1935, Semenov 1964). For the most part the examination of wear traces was only on a very cursory macroscopic level looking at only the grossest of scar damage.

The work of Semenov (1964) was the first extensive study involving the microscopic examination of damage patterns resulting from use. He was the first to observe that patterns existed in damage produced on stone tool edges and that these damage patterns correlated directly with the material being worked and/or the action carried out. Semenov identified three basic types of wear that he thought were the principal attributes involved in the identification of function. These were polish, striations, and scarring. He concluded that striations were the key attributes in establishing the use of a prehistoric stone tool.

Later microwear analysts built upon these early experiments and, after Semenov, concentrated on looking for striations as indicators of use (Rosenfeld 1971). Deeper

investigations were unsuccessful. For this reason then, microwear analysis turned to the systematic examination of microflaking, or the chips on the edges of stone tools, as a better indicator of use.

The assessments of wear patterns and attribute definitions that are used today by proponents of low-magnification microwear analysis are the result of an extensive experimental program that began at Harvard under the direction of Ruth Tringham and her students in the 1970's. These experiments were both extensive as well as systematic. Rather than replicating prehistoric tasks, experiments controlled for various attributes in order to investigate the precise relationship between different variables and use traces. Tringham (et al. 1974) focused on scar patterns as the most sensitive indicator of both material worked and action carried out.

Tringham's hypothesis was: "a tool made of a specific raw material, whose edge is activated in a specific direction across a specific worked material will develop a distinctive pattern of edge-damage of a kind that is recognizable on the edges of prehistoric tools" (1974:178).

All their experiments were conducted on English chalk

flint in order to evaluate scar patterns that were the direct result of use. The flaked stone tools were of the types found in the Neolithic of Central and Eastern Europe. However, the results are applicable to assemblages from throughout prehistory in both the New World and the Old World because for the most part, cherts and flints fracture alike (Cotterell and Kamminga 1979).

The experiments themselves involved producing an edge and then working a specific material with a specific action. In so doing, several variables beyond material and action were controlled. Raw material was held constant, every experiment being conducted using English chalk flint. Edge angle was measured and controlled. The angle of the tool to the worked material was controlled at 20 degrees. In addition, the duration of use was kept constant and measured after a predesignated number of strokes. Pressure was also kept constant for the most part varying slightly due to human inconsistency. Keeping all of these variables constant allowed for the distinguishing of different patterns of damage due to use (Tringham et al. 1974).

Results of the experimentation indicated that the best evidence of motion was the location and distribution of

scars. On the other hand, the worked material was best defined by morphology of the damage scars. Striations and edge rounding were also used as indicators. The results of these findings are summarized in a following portion of the chapter under the heading "Terminology and Variables".

Scanning Electron Microscopy

Another aspect of microwear analysis involves the application of the scanning electron microscope (SEM) to investigate residues. First the term "residue" must be defined. Residue can be defined as either the material left on the edge of the tool from use, in other words, material that is on top of the surface of the piece and could be removed in the cleaning process. Residue can also refer to material that is presumably incorporated into the polish during use. The second type of residue will not be removed during the cleaning process.

First, I will discuss the residue that adheres to the surface of stone tools. Few of these studies have been conducted due to the fact that many organic materials, even under the best circumstances, are not preserved. Experimental work by Kooyman (1992) on blood residue analysis has been fairly successful. A sample of points

from "Head-Smashed-in-Buffalo-Jump" were used as a test because of the very high probability that they would contain blood residue and that residue would be from one type of animal, *Bison bison bison*. Blood residue was extracted from the tools using a 5% solution of ammonia. Then, using cross-over electrophoresis, the unknown residue was compared to the serum of bison, elk, deer, antelope, mouse, rabbit, rat, quail, trout and human. The only antisera that showed positive results were buffalo and elk.

In addition to the analysis being conducted on blood residues, there has been some work investigating the adherence of non-organic residues to the edges of stone tools. Moss (1983), Plisson and Mauger (1988), and Keeley (1988) each independently with their work at Pincevant have noticed red ochre adhering to the edges of stone tools. It is possible that this ochre has been deposited on the tools postdepositionally because it is present in the soil at Pincevant. However, the fact that with further microwear analysis these tools show usewear from hide working supports the hypothesis that the ochre was used in hide processing and is indeed a residue from use. Vaughan (1981) with his work at Cassagros has also noted the presence of ochre

adhering to tools later identified as hide working tools.

Work has been conducted looking at residues which are thought to have been incorporated into the polish on the edge of the stone tool. This assumes that polish is additive rather than reductive which will be discussed later when investigating polish formation. Anderson (1980, 1986) has conducted extensive experimentation under the assumption that the formation of polish involves a silica gel state into which material being worked is incorporated. In her analysis using SEM, Anderson has identified, both experimentally and archaeologically, the presence of phytoliths and animal cells incorporated into polish. She has designed experiments to look at different plant phytoliths as well as different hide cells from animals to aid in identification of the genus and species of the organic material in question.

Anderson (1980) used experimental tools to work six species of wood in both their fresh and dry states. Modern wood samples were studied to understand the plants' structure. Using SEM analysis the experimental tools were observed. Phytolith bodies could be seen sunk into the flint surface and incorporated into the silica of the stone

tool edge.

Unger-Hamilton (1984, 1989) also using SEM has identified objects that have the appearance of phytoliths similar to the ones identified by Anderson. Unger-Hamilton contends that these are on top of the flint surface and not actually phytoliths. He claims that the results of his research refute or at least bring into question the work of Anderson.

High Magnification

The high-magnification approach is often referred to as the "Keeley method" after the work done by Lawrence Keeley (1974, 1978, 1980, 1988). Keeley felt that, though work had been conducted to develop methods for determining the function of stone tools, the work was still inconclusive. The methods were inconclusive in the area of actually identifying the material that the tool had come in contact with. In his dissertation research he set out to remedy that problem.

Keeley developed an experimental program to replicate tools and activities that would have been present during the British Lower Paleolithic. He did this in order to be able to examine the function of Clactonian and Acheulean

implements. His most important contribution to the discipline of lithic analysis was to discover that there was a strong correlation between particular attributes and the detailed appearance of micropolishes formed on the edge of stone tools. These polishes were the direct result of contact with particular materials. By combining polish type with other attributes of microwear, the precise function of the stone tool could now be determined.

The "Keeley" method uses a binocular microscope with an incident-light attachment in bright field illumination, employing a range of magnifications up to 500X in the identification of use wear. The high-magnification method evaluates utilization damage in the form of microscopic polishes and striations produced through utilization (Keeley 1974, 1978, 1980) while also assessing microscar patterns and edge rounding.

Cleaning of the pieces requires washing first with an ammonia based solution to remove general dirt and finger grease. The second stage involves the submersion in a 10% solution of NaOH for five minutes to remove any organic residue from the experiments. Lastly, the piece is soaked in a 10% solution of HCl for five minutes (Keeley 1980).

This last step is for the removal of concretions on the pieces and is not really necessary for experimental collections but, must be done to maintain control for archaeological collections that will be viewed and compared (Keeley personal communication). The entire process from cleaning to assessment can take up to 35-40 minutes per piece.

Cleaning Debate

Plisson (1985) has conducted research on chemical alterations to usewear polish and has discovered that NaOH, warm HCl and several other chemicals can completely remove polish from a stone tool in about 40 minutes. For cleaning purposes this does not seem to be a problem. However, he has demonstrated under chemical conditions polish can be removed completely. This has cautionary implications in a depositional setting where a great deal of chemical alteration has taken place.

Moss however, opts for cleaning with just soap and water and has very good results. There may be some alteration of the polish due to cleaning with NaOH in that bone polish looks pitted after cleaning and this may be the result of bone mineral being removed from the polish itself

(Keeley 1980, Anderson 1980).

In regards to cleaning Keeley has been accused of using chemicals too harsh and potentially damaging to polish. Keeley would note that a 10% solution of NaOH and HCl for 5 minutes is far from destructive and the HCl is necessary for the removal of concretions on the stone tools that obscure the polish. Anderson would also contend that polish is much more readily viewed once the piece has been cleaned chemically.

Whichever cleaning method is used, there needs to be consistency between the processing of both experimental and archaeological specimens. Exact methods used for this study will be discussed below.

Polish Formation

Now that the various techniques used in microwear analysis have been discussed, as well as positions on chemical use in cleaning and its effects on polish, it is necessary to investigate the nature of microwear polish. As defined, "micropolishes constitute a change in the surface of the flint both topographically as well as in its reflectivity" (Jeul-Jensen 1988:55). The question of how microwear forms is, as of yet, a topic of debate. Simply

put it may be that microwear forms when cryptocrystalline rock comes in contact with another material. Unfortunately it is not as simple as that. The mechanics that cause edge damage are more straightforward and less debated than actual polish formation and striations.

The mechanics of fracturing have been investigated and discussed at the Ho Ho convention in 1979 (DelBeene 1979, Diamond 1979, and Cotterell and Kamminga 1979, Hayden 1979, Odell 1979). Microwear analysts have concluded, based on experiments in the material sciences controlling for the loading force on flint, that scar patterns and types are the direct result of the force involved when chert comes in contact with another material. The results are the various feather, hinge, and step terminated scars that are utilized in low-magnifications studies (Tringham et al. 1974, Odell 1977).

Striation formation is a bit more controversial. Moss (1983b) and Keeley (1980) have investigated the formation of striations and the presence of abrasives such as ocher or dirt in hide working. Though striations are more abundant in the presence of abrasives, they are still present in hide working without the addition of an abrasive. Fullagar

(1991) has investigated the formation of striations as the result of phytoliths acting as the abrasive.

More controversial still is the debate over the formation of polish. Is polish reductive or additive?

Those that propose that polish is reductive see polish as the result of chert coming in contact with another material, and due to the abrasion the chert is worn away in a patterned manner. Diamond (1979), DelBeene (1979), and to a certain extent Unger-Hamilton (1984) view polish as the result of abrasion.

Those that view polish as additive have done extensive experimentation on the role of water, silica and friction in polish formation. Some of the major contributors to this study are Anderson and Whitlow (1983), Anderson-Gerfaud (1980) and Fullagar (1991). In their studies polish seems to be an alteration of both the surface topography of chert as well as an alteration in its brightness caused through contact. Anderson has proposed that in the presence of friction and water chert goes into a silica "gel state". This "gel state" creates the polish and allows for the incorporation of hide cells and phytoliths into the polish.

Anderson and Whitlow (1983) took this idea one step

further by investigating the role of water in polish formation. Using ion beam diffraction they measured the amount of hydrogen on unused versus used portions of the stone tools. They found that there was an increased proportion of hydrogen in the area of the chert that had been used. They attributed this to its incorporation from water during use.

Fullagar (1991) wanted to investigate the role of silica in polish formation and used several plant materials with varying amounts of silica to investigate this. Fullagar employed some of the studies from the material sciences that have investigated glass polishing. Silica will go into a gel state when the proportion of water to silica is 1:15, the pH is at least 9 and temperature is at least 25 degrees centigrade. Investigations with glass have shown that a polish forms when it comes in contact with ice. Therefore, water must play a role. He also noticed that through a series of use-lapsed experiments, polish goes through stages. Others have also observed these phenomena where polish goes through a generic weak stage before its diagnostic features begin to appear (Jensen 1988, Keeley 1980, Moss 1983a). Fullagar discusses four polish stages.

The first appears to be reductive and there is actual loss of material. The second stage involves edge rounding and generic polish formation. In stage three, microwear identification of polish can be accomplished as the diagnostic attributes of the polish form. The fourth stage is an extension of stage three where the polish becomes developed. Silica both in the chert and in the material being worked, in combination with water and friction, cause an alteration of the chert surface that is additive. Materials with large amounts of silica like plant materials tend to produce the best defined, smooth and bright polishes. While working with hides tends to produce a polish with a rather matte appearance, it brightens, however, when grease is added.

Blind Tests

For the most part the interpretation of micropolishes rests on analogy and the comparison of prehistoric polishes with experimentally produced ones. Therefore, blind tests and carefully controlled and organized experiments are critical. Through the use of blind tests (Bamforth 1986, 1990; Bamforth, Burns, and Woodman 1990; Keeley and Newcomer 1977; Moss 1987b) the high-magnification method has proved

to be quite reliable. Vaughan (1981) experimented with both the low-magnification, as well as the high-magnification methods. He demonstrated that the attributes assessed using low-magnification methods, namely microscarring, exhibited too much variability to be considered as reliable indicators of function. He concluded that the combination of polishes, striations and edge rounding were much more reliable indicators of the use action and the material contacted. These studies and the limitations of the methods will be discussed below.

Blind tests have been conducted using both the low-magnification (Odell and Odell-Vereecken 1980) and the high-magnification (Keeley and Newcomer 1977, Bamforth 1988, Bamforth et al 1990) approach. These tests have aided in identifying the limitations of microwear analysis (Newcomer et al 1986). Both low-magnification and high-magnification approaches scored equally well when the limitations of the method are taken into account. In general, microwear analysts score about 75%-80% correct in the interpretation of the motion of the tool. The assessment of the material used ranges from 65%-75% correct.

Blind tests (Odell and Odell-Vereecken 1980, Keeley and

Newcomer 1977, Newcomer et al. 1986, Bamforth 1988, Vaughan 1985, and Bamforth Burns and Woodman 1990) along with investigations in the formation of polish have been able to identify some of the limitations in usewear interpretation. While experiments showed that there were certain wear patterns and polishes that developed as the result of use, it was not until these assessments were challenged in blind tests that some of the limitations began to be identified. Keeley and Newcomer (1977) began some of the first blind tests using the high-power approach. Under experimental conditions polishes showed distinct attributes dependant upon the material worked. When subjected to blind tests as well as under archaeological conditions, there were some ambiguities. For example, to distinguish between bone, antler and ivory, though possible under experimental conditions, was difficult unless the polish was well developed with archaeological specimens.

Blind tests show great success (Odell and Odell-Vereecken 1980) with a 75% accuracy in the interpretation of motion (this coincides with the tests on motion for high-magnification) and a little lower 67%-75% accuracy in assessment for material worked. Vaughan's (1985) work did

not indicate such success. While polish was deemed a good indicator for action as well as material worked, scar patterns were not.

On the other hand, Newcomer (et al 1986) at the Archaeological Institute of the University of London conducted blind tests and concluded that polish was not a reliable indicator of function because the analyst at the Institute did not perform well in the tests. Most of the ambiguity rested on the material worked and was in the distinction between antler, bone and ivory. However, to counter those findings Moss's (1987b) publication, as well as those later by Bamforth (1988), paint another picture. Bamforth (1988) allows that if you take into consideration the limitations of the interpretations (for example it is difficult to distinguish bone, antler and ivory), and then proceed from there with those materials grouped as a single category of wear, then the results show a high level of successful interpretations.

Limitations

Though sometimes it is purported as the be all and end all in lithic analysis and for the interpretation of site function and activity areas, microwear analysis does have

its limitations. All lithic assemblages can provide relevant information using this methodology though some methods are more appropriate than others depending upon the condition of the assemblage. Both diachronic as well as taphonomic effects are taken into account during microwear analysis, though often these conditions are difficult to replicate in experimentation. However, given that these limitations are acknowledged and caution is employed, an interpretation of function can be proposed at most sites.

Having just discussed the methods involved in microwear analysis, a discussion of microwear's limitations is in order. Low-magnification analysts accepted their limitations from the beginning when they looked at the material worked as a reflection of the hardness and categorized the materials into groups (soft, medium and hard). This is a little less precise an assessment of the material worked. However, in a much shorter period of time, and with quite a high proficiency, an assessment of the economic activities and functions at a site can be assessed.

Along with these general limitations in the assessment of function, there are other post-depositional factors to be considered. This leads to a reflection on assemblages that

microwear can be used on successfully. It is here that one must consider the method that is most appropriate. The wear that is assessed in the high-magnification method is more susceptible to post-depositional alteration (Keeley 1980). Therefore, sites that have a great number of highly patinated pieces or show evidence of cryoturbation or surface collections should use the methods developed for the low-magnification approach. Odell (1985) in his article "Small Sites Archaeology" advocates that microwear analysis should not dismiss these small surface collections because a great deal of information on temporary campsites can be gained from microwear studies on these assemblages. High-magnification methods should be used only on those sites that have less evidence of post-depositional alteration. Alterations to wear polishes will be discussed in the following chapter.

2. Methods Specific to This Study

Microwear

Thus far, methods have been discussed for the various analytical techniques used in microwear studies. The

section to follow will deal specifically with the methods used for this dissertation. High-magnification microwear methods, as defined and developed by Lawrence Keeley (1980), were employed to analyze the Magdalenian assemblage from Grotte XVI. High-magnification microwear analysis involves the optical microscopic study at a wide range of magnifications (up to 500x) of polishes and striations that have developed on the edges of stone tools as the direct result of use. High-magnification microwear analysis was used in compliment with, rather than as the replacement for, low-magnification microwear analysis. While this analysis emphasized the assessment of use polishes and striations, it did not overlook the interpretive potential of the microscars and edge rounding that are the foci of low-magnification studies.

Experimental Program

The interpretation of microwear relies heavily upon analogy (Juel-Jensen 1988; Keeley 1980). Therefore, experimentation is a necessary step toward understanding and interpreting stone tool function. Experimental studies were conducted using modern replicas of ancient stone tools in a variety of ways (per Anderson-Gerfaud 1981; Keeley 1980;

Moss 1983; Plisson 1988; Vaughan 1985). These stone tools were then microscopically analyzed and their wear patterns recorded. Ancient uses are inferred from the similarities in the wear patterns of the modern replicas and the wear patterns found on the ancient tools.

Developing a comparative collection is of vital importance to making reliable and accurate interpretations of usewear damage. It is an integral step in every microwear analyst's training. In developing a comparative collection there are several variables that should be controlled. Most experiments are a melange that tried to strike a balance between a scientifically controlled replicable experiment and the reproduction of conditions as they might have been in prehistoric times. For example, most analyses control for the angle that the tool is held at and number of strokes that the tool is used. The tool is often examined at several stages during the experiment. However, several analysts have remarked that the lab conditions are much less dirty and more sterile, than prehistoric conditions (Moss 1983) and this can effect polish and wear formation. Other variables that should be assessed are chert type, tool type, actions, and materials

that are worked.

Though it was agreed upon at the Ho Ho convention (Hayden 1979) that most chert types fracture alike (Cotterell and Kamminga 1979) and that polish is similar on different cherts, experiments should be conducted on local materials nonetheless. The high-magnification approach is somewhat subjective and relies on learning polishes by sight. The topography and characteristics of the polish remain standard from chert type to chert type. Even though this is the case, experiments need to be done on materials found at the site being excavated in order to establish a base line from which to gauge polish brightness (Keeley personal communication).

The most important variables to assess in any microwear study are those associated with action and the contact material worked. Through the combination of use action and contact materials, a full range of activities that may have been practiced in the region through time should be represented in the experimental collection. Even taking all of these ranges of activities into account, there will still be unidentifiable and ambiguous pieces in the archaeological assemblage.

Once the experiments are completed and the experimental collection has been studied, a series of blind tests should be conducted. The assessment of usewear and ultimately the interpretations of usewear in the archaeological assemblage, are only as reliable as the microwear analyst.

An experimental program for this dissertation research was designed after those experimental programs conducted by Anderson-Gerfaud (1981), Keeley (1980), Moss (1983), Plisson (1983), and Vaughan (1985). These experiments included both a wide range of motions (cutting, scraping, graving, boring) and worked materials (wood, hide, bone, antler, meat, vegetal material). Combinations thereof were used to replicate plausible prehistoric activities.

Using the *Bergeracquois* variety of flint, and local flint found in the fields above Grotte VXI, both retouched and non-retouched tools were fashioned. Each tool was used on a range of materials from meat to antler in hardness. Tools were also used in a variety of motions for each material. These motions were cutting, scraping, graving and boring. Though the experimental collection was not nearly as extensive as those created by my predecessors in microwear analysis, it was felt that those previous

experiments should act as a starting point and not be replicated once again.

After each tool was used it was drawn to scale and the area of use was recorded along with the duration of use, material, and motion. Recording techniques along with specific attributes and their descriptions and definitions will follow later in the chapter.

Following the creation of the experimental collection, an intensive apprenticeship was undertaken at the University of Illinois at Chicago under the direction of Dr. Lawrence Keeley. The experimental collection was studied with Dr. Keeley's guidance. Under his direct supervision, I came to know and understand the attributes that distinguished one type of polish from another.

Cleaning

Previously in this chapter the pros and cons of chemical cleaning were discussed. Having taken each argument into consideration, it was decided to follow the cleaning methods outlined by Keeley (1980). Each of the experimental tools was cleaned following several steps. Initially each tool was cleaned with an ammonia based cleaning solvent to remove finger grease and the more easily

of the removable debris left over from experimentation, in this case "Fresh Scent Top Job". Next each piece was set to soak for 5 minutes in a 5% concentration of sodium hydroxide. This stage of the cleaning process removes the more stubborn of the organic material still left adhering to the tool surface as the result of contact with experimental materials. Additionally, each implement was then left to soak in a 5% concentration of hydrochloric acid for five minutes. Though this stage of cleaning is not necessary for experimental pieces, it is a necessary stage in the cleaning of archaeological pieces to remove stubborn concretions. Therefore, for the sake of consistency neither stage is eliminated whether cleaning experimental or archaeological implements. Finally, each implement is soaked in water for 10 minutes to allow any residual chemicals to leach out of the flint.

Microscopy

Once the pieces were cleaned and drawn, a Wild-Lietz binocular microscope with an incident light attachment was employed to assess the use damage. With an incident light scope the light intensity increases as the magnification increases which is critical to the viewing of use polish

(Keeley 1980). Unfortunately, with an increase in magnification, three dimensional viewing decreases. However, with practice and adjustment with the fine focus at low magnifications, there can still be an assessment of the three dimensional aspects of the polish topography and edge damage. The microscope used for this study had the advantage of having both the bright field and the dark field illumination options. In bright field illumination the light is reflected at 90 degrees to the tool edge. This is essential for viewing polishes at high magnifications. Dark field illumination, however, where the light is reflected at 45 degrees all around the tool surface, is useful for viewing edge damage at low magnifications. Since both illumination modes were available, each was used to its own purpose. This allowed for the recording of several different types of use damage and therefore, in combination allowed for the most reliable of interpretations.

Attributes such as scar type and edge rounding were first viewed at 50X magnification and recorded. The entire piece was scanned and polish and striations were generally located on the implement edge using 100X magnification. After the polish was located, magnifications up to 400X were

used to evaluate the polish type and to interpret function.

Blind Tests

In order to test my proficiency at accurately assessing usewear and interpreting function, blind tests were later conducted. Tools were made and used by someone other than the author. They were then cleaned using the above methods so that interpretations would not be influenced by any material residues left adhering to the edges of the tools. Results from these blind tests demonstrate that I could accurately assess both motion and material used, 75% of the time. However, this accuracy level increases to 85%, as does the confidence in the interpretation, when the categories bone and antler are collapsed, as well as the categories hide and meat (Appendix A). This accuracy level falls within the range of blind tests performed by Bamforth (1988), Keeley and Newcomer (1977), and Newcomer, Grace and Unger-Hamilton (1986).

Archaeological Collection

The methods of analysis for the archaeological assemblage from Grotte XVI followed similar steps to those used for the experimental collection. First, however, there

needed to be some level of sampling even if only for the debitage. Because the number of formal tools was not undaunting, 100% were viewed microscopically. This was also the case for the microliths and, therefore, 100% were also viewed. The debitage proved to be a more intimidating number and therefore a stratified random sample of the debitage was selected for analysis. This sample was selected by square so as to have even coverage over the site to later allow for spatial analysis. It was also determined by a size criterion; only pieces larger than 3 centimeters were selected. Once those criteria were met, an undergraduate student assistant randomly selected 50% of debitage meeting those criteria.

Terminology and Variables

Usewear is examined so that we may interpret function (Hayden 1979). The action that a stone tool is used in will produce a patterned wear. Tringham (et al 1974) discovered that scar location and orientation combined with striation was the best indicator of action. Keeley (1980) on the other hand, while still observing and recording scar location, orientation and striations, uses polish type as the decisive indicator of what materials were worked

prehistorically.

This analysis observed and recorded a series of variables. In combinations they were used to interpret past activities. First to be defined will be the individual attributes and second will be various combinations that act together to define motion and material worked. These then allow for an interpretation of function.

Variables (Figure 2)

The first three items recorded on the data sheet, *Square*, *Number* and *Page*, are locational designators for the piece being analyzed. Because of the tight spatial control at Grotte XVI, each artifact larger than 2 cm. is measured in three point provenience. *Square* is the one by one meter square from which the artifact was excavated. *Page* is the map page in sequential order on which the artifact is both drawn and its coordinates are recorded. *Number* is the unique sequential artifact number identifying the piece. *Square* and *page*, in combination with *number*, allows the artifact to be tied to its three dimensional coordinates and any additional information recorded about the artifact.

Each of the lithic artifacts from the Magdalenian occupation at Grotte XVI has been typed by Chadelle using

- | | | | |
|----|------------------------|-----|---------------------|
| 1. | square | 10. | damage type |
| 2. | number | 1 | step |
| 3. | page | 2 | scalar |
| 4. | type | 3 | feather |
| 5. | location | 4 | snap |
| | 1 no retouch | 11. | damage distribution |
| | 2 retouch | 1 | vantral |
| 6. | polish description | 2 | dorsal |
| | 1 soft plant | 3 | ventral/dorsal |
| | 2 wood | 12. | edge shape |
| | 3 bone | 1 | straight |
| | 4 shell | 2 | convex |
| | 5 fresh hide | 3 | concave |
| | 6 meat | 4 | point |
| | 7 greased hide | 5 | straight/point |
| | 8 dry hide | 13. | edge rounding |
| | 9 antler | 1 | no |
| | 10 indeterminate | 2 | yes |
| | 11 flint on flint | 3 | extreem |
| 7. | polish distribution | 14. | action |
| | 1 ventral | 1 | bore/pierce |
| | 2 dorsal | 2 | cut |
| | 3 ventral/dorsal | 3 | grave |
| 8. | striation description | 4 | scrape |
| | 1 broad/shallow | 5 | trampled |
| | 2 narrow/deep | 6 | haft |
| | 3 broad/deep | 7 | butcher |
| | 4 narrow/shallow | | |
| 9. | striation distribution | | |
| | 1 vent 1 perp | | |
| | 2 dor 2 par | | |
| | 3 ventral/dorsal | | |

Figure 2. Variables Recorded During Analysis

the traditional typology established by Sonneville-Bordes (1974) for the Upper Paleolithic. Type (Figure 3) is one of 105 coded numbers used to establish the tool chronologically and culturally.

Technology for the materials from Grotte XVI has been established through the work of Chadelle (1983) and Marino (1996). The number designation corresponds with a particular phase in the production sequence of the stone. The technological analysis focuses on identifying the various phases of manufacture. This is then used to place the lithic piece in its position in the *chaîne opératoire*. The classification scheme used here was designed after Geneste (1985) and is composed of 24 technological types that can be ordered into 4 technological phases.

Raw material has also been identified by Chadelle (1983) and Marino (1996). Raw material has been classified into nine categories, the ninth of which is a catch all, diverse, category. The most common lithic raw material is Senonien. It is a local material found within a few kilometers of the site. There are three other materials considered to be local, or at least occurring within 5 km of the site. These are a chalcedony, a jasper, and a tertiary

1. Grattoir simple en bout de lame
2. Grattoir double sur lame
3. Grattoir sur éclat
4. Grattoir type "la Gravette"
5. Grattoir circulaire
6. Grattoir unguiforme
7. Grattoir "Caminade"
8. Grattoir en éventail
9. Grattoir sur lame retouchée
10. Grattoir sur lame aurignacienne
11. Grattoir carene
12. Grattoir carene atypique
13. Grattoir carene a museau/epaulement
14. Grattoir carene a museau/epaulement atypique
15. Grattoir a museau plat
16. Grattoir a epaulement plat
17. Grattoir-burin
18. Grattoir-troncature
19. Burin-troncature
20. Percoir/Bec-troncature
21. Percoir/Bec-grattoir
22. Percoir/Bec-burin
23. Percoir simple ou double
24. Micro-percoir simple ou double
25. Percoir en étoile
26. Zinken
27. Bec
28. Epine
29. Bec burinant alterne
30. Burin diedre d'axe
31. Burin diedre d'angle
32. Burin d'angle sur cassure
33. Burin carene
34. Burin de Corbiac
35. Burin busque simple, double, mixte
36. Burin diedre multiple
37. Burin d'axe sur troncature retouchée
38. Burin d'angle sur troncature retouchée
39. Burin de Lacan
40. Burin "bec de perroquet"
41. Burin transversal simple, double, mixte
42. Burin multiple sur troncature retouchée
43. Burin de Noailles
44. Burin de "Bassaler-Raysse"
45. Burin de "Bassaler-Raysse" atypique
46. Burin multiple mixte
47. Piece a chanfrein
48. Piece a dos et fragment
49. Couteau/ Pointe de Chatelperron
50. Pointe des Cottés
51. Pointe de la Gravette
52. Micropointe de la Gravette
53. Element tronque
54. Flechette perigordienne
55. Pointe de la Font-Robert
56. Pointe a cran perigordienne
57. Piece a troncature retouchée normale
58. Piece a troncature retouchée oblique
59. Piece a troncature retouchée partielle
60. Piece bitronquée
61. Piece a retouchée continue sur 1 ou 2 bords
62. Fragment de piece retouchée
63. Lame aurignacienne
64. Lame a étranglement
65. Pointe a face plan
66. Piece solutreenne bifaciale
67. Feuille
68. Pointe a cran solutreenne
69. Pointe solutreenne a pedoncule
70. Armature mediterraneenne
71. Pic
72. Piece a encoche
73. Lame a encoche
74. Denticule
75. Racloir
76. Raclette
77. Triangle
78. Lamelle scalene
79. Rectangle
80. Trapexé
81. Segment
82. Microlithe geometrique
83. Lamelle tronquée ou bitronquée
84. Lamelle a dos pointue
85. Lamelle a dos
86. Fragment de lamelle a dos
87. Lamelle a dos tronquée ou bitronquée
88. Lamelle a dos denticule
89. Dard
90. Lamelle denticulee
91. Lamelle a encoche
92. Pointe de la Font-Yves
93. Lamelle Dufour
94. Lamelle a fine retouche direct
95. Lamelle a fine retouche inverse
96. Pointe azilienne
97. Pointe de Laugerie-Basse
98. Pointe de Teyjat
99. Pointe a cran magdalénienne
100. Pointe de Hambourg
101. Lame appointee
102. Pointe arenienne
103. Lame magdalénienne
104. Lame a encoche basale
105. Divers

Figure 3. Upper Paleolithic Typology
(after de Sonneville-Bordes 1974)

chert. There are four types of material classified as exotic. These materials are found more than 20 and sometimes 40 km away from the site. These are cherts from Bergerac, Fumel, Gavaudun and Mussidan. These compose a very small percentage of the lithic material from the site. The last raw material category from Grotte XVI is a diverse collection of unidentifiable materials. For the purposes of this analysis these have been lumped into local and non-local groupings.

The various attributes to follow are directly associated with the determination of use:

* *Location of damage* is the area where the use damage was identified on the implement. Often there was more than one location recorded for each piece indicative of tools with multiple uses.

If the tool was retouched, the presence or absence of *retouch* was recorded. This was also later used as an indicator of a formally typed tool as opposed to debitage.

Polish distribution is critical to the determination of the use motion. Location of polish was recorded as either being present on the ventral, dorsal or both ventral and dorsal surfaces of the artifact.

Striations were recorded when present as an indication of both material used and motion. *Striation description* was described as broad and shallow, narrow/deep, broad/deep, or narrow/shallow. The *distribution* of the striations was also recorded as an indicator of use motion. These were recorded as located on the ventral, dorsal, or ventral and dorsal side of the artifact. It was also recorded as to whether the striations ran parallel or perpendicular to the tool edge.

Both *damage type* (Figure 4) and *damage distribution* were collected. Damage type refers to the type of micro scarring present on the edge of the tool. A "step" scar is one that results when the flake detaches at a right angle break at the distal end of the flake. A "feather" is one that has a smooth, gradual transition between the scar and the rock surface. A "hinge" scar is a scar where at the distal end of the scar the force turns back into the edge resulting in a scar whose distal termination has a ridge or lip. A "scalar" scar is the result of force somewhere between that which produces a feather and a hinge scar. The distal termination of the scar is more abrupt than that of a feather scar but does not result in a ridge or lip. A

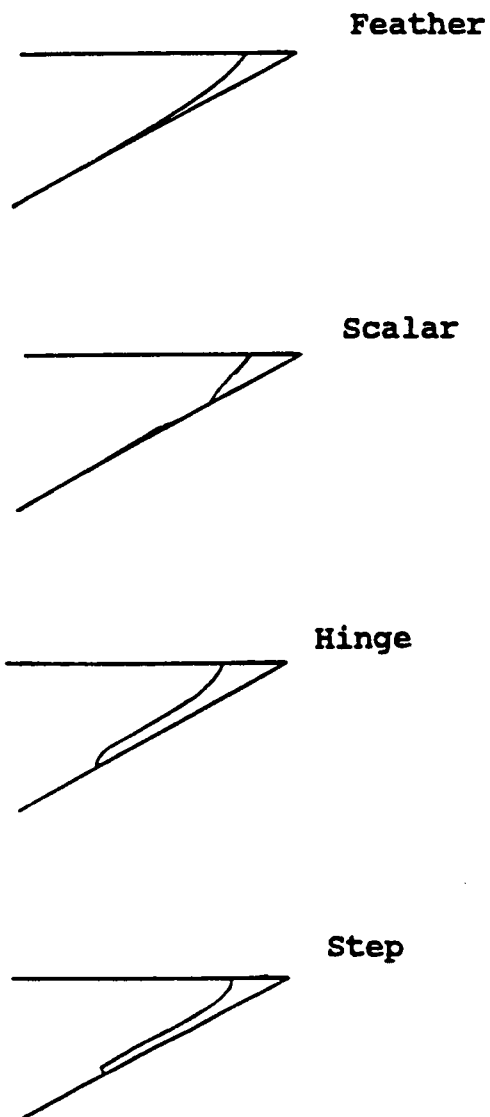


Figure 4. Types Of Damage Scars Produced During Use
(after Cotterell and Kamminga 1977)

"snap" fracture is one where the material is completely removed and the overall appearance is that of nibbling on the tool edge. *Damage distribution* located the micro-scarring on either the ventral, dorsal or ventral and dorsal surface of the tool.

Edge shape was recorded after Bordes (1979) as straight, convex, or concave. Classifications of point or nib were defined to indicate a point, burination or boring tool.

Motions

There are several classes of motions and materials that need explanation. There is not a single variable class that is a direct indicator of a particular motion or for that matter, a specific material. Each of these classifications is defined by a series of variables, some of which have previously been described.

Low-magnification using scar patterns can categorize the material worked into groups such as soft (plant material, meat, hide), medium (most soft woods) and hard (bone, antler, and some dry hard woods) (Tringham et al. 1974, Odell and Odell-Vereecken 1980, Odell 1977). High-magnification uses polish descriptions as its main criteria

for interpreting the material worked. Keeley (1980) was the first to recognize that polishes had distinct characteristics of both topography as well as brightness dependant upon the material that the tool had come in contact with. Unfortunately, nearly 20 years after his research and the research of others (Anderson-Gerfaud 1980, Moss 1983, Plisson 1985 and others) the descriptions of these polishes tend to still be unquantified and somewhat imprecise in their descriptions using terms such as "melted snow appearance" and "comet shaped pits" to name a few. For the sake of convention and for lack of a better language of description, those descriptions will be perpetuated here.

Direct- Projection

Use wear from projection is generally in the form of scar patterns at the tip of a point. Impact fractures are generally of the step or hinge variety (Odell and Cowan 1986, Shea 1988). Polish is often not present in these cases due to the nature and short duration of the motion.

Longitudinal- Cutting

Cutting motions tend to produce a pattern of alternating scars on both sides of the tool. This is because with a longitudinal motion, pressure is exerted on

both faces of the implement. The scars are generally angled from the edge due to the back and forth motion. Striations, if present, run parallel to the edge (Keeley 1980; Tringham et al. 1974). Polish itself also at times exhibits a directionality (Keeley 1980). In a longitudinal motion as with cutting, the polish appears to flow parallel to the use edge.

Transverse- Scraping

Motions such as scraping generally produced scars on only one side of the tool because pressure is only exerted on one side of the tool. The scars themselves are straight to the edge. Striations run perpendicular to the edge on the opposite side of that with the scars (Keeley 1980; Tringham et al. 1974). Often this scarring can be replaced by edge rounding. There is little attrition of material from the edge, though the edge is smoothed and rounded through use. If polish has a direction that can be observed, with a transverse motion it runs perpendicular to the edge on the same side as the striations (Keeley 1980).

Longitudinal and Transverse- Graving

Use damage resulting from the latitudinal and transverse motion of graving are generally identified

through their location, on the nib portion of the tool (Keeley 1980; Tringham et al. 1974). In addition, scar removal was restricted to the nib side opposite to the contact surface. Striations when present were at nearly 90 degree angles to the bit edge. Polish was concentrated at the bit of the tool on the edge opposite that of the location of the scars (Keeley 1980).

Circular- Boring

Circular motions like those involved in boring produced scar patterns on alternating edges of the tool. Striations, when present, run perpendicular to the tool edges but parallel to the tip of the borer (Keeley 1980; Tringham et al. 1974). Polish is also located on that nib (Keeley 1980).

Materials (see Appendix B)

Meat

The polish that develops as the result of contact with meat is a relatively dull polish. It is somewhat greasy in appearance. The entire ^{*} surface is altered, and thus there is little contrast between the polished area and the unaltered surface of the flint. For this reason, meat polish is very difficult to discern, especially in an archaeological context. Meat polish is often quite

undistinguishable from hide polish in archaeological specimens. Striations appear very rarely as does edge damage in the form of scarring. When there is edge damage present, the scars are very shallow and small. They are of the half moon or feather variety (Juel Jensen 1988; Keeley 1980; Keeley and Newcomer 1977; Moss 1983) (Figure 4)

Hide

There are several types of hide polish that can be distinguished from each other experimentally. These hide polishes are dependant upon the state that the hide is in when it is processed. These polishes are the result of processing dry hide, greased hide, or fresh hide. There seems to be a correlation between lubrication and the intensity of the polish in hide working. A relatively bright polish forms upon contact with fresh hide. It tends to be greasy in appearance and often is indistinguishable from meat polish. It is a very slow-forming polish as evidenced by experimentation in series. The topography of the polish is somewhat rough and bumpy, though not pitted. Greased-hide polish is duller than fresh hide polish. It is matte though still slightly greasy in its appearance. The processing of dry hide produces the least bright of the hide

polishes. Dry hide produces a rather dull, matte polish with small pits. There is one striking commonality in usewear in the processing of hides in all stages. During hide working there is little attrition of material from the edge. Very little scarring develops. There is however, always a degree of edge rounding and sometimes it is extreme (Juel Jensen 1988; Keeley 1980; Keeley and Newcomer 1977; Moss 1983).

Vegetal

As opposed to hide polish, the polish produced from contact with soft plant material is very bright and highly reflective. The polish is smooth and has a fluid appearance. The distinguishing feature of plant polish is the "comet shaped pits" (Keeley 1980). If the polish is not very well developed then it can be confused with wood polish. Plant material produces very little edge damage. If there is edge damage it is in the form of small feather scars (Juel Jensen 1988; Keeley 1980; Keeley and Newcomer 1977; Moss 1983) (Figure 4).

depends on the plant

Wood

Wood polish is very bright and very smooth. It is domed and gently undulates. It is fluid and has direction.

The polish seems to spread and is not concentrated near the edge but instead is invasive spreading inward away from the edge. There is commonly some edge damage, and this is of the scalar variety (Juel Jensen 1988; Keeley 1980; Keeley and Newcomer 1977; Moss 1983) (Figure 4).

Bone

Bone polish is a very bright polish. It develops quickly and does not spread away from the edge of the tool like wood polish. Bone polish is concentrated close to the use edge itself and there is a marked boundary between the polished surface and the natural surface of the flint. The polish is infrequently invasive. The polish itself, while being very bright, it is not very smooth. It is matte in appearance and contains tiny pits. Striations are very common. Edge damage in the form of micro-scarring is always extensive. The micro-scarring is generally of the step variety (Figure 4) and they can often be quite large in size (Juel Jensen 1988; Keeley 1980; Keeley and Newcomer 1977; Moss 1983).

Antler

Antler polish is a very bright and smooth polish and has been described as having the appearance of "melted snow"

(Keeley 1980). It has some micropitting in the polish. This polish is indistinguishable from bone polish unless it is well-developed. With archaeological assemblages it is often safer to refer to both bone and antler polish as bone/antler. Edge damage is extensive due to the hardness of antler. The damage is in the form of large step fractures (Juel Jensen 1988; Keeley 1980; Keeley and Newcomer 1977; Moss 1983) (Figure 4).

Post Depositional Alterations

Post depositional alteration to stone tools comes in many forms. Experiments and patterns from assemblages known to have been greatly disturbed have been assessed (Flenniken and Haggarty 1979, Gero 1979, Keeley 1980, Keller 1979, Levi-Salla 1986, 1989, Odell 1977, 1985). Not only do these studies take into account processes prior to excavation but also after excavation. Trampling, toothbrush damage, bag damage, and drawer damage are to name but a few. Mostly, as far as the scar patterns are concerned, post-deposition damage tends to be random and all over the piece in question, while usewear tends to be patterned and concentrated near the edge of the tool. Also, fresh scars can usually be distinguished from prehistoric scars. Using

the low-magnification approach most of the time this random damage can be screened out and an accurate assessment of the usewear can still be made. Sometimes however, there is just too much post-depositional damage, and wear cannot confidently be assessed. As for these types of alterations and polish, that is another story. Much of the polish can actually be removed with extensive post-depositional scarring and in that case there is little to nothing left to assess. With a little post-depositional scarring, enough polish remains for an accurate assessment.

Much more damaging to microwear polish, clouding the ability for an accurate assessment, are chemical alterations. Patination can completely obscure evidence of polish (Akoshima 1993) and geochemical processes in caves can alter or remove polish. This chemical alteration of polish has been an area of investigation, both for reasons of tool preparation and cleaning for polish observation, as well as for trying to understand chemical alterations that may occur in the ground (Plisson 1985).

Statistical Tests

Two primary statistical tests were used in this analysis. In order to investigate the interdependence of

function with several other variables, a chi-square test was performed. In addition, beyond looking solely at function and its dependance or independence with several other variables, the relationship of function in space was investigated. In order to look at the spatial dimension of function, a K-means analysis was performed and the resulting clusters were analyzed for content.

Chi-square Statistic

One purpose of this dissertation was to investigate the relationship between function and raw material, typology, and technology. Having collected data for two variables concurrently (function with either raw material, typology or technology), it was then necessary to ask if those variables were independent of one another. In other words, the hypothesis to be tested was that the frequency of the occurrence of function was independent of the frequency of the occurrence of either of the other variables. These data were then arranged into contingency tables to test the interdependence of the row and column variables. The analysis of these contingency tables rested in the chi-square statistic. The chi-square statistic uses observed and expected frequencies.

Chi-square analysis uses the following formula for calculating the expected frequencies in a contingency table:

$$f_{ij} = \frac{(R_i)(C_j)}{n}$$

and the X^2 value equals the sum of:

$$\frac{(f_i - f_j)^2}{f_i}$$

(Zar 1984:63)

With contingency table data, the chi-square test for goodness of fit tests the null hypothesis that the row and column variables are independent in the population sampled. The significance of the test rests also on the calculation of the degrees of freedom. This is calculated as (row-1)(column-1) (Zar 1984).

K-means Analysis

K-means analysis was used to investigate the spatial distributions of artifacts at Grotte XVI. K-means is a non-hierarchical cluster analysis program designed by Kintigh (1990) and Kintigh and Ammerman (1982) and tested by Simek (1984), Simek and Larick (1983) and Koetje (1987). K-means finds an arbitrarily defined number of clusters, whether

they are optimal solutions or not, and works to create the defined number of clusters. The program is applied to two dimensional point provenience data. "The cluster analysis allocates each point into one of a specified number of clusters in a way that attempts to minimize a global goodness of fit measure, called sum-squared error (SSE)" (Kintigh 1990:185). The clustering program then locates the center of the cluster and then defines points that are associated with that center point. The %SSE is plotted and the fluctuations in the graph expresses the best fit or optimal cluster solutions. The K-means clustering program also allows for an artifact designator so that cluster content can be analyzed.

K-means clustering analysis was used to investigate the spatial dimensions of function at the site. Initially the entire assemblage was analyzed as a whole to look for optimal clusters of lithic artifacts. Each cluster was then analyzed for content and activity areas were defined.

In this chapter the methods and debates in microwear analysis have been discussed. More precisely, the methods used in the following research have been presented and justification for their use made. The following chapters

will outline the analyses conducted thus far at the Grotte XVI. The main focus will be on microwear analyses and its contribution to the functional interpretation of the site.

IV. THE GROTTA XVI COLLECTION

1. History of the Excavation

The focus of this chapter will be to place Grotte XVI in time and space as it applies to the study collection. The opportunity will also be taken to summarize the various other analyses of the archaeological materials from Grotte XVI to date. The cave is so named because it is the 16th in the series of 23 caves that comprise the large karstic cavity making up the Le Conte Cliffs. The Le Conte Cliffs are located in the Dordogne region of southwest France, between the villages of Roque-Gageac and Castelnaud (Figure 5). The cliff face overlooks the Ceou River, a small tributary flowing into the Dordogne River. The cave itself is a very large open cavity with the main portion of the cave measuring 8 meters in width and 25 meters in length. In addition, there is a smaller gallery in the rear of the cave measuring on average 3 meters in width and 10 meters in length.

In 1983, test excavations were begun at the Grotte XVI. Based on the findings, excavations continued on a larger

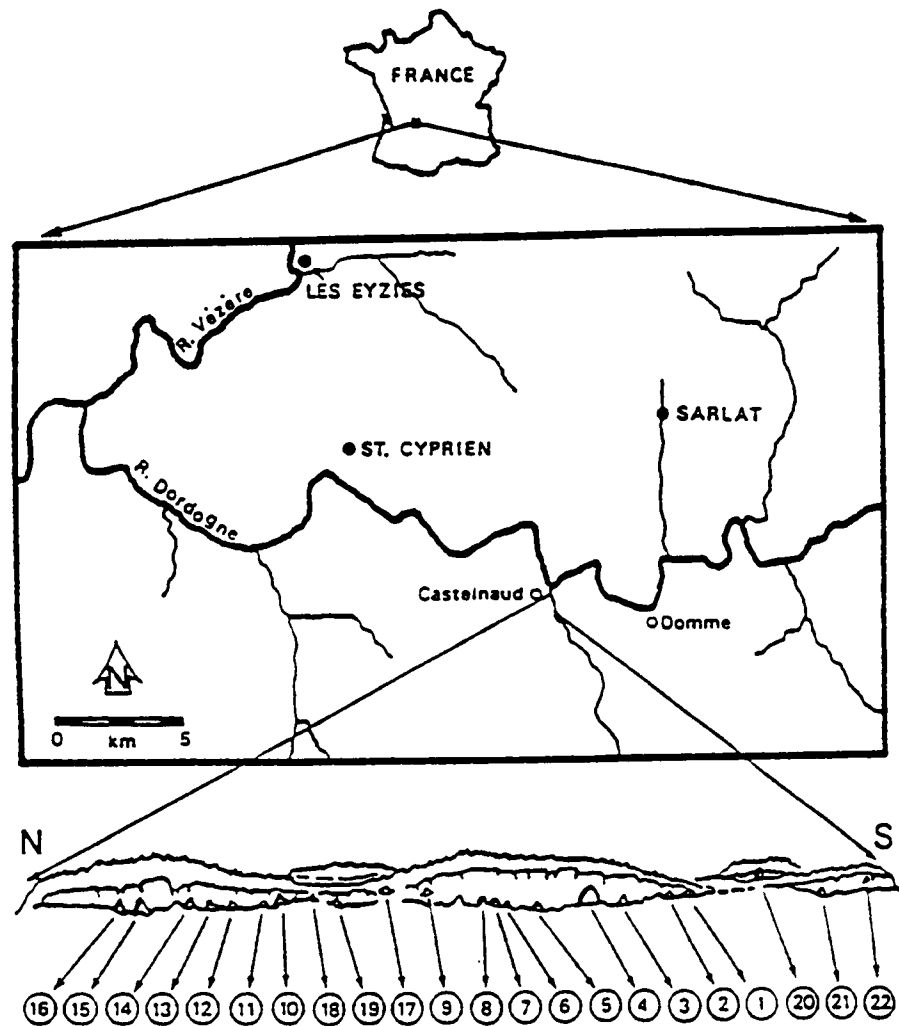


Figure 5. Location Of The Grotte XVI In The Le Conte Cliffs Near Cenac-et-St. Julien In Dordogne, France (after Rigaud, Simek and Ge 1995)
Note: the numbers represent individual caves.

scale in the summer of 1984. Investigations both in excavation and analysis have been on-going the last thirteen years as a cooperative venture of the Institut du Quaternaire at Bordeaux and the University of Tennessee, Knoxville. The Grotte XVI contains a stratigraphic profile representing the entire Upper Paleolithic cultural sequence with underlying Mousterian levels.

Though excavations at the Grotte XVI have produced a rich archaeological record through the entire paleolithic sequence, the materials for this study are from a limited location and period of occupation in the cave. The research described here concentrates on the Magdalenian deposits from the cave.

Both the excavation techniques as well as the preservation of the collection make the Magdalenian assemblage from Grotte XVI an excellent candidate for microwear analysis. An assemblage must be in pristine condition for high-magnification techniques to be performed. The Magdalenian assemblage appears to be virtually *in situ* at Grotte XVI. Justifications for this will be discussed below.

2. The Magdalenian Deposit

The Magdalenian deposits found in Couche 0 are isolated in the upper levels of the back portion of the cave (Figure 6). This "gallery" comprises approximately 30 square meters, nearly $1/5$ the area of the entire cave.

Investigations into the geology of the deposits by Keravazo and Ge (1995) have shown that the sediments have been disturbed by periglacial soil movement in only a few small areas; otherwise, Couche 0 artifacts are undisturbed and *in situ*. In addition, the layer is shallow. It appears that the Magdalenian occupation was not a continuous one, but rather a series of short term occupations. It is this, in part, that will be tested in this dissertation as the models for site formation and Magdalenian settlement and subsistence are investigated. The Magdalenian deposit is the best-documented level so far excavated from the cave due to its preservation and limited distribution. AMS dates of carbon from the deposits are $12,285 \pm 100$ BP and $12,530 \pm 105$ BP, placing it chronologically in the late Magdalenian.

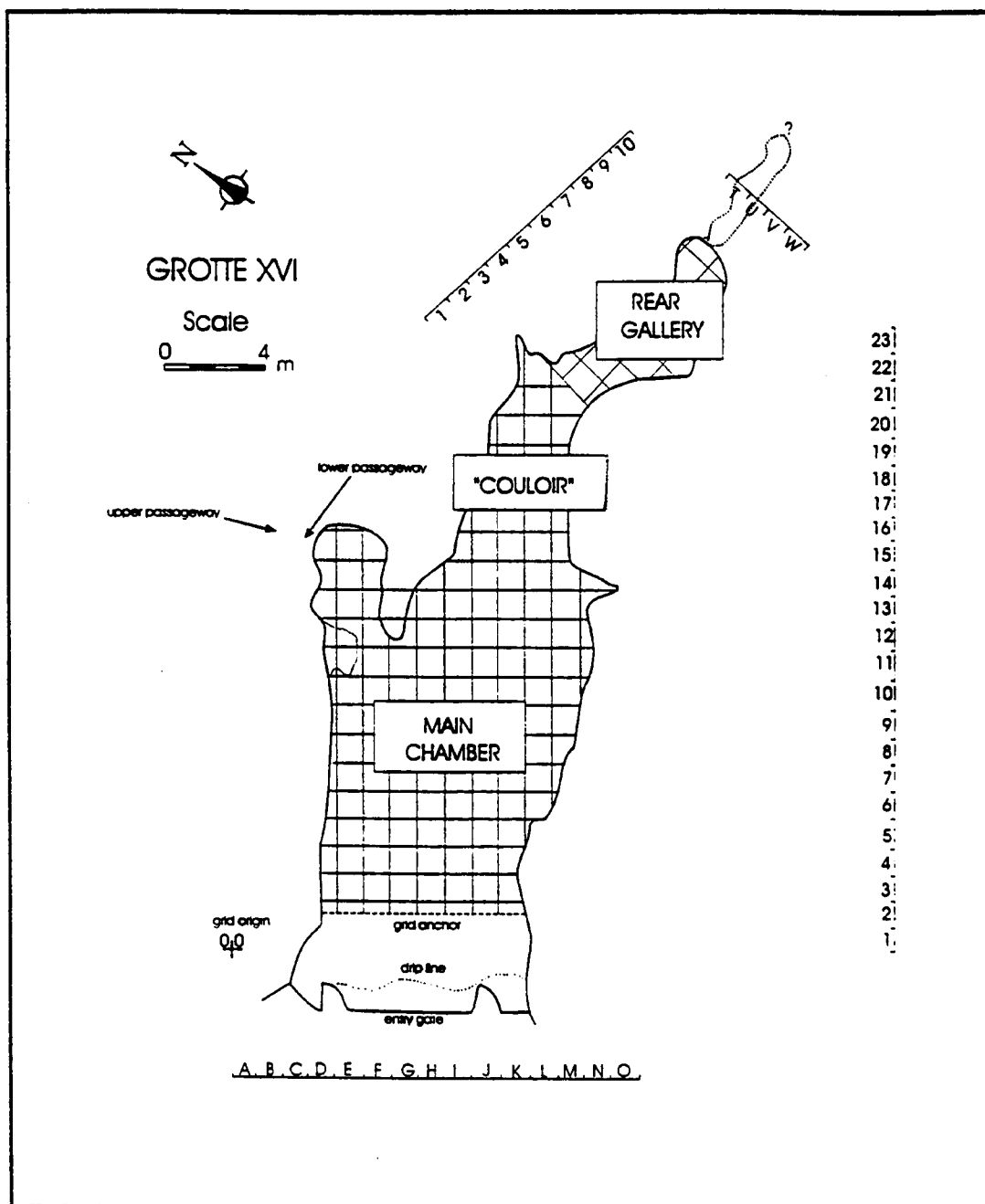


Figure 6. Plan Of The Interior Of Grotte XVI, Note That The Magdalenian Assemblage Is Located In The Gallery Of The Cave
(after Rigaud, Simek and Ge 1995)

3. Excavation Methods

Excavation techniques in the Grotte XVI were designed to obtain a large sample of archaeological and geological information from all areas of the cave. More than 90 meter-square excavation units have been opened in the entire cave and of these approximately 30 square meters are located in the back gallery of the cave and are associated with the Magdalenian deposits. Excavation techniques are designed so that all artifacts more than one centimeter in size are recovered with three-dimensional spatial provenience. All sediment is water washed through .2 centimeter wire mesh to recover small faunal materials and artifacts missed during excavations. These materials are collected by the one meter square from which they were removed (Rigaud and Simek 1990). The fact that all materials more than one centimeter in size are collected with three-dimensional provenience during excavation is important to this microwear investigation. Because there is such tight spatial control at Grotte XVI, when the final functional assessment is made for an implement, that function can then be tied to an exact point in space. This then allows for activity areas to be defined

at the site.

Processing and curation techniques at Grotte XVI play an important role in reducing the potential for post-excavational damage. Each lithic piece is first wrapped in tissue paper and then in foil just after it is removed from the cave sediments. This alleviates any undo contact with other artifacts within the same excavation unit bag and post-excavational damage that could result from such contact.

Later in the laboratory, each piece is individually washed, taking care not to use a brush on the lithic material nor rub too enthusiastically along the tool edges. Each artifact is then sun dried. After the artifact is completely dry, it is marked with the site, square, and artifact number using permanent ink. Each artifact is placed into a separate plastic bag also marked with all provenience information. Each bag is then curated with the other artifacts from the same square. Though excavation is destructive, because there is such tight control in both the excavation and laboratory methods, there is little data lost, and what is collected is ideal for spatial analysis. Moreover, because the implements are bagged individually,

they suffer little to no post-excavational damage. Poor processing and curation techniques can create new polish and striations where there were none before (Keeley 1980). This can obscure or even obliterate existing polishes making functional interpretations impossible. Because of the curation techniques practiced at Grotte XVI, any functional interpretation will be accurate and reliable.

4. The Grotte XVI Magdalenian Collection

The General Collection

Overall, there have been 7489 artifacts mapped and removed from the Couche 0 Magdalenian sediments. Of those, 3788 comprise the lithic assemblage and 4099 are animal bones making up the faunal assemblage. In addition there are numerous stone and bone artifacts from the screening materials that have been identified and analyzed. They, however, are not point provenienced but are located only by square and couche designations. Each category of artifacts will be discussed in more detail below.

Artifacts are fairly evenly distributed across the gallery area. There is an area of rather sparse artifact

disbursement in the central portion of the gallery. This central area was the target of artifact hunters prior to the commencement of systematic excavations at the Grotte XVI. This will be taken into account when the spatial patterns are interpreted. However, given the initial spatial analysis, it can be said that spatial integrity remains intact at the site.

When artifact density is investigated in Couche 0 of the gallery area, intuitively there appears to be a fairly simple pattern of artifact distribution falling into two main areas. This simple structure is quantitatively corroborated with K-means cluster analysis. By looking at a graph of the log percent sum squared error, a deviation in the plot indicates that a two cluster solution is optimal for the data (Figure 7) (Rigaud, et al. 1997). The first of these two discrete clusters is formed at the gallery mouth near a hearth and the second is located in the back of the portion of the cave (Figure 8). The contents of these two distinct spatial clusters will be discussed as they refer to lithic or faunal artifacts. Though information has been lost due to the enthusiastic and efficient endeavors of the artifact hunters at the site, when artifact content is

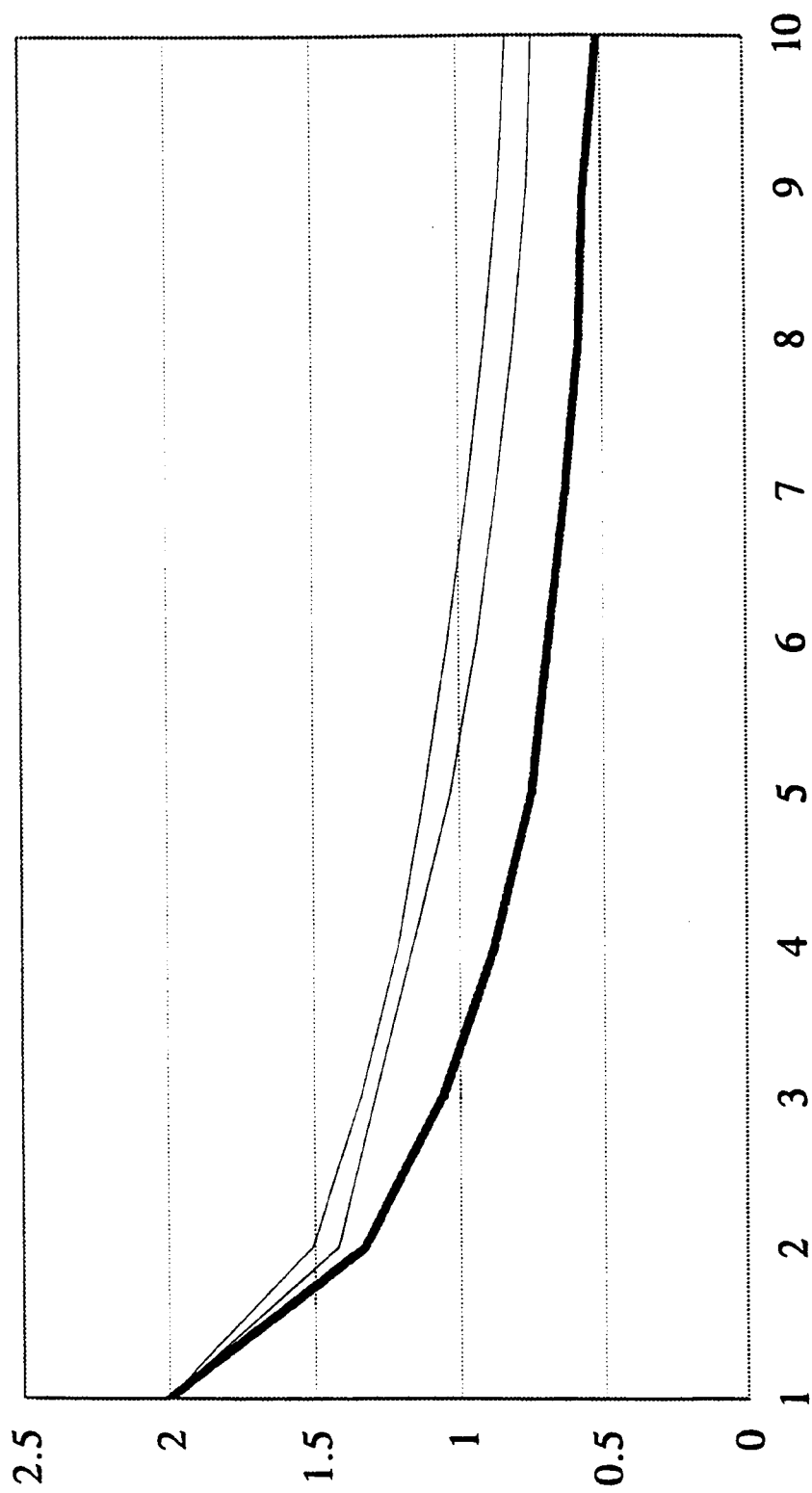


Figure 7. Log (%SSE) For All Artifacts

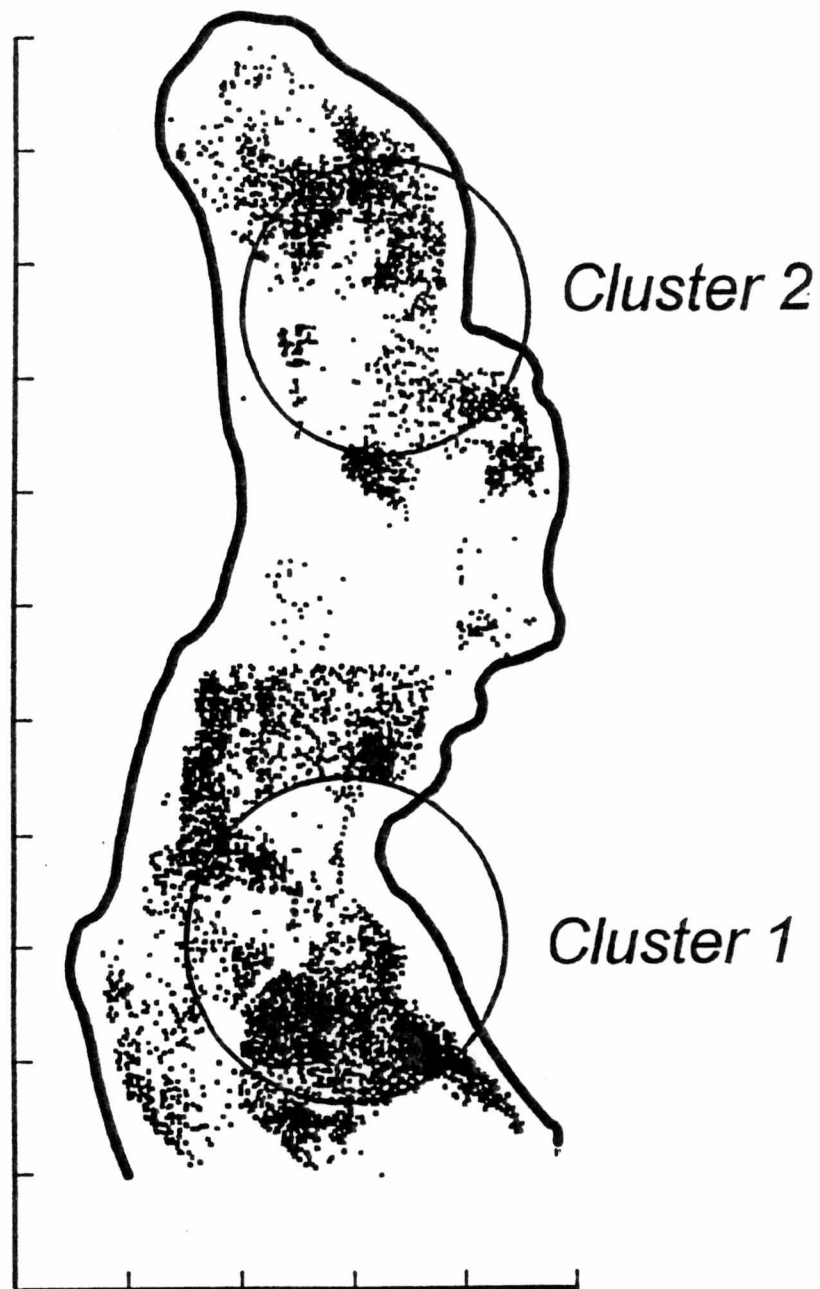


Figure 8. Plan Map Of All Artifacts With 2 Cluster Kmeans Solution

analyzed it is clear that these two clusters are genuine. Their content differences indicate behavioral variability at the site and may reflect separate activity areas.

Investigation of the excavated materials from Grotte XVI as they relate to lithic typology, raw material, and technology as well as a brief discussion of the faunal materials and bone technology follows.

Typology

There are 3788 pieces of lithic debris from Couche 0 at the Grotte XVI. Debitage comprises nearly 85% of the lithic material while the other 15% of the assemblage are formally typed tools. When looking at the formally typed materials, microliths by far dominate the assemblage at 73%. Scrapers, burins, and pieces with lateral retouch are roughly equal in abundance and make up the basis of the rest of the lithic collection (Figure 9).

When the spatial dimension of typology is investigated there are distinctions between Cluster 1 and Cluster 2 (Figure 10). With respect to cluster content, the area near the mouth of the gallery, Cluster 1, is dominated by microliths. Relative to microliths, the other tools are under represented. However, microliths aside, the

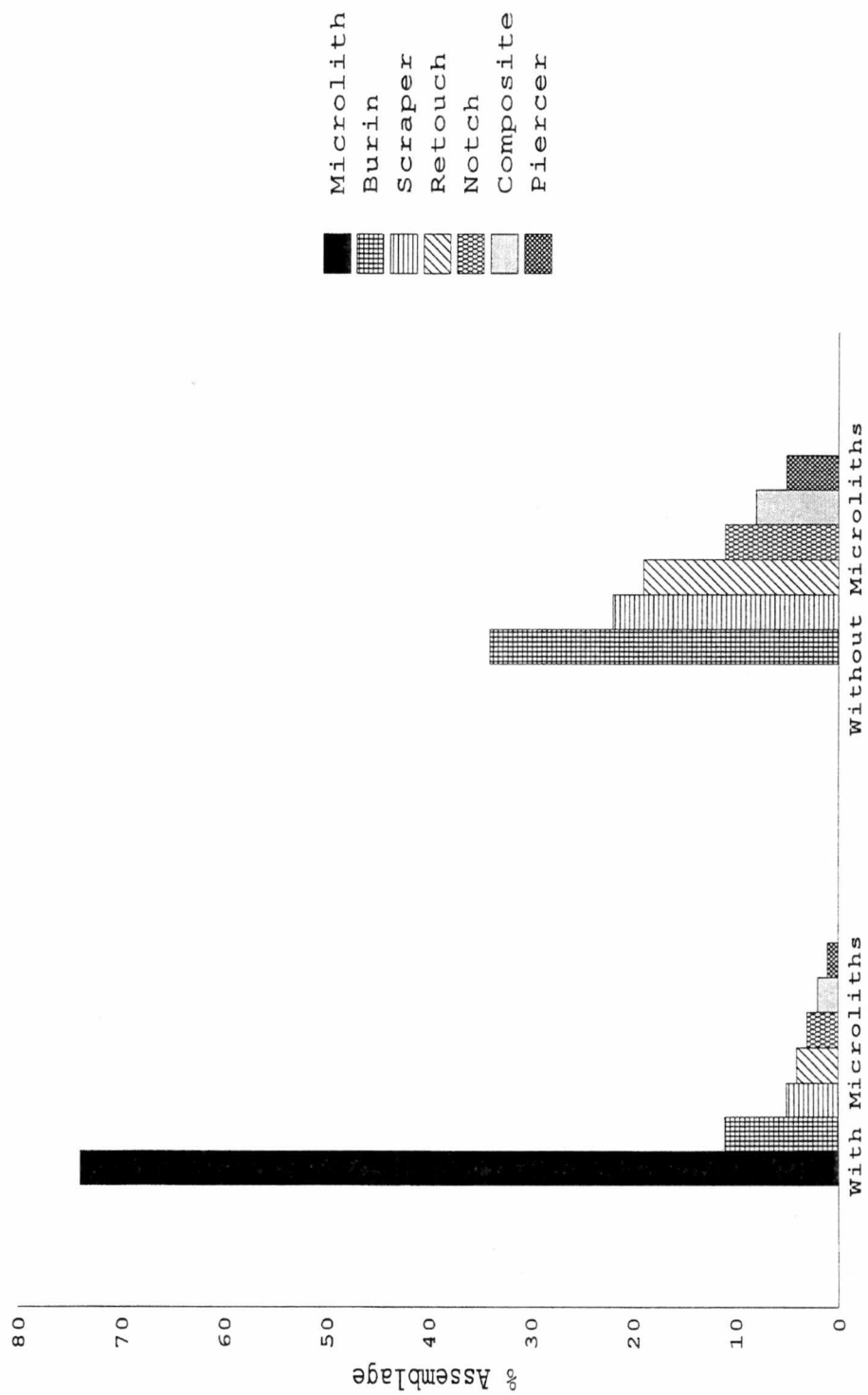


Figure 9. Lithic Assemblage Composition

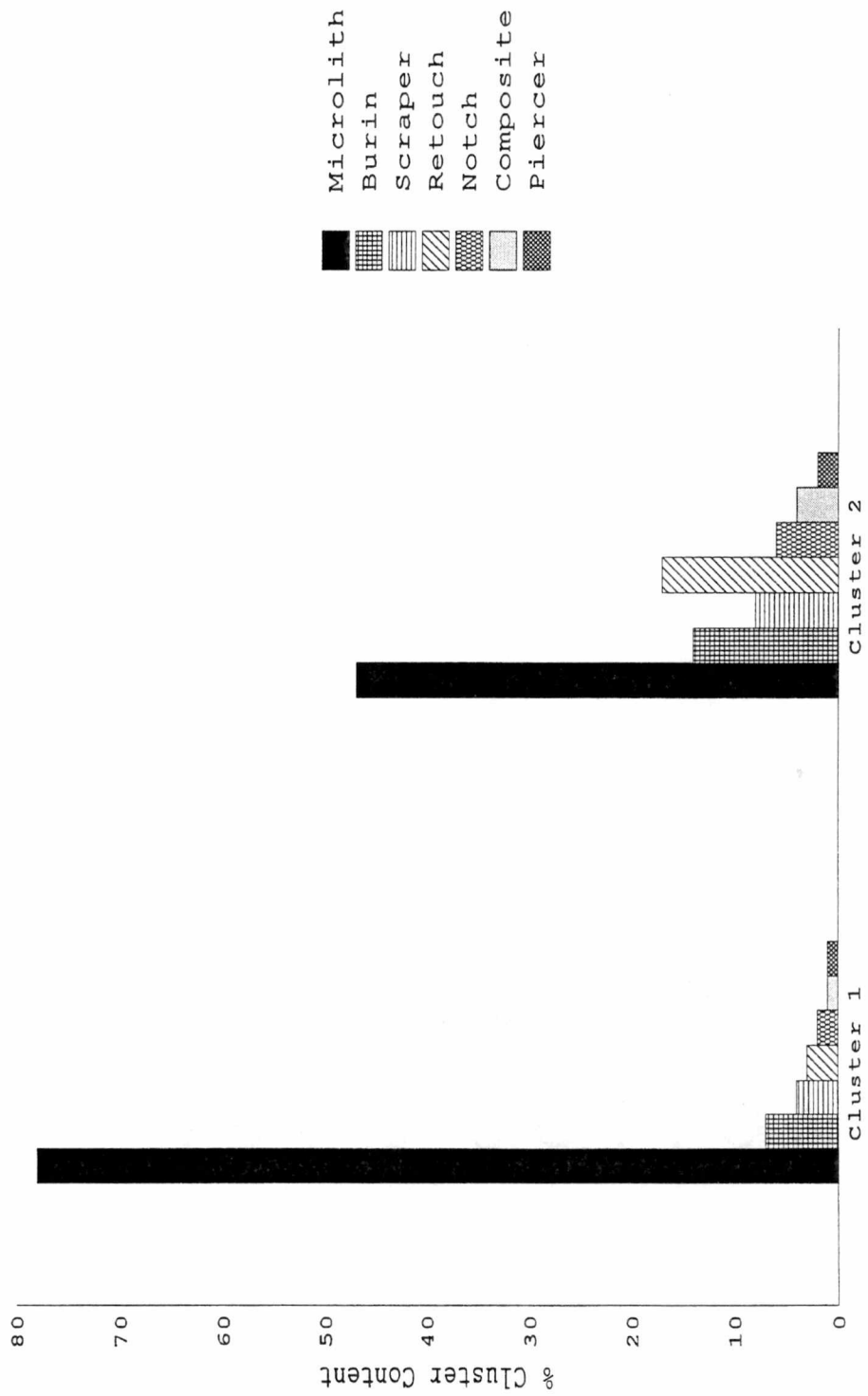


Figure 10. Comparison Of Assemblage Typology Between Cluster 1 And Cluster 2

distinction between Cluster 1 and Cluster 2 lies in the spatial distribution of burins and endscrapers (Figure 11). While the exact counts are higher in Cluster 1 for all tools, this is a reflection of a higher absolute count for all tools in both clusters. When frequencies in the distributions of endscraper and burins are investigated, the frequency of burins is important in Cluster 1 near the entrance of the gallery. The back portion of the gallery is, in contrast, dominated by endscrapers.

This spatial patterning in tool types may reflect differential use of space in the cave. The association of burins with microliths in the mouth of the gallery where there is more light, may reflect an activity associated with the use or retooling of composite tools, in other words, the production of bone and antler hafts that later will incorporate microliths. The back portion, or dark zone of the gallery, may have been used for quite a different activity involving the use of endscrapers. Nonetheless, this spatial pattern reflects different behaviors within a rather tight spatial constraint. These spatial patterns will later be tested through microwear analysis.

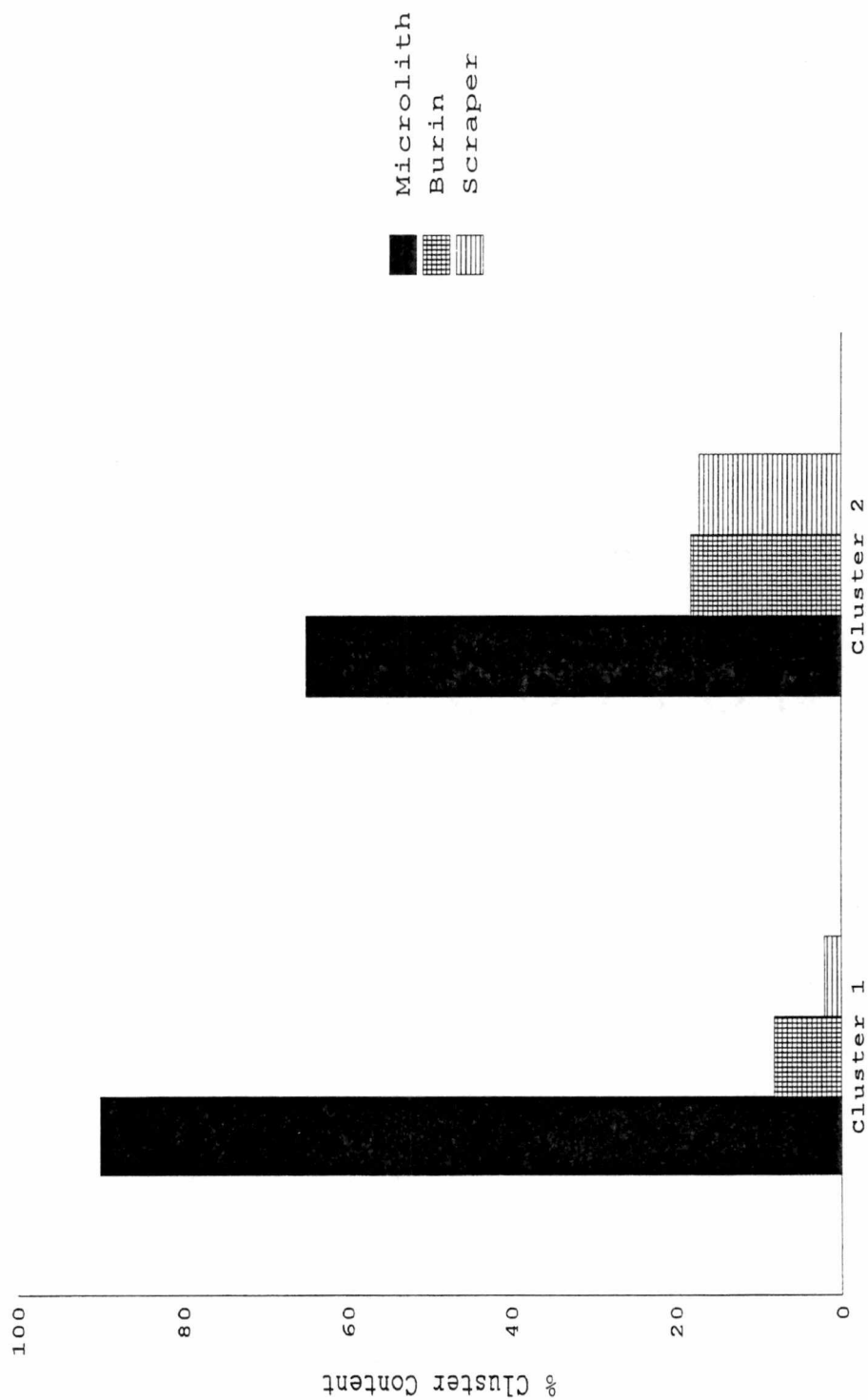


Figure 11. Comparison Of Common Tool Types Between Cluster 1 And Cluster 2

Raw Material

More is known about the sourcing of raw materials in the Dordogne region of France than anywhere else in the world (Chadelle 1983, Geneste 1985). Extensive analyses of the raw material and their sources by Chadelle (1983) and Marino (1986) have provided us with invaluable information about the Magdalenian at Grotte XVI. There are eight different types of identifiable raw materials present. There is also another category of diverse or unidentifiable materials. These materials are: Senonian flint, chalcedony, jasper, tertiary flint, bergeracois flint, flint from the Fumel region, flint from the Gavaudun region, and Mussidan flint. Senonian and Tertiary flint, as well as chalcedony, are found locally, Fumel and Gavaudun are found about 20 km from the site, and Bergeracois and Mussidan are as far as 60 km from the Grotte XVI. For our purposes here raw materials will be divided into local and exotic materials.

An analysis of the frequency of occurrence of lithic raw materials from Couche 0 indicate that local materials are used most frequently at the site, making up 90% of the assemblage (Figure 12). The use of exotic materials accounts for the other 10% of both tools and debitage.

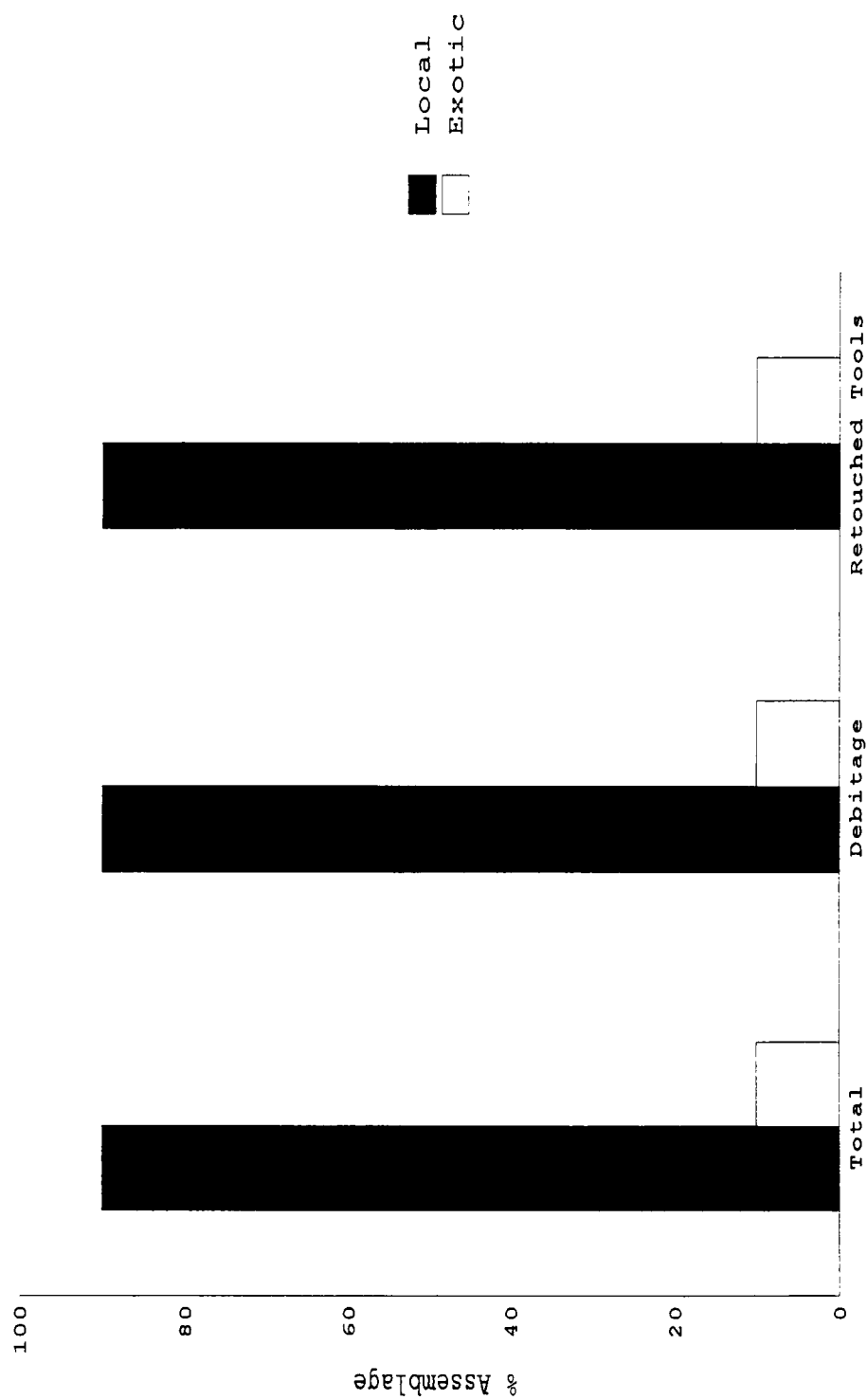


Figure 12. Assemblage Raw Material

Flint from sources around Bergerac (some 60km away) is the most common non-local material.

The correlation of raw material and formal tool typology at the site was investigated. The Chi-square Test for Independence was used to look at whether raw material and tool typology were mutually independent. The results of the test can be seen in Table 1. With a P value of .0000607, the null hypothesis of mutual independence is rejected. Therefore, raw material and tool typology are dependant. If the observed and the expected values in the contingency table are compared, it is clear that this is not a homogenous assemblage. The discrepancies lie in the categories of microliths and scrapers. There seem to be too many scrapers of exotic materials than would be expected using Chi-square and too few microliths of exotic materials. This might be interpreted as evidence for logistical planning. Scrapers, curated and produced of exotic materials, were brought into the site for a specific purpose. This will be tested through microwear analysis when function is examined. This may however, be a false rejection of the null hypothesis due to the fact that 50% of the squares have values less than 5.

Table 1. Test for Independence Between Raw Material and Type

H0: Raw Material and Type are Mutually Independent

P= $6.1E-5$ Therefore, reject the H0

	Local	Exotic
<u>Burin</u>	46 (45.7)	2 (2.2)
<u>Composite</u>	9 (9.5)	1 (0.5)
<u>Debitage</u>	1558 (1559.3)	78 (76.7)
<u>Microlith</u>	268 (259.2)	4 (12.7)
<u>Notch</u>	11 (12.4)	2 (0.6)
<u>Piercer</u>	4 (5.7)	2 (0.2)
<u>Retouch</u>	9 (9.5)	1 (0.4)
<u>Scraper</u>	23 (26.7)	5 (1.3)

When the spatial dimension of the raw materials is investigated, raw materials are distributed equally in both areas of the Couche 0 occupation (Figure 13). Both clusters are dominated by local materials, with small quantities of both Bergeracois and other exotic materials present in each cluster. Unlike the tool typology, there is no real spatial distinction associated with raw material. Overall, the materials are quite uniformly distributed across the site area.

Technology

The *chaîne opératoire* approach to lithic analysis views production technology as a series of stages (Chadelle 1983, Geneste 1985, Inizan et al. 1992, Marino 1996). These stages in production are represented by particular products. These stages and their individual products are then lumped together to define the Phases 0-4 in the *chaîne opératoire*. Using the *chaîne opératoire* approach, work by Chadelle (1983) and Marino (1996) has shown that stone tool technology in the Magdalenian at Grotte XVI is characterized primarily by two of the four phases of production. Phase 0, or acquisition, is comprised of tested blocks of raw material and cortical flakes. Phase 1, is composed of



Figure 13. Comparison Of Raw Materials Between Cluster 1 And Cluster 2

mostly decortification flakes. Phase 2 products are blades, crested blades and blade cores, while Phase 3 products involve the production of supports. At Grotte XVI Phase 2 products constitute nearly 80% of the lithic material (Figure 14). Phase 1 is present but quite under-represented if early core preparation were practiced at Grotte XVI (the debitage to tool ratio is about 5:1), this also holds true for Phase 0. Thus, technological analyses suggest that fully formed blade cores, procured and shaped elsewhere, were brought to the site for transformation into tools.

An inquiry into the relationship between technological phase and raw material and technological phase and typology has shown significant results. Chi-square results with a P value of .0000000000076 for the test of independence between technological phase and raw material allows for the rejection of the null hypothesis of mutual independence of those two variables (Table 2). This positive correlation between tool type and technology is not earth shattering. The correlation shows that tools were made on Phase 2 products, blades.

More interesting is the correlation between technology and raw material that may shed some light on economic

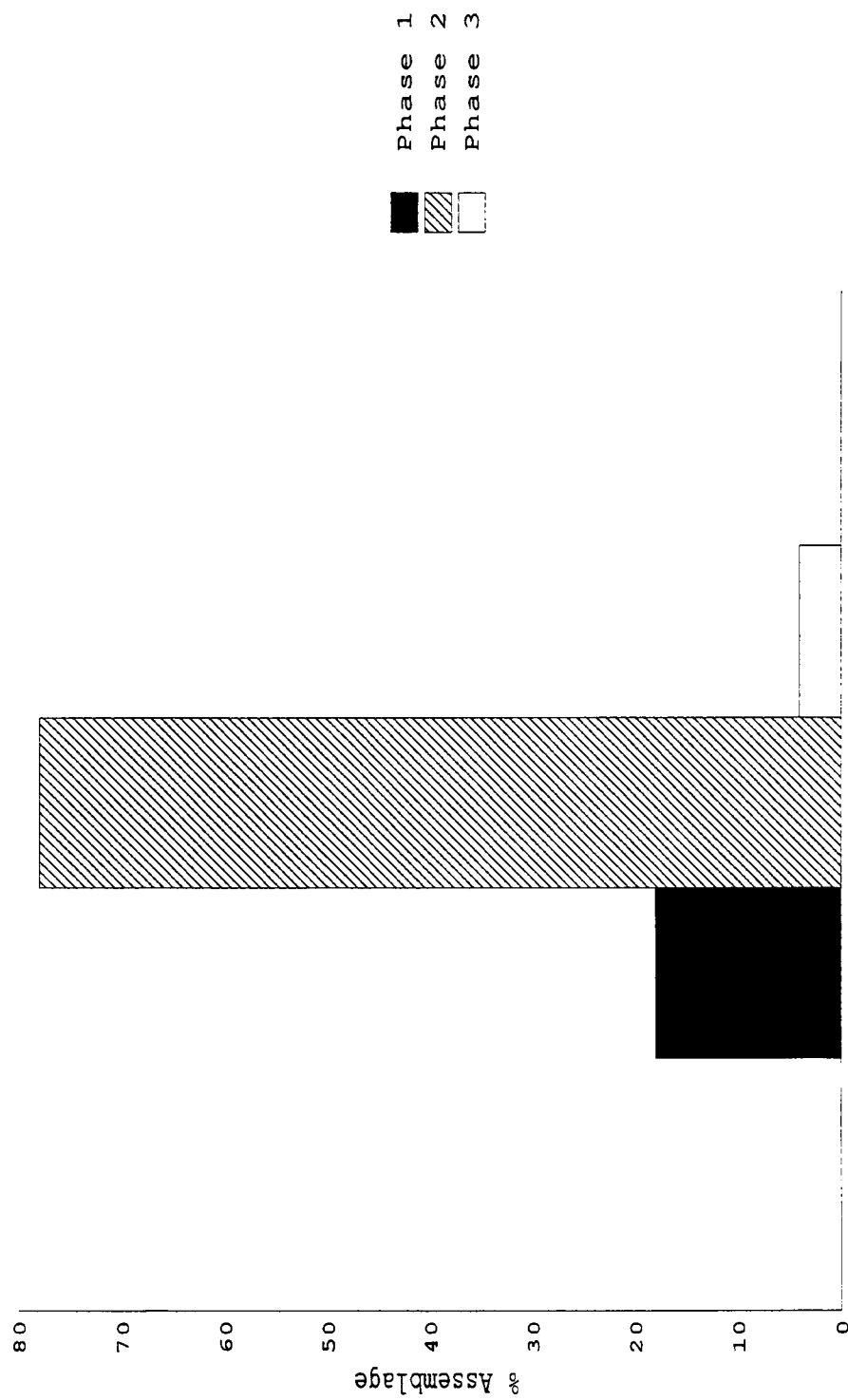


Figure 14. Assemblage Technological Phases

Table 2. Test for Independence Between Type and Technological Phase
H0: Type and Technological Phase are Mutually Independent
P= 7.6E-12 Therefore, reject the H0

	Phase 0	Phase 1	Phase 2	Phase 3
<u>Burin</u>	0 (0.1)	4 (7.3)	51 (46.1)	1 (2.5)
<u>Composite</u>	0 (0.0)	1 (1.7)	12 (10.7)	0 (0.6)
<u>Debitage</u>	4 (3.2)	331 (270.9)	1032 (1107.5)	109 (94.3)
<u>Microlith</u>	0 (0.6)	1 (51.3)	386 (323.3)	6 (17.9)
<u>Notch</u>	0 (0.0)	3 (2.1)	13 (13.2)	0 (0.7)
<u>Piercer</u>	0 (0.0)	0 (0.7)	5 (4.1)	0 (0.2)
<u>Retouch</u>	0 (0.0)	1 (2.9)	21 (18.1)	0 (0.9)
<u>Scraper</u>	0 (0.1)	1 (4.4)	30 (27.9)	3 (1.5)

patterns. Chi-square results with a P value of .0000025 for the test of independence between technological phase and raw material allows for the rejection of the null hypothesis of mutual independence of those two variables (Table 3). If one compares the observed values with the expected values in the contingency table, it can be seen that there is a relationship between raw material and technological Phase 1 and 2. Relatively exotic materials are represented more frequently in technological Phase 1 and local material in technological Phase 2. This may indicate with a relationship between Phase 1, decortification flakes and exotic materials, that small nodules of exotic raw materials were being brought into the site and initial shaping was being done. Conversely with a negative relation between exotic raw material and Phase 2 products, it may be that the blades produced at the site from exotic materials were then taken away from the site. With a positive relation between Phase 2 products and local materials, the blades produced at the site were then used and discarded in place.

The distribution of technological groups between Cluster 1 and Cluster 2 (Figure 15) shows that in this regard the two areas are indistinguishable from one another.

Table 3. Test for Independence Between Raw Material and Technological Phase
H0: Raw Material and Technological Phase are Mutually Independent
P= 2.5E-6 Therefore, reject the H0

	Phase 0	Phase 1	Phase 2	Phase 3
<u>Local</u>	4 (3.8)	268 (286.8)	1194 (1175.7)	77 (76.7)
<u>Exotic</u>	0 (0.2)	35 (16.2)	48 (66.3)	4 (4.3)

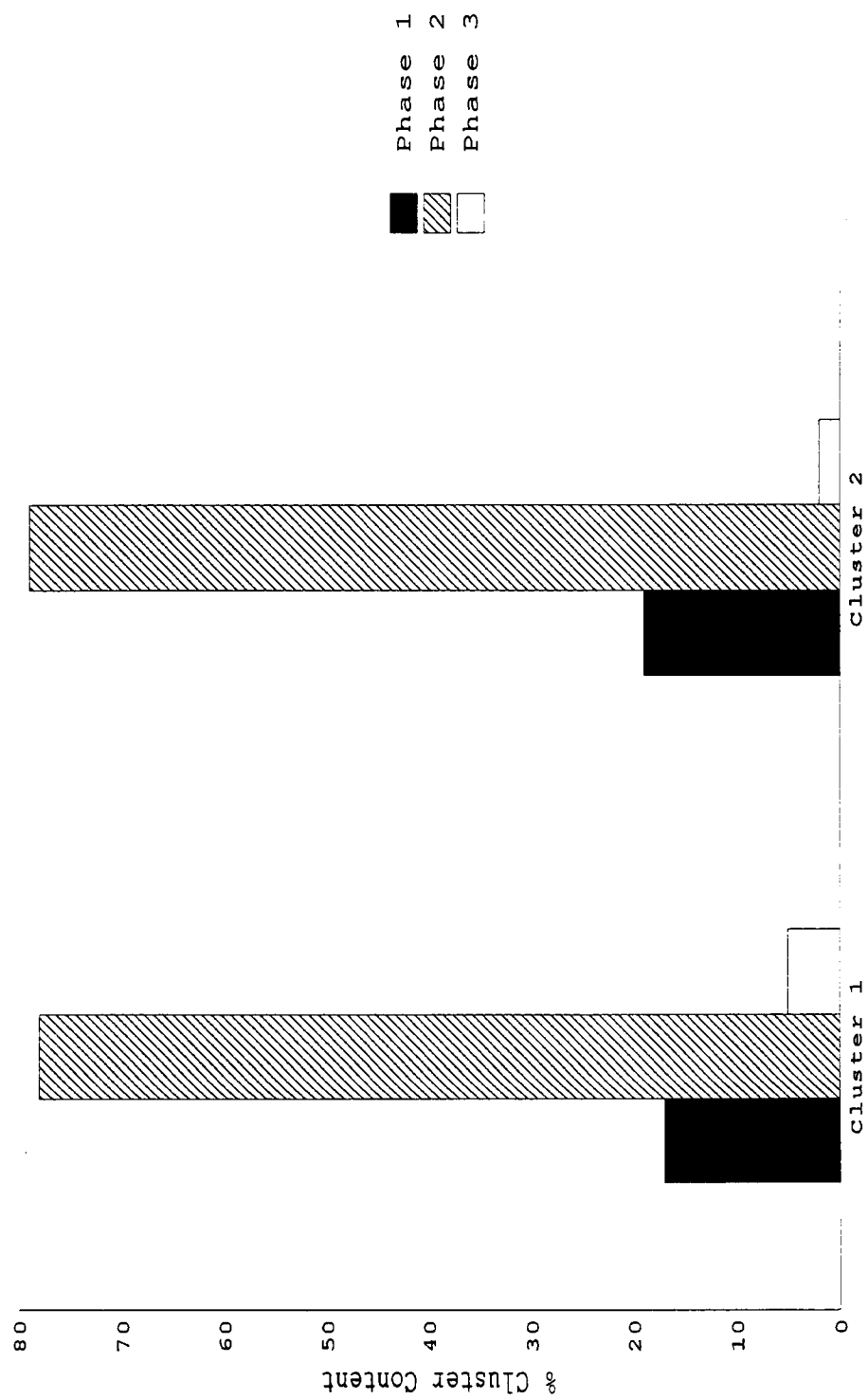


Figure 15. Comparison Of Technological Phases Between Cluster 1 And Cluster 2

Since reduction Phase 2 is the most frequent at the site, and it is evenly distributed across the whole area, tool manufacture occurred across the entire occupied area and not in one specific location.

Fauna

Delpéch's faunal analysis indicates that reindeer (*Rangifer tarandus*) is by far the dominant species present in Couche 0 (Figure 16), comprising 91% of the assemblage. The remaining 9% is divided among birds, bovids, carnivores, equids, and small mammals.

Faunal variation between clusters is examined. Figures 17 and 18 show the distribution of animal species throughout the site. There are no conspicuous differences between the two clusters. When the relationship between space and the distribution of anatomical parts is examined, there is also no spatial distinction (Figure 19). Thus, the two zones do not seem to represent different activity areas with respect to animal processing.

Bone Industry

The bone industry at Grotte XVI is not particularly rich. However, it does conform to the Upper Magdalenian of the Perigord. There are bone harpoons present with both

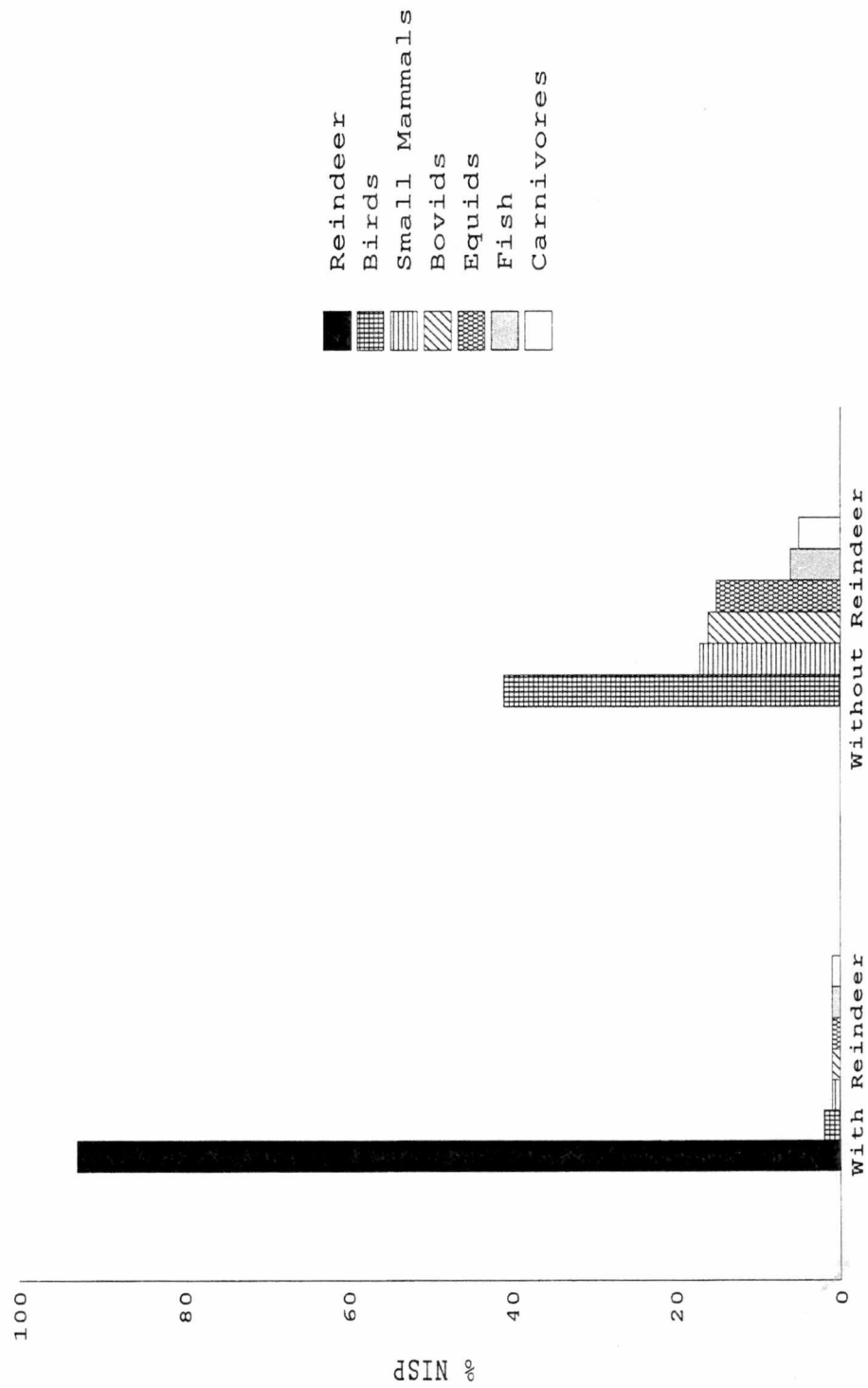


Figure 16. Animal Taxa In Assemblage

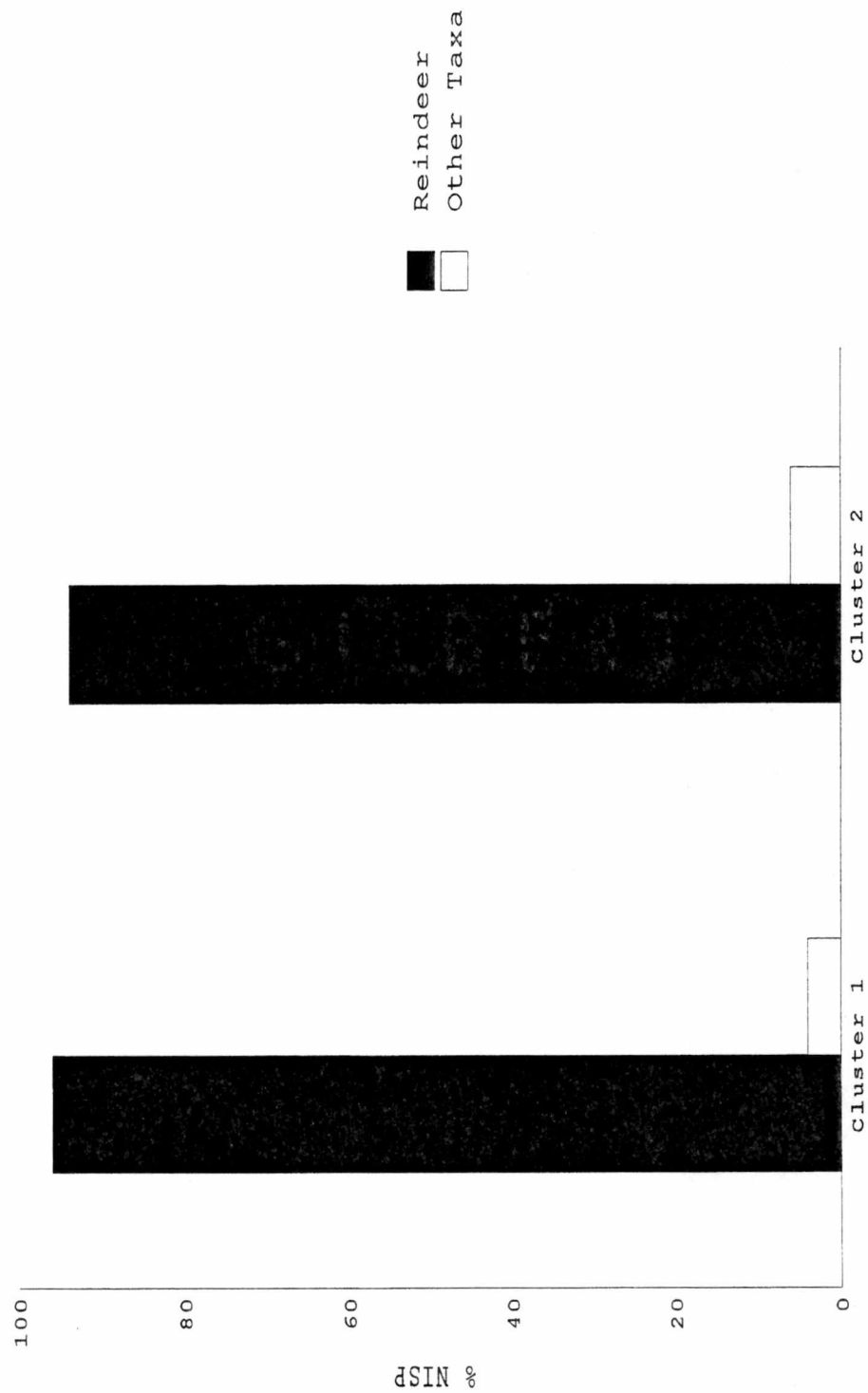


Figure 17. Comparison Of Animal Taxa Between Cluster 1 And Cluster 2

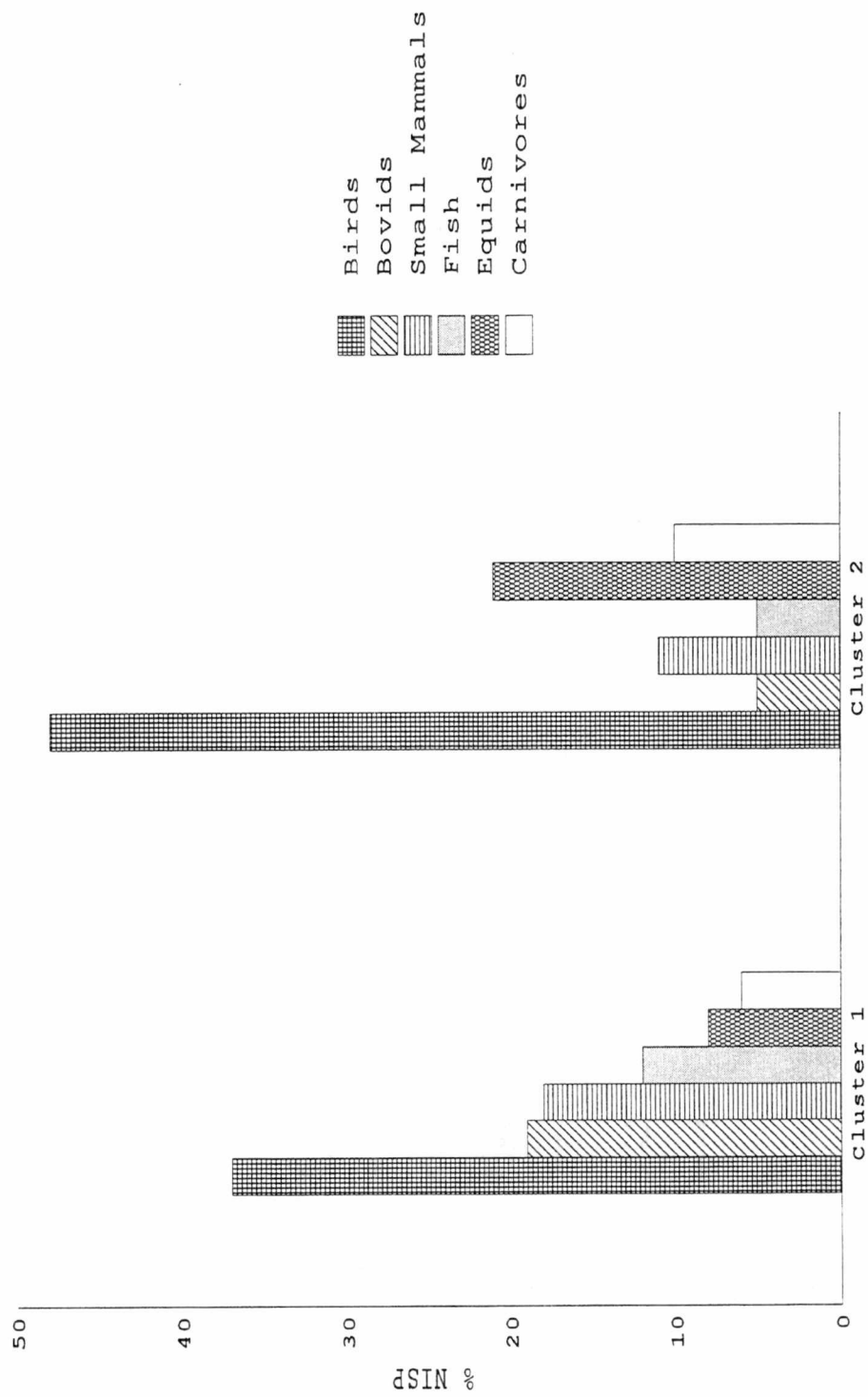


Figure 18. Comparison Of Uncommon Animal Taxa Between Cluster 1 And Cluster 2

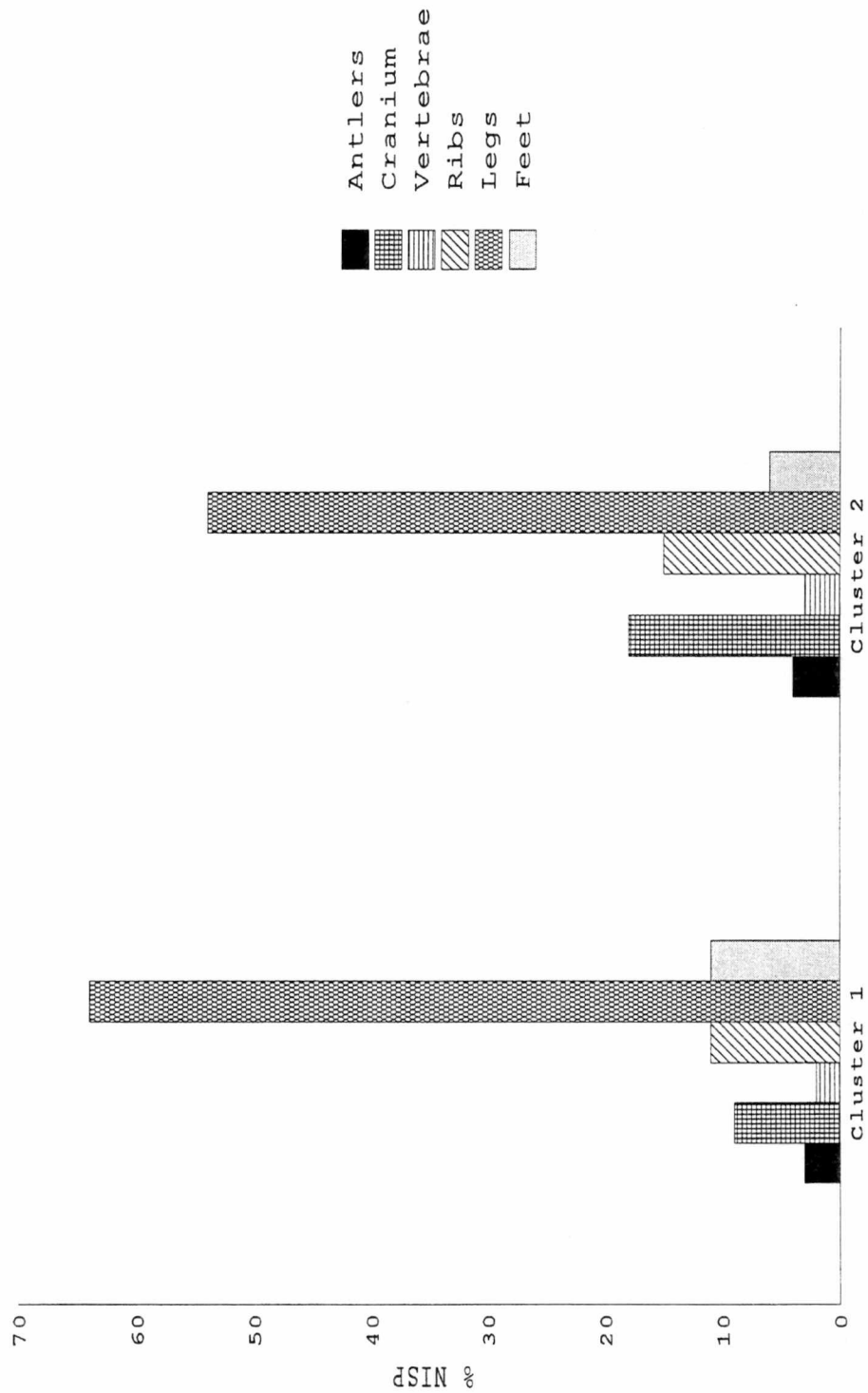


Figure 19. Comparison Of Reindeer Anatomy Between Cluster 1 And Cluster 2

single and double barbs as well as decorated bone points.

Art

Like the bone industry, "art" is almost nonexistent at Grotte XVI. Several engraved limestone plaquettes have been found, though quite unspectacular. There has been only a single representational engraving found. A bird bone engraved with the outline of a horse's head and another partial head was also recovered.

Study Assemblage for Microwear

The study assemblage for the microwear analysis consists of 1675 lithic artifacts. Of those 1331 of the artifacts have point provenience data. Artifacts from the screened materials make up the other 344 pieces. It was absolutely necessary to examine the screened materials due to the small size of the microliths; they are almost always found in the screening and not *in situ*. The composition of the study assemblage is as follows: 15% formal tools, 59% debitage and 26% microliths.

V. RESULTS AND INTERPRETATIONS

1. Introduction

In chapter IV the results of analyses from Grotte XVI, both faunal and lithic, were discussed. The overall spatial distribution of faunal species and anatomy, as well as the distribution of raw material types and technological phases throughout the gallery is very uniform. However, the occupation at Grotte XVI has two distinct activity areas, as evidenced by the distribution of tool types.

To further explore the activities within these distinct spatial zones, an investigation of microwear damage to stone tool edges was undertaken. In this analysis 100% of the formally typed tools were analyzed, and their use wear interpreted. From microwear analysis it is possible to assess both the material that the tool was used on, and the motion or past action of the tool. The assessment of the kinematics, in combination with the material that the edge came in contact with, provides for a reasonable interpretation of prehistoric activities. This patterning, in conjunction with the results of the functional analyses,

is used to support the interpretation that the Magdalenian occupation at Grotte XVI was a specialized, short term episode. The results and hypothesis of these findings are the focus of this chapter.

2. Microwear Results

The analysis undertaken at Grotte XVI was extensive. Two-hundred and sixty-eight lithic artifacts showed evidence of use. For this reason it was neither possible nor desirable to describe each piece in detail with its microwear traces. However, artifacts are grouped into functional categories and described below. While all artifacts were analyzed in the field, technical conditions did not allow for microphotographs to be taken of each piece at the time of analysis. A sample of artifacts was brought back to the United States for the purpose of microphotography. These pieces are used for illustrative purposes when examples are necessary. It was not the intention of this dissertation to document all variations of microwear traces, nor was it to prove the reliability of the method. That has already been accomplished in previous

microwear investigations. The work by Keeley (1980) is a prime example. Microphotographs of the wear traces are included in Appendix B at the end of the document.

As was stated earlier, the condition of the artifacts is critical for an accurate interpretation of function. Though the materials from Grotte XVI are remarkably preserved for their age, there were still some artifacts that were excluded from analysis due to preservation. So as to not bias the interpretations, any implement that showed obvious signs of weathering, patination, burning or natural abrasion was immediately excluded from the study. Upon further microscopic investigation, if a piece showed signs of natural abrasion or extensive trampling, that was noted and the implement was excluded from further analysis. Of the 1206 pieces analyzed, 255 (21%) showed evidence of use. When divided into categories of formal tools, microliths and debitage, 425 tools were analyzed and 230 (54%) showed evidence of use, 203 microliths were analyzed and 43 (21%) were used; and lastly, 781 pieces of debitage were analyzed and 52 (6%) showed evidence of use. An additional 553 lithic artifacts were macroscopically observed, but upon closer inspection they proved to be either too patinated or

otherwise altered for inclusion in the microwear study.

Description of Used Pieces

(see Appendix B for examples of polish; see Appendix C for Raw Data Counts)

The implements from Grotte XVI that showed evidence of use are grouped below by functional categories. They are described in regards to their overall typology, raw material, and functional attributes.

Cut Antler/Bone

Pieces that have been identified as cutting antler/bone were typed in several categories of formal tools. Several burins (3), retouched pieces(10) and notches (3) were used to cut antler/bone. However, the highest percentage of the tools used to cut bone and antler were pieces of debitage (20). All of these implements were made of local material except one.

The cutting motion produced a pattern of alternating scars on both sides of the tools. The scars produced were generally angled from the edge due to the back and forth motion. Striations, when they were present, ran parallel to the edge. Polish itself also at times exhibited a directionality. The polish appears to flow parallel to the

use edge.

The polish identified on the archaeological collection is referred to as "antler/bone" polish. Antler and bone are very hard to distinguish unless they are fully developed in experimental collections, and they are even harder to discriminate in an archaeological context. Rather than try to make interpretations at a level that would undoubtedly produce faulty results, antler and bone are lumped into one category. The antler/bone polish on the archaeological specimens was very bright and sometimes it exhibited the "melted snow" appearance that Keeley (1980) identified with antler polish. It did not spread away from the edges of the tools. The antler/bone polish was concentrated close to the edge and there was usually a marked boundary between the polished surface and the natural surface of the flint. The polish itself, while very bright, was not very smooth. It was matte in appearance and contained tiny pits. Edge damage in the form of micro scarring was always extensive. The micro-scarring was generally of the step variety.

Scrape Antler/Bone

The activity of scraping antler/bone was identified on a number of tools in the Grotte XVI collection. No tool

type dominates this category. Burins (3), notches (1), retouched implements (5), scrapers (2) and pieces of debitage (7) were used to scrape bone/antler. All of these were produced from local materials.

The scraping motions produced scars on only one side of the tool. The scars themselves were straight to the edge. If the polish had a direction that could be observed, it ran perpendicular to the edge on the opposite side of the scars. Other than the directionality, the polish itself looks like the polish that was identified on experimental tools interpreted as cutting antler/bone.

Grave Antler/Bone

The engraving of antler/bone was predominantly done using burins (16). However, there were several retouched pieces (2) and pieces of debitage (9) that were used in this manner as well. While most of the implements were produced from local materials there were several pieces of exotic materials used to engrave bone and antler including a burin.

Use damage resulting from the latitudinal and transverse motion of graving were generally identified through their location, on the nib portion of the tool. In addition, scar removal was restricted to the nib side

opposite to the contact surface. Striations when present were at nearly 90 degree angles to the bit edge. Polish was concentrated at the bit of the tool on the edge opposite that of the location of the scars. The polish description is the same as that described for cutting antler/bone. It was always concentrated on the nib portion of the tool.

Bore Antler/Bone

There were only a few tools used to bore antler and bone, and they were all typologically defined as piercers. In addition, all of the tools used to bore antler/bone were made of local materials.

Circular motions like those involved in boring produced scar patterns on alternating edges of the tool. Very similarly to graving, polish was also concentrated on the nib of the implement.

Cut Wood

When investigating the distribution of wood cutting among the tool classes, several burins, notches and pieces of debitage were used, all of which were produced on local materials.

The cutting of wood was interpreted by the presence of alternating scars on both sides of the tool. This is

combined with the presence of "wood" polish. This polish was very bright and very smooth. It had a domed appearance and gently undulated away from the tool edge. There was commonly some edge damage and was of the scalar variety.

Scrape Wood

Few pieces were identified to have scraped wood. In fact each piece was represented by a different tool type. They included a burin, notch, a retouched piece, a piece of debitage, and one scraper.

Scraping wood was identified though the presence of scars on only one side of the tool. The scars themselves are straight to the edge. Striations ran perpendicular to the edge on the opposite side of that to the scars. The polish as with cutting wood is very bright and smooth; with scraping it is even more invasive into the body of the tool.

Grave Wood

Three pieces were used to grave wood. All three were burins and all were made of local materials.

Use damage resulting from wood graving are generally identified through the location of the damage on the nib portion of the tool. Wood polish was also concentrated at the bit of the tool on the edge opposite that of the

location of the scars.

Bore Wood

The boring of wood was represented in the assemblage by a singular lithic implement. Typologically it was a burin and produced on local material.

Boring wood was identified in the archaeological collection by the presence of scar patterns on alternating edges of the tool nib. Polish is also located on that nib.

Cut Hide/Meat

Evidence for the cutting of hide/meat is evenly distributed across most of the typological tool classes. There is a predominance of hide/meat cutting with debitage. All of the implements were made of local materials except for one scraper.

Cutting motions were interpreted when there was a pattern of alternating scars on both sides of the tool. As with the interpretation of antler and bone, hide and meat are very difficult to discern in experimental tools, let alone archaeological tools. For that reason an interpretation is made of hide/meat polish. However, in combination with other use attributes, it is often possible to determine whether the polish was the result of meat or

hide working. With cutting this is not the case. When associated with the attributes defined for cutting, polish must be interpreted no farther than hide/meat.

The polish identified was relatively bright and somewhat greasy in appearance. The entire surface was altered and thus there was little contrast between the polished area and the unaltered surface of the flint. The scars are very shallow and small. They were of the half moon or feather variety.

Scrape Hide/Meat

Asside from scrapers that dominate, craping hide/meat is fairly evenly distributed throughout the typological classes. In addition, all tools were produced on local materials except for a scraper made of exotic raw material.

The scraping of hide/meat (or for all intents and purposes just hide) was identified through the presence of scars on only one side of the tool. However, the most defining factor was edge rounding. When hide/meat polish was identified and coupled with edge rounding, it could be interpreted with fairly high certainty, as the result of hide scraping. In the case of Grotte XVI, the type of hide is interpreted to be fresh hide. A relatively bright polish

forms upon contact with fresh hide and it tends to be greasy in appearance. The topography of the polish was somewhat rough and bumpy, though not pitted.

Bore Hide/Meat

Only two tools were used to bore/pierce hide. These were produced of local materials and were represented by one piercer and one microlith.

The boring, or piercing of hide, is identified through the presence of tiny scars on alternating sides of the boring nib. In addition hide/meat polish is concentrated at the nib.

Tools with Multiple Uses

There were several tools with multiple uses. While they could be classified as multiple uses because they involved separate edges and separate motions, they were always used to work the same material. Thus while they are multiple use tools they were probably used within the same activity. The most typical multiple tool use was burins used not only to grave antler/bone but also to cut the same material. Second most common were blades with both edges used to cut. Last, there were scrapers that were also used to cut.

Each tool usewear class has been described and individual pieces have been presented. For interpretive clarity it is helpful to group artifacts with regards to basic typological classifications. These designations are formal tool types (de Sonneville-Bordes 1974), microliths, because they are both typologically and functionally specific, and debitage.

Tools

A wide range of motions have been interpreted from the usewear observed on the tools from the Magdalenian occupation of Grotte XVI. These are, however, within the range of typical prehistoric activities, and comprise cutting, scraping, graving and boring. Figure 20 shows that, of the implements for which motion could be interpreted, the most frequently observed motion was cutting. Scraping ranks as the second most prevalent activity, while graving was represented by only a few tools less than scraping. Tools used for boring are very scarce.

There seems to be a limited range of materials worked at Grotte XVI, and they are fairly evenly distributed across the classes defined for motion. These materials, as represented by the presence of distinct polishes, are: bone,

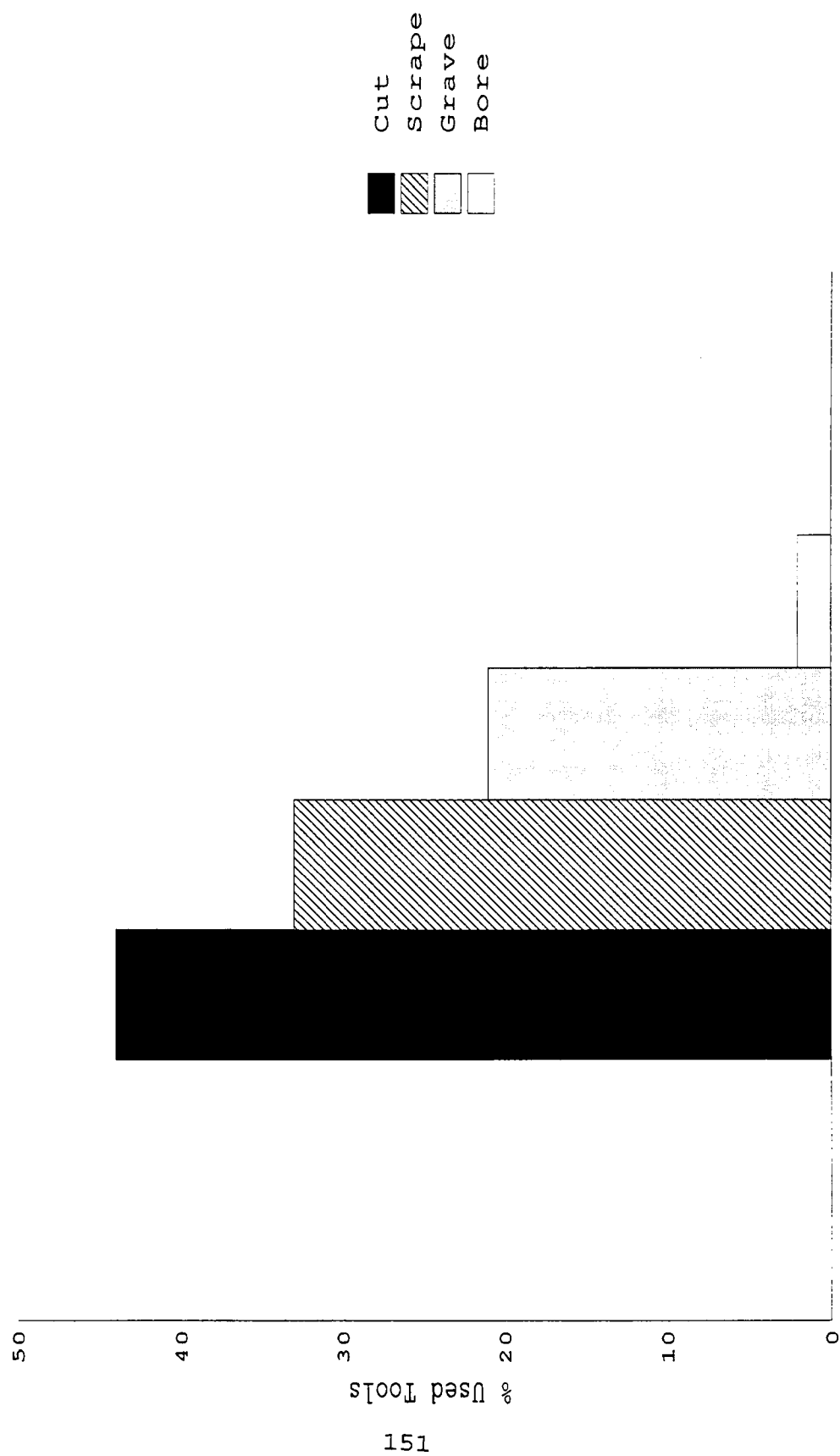


Figure 20. Used Tools According To Action

antler, hide, meat and wood. Figure 21 shows that, where material could be identified, bone and antler working were the dominant activities. Tool use on hide and meat ranks as the second most prevalent activity, while only a few tools were used to work wood.

When action and material worked are combined, a picture of site activity begins to emerge (Figure 22). Cutting antler and bone is the predominant activity at the site. This may be an over representation of that activity due to the fact that, for expedient activities such as cutting, larger numbers of tools may be used. That, coupled with the fact that antler and bone are very hard materials that dull an edge quickly, would necessitate the use of greater quantity of edges. After cutting antler and bone, cutting hide and meat is the dominant activity. These too, for the same reasons as cutting antler and bone, may be over represented. In general often unretouched waste flakes are used for expedient cutting activities such as these (Keeley 1980). Engraving antler and bone is the next prevalent activity at 20% of the tools. Scraping antler and bone is represented by 17% of the tools. It makes sense that these two activities fall just under the number of tools used for

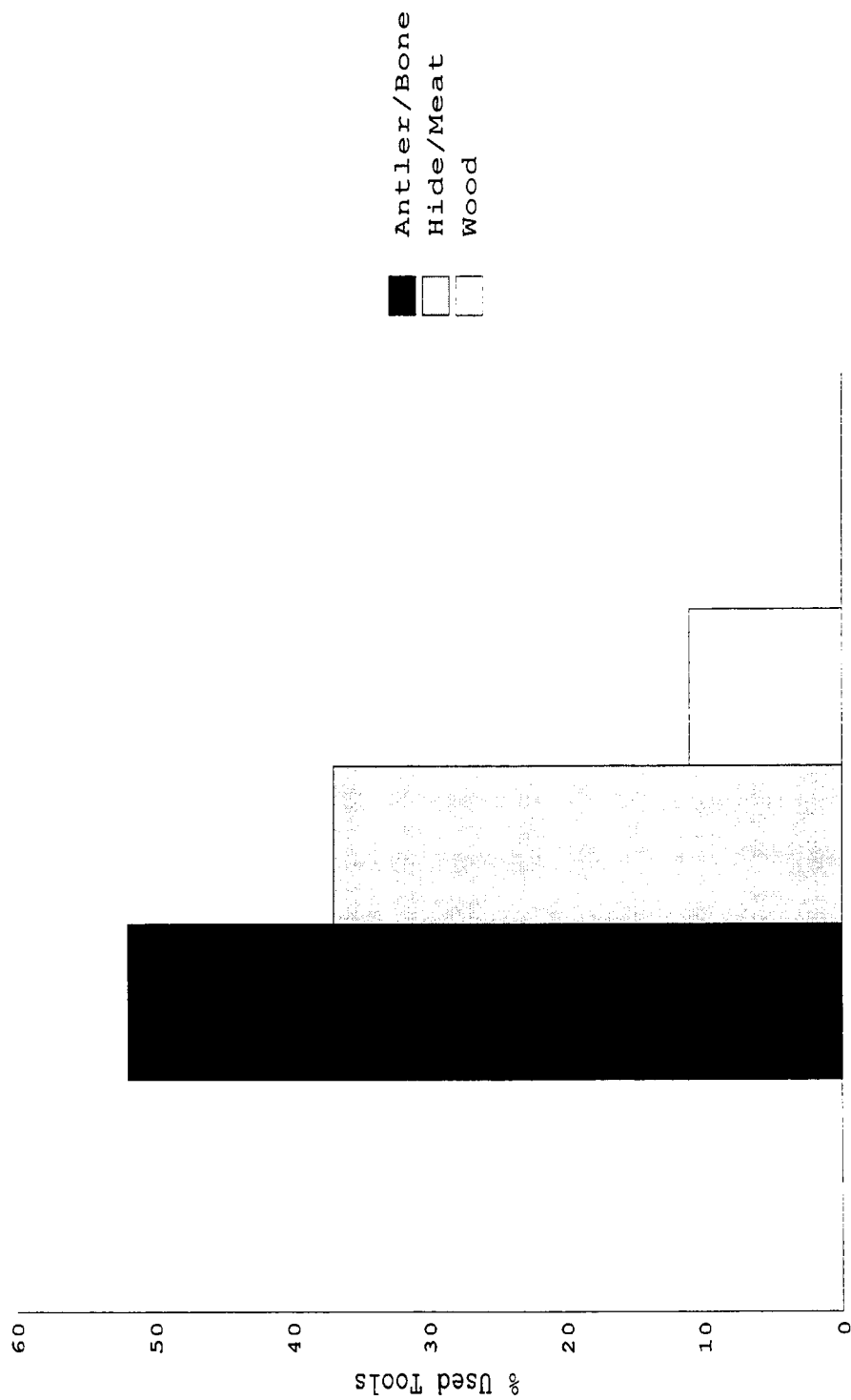


Figure 21. Used Tools According To Material Worked

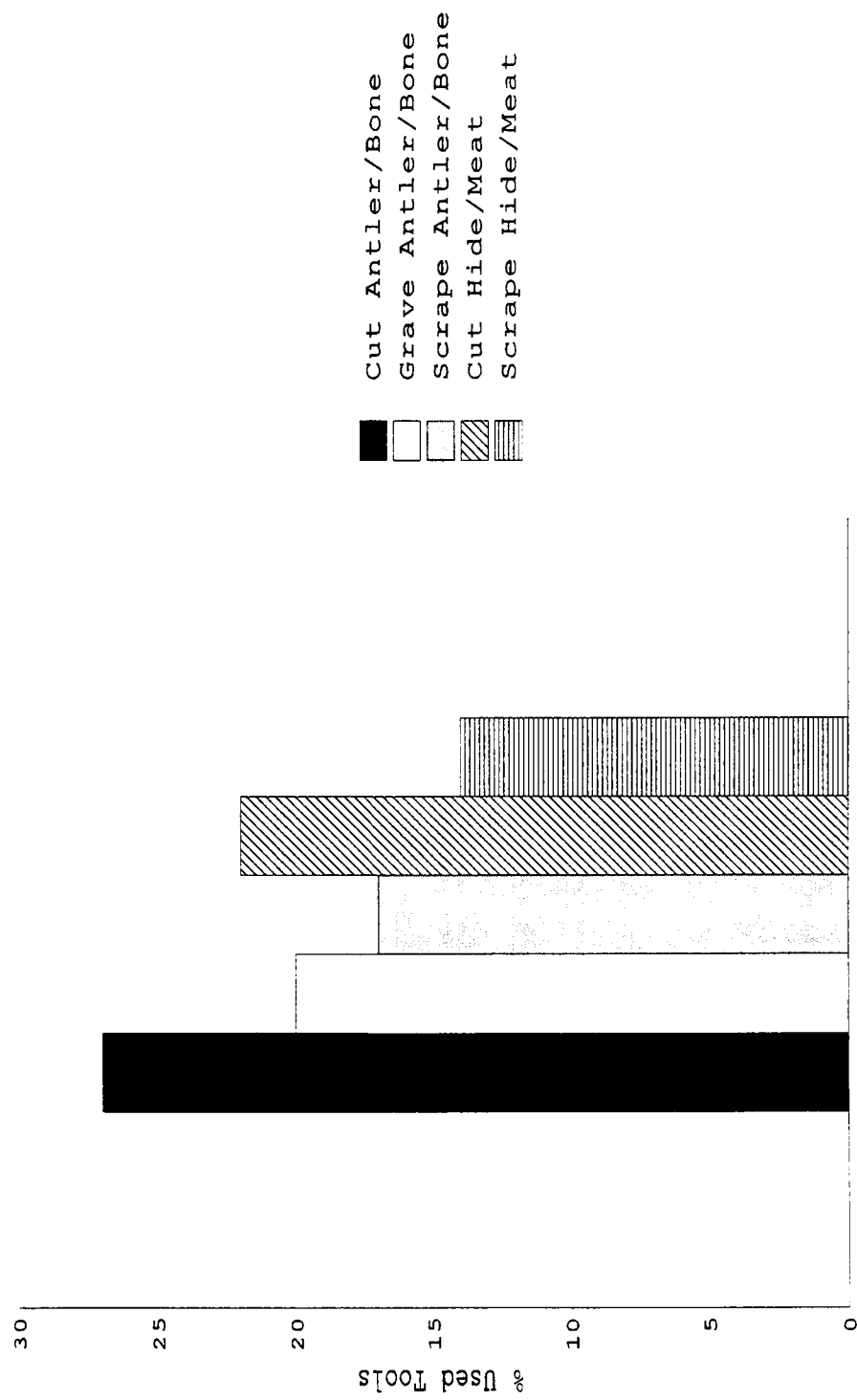


Figure 22. Used Tools According To Activity

cutting activities. Tools used to engrave and to scrape are generally formal curated tools. Though they will dull during the activity, they may be resharpened and use will continue. Scraping of hides is the least represented activity at 14%. Because during hide processing there is little attrition of the tool edge, a single tool can be used for a longer period of time. In addition, the resharpening process required for a scraper is much less reductive than that of sharpening a burin.

Microliths

In a site dominated by microliths it is hard to ignore their technological and functional roles. Usewear analysis of the 458 microliths showed that only a small percentage (20%) were actually used. About 85% of the microliths that showed evidence of wear showed evidence of hafting. The other 15% have wear traces from cutting and boring (Figure 23). When the contact material is assessed, that same 85% of the microliths that were hafted also were in contact with bone or antler. Not surprising given that most hafts made for composite tools were made of antler or bone. The remaining microliths were in contact with either hide/meat or wood (Figure 24). When motion categories and materials

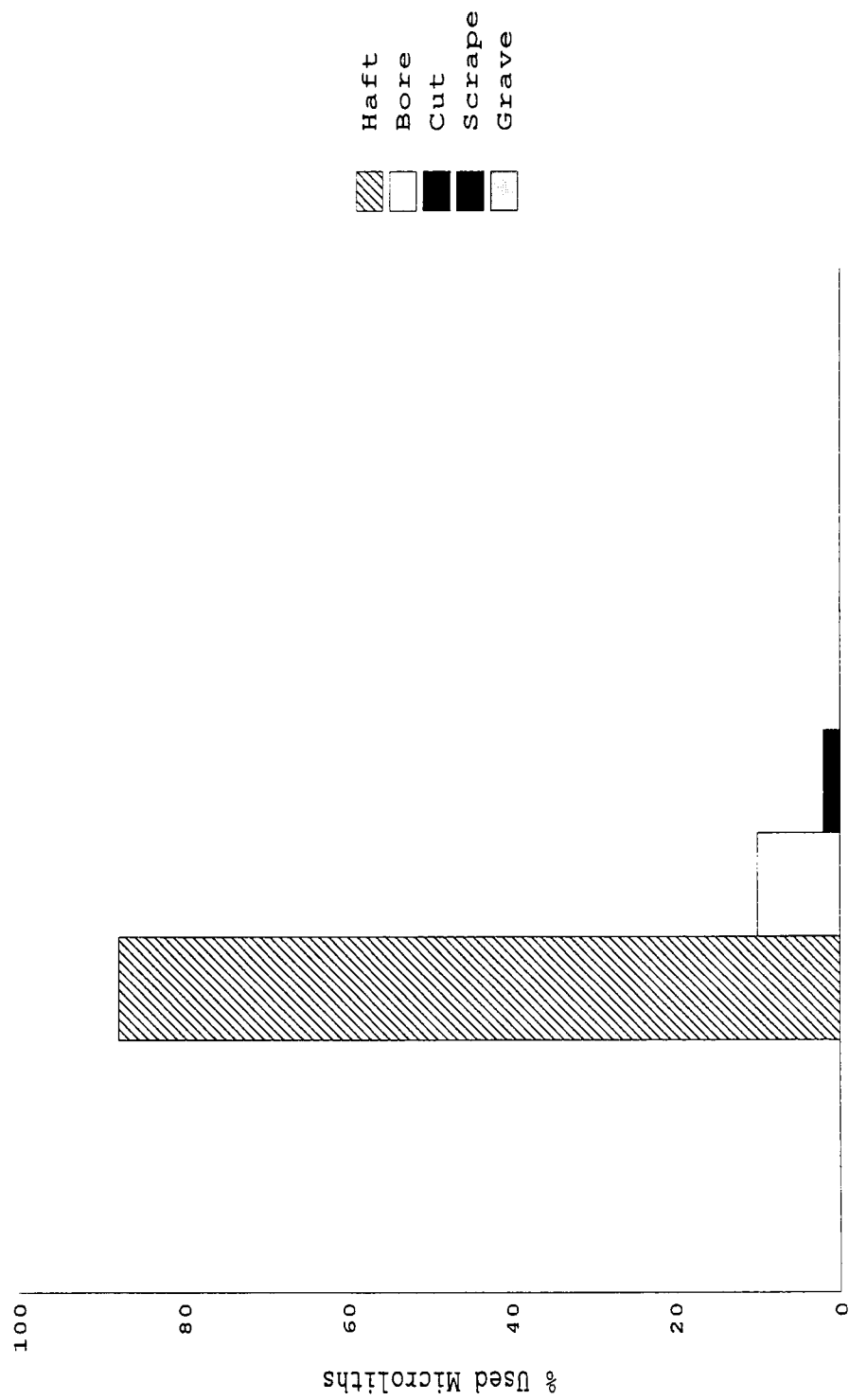


Figure 23. Used Microliths According To Action

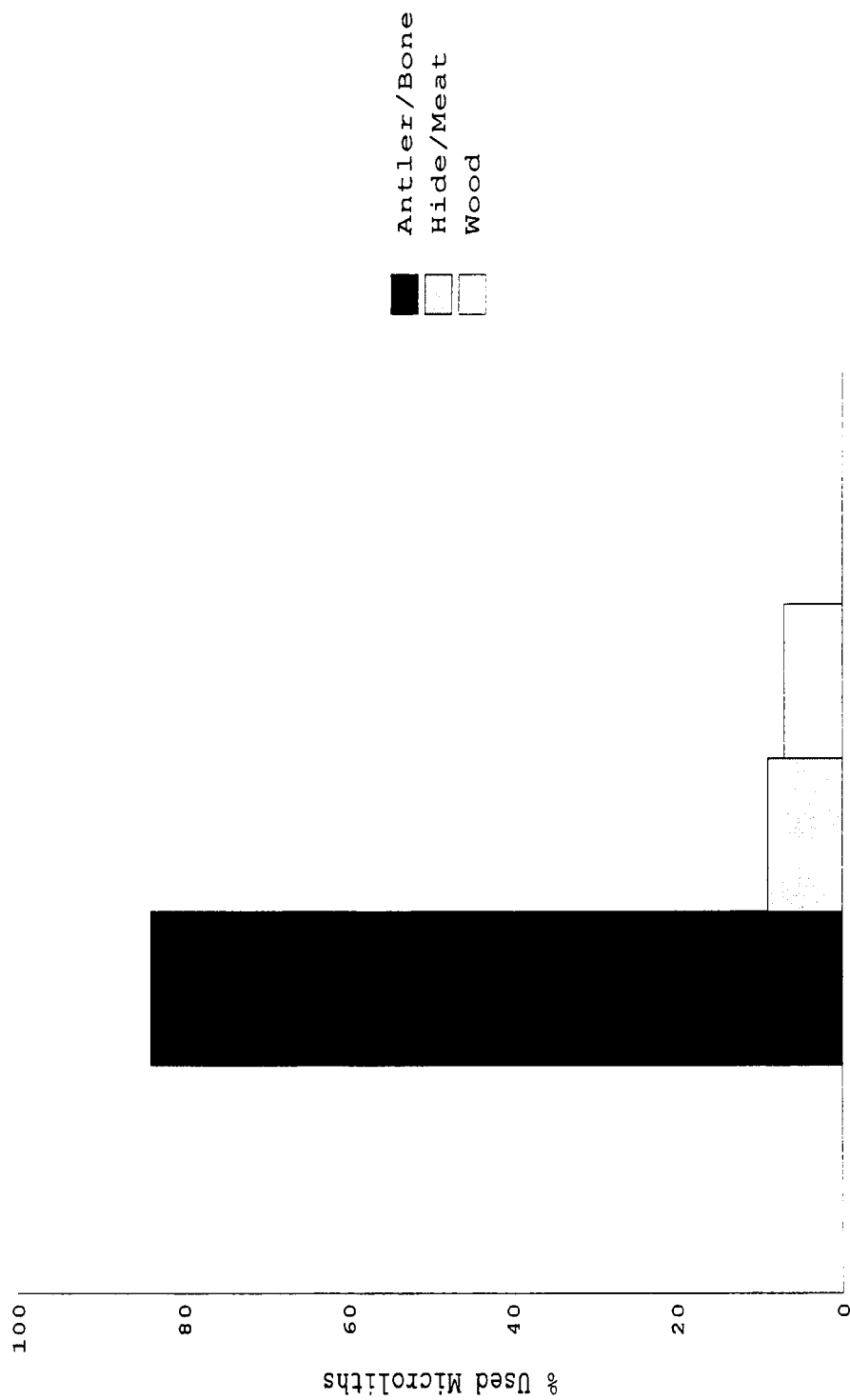


Figure 24. Used Microliths According To Material Worked

worked are combined to investigate activities, the dominant activity represented in the microlith usewear is hafting in bone and antler (Figure 25).

This wear may reflect production and retooling at the site rather than the extensive use of composite tools. These wear patterns may be interpreted as traces left from the use of the composite as a projectile. However, I do not believe any of these traces were produced at the Grotte XVI. Generally, hafted tools, especially those that were part of a composite tool, are deposited where rehafting occurs not where they were used (Keeley 1991). Additionally, the tasks for which microliths are assumed to be used, projectiles and light duty cutting, are not activities that produce a great deal of identifiable wear.

Debitage

A sample ofdebitage was chosen for microwear analysis at Grotte XVI. In the end, 100% of thedebitage larger than 3 centimeters in size was analyzed. This was 60% of the totaldebitage at the site. Only a small percent (5%) of the analyzeddebitage had usewear present on the edges.

Cutting was the dominant motion represented by the microwear at 68% (Figure 26). This is not surprising given

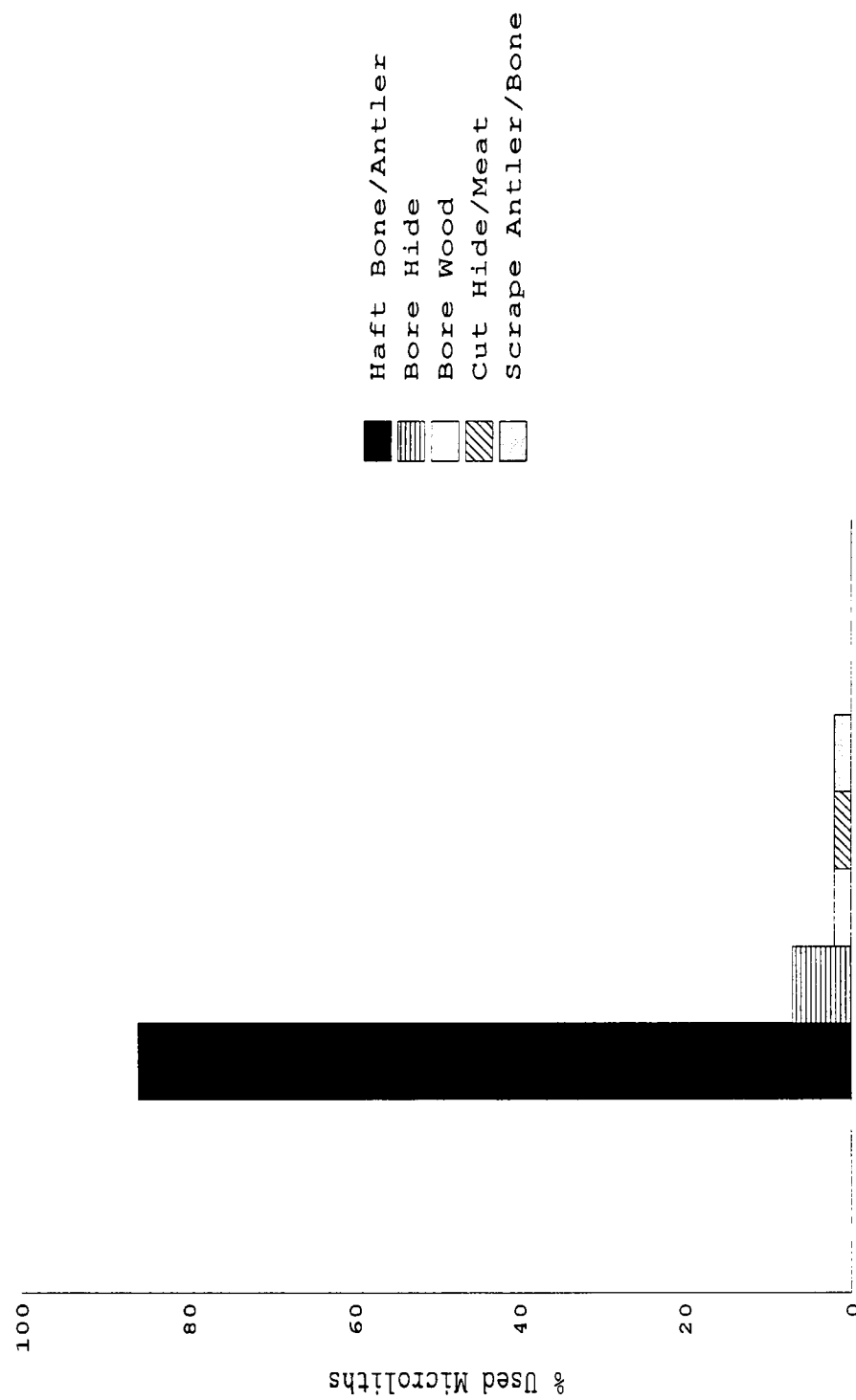


Figure 25. Used Microliths According To Activity

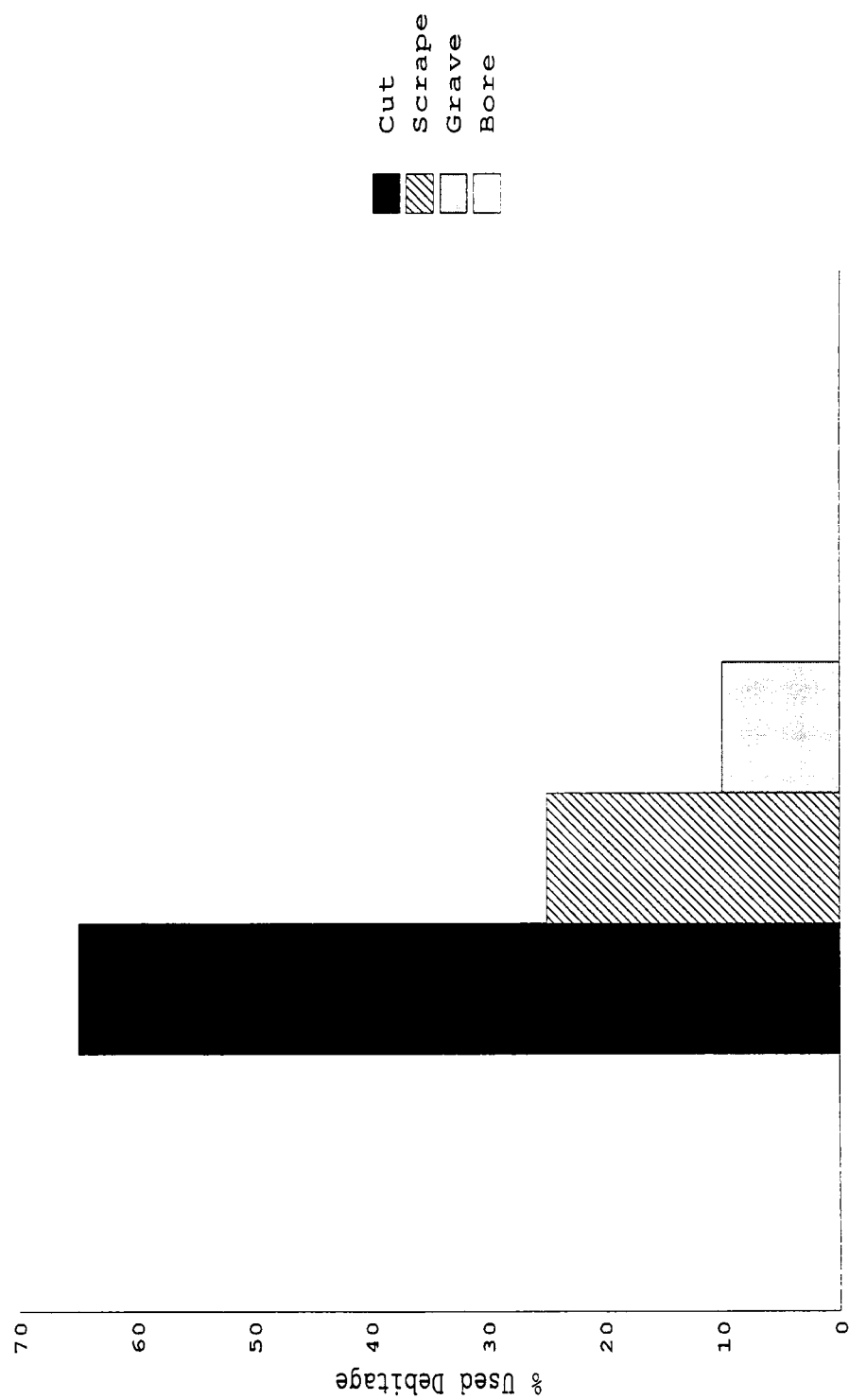


Figure 26. Used Debitage According To Action

that cutting dulls edges very quickly and therefore it would be a more efficient use of raw materials if waste flakes were used rather than formally fashioned tools. 23% of the used debitage had microwear evidence indicative of the scraping motion. Only 9% of the used debitage showed traces associated with the graving motion. Not a single piece of debitage showed evidence of boring.

When the contact materials are investigated (Figure 27) antler/bone is the principal contact material (55%) for debitage tools. Antler and bone are extremely hard materials and will dull an edge quickly. An expedient tool such as a raw unmodified piece of debitage would work well for the gross initial shaping of bone or antler. When the flake dulls it is tossed away and little time has been wasted fashioning a formal tool for the task. Hide and meat wear are represented on 35% of the used debitage. The edge of an unmodified flake is at its sharpest. It would not make a good tool for later stages in hide processing because a duller tool is needed so as to not cut into the hide, making it susceptible to tearing when later stretched. However, the unmodified piece of debitage would be very efficient for the earlier stages of hide processing. Only

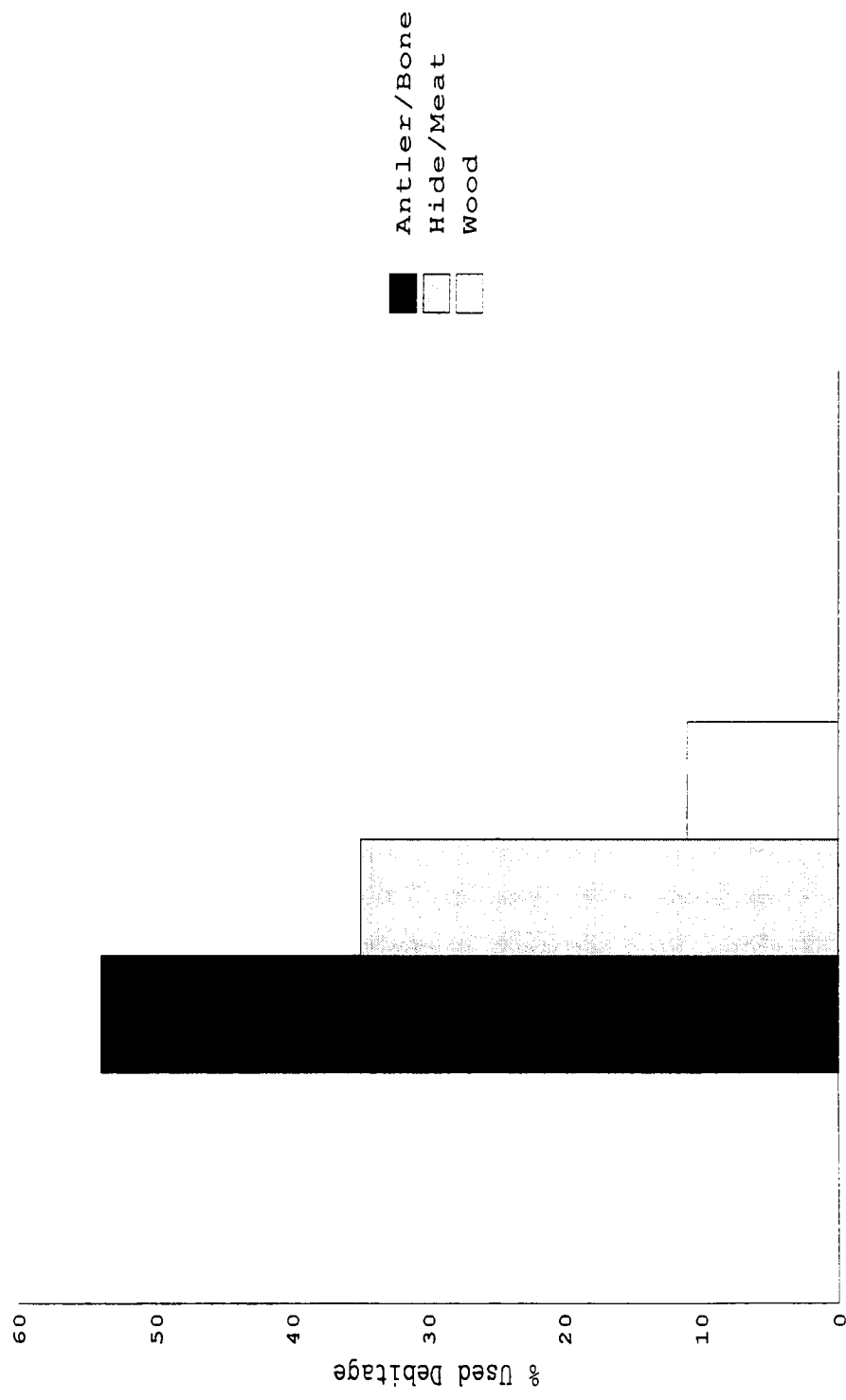


Figure 27. Used Debitage According To Material Worked

10% of the useddebitage had microwear traces associated with wood working.

When microwear evidence for contact material and action are combined to investigate functional activity and debitage use (Figure 28), a pattern emerges that sees debitage use in the primary stages of activities associated with antler/bone working and hide processing or butchery begins to emerge. The largest percentage (60%) of the used debitage showed microwear traces associated with cutting antler/bone or hide/meat. The next 27% of the used debitage had microwear damage indicative of its use to scrape or grave antler/bone. Therefore, 87% of the debitage that showed traces of use evidenced traces associated with cutting, an expedient task, and contact with very aggressive materials, bone/antler.

3. Chi-Square

The Chi Square Test for Independence was applied to several sets of data to test for the mutual independence of the variables. The data sets chosen focused on the variables raw material, technology, typology and their correlation with function. This was done to investigate the relationships between these different phases in the *chaîne*

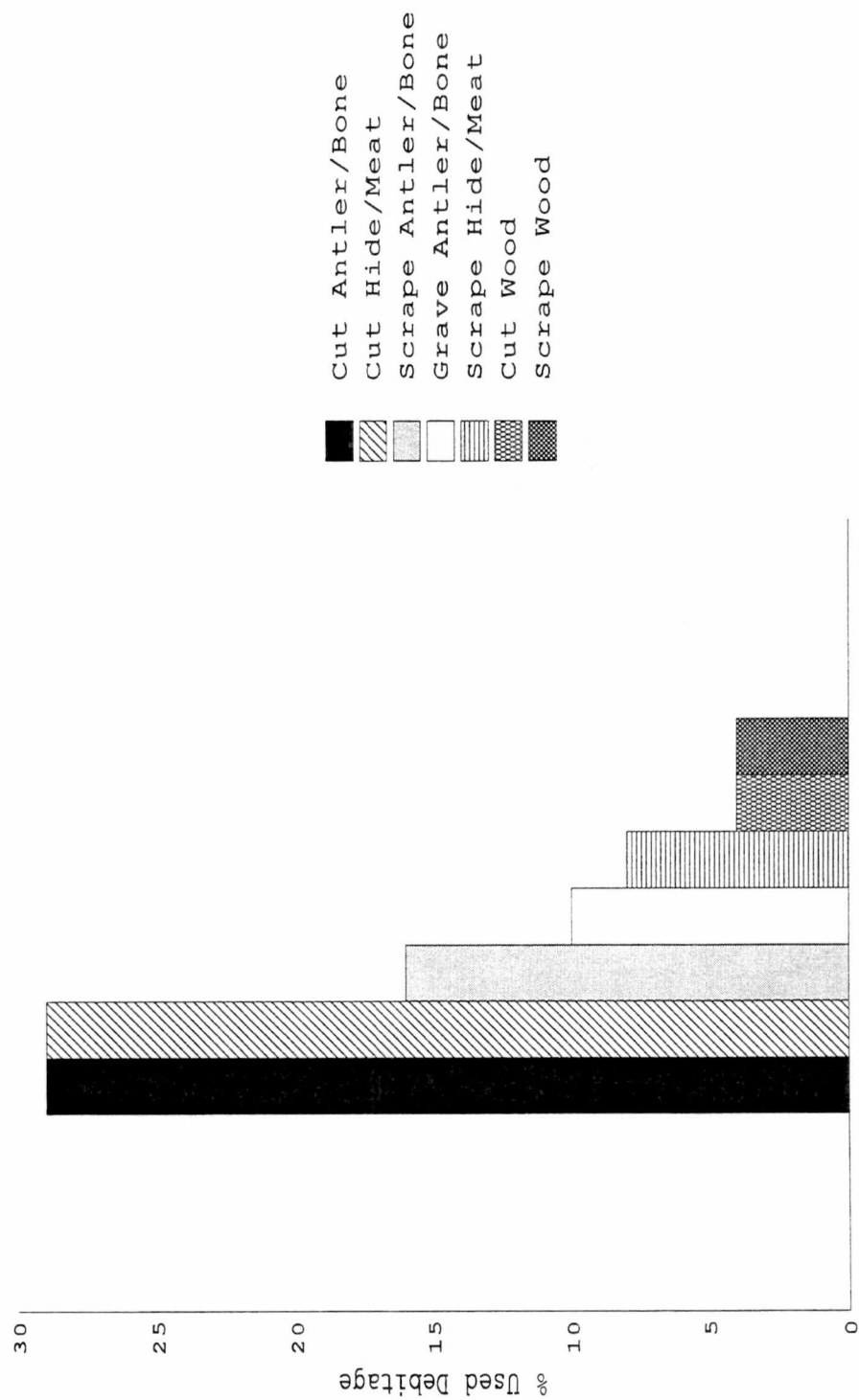


Figure 28. Used Debitage According To Activity

operatoire.

Function and Raw Material

The chi-square test for independence was used to test the null hypothesis of mutual independence for the variables raw material and use action. When the relationship between raw material and use action was tested (Table 4), looking at the functional variables cutting, scraping, graving and boring, there does not appear to be a statistically significant relationship. The P value of .58 does not allow us to reject the null hypothesis of independence. Given the overall proportions between the classes, the use actions and the choice of raw materials are equally distributed throughout the classes. However, without investigating the relationship between these operational phases the relationship, though slight, between the choice of exotic raw material and graving might have been missed. The observed count for exotic material and graving is 3 while the expected is 1.5.

The chi-square test for independence was used to test the null hypothesis of mutual independence for the variables raw material and material worked (Table 5). Raw material was subdivided into local materials and exotic materials

Table 4. Test for Independence Between Action and Raw Material

H0: Action and Raw Material are Mutually Independent

P= .58 Therefore, do not reject the H0

	Local	Exotic
<u>Cut</u>	83 (82.0)	3 (4.0)
<u>Scrape</u>	47 (46.7)	2 (2.3)
<u>Grave</u>	30 (31.3)	3 (1.5)
<u>Bore</u>	4 (3.8)	0 (0.2)

Table 5. Test for Independence Between Material Worked and Raw Material
H0: Material Worked and Raw Material are Mutually Independent
P= .87 Therefore, do not reject the H0

	Local	Exotic
<u>Hide/Meat</u>	54 (53.4)	2 (2.6)
<u>Bone/Antler</u>	106 (106.7)	6 (5.3)
<u>Wood</u>	22 (21.9)	1 (1.1)

while the functional designations for material worked were hide/meat, bone/antler and wood. With a P value of .87 the null hypothesis of independence cannot be rejected.

However, though not statistically significant, had I not looked at the relationship between these two stages in the *chaine operatoire* the relationship between the use of exotic materials and the working of bone/antler which accounts for 66% of the exotic materials as opposed to the working of other materials might have been missed.

When the relationship between function and raw material is investigated, the only behavioral pattern that emerges is the dependance between graving bone/antler and the preference for exotic raw materials. This may also be representative of curated tools.

Function and Technology

The test for independence between use action and technological phase (Table 6) is not significant with a P value of .78. However, though there does not appear to be any relationship between use action and technological phase, the action cutting in relation to Phase 2 seems to be high.

The test for independence for material worked and technological phase (Table 7) also indicates with, a P value

Table 6. Test for Independence Between Action and Technological Phase
H0: Action and Technological Phase are Mutually Independent
P= .79 Therefore, do not reject the H0

	Phase 0	Phase 1	Phase 2	Phase 3
<u>Cut</u>	1 (0.5)	13 (10.5)	82 (86.0)	2 (1.0)
<u>Scrape</u>	0 (0.3)	6 (6.2)	52 (50.9)	0 (0.6)
<u>Grave</u>	0 (0.2)	2 (3.5)	31 (28.9)	0 (0.3)
<u>Bore</u>	0 (0.0)	0 (0.8)	7 (6.1)	0 (0.1)

Table 7. Test for Independence Between Material Worked and Technological Phase
H0: Material Worked and Technological Phase are Mutually Independent
P= .42 Therefore, do not reject the H0

	Phase 0	Phase 1	Phase 2	Phase 3
<u>Hide/Meat</u>	1 (0.3)	6 (5.7)	58 (59.4)	1 (0.6)
<u>Bone/Antler</u>	0 (0.6)	11 (10.8)	114 (112.5)	0 (1.1)
<u>Wood</u>	0 (0.1)	2 (2.5)	26 (26.1)	1 (0.3)

of .42, that the variables are independent. Phase 3 of the technological sequence so dominates the assemblage that the statistically significant dependance between the variables is lost. Once again, through this investigation bone/antler in Phase 2 of the technological sequence, the presence of decortification flakes, is proportionally high.

Thus, when technological phases are investigated as they relate to function, the only pattern that emerges is a high frequency of bone/antler in Phase 2 of the technological sequence. This may make sense in the expedient production of flakes for the heavy task of cutting bone and antler where the tool will dull very quickly.

Function and Typology

When the chi-square test for independence is used to test the relationship between the variables action and typology there proves to be significant results (Table 8). With a P value of $4.8E-19$, the null hypothesis can be rejected and the alternative hypothesis of dependance can be accepted. One should not be surprised that burins were used to grave and scrapers were used to scrape! However, the relationship between cutting and the burin, as well as cutting and notches, might be overlooked had relationships

Table 8. Test for Independence Between Action and Type
H0: Action and Type are Mutually Independent
P= 4.8E-19 Therefore, reject the H0

	Cut	Scrape	Grave	Bore
<u>Burin</u>	11 (19.3)	11 (14.7)	22 (9.5)	2 (2.4)
<u>Composite</u>	2 (4.2)	5 (3.2)	3 (2.0)	0 (0.5)
<u>Debitage</u>	34 (21.8)	13 (16.6)	5 (10.8)	0 (2.8)
<u>Microlith</u>	1 (2.1)	0 (1.6)	0 (1.0)	4 (0.3)
<u>Notch</u>	7 (4.6)	4 (3.5)	0 (2.0)	0 (0.6)
<u>Piercer</u>	0 (1.7)	2 (1.2)	0 (0.8)	0 (0.2)
<u>Retouch</u>	14 (10.9)	6 (8.3)	5 (5.4)	1 (1.3)
<u>Scraper</u>	0 (5.0)	12 (3.8)	0 (2.5)	0 (0.7)

not been investigated.

The tests for the independence between the variables of typology and material worked (Table 9) are significant with a P value of $6.7E-6$. Therefore, the null hypothesis of mutual independence can be rejected in favor of the dependence of these variables. The dependence of several of these variables is most logical when one considers traditional functional interpretations based on type. It is not surprising to see that there is a significant relationship between burins and working bone/antler or scrapers and hide working. However, it is interesting to see the relationship between burins and wood working, retouched pieces and bone/antler working as well as the use of debitage to process hides. These relationships might be overlooked if only the traditional typologies were investigated.

In conclusion, the use of the *chaîne opératoire* concept in lithic analysis to investigate the relationships between the various technological phases and function allows us to more thoroughly investigate the collector land use pattern of the Magdalenian occupation of the Grotte XVI. The relationship between the use of exotic raw materials and

Table 9. Test for Independence Between Material Worked and Type

H0: Material Worked and Type are Mutually Independent

P= 6.7E-6 Therefore, reject the H0

	Hide/Meat	Bone/Antler	Wood
<u>Burin</u>	12 (12.4)	23 (27.7)	12 (6.9)
<u>Composite</u>	3 (2.6)	6 (5.9)	1 (1.5)
<u>Debitage</u>	18 (13.7)	28 (30.7)	6 (7.6)
<u>Microlith</u>	4 (11.4)	36 (25.4)	3 (6.3)
<u>Notch</u>	2 (2.9)	5 (6.4)	4 (1.6)
<u>Piercer</u>	3 (1.1)	0 (2.3)	1 (0.6)
<u>Retouch</u>	3 (6.9)	21 (15.3)	2 (3.8)
<u>Scraper</u>	10 (4.0)	3 (8.8)	2 (2.2)

graving bone and antler, may reflect a behavioral choice planned for an activity surely to be practiced by a hunting party intending to retool their composite tools, while the use of local material would suffice for the tasks associated with hide processing. Though technological Phase 3 dominated the assemblage and the functional activities associated with the site, Phase 2 products produced were used for heavy tasks where edges would dull quickly. There are definite relationships between typology and function, some very logical, and others that would be overlooked should these relationships not be investigated. These analyses further support the interpretation of the Magdalenian occupation at Grotte XVI as a short term, specialized use of the site by small, mobile task groups. The site use was most certainly part of a larger, logistically organized collector land use strategy.

4. Spatial Results

When viewed independently from spatial patterning, these observations are interesting but predictable at an Upper Paleolithic site. However, these activities do have a

spatial dimension. As discussed in Chapter IV, the artifacts at Grotte XVI have a very simple spatial distribution. This distribution can be observed in the scatter plot of the artifacts and it is confirmed by K-means spatial analysis. Two clusters are separated in space. One cluster is located in the front of the gallery associated with burins, microliths and a small hearth. The second cluster is located in the back portion of the gallery and is associated with a large proportion of scrapers. While K-means was applied to all materials at the site to establish this two cluster solution and their locations, K-means was also applied to the used pieces at the site. Once again, a two cluster solution was confirmed; however, this allowed for content analysis to be performed and activity areas defined based on functional interpretations of the lithic artifacts.

Figure 29 shows the distribution of motions in Cluster 1 and Cluster 2. Though each cluster contains the full range of motions represented at the site, Cluster 1 has a higher percentage of wear resulting from a graving motion while Cluster 2 is dominated by evidence of wear from scraping. Cluster 1, with its high proportion of graving,

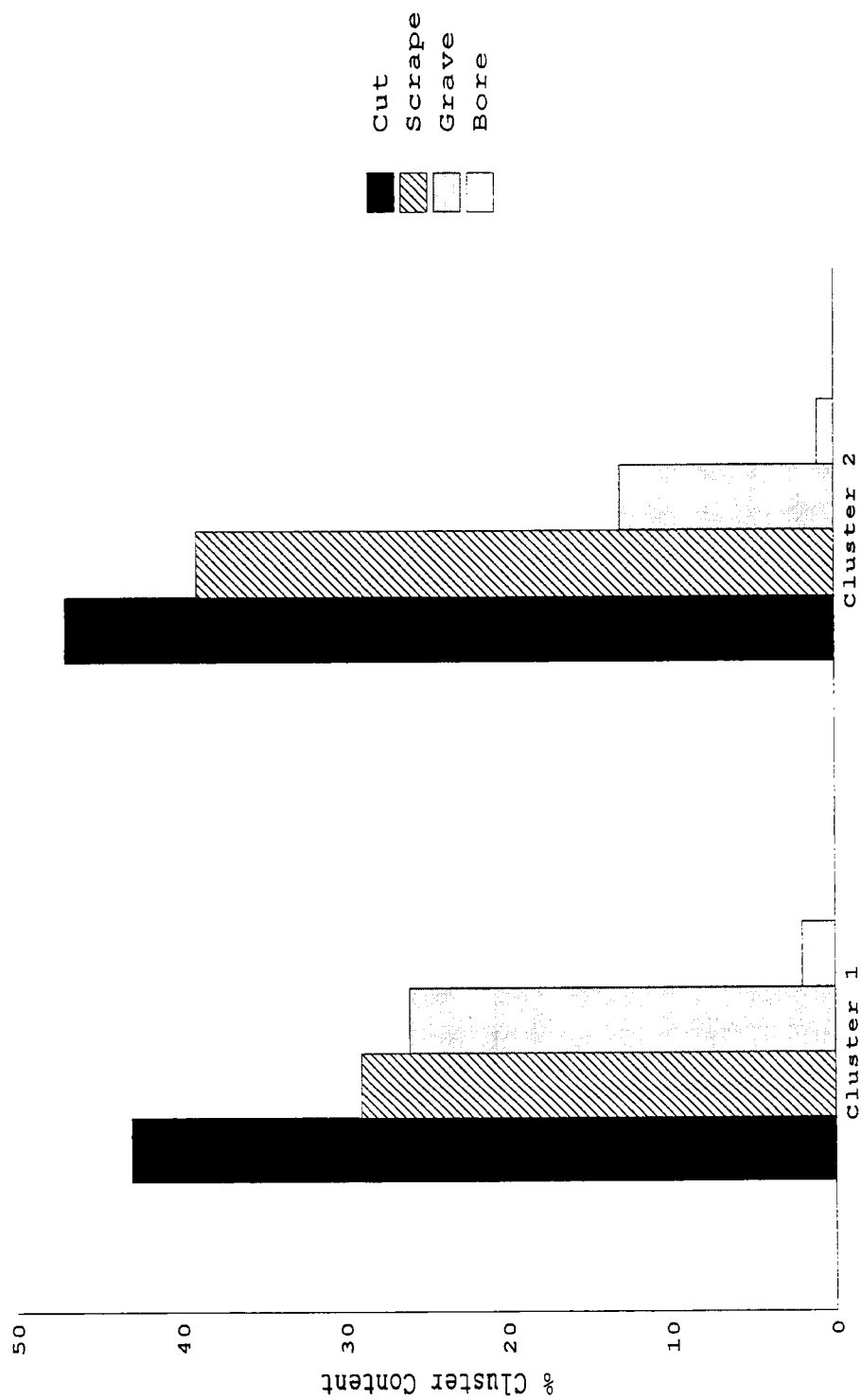


Figure 29. Comparison Of Action Between Cluster 1 And Cluster 2

is associated with burins and the larger percentage of the microliths in the cave. Cluster 2, with its high proportion of scraping, is in association with a high proportion of typological scrapers in the back section of the gallery. Thus, activity area differentiation is indicated by microwear evidence. Still, to identify the actual activities carried out in specific areas, we must combine all of the above with an assessment of the materials worked during the Magdalenian occupation.

When functional data associated with the contact material are examined in space (Figure 30), fairly strong distributional patterns emerge. Cluster 1 is dominated by the processing of bone and antler, while Cluster 2 is dominated by hide and meat processing.

In sum, functional analyses of the Magdalenian assemblage indicates that a limited number of activities took place at the Grotte XVI. However, to investigate activity areas the motions must be combined with the contact material. When this is done there appears to be two functionally distinct activity areas (Figure 31). Cluster 1, in the front portion of the gallery associated with a hearth, is dominated by the graving and scraping of antler

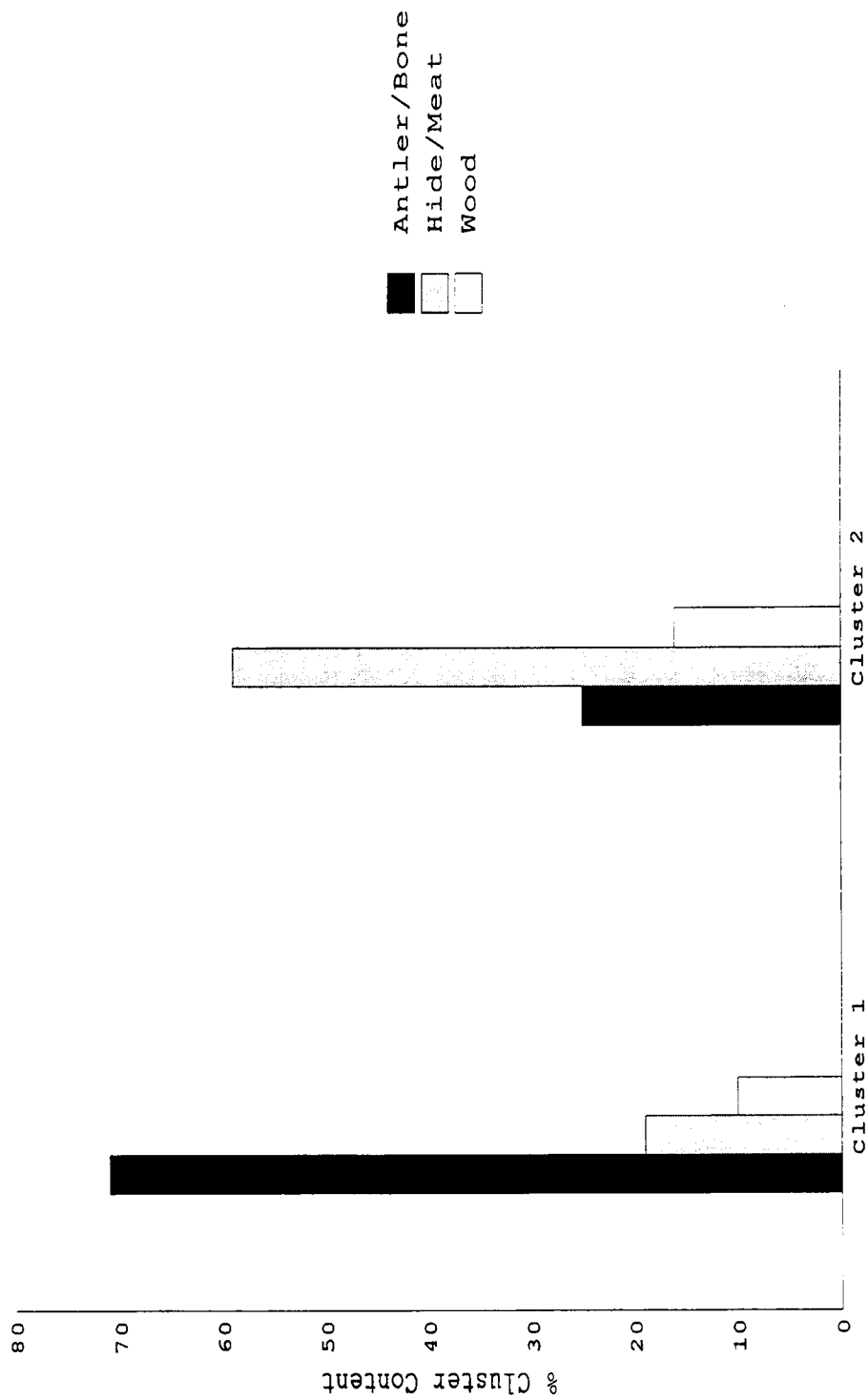


Figure 30. Comparison Of Material Worked Between Cluster 1 And Cluster 2

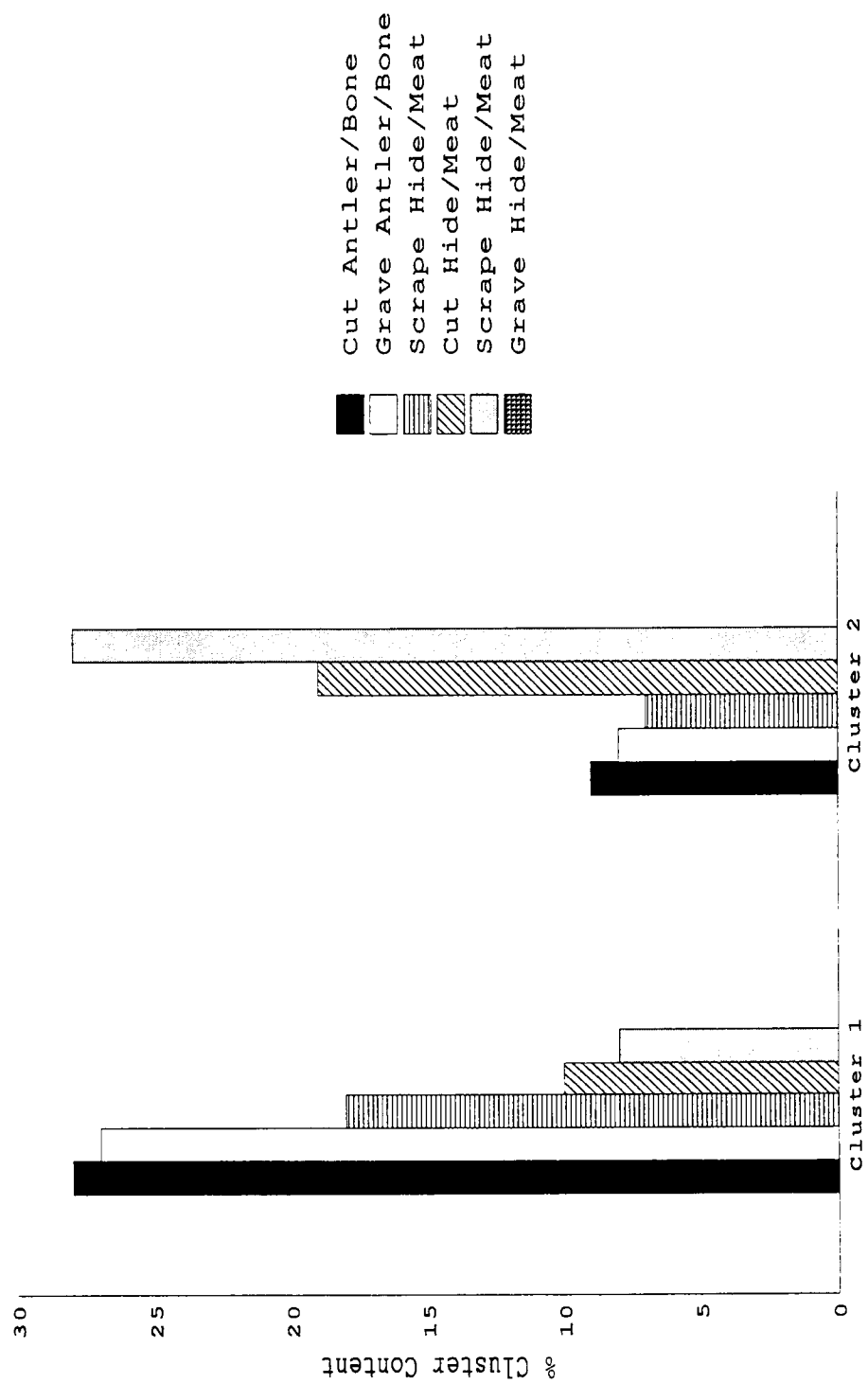


Figure 31. Comparison Of Activities Between Cluster 1 And Cluster 2

and bone. The front of the gallery is also the area that has the highest proportion of microliths. This combination is indicative of the manufacture and repair of bone and antler hafts and composite projectile points. Cluster 2, in the back portion of the gallery is dominated by cutting and scraping hide and meat. These activities are associated with the early stages in the processing of hides. Thus, functional assessments in combination with tool distributions in the two spatial clusters at Grotte XVI, support the interpretation that the Magdalenian occupation of the site was both short and activity specific.

5. Models

In Chapter II, several theoretical models were developed to be tested with the Grotte XVI functional data. These models outlined hunter-gatherer systematics as defined through ethnographic observations. The models investigated a number of aspects pertaining to collector/forager land use patterns, spatial allocation at sites, and elements of planning. These models also postulate how function might interact with stages in the *chaine operateire* of the tool.

The last section of this chapter focuses on how the functional data collected through microwear analysis at Grotte XVI fit with those theoretical models.

The first model investigated the types of sites that would be present under the parameters defined for forager and collector systems. This not only looks at types of sites but also at their placement on the landscape and their relation to a general base camp.

It was stated earlier that forager systems would be represented in the archaeological record by only one type of site, a base camp. This base camp would be defined through a very generalized tool assemblage for the maintenance of domestic activities. If there are peripheral activity areas they would have a very slight archaeological signature due to the fact that they represent activities that are not repeated. At the base camp, microwear evidence should point to general, not specialized activities.

A base camp in a collector system would look exactly like that of a forager system. However, the key to identifying a collector system is the presence of sites other than base camps. These sites include, but are not limited to, processing sites, lithic production sites, and

specialized temporary hunting camps. All of these sites are specialized task oriented camps located at a distance from the main base camp. Though they are temporary in nature, they are places that are revisited, and with activities being repeated they produce a strong signature in the archaeological record. The lithic assemblage at these sites would be specialized with tools oriented to the task at hand. Consequently, usewear analyses should reflect these specialized tasks rather than general domestic tasks.

At Grotte XVI, specialized tools, scrapers and burins, produced elsewhere, as indicated by technological studies, were brought into the site for a specialized task. In addition, this specialized task was probably repeated given the strength of the signature of the archaeological record. This, in and of itself, is contrary to what is outlined for a base camp. Microwear traces, as discussed above, indicate that rather than a homogenized general distribution of domestic activities, the site is dominated by two very specialized activities. The primary activity was working antler/bone and the secondary activity involves the early stages in processing hides as demonstrated by use traces indicative of hide/meat.

The hypothesis has been proposed that these Magdalenian hunters and gatherers were utilizing a collector land use strategy. If Grotte XVI was a specialized task camp within that system, it is necessary to investigate whether or not the data from Grotte XVI conforms within a spatial dimension to this collector pattern.

At a forager base camp the artifacts are in a redeposited context. Though functional interpretations may still be made about the site, these interpretations will be homogenized at that central refuse area. Therefore, activity areas will not be able to be defined. The only pieces potentially not in a redeposited context are hafted elements. However, these implements are deposited where they were rehafted, not where they were used.

In a specialized collector camp, because of the short term nature of the site, there is a higher likelihood that the tools were deposited in or near the place where they were used rather than being redeposited in a refuse area. For this reason site function is not homogenized. Site function can not only be determined but activity areas may also be defined.

At Grotte XVI there is a solid two cluster solution

defined through K-means analysis. Not only are there two clusters of artifacts at the site but, when their content is analyzed in regards to typology, the two clusters are distinguishable. One cluster is dominated by scrapers in the back portion of the gallery and the front portion of the gallery is dominated by burins. This front area is also where the hafted pieces, in this case microliths, were deposited. An archaeologist is always at risk when trying to interpret activity areas because there is always some element of the "Pompeii Premise" involved. When interpretations are made of the activities that took place at Grotte XVI it is not assumed that everything is perfectly *in situ*. However, Grotte XVI is unique in its spatial constraints. The way the gallery is oriented and the small size of the area involved limits the "toss zone". So, even if artifacts were tossed, they could not be tossed far from where they were used.

When these data are combined with microwear analysis a very clear picture of the activity areas at the site emerges. In the back portion of the gallery the Magdalenian hunters were preparing fresh hides. This is supported by use traces of hide polish on scrapers and cutting edges. In

the front portion of the gallery they were working antler and bone. In combination with the location of the microliths a very strong argument can be made that this is an area assigned for the retooling of composite tools.

This then brings us to a consideration of planning and intention. As stated earlier, in a forager system there is little planning involved. Therefore, there should be no correlation between function and typology, technology, and raw material. There should also be no correlation between site size and "anticipated" length of stay at the site.

A collector system on the other hand requires a great deal of planning and should be reflected in the choice of tools, technology, and raw material. All of this should have a strong correlation with function given that there is foresight and intention as the group sets off from the base camp on a specialized task. There should also be a correlation between site size and the "anticipated" short term stay at the site. Following Kent's (1991) model, a short term site should be no more than 33 square meters per person.

Given that the gallery at Grotte XVI is no more than 30 square meters, following Kent's (1991) model, it could not

have been anything but a short term camp. When relationships that might indicate planning are investigated, there are correlations between raw material and tool type that indicate that scrapers of exotic raw material are being brought into the site. It might be interpreted that they were "intended" for the hide processing task that would be foreseen on a hunting expedition. The relationships between local materials and microliths would indicate that they were making use of the available raw materials for retooling composite projectiles. A correlation between all types and Phase 2 technological products indicates that tools were being produced on blades elsewhere and brought into the site. Unfortunately, there is no strong correlation between raw material and function or technology and function. Though there is a correlation between typology and function, it tells us no more than the fact that scrapers were used to scrape and burins were used to engrave.

The *chaine operateire* approach to lithic artifact analysis is a framework that positions a tool in its place in the operational sequence. It investigates the life history of the tool. Here the sequence from raw material procurement, to production, to use, to discard, is not

viewed as linear but rather as a series of loops where one decision may effect one or more of the other phases. If this is the case then there should be strong correlations between function and each of the phases in the *chaîne opératoire*. For example, with raw materials there are local and non local materials present at Grotte XVI. If there were logistical planning involved, as would be suggested by a collector model, then functions related to the pre-planned tasks should be correlated with specialized tools made of exotic materials curated and brought to the site for a specific purpose. If the intended use of Grotte XVI in a logistically organized collector pattern was as a temporary camp for the processing of fresh hides acquired on a hunt and the retooling of composite projectiles, then tools associated with those tasks should be formal curated tools brought into the site and used for that purpose. This is the case at Grotte XVI. While the assemblage is dominated by local raw materials, the fact remains that most of the tools were not made at the site but rather brought in. To further support this there are several burins and scrapers of exotic materials used at the site. It could be said that these scrapers and burins were brought into the site for the

specific purpose of scraping hides and retooling bone and antler hafts. Microwear evidence directly supports this interpretation.

On the other hand, wear as the result of unplanned or expedient tasks should be associated with expedient tools made from local materials. Microwear evidence supports this in that debitage is most often used for the expedient tasks involved in the gross early stages in hide processing and antler/bone work. Tasks that would exhaust a tool quickly are conducted with waste flakes, while formally prepared tools are reserved for detailing and precision work.

If there is a relationship between the decision making process involved in the selection of particular tool types, or technological phases, and function, then usewear should reflect a strong correlation with specialized tasks. This is supported in particular by the use of formal tools, burins and scrapers in multiple tasks. More often than any other tool, burins and scrapers have multiple uses that also involved cutting.

The last stage in the use life of the stone tool is its final discard and incorporation into the archaeological record. This could present the strongest correlation yet.

If the position of the stone tool within the site has an operational feedback with function, then activity areas will be present at the site and these activity areas will be separated in location at the site. Grotte XVI is a prime example of this. Even under very tight spatial constraints, two distinct areas of the gallery are defined, and they are associated with specific activities. All evidence at Grotte XVI supports the interpretation of the site as a specialized, task oriented camp. This camp was a part of a larger logistically organized collector system. While Grotte XVI is one stage in a larger *chaîne opératoire* of a hunter-gatherer strategy, there is also evidence for relationships between the various stages in the life history of the stone tools within the site itself.

6. Comparison to Other Magdalenian Sites

The Magdalenian peoples from Grotte XVI did not operate in a void. As indicated earlier, they were a small part of a much larger collector system operating on the landscape. For this reason it is necessary to compare Grotte XVI to other Magdalenian sites. Unfortunately, there are not very

many sites where microwear analyses have been used to investigate site function. These few sites were discussed in detail in Chapter II. Here however, I would like to briefly compare Grotte XVI to those sites in terms of site structure and function.

Pincevent, Verberie, Rascano, El Juyo and Cassagros are the five Magdalenian sites where the most work has been conducted using microwear methods. While all five sites have similarities with each other and Grotte XVI, there are marked differences as well. Like Grotte XVI, Pincevent, Verberie, Rascano and Cassagros are all interpreted as short term specialized camps. El Juyo, on the other hand, is interpreted as a base camp.

El Juyo, like Grotte XVI, is a cave site. The highest proportion of the tool use is ascribed to cutting and scraping. If only the total counts are taken into consideration, this would be the same case at Grotte XVI. However, because the area could be subdivided into Cluster 1 and Cluster 2, the proportions are different thus altering the interpretation as it is ascribed to each cluster. Once the areas are divided at Grotte XVI, cutting and scraping dominate one area and graving dominates the other. When

contact materials are considered, the people at El Juyo were processing a higher proportion of dry hides, later stages in hide production, and at Grotte XVI they were processing fresh hides. It also appears that the activities at El Juyo are homogenized where activity areas are defined at Grotte XVI.

Cassagros, also a cave site, is a specialized camp. It has a different functional interpretation than does Grotte XVI. Though there is evidence of bone and antler working at Cassagros, the dominant activity at the site was the processing of fresh and dry hides. Given the low proportion of microliths at the site, the bone and antler polish is interpreted as evidence for the production of hide working tools rather than for the retooling of composite projectiles like at Grotte XVI.

Rascano is another Magdalenian cave site interpreted as a specialized camp. At Rascano graving accounts for 45% of the motions and antler/bone working accounts for 39% of the contact material. A smaller percentage of the tools showed evidence of cutting, but I would say that this is due to sampling more than anything else. The sample from Rascano only included retouched tools. Therefore, cutting would be

under represented due to the fact that unretouched tools and debitage were not included in the sample. Even so, because of the presence of fresh hide-working polish on scrapers and antler/bone polish on burins, the camp has the same interpretation as that of Grotte XVI, a short term hunting camp used to process fresh hides and retool composite tools.

Verberie, unlike the other sites discussed, is an open air site. Verberie looks similar to Rascano in terms of the ratio of graving to cutting and scraping, and bone and antler working to hide working. At Verberie the activities associated with the retooling of composite projectiles dominates the assemblage. While both activities took place at Grotte XVI as well, there was a more equal division between hide working and antler/bone working.

Of all the sites described Pincevent is the most similar to Grotte XVI both functionally and spatially. While Pincevent is an open air site, the tools were in a very good state of preservation. Work by Moss (1983a, 1986a, 1987a) focused on two of the hearth features. From her microwear analyses her interpretations of the site fit perfectly with the interpretations made for Grotte XVI. One of the hearths had a high proportion of tools used to scrape

hides. The other hearth had a high proportion of antler and bone working tools and their interpreted activity was the retooling of composite tools. In addition, as at Grotte XVI, the microliths showed little to no evidence of use. When they did have microwear traces the traces, were associated with projectile impact, contact with hide/meat and hafting.

The Magdalenian was a period of change. Assemblage systematics are complex but patterns are emerging. Microwear evidence is providing the data for the interpretation of site function. In combination with other studies that are being conducted on Magdalenian assemblages, a clearer picture of Magdalenian hunter-gatherer land use systems is emerging.

VI. CONCLUSIONS

It was my intention in this dissertation to apply the methods developed for microwear analysis to a lithic assemblage in order to investigate site function. This lithic assemblage came from the Grotte XVI, a cave site in Dordogne, France with stratified deposits dating from the Magdalenian back through the Mousterian. Initially, it was necessary to determine whether materials from the Grotte XVI were appropriate for microwear analysis. If indeed they were in a condition that would merit the attentions of microwear analyses, then the appropriate methods needed to be chosen.

I chose to explore the Magdalenian deposits from the Grotte XVI for several analytical and logistical reasons. For logistical reasons the Magdalenian assemblage was chosen because the deposits had been excavated in their entirety. This allowed for the maximum analytical coverage in both microwear analyses and spatial analyses. In addition, the assemblage had been the focus of research for fifteen years at the cave, and for that reason, faunal, typological, raw material, and technological studies had been completed.

This permitted the investigation of the correlations between function and these additional aspects of the assemblage.

It had also been determined through geological studies that the deposits from the Magdalenian were undisturbed and intact. This, combined with the fact that for the most part the lithics were not suffering from patination, were deciding factors in choosing the Magdalenian assemblage for microwear analysis. Once this had been decided, the method of analysis had to be chosen. Given that the lithic collection was in virtually pristine condition, the methods developed for high power microwear analysis were applied.

Prior to the application of the methods an experimental program was developed to aid in the interpretation of the use traces. Through analogy, using experimentally produced and used tools, functional interpretations were made concerning the Magdalenian occupation of the cave. Ultimately, interpretation were not based solely on the results of the microwear analyses. They were integrated with previous analyses of the lithic and faunal materials and with spatial analyses. All of this allowed for synthetic explanation of site systematics.

Through my work at Grotte XVI a pattern not dissimilar

to the one at Pincevent is made evident. Given the large proportion of burins with evidence of polish from graving and scraping antler/bone, along with the number of microliths and scrapers used on fresh hide, a picture of a temporary camp with the very specialized activity of retooling composite tools has emerged. There are bone harpoons and engraved bone from Grotte XVI; however, I believe that the bulk of the bone working at Grotte XVI went into the retooling of the haft element for the microliths. These hafts would not be found in abundance rehafting sites because they would have been taken away from the site as a curated implement, and the only real evidence for their existence is the discarded microliths, as well as the bone/antler usewear on the edges of the stone tools.

In addition to the evidence from microwear analysis, there is also evidence of activity areas at the site, even under restricted spatial parameters in a very small area. The evidence from this dissertation research paints a picture of a logistically organized, temporary hunting camp.

Areas for further research should involve a number of investigations. This dissertation has produced interesting results that have allowed for interpretations that

contribute to the broader literature on hunter gatherer systematics and more specifically those in the Magdalenian. However, as it stands, it is a very synchronic approach. To expand our knowledge of site systematics at the Grotte XVI, a more diachronic approach should be the focus of further investigations. Functional analyses should be undertaken for the materials from the other cultural periods represented in the cave.

All materials at the site from each chronological period are recorded with three dimensional provenience. It would be interesting not only to compare site function through time at the Grotte XVI, but also use of space. While the Magdalenian is isolated in the back portion of the cave, the other cultural occupations are located in the front portion of the cave. Also interesting, would be an investigation into the functional systematics at Grotte Vaufrey, a neighboring site in the Le Conte cliffs.

Given the precision at which the excavations in Grotte XVI and Grotte Vaufrey took place, functional studies integrated with typological, technological, raw material studies and spatial analyses would greatly expand our knowledge of the Paleolithic. Studies such as these will

strengthen and broaden our understanding of site
systematics, land use patterns and subsistence strategies
throughout the Paleolithic.

BIBLIOGRAPHY

BIBLIOGRAPHY

Akoshima, K.

- 1993 Microwear Patterns and Distributional Variabilities in Terminal Paleolithic Site Structure (Abri Dufaure Site, France, Montana, Mill Iron Site) Ph.D. Dissertation, University of New Mexico.

Anderson, H. and H. Whitlow

- 1983 Wear Traces and Patination on Danish Flint Artifacts. Nuclear Instruments and Methods in Physics Research 218:468-474.

Anderson, P.

- 1979 A Microwear Analysis of Selected Flint Artifacts from the Mousterian of Southern France. Lithic Technology 9:32.
1980 A Testimony of Prehistoric Tasks: Diagnostic Residues on Stone Tool Working Edges. World Archaeology 12:81-94.
1986 A Few Comments Concerning Residue Analysis of Stone Plant Processing Tools. In Technical Aspects of Microwear Studies on Stone Tools. Early Man News, 9/10/11, edited by L. Owen and G. Unrath, pp. 69-81. Tubingen.
1990 Aspects of Behavior in the Middle Paleolithic: Functional Analysis of Stone Tools from Southwest France. In The Emergence of Modern Humans, edited by P. Mellars, pp. 389-418. Edinburgh University Press, Edinburgh.

Audouze, F.

- 1987 The Paris Basin in Magdalenian Times. In The Pleistocene Old World: Regional Perspectives, edited by O. Soffer, pp. 183-200. Plenum Press, New York.

Audouze, F. and J. Enloe

- 1991 Subsistence Strategies and Economy in the Magdalenian of the Paris Basin, France. In Late Glacial in North-West Europe: Human Adaptation and Environmental Change at the End of the Pleistocene, pp. 63-71. Council for British Archaeology, London.

Bahn, P.

- 1977 Seasonal Migration in South-west France During the Late Glacial Period. Journal of Archaeological Science 4:245-257.
- 1978 The "Unacceptable Face" of the West European Upper Paleolithic. Antiquity 2:183-192.
- 1982 Inter-Site and Inter-Regional Links During the Upper Paleolithic: the Pyrenean Evidence. Oxford Journal of Archaeology 1:247-268.
- 1983 New Finds at Pincivent. Nature 304:682-683.

Bamforth, D.B.

- 1988 Investigating Microwear Polishes with Blind Tests: The Institute Results in Context. Journal of Archaeological Science 15:11-23.

Bamforth, D.B., G. Burns, and C. Woodman

- 1990 Ambiguous Use Traces and Blind Test Results: New Data. Journal of Archaeological Science 17:413-430.

Bar-Yosef, O., B. Vandermeersch, B. Arensburg, A. Beifer-Cohen, P. Goldberg, H. Laville, L. Meignen, Y. Rak, J. Speth, E. Tchernov, A. Tillier, and S. Weiner

- 1992 The Excavations in Kebara Cave, Mt. Carmel. Current Anthropology 33:497-550.

Beyries, S.

- 1989 Analyse Traceologique du Materiel Lithique de Couche VIII de la Grotte Vaufrey. In La Grotte Vaufrey: Paleoenvironnement-Chronologie-Activites Humaines, edited by J.-Ph. Rigaud, pp. 519-528. Ministere de la Culture et de la Communication, Bordeaux.

Binford, L.

- 1978 Nunamiut Ethnoarchaeology. Orlando, Florida: Academic Press.
- 1980 Willow Smoke and Dogs Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Information. American Antiquity 45:4-20.

Bordes, F.

- 1979 Typologie du Paleolithique Ancien et Moyen.
Institut de Prehistoire, Bordeaux.

Breuil, H.

- 1912 Les Subdivisions du Paleolithique Superior et Leur
Signification. Comptes Rendus du 14 Congres
International d'Anthropologie et d'Archeologie
Prehistoriques, Geneve, 165-238.

Burke, A.

- 1992 Prey Movement and Settlement Patterns During the
Upper Paleolithic in Southwestern France (Cementum
Analysis). PhD. dissertation, New York University.

Cahen, D. and L. Keeley

- 1980 Not Less Than Two, Not More Than Three. World
Archaeology 12:166-180.

Cahen, D., C. Karlin, L. Keeley, and F. Van Noten

- 1979 Methodes d'Analyses Technique, Spatiale et
Fonctionnelle d'Ensemble Lithiques. Helinium 20:209-
259.

Camps-Fabrer, H.

- 1974 L'Industrie de l'Os dans la Prehistoire.
University of Provence, CNRS.

Campbell, J.M.

- 1968 Territoriality Among Ancient Hunters:
Interpretations from Ethnography and Nature. In
Anthropological Archaeology in the Americas. edited
by B.J. Meggars, Anthropological Society of
Washington, Washington.

Capitan, L. and D. Peyrony

- 1928 La Madeleine. Son Gisement, Son Industrie, Ses
Oeuvres d'Art. Publications de l'Institut
International d'Anthropologie 2, Paris.

Chadelle, J.P.

- 1983 Technologie et Utilisation du Silex au Perigordien Superieur: l'Exemple de la Couche VII du Flageolet I, Memoire en Vue de l'Obtention du Diplome de l'Ecole des Hautes Etudes en Sciences Sociales.

Cheyrier, A.

- 1949 Badegoule, Station Solutreenne et Proto-Magdalénienne. Archives de l'Institut de Paleontologie Humaine, 23.

Clarke, D.L.

- 1968 Analytical Archaeology. London: Methuen.

Clottes, J.

- 1987 Le Magdalénien des Pyrenees. In Le Magdalénien en Europe: La Structuration du Magdalénien, edited by J.Ph. Rigaud, pp. 281-360. Etudes et Recherches Archeologiques de l'Universite de Liege no 38.
1990 The Parietal Art of the Late Magdalénian. Antiquity 64:527-548.
1993 Paint Analysis from Several Magdalénian Caves in the Ariège Region of France. Journal of Archaeological Science 20:223-235.

Conkey, M.W.

- 1978 Style and Information in Cultural Evolution: Toward a Predictive Model for the Paleolithic. In Social Archaeology, edited by C.L. Redman et al., pp. 61-85. Academic Press, New York.
1980 The Identification of Prehistoric Hunter-Gatherer Aggregation Sites: The Case of Altamira. Current Anthropology 21:609-630.
1987 New Approaches in the Search for Meaning? A Review of the Research in Paleolithic Art. Journal of Field Archaeology 14:413-430.
1989 Structural Analysis of Paleolithic Art. Archaeological Thought in America, pp. 135-154. Cambridge University Press, England.
1991 Contexts of Action, Contexts for Power: Material Culture and Gender in the Magdalénian. In Engendering Archaeology: Women and Prehistory, pp. 57-92. Oxford, England.

- Cotterell, B., and I. Kamminga
1979 The Mechanics of Flaking. In Lithic Use-Wear Analysis, edited by B. Hayden, pp. 100-112. Academic Press, New York.
- Curwen, E.C.
1935 Agriculture and the Flint Sickle in Palestine. Antiquity 9:62-66.
- Del Bene, T.
1979 Once Upon a Striation: Current Models of Striation and Polish Formation. In Lithic Use-Wear Analysis, edited by B. Hayden, pp. 167-177. Academic Press, New York.
- Delpech, F.
1987 L'environnement Animal des Magdaleniens. In Le Magdalénien en Europe: La Structuration du Magdalénien, edited by J.Ph. Rigaud, pp. 5-30. Etudes et Recherches Archeologiques de l'Universite de Liege no 38.
- Diamond, G.
1979 The Nature of So-Called Polished Surfaces on Stone Artifacts. In Lithic Use-Wear Analysis, edited by B. Hayden, pp. 159-166. Academic Press, New York.
- Flenniken, J.J., and J.C. Haggarty
1979 Trampling as an Agency in the Formation of Edge Damage: An Experiment in Lithic Technology. Northwest Anthropological Research Notes 13:208-214.
- Frison, G.
1968 A Functional Analysis of Certain Chipped Stone Tools. American Antiquity 33:149-155.
- Fullagar, R.L.
1991 The Role of Silica in Polish Formation. Journal of Archaeological Science 18:1-24.

Gambel, C.S.

1983 Culture and Society in the Upper Paleolithic of Europe. In Hunter-Gatherer Economy in Prehistoric Europe, edited by G.N. Bailey, pp. 201-211. Cambridge University Press, Cambridge.

Gargett, R. And B. Hayden

1991 Site Structure, Kinship, and Sharing in Aboriginal Australia: Implications for Archaeology. In The Interpretation of Archaeological Spatial Patterning, edited by E. Kroll and D. Price, pp. 11-32. New York: Plenum Press.

Geneste, J.M.

1985 Analyse Lithique d'Industries Mousteriennes du Perigord: une Approche Technologique du Comportement des Groupes Humains au Paleolithique Moyen. These de Doctorat Bordeaux I.

Gero, J.

1978 A Summary of Experiments to Duplicate Post Excavational Damage to Tool Edges. Lithic Technology 17:112-120.

Grace, R.

1996 Use-Wear Analysis: The State of the Art. Archaeometry 38:209-229.

Inizan, M., H. Roche, and J. Tixier

1992 Technology of Knapped Stone. CREP, Meudon.

Hemingway, M.F.

1980 The Initial Magdalenian in France. BAR International Series 90, Oxford.

Jochim, M.A.

1976 Hunter-Gatherer Settlement and Subsistence. Academic Press, New York.

1983 Paleolithic Cave Art in Ecological Perspective. In Hunter-Gatherer Economy in Prehistory, edited by G.N. Bailey, pp. 212-219. Cambridge University Press, Cambridge.

Juel Jensen, H.

- 1988 Functional Analysis of Prehistoric Flint Tools by High Power Microscopy: A Review of West European Research. Journal of World Prehistory 2:53-88.

Julien, M.

- 1987 Activites Saisonnierees et Deplacements des Magdaleniens dans le Bassin Parisien. In Le Magdalenien en Europe: La Structuration du Magdalenien, edited by J.Ph. Rigaud, pp. 177-192. Etudes et Recherches Archeologiques de l'Universite de Liege no 38.

Keeley, L.H.

- 1974 Technique and Methodology in Microwear Studies: A Critical Review. World Archaeology 5:323.
1980 Experimental Determination of Stone Tool Use: A Microwear Analysis. University of Chicago Press, Chicago.
1982 Rehafting and Retooling: Effects on the Archaeological Record. American Antiquity 47:798-809.
1988 Lithic Economy, Style and Use: A Comparison of Three Late Magdalenian Sites. Lithic Technology 17:19-25.
1991 Tool Use and Spatial Patterning: Complications and Solutions. In The Interpretation of Archaeological Spatial Patterning, edited by E. Kroll and D. Price, pp. 257-268. New York: Plenum Press.

Keeley, L.H., and M. Newcomer

- 1977 Microwear analysis of Experimental Flint Tools: A Test Case. Journal of Archaeological Science 4:29-62.

Keller, D.

- 1979 Identifying Edge Damage on Surface Occurring Lithic Artifacts: Some Comments. Lithic Technology 8:15-17.

Kent, S.

- 1991 The Relationship Between Mobility Strategies and Site Structure. In The Interpretation of Archaeological Spatial Patterning, edited by E. Kroll and D. Price, pp. 33-60. New York: Plenum Press.

Kintigh, K.

- 1990 Intrasite Spatial Analysis: A Commentary on Major Methods. In Mathematics and Information Science in Archaeology: A Flexible Framework, edited by A. Voorrips. Studies in Modern Archaeology 3:165-200, Holos, Bonn.

Kintigh, K. And A. Ammerman

- 1982 Heuristic Approaches to Spatial Analysis in Archaeology. American Antiquity 47:31-63.

Koetje, T.

- 1987 Spatial Patterns in Magdalenian Open Air Sites from the Isle Valley, Southwestern France. Oxford: British Archaeological Reports, International Series.

Kooyman, B.

- 1992 Verifying the Reliability of Blood Residue Analysis on Archaeological Tools. Journal of Archaeological Science 19:265-269.

Laville, H., J.-Ph. Rigaud, and J.R. Sackett

- 1980 Rock Shelters of the Perigord. Academic Press, New York.

Lawrence, R.

- 1977 Experimental Evidence for the Significance of Attributes Used in Edge-Damage Analysis. In Lithic Use-Wear Analysis, edited by B. Hayden, pp. 113-121. Academic Press, New York.

Lee, R.B. and I. DeVore

- 1976 Kalahari Hunter-Getherers. Harvard University Press, Cambridge, Mass.

Legall, O.

- 1992 Fish and Fishing During the Paleolithic.
Anthropologie 96:121-134.

Leroi-Gourhan, A.

- 1943 Evolution et Techniques I: L'Homme et la Matiere.
Paris, Albin Michel.
1968 The Art of Prehistoric Man in Western Europe.
Thames and Hudson, London.
1982 The Dawn of European Cave Art. Cambridge
University Press, Cambridge.

Leroi-Gourhan, A., and M. Brezillon

- 1966 L'Habitation Magdalénienne No. 1 de Pincevent
(Seine-et-Marne). Gallia Prehistoire 9:263-385.
1972 Fouilles de Pincevent: Essai d'Analyse
Ethnographique d'un Habitat Magdalénien. Gallia
Prehistoire, supplement 7.

Levi-Sala, I.

- 1986 Use Wear and Post-Depositional Surface
Modification: A Word of Caution. Journal of
Archaeological Science 13:229-244.
1989 What Can Microscopic Studies of Stone Artifacts
Really Tell Us. Anthropologie 93:643-658.

Mansur-Francomme, M.E.

- 1983 Scanning Electron Microscopy of Dry Hide Working
Tools: The Role of Abrasives and Humidity in Polish
Formation. Journal of Archaeological Science
10:223-230.

Marino, H.

- 1996 Un Exemple D'Economie du Silex au Magdalénien
Superieur, la Grotte XVI (Cenac-et-St. Julien), la
Phase d'Occupation Oa. Diplome d'Etudes
Approfondies d'Anthropologie Option Prehistoire.

Mithen, S.J.

- 1986 Reindeer and Risk: Simulating Reindeer
Exploitation During the Upper Paleolithic in the
Perigord. Archaeological Review from Cambridge
5:88-105.

1988 Looking and Learning: Upper Paleolithic Art and Information Gathering. World Archaeology 19:297-327.

Moss, E.H.

1983 The Functional Analysis of Flint Implements: Pincevent and Pont d'Ambon: Two Case Studies from the French Final Paleolithic. BAR International Series, 177, Oxford.

1986a Further Work on the Functions of Flint Tools at Pincevent (Seine-et-Marne), France: Sections 36 and 27. The Upper Paleolithic of Britain and Northwest Europe, edited by D.A. Roe, pp. 175-185. BAR International Series, 296, Oxford.

1987a Functional and Spatial Distribution of Flint Artifacts from Pincevent Section 36 Level IV 40. Oxford Journal of Archaeology 6:165-184.

1987b A Review of "Investigating Microwear Polishes with Blind Tests". Journal of Archaeological Science 14:473-481.

Moss, E.H., and M. Newcomer

1982 Reconstruction of Tool Use at Pincevent: Microwear and Experiments. Studia Praehistorica Belgica 2:289-312.

Newcomer, M., R. Grace, and R. Unger-Hamilton

1986 Investigating Microwear Polishes with Blind Tests. Journal of Archaeological Science 13:203-217.

O'Connell, J. K. Hawkes, and N. B. Jones

1991 Distribution of Refuse-Producing Activities at Hadza Residential Base Camps: Implications for the Analysis of Archaeological Site Structure. In The Interpretation of Archaeological Spatial Patterning, edited by E. Kroll and D. Price, pp. 61-76. New York: Plenum Press.

Odell, G.

1975 Micro-Wear in Perspective: A Sympathetic Response to Lawrence Keeley. World Archaeology 7:226-224.

- 1977 The Application of Micro-Wear Analysis to the Lithic Component of an Entire Prehistoric Settlement: Methods, Problems, and Functional Reconstructions. Ph.D. dissertation, Department of Anthropology, Harvard University, Cambridge, Massachusetts.
- 1981 The Mechanics of Use-Breakage of Stone Tools: Some Testable Hypotheses. Journal of Field Archaeology 8:197-209.
- 1985 Small Sites Archaeology and Use-Wear on Surface-Collected Artifacts. Midcontinental Journal of Archaeology 10:21-48.
- Odell, G. and F. Cowan
- 1986 Experiments with Spears and Arrows on Animal Targets. Journal of Field Archaeology 13:195-212.
- Odell, G., and F. Odell Vereecken
- 1980 Verifying Reliability of Lithic Use-Wear Assessments by "Blind Tests": The Low-Power Approach. Journal of Field Archaeology 7:87-120.
- Pfeiffer, J.E.
- 1982 The Creative Explosion. Harper and Row, New York.
- Pigeot, N.
- 1987 Magdaleniens d'Etoilles: Economie de Debitage et Organisation Sociale. XXV Supplement a Gallia Prehistoire. Paris: CNRS.
- 1990 Technical and Social Actors: Flintknapping Specialists and Apprentices at Magdalenian Etioilles. Archaeological Review from Cambridge 9:126-141.
- Pike Tay, A.
- 1990 Red Deer Hunting in the Upper Paleolithic of Southwest France: A Seasonality Study (Paleolithic). PhD. dissertation, New York University.
- Plisson, H.
- 1983 Application of Casting Techniques for Observation and Recording of Microwear. Lithic Technology 12:17-21.

- Plisson, H., and M. Mauger
1988 Chemical and Mechanical Alterations of Microwear
Polishes: An Experimental Approach. Helinium 28:3-
16.
- Plisson, H., and A. Vanglin
1989 Microwear Analysis- Directions for Use.
Anthropologie 93:631-642.
- Rigaud, J.P. and J. Simek
1990 The Last Pleniglacial in the South of France
(24,000-14,000 years ago). In The World at 18,000
B.P.: High Latitudes, edited by C.S. Gamble and O.
Soffer, pp. 69-88. Unwin Hyman, London.
- Rigaud, J.P., J. Simek, and T. Ge
1995 Mousterian Fires from Grotte XVI (Dordogne,
France). Antiquity 69:902-912.
- Rigaud, J.P., J. Simek, and M. Hays
in press The Magdalenian of Grotte XVI, (Dordogne,
France). in Late Pleistocene of Western Europe.
edited by H. Price and G. Peterkin.
- Rosenfeld, A.
1971 The Examination of Use Marks on Some Magdalenian
Endscrapers. The British Quarterly 35:176-182.
- Schmider, B.
1971 Les Industries Lithiques du Paleolithique
Superieur en Ile-de-France. VI Supplement a Gallia
Prehistoire. Paris CNRS.
1982 The Magdalenian Culture of the Paris River-Basin
and Its Relationship with the Nordic Cultures of the
Late Old Stone-Age. World Archaeology 14:259-269.
1987 Le Magdalenien dans le Centre du Bassin Parisien:
les Gisements, l'Industrie Lithique. In Le
Magdalenien en Europe: La Structuration du
Magdalenien, edited by J.Ph. Rigaud, pp. 219-238.
Etudes et Recherches Archeologiques de l'Universite
de Liege no 38.

- 1990 The Last Pleniglacial in the Paris Basin 22,500-17,000 B.P.. In The World at 18,000 B.P.:High Latitudes, edited by C.S. Gamble and O. Soffer, pp. 41-53. Unwin Hyman, London.
- Semenov, S.A.
1964 Prehistoric Technology. Adams and Dart, London.
- Shea, J.
1988 Spear Points from the Middle Paleolithic of the Levant. Journal of Field Archaeology 15:441-450.
1989 A Functional Study of the Lithic Industries Associated with Hominid Fossils in the Kebara and Qafzeh Caves, Israel. In The Human Revolution: Behavioral and Biological Perspectives on the Origins of Modern Humans, Vol.1, edited by P. Mellars and C. Stringer. Aldine, Chicago.
1990 A Further Note on Mousterian Spear Points. Journal of Field Archaeology 17:111-114.
- Simek, J.
1984 A k-Means Approach to the Analysis of Upper Paleolithic Habitation Sites: Le Flageolet I and Pincevent 36. British Archaeological Reports International Series, Oxford.
- Simek, J. And R. Larick
1983 The Recognition of Multiple Spatial Patterns: A Case Study from the French Paleolithic. Journal of Archaeological Science 10:165-180.
- Sieveking, A.
1976 Settlement Patterns of the Later Magdalenian in the Central Pyrenees. In Problems in Economic and Social Archaeology. edited by pp.583-603. Duckworth, London.
1988 Cave Art in Magdalenian Ariège-French-Vialou, D. Antiquaries Journal 68:338-339.
- de Sonnevile-Bordes, D.
1963 Upper Paleolithic Cultures of Western Europe. Science 143:347-355.

- 1973 The Upper Paleolithic: c. 33,000-10,000 BC. In France Before the Romans, edited by S. Piggott, G.E. Daniel and C. McBurney, pp. 30-60. Thames and Hudson, London.
- 1974 Les Listes-Types, Observations de Methode. Quaternaria XVIII, Rome, pp. 9-37.
- 1987 Chronostratigraphie du Magdalenien dans le Sud-Ouest de la France. In Le Magdalenien en Europe: La Structuration du Magdalenien, edited by J.Ph. Rigaud, pp. 477-479. Etudes et Recherches Archeologiques de l'Universite de Liege no 38.

Straus, L. G.

- 1986 Late Wurm Adaptive Systems in Cantabrian Spain: The Case of Eastern Asturias. Journal of Anthropological Archaeology 5:330-368.
- 1987a Paleolithic Cave Art of Vasco-Cantabria, Spain. Oxford Journal of Archaeology 6:149-163.
- 1987b Paradigm Lost: A Personal View of the Current State of Upper Paleolithic Research. Helinium 27:157-171.
- 1987c Upper Paleolithic Ibex Hunting in Southwest Europe. Journal of Archaeological Science 14:163-178.
- 1991 Human Geography of the Late Upper Paleolithic in Western Europe: Present State of the Question. Journal of Anthropological Research 47:259-278.

Symens, N.

- 1986 A Functional Analysis of Selected Stone Artifacts from the Magdalenian Site of Verberie, France. Journal of Field Archaeology 13:213-222.

Tringham, R.

- 1978 Experimentation, Ethnoarchaeology, and the Leapfrogs in Archaeological Methodology. In Explorations in Ethnoarchaeology, edited by R.A. Gould, pp. 169-200. Albuquerque: University of New Mexico Press.

- Tringham, R., G. Cooper, G. Odell, B. Voytek, and A. Whitman
 1974 Experimentation in the Formation of Edge Damage: A
 New Approach to Lithic Analysis. Journal of Field
 Archaeology 1:171-196.
- Unger-Hamilton, R.
 1984 The Formation of Usewear Polish on Flint: Beyond
 the Deposit versus Abrasion Controversy. Journal of
 Archaeological Science 11:91-98.
 1985 Microscopic Striations on Flint Sickle-Blades as
 an Indication of Plant Cultivation: Preliminary
 Results. World Archaeology 17:121-126.
 1989 Experimental Microwear Analysis: Some Current
 Controversies. Anthropologie 93:659-672.
- Van Noten, F., D. Cahen, and L. Keeley
 1980 A Paleolithic Campsite in Belgium. Scientific
 American 242:44-51.
- Vaughan, P.
 1981 Lithic Microwear Experimentation and the
 Functional Analysis of a Lower Magdalenian Stone
 Assemblage. Ph.D. dissertation. Department of
 Anthropology, University of Pennsylvania,
 Philadelphia (University Microfilms International.
 Ann Arbor, Mich.)
 1985 Use-Wear Analysis of Flaked Stone Tools.
 University of Arizona Press, Tucson.
- White, R.
 1987 Glimpses of Long-Term Shifts in Late Paaleolithic
 Land Use in the Perigord. In The Pleistocene Old
 World Regional Perspectives, edited by O.Soffer, pp.
 263-277. Plenum Press, New York.
 1989 Husbandry and Herd Control in the Upper
 Paleolithic: A Critical Review of the Evidence.
Current Anthropology 30:609-632.
- Yellen, J.E.
 1977 Archaeological Approaches to the Present: Models
 for Predicting the Past. Orlando, FL: Academic
 Press.

Zar, J.

1984 Biostatistical Analysis. Prentice Hall, Inc., New
Jersey.

APPENDIX

APPENDIX A

Results from Blind Tests N = 44

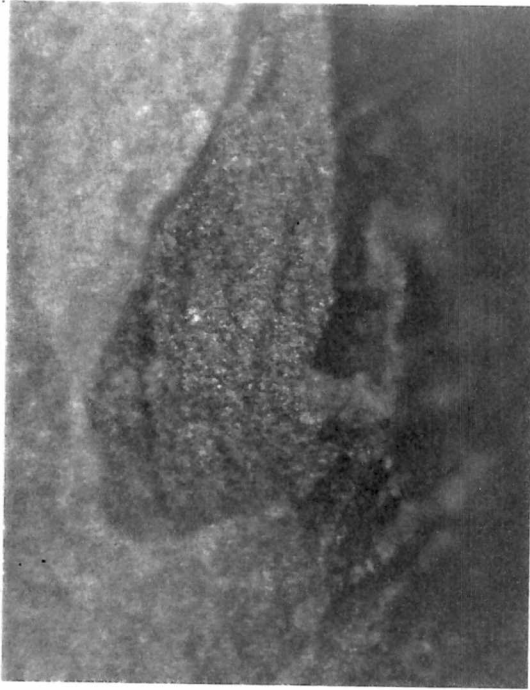
%Accuracy for Materials = 70% %Accuracy for Materials Combined Classes = 86%
 %Accuracy for Motions = 75%

Interpretation		Experiments				
	Antler	Bone	Hide	Meat	Wood	
Number	11	9	7	9	8	
Antler	9	2	0	0	0	
Bone	1	6	0	0	0	
A/B	10	8	0	0	0	
Hide	0	0	4	2	0	
Meat	0	0	2	4	0	
H/M	0	0	6	6	0	
Wood	1	1	0	0	7	
No use	0	0	1	3	1	
Correct	9	6	4	4	7	
Combine	10	8	6	6	7	

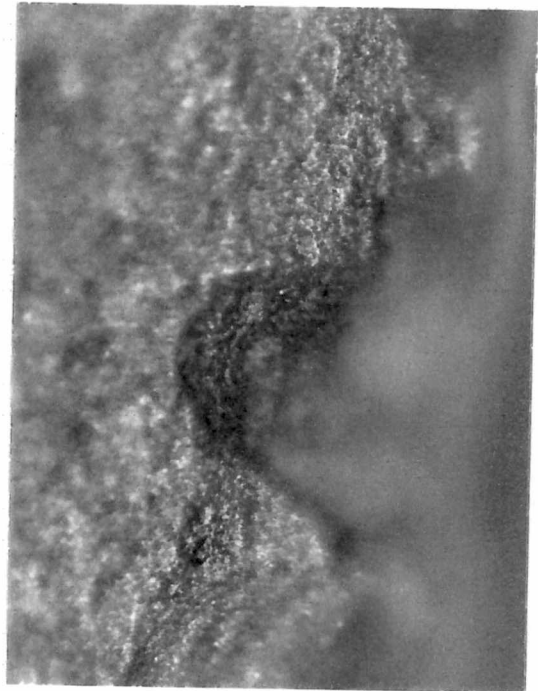
Interpretations		Experiments			
	Cut	Scrape	Grave	Bore	
Number	14	10	12	8	
Cut	11	4	0	0	
Scrape	1	6	0	0	
Grave	0	0	10	1	
Bore	0	0	1	6	
No use	2	0	1	1	
Correct	11	6	10	6	

APPENDIX B

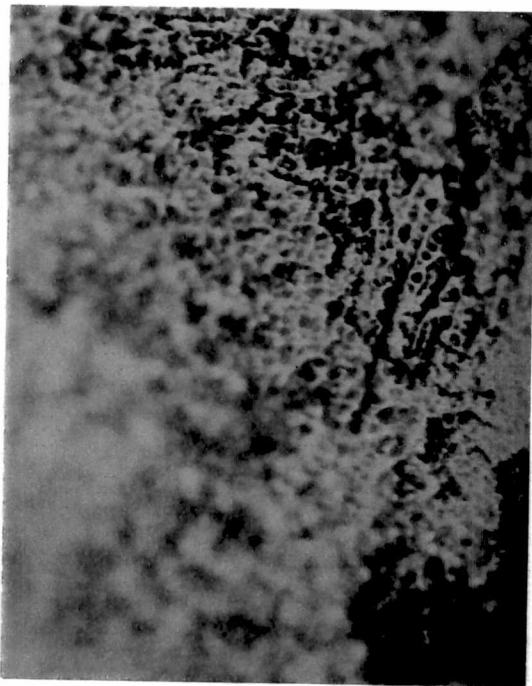
Hinge Scar



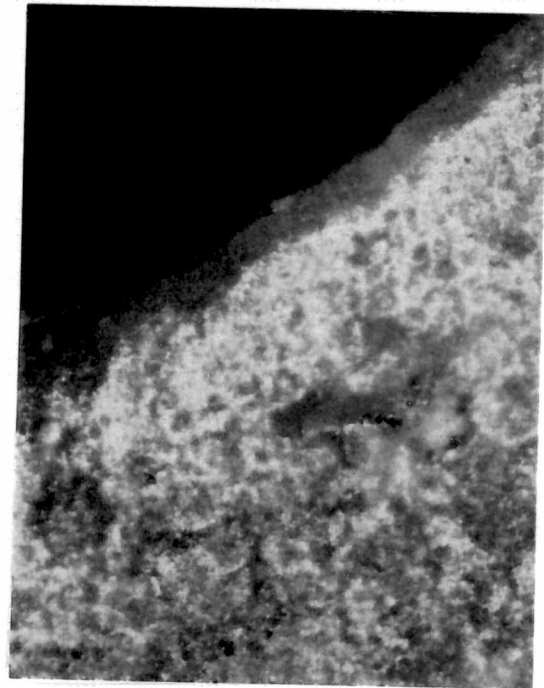
Scalar Scar



Striations



Edge Rounding



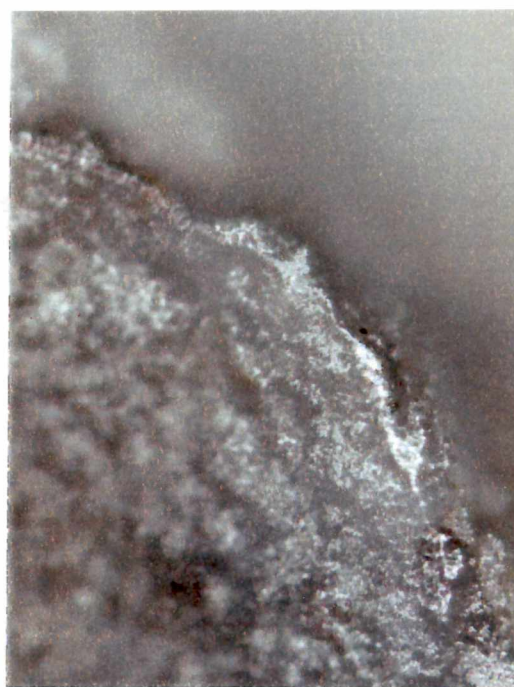
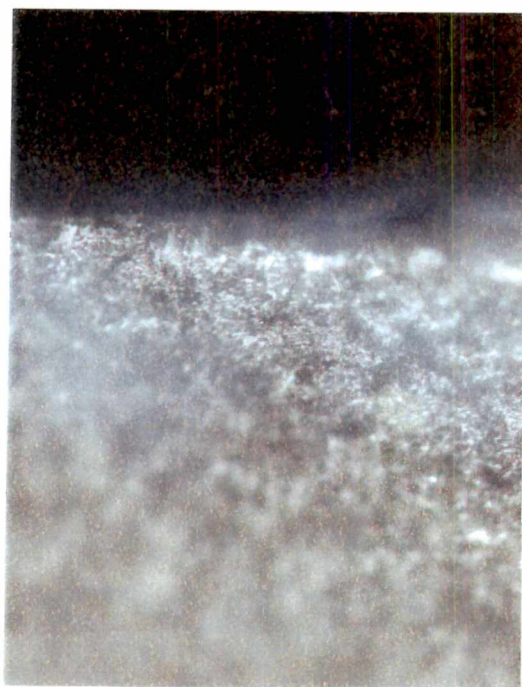
Photos Illustrating Edge Damage

All photomicrographs are taken at 100x magnification unless otherwise noted.

Experimental

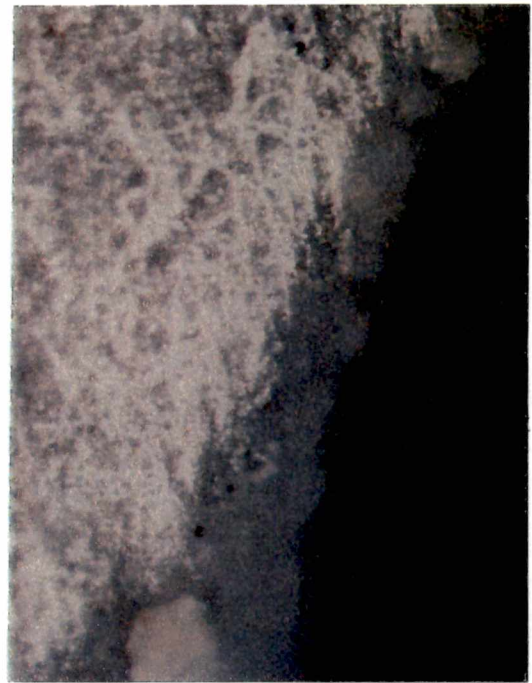
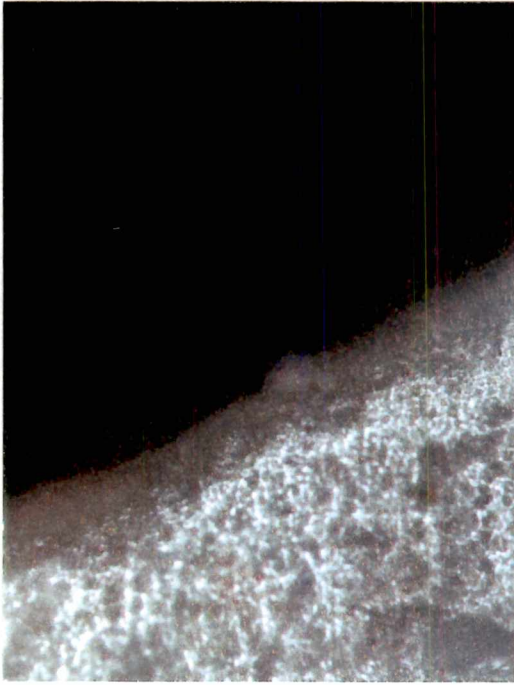


Archaeological

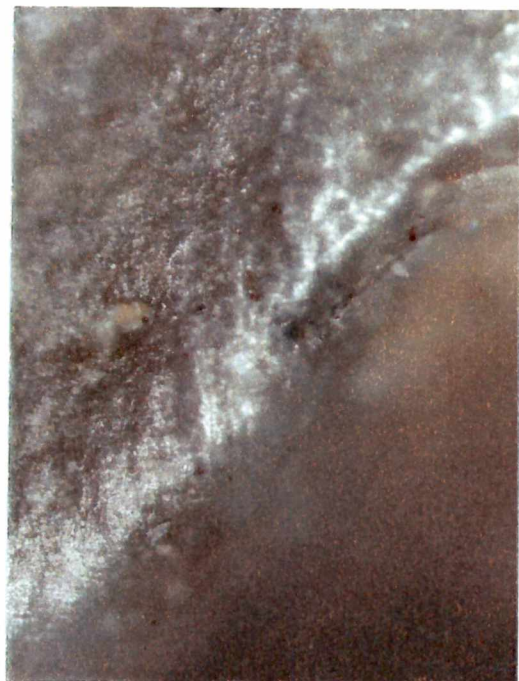
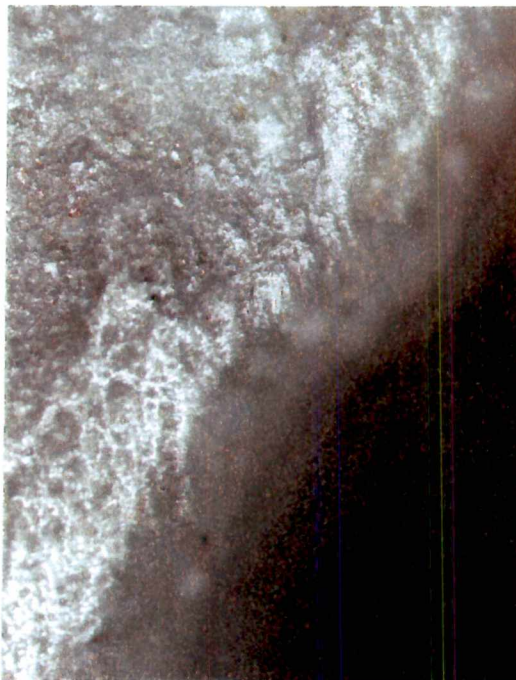


Photos Illustrating Antler/Bone Polish

Experimental



Archaeological

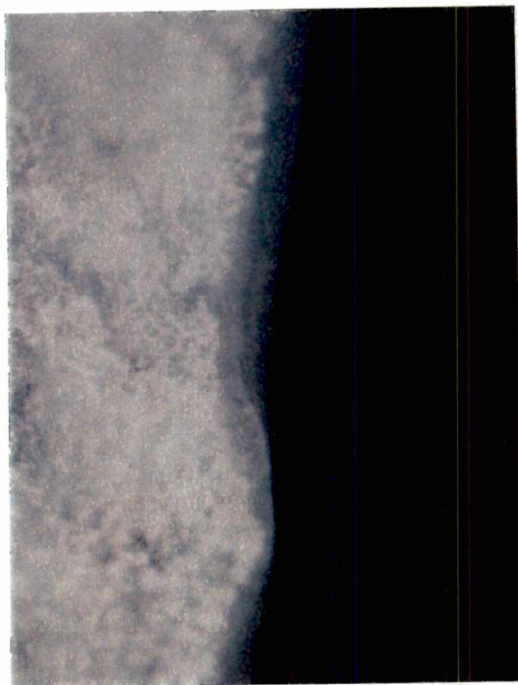


Photos Illustrating Hide/Meat Polish

Experimental



Archaeological



Photos Illustrating Wood Polish

APPENDIX C

Raw Data Counts

note: Totals do not match from table to table due to the fact that data is collected for different variables.
2170 pieces of debitage were not in the sample.

	Total	Excluded	Analyze	Unused	Used	Cut	Scrape	Grave	Bore	Bone/ Antler	Hide/ Meat	Wood
Burin	59	0	59	12	47	11	11	22	2	23	12	12
Composite	13	0	13	4	10	2	5	3	0	6	3	1
Debitage	3183	232	781	729	52	34	13	5	0	28	18	6
Microolith	480	277	203	160	43	1	0 haft 38	0	4	36	4	3
Notch	18	1	17	6	11	7	4	0	0	5	2	4
Piercer	6	0	6	2	4	0	2	0	0	0	3	1
Retouch	32	0	32	13	26	14	6	5	1	21	3	2
Scraper	36	16	23	8	15	0	12	0	0	3	10	2
Indeter.	99	27	72	25	47	28	11	8	0	26	16	3

Raw Data Counts

	Total	Excluded	Analyze	Unused	Used	Cut	Scrape	Grave	Bore	Bone/ Antler	Hide/ Meat	Wood
Phase 0	4	3	1	0	1	1	0	0	0	0	1	0
Phase 1	356	42	169	148	21	13	6	2	0	11	6	2
Phase 2	1550	227	718	545	172	82	52	31	7	114	58	26
Phase 3	120	6	31	29	2	2	0	0	0	0	1	1
Indeter.	1896	17	436	240	196	98	58	33	7	125	66	29

Raw Data Counts

	Total	Excluded	Analyze	Unused	Used	Cut	Scrape	Grave	Bore	Bone/ Antler	Hide/ Meat	Wood
Local	1991	292	899	735	164	83	47	30	4	106	54	22
Exotic	100	4	48	39	9	3	2	3	0	6	2	1
Indertter.	1835	369	164	120	44	21	14	6	3	37	15	8

VITA

Maureen A. Hays was born in Oak Park, Illinois on June 2, 1966. She graduated from Oak Park and River Forest High School in 1984. The following August she matriculated at Vassar College in Poughkeepsie, New York. In May of 1988 she graduated with the degree of Bachelor of Arts in Anthropology.

Maureen entered the Graduate School of the University of Tennessee in 1988 and beginning in 1990 her graduate studies have been funded by the Department of Anthropology. In 1992, upon completion of her Masters of Arts degree in Anthropology, Maureen began her doctoral research.

Her field work has included positions in France at Grotte XVI under the direction of Jean Philippe Rigaud and Jan Simek, and at Combe Sauniere under the direction of Jean Michelle Geneste, in Alaska at the Chernibura site under the direction of Lucille Johnson, in Egypt at Hierakonpolis under the direction of Walter Fairservis and Michael Hoffman, and various contract projects in the state of Tennessee.

Currently Maureen is an Assistant professor of

Anthropology at Adirondack Community College. During the summers she pursues her research and directs the laboratory at Grotte XVI, Dordogne, France.