NAME OF AUTHOR *NOM DE L'AUTEUR* John W. Brink

TITLE OF THESIS *TITRE DE LA THÈSE* An Experimental Study of Microwear Formation on Endscrapers

UNIVERSITY *UNIVERSITÉ* University of Alberta

DEGREE FOR WHICH THESIS WAS PRESENTED / *GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE* M.A.

YEAR THIS DEGREE CONFERRED *ANNÉE D'OBTENTION DE CE GRADE* 1978

NAME OF SUPERVISOR *NOM DU DIRECTEUR DE THÈSE* Clifford Hickey



DATED/*DATÉ* Feb 22 1978 SIGNED/*SIGNÉ* John W. Brink

PERMANENT ADDRESS/*RÉSIDENCE FIXÉ* Archaeological Survey of Alberta
10158 - 103 St.
Edmonton, Alberta

National Library of Canada

Cataloguing Branch
Canadian Theses Division

Ottawa, Canada
K1A 0N4

Bibliothèque nationale du Canada

Direction du catalogage
Division des thèses canadiennes

# NOTICE

The quality of this microfiche is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us a poor photocopy.

Previously copyrighted materials (journal articles, published tests, etc.) are not filmed.

Reproduction in full or in part of this film is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30. Please read the authorization forms which accompany this thesis.

## THIS DISSERTATION HAS BEEN MICROFILMED EXACTLY AS RECEIVED

# AVIS

La qualité de cette microfiche dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il [illegible]nque d[illegible]es, veuillez communiquer avec l'univers[illegible] le grade.

La q[illegible]ssion de certaines pages peut laisser à dés[illegible]tout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de mauvaise qualité.

Les documents qui font déjà l'objet d'un droit d'auteur (articles de revue, examens publiés, etc.) ne sont pas microfilmés.

La reproduction, même partielle, de ce microfilm [illegible] soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30. Veuillez prendre connaissance des formules d'autorisation qui accompagnent cette thèse.

## LA THÈSE A ÉTÉ MICROFILMÉE TELLE QUE NOUS L'AVONS REÇUE

NL-339 (3/77)

THE UNIVERSITY OF ALBERTA

# AN EXPERIMENTAL STUDY OF MICROWEAR FORMATION ON ENDSCRAPERS

by

© JOHN W. BRINK

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF ARTS

DEPARTMENT OF ANTHROPOLOGY

EDMONTON, ALBERTA

SPRING, 1978

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled AN EXPERIMENTAL STUDY OF MICROWEAR FORMATION ON END-SCRAPERS submitted by John W. Brink in partial fulfillment of the requirements for the degree of Master of Arts.

..........................
Supervisor

R. J. Byrne

..........................

..........................

..........................

Date June 15, 1977

ABSTRACT

This thesis is an experimental lithic study designed to test the hypothesis that wear patterns which form on stone tools are diagnostic of the material on which the tool was used. Testing the hypothesis is accomplished by using thirty modern endscrapers on four worked materials and examining the resulting wear patterns. Photography is used extensively to document both the unused and utilized tools. The results of the experiments indicate that the hypothesis is substantiated, or not refuted. The wear patterns which developed on tools used on wood, antler, bone and hide were all distinguishable based on observation of the occurrence of the four types of use-wear; microflaking, rounding, polish and striations. Results also indicate that adding an abrasive agent to the worked material causes a radical change in use-wear formation. The wear patterns exhibited by the experimental tools were compared with wear patterns on prehistoric tools from an archaeological site in western Alberta. Out of a sample of twenty-seven, functional interpretations were advanced for fifteen prehistoric endscrapers.

ACKNOWLEDGMENT

I wish to thank the members of my thesis committee Drs. Clifford Hickey, Charles Schweger, Gloria Fedirchuk, William Byrne and Marvin Dudas for their constructive criticism and help with this thesis. My thanks also go to Dr. Alan Bryan who served as my advisor through several years of graduate work but who was on sabbatical leave at the time of the thesis defense. Dr. Hickey deserves special recognition for taking over as thesis supervisor and inheriting the thankless task of final editing. My gratitude is extended to Cort Sims who made the experimental tools and to the helpful people at University of Alberta Technical Services for their assistance with photographic reproductions. Finally, many thanks to Kay Thatcher who helped the most.

TABLE OF CONTENTS

CHAPTER PAGE

CHAPTER PAGE

CHAPTER PAGE

## LIST OF TABLES

LIST OF FIGURES

## LIST OF PHOTOGRAPHIC PLATES

# CHAPTER 1

# INTRODUCTION

During the summers of 1974 and 1975 I excavated a buried prehistoric campsite in west-central Alberta. The Smoky site (GaQs 1) is situated on the flanks of the eastern slopes of the Rocky Mountains about 170 km north of the town of Jasper, Alberta. The lithic part of the recovered cultural assemblage, while meager, was dominated by the familiar "end or thumb scraper" tool category. As part of the general artifact analysis, information on tool function was sought and this inevitably led to the literature on microwear or functional analysis. However, study of this literature produced little in the way of useful interpretive information and it became clear that I would have to generate my own data on the relationship between end-scraper use and microscopic wear patterns. Producing this data required an experimental setting where stone tools could be used under known and partially controlled conditions. The complexities and length of an experimental microwear study were such that this, rather than the interpretation of the Smoky site material, became the primary focus of my thesis research.

Accordingly, the goal of my thesis is to generate data on the formation of microscopic use-wear on stone tools when these tools are used in experimental test situations. To achieve this end a set of stone tools was manufactured, microscopically examined and photographed, used and then re-examined. Throughout this process all variables considered during experimentation and analysis were recorded and are here presented. This explicit approach to an experimental study in archaeology should provide the reader with a greater awareness of the input into the project and lead to a better understanding of the results.

Central to this experimental study is a test of the hypothesis that use-wear patterns are specific to and diagnostic of tool use on a particular worked material. In executing this test four materials were selected for use which are believed to have meaning or relevance to prehistoric peoples; these are wood, antler, bone and hide. The lithic assemblage used on these materials consisted of thirty modern endscrapers. Careful records of all experiments were kept; specifically, the physical characteristics of the tool edges were noted and photographed before, during and after tool use.

Any study of microscopic traces of wear on stone tools is necessarily dependent upon a visual transmission of information. Experimental results, if they are to be convincing, should be presented in a form suitable for examination and/or utilization by others. Accordingly, a second major goal of the thesis is to effectively communicate the results of my work. Photography is the vehicle of this presentation.

## Archaeology and Microwear Analysis

The bulk of archaeological concern is directed towards the study of prehistoric peoples via their preserved artifactual remains. In the quest for information, the study of these materials may focus on any number of attributes of the data. Certainly one of the most commomly discussed attributes of archaeological data is the "function" of human artifacts. Questions such as "How was this artifact used?", and "Are there any features of this artifact which may give clues to interpreting its use?" are commonplace to archaeologists. Accurate answers to these questions are often essential to further analysis and understanding of prehistoric material culture.

Determining artifact function may be approached from many directions. Undoubtedly, the most common is through the use of ethnographic analogy. While analogy is a useful device for suggesting possible uses of an artifact, the question remains whether or not tool function may be determined by actual observation of the artifact itself without recourse to generalized statements in the ethnographic record. The field within archaeology known as use-wear studies, or microwear analysis, has taken upon itself the task of answering this question. These attempts have been directed primarily towards the examination of microscopic use-wear marks found on the surfaces of stone tools.

Knowing, the use to which a tool has been put may ultimately lead to a broader understanding of cultural mechanisms. Portions of prehistoric diet, for example, may be directly inferred from particular, recognizable patterns of wear found on certain kinds of tools. Further, when the tasks of specific tools are known, reference back to context and provenience at the site may help delineate activity areas which in turn may identify the type and organization of the site, modes of population organization, division of labour and similar interpretations. Most archaeologists would agree that the potential of microwear studies for solving archaeological problems is enormous and exciting. However, I would argue that there are few archaeologists who feel that microwear research has adequately demonstrated its ability to accomplish its explicit goal: that is, determining the functions of prehistoric tools. A further discussion of this last point will be presented in Chapter 2.

It is imperative that the design of an experimental microwear study reflect a concern with both the scientific method of inquiry and known or presumed aspects of prehistoric lifeways. Even experiments which are designed to test a narrowly defined archaeological problem must select from a nearly limitless number of relevant variables which may be organized in a countless variety of ways. This selection process gives the experiments a formal structure or direction. In this thesis, interpretations from the Smoky site and the use of certain ethnographic analogies provide the structure around which the experiments have been shaped. Throughout the project many decisions had to be made regarding such matters as the morphology of the experimental tools, the raw material to use, the manufacturing techniques to employ, the types of tasks the tools would be put to, and so on. In nearly all cases these decisions were made on the basis of a perceived prehistoric condition. For example, tools were made in the likeness of the prehistoric scrapers from the Smoky site, they were used on materials believed to be representative of prehistoric conditions, and so on. The details of these interpretations and decisions are presented throughout the thesis as the pertinent topics arise.

The Smoky Site

Since this site in western Alberta served as a model for the tool-using experiments some additional information on the site and the lithic assemblage is in order.

The Smoky site lies on a south-facing terrace, some 75 m above the present level of the Smoky River, just opposite the confluence of the Smoky and Muskeg Rivers. The site is in a mixed environmental region, being subjected to montane, boreal forest and riverine influences. The local vegetation is dominated by young stands of trembling aspen, balsam poplar, white spruce and wild rose bushes. Importantly, the soils at the site are aeolian or loessal. Airborne silts which have as their source the numerous floodplains located upvalley from the site are brought over the site area by the prominent downvalley winds. All of the cultural material recovered at the site was buried in a homogeneous matrix of this silt. This is important to the microwear analyst because it means that a gritty silt was both present on the ground and on many days settling out of the air, and thus likely to find its way into many aspects of the daily lives of the prehistoric inhabitants. As will be discussed further in Chapter 3, silts were collected from the site and added to several tool-using experiments.

Three radiocarbon dates indicate that the site was occupied at least three times between 5000 and 1500 B.P. Unfortunately, the exact dates [illegible] in error, as nearby mining activities have distributed [illegible] coal dust over the site area possibly contaminating the radiocarbon [illegible]es. However, potential contamination does not negate multiple occupation and the precise age of the prehistoric material is less important than the fact that the site was occupied several times. This means the recovered cultural material is not contemporaneous. Nor can discrete temporal occupations be isolated by stratigraphy. The aeolian silts are unstratified and the cultural material occurred throughout this depositional unit without apparent vertical patterning. Tests designed to measure the influence of frost on buried objects have indicated that the processes of frost-heaving are active in the silt layer and may account for the lack of vertical organization of cultural material (Brink 1976). Thus, the sample of prehistoric endscrapers selected as a model for the tool-using experiments cannot be precisely dated and cannot be grouped according to their inclusion in temporal components.

Cultural material recovered from the Smoky site consisted mainly of thousands of small flakes and pieces of broken bone. Finished artifacts were rare, with unifacially retouched ~~tools~~ the dominant morphological category. Of the total sample of these presumed scraping tools, twenty-seven were singled out as the model for my experiments because of their general correspondence to a standard definition of "endscraper:"

> Beveled implement made on flake or blade with working edge on one or both convex ends. The bevel is formed by unifacial flaking or by use (Crabtree 1972b:60).

These twenty-seven tools may be seen in Plate 48. Some basic metric information of this tool sample is presented in Table 2. Because scraping tools comprised a large portion of the Smoky lithic assemblage, an understanding of their significance at the site is highly desirable. Determining the function of these tools would make a substantial contribution toward the reconstruction of prehistoric lifeways at the site.

Other aspects of the archaeology at the Smoky site that may be relevant to the thesis, such as identifiable faunal remains and additional features of the endscrapers, are dealt with in Chapter 3.

CHAPTER 2

# BACKGROUND AND PREVIOUS RESEARCH

## Definitions

Simply defined, microwear studies are those undertaken to collect, analyze and interpret data pertaining to the physical, observable features found on human artifacts which are a direct result of human utilization of these artifacts. As the name implies, most, though not all, of the alteration of tools through use is at the microscopic level. Terms such as "wear pattern analysis" and "use-wear" are here considered synonymous with microwear study. Furthermore, the terms "use" and "function" are treated as equivalent although it is recognized that "function" may be a much more inclusive term. Likewise, the term "functional analysis" (which is used so frequently in the literature that it has become almost synonymous with wear analysis) should be viewed as a more inclusive level of analysis which may or may not incorporate microwear data. Thus, while all microwear studies are, at least in theory, designed to discover the function of human tools, not all functional analyses will utilize microwear data to achieve this end. For example, Cox (1936), Over (1937) and Ray (1937) debate the function of stone scrapers without ever mentioning microscopic information. Others, like Frison (1968) and Wilmsen (1968, 1970) have asked functional questions of lith  data with microwear information serving only as a minimal or adjunct line of evidence.

Paradigms

The young field of microwear analysis has produced at least one fundamental hypothesis, confirmation of which is essential for the continuation of research and the application of results. A specific example of such an hypothesis is provided by Tringham:

> 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 (Tringham et al. 1974:178).

More generally, microwear research has concentrated attention on the question of whether or not wear patterns are "task specific." That is, that tools used on a particular worked material will develop patterns of wear which are diagnostic of that, and no other, worked material. Confirmation of this basic hypothesis would, in theory, allow archaeologists to interpret from the prehistoric collections the materials on which the tools were used. This general hypothesis, in a variety of forms, has been tested and partially confirmed by a number of contemporary microwear researchers: Ahler (1971), Hayden and Kamminga (1973), Keeley and Newcomer (1977), Keller (1966), Nance (1971), Semenov (1964), Tringham et al. (1974), Witthoft (1967) and Wylie (1975) among others. There is, however, considerable variability in the form that this confirmation may take. For example, Lawrence (1976) used experimental tools on a variety of materials and, on the basis of microwear, was able to distinguish between tools used on hard substances (eg. bone and antler) and tools used on soft substances (eg. hide and vegetal matter). In contrast, experiments by Keeley and Newcomer (1977) suggest that microwear analysis is capable of such fine distinctions as the isolation of tools used on wood from those used on bone, or tools used on meat from those used on hide. These conflicting results may or may not be a serious issue. The studies cited above utilized different kinds of tools, made of different raw materials, used in different ways and analyzed with different technical equipment. The influence of these and other experimental variables on the production or recognition of use-wear are largely unknown. Until this situation has been rectified by a gradual accumulation of tested information, we will continue to have difficulty accounting for the different results of microwear studies. The important point is that the basic microwear hypothesis requires repeated testing. If one well-controlled study suggests that a certain form of tool used in a specific manner on particular worked materials produces distinctive wear patterns it does not necessarily follow that other forms of tools used in different ways will also yield task specific wear patterns. As Keeley has noted:

> There is not just one...study to be done but very many, each related to the specific problems and conditions of various areas and archaeological periods (1974:334).

Thus we might claim that the basic microwear hypothesis has (in many forms) been substantiated in a small number of experimental situations. There are, however, such a tremendous number of variables involved in each study (edge angle, worked material, mode of use, etc.) that it remains for this hypothesis to be tested in many more controlled studies. In this thesis I will test the hypothesis that a particular form of tool used in a partially controlled manner on a variety of worked materials will develop wear patterns which are specific to and diagnostic of tools used on each different worked material. Several tests of secondary importance are also being made; these will be discussed in the next chapter.

The remainder of this chapter is devoted to reviewing selected portions of the literature on use-wear analysis from the perspective of its formative influence on my own study.

Microwear: The State of the Art

To facilitate discussion, the microwear literature under consideration may be divided into three categories: 1) those studies designed to conclude the function of certain tools or groups of tools --- usually artifacts from archaeological sites; 2) those studies designed to experimentally produce and interpret use-wear patterns; and 3) those studies which combine (1) and (2) usually in a sequence where experiments are initiated with the intent of utilizing the experimentally produced wear pattern data as a comparative tool in assessing the function of some prehistoric artifact sample.

Reports in category (1), which are partially or wholly dedicated to deducing the function of either specific specimens or groups of prehistoric tools, include the works of Frison (1968), Hester (1970, 1971), Kinsaul (1972), Nance (1969, 1971, n.d.), Rosenfeld (1971), Walcott (1965), Wilmsen (1968, 1970) and Witthoft (1955, 1967).

What these reports have in common is their dependence upon pre-existing information on the nature and form of microwear. That is, since none of the above reports directly generate any experimental evidence on the nature of tool alteration during use they must, therefore, be drawing upon existing sources of information which stipulate "what wear is" and "what wear is not." I suggest that the traditional sources of information are intuition and the works of S. A. Semenov, and that both of these sources have drawbacks which should be examined.

Certainly "intuition" historically has played an important role in microwear identification. Intuitive statements are defined as those not infrequent remarks to the effect that "the edge of specimen X is dull and rounded indicating Z activity." Such unreferenced and unsupported statements may certainly be grounded in the logic of common sense, but still must be regarded as opinions, not explanations. Reliance on intuition as an interpretive aid is now quite rare among current researchers.

A second and more important source of information upon which other workers have drawn is S. A. Semenov. After the western publication in 1964 of his classic text, Prehistoric Technology, Semenov quickly became the basic reference for the interpretation of patterns of alteration on stone tools. Few microwear reports have not acknowledged the influence of this text. Semenov incorporated the microscopic examination of prehistoric tools with experimental and ethnographic analogies. Thus, his work became an available data bank for many use-wear researchers, especially those of category (1) who were not producing their own experimental information. I maintain that certain features of the Russian analytic method, as developed by Semenov, are flawed, and furthermore, that the Soviet method of analysis is precisely the sort which is difficult for others to employ comparatively.

Semenov's work has been ably criticized by Bordes (1969), Keeley (1974), Odell (1975), Tringham et al. (1974) and especially Levitt (1976). Only a few issues need be raised here. Thompson (1964) has noted Semenov's strong bias in choosing prehistoric tools to investigate. Tools were selected which already showed pronounced evidence of wear. This would suggest that at the beginning of the analytic process Semenov had preconceived ideas about "what wear is" and "what wear is not." The source of these ideas is never made explicit. It is difficult to place confidence in the results arising from this selection process. Entire groups of task-specific tools with more subtle types of wear may have been ignored altogether.

Second, Semenov's work with experimental and prehistoric tools led him to emphasize the formation and identification of striations on stone tools. This emphasis may have been a direct result of his biased selection process. In the years following the publication of Semenov's book there appeared numerous reports supporting or refuting Semenov's claim for the significance of striations (see Odell 1975 and Keeley 1974 for a review of these conflicting reports). Several researchers have failed to find any microscopic evidence of striations (Ahler 1971; Gould, Koster and Sontz 1971). Most current research has indicated that the formative processes and morphology of striations are far more complex and variable than has been previously suspected (Del Bene 1977, Clouse 1977, Fedje 1977). Hence, Semenov's emphasis on striations as the prime functional index has largely been replaced by broader conceptions of the configuration and variability of use-wear.

These criticisms, while historically important, are not meant to detract from the profound impact of Semenov's work, nor are they to be viewed as the current state of affairs in Russia. Levitt (1976) provides a valuable update of Semenov's work demonstrating that there have been many changes since the original publication of Prehistoric Technology. Semenov remains very much at the vanguard of microwear studies.

However, a final and most important criticism needs to be raised. This concerns the underlying theory and method of contemporary Russian use-wear analysis as led by Semenov. The methodology employed by Semenov and his colleagues is as follows: tools were examined for evidence of use; based on what was observed a function for the tool was hypothesized; a tool of similar form was made and used in the hypothesized manner; the tool was then examined and the use-wear marks were compared to those of the prehistoric tool; if the use marks corresponded then the hypothesis was confirmed; if the marks did not correspond then a new hypothesis was put forth and the process repeated (Levitt 1976:7-9). This methodology has merit. Functions are suggested for the sample of prehistoric tools which served as the model for the experiments. Ultimately, this interpretation of the prehistoric record is the goal of all microwear research. But with the founding of a new field of inquiry such as microwear analysis, we might ask whether our priorities should be toward the interpretation of individual prehistoric samples, or perhaps toward gathering more information on the nature of use-wear and making this basic data available to other researchers.

The Russian methodology outlined above clearly emphasizes the end product of the analytical process: the pronouncement of the function of a particular tool. I repeat, this is a laudable goal, but I maintain it is not the direction in which microwear research should presently be moving. The hypotheses tested by the Russian method are of little interest or value to anyone not directly involved in the study of the same lithic materials as the microwear analyst. Confirmed or refuted hypotheses proposed for individual tools will not lead to the development of a science for the study of the functions of human artifacts. At best, the Russian method will provide a greater understanding of certain aspects of local cultural processes. In the future it may be that most microwear analysis will be concerned with just these sorts of problems. I contend, however, that the most pressing needs are not to discover the function of a particular tool, but rather to lay some ground work for the microwear discipline. We have yet to demonstrate, to the satisfaction of many skeptical archaeologists, that the much touted claims for microwear analysis are founded on solid principles. We need to discover more about the highly variable nature of use-wear; we need to document and describe the many forms this damage may take; and most importantly, we need to look for correlations between specific forms of use-wear and specific tool using activities and worked materials. Given the proper format, principles or rules should begin to emerge which can then be scrutinized or implemented by any researcher. The basic methodology of Semenov and his collegues will lead to the determination of the function of more and more individual tools, not to the rules which govern the formation and multifaceted nature of use-wear on stone tools.

A secondary result of the Russian emphasis on interpreting the function of single prehistoric specimens is a corresponding de-emphasis of the intermediate stages of the analytic process. Specifically, there is a paucity of information on the details of the tool-using experiments conducted. Details such as the techniques used to manufacture the experimental tools, the specific characteristics of the unused tool edges, the exact mode of tool use, and the like, are seldom made clear. Without knowing more about what went into the experiments, other researchers can profit little from the results. Furthermore, the omission of this kind of intermediate data could cause needless repetition of experiments. This last criticism, of course, is relevant to many microwear reports, not just those of Semenov.

In summary, many archaeologists interested in determining the functions of prehistoric tools but who have not initiated their own experiments have had to look elsewhere for use-wear information. The pioneering works of Semenov have been a major focal point of their attentions. Yet the basic methodological approach of Semenov relies on personal knowledge of the processes of wear formation and is primarily concerned with the results of the analysis (assigning a function to a tool) rather than being explicit about the details of the experimental procedure. It is precisely this methodological format which produces results lacking comparability. Reports which have drawn heavily on the work of Semenov and his colleagues should be viewed accordingly.

The second category of literature on microwear research is the experimental type. As indicated, the aim of these papers is to illuminate the kinds of wear produced on tools when used under specified circumstances, not to interpret any specific artifact samples. Reports of category two are not numerous, with Keller (1966) and Tringham et al. (1974), Broadbent and Knutsson (1975) and Keeley and Newcomer (1977) being good examples.

The greatest asset of these reports is that by being strictly devoted to experimentation there is almost always an attempt to report the details or variables of the experiments. Assuming that the methods used are acceptable to other researchers, these reports can help to generate usable reference data on microwear. I agree in general with the aims and methods of these reports. Their influence on my work is acknowledged in that I am attempting to elaborate on themes already developed in these reports.

The third category of microwear studies is that which combines the first and second approaches: examining the wear patterns found on a sample of prehistoric tools and also using evidence from experimental conditions to enable the identification of wear patterns resulting from specific uses. To the best of my knowledge, in all of these reports the experimental tool usage was intentionally designed to facilitate the functional analysis of a set of prehistoric tools. Such reports include the works of Ahler (1971), Dodd (1977), Hayden and Kamminga (1973), Hester et al. (1973), Hester and Heizer (1972), Levitt (1976), Ranere (1975), Sonnenfeld (1962) and Wylie (1973, 1975).

Many of these reports follow the pattern set by Semenov by concentrating their emphasis on the final interpretation of the prehistoric sample. Again, much important information relating to the nature of the experiments conducted is either ignored or is ambiguous. When this occurs the utility of the reports to archaeologists searching for assistance in functional analysis is greatly reduced. Ahler (1971) deserves mention as a noteworthy exception.

Thus, the literature combining experimental research with analysis of prehistoric tools has influenced the present study by suggesting a greater need for accurate recording and reporting of the experimental data. Failure to report such data may detract from the credibility or at least utility of the results, as other workers are not in a position to evaluate these results. It should be kept in mind that the suggested emphasis on the procurement and presentation of primary data on tool alteration is a temporary emphasis, designed on the one hand to compensate for the lack of such information, and on the other to correct some existing misconceptions about tool alteration.

My own study, then, is most similar to the third category of microwear reports in combining experiments in wear pattern formation with analysis of a prehistoric artifact sample. But, I also hope to achieve the same end as the reports of the second category by including as complete a description of the nature and results of the experiments as possible. Given the state of microwear studies I would argue that this latter goal is at least as important as the interpretation of any specific prehistoric sample.

# CHAPTER 3

# EXPERIMENTAL DESIGN

## Introduction

The need to identify the variables of microwear experiments has been stressed by Odell (1975) and Keeley (1974). Much, though not all, of the work reviewed in the last chapter suffers from a failure to report pertinent variables:

> a fact which either makes one doubt the validity of the results or simply renders the procedure inexact and therefore less usable to others. In addition the experiments become unrepeatable and therefore slightly less than scientific (Odell 1975:227).

This chapter, therefore, is largely devoted to making explicit the materials, assumptions, decisions and rationale which make up the experiments to be reported. While this does not guarantee scientific validity it does allow the results to be evaluated by the reader and its utility and general applicability to be assessed.

The experiments to be described below are similar to what Asher (1961) has called "imitative" experiments. That is, they are structured to simulate a past condition; in this case the shape and use of certain stone tools. The general aim of such experiments, Asher (1961:793) says, is to test beliefs about past cultural behaviour. Other scientists can repeatedly test and retest hypotheses about the rules which govern contemporary behaviour (or phenomena). This is because the experimental conditions can be reassembled time and again with a high level of accuracy. Most archaeological experiments cannot attain such levels of empiricism. For instance, it is unlikely that in the history of humanity two identical stone tools have ever been produced. Thus, the archaeologist wishing to reconstruct behaviour must recognize that, in the sense of the strict scientific method, the statement that a certain prehistoric tool was used in a specific manner is an untestable statement. The prehistorian must apply the tool of analogy. He must inevitably state "similar tools used in specific ways," or one must make reference to the ethnographic record. Either way analogy is employed and the information retrieved from the tests or experiments, when applied to the archaeological data, produces inferences of cultural behaviou [illegible] would concur, somewhat reluctantly, with Asher's remark that [illegible] d of order (pattern) with which imitative experiments are conce[illegible]ed [illegible] cultural, not natural; hence it is not like an experiment in t[illegible] natural sciences" (1961:807). Hopefully, the experiments describe[illegible] below can be considered scientifically valid in their replicability by other researchers. While this may be the case it is not argued that it will be the case. Beginning with the fact that no two stone tools are ever identical and ending with the use of analogy as a link between prehistoric and "modern" behaviour, the experimental process is replete with instances of either imprecision or subjectivity. Stringent control of some of the experimental situations and full recording of the pertinent variables can greatly reduce the potential margin of error and hopefully enhance, but not guarantee, the replicability of the results.

My experiments, however, were not completely imitative in that they did not always attempt to simulate presumed past conditions. Many parts of the experimental process were designed to facilitate testing the hypothesis that tools used on different worked materials develop different wear patterns. For example, no tool was used on more than one worked material, no tool was resharpened, no tool was used at different angles, and so on. Such controlled conditions are not proper imitations of prehistoric tool-using conditions. Yet within the framework of controlled experiments I have attempted to strike a balance with the more "natural" tool-using conditions as indicated by ethnographic data or recovered information from the Smoky site.

The remainder of this chapter is devoted to making explicit as much information as possible on the details of the tool-using experiments.

Raw Material

The raw material selected for tool manufacture was a cryptocrystalline black chert. The material was obtained from the collection of the Jakubowski site (GkQo 100), an archaeological site also located in west-central Alberta, some 190 km north of the Smoky site. One of the features of the Jakubowski site was a cache pit of several hundred chert flakes. All of the flakes had nearly identical morphological properties and it appeared that many had been struck from a few cores. The color of the chert was almost invariably a rich jet black. The texture is extremely smooth and impurities seem minimal. The hardness of the material on the Mohs scale is seven.

While three types of material were represented in the endscraper sample from the Smoky site (chert, quartzite and quartz), I decided to restrict the experiments to a single lithic type (chert). This was done for four reasons: 1) the majority of the artifacts were made of chert (n=20, 74%); 2) the addition of a second raw material would greatly increase the interpretational problems and this seemed unwarranted given the small size of the other lithic classes (n=7, 26%); 3) the difficulty encountered in detailing the microscopic alteration to tools made of quartzite, and 4) the unavailability of the third material type --- pure quartz crystal. Experiments by Greiser and Sheets (1977) indicate a relationship exists between specific types of lithic raw material and resulting wear pattern formation. Thus, the functional interpretations of the quartzite and the quartz artifacts arrived at by examining wear patterns experimentally produced on chert tools should be viewed with the possibility of alternate interpretations kept in mind.

## Heat Treatment

I know of no experimental work indicating that artifacts which have been heat-treated exhibit different wear patterns than non-treated tools when used in an identical manner. It has, however, been repeatedly demonstrated that heating can cause significant changes in the morphological and fracture properties of cryptocrystalline rocks (Purdy and Brooks 1971; Purdy 1974; and Crabtree 1964). It would seem consistent to assume that the wear patterns found on tools made from heated rocks might be different than the wear patterns found on tools of un-heated material, all other things being equal.

For this reason, before manufacture of the experimental tools a decision had to be made regarding heat treating the raw material. Since the prior decision had been made to replicate in the experiments the activities at a particular time and place in prehistory, this decision should be based on whether or not the scrapers from the Smoky site were heat-treated. Examination of the artifact scrapers suggests that often there is no clear cut answer. Several specimens show strong development of the so-called "classic" symptoms of thermal alteration; namely, a lustrous or glossy appearance and a waxy or soapy feel to the stone (Mandeville 1973; Purdy and Brooks 1971; and Crabtree 1964). Other scrapers from the site are problematical in the sense that these symptoms are poorly or weakly developed. Still other tools possess none of the characteristics of having been heated. It may be noteworthy that most of the tools in this latter category are made of quartz or quartzite, materials which may not readily exhibit clues to thermal action.

On the other hand, all of the cache material from the Jakubowski site has probably been heat-treated. All 30 of the flakes used to manufacture the experimental tools show some signs of the standard diagnostic criteria. As a comparative experiment another set of chert flakes also from the cache pit were heated in an oven at 500°C for fourteen hours. Most of these flakes fractured and experienced some color change, going from a rich black to a duller ashen black. None of the flakes came out of the oven looking heat-treated in the classic sense. The interpretation given here is that this modern heating was applied to rocks already heated during prehistoric times. The second heating may have caused over-dehydration and consequently a proliferation of internal microfractures. This conclusion is supported by independent research conducted by Conaty (n.d.). Working with chert flakes also from the Jakubowski site, Conaty heat-treated several specimens and experienced breakage similar to that of my own experiments. He also noted that the heat-treated specimens failed to typify the "classic" symptoms any more, or even less, than they already had prior to heating (Conaty n.d.:84-86). It seems fairly certain that the Jakubowski cherts had already been heated by aboriginal peoples. It was decided to use the material in the condition in which it was recovered.

Tool Manufacture

The modern stone tools used in the scraping experiments were manufactured by a flintknapper with considerably more experience than myself: Mr. Cort Sims of the Department of Anthropology, University of Alberta. Mr. Sims had seen the entire sample of prehistoric scrapers and had these tools with him when chipping the modern sample. The intent was not to produce exact copies of the artifacts, but rather to manufacture tools of roughly similar form. Of the tools made, those selected for use were the ones which fell in or near the range of variation of formal attributes exhibited in the prehistoric sample. The same gross formal attributes were measured for both the modern and the prehistoric tools and are presented in Tables 1 and 2.

In arriving at a set of decisions as to how the tools should be made two important guidelines or constraints were kept in mind The first concerned the size, shape and flaking properties of the raw material to be used. For example, the Jakubowski chert flakes were already quite small and needed only secondary trimming, shaping and retouching. The use of a hard hammer was generally unnecessary. Second, the method of manufacture was also based on the interpretations arrived at regarding the probable techniques used to manufacture the Smoky scrapers. I believe that the prehistoric sample is composed mainly of tools made by direct percussion with a soft hammer. A few specimens show long, evenly spaced, parallel flake scars suggestive of pressure flaking. The manufacture of the modern sample was intended to mimic these interpretations.

There are, of course, many unknowns regarding aboriginal manufacturing techniques. For example, an important factor would be whether or not the edges of a tool were abraded before or during manufacture as is commonly done to strengthen an edge (Sheets 1973). Any portion of this abraded edge, if not removed during chipping, might be microscopically similar to wear resulting from certain kinds of tool use. To avoid confusion, the edges of the experimentally made tools were not abraded.

The possibility existed that some of the Jakubowski chert flakes were retouched and/or utilized at the time of recovery. To eliminate the possibility of prehistoric manufacture or use marks contaminating the modern sample, Mr. Sims was especially careful to remove all previous edges of t.. flakes so that the tools possessed only freshly chipped edges. Most of the surface areas as well were freshly chipped.

A total of thirty modern tools were used and are described in this report (Plate 1). Of these, twenty-five (83%) were made by direct percussion with a soft hammer (see Table 1). Mr. Sims employed the soft hamm.. .echnique by stationing himself in a sitting position, holding the specimen in his left hand and flaking the piece with .. deer antler billet. Four (13.3%) of the experimental tools were made entirely by pressure flaking (#s 20, 21, 27, 28). The manufacturing tool was a percussor tip of ¼inch thick copper wire socketed in a wooden handle. The remaining tool, #29, was made entirely by direct percussion with a quartzite hammerstone. As indicated above, Mr. Sims was not asked to conform to any rigid standards of scraper morphology, but was asked to flake in a style natural and comfortable to him. He is right-handed.

To avoid unintentional damage to the modern sample each tool was immediately placed in its own small paper bag from which it was taken only during times of examination and use. The completed tools were numbered and the pertinent information of each tool's history was catalogued. The tools were then washed with a soft tooth brush and warm, soapy water to remove any particles of chert, antler, and so on.

## Initial Examination

Before any of the tools were used they were microscopically examined, described and partially photographed. This significant stage of the procedure has been omitted by many researchers, or has not been reported by them, resulting in the experiment beginning in an "unknown" condition --- the state of the tool prior to use. One must seriously question the value of experiments which proceed from an "unknown" condition (lack of information on the microcharacteristics of the tool prior use) to a supposedly "known" condition (identification of wear caused by use). In short, in our haste to define "wear" I believe we have neglected our definitions of "non-wear." Yet only a juxtaposition of the two can lead to an accurate assessment of causation in tool damage. Sheets is one who has perceived this gap in our research:

> The analysis of lithic materials, whether from a functional, technological or stylistic approach must be founded on a clear understanding of the nature of the attributes observed. A great disservice to lithic analysis is done when the origins of the observed phenomena are either confused or ignored (1973:215).

The majority of the work done with experimental tools has either ignored or failed to report on the condition of the unused tool. A few notable exceptions are the works of Ahler (1971) and Tringham et al. (1974), both of whom published photographs of tool edges prior to their use. I should note, however, that microwear studies using unmodified flake tools, such as Lawrence (1976) and Tringham et al. (1974), may have less need to document the unused edges of the experimental tools.

All tools were examined with a Wild M5 stereomicroscope on a swing arm stand with magnification powers of 6, 12, 25 and 50X and two mobile light sources powered by separate light transformers. A

Leitz 35mm camera back was attached to a monocular stem thus employing the optics of the microscope as the camera lens (Plate 2).

Photographs were taken at all powers but most frequently a subject was photographed in duplicate either at 12X and 25X, or 25X and 50X. In addition, many photographs were taken both with and without a light dusting of the powder produced by heating ammonium chloride ($NH_4Cl$). Use of this coating proved useful when viewing certain kinds of wear related to microfracturing of the tool edge. The coating was not useful when viewing rounded or polished surfaces, ridges or most striations. Generally the coating served to highlight and/or shadow areas of sharp or abrupt topography. All photos with the notation "coated" illustrate tools which have been treated with ammonium chloride. All photographs were taken with Kodak Panatomic X black and white film.

A dissatisfaction with viewing other photomicrographs of tools led to the implementation of a system of marking the tools at the precise spot where a photo was taken. This allowed repeated photography of exactly the same part of the tool before and after each use. A small dot of ink was placed on the tool near the subject of the photo (Plate 3). The dot was fixed with an equally small amount of enamel. While I realized that many dots were in jeopardy of removal due to their proximity to the active part of the tool, utilization of the tool was never altered for fear of obliterating these reference marks. The numerous dots on each specimen were recorded and numbered on a simple sketch of each tool. The same numbers were entered into the photo record at the time of each photograph.

This dotting technique requires considerable time and effort and may not be practical for other studies with a large sample size. Subsequent to my implementing this referencing system I noted the independent use of a nearly identical system by Broadbent and Knutsson (1975).

All tools were completely examined before and after use, including viewing and photographing edges and surface areas. The placement of the dots (and thus the loci of the photographs) was by and large an intuitive process, with a concentration of attention on the distal end which would receive most of the work. However, less frequently, dots were also placed on the lateral edges, proximal ends and on dorsal surface ridges. An attempt was made to dot and photograph a variety of areas of the working edge; from the concavities and protrusions of the flake scars at the distal end, to the dorsal and ventral surfaces immediately adjacent to the working edge. I believe that this technique, by concentrating research attention to specific areas selected before tool use, has the beneficial effect of forcing the worker to return to and examine these areas after tool use regardless of whether the area exhibits "expected" evidence. In other words, the dotting method reduces the urge to scan a just-used tool in search of a text book example of what the worker anticipated finding and perhaps ignoring some less spectacular wear damage marks. And finally, the method, again by drawing attention to areas other than those of obvious alteration, may help to emphasize the absence of wear.

Weight

After completion of the dotting process and just prior to use, the tools were weighed on a Mettler electronic balance. Assuming that the tools are cleaned and that neither the reference dots nor the enamel were removed during tool use, then a re-weighing after tool use should document any net gain or loss of mass. Just before each weighing all the tools were carefully cleaned with a soft toothbrush in warm soapy water to remove finger grease, residue of worked material and/or fragments of the tool itself. Weights were recorded to the nearest milligram (mg).

Hafting

Most authors agree that endscrapers were usually hafted. Wilmsen (1970) reviews the form and function of endscrapers and concludes that "there is suggestive evidence that these tools were hafted...since endscrapers tend to be among the smallest tools in any assemblage, their functional effectiveness probably depended upon hafting...we may, for the present, assume that most, if not all, tools of this type were hafted" (Wilmsen 1970:71). Wilmsen also notes that hafted scrapers used by Eskimos show evidence of wear on the proximal end, and Frison (1968) cites this same feature as indicative of hafting: "It is suggested that most endscrapers were hafted judging from the polish on ridges between flake scars on the back of the tools" (Frison 1968:152). Semenov (1964:87-88) is one of the few who argues against hafting of endscrapers, but he says if any were hafted it would be the smaller ones; just what smaller means is unclear. Gould et al. (1971) provides valuable information on the manufacture and use of the Australian hafted-adze, a tool with at least formal resemblances to the endscraper. Significantly, when these tools are small (less than 6.6 cm long and less than 2.2 cm thick) they are always hafted (Gould et al. 1971:149). In addition, many ethnographic or prehistoric endscrapers have been collected complete with the haft element (see Hester 1971; Mason 1890; Metcalf 1970; Nissen and Dittemore 1974; Osgood 1940; Wedel 1970; and Wissler 1910).

Furthermore, there is mounting experimental evidence that endscrapers must be hafted to function effectively as scraping implements. Ranere, for example, made and used stone scrapers and found them virtually useless unless hafted (1975:197). Levitt (1976) came to the same conclusion.

Finally, the large number of incomplete endscrapers recovered from the Smoky site may be interpreted as evidence of the use of a handle. The incomplete specimens are all broken in a similar manner (see Plate 48). Semenov (1964:88) makes a brief but intriguing statement regarding endscrapers: "Broken examples found at some sites suggest the use of handles." Unfortunately, he provides no data on the nature of the fractures or what led him to believe that certain types of broken tools indicate the use of a haft. Logically, tools hafted at their proximal end and contacting a working surface at the distal end, and simultaneously subjected to downward and back and forth pressure, would be weakest at a point between the end of the haft and the distal end of the tool. The broken Smoky endscrapers are consistent with this outline. The thinnest tools would be especially sensitive to breakage in this manner. The mean thickness of the broken endscrapers is 3.72 mm compared to a mean of 6.72 mm for the complete specimens. However, none of the experimentally made endscrapers broke during use, thus the possible correlation between broken tools and use of a handle remains problematical.

I consider it in keeping with presumed prehistoric conditions to haft the experimental endscrapers. However, the details of the hafting apparatus must be considered. Reported or recovered handles take several shapes and are made of several materials. Undoubtedly, different types of handles will result in different angles of the tool contacting the worked surface, different rigidity, different application of pressure and leverage, and so on. Any or all of these factors could have subtle effects on the production of wear on the hafted tool. Further experimentation will be needed to empirically verify this possibility.

With the small sample of experimental tools in my study I decided not to test the difference between several types of handles, but rather to limit experimentation to a single type. The right-angle type handle chosen is ethnographically common, though not the only type reported, in Alberta (see Wissler 1910 for use of this handle among the Blackfeet of Southern Alberta, and Goddard 1916 for use of this handle by the northern Beaver).

Handles for the experimental tools were made from freshly cut branches of a tree with numerous near-right angle curves. Branches were stripped of their bark and sawed to the desired lengths. To accomodate the variety of experimental tools, the distal ends of the handles were shaped in different ways. For scrapers with the common "hump" on the dorsal surface the ends of some hafts were gouged out forming a concave hollow to socket the tool. The ends of some hafts were left flat to accommodate tools with flat dorsal surfaces. All the tools fit comfortably into one of seven handles (Plate 4). These were used for the duration of the experiments.

Tools were lashed onto the hafts with dental floss, which, although inconsistent with ethnographic analogy, fulfilled the required task. The only problem encountered in hafting was that the unabraded edges of the tools occasionally cut the floss when pulled tight. The problem was resolved by applying a loose underwrapping then a tight outer wrap. The result was a comfortable handle with a secure hold on the tool.

<u>Loess Inclusion</u>

> Another <u>caveat</u> to be considered is that prehistoric men, their food sources and immediate environments were all a good deal grittier than present-day archaeological laboratories and their inhabitants, so that some effort may be necessary to approximate these earlier, dirtier conditions in the course of the experimental work (Keeley 1974:330).

Keeley's warning deserves attention. Wear patterns produced by working clean materials may differ significantly from those produced by working dirtier, grittier materials. As Keeley notes, prehistoric tool using situations may have incorporated dirt or grit simply by accident.

In addition, there is some ethnographic evidence indicating the intentional inclusion of gritty substances onto hide surfaces during processing. Mason (1890:568), reporting on the skin dressing techniques of the Naskapi Indians, refers to the use of additives: "when the desired pliability is gained, the superabundant fat and moisture are removed by calcareous earths, bone dust, or flour, to act as absorbents." Clifford Hickey (pers. comm.) reports a similar practice among certain contemporary Eskimo groups who, prior to scraping, add cornmeal to the surface of fresh hides, the justification being to absorb grease and fat. A similar practice for a different reason has been noted among modern Carrier Indians of British Columbia. The Carrier add flour to the flesh side of a sun-dried hide which acts as a dry lubricant during the subsequent scraping process (Douglas Hudson, pers. comm.). Thus, in the process of skin preparation the hide may become dirty by both accidental and intentional means.

The possibility of grit inclusions becoming part of the too' using situation is especially strong at the Smoky site where so are of aeolian origin. These wind blown deposits consist of 60 to 70% silt sized grains and 10 to 20% very fine sand; both are predominantly quartz. Thus, at the Smoky site a relatively small but hard grit was available for inclusion into many facets of prehistoric life. The hypothesis may be advanced that the incorporation of this grit into tool using situations will result in wear patterns distinct from those produced by working clean materials. Unfortunately, accurate testing of this hypothesis would require spheres of prehistoric information which are not available: how much soil to add and how often to repeat these additions. The answers to such precise questions will never be known, but at least the general hypothesis that working with grit inclusions causes different wear patterns than working clean materials may be tested.

In order to test for the influence of grit inclusions on use-wear formation, different tools must be used on the same material with and without grit. This requires a larger sample of experimental tools than was available for my study. Accordingly, only two of the four worked materials (bone and hide) were scraped in both a clean and dirty condition. Prior to scraping, thirty-five grams of soil collected from the Smoky site were sprinkled over these two worked materials. The actual amount of soil which adhered to the worked surface would be somewhat less than thirty-five grams. Some additional details of the grit application are provided in the chapters on bone and hide working results.

## Worked Materials

Four categories of worked materials were selected for use in the scraping experiments: wood, bone, antler and hide. While not an exhaustive list of possible objective materials, these four categories would probably have been found in abundance at the camps of prehistoric peoples of Grande Cache. Beyond this generalization the selection of worked materials is based as much on ethnographic and logical grounds as it is on hard evidence from the Smoky site. For example, it seems unlikely that steeply beveled, unifacial tools such as endscrapers would have been used to cut meat; hence this material was not included in my experiments.

Direct evidence does exist for the utilization of bone. The few identifiable remains from the Smoky site attest to the presence and utilization of mountain sheep (Ovis canadensis) and elk (Cervis canadensis). Undoubtedly this narrow sample is due to factors of preservation or recovery rather than dietary restrictions of the native people. No antler was recovered at the site, but by using the faunal material as an indirect line of evidence we can infer that antler from the numerous large ungulates of the region was available. Likewise, no hide was recovered but was certainly present at the site. No wood remains were recovered and without pollen analysis the specific types of plants existing at the site from 1500 to 5000 years ago cannot be known with any great confidence. Evidence of Holocene environmental conditions from the region is non-existent. I will assume that the present day dominant spruce and poplar vegetation also occurred in high frequency in prehistoric times.

Unfortunately, specimens of materials believed to be important to prehistoric peoples are not always available for modern research. For example, moose or elk hides and bone are difficult to obtain most of the year. Consequently, some of my experiments had to be conducted on materials not available to aboriginal people; specifically bone and hide from the genus Bos. How this has affected my results is open to debate. There is presently no evidence to suggest that, all other things being more or less equal, the working of different kinds of animal hide, bone or antler produce demonstrably different kinds of wear patterns. Hayden and Kamminga (1973) have demonstrated that working extremely hard wood produces different use-wear than working very soft wood. Levitt (1976:34) has noted that there are chemical and structural differences between different animal hides, but there is no information on whether or not these subtle differences can cause a concomitant variation in wear patterns. Likewise, I am not aware of any research suggesting that the sole variable of type of bone or antler is sufficient for the production of differential use-wear. More testing is needed to answer these questions.

Two species of wood were scraped: white spruce (Picea gluca) and trembling aspen (Populus tremuloides). Both woods were worked in a fresh condition and spruce was also worked in a dried condition. Although technically a hardwood, aspen is at the "soft" end of this scale with an average oven-dry density (weight of wood per unit volume) of 24.92 lbs/ft$^3$. Spruce is only slightly softer with an average oven-dry density of 21 [illegible] lbs/ft$^3$ (U.S.F.P.L. 1974). These two woods are in the same density range of the other woods available in the Grande Cache area, with the exception of the rarely seen birch. The most obvious difference between spruce and aspen was the nature of the bark. Spruce bark is scaly and harder than the smoother aspen bark. All woodworking experiments were conducted on branches of mature trees or trunks of young saplings between 4 and 20 cm in diameter.

Bone scraping was executed on four femurs of recently killed animals; two from a pig and two from a cow. One femur from each animal was worked with the addition of silt abrasive particles. Particular bones were used consistently either with or without silt inclusions. Prior to use the distal ends of the femurs were removed with a metal axe and the bones boiled several hours to remove grease and marrow.

Antler scraping was conducted on an elk antler tine. It may be noteworthy that this piece was at least several years old. Many authors feel that dense materials such as bone and antler were soaked in water, urine or some other liquid prior to alteration. The rationale for this practice is to soften the materials. For example, Broadbent and Knutsson (1975:119) commenting on their bone scraping experiments say that "the bone was softened somewhat through boiling. Boiling or soaking was undoubtedly practised in prehistoric times. We consider this important for effective scraping." With this possibility in mind, all of the bone and antler used in my experiments was soaked in water for two weeks before scraping. In addition, all bone and antler pieces were returned to water in between all experiments. The effectiveness of this practice will be discussed in subsequent chapters.

Of the four raw materials, hide working was the most complicated. In the activities described above, the needs placed upon a stone tool are fairly consistent. That is, the particular requirements of a tool used to effectively scrape bone or wood (such as edge angle, strength of lithic material, sharpness, etc.) are probably very similar from beginning to end of a task. Hide working, however, is composed of numerous distinct working stages. Certain stages of the hide working process may be best completed by some types of tools, other stages by other types of tools. Furthermore, tools used for one stage of this process may have undergone alterations which now make then suitable for other st..ges. For example, a freshly sharpened stone scraper may be employed in the fleshing process, and then once dulled this tool is suited for de-hairing. ..ch complexities of multiple function are only significant to the microwear analyst if it can be demonstrated that similar tools used in the different hide working stages will exhibit different wear patterns. I partially tested this possibility by using three sets of stone tools in three separate stages of cow hide working: fleshing, dry scraping and de-hairing. Abrasive silt particles were added to some of the dry hide scraping experiments. Details of hide preparation and silt inclusion are presented in the chapter on hide working results.

Tool Use

In order to test the influence of the worked materials on the formation of wear patterns, an attempt was made to hold constant or control the variables of direction of tool use, angle of tool use and the pressure applied to the working tool. Without the use of a machine it is difficult to maintain consistency in the application of these variables. These tool using controls should be regarded as close approximations.

The direction of tool use was similar in all experiments and consisted of pulling the hafted tool towards the worker with the ventral surface of the tool facing the direction of movement (Fig. 1). This is not a universal pattern of endscraper utilization. When end-scrapers are hafted in a straight handle they may be used in a planing-like motion towards or away from the worker as is common among many Eskimo groups (see Nissen and Dittemore 1974; Mason 1890).

My use of the right angle handle, however, prohibits this type of motion.

The angle of the hafted tool to the worked surface, or contact angle, was a compromise between consistency and working comfort (see Figure 1). Mechanical controls would undoubtedly lead to more precise experimental conditions but might give cause to question the degree of relationship between the "controlled" and the "real" situation. In attempting a compromise the contact angle was not held constant, but rather the variation of this angle was held nearly constant and was recorded. As a rule, with each stroke the tool first contacted the work with the edge of the tool at an angle of about 65°. As the tool was moved down the surface (toward the worker) the angle became more obtuse reaching a maximum of 90-95°. I believe that most scraping was done with a contact angle of between 70-80°. This angle of work was both comfortable to sustain for fairly long periods and usually effective in the removal of material from the worked surface.

More difficult to measure or control is the factor of pressure applied to the working edge of the tool. While it has not been shown that manipulation of this variable alone will cause the production of differential use-wear, logically I would assume this to be true. Lawrence (1976) used stone tools set in a mechanical arm to cut and scrape various materials at a constant pressure. This pressure load was calculated to simulate pressure exerted by a human. Apparently, however, the pressure load was never varied so that the direct influence of this variable remains untested. I attempted to use the endscrapers with roughly similar applications of pressure in each experiment. Over nearly a year of experimentation, however, this must have varied considerably.

The duration of the experiments was recorded in numbers of strokes on the worked surface rather than in elapsed time or in the achievement of a goal. The tests were not task-oriented in that they did not culminate in the straightening of an arrow shaft or the production of a bone tool. Tools were generally used for a determined number of strokes, then examined, then reused for another set of strokes, and so on. Tools were used until they were deemed to be very dull, or functionless for their specific task. None of the tools were used on more than one worked material. Frequently three or four tools were used in one experimental setting on one material. For example, at the beginning of a wood working test one tool might be used 250 strokes, a second tool 500 strokes and a third tool 1000 strokes. Taken into a lab these tools would then be cleaned, weighed, examined, photographed, re-weighed and then used again on the same material for an additional 500, 1000 and 2000 strokes respectively.

Resharpening

Obviously, the relationship between resharpening of a tool and the observation of wear patterns may be of great importance. This is especially true when dealing with endscrapers, as there is abundant ethnographic evidence to suggest that these tools were frequently re-edged. Mason, in reference to northwestern Alaskan Eskimos, reports:

> The leather worker is incessantly touching up his scraper edge with the chipper, and that in time he wears it out to a mere stub. This constant sharpening also accounts for the fact that few specimens show signs of great wear (1890:586).

Osgood (1940:80) reports that the Ingalik Athapaskans may sharpen a hafted endscraper five times while scraping one caribou hide. Gould et al. (1971) and Tindale (1965) provide ample documentation of the importance of scraper resharpening among Australian aborigines.

While recognizing the potential significance of this process, the experimental tools used in my study were not resharpened. This decision was made in order to facilitate hypothesis testing. Testing the hypothesis that specific wear patterns form in response to tool use on a particular worked material may not be possible when the experimental tools are resharpened. It will be up to future studies to test a more complex hypothesis which includes tool resharpening.

## CHAPTER 4

## MICROWEAR TERMINOLOGY AND EXAMPLES

In this chapter I will introduce the basic terminology to be used in describing the results of the experiments. In so doing I will refer frequently to examples of the different wear types as illustrated in the plates at the end of the thesis.

### A Rose By Any Other

No microwear study in recent years has been able to avoid the difficulties of nomenclature. While a prime directive is to produce, examine and document wear patterns resulting from specific kinds of activities, it follows that terms must be attached to these patterns. The terminology presented below should not be regarded as a fixed or complete catalog of types of wear. It is a terminology designed to fit the needs of the project.

Odell correctly stated "there is a crying need for precision and standardization in microwear studies" (1975:228). One example should suffice to bring the point home: virtually all scholars agree that one type of tool alteration which may occur during use is the removal of tiny flakes from the edge in contact with the worked surface. This process has been referred to by no less than the following terms: "nibbling" by Hester and Heizer (1973); "chattering" by White (1969); "microflaking" by Tringham et al (1974); "edge-scarring" by Odell (1975); "small terminated flakes" by Gould et al. (1971); "use-flaking" by Sollberger (1969); "squills" by Barnes

(1932); "chipping" by Rosenfeld (1971); "uni-directional flaking" by Nance (1969); and "utilization retouch" by Ahler (1971). Other microwear terminology is similarly confused.

Furthermore, the number of wear types recognized will vary widely. For example, Nance (1971) distinguishes between striations and attrition, while Ahler (1971) proposes fifteen wear types. However, as a rule the more complex terminology schemes are actually composed of only a few kinds of wear which are then subdivided into categories based on locus, orientation or the extent to which they are developed. Perhaps the greatest need at present is to standardize terminology for the few fundamental kinds of microwear, and despite the preponderance of terms in the literature there does seem to be a general consensus.

A preliminary distinction should be made between additive and subtractive types of tool alteration. The term "wear" implies a subtractive process, and indeed recognition of tool wear almost always represents a net reduction (however minute) of tool mass. Witthoft (1967) is one of the few to argue for "wear" by addition to a tool surface. Witthoft's argument is based on specialized usage of a particular form of tool and is not analogous to the concerns of this thesis.

Most microwear research recognizes subtractive, or attritional, kinds of wear. Synthesizing the extant nomenclature on the dominant classes of microwear the following categories are recognized: 1) what has been referred to as chipping, micro-flaking, nibbling, and stands for the process of removing minute flakes from a tool's edge or surface; 2) what has been referred to as rounding, smoothing, abrasion, and stands for the gradual reduction of angularity of a tool edge or surface resulting in a dulling effect; 3) what has been referred to as gloss, polish, sheen, and stands for an increase in the degree of reflectivity or luster of a portion of a tool relative to the reflectivity of the rest of the tool; and 4) what has been referred to as striations and includes scratches, furrows, and grooves manifested by a tiny linear gouge or groove in the edge or surface of a tool. With slight reservations, I believe these four categories represent irreducible classes of micro and/or macrowear, which are visually and perhaps demonstrably different. As explained below, the wear type known as "polish" is a partial exception to this belief.

The following terms will serve as the base categories of wear to be used in this report. All are terms already in the literature and are descriptive of some physical characteristic.

> The term microflaking shall be used to designate the removal of tiny flakes from a portion of a tool which is under pressure and in contact with another object. The important element of this class of wear is that it represents more than single-grain removal or attrition. Relatively large, cohesive portions of the rock surface are being removed at a single time producing a flake, and leaving on the rock a corresponding scar. The mechanical basis of the microflaking process is essentially similar to the intentional flaking of tools during manufacture (Crabtree 1972a:34-35). The term microflaking is intended to subsume many variations of this general process. Consequently, microflaking may be complete, stepped, hinged, contiguous or scattered, extremely microscopic in size or visible at the macro level, at any loci and of any orientation.

Precise quantification of this wear type is permitted by the micrometer in the binocular scope.

The second class of wear recognized is <u>rounding</u>.

> <u>Rounding</u> represents the process of fine abrasion or attrition of any portion of a tool through the gradual removal of fine particles or single grains, the truncation or smoothing of grains, or a powdering of a portion of the tool while in contact with another object. The essence of this kind of wear is that material being removed or worn down is extremely small and therefore no true flake scar is produced. The physical observation of rounding rests upon the recognition of a reduction in angularity, especially at edges and along the ridges of flake scars and other protrusions. Again, the term is an inclusive one, subsuming many of the features previously assigned to terms such as smoothing, dulling, blunting and abrading, and other expressions of the processes of trituration and comminution.

As a form of microwear, rounding is difficult to quantify. No system for measuring this trait has been proposed and most reports simply note its presence or absence or occasionally add the prefixes "light," "heavy," and so on. I offer no solution to this dilemma, but I will distinguish between and illustrate two forms of the rounding process.

The third class of microwear is the striation.

> The term <u>striation</u> will be used to designate a linear groove, scratch or furrow found on any portion of a tool. These grooves are apparently the result of a gouging out of a channel in the surface of the raw material, and occur when the tool is under pressure and in contact with another object.

Semenov (1964) has argued convincingly that striations are caused by foreign inclusions coming between the tool and the worked surface. Recently however, the nature and origin of striations has been reexamined (Del Bene 1977; Clouse 1977) and Semenov's model may be too simplistic to explain the full range of striation formation. My experiments which include silt abrasives will help test Semenov's ideas.

Striations, like microflaking, can be accurately quantified on the basis of length, width, orientation, loci, frequency and so on.

The last, and perhaps most complex, wear type is termed polish.

> Polish usually refers to a reflective quality of a part of the stone tool where there is an enhanced luster or sheen relative to adjoining, unaffected parts of the tool.

Polish is thus defined and identified on the basis of reflected light, not on the basis of micro-morphology. According to this view polish stands apart from other wear types which are recognized as morphological alterations to a rock surface. Many authors would argue however, that this reflectivity of a surface is in fact the result of morphological changes on the polished surface. The mechanics of polish formation are complex and subject to much debate. Some argue that polishing is caused by the abrasion of a surface, others argue deposition of some substance causes the polished appearance (see Del Bene 1977; Kamminga 1977 and Rabinowicz 1968 for a discussion of different theories of polishing). Regardless of the answer to these questions the important point is whether or not polish has any diagnostic value as an indicator of specific tool using activities. Keeley and Newcomer (1977) convincingly argue that polish is an important functional index. Accordingly, I will treat polish as a formal class of use-wear.

> Polish will refer to the visual appearance of the utilized tool as expressed in degrees of light reflectivity and as opposed to the adjoining, unaffected surfaces. Thus my use of the term polish emphasizes the visible light properties of the utilized tool surface, and should not be confused with more traditional concepts of polish as a glossy or lacquer-like coating on the tool surface.

As with rounding, polish is a nondiscrete feature posing problems in quantification. Although Keeley and Newcomer (1977) have differentiated polish to finer levels than previous authors, these distinctions are still subjective assessments such as "bright," "dull," and so on. I will use similar modifiers and will cite examples below.

Examples of Specific Wear Types

From this point in the thesis frequent reference will be made to the accompanying photographic plates. Accordingly, a few preparatory words may assist in their viewing. With only a few exceptions, all of the photomicrographs are of the distal, or beveled, end of the scraping tools. This portion of the tool is also referred to as the working end and the dorsal face (see Fig. 1 for a schematic representation of these areas). The experimental endscrapers were photographed in two different positions: first, with the longitudinal axis of the endscraper oriented vertically, forming right angles between the dorsal and ventral surfaces of the tool and the horizontal plane on which the tool stands (see Fig. 1, and Plate 3). In this position the endscraper is standing on its proximal end, the working or distal end of the tool is in view, and the ventral surface of the tool cannot be seen (see Plates 8, 9a, b, c, d). The second photographic position is with the tool tipped back from the first position forming an obtuse angle between the tool's ventral surface and the horizontal plane and an acute angle between the tool's dorsal surface and the horizontal plane (Fig. 1). In this position both the dorsal and ventral surfaces of the tool are visible but out of focus as distance increases from the point of juncture between the dorsal and ventral surfaces (see Plates 15b, 18a, b).

The juncture of the ventral and dorsal surfaces forms the working edge of the tool. In this thesis the term immediate edge will refer to the centre of the juncture of the dorsal and ventral surfaces (Fig. 1). Moving from this point onto the chipped (distal or worked) face of the tool is referred to as movement onto the dorsal face of the tool (Fig. 1). For example, Plate 12a illustrates the distal end of an endscraper with tiny flake scars near the immediate edge, and the ink dot is 2.05 mm up the dorsal face.

Microflaking

Traditional archaeological treatment of attribute analysis has focused on the taking and manipulation of metric measurements. The use-wear category known as microflaking fits most comfortably into this traditional mold and accordingly has received the greatest amount of attention. Given the proper equipment the shape, length, width and even the depth of micro-scars on stone tools can be measured. The shape of the scars may be classed according to their correspondence to some pre-established taxonomy of scar shapes. An approach to microwear analysis emphasizing this aspect of microwear classification has been championed in recent years by Tringham et al. (1974) and Odell (1975; 1977).

I have recognized three morphological categories of microflaking (feather, step and hinge), and two configurations which these flake scars may take (crushing and nibbling). All of these terms are in fairly common usage among lithic researchers (see Crabtree 1972b; Tixier 1974) and will be discussed only briefly here.

The three [illegible]al categories of microflaking are distinguished by the t[illegible]mination of the detaching flake. A "feather" flake o[illegible] results when the force of the initiated flake travels through the rock mass, gradually moving closer to the rock surface until the flake detaches. The distal end of a feather scar has a smooth, gradual transition between the scar and the rock surface. There is no ridge or lip at the distal end of feather scars. Feather scars are visible on the edges of the tools in Plates 10b; 11a; 12a, b; and 15a.

The second type of flake termination is called "step." A step flake and scar result when the flake detaches in a right angle break at the distal end of the flake. This breakage occurs just under the rock surface, hence there is a "step" formed from the rock surface down into the flake scar. The detached step flake has a blocky distal end with approximately a $90^{\circ}$ angle between the ventral surface and the blocky end. The scar on the tool mirrors this blocky termination. Step scars can be seen near the edges of the tools pictured in Plates 9a and 12c, along the edge below the dot in Plate 16a, b, c, and in Plates 28a and 31a, b.

The third type of flake termination is called "hinge." A hinge flake and scar result when the force of the detaching flake abruptly turns back and connects with the rock surface. The detached flake has a rounded or convex distal end in cross-section, while the flake scar has a concave terminus usually with an overhanging lip. Hinge fractures are difficult to distinguish from step fractures; they are usually identified by the presence of an overhanging lip hiding the terminus. These overhangs, however, are quickly removed during use and once gone the hinge scars resemble step scars. Some examples of hinge fractures can be seen on the right side of Plate 9b; the upper left of Plate 9c; and the central and upper parts of the tool edge pictured in Plate 20a, c.

The two flake configurations are arrangements of the types of scars listed above. "Crushing" refers to a dense concentration, usually near the tool edge, of overlapping scars resulting from flaking and breakage of the edge area. Repeated flake initiation in a restricted area causes the partial removal of lateral ridges and termini of previous scars. Thus the crushed area is heavily scarred, but the majority of the scars lack definition because they are not complete. Crushing can occur during either tool manufacture or use. Crushing can be seen in Plates 8 and 9a; at the lowest part of the tool edge in Plate 20a; on the right side of Plate 24c; and the lowest parts of the edges in Plates 26a, b and 31b.

"Nibbling" is a term used to describe an orderly, parallel arrangement of flake scars. There seems to be a tendency for nibbling scars to have feather terminations. Apparently, nibbling is caused by a consistent application of pressure or force along an edge, the ventral side of which serves as the striking platform. Nibbling may also be caused by manufacture or by use. Examples of nibbling are seen in Plates 11a, b and 12a, b.

Rounding

For obvious reasons the use-wear type termed rounding is much less amenable to metric quantification. I know of no attempts to standardize subdivisions of this wear type (also referred to as abrasion and smoothing). In this report rounding will be divided into two categories based on the manner in which the physical process of rounding occurs, and subsequently, the visual appearance of the rounded areas. Specifically, the first type of rounding occurs as a result of breakage of rock material from the working end of the tool. In this process grains or clusters of grains of rock material are removed or truncated from the tool edge leaving a rough, pitted appearance. Thus, while the overall effect is a rounding off of the tool edge, the method by which this is achieved emphasizes the microangularity of the rounding process (see Plates 28d; 33c, d; 39a, b; 41b, c).

The second type of rounding occurs as a result of a smoothing or wearing down of the rock surface. Grain removal is achieved through a fine abrasion of the tool edge rather than by the breakage or truncation of rock mass. The resulting appearance is of a smooth surface lacking the microangularity noted above (see Plates 18a, b; 23a, b; 47a, b, c, d).

A further consideration of the rounding phenomena is the physical extent of the use-wear. Distribution of this use-wear is described according to its location in relation to the juncture of the dorsal face and ventral surface (immediate edge). For example, Plates 18a and 22b depict rounding use-wear extending a maximum of 1.0 mm up the dorsal face of the tools.

Polish

As defined above, polish refers to the visual appearance of reflected light on the tool surface. Consequently, subdivisions of this wear type must be relative and imprecise. Polish is described according to its intensity as being either matte, moderately bright or very bright; and secondly according to its arrangement as being either scattered and discontinuous (pitted), or as continuous.

Matte polishes appear flat or dull (see Plates 42c, d; 43d, e, f, g). Moderately bright polishes appear as reflective areas with some gloss or sheen but less intense than the very bright polish (see Plates 24d; 27a, b; 28d; 33c, d; 39b). Very bright polish appears as a highly reflective surface with a greasy or smooth quality (see Plates 18a, b; 20d, f; 22b; 23a, b; 47a, b, c, d).

The scattered or discontinuous polish arrangement is typified by a variation in the reflective properties of a portion of the tool surface. In such cases the examined tool surface has many point sources of reflected light of differing intensity resulting in a scattered, or sometimes pitted appearance (see Plates 13c; 24d; 25c, d; 28d; 30d). The continuous, or smooth, polish arrangement refers to surfaces which exhibit a fairly consistent degree of reflectivity over a portion of the tool. Thus, there is an apparent homogeniety of reflectivity rather than a scattered or pitted appearance (see Plates 18a, b; 22a, b; 32b, e; and the vertical flake ridge in 35b).

The subclasses of polish are also described according to their physical distribution over the surface of the utilized tool.

No subclasses of the striation use-wear class are being established.

CHAPTER 5

UNUSED TOOLS

In Chapter 3 I argued that lithic studies need to pay greater attention to the unused edges of experimental tools. The gist of this argument was that the accurate documentation of use-wear formation requires a precise knowledge of the unused edge, thereby allowing an objective comparison of the used and unused tool. Only through such comparisons can the exact nature of use-wear be understood. Experimental studies which utilize retouched stone tools must be especially cognizant of these needs. In this chapter I will present the more important details of unused tool morphology, emphasizing the possible interpretational problems in use-wear identification.

The thirty experimental endscrapers were microscopically examined and photographed prior to use. The plates which document the use of each tool on a particular worked material always begin with a photograph of the tool in an unused condition. Examination of these plates along with written descriptions made at the time of manufacture form the basis for the following discussion.

It was evident that three of the four use-wear types did not occur during tool manufacture. Rounding of edges or surfaces was not observed on any of the unused tools. Likewise, striations were not observed. Tool manufacture will necessarily affect the reflectivity of the chipped surfaces. However, my results suggest that the arrangement of reflected light, and not the intensity, is directly affected. Thus, freshly chipped edges may exhibit a scattered pattern of light, but will not acquire a dull or bright polish. I emphasize that these results may be peculiar to the mode of manufacture and examination employed in my thesis. Other researchers using different manufacturing techniques and technical equipment may achieve different results. In support of my results, however, I might note t[illegible]ile the published information on unused edges is meager I have never seen reference to rounding, polish or striations occurring through the processes of manufacture alone.

The wear type termed microflaking occurs repeatedly during tool manufacture creating a serious interpretational problem for the microwear analyst. Retouching a tool edge, regardless of the mode of manufacture, produces a micro-morphology of great complexity and variability. At the macro level the flakes detached from the distal, or working, end of the scraping tool may seem regular and patterned (see Plate 3). At the microscopic level, however, the complexity and variability are increased.

Examination of the thirty unused tools revealed the following [illegible]formation pertaining to microflaking. All of the subclasses of microflaking defined in the previous chapter are to be found on the edges of the unused tools (refer to plates cited in these definitions). Most commonly, the edges of freshly chipped tools exhibit step scars. Unused edges may also exhibit features often associated with used tools, such as crushing (Plates 8; 9a), and nibbling (Plate 11a, b). In addition, manufacture scars exhibit a full range of shapes in plan view: from cone-shaped (Plate 12a, b); to rectangular (Plate 45a); to cresent-shaped (Plate 21a; 28a); to semi-circular (Plate 24a); to irregular (Plate 16a; 17a). Of these, cresent-shaped scars are most common. The density or frequency with which microflake scars occur at any one portion of the distal end of the tool varies from few or none (Plates 25a; 33a; 40a), to dozens or hundreds (Plates 8; 9a, c; 20a; 26a). Typically, an abundance of these scars is more common than their absence. Finally, microflake scars show considerable variability in their occurance on the tool edge in relation to the overall morphology of the tool. That is, the micro-scars may form at the base of the ridges of the macro retouch scars (Plates 33a; 38a), or they may form in the slight concavities between these ridges (Plates 12a, b; 14a; 40a), or they may occur along most of the tool edge at both of these locations (Plates 16a; 17a; 20a; 21a).

Most of the micro-scar morphology described above can be explained by the normal processes of force initiation, force transmission and conchoidal fracture. Sometimes, however, micro-scars appear which are not easily explained by these processes. While examining the unused endscraper edges I noted several instances of flake scars arranged in neat, parallel fashion yet so small that it seemed impossible they could have been individually struck by the artisan. Very recently a publication has appeared which notes and explains the same phenomena. Newcomer coins the term "spontaneous retouch" and defines it as follows:

> Spontaneous retouch results in the fraction of a second when a flake is struck from a core by whatever part of the knapper's anatomy is supporting the core --- usually his hand, foot or padded thigh. The force which detached the flake pulls the proximal end of the flake away from the core, while the knapper's hand, foot or thigh acts as a pivot forcing the other end of the flake against the core. This pressure is often strong enough to detach a row of tiny chips or 'spontaneous retouch' (1976:62).

Plate 10a and 10b illustrate what I consider to be a classic example of spontaneous retouch. The tiny, parallel scars at the top of the semi-circular step scar are well removed from the edge of the tool and thus could not have been struck by the antler billet. Instead, as the larger step flake was detached, force was transferred into the surrounding rock mass causing the detachment of the tiny flakes. Because of their small size, if these tiny scars had occurred at the edge of the tool they could easily be interpreted as use-retouch. While Newcomer reports that most spontaneous retouch occurs at the distal end of a flake scar (hence, on a unifacial tool these tiny scars would tend to be found away from the immediate edge), he also notes, "where the flake is allowed to roll sideways, however, lateral retouch or notches may occur, sometimes near the proximal end" (1976: 64). Thus spontaneous retouch may occur along the edge of a unifacial tool. I believe Plate 11a, b illustrates two examples of this occurence. Again, the scars are neatly arranged, parallel and have feather terminations. The frequency with which spontaneous retouch occurs is not known. In examining the thirty experimental tools I have noted at least four instances of what I believe to be spontaneous retouch.

Summarizing the above information; rounding, polish and striations did not occur during manufacture of the experimental tools. Microflaking occurred and resulted in a highly complex micro-morphology. The unused tools displayed a high degree of variability in such matters as microflake morphology, flake scar shape, density and distribution. Furthermore, the occurence of spontaneous retouch enhanced the complexity of the unused tools.

These conclusions are relevant in assessing the value of use-wear types as indications of tool function. The absence of three of the use-wear types on unused tools makes these wear types particularly useful in at least the initial step of functional analysis --- determining whether or not a tool has been used. It remains to be demonstrated whether or not these wear types are also useful as indicators of specific tool use. Microflaking, however, presents special interpretational problems, as it occurs in a variety of forms as a result of manufacture alone. Thus, to be useful as either an indicator of first, a used tool, and secondly, the specific function of that tool, it must be demonstrated that microflaking occurs in dissimilar ways on unused and utilized tools. This question will be discussed in Chapter 10 after the results of the tool-using experiments are presented.

# CHAPTER 6

# WOOD WORKING RESULTS

## Introduction

The next four chapters will present the data and information generated from the tool-using experiments. Since the primary purpose of this thesis is to test whether or not wear patterns are task specific, the results are organized and presented according to the four worked materials: wood, antler, bone and hide. Each of the four chapters begins with a section which assesses the effectiveness of working each material with the hafted endscrapers. This is followed by a discussion of the life span of the tools relative to the requirements of each task. Data on weight loss or gain is also presented in this section. These results are then compared to the works of others who have discussed factors such as the effectiveness of working certain materials and the life span of tool use. The second section of each chapter will discuss and illustrate the use-wear produced by the scraping of the different worked materials. The dominant configuration of the use-wear type or types believed to be diagnostic of each task will be presented. Comparisons of these results are postponed until Chapter 10 when all the experiments are completed.

Wood Working Results

A total of nine experimental tools were used to scrape wood: tools #1, 13 and 22 were used on fresh spruce; tools #10, 24 and 26 were used on fresh aspen; tools #28, 29 and 31 were used on dried spruce.

Fresh Wood. Scraping the fresh wood specimens consisted of scraping away the outer bark, then the inner bark, then scraping the sapwood. Dead heartwood was never encountered in the fresh or seasoned wood. Working these three wood layers with hafted scrapers was generally effective and rapid, with the exception of the fresh sapwood layer. This layer is composed of extremely moist, fiberous tissue, shreds of which adhere to the working edge of the tool causing it to slide over the wood surface. This clogging happens constantly when working the sapwood layer, requiring the tool to be cleaned after virtually every stroke. It seems unlikely that aboriginal people using similar tools in a similar fashion would have used these tools to scrape fresh sapwood. My experiments quickly focused on the removal of the inner and outer bark layers only. These layers were effectively removed with the stone tools, as the dry strips of bark simply fell away from the tool edge.

There were few noticeable differences between working the two types of fresh wood. Spruce seemed slightly more resistant to work. Perhaps this was due to the roughened scaly nature of the outer bark causing the tool to grip and tug more so than on the smoother aspen. Perhaps the sticky nature of spruce sap added to this resistance. Occasionally, the sticky spruce wood would have to be picked off the end of the working tool.

<u>Dried Wood.</u> Only spruce was scraped in the dried condition. Working dried wood was different from fresh wood in one respect. The sapwood layer, once dried, behaves more like the bark layers, falling off the edge of the tool, and effective scraping of this part of the wood was now possible. Dried bark (and sapwood) have less internal cohesion than when moist and tend to scrape off in small shavings.

Tools used to scrape fresh and dried wood tended to have the same effective life span, hence they will be considered together Of all the experiments conducted, wood working tools tended to have the longest life span. Frequently, these tools were still effectively scraping wood after 2000-4000 strokes. This longevity may be due in part to the frequent microflaking of the working edge. This flaking process, to be described below, was a common occurence on wood working tools and served to rejuvenate the tool edge. Also, scraping the inner and outer bark layers of spruce and aspen are not tasks which require a particularly sharp edge. Once broken, strips of bark may be pushed off mainly by exertion and lateral force. Only in the scraping of dried sapwood was a sharp edge a real necessity. Removal of sapwood is more of a true scraping process rather than a peeling process as with bark. After about 2000 strokes tools used on dried spruce were no longer sharp enough to scrape sapwood, and for the remainder of the experiments these tools were used only to scrape bark layers.

Broadbent and Knutsson (1975) also used a few experimental endscrapers to scrape pine and birch. They report that scrapers used on pine were generally dulled after about 600 strokes, and tools used on birch about half that number (1975:117-119). The discrepancy between their results and mine may be due to the fact that their tools were made from quartz. My chert scrapers may retain a sharp edge longer than quartz scrapers. Hayden and Kamminga report Australian aborigines using a scraper-like adzing tool on soft woods for up to an hour without resharpening (1973:4). I would expect this would be equivalent to at least several thousand strokes. Gould et al. (1971) also reported on Australian aborigines use of the hafted adze or scraper. These authors confirm the effectiveness of this tool as a wood scraper, and recount one event where a scraper was resharpened twenty times in an eight and a half hour project (Gould et al. 1971:152), or about once every twenty-five minutes.

I suspect that there is great variability in the effective lives of tools used to scrape wood. The raw material of which the tools are made, the kind of wood being worked, and the different layers of wood to be worked (eg. bark vs. sapwood) are all likely to be important in determining the effective period of use of a tool.

Wood working tools exhibited a great range of weight changes. Seven of the nine tools used to scrape wood registered a loss of weight. In most cases only a few milligrams were lost (Table 1). However, the three tools which experienced the greatest amount of microflaking showed substantial loss of weight (27, 14 and 10 mg). One tool showed no loss of weight and one tool registered a gain of 2 mg.

## Wear Patterns on Wood Working Tools

After viewing and photographing tools used on fresh and dried spruce and fresh aspen it was concluded that there were no demonstrable differences between the use-wear of these different tasks. As mentioned previously, the two species of wood are very similar in density, and the only noticeable difference between scraping of fresh *vs.* dried spruce is in the efficiency of scraping the sapwood layer. The following information on use-wear characteristics, then, is drawn from the wood working tools considered as a single functional activity.

*Microflaking.* Microflaking, though not the dominant form of use-wear associated with wood working, was quite common on all of the scrapers used on wood. All nine tools experienced some flaking of the working end, and most tools experienced flaking at several locations on this end. As will be illustrated below, the size, shape and frequency of the microflaking process was highly variable and is not considered to be diagnostic of wood working activities.

One of the more common forms of microflaking of these tools was the removal of large feather or step flakes from the dorsal face of the tools. Plate 12a and Plate 12b show at least four cone-shaped feather scars on the edge of Experimental Tool No. 24 in an unused condition. After 500 strokes on aspen these manufacture scars have been eliminated and replaced by at least four new scars which have traveled a maximum of .71 mm up the dorsal face terminating in step fractures (Plate 12c). The tool edge at this same spot did not change with an additional 1000 strokes. Some analysts might interpret this as an indication of edge stability. With wood working tools this is not necessarily the case; the conditions necessary for flake detachment --- be it the proper contact of this portion of the tool with the wood or the striking of a projection on the wood surface --- may not occur for extended periods of use. After an additional 2000 strokes (N=3500) with the same tool at least one new scar is visible (Plate 12d), and after 3500 more strokes (N=7000) numerous new scars of a considerable size range can be seen (Plate 12e). Notice that all of the use scars are very shallow in depth and thus their terminations, being so close to the rock surface, appear to be feathers but in fact are small steps.

This example of prolonged microflaking illustrates an important principle in the use-wear formation on the tools I used to scrape soft woods. On several occasions during the wood scraping sessions actual flaking of the working edge was noticed; frequently the flaking could be heard; sometimes the detached flakes were felt by the experimenter as they flew off, and on several occasions these flakes were recovered and retained (Plate 13a, b, c). This noticeable flaking of the tool edge was nearly unique in all the scraping experiments (with the partial exception of some bone scraping experiments discussed below) and allows the researcher to state exactly when the flaking occurs. In the case of wood scraping tools this microflaking occurred when the moving tool struck a projection (usually the raised area of the wood surface where a twig or branch had formerly been) momentarily stopping the tool and flaking the tool edge. Most likely scraping a [illegible]oth surface of these soft woods would, in itself, cause littl[illegible] [illegible]oflaking. Importantly, this contact with a projection [illegible]ld obviously happen at any time in the working life of the tool. Thus, there is no reason to suspect greater microflaking during earlier uses of the tools than during later uses. The results of the experiments confirm this suspicion. Plates 14-16 provide additional examples of these tools experiencing microflaking at various times in their life cycle.

Correlated with the tendency of wood working tools to microflake only when the motion of the tool is interupted is the tendency for the resulting flake scars to be relatively large. Comparison of most of the plates presented in this section with those of microflaking caused by other kinds of tool use will demonstrate this point. The production of fairly large scars on the working edge of the scrapers is not sufficient for identification of wood working activities. In my limited experiments neither the morphology, the distribution nor the frequency of these scars were distinctly different from the scarring produced by manufacture. Furthermore, for every apparent pattern of edge-scarring there were many conflicting cases. For example, most of the plates presented so far illustrate a tool edge becoming more heavily scarred in that new scars are added, thus increasing the complexity of the local micro-topography. Plate 17 illustrates the reverse effect, where a tool edge, after 9000 strokes on fresh aspen, has been simplified considerably from the unused form. Perhaps noteworthy is the fact that the type of microflaking defined as crushing (Plate 9) almost never occurred on wood scraping tools.

Rounding and Polish. Although microflaking commonly occurs on the tools used on wood the nature of the flaking lacks diagnostic value. Of greater functional significance is the finer abrasion which occurred on all tools used on wood, leaving a rounded or smoothed and polished edge. As defined in Chapter 4, the rounding process involves the removal or truncation, or the wearing down and smoothing of surface grains. No flake scar is produced. Polish, the reflectivity of utilized parts of a tool relative to the unused portions, may be inseparably linked with the rounding and smoothing process, or it may be a separate phenomenon. Whatever the case, no wood working tools exhibited rounding without polish, hence these forms of use-wear will be discussed together.

From the experiments conducted it may be concluded that the distribution and the nature of the rounding and polish on the wood working tools show recognizable patterns which tend to typify this particular tool use. However, it must be emphasized that the patterns described below are based on samples too small to be statistically significant and thus require confirmation or refutation by further research.

Rounding and polish both tend to form in the immediate edge area; that is, on the exact edge itself or within 0.50 mm on the dorsal face of the tool (see Plate 19a; but also see Plate 22b for an exception). Both rounding and polish were found in their most pronounced form on projections at the distal end of the tool --- usually the ends of the flake scar ridges which run perpendicular to the working edge (Plate 18). It was on the faces of these ridges where evidence of rounding or polish would be found the furthest distance up the dorsal face. In areas where the tool edge was straight or smooth, rounding and polish were found continuously along the edge (Plate 19). Given the convex curvature of both the tool edges and the wood surfaces, and considering the nonelastic properties of the wood surface, the resulting area of contact between the tool and the wood is probably no more than a few millimeters at a time. Bearing this in mind, it i[illegible]o understand why the wood working tools exhibit most use-w[illegible]he center of the distal ends. The nonelastic nature of the wood surface also accounts for the lack of polish or rounding higher up the dorsal faces of the tools where the rock surface would not contact the wood.

The type of rounding characteristic of wood working tools was a wearing down or smoothing of the rock surface rather than a breakage of the tool edge. The used tool edge appears smooth, not rough. As surfaces become more and more rounded they also become polished. Plate 20 illustrates a sequence of microflaking on the dorsal surface and rounding and polishing of the edge area as the tool is used to scrape wood. In the final photo of the dorsal face, Plate 20e, one can see the loss of angularity of the flake scars. This rounding of the first 0.5 mm of the dorsal face was common to all the tools used extensively on wood and definitely increased with continued use (see Plates 21, 22).

The polish caused by working fairly soft woods can be described as very bright and continuous. That is, relative to the polish formed by other tool uses, this polish is highly reflective (Plates 18a, b; 23a, b). Where the tool edge is fairly straight and smooth (lacking prominences) the polish forms in long thin bands (Plates 19a, 22a). Where the edge is complicated with protrusions, or simply where the edge angle is steeper thus bringing more of the tool surface into contact with the worked material, the polished areas may become much more extensive (Plates 23a, b; 20f). Note, however, that all of the polished surfaces display a certain homogeneity or smoothness of the lusterous areas as opposed to a more discontinuous type of light reflection typical of more rugged topography (as described in following chapters). I believe that this homogeneous, bright polish correlates directly with the rounding process as dominated by a fine smoothing down of the surface of the rock. I would argue that these two features are the most representative forms of use-wear associated with scraping wood.

<u>Striating</u>. None of the wood working tools exhibited any striations. Many of the tools exhibited "soft" striae; that is, etchings or grooves in the enamel used to cover the ink dots (see Plate 37d).

The presence of these soft striae suggests an abrasive agent of some sort getting into the working situation. This agent may have been bits of chert from the tool, or phytoliths in the wood, or dust and dirt which accidently got onto the wood surface. Whatever the case, all of these soft striae abruptly ended at the edge of the enamel.

Summary. Scraping wood with hafted endscrapers was an efficient and effective process. Bark layers were easily removed on fresh and dried specimens of spruce and aspen. Sapwood layers could not be scraped when fresh, but were effectively removed when dried. Tools used on wood remained effective for very long life spans.

Microflaking is very common on wood working tools but is not considered diagnostic. Flake removal seems to be connected with the tool's striking of projections on the wood's surface. The detached flakes are large and cannot be confidently distinguished from manufacture scars. The immediate working edges and adjacent dorsal faces of all tools used on wood were rounded and polished. The rounding process seemed to be one of slow, gradual wearing down of the rock surface, producing a very smooth surface texture. All rounded areas are also polished. [illegible] polish takes the form of a very bright, homogeneous luster. It is believed that the combined features of rounding and polishing represent the best chance for a functional indicator of wood working tools. True striations were not observed.

CHAPTER 7

RESULTS OF WORKING ANTLER

Introduct on

Fc experimental tools were used to scrape antler (#s7, 16, 17, 20).

ior to the scraping experiments an elk antler tine was soaked in water for two weeks. This soaking proved extremely beneficial. Dry antler is hard and brittle and gives up little of its surface material to the tool edge. Soaked antler is soft, pliable and easily scraped. These findings are in agreement with the results of numerous experiments conducted by Mark Newcomer (pers. comm.). After each of my scraping sessions the antler was replaced in a container of water.

As will be discussed below, microflaking of the tool edge was minimal. Consequently no rejuvenation of the tool edge took place, and dulling was a slow, gradual process. Beginning at about 700-800 strokes and continuing on to about 1500 strokes the tools slowly became less and less effective. The center of the distal end of the tool was the first to dull. The sides of the distal end remained sharp the longest. Near the end of each experiment I found myself almost unconsciously tipping the tool so that the sides would contact the antler surface and some effective scraping was achieved. The lack of flake scar rejuvenation of the working edge is certainly a prime factor in this gradual dulling process. Based on my experiments, I consider a sharp edge an essential requirement for tools to be used on antler.

The surface of the worked antler remained soft even after prolonged scraping during a single experimental setting. Furthermore, the surface of the antler never became heavily grooved by the edges of the stone tools. This is probably due to the very effective removal of material from the antler surface thus preventing the build up of deep grooves or furrows.

All four of the tools used on antler registered a small loss of weight (2, 2, 3 and 4 mg).

I am not aware of any other research where experimental tools were used to scrape antler. Hence, no comparisons can be made with the observations stated above.

Wear Patterns on Tools Used on Antler

Microflaking. In contrast to the wood working tools, microflaking was uncommon and of little consequence on tools used to scrape elk antler. This statement is true for nearly all areas of all four experimental tools used on antler; there was little variability in this regard. Two of the four experimental tools failed to show any evidence of microflaking (no flake scars visible at 50X, see Plate 26a, b). On the two remaining tools, microflaking was rare rather than the norm. As mentioned above, soaked antler is very easy to work, the surface being smooth and free of projections or other hinderances to hamper scraping. The paucity of microflaking is probably related to the soft, smooth nature of the antler surface. The most extreme case of microflaking is illustrated in Plate 24a, b and c. In this example multiple new step scars are visible after 1000 strokes. Subsequent use, however, caused little additional alteration with the exception of extremely fine breakage at the very edge (as noted in the plate captions). This latter feature, the tiny edge breakage seen on the right hand side of Plate 24b and all across the edge of Plate 24c, is the result of individual scars so small that their inclusion in the micro-flaking section should be questioned. Nearly all of this small scale use-wear seen on Plates 24b, c and Plates 25a, b is within 75 $\mu$ (0.075 mm) of the tool edge. On antler scraping tools it is more common to find this kind of minute edge breakage than it is to find larger, undisputed microflake scars. I believe that this tiny scarring occurs fairly continuously during antler scraping. However, identification of individual scars is only possible when they appear on a "very clean" portion of the tool edge (see the left side of Plate 24c and the straight, smooth edge of Plate 25b). It is believed that this kind of damage represents the upper end of a spectrum of use-wear which is characteristic of antler scraping tools. The majority of this spectrum occurs on a scale where no scar is visible; that is, the major attritional process caused by antler scraping is a breaking away of small amounts of rock material. Sometimes this leaves a tiny scar, but more often grains or clusters of grains of rock material are broken off or plucked out leaving a rugged, pitted appearance. This kind of use-wear is more appropriately considered under the category of rounding.

Rounding and Polish. As was the case with wood working tools, rounding and polishing of the distal ends was the dominant form of use-wear associated with antler scraping tools. All of the antler scraping tools experienced some degree of rounding and polishing. I believe that the development and form of these use-wear types on tools used on antler are distinctly different from the rounding and polish on wood working tools. A comparison of the two will be made after the main features of rounding and polish on antler tools are presented.

As mentioned above, the rounding process is believed to be caused by the breaking off or plucking out of rock material at the tool edge. This is opposed to the rounding of wood working tool edges which are characterized by a wearing down of the surface rock. Antler scraping causes an attritional process which results in a rounded area with a rugged, pitted appearance. This damage is seen only at the very edge (see Plates 24d; 25c, d; 27a, b). Breakage of the edge probably began immediately with the beginning of the experiments; however, little damage was visible prior to completion of 500 strokes. Rounding and polishing of the edge were both well developed after 800-1000 strokes, or about fifteen minutes of scraping.

Restricted distribution of this type of damage is characteristic of the rounding on antler scraping tools. This limited distribution is probably due to the hard, unyielding nature of the antler surface which results in a very narrow zone of contact between the tool and antler. With few exceptions, rounding was confined to a zone from 0 to 0.20 mm up the dorsal face.

The same edge areas which were rounded or smoothed were also polished. The rugged or pitted rounded edge gave rise to a scattered or discontinuous type of polish. The reflectivity or luster of the smoothed areas may be classed as moderately bright.

I would argue that antler scraping and wood scraping tools may be distinguished on the basis of differential expressions of rounding and polish. Because of what seem to be slightly different attritional processes, as described above, the two scraping tasks produce wear patterns which are visually distinct and, at least in one regard, measurably different.

Visually, both the rounding and the polishing appear different. Wood working tools have very smooth edges and surfaces while antler working tools are more rugged or pitted at the edges. Accordingly, the polish on wood working tools appears brighter and more fluid or homogeneous when compared to the scattered or discontinuous polish of tools used on antler (compare Plates 24c, d; 27a, b; 20d, f; 22b; 23a, b). The polish on antler scraping tools appears slightly duller than that found on wood working tools.

Measurably, the two tasks differ in the amount of surface area of the tool affected by utilization. While both wood and antler surfaces are relatively hard and unyielding, certainly the wood surface flexes a bit more than the antler. Because of this, one would expect the tools used on wood to show evidence of wear further up the dorsal face. This is in fact the case. The rounding associated with tools used on antler did not often affect the ridges or termini of flake scars more than 0.20 mm up the dorsal face.

Rounding on wood working tools was visible for as much as 0.50 mm up the dorsal face (compare Plates 24b, c with 20d, e, f; 21b; 22b; 23a, b). This difference in distribution of rounding and polishing may only be meaningful within the context of my own experiments where such factors as tool-to-work angle were held more or less constant. Obviously, manipulating this latter variable could radically affect the amount of surface area of the tool coming into contact with the worked material.

Striating. No striations were observed on any of the antler scraping tools, not even soft striae in the enamel.

Summary. Scraping soaked antler with hafted endscrapers was a very effective process. Tools worked well for the first 700-800 strokes at which point they were noticeably dull. Beyond 1250 strokes the tools ceased to function. All tools lost a small amount of weight.

Microflaking, rounding and polishing occurred on all of the tools used to scrape antler. Striae never occurred. The amount of microflaking is minimal, with two of the four tools failing to show any use scars. When detectable flaking did occur the scars were not demonstrably different from manufacture scars.

It is suggested that rounding and polishing are the st useful indices for identification of antler scraping. Rounding of antler scraping tools is noted for its rugged or pitted appearance. The reduction of angularity on the edges of these tools is caused mainly by a breakage or truncation of rock material rather than a wearing down process. Polish or luster from this rugged surface is scattered or discontinuous in appearance. Together these two use-wear features differ visually from the rounding and polish found on wood working tools. Also, the physical distribution of these wear features differ: tools used on wood show evidence of use-wear as much as 0.50 mm up the beveled edge, while antler working tools seldom exhibit use-wear further than 0.20 mm up this face.

CHAPTER 8

# BONE WORKING RESULTS

## Introduction

A total of eight experimental tools were used to scrape fresh bone: four of these tools (#s 2, 3, 27 and 30) were used on "clean" bone; four other tools (#s 5, 11, 21 and 23) were used on silty bone.

Clean Bone. Scraping clean bone with the experimental endscrapers was, in general, an unproductive task. Only minimal amounts of bone material were scraped away, and the rate was very slow. In contrast with the easily worked soaked antler, the soaked bone remained hard and intractable. Apparently, soaking and boiling did little to enhance the workability of the bone. These conclusions concur with those of Mark Newcomer (pers. comm.) who has conducted numerous experiments and found boiling and soaking bone to be of no assistance. Broadbent and Knutsson (1975) also scraped soaked cow bone but arrived at different conclusions. As cited in Chapter 3, they maintain that soaking and boiling did soften bone and make it easier to scrape (Broadbent and Knutsson 1975:119). I cannot explain the discrepancy between their results and my own.

Dulling, or loss of usefulness of the bone scraping tools, was more complicated than any of the other tasks. Microflaking of the tool edges was the cause of this complexity. As will be discussed in detail below, microflaking was exceedingly common on bone scraping tools. Flaking of the tool edge often caused a rejuvenation of the edge, thus temporarily extending the tool's life span. On several occasions the amount of microflaking was such that bits of rock material were visible on the bone surface (Plate 5). Consequently, the effective life of the tools was always in flux. No generalizations can be made regarding the number of strokes for which the tools remained effective. Some parts of the tool edge seemed dull after the first 100-200 strokes and remained that way for the rest of the experiment. Other parts of the same edge, presumably those which were rejuvenated through microflaking, seemed sharp after thousands of strokes. Generally, the central portion of the distal ends of the tools was dulled sooner than the side areas. If the process of rejuvenation through microflaking could be temporarily ignored, I would estimate that scrapers used on bone are quite dull after 250-350 strokes. Frequent rejuvenation, however, may prolong the effective life of parts of the working edge for hundreds or even thousands of strokes. Broadbent and Knutsson (1975:120) do not specifically discuss the influence of microflaking rejuvenation on bone working tools, but they report that such tools had a functional limit of about 250 strokes.

The clean bone scraping experiments were the only ones to produce consistently substantial weight reductions. The four tools used on clean bone registered losses of 17, 20, 29 and 33 mg (Table 1). There can be little doubt that this weight loss corresponds to the extensive loss of tool mass caused by microflaking.

Silty Bone. As discussed in Chapter 3, the bones used for the gritty scraping experiments were dusted with 35 g of silt just after they were brought out of water. Scraping seemed to rapidly remove most of the inclusions, so that after only ca. 50 strokes the bone appeared generally free of grit. As will be discussed shortly, however, the wear patterns associated with this task suggest that the silts, regardless of how long they remained on the work surface, have an important effect on the development of use-wear.

Most of the information presented above for working clean bone also applies to working silty bone. Again, scraping silty bone was not a particularly effective task. The addition of silt did not make the bone easier to work.

Dulling of the tools used on silty bone differed somewhat from tools used on clean bone. For reasons discussed below, microflaking of the edge was less common on scrapers used on silty bone. Consequently, some of the rejuvenating effects of the microflaking process were lost and the tools dulled sooner. Ignoring microflaking, these tools were probably quite dull after about 200 strokes. Since microflaking did occur, some parts of the distal end were sharp for longer periods of use.

Weighing of these tools did not produce consistent results. Two tools registered a slight gain in weight (+1 and +6 mg). These figures may be the result of errors made somewhere in the series of weighing sessions, or they may be caused by the adherence of silt particles in the numerous cracks of the step and hinge fracture termini. The other two tools registered substantial weight reductions (28 and 132 mg). The loss of 132 mg on one tool was primarily due to the removal of a large flake from the ventral surface. This flake detached during the first use of the tool and measured over 1.5 cm in length.

Wear Patterns on Tools Used on Clean Bone

It was found that there was a substantial difference between the use-wear formed on tools used to scrape silty bone and those used on clean bone. Accordingly, the results of these two different activities will be presented separately. What follows first is a description of the use-wear found on tools used to scrape clean bone.

Microflaking. Without exception the distal ends of the four scrapers used on bone were severely microflaked. Fracturing began as soon as tool use began and continued for several hundred and in some cases several thousand strokes. Commonly this flaking occurred at many locations on the working end of each tool. It will be argued below that microflaking is the dominant and potentially most diagnostic form of use-wear on bone scraping tools.

The extensive microflaking of bone scraping tools was often visible to the naked eye (Plate 5). Flaking of the tool edge and surface areas often caused a complete modification of macro and micro-morphology. Plates 28, 29 and 30 illustrate this dramatic tool alteration. It is apparent that this edge attrition occurs in a wide range of sizes; from tiny scars formed only in the vicinity of the immediate edge (Plates 32a, b; 33a, b), to large scars measuring more than several millimeters on their longest axis, and extending several millimeters up the dorsal face of the tool (Plates 29c, d; 30b, c; 31b). For the purposes of the present discussion, large scars are those with one dimension greater than 0.50 mm.

While it was noted that microflaking occurred as soon as tool use began, the tools were not rephotographed until after 250 strokes at the earliest. As can be seen, appreciable edge damage had already occurred by this time (Plate 28a, b; 29a, b; 30a, b). I would recommend that future studies examine bone working tools at earlier intervals. Sometimes this early microflaking was only the beginning of a long sequence of almost continuous fracturing (Plate 29a-e). Sometimes edges microflaked early in their use cycle and then remained very stable during subsequent use (Plates 28b, 30c and 31b illustrate edges which have already experienced considerable flaking, but which remain essentially as they are for several thousand more strokes). I am not sure what processes are at work which give rise to a stable edge as opposed to an unstable edge. I suspect these differences are due to a variety of factors, perhaps most importantly micro-edge morphology and edge angle. What is clear is that most parts of the distal ends of the bone working tools experienced considerable microflaking, and that this tended to occur early in the sequence of tool use. This is supported by the fact that the substantial loss of weight registered by these tools was greatest during the first and second uses of the tools. There were no instances where a portion of an edge which had remained more or less stable during early uses would suddenly begin to flake during later uses. This contrasts sharply with microflaking of wood working tools where flake detachment occurred at any time in the life span of the tool.

Microflaking on bone working tools was characterized by numerous, large, cresent or rectangular shaped flake scars with step terminations. However, the arrangement of these scars displayed considerable variability; from "crushing" as caused by multiple overlapping step scars (Plate 31b), to relatively "clean" edges [illegible] few large feather scars had detached (Plate 30a, b).

Another feature highly distinctive of [illegible] on bone working tools was the removal of microflakes fr[illegible] the ventral surface adjacent to the immediate tool edge. Again, these flake scars were large and had step terminations (Plates 28c; 29d). No other scraping activity produced microflaking, or any other use-wear type, on the ventral surface of the tool. Considering all eight tools used on bone (both clean and silty), ventral scarring was observed on four different specimens. Thus, ventral scarring occurred on half of the bone scraping tools and on none of the other twenty-two end-scrapers us[illegible] in the experiments. The presence of ventral scarring is considered a good indicator of bone scraping.

Rounding and Polish. Despite the frequent flaking of the bone scraping tools, and hence the repeated removal of rock mass from the tool edge, rounding and polishing of the working edge occurred. Determining the beginnings of the rounding and polishing processes was hampered by the rapid removal of rock material from the tool edges. The earliest I detected rounding and polish was after 750-1000 strokes (Plate 32b). In this instance the affected portion of the tool did not experience repeated microflaking. However, more typically, the working edge did microflake and rounding and polishing began only after some edge stability was achieved. After stabilization, rounding and polishing gradually developed as the number of strokes increased (compare Plates 32e, f and 33c, d with [illegible] and 30d). Yet even the most extensive expression of rounding and polish on bone scraping tools did not approach the development of these use-wear types on wood working, and to a lesser extent, antler working tools.

A further consideration of the development of rounding and polish on bone scraping tools pertains to the type of edge necessary for even minimal success with bone scraping. The scraper edge must be quite sharp. Microflaking helps maintain a sharp edge for long periods of use. Once the edge has stabilized and rounding and polish become better developed the tool gradually becomes less functional for this specific task. The native artisan would likely resharpen the tool at this point. Hence, well developed rounding and polish (as in Plates 32e, f; 34c, d) would not likely occur on prehistoric specimens.

Rounding on bone scraping tools is classed as the rough or pitted type where rock material is broken away. In this sense, the nature of the rounding of bone scraping tools is similar to that of antler scraping tools, in that the surface area of the tool affected by the smoothing process is minimal. An examination of Plates 28d, 30d, 32d, e, f and 33c, d will demonstrate the extremely thin dimensions of the smoothed area. Seldom does rounding occur further than 0.20 mm up the dorsal face of the tool. In addition, viewing the plates referenced above, notice how flake scars very close to the immediate edge retain their angularity even after long periods of use. For example, the scars seen near the edge of the dorsal face in Plate 32b were produced during the first 1000 strokes on bone. Plate 32c illustrates these same scars, viewed from a ventral perspective, after an additional 3000 strokes. The termini and ridges of the scars have for the most part remained quite sharp and distinct. Thus the distribution of this use-wear type does not differ from that of use-wear on antler working tools.

What does seem to differ slightly is the degree of smoothing. Though this is difficult to quantify, it seems as if the working edges of antler scraping tools are more completely rounded than are the edges of bone working tools (compare Plates 24d; 27a, b; with 28d, 30d, 32d, e, f). Given the greatly reduced amount of microflaking occurring on the edges of tools used on antler one would expect a greater rounding effect. This is a tenuous conclusion, however, given the small sample size.

The polish found on bone working tools is also similar to polish induced by antler. Polished surfaces tend to be of a discontinuous nature, scattered and pitted in appearance. The degree of reflectivity seems highly variable, but might be generally considered moderately bright. I cannot distinguish between antler and bone working polishes except to say the bone polish forms later and is more poorly developed than antler polish.

Striating. No true striations were found on any of the tools used to work clean bone. In a few cases, the enamel covering the dots was etched with grooves perpendicular to the working edge. These may have been caused by the small particles or large pieces of chert detaching from the tool edge, or on the steeper angled portions of the tool the dots may have come directly in contact with the bone surface.

Summary. Hafted endscrapers did not perform particularly well at scraping soaked bone. The best explanation for this probably relates to the extremely hard nature of the bone surface. Boiling and soaking did not increase the workability of the bone. Dulling of these tools was highly variable and was dependent upon the amount of of microflaking occurring at different loci on the tool edge. Weight loss of all four tools used on clean bone was substantial and probably relates to the frequent microflaking.

Microflaking is considered the dominant and potentially diagnostic form of use-wear associated with bone scraping. Usually, most areas on the distal ends of each experimental tool experienced repeated flaking. The resulting scars appear in all shapes and sizes, but large step scars ($>$ 0.05mm) dominate. Noteworthy is the fact that ventral microflaking occurred on four of the bone scraping tools. This was the only task which produced use-wear on the ventral surface of the tools.

Because of the predominance of microflaking, formation of rounding and polishing was inhibited. Stabilzed edges began to smooth and acquire localized areas of polish, but neither of these wear types was well developed or pronounced. The most notable feature of these two wear types is their restricted physical distribution. This distribution cannot be confidently distinguished from that of the same wear type found on antler scraping tools. The degree of polish is variable and cannot be classed as patterned. The degree of rounding of edge areas may be slightly less pronounced than for antler scraping tools, and certainly much less than for tools used on wood. No striations were found. Although microflaking was the dominant type of use-wear, the nature of these other wear types must be considered when attempting to assign the use of a particular tool.

Wear Patterns on Tools Used on Bone With Silt

As previously discussed, a new set of four scrapers was used to scrape bone with 35 g of silt sprinkled over the bone surface prior to the use of each tool. The inclusion of an abrasive agent was the only change in the experimental procedure. After use, all four tools exhibited use-wear patterns strikingly different from those found on tools used on clean bone. All four general types of use-wear (microflaking, rounding, polish and striations) are believed to have been affected by the addition of silts. I believe, however, that all of these changes can be attributed to changes in "rounding," the most important wear type. Accordingly, the nature of all of the wear types will be discussed within the context of the discussion on rounding and polish.

Rounding and Polish. The addition of silts to the working surface caused a significant and rapid rounding or smoothing of the immediate edge and the adjacent dorsal face. Relative to the unused condition, edges were noticeably rounded after only 250 to 750 strokes (Plates 34a, b; 36a, b, c, d). The degree of rounding at these early stages of use was greater than the degree of rounding of the tools used much longer periods on clean bone. As use of the tools on silty bone continued, the rounding became more and more severe until 1000-2000 strokes at which point the tools were completely exhausted. Damage to the immediate edge and dorsal face was frequently visible to the unaided eye (Plates 34c, d, e, f; 35b, d, e, f). As illustrated in Plates 34e, f and 35b, f, the extent of surface area affected by the rounding process was often much greater than that with clean bone. Note that the most heavily and extensively altered areas were the projecting ends of the manufature flake ridges on the dorsal face.

This impressive attritional process may be described as an abrasion of the immediate edge and dorsal face by the tough quartz silt particles. The particles are drawn across the edge under pressure, apparently gouging out bits of the tool surface in a linear fashion. Plate 34e, f gives the impression of a dense striating of the working edge. Categorization of use-wear types becomes hazy; rounding by this linear abrasion process might instead be viewed as a massive striating effect. I will continue to call this type of edge damage rounding or smoothing because I was not able to distinguish individual striation tracks. Other researchers using magnification powers greater than 50X might make such distinctions and prefer to call this type of damage striating.

As the angularity of a sharp edge was rapidly eroded by the abrasive particles, an increasingly greater amount of tool surface came into contact with the worked material. This resulted in a more extensive distribution of the rounding phenomena, especially on the dorsal face. In addition, as long as a fairly constant working angle was maintained the abraded area may take on the form of a facet. Rudimentary expressions of this are seen in Plate 34d, e, f. Several areas of tools used on gritty bone also developed this same facet feature.

All four tool areas were rounded or smoothed by this abrasive process and were also polished. A luster on the immediate edge was visible after only 250-500 strokes (Plates 34a, b; 36a, b). Unlike the rounding process, which constantly increased with extended use, polishing of these tools was not cumulative. Rather, the constant removal of rock material from the tool's edge prevented the full development of polish. The polish which does form is moderately bright and has a scattered or discontinuous appearance (Plates 34b, c, e, f; 35f; 36b, c, d). Plate 35b illustrates how localized features sometimes acquired a bright, smooth, homogeneous type of polish. This rarely occurred on the tools used on bone, with or without silt.

Thus, by itself, the polish is not substantially different from that formed on tools used on clean bone or those used on antler. What was different was the rounded and smoothed surfaces associated with this polish. Of the tools used on antler or clean bone, none were marked by the degree of rounding or smoothing found on tools used on gritty bone. Some of the wood working tools had nearly equivalent amounts of edge and dorsal surface rounding. However, the smooth, lustrous nature of the wood working tools is easily distinguished from the lineally abraded appearance of the tools used on gritty bone. Also, the polish on the latter group of tools is more scattered or pitted when compared to the homogeneous type of wood working polish. In sum, the type of use-wear found on tools used on bone with silt added is quite distinctive, and easily distinguished from the types of use-wear associated with other functional activities so far discussed.

Microflaking was fairly common on tools used on bone with silt, especially during the early period of use. All four tools used in this task showed evidence of repeated flaking. However, the rapid abrasion of the distal end, and the concomitant reduction of the angularity of the working edge, serve to reduce the amount of microflaking. A rounded edge becomes much tougher to flake than an angular edge. Rounded or smoothed edges on the ends of these stone tools reduced the number of striking platforms from which microflakes may be initiated. Thus, while microflaking occurred, the frequency of this wear type was greatly reduced from the amount seen on tools used on clean bone. Working gritty bone was not distinguished by a proliferation of microflaking, but rather by the development of a distinct form of rounding. The absence of continuous edge flaking helps account for the more rapid dulling of these tools relative to tools used on clean bone where microflaking caused temporary edge rejuvenation.

No true striations were observed although, as mentioned, other researchers might refer to the linear abrasion as striating. I have included these abrasion marks in the rounding use-wear category. No distinct individual striation tracks were observed except in the enamel over the ink (Plate 35c).

Summary. Working silty bone was mechanically indistinguishable from working clean bone. Rates of tool dulling differed slightly, as the tools used on silty bone dulled more quickly than tools used on clean bone.

The different sets of tools used on clean and silty bone showed substantially different kinds of wear patterns. It may be posited that the addition of silt to the bone surface was the cause of these differences. Wear patterns of tools used on the hard silty surface were characterized by: 1) a rapid and pronounced rounding or abrasion of the edge and dorsal face apparently caused by the tough quartz particles in the silt; 2) the development of a striated appearance at the tool edge; 3) the rudimentary development of a faceted edge on some portions of the distal ends of the tools; 4) a poorly developed, moderately bright polish associated with the abraded areas; 5) a reduction of the frequency of microflaking relative to working clean bone. It is argued that the rapid rounding of the working end helps remove parts of the tool edge which may serve as striking platforms, hence flaking is reduced. These wear patterns are believed to be quite distinct from those of any other task discussed so far.

CHAPTER 9

HIDE WORKING RESULTS

## Introduction

Nine experimental tools were used to scrape cow hide: three tools (#s 4, 6, 25) were used to flesh a fresh hide; three tools (#s 9, 12, 14) were used to scrape the flesh surface of sun dried hide; two tools (#s 8, 15) were used to scrape the surface of a dried hide to which silt particles had been added; and one tool (# 18) was used to de-hair portions of the cow hide.

The hide of recently killed cow was acquired for the experiments. As mentioned in Chapter 3, three stages of hide working were attempted: 1) fleshing, where the flesh side of a fresh hide is scraped; 2) dry scraping, where the flesh side of a dried hide is scraped; and 3) de-hairing, where the hair side of the hide is scraped. Initially, a one meter square section of hide was cut out and stretched on a wooden frame (Plate 7). The remainder of the hide was wrapped in plastic and frozen for use in later experiments. As far as I was able to determine, this repeated freezing had no affect on the working properties of the hide. However, a tight plastic wrap was essential to prevent dehydration.

The fleshing experiments required special consideration. That is, on the one hand the hide had to be scraped in a fresh condition, on the other the experiments had to be interrupted for examination and photography of the utilized tools. The dilemma was solved by repeated freezing of the fresh hide until all fleshing experiments were completed.

After the fleshing experiments, the meter square pieces as well as several smaller pieces were staked out and sun dried for two days. Finally, in preparation for the de-hairing experiments, one of the sun dried pieces was submerged in water for 48 hours. This soaking softened the hide and loosened the hair follicles making removal easier. All of the hide working experiments were done with the hide on the frame and the frame leaning against a support so that nothing touched the back of the hide.

Fleshing. Hafted scraping tools proved to be quite ineffective at fleshing a fresh hide. The distal end of the scrapers simply slid over the hide failing to grip the pieces of meat and fat on the hide surface. The greasy nature of the fresh hide added to this inefficiency of the stone tools. These results are in complete agreement with the fleshing experiments of Levitt (1976:89-93). Broadbent and Knutsson (1975) report strikingly different results. Also scraping fresh cow hide with unifacially retouched tools, they found that tools with edge angles between 70-75° were ineffective, while those with angles between 55-65° when drawn obliquely over the hide successfully removed the fat tissue (Broadbent and Knutsson 1975:121). According to these authors, tools with more acute edge angles were able to cut through the greasy tissue whereas the obtusely angled tools lacked this cutting ability. Yet two of the tools used in my fleshing experiments (#s 6, 24) had edge angles well within the functional range suggested by Broadbent and Knutsson and still failed to achieve any positive results. Brose (1975) has suggested that animal fats build up on the edges of butchering tools partially protecting the tool edge from certain types of use-wear. It may be that this same process acts to reduce the effectiveness of unifacially retouched scraping tools.

Because the tools never effectively fleshed the hide it is difficult to estimate dulling time. In order to document the use-wear produced by this task the tools continued to be used long after their ineffectiveness was noted. An interesting discrepancy exists between the results of Keller (1966) and Broadbent and Knutsson (1975) concerning the longevity of scraping tools. Keller (1966:507) used an unmodified acutely-angled flake to scrape the flesh surface of a fresh cow hide. He reports the tool failed to work beyond 90 strokes. Broadbent and Knutsson performed the same task with unifacially retouched tools and report tools being used up to 1000 strokes before reduced efficiency was noticed. The tools used in my experiments are formally similar to those used by Broadbent and Knutsson but my results are more like those of Keller.

All the tools used in the fleshing experiments lost weight (.5, .2, 1 mg). As will be discussed below, none of the fleshing tools experienced any microflaking of the edge. Thus loss of weight must be due to abrasion.

<u>Dry Scraping on Cow Hide.</u> In contrast to the fleshing experiments, the hafted scrapers used on a sun dried hide effectively removed the dried bits of fat and meat as well as the membrane-like

layer known as adipose tissue. The hide became extremely stiff when dried and provided a firm working surface for the scrapers. The fats and tissue, having lost their greasy texture, were scraped away in thin strips which curled away from the tool edge. There was little build up of material on the working edge and clearing the edge was not required.

Published reports of experimental scraping on dried hide are quite rare. Levitt's (1976:99-102) experiments were nearly identical and the results are strikingly similar. Using endscrapers hafted in right-angle handles he effectively removed the adipose tissue from a dried cow hide.

Tools used on dry hide lost their initial sharpness surprisingly quickly. After 500 and 800 strokes the tools seemed noticeably dull. By 1200 strokes the tools are working poorly, and after about 1500 strokes the tools are removing little hide material. Although Levitt (1976) does not present his findings in terms of number of strokes, it is clear that his dry scraping experiments also resulted in a rapid dulling of the tool edge:

> this type of use is very hard on the working edge on the scrapers. To be effective they must be kept very sharp, and this meant resharpening them by retouch at least every 8-12 minutes (Levitt 1976: 102).

All of the tools used on clean dry hide lost weight; however, the figures are very small (1, 2, 3 mg).

<u>Dry Scraping With Silts Added.</u> Several small pieces of cow hide (c. .5 X .5 m) had 35 grams of silt added to the still fresh

flesh surface and then were sun dried for several days. Silts were also added to one piece of hide after it had been dried. As mentioned in Chapter 3, the reason for this is based on the assumption that dirtier worked materials are more representative of aboriginal conditions.

I have seen no comparative literature regarding the effectiveness or efficiency of using endscrapers on silty dry hides.

As discussed and illustrated below, by the end of these experiments the two tools used on silty hide displayed extreme development of use-wear. The weighing of these tools is somewhat problematical in that one tool lost 2 mg while the other lost 17 mg. Given the extreme development of use-wear the loss of only 2 mg seems inconsistent, and may be the result of a weighing error.

Dulling of the tools used on silty dry hide was very different from the dulling of tools used on clean dry hide. After only a few hundred strokes the tools were noticeably less effective. After 400 strokes the tools were so dull that the extremely rounded edges were visible to the unaided eye. The effective life of the tool is estimated at a maximum of 400 strokes.

Hide De-Hairing. Only one experimental tool (#18) was used to de-hair part of a cow hide.

The hafted endscraper was found to be a very useful tool in de-hairing the hide. As mentioned, the hide was soaked for 48 hours prior to scraping. This soaking began a decaying process which partially loosened the hair follicles. Removal of the hair was now very easy (Plate 7). Clumps of hair came up with each tool stroke, and the tool edge needed to be cleared of hair after about every twenty strokes.

The tool continued to remove hair from the hide effectively for thousands of strokes. This longevity may be due to two reasons. One, the de-hairing task does not seem to require a very sharp tool edge. Once the follicles were loosened the hair could be removed by dragging almost anything over the hide. Secondly, as discussed below, use-wear damage to these tools was very slow to develop and involved onl the slightest alterations to the tool edge. Thus, if there were any advantage to de-hairing with a sharp edged tool this advantage would have persisted throughout virtually all of the experiment. The experiment was terminated after 2500 strokes with no perceptible loss of efficiency.

Levitt (1976:95-98) has also experimentally de-haired a cow hide with endscrapers. His report of the effectiveness of these tools at this task is very similar to my own. However, he does not comment on the life span of the scraping tools.

The single tool used to de-hair a hide experienced a 2 mg loss of weight.

## Wear Patterns on Tools Used to Flesh a Hide

As mentioned above, fleshing a fresh hide with stone tools was an ineffective process. It may be assumed, then, that this experiment represents a poor analogy to prehistoric behaviour. That is, scraping the fleshy surface of a fresh hide with the kinds of tools

I used, in the manner in which I used them, was probably not a common activity among prehistoric hide workers. Accordingly, I will devote little attention to the wear patterns found on these tools.

At no time did any of the tools used to flesh a hide experience microflaking. Not a single scar of any size on any portion of the working ends was ever located. The only detectable use-wear was a poorly developed rounding or smoothing and a moderately bright polish at the immediate edge (Plate 37a, b, c). These faint traces of wear only appeared after 1000 strokes. It is believed that the minimal rounding which does occur is the result of a very fine process of smoothing the surface rock material by slowly wearing down the rock. This attritional process is probably similar to that occurring on wood working tools except on an even finer level. No evidence of a breakage or truncation of rock material was observed.

Interestingly, the evidence of wear on these tools was almost always confined to the immediate edge area. Yet obviously the fresh hide is the softest, most resilient of all the worked materials. When scraping the hide one can easily see the entire distal end of the tool engulfed in the flexible hide. The absence of wear on the ridges and projections on the dorsal face can only be explained by the general failure of this type of tool use to cause much in the way of physical alteration. The very edge, however, is the center of concentration of pressure exerted on the tool. If damage were to be visible anywhere it should be on the extreme edge.

As can be seen in Plate 37a, b, c rounding or smoothing and polish is minimal. By itself, this wear type does not resemble those of any other tool uses presented so far. It is suggested that the unused tool is the one most likely to be confused with the tool used to flesh a hide.

No true striae were found. It is noteworthy, however, that there was something on the hide surface which was hard enough to scratch enamel (Plate 37d). This scratching may well attest to the unknown presence of a grit of some sort on the supposedly clean hide.

In summary, endscrapers used to flesh a fresh hide were poorly suited to this task. Consequently, I would assume that this experimental activity does not accurately simulate prehistoric scraping activities. By and large this activity causes very little alteration to the tool. No microflaking occurred. Localized areas of the extreme edge area showed a poorly developed rounding, probably produced by smoothing of surface areas. No striations were observed. Use-wear observed on hide fleshing tools does not resemble use-wear found on tools used in any tasks so far discussed. In this respect the use-wear on fleshing tools can be regarded as distinct. Since these tools most closely resemble unused tools this distinctiveness is largely by default.

## Wear Patterns on Tools Used to Scrape Dried Hide

Unfortunately, in the early stages of the dry hide scraping experiments several roles of film were spoiled. By the time this was discovered the tools had already been used and examined several times. Thus there is no photographic record of the beginning of wear formation. Written descriptions were also made at the time of each examination, but they were done in conjunction with visual presentation in mind and seem meager when presented alone. Photographs exist for the unused tools and those used more than 1500 strokes.

Microflaking. Removal of flakes from the tool edges occurred but was rare. Only four instances of microflaking were noted on the three tools used on dry hide. As with wood working tools, flakes seem to be removed at irregular intervals at any time in the life of the tool. Plate 40a, b illustrates an edge which remained stable for thousands of strokes, then microflaked. The cause of this irregular flaking is not known but may be related to striking more resistant areas of connective tissue on the hide surface.

As seen in Plate 38 and Plate 40a, b, the scars produced are generally small and occur only in the immediate edge area. Furthermore, it was unusual to find more than a few use scars at any one location on a tool edge. As illustrated in Plates 38 and 40a, b, neither the size nor shape of the use scars is demonstrably different from manufacture damage. The value of these scars as a functional indicator must be considered minimal.

Rounding and Polish. Rounding and polishing of the edge area was the most important kind of use-wear associated with dry hide scraping. It was noted above that working dry hide caused a rapid dulling of the tools and this was reflected in the rapid formation of rounding and polish. After 500 strokes on dry hide the working edges were [illegible] rounded and a faint polish had developed. By 1000 strokes the [illegible]ing had advanced to a stage where tool effectiveness was greatly reduced. Plate 39a, b illustrates the degree of rounding and polish afer 1500 strokes. Plates 41a, b, c and 40c, d, e document more advanced stages of these use-wear features.

The rounding attritional process was accomplished by removal of single or multiple grains from the tool surface leaving a pitted appearance (Plates 39b; 40d, e; 41b, c). The polish associated with the smoothed areas had a scattered or discontinuous look and was moderately bright. These use-wear features are most similar to those found on tools used on antler, and to a lesser extent, tools used on wood and bone with silt. The remainder of this section will attempt to distinguish tools used on dry hide from tools used on these other worked materials.

Tools used on dry hide are most easily distinguished from tools used on silty bone. The bone scraping tools exhibited the distinctive linear abrasion marks. Nothing similar to this form of abrasion occurred on the dry hide scraping tools. Wood working tools experienced much more microflaking than did dry hide scraping tools, but this may not be a useful index when retouched tools are considered as manufacture and use-wear scars are difficult to distinguish.

The greatest degree of similarity between wood working and dry hide scraping tools is in the extent of surface area affected by the rounding and polishing process. Both wood and hide working tools displayed evidence of rounding some 0.25 to 0.40 mm up the dorsal faces of the tools (compare Plates 39b; 40d, e; 41b, c with Plates 18a, b; 19a, b; 20c, d, e, f). The resulting appearance of the use-wear, however, is different. Edges and adjacent surfaces of wood working tools were rounded off by a wearing down or smoothing of the surface rock material. This created a very smooth appearance of the edge and a homogeneous look to the polish. Dry hide scraping, on the other hand, involved a breaking off or plucking out of surface rock material. There was less smoothing and hence a more rugged, pitted appearance. Also, the polish of wood working tools was considerably brighter than that of dry hide scraping tools. It is these differences which are considered crucial for distinguishing wood working from dry hide scraping tools.

Of all the experiments conducted, the tasks which yielded the most similar types of use-wear were antler and dry hide scraping. Alterations made to the antler and hide prior to experimental scraping resulted in imparting a number of common features to these two materials. Specifically, the hard antler had been significantly softened by soaking in water, while the soft hide had been hardened by drying in the sun. Based on a subjective assessment I would suggest that soaked antler and dried hide have very similar hardness or density values.

Both antler and dry hide scraping were marked by a paucity of microflaking. Both tasks achieved a rounded edge area apparently caused by removal or plucking of rock material rather than a slow wearing down of the rock. Both tasks produced a polish of roughly moderate brightness with a discontinuous or scattered appearance. Neither task produced any true striations. However, I will suggest one possible means by which antler and dry hide scraping may be distinguished, though I wish to emphasize the tenuous nature of this distinction. The use-wear produced by these two tasks is obviously very similar and my differentiation of them may only be permitted by the limited amount of testing I have done. More statistically valid sampling may show the use-wear produced by these tasks to be inseparable.

While I have said the hardness of the two worked materials is probably very similar, the flexibility of the materials when under pressure differed. For all practical purposes the antler surface was inflexible and did not give or bend as the tool was drawn across. The stretched piece of hide, while hard, did give or bend under pressure. The working surface of the hide became slightly concave towards the hafted tool. This concavity resulted in a greater area of contact between the working surface and the beveled edge of the tool. Increased contact surface should cause the use-wear to be distributed over a larger area of the edge and dorsal face. I believe this to be true for the tools used on dry hide (compare Plates 39b; 40c, d, e; 41b, c; with Plates 25c, d; 27a, b).

<u>Summary.</u> Unlike fresh hide scraping, working a dried hide with hafted endscrapers was a productive and efficient task. The dried flesh and fat were nicely removed by the tools. This kind of work is hard on the working ends of the tools, causing a rapid dulling.

Microflaking at the distal end did occur but was relatively rare. When flaking did occur it was usually limited to removal of a few flakes at any one tool loci. Considering both the rarity of microflaking and the inability to distinguish use scars from manufacture scars leads to the conclusion that this type of use-wear was not suited for distinguishing dry hide scraping tools from tools used on other tasks.

Rounding and polishing both occurred and were detected after 400-500 strokes on dry hide. The rounding, or attrition, of the edge appeared to be due to edge breakage and plucking out of single and multiple grains of rock material. The resulting edge area appeared pitted and irregular rather than smooth. The area of the tool surface affected by the rounding process was also polished. The polished areas had a scattered type of reflectivity which is considered moderately bright. No striations were observed.

The patterns of use-wear found on dry hide scraping tools are very similar to those found on antler scraping tools. In most respects the wear patterns of the two tasks are indistinguishable. I have suggested that the greater flexibility of dried hide as opposed to antler results in the distribution of the rounding and polish over a greater surface area of the tools used on dried hide.

Wear Patterns on Tools Used to Scrape Dry Hide With Silt

Of all experimental tool using situations, the wear patterns exhibited on tools used to scrape silty hide were the most dramatic and distinct. Within a very short period of use the entire tool edge is virtually ground down, obliterating large flake scars, and in some places forming a completely rounded edge. The wear patterns which most resemble those described below are the patterns found on tools used on silty bone. The conclusion is reached that the addition of a gritty agent to the surface of the worked materials is of major significance in the formation of certain specific wear patterns.

Microflaking. Microflaking of tools used on silty hide was very rare. Plate 45a, b illustrates one of the two instances where I noticed microflaking to have occurred. It was argued above, in the section on clean dry hide scraping, that the major attritional process was a breaking off or plucking out of rock mass from the area of the distal end. With silty hide this is no longer the case. The hard silt particles gouge out mass from the rock surface giving rise to a rapid loss of angularity. Hence, striking platforms for microflake removal are quickly smoothed off making flake initiation unlikely.

Rounding and Polishing. Rounding is certainly the major wear type associated with scraping silty hides. Silt particles were dragged across the tool edge and up part of the dorsal face. In the course of this movement the particles scrape off or gouge out material from the tool surface leaving an appearance best described as linear abrasion. Viewing Plates 42c, d; 43d, e, f, g there can be little doubt as to the role of the silt particles in use-wear formation.

The rounding process began early during tool use. After 250 strokes the immediate edge and a large portion of the dorsal face were noticeably smoothed, especially on ridges or other pronounced areas (Plate 44b). By 500 to 750 strokes the rounding was so severe that most parts of the working edge were functionless (Plates 42b; 43b, c, d, e; 44c). Continuation of the experiments demonstrated that this abrasion process continued uninterupted for at least 1500 strokes (Plates 42c, d; 43f, g).

The extent of the area affected by the rounding process is impressive. Portions of tool edges with steep edge angles (as seen in Plate 43a, c, f) displayed the greatest extent of rounding. More acute portions of the working edge were characterized by a zone of extreme rounding concentrated at the immediate edge (see Plate 42a, b, c). For the most part the abrasion was found only on the edges and dorsal faces. However, as Plate 42d and 43f, g illustrate, advanced stages of this abrasion virtually eliminated an edge, making dorsal/ventral distinctions more difficult.

Polishing of the abraded edges and faces seemed highly variable, with a possible inverse relationship between length of tool use and brightness of polish. In the earliest stages of silty hide scraping, the tool surfaces which became rounded also became quite lustrous (Plates 42b; 44b, c). As tool use continued, however, this luster disappeared and was replaced by a dull, non-reflective matte finish (Plates 42c, d; 43d-g). This type of polish on the well worn specimens is not surprising, as the rapid erosion of the tool material prevented the build up of a polished surface. The appearance of a bright polish early during tool use cannot be immediately explained.

<u>Striating.</u> As was the case with the use-wear found on tools used to scrape silty bone, the extreme linear abrasion marks observed on the silty hide scraping tools raises the problem of use-wear

nomenclature. I have referred to the use-wear seen in Plates 42c, d; 43c-g as "rounding." Other researchers using different equipment might term these same features "striations." Using the criterion of being able to distinguish individual striation tracks, no true striations were observed on the tools used on silty dry hide.

The use-wear which developed on the silty hide scraping tools was highly distinctive and was easily distinguished from the other forms of use-wear discussed so far. Morphologically the most similar wear was found on tools used to scrape silty bone. The major difference between the tools used on silty hide and those used on silty bone was the physical extent of the extreme abrasion. The greater flexibility of the dried hide resulted in a larger zone of contact between the dorsal face of the tool and the hide surface. Also, the flexible nature of the hide caused a true rounding of the immediate edge (Plate 34f, g), as opposed to the facet-like feature which sometimes developed on tools used on hard, inflexible bone (Plate 34d).

Summary. Two hafted endscrapers were used to scrape the flesh side of a dried hide which had 35 grams of silt added to its surface. The working efficiency of the tools used on silty dry hide was not noticeably different from that of the tools used on clean dry hide. Weight loss for one of the tools used on silty hide was substantial (17 mg); for the other tool the loss was minimal (2 mg).

Microflaking was of little importance on tools used to scrape dry hide as only two instances of its occurrence were noted.

Rounding was the dominant form of use-wear on these tools. The rounding process occurred rapidly and was manifest by an extremely abraded edge and dorsal face. The abrasion took the form of multiple linear striation-like tracks running perpendicular to the edge. A bright polish formed during the early stages of tool use, but was rapidly eliminated by the severe abrading of the tool surface. Subsequent polish always appeared matte or dull. Individual striations were not observed.

The use-wear produced by scraping silty hide was most distinctive. The only task which produced a somewhat comparable form of use-wear was scraping silty bone. The greater extent of abrasion on the dorsal face serves to distinguish tools used on silty hide from those used on silty bone. Also, the hide working tools did not become faceted on the distal end as seen on some bone working tools.

<u>Wear Patterns on Tool Used to De-Hair a Hide</u>

<u>Microflaking.</u> Microflaking never occurred on the single tool used to de-hair a hide. While one tool is a poor sample from which to draw any conclusions, working of the wet, soft hide stretched on a frame was so effortless that I would be surprised to see any microflaking occur even with a larger tool sample. De-hairing the hide under different conditions, for example with the hide laid on the ground or on a hard backing such as a log, might produce different results.

<u>Rounding and Polishing.</u> Rounding and polishing were the dominant forms of use-wear on the de-hairing tool. These features

developed very slowly, were found on an extremely limited surface area of the tool, and were difficult to observe even with the use of 50X magnification.

Rounding on the de-hairing tool occurred only at the immediate edge. Seldom was any evidence of rounding observed more than 0.05 mm up from the edge. The dorsal flake ridge in Plate 46a and the left side of the tool edge in Plate 47c illustrate two partial exceptions to this rule. This limited distribution of use-wear is interesting because there is no question that during tool use the entire distal end of the tool is constantly in contact with the soft, flexible hide. Thus, the absence of use-wear from much of the dorsal face of the tool is not due to a failure of the tool to contact the hide surface, but rather is probably a result of the slow forming and subtle nature of the wear found on this tool. Given very long use I would expect more of the dorsal face to eventually exhibit the same use-wear as seen at the immediate edge. The immediate edge probably displayed the first signs of use-wear because pressure applied to the tool was most concentrated at this point.

The type of rounding associated with the de-hairing process was a very slow wearing down or smoothing of the rock material at the edge. No evidence was observed which suggested a breakage of rock. The wearing down process was barely perceptible at selected locations after 250 strokes (Plate 46a, b), but was quite detectable on most parts of the tool edge after 1000 strokes (Plate 47a, b, c, d). Because the rounding was the result of a slow, gradual abrasion the immediate edge appears very smooth. The smoothness of the rounded edge had a direct bearing on the nature of the polish which accompanied the rounding process.

All of the rounded areas were polished. The polish takes the form of a very bright, lustrous finish (Plate 47a, b, c, d). In addition to being very bright the polish appeared quite smooth, homogeneous and continuous. These latter features probably relate to the fact that the polish was reflecting from a smooth rather than a rugged edge.

Striating. No striations were observed.

Wear patterns on the de-hairing tool were most similar to those of the hide fleshing tool. Both tasks were characterized by the slow rounding of the immediate edge accompanied by a bright, lustrous polish and a complete absence of microflaking. Use-wear on the fleshing tools formed more slowly than on the de-hairing tool; however, this difference is not likely to be of any use when analyzing prehistoric specimens. Thus, on the basis of wear morphology alone I was unable to distinguish between de-hairing and fleshing tools. It will be recalled, however, that the fleshing tools were very poorly suited to their task, while the de-hairing tool was most efficient. Accordingly, I would argue that the observation of the wear patterns described above on a prehistoric specimen would likely be indicative of de-hairing activities and not fleshing activities. Further experimentation with de-hairing tools may lead to a more convincing method of distinguishing these closely related wear patterns.

Summary. One tool used to de-hair a hide was very effective at this task and maintained this efficiency throughout its entire span of use.

No striating or microflaking were observed to have occurred. Wear patterns were dominated by the rounding and polishing processes. For the most part the immediate edge was the only affected part of the tool. This edge area was rounded by a fine, slow process of wearing down the rock surface. A very bright polish was associated with the rounded areas. This polish was fairly continuous along the smoothed edge and appeared homogeneous and lustrous. These wear patterns were nearly identical to those seen on hide fleshing tools. Separation of the two tasks on the basis of use-wear was not possible. In attempting such a separation some weight should perhaps be given to the fact that hafted endscrapers are considered excellent tools to de-hair but not to flesh a fresh hide.

CHAPTER 10

# SUMMARY, CONCLUSIONS, COMPARISONS

## Introduction

In this chapter I will first draw together and summarize the more important results of the tool using experiments. Some additional information gleaned from the experiments but not previously presented will be mentioned. Also, comparisons will be made with those studies felt to be most relevant, by either their agreement or disagreement, to my own results. In the second section of this chapter I will turn to the prehistoric sample of endscrapers from the Smoky site and present brief functional interpretations of these tools as permitted by the experimentally generated use-wear data.

## Summary and Synthesis of Results

The hafted endscrapers performed well at most of the tasks to which they were put. The tools worked particularly well at scraping antler, de-hairing a cow hide, scraping a dried cow hide and to a slightly lesser extent working of seasoned and fresh wood. The tools were less effective at bone scraping and I believe this was due to the hardness of the bone, even after soaking and boiling. The tools were completely useless when used to flesh a fresh hide. I have argued that this last experimental activity does not represent a likely analogy with prehistoric tool using conditions. Excluding this last task, the remainder of the experiments were efficient and reasonable tool using activities and hence are believed to represent sound analogies with prehistoric tool use.

Weighing of the tools before and after each use produced variable results. Only bone scraping tools showed a consistent loss of substantial amounts of weight --- a testimony to the repeated microflaking of these tool edges. Tools which displayed alteration primarily through the agencies of rounding or abrasion experienced minimal loss of weight.

None of the experimental tools snapped or broke in half as commonly seen in the prehistoric sample (Plate 48). Also, none of the experimental tools displayed any evidence of "haft wear." These two points will be discussed further in the second section of this chapter.

The five experimental tools which were not made by percussion with an antler billet (see Table 1) did not exhibit wear patterns which differed from the remainder of the tools used on the same tasks. This sample of five tools, however, is too small to permit the conclusion that wear pattern formation is not affected by the mode of tool manufacture.

From the examination of unused tool edges it was observed that retouched tools exhibit a tremendous range of macro and micro scarring. Microflaking occurred in all shapes, sizes and distributional arrangements. While some patterns were apparent, such as the tendency of manufacture scars to have step terminations, the variability was such that no "typical" unused edge could be defined. This being the case it will often be difficult or impossible to separate manufacture scars from utilization scars on prehistoric specimens. The experimental results presented in the past four chapters have supported this conclusion by demonstrating that, with the exception of bone working, microflake utilization scars did not differ in form or distribution from manufacture scars. Two of the experimental tasks (hide de-hairing and fleshing) failed to produce any microflaking, while two other tasks (antler and dry hide scraping) produced only minimal amounts of microflaking. Considering all these results the value of microflaking as an indicator of tool function is low.

The other wear types (rounding, polishing and striating) were not found on unused tools, and consequently their presence was a certain indication of a used tool. Furthermore, every tool used in my experiments produced some kind of rounding or polish on the edge, even bone scraping tools which displayed minimal rounding and polish due to prolific microflaking.

There is currently a debate in microwear analysis as to which, if any, of the types of microwear are most useful as indicators of tool function. Odell has argued that:

> edge scarring by utilization manifests far greater internal variability than polish, abrasion or striations....In addition, scarring usually appears before any of the other forms of use-wear. These two facts render the scarring index more responsive to function than others and therefore potentially more desirable to use (1975: 231).

Odell's claim that edge scarring is the first use-wear to form can be shown to be incorrect by referring to my experiments which produced no microflaking. At the same time, Odell is certainly correct that microflaking possesses great internal variability, and it is clear that Odell considers this variability to be an advantage. This would only be true, however, if the microwear analyst can demonstrate the existence of patterns in this variability; patterns which relate to used as opposed to unused tools, and patterns which relate specifically to different worked materials. My results do not support the existence of these microflaking patterns. Odell's claims may have greater relevance to the analysis of unmodified flakes.

In my experimental analysis the wear types of rounding (abrasion) and polish have been the most useful functional indices. In this respect, my results closely parallel those of Keeley (1974) and Keeley and Newcomer (1977). As will be discussed in the following pages several of the task specific wear patterns which I have described bear striking similarities to those described by Keeley and Newcomer.

Striations were never observed and this wear type was of little consequence in my experimental functional interpretations. The linear abrasion marks found on tools used on silty surfaces were classed as part of the rounding process. This decision was based on the inability to discern individual striations.

As Morwood (1975:112) points out:

> in a formal deductive system, the occurrence of a predicted observation does not confirm or even make more likely the hypothesis from which it was drawn....A strict adherence to deductive logic in determining the acceptability of a particular hypothesis, allows

> the hypothesis to be refuted by non-occurrence of the prediction, but not confirmed by its occurrence.

The primary hypothesis tested in this thesis was that similar tools used in similar ways on different worked materials will develop wear patterns which are distinct to and diagnostic of each particular worked material. The results of the tool using experiments have not falsified this hypothesis. The experiments were designed to hold constant or nearly constant many variables of the tool using situation while manipulating the material the tools were used on. In this manner the wear patterns observed on tools used on different materials may be directly attributed to the influence of the worked material. Specifically, the thirty endscrapers selectively used on fo[illegible]erial categories --- wood, antler, bone and hide --- displayed wea[illegible]ns consistent within each material category and sufficiently diffe[illegible]nt from other categories to permit isolation of the tools used on eac[illegible] material.

Some attempts at finer functional distinctions within each material category were not realized. Scraping different kinds of wood did not produce demonstrably different kinds of use-wear, nor did scraping fresh as opposed to seasoned wood. In addition, the use-wear on tools used to flesh a hide could not be distinguished from the use-wear on tools used to de-hair a hide. On the other hand, dry scraping of the hide resulted in wear patterns of a different nature than those observed on both the fleshing and de-hairing tools.

The addition of silt to two of the worked materials (bone and dry hide) was intended to test the theory that such inclusions directly affected the resulting wear patterns. Semenov (1964) has championed the cause of the important role of abrasives in use-wear formation, especially in the production of striations. My results corroborate, or do not falsify, Semenov's theory. All six tools used on silty surfaces developed wear patterns markedly different from those developed on tools used to scrape clean surfaces. Furthermore, these former wear patterns were characterized by a massive linear abrasion of the distal ends of the tools similar to the striating of endscrapers discussed and illustrated by Semenov (1964:88,91).

Although the primary hypothesis of my thesis withstood experimental testing, this does not mean that the identification, or segregation, of wear patterns characteristic of each worked material was made with equal certainty. That is, wear patterns associated with some tasks or materials were highly distinctive, while wear patterns associated with other tasks or materials were less distinct and required greater effort to segregate. These differences have a direct bearing on the confidence or reliability of the experimental results and will be briefly reviewed. Also pertinent to this review is the question of whether or not my results are in agreement with those of other researchers.

First, as mentioned above, the most distinctive results were those associated with the scraping of silty surfaces, and that these results compare favourably with those of Semenov (1964).

Secondly, I regard the use-wear which formed on hide fleshing and de-hairing tools as quite distinctive and hence not likely to be confused with the use-wear of other tasks. The fine, tiny band of bright smooth polish seen on these soft hide working tools was somewhat similar to the polishing of wood working tools. However, the wood working tools also exhibited a greater degree and extent of rounding, a greater extent of polished surface, and considerable microflaking of the edge. When all of these are considered it was not difficult to distinguish the de-hairing and fleshing tools from the wood working tools. It follows, then, that the use-wear formed on wood working tools was also quite distinctive and was separated with confidence from the other use-wear of other task specific tools.

The above descriptions of soft hide and wood working use-wear correspond very closely with those presented by Keeley and Newcomer (1977). Broadbent and Knutsson scraped fresh cow hide and report the observation of a slight rounding of the tool edge (1975:122). They make no mention of polish.

Bone scraping tools were distinguished on the basis of a preponderance of microflaking of the working edge of the tool. Often this scarring was so extensive that edge micro and macro morphology was entirely rearranged. Frequent flaking during tool use resulted in rejuvenation of the edge thus prolonging its effective span of use. This flaking also tended to reduce the formation of rounding and polishing on the edges. No other tasks produced comparable microflaking. In addition, of all the tool using experiments, only bone scraping produced use-wear on the ventral surface. This damage to the ventral su[illegible] took the form of [illegible]roflaking and occurred on four of the eight bone scraping tools. This last point is supported by Broadbent and Knutsson:

> One crucial difference was that the downward pressure of the scraper upon the hard, unyielding bone caused larger chips to detach from the ventral surface creating a form of bifacial wear. This was seen to occur on all five of these scrapers. This was not observed, by comparison, on any of the other scrapers which were used on other types of raw material (wood or hide) (1975:119).

Tools used to scrape bone were also rounded and polished at the immediate edge. The "bone polish" discussed by Keeley and Newcomer (1977) is very similar to the rounding and polishing seen in my own experiments. Furthermore, Keeley and Newcomer (1977:39) concur that bone polish is slow to form, does not spred significantly in space and tends to be localized along the edge.

At a lower level of confidence, I have suggested means by which antler scraping and dry hide scraping tools may be distinguished. The wear patterns found on these tools were typified by rounded but not smooth edges accompanied by a moderately bright, scattered or discontinuous type of polish. Differentiating between these tools was achieved only by consideration of very subtle differences in the distribution of rounding and polish. Such subtle delineations may not be possible when the tools are used in more "natural" working contexts, where factors like edge angle and pressure aren't controlled.

Few authors have scraped dry hide, and working with antler seems to have lagged behind the use of more common worked materials, hence comparisons are difficult. After a wide range of hide scraping experiments, Levitt reports being unable to distinguish between the wear patterns formed on tools used in four different hide working stages (fleshing, dry scraping, de-hairing, softening). The wear patterns he describes for all these tasks are quite similar to those I have associated with de-hairing and fleshing (Levitt 1975:114). My results disagree with Levitt in that I contend wear patterns on dry hide scraping tools are distinct from those found on the other hide working tools. In this I am again supported by Keeley and Newcomer.

> The working of hide of various kinds does not produce a single, distinct type of polish. The polishes caused by hide-working range from the relatively bright, greasy polish that is the result of working fresh, wet hide to the dull pitted matt polish which results when working leather or dry hide (1977:39).

While we are not in complete agreement on all of these points, I find the general correspondence encouraging. I have not come across any author who remarks on the similarity between antler and dry hide use-wear patterns.

In concluding this summary of my results one final point needs to be stressed. It should be clear from the previous four chapters that use-wear is not a discrete form of data. Task specific tools are not recognized by some unique alteration which is exclusive to that task. Rather, use-wear is a continuum. For the most part the same kinds of data are associated with each task, only to a greater or lesser extent, or expressed in a slightly different form. Polish may be classed according to its brightness, but this does not mean it occurs in discrete classes. The brightness of polish occurs along a continuous gradient. Subdivisions of this continuum must inevitably be arbitrary. The same is true of the other types of use-wear. This does not mean that we should not or can not strive for quantification, only that we should not let quantification mask the true nature of the data we study.

C parisons

In this final part of the thesis, the endscrapers recovered from the Smoky site will be examined in light of the wear pattern information gleaned from the tool using experiments. By necessity, this examination must be very brief.

The endscrapers from the Smoky site are illustrated in Plate 48, and basic metric data on this tool sample is presented in Table 2. Comparison of Tables 1 and 2 shows that the experimental and prehistoric tools are morphologically very similar. All of the prehistoric tools were examined in the same manner as the experimental tools. Photography was again extensively used. At the time of excavation all cultural material was individually bagged. Thus "wear" resulting from bulk bagging should not be a factor.

For the moment, it is useful to look at the prehistoric endscrapers from the perspective of raw material. Three lithic types are represented in the prehistoric sample: chert, quartzite and pure quartz. From the examination of these tools it was concluded that raw material type is an important variable in the observation of use-wear. Only one (#117) of six quartzite tools was amenable to functional analysis. The other five quartzite tools (#1, 2, 84, 323 and 485) are made of large grained, silica cemented quartz crystals and are so dissimilar to the experimental chert tools that I was totally unable to relate their microscopic appearances to the results of the experiments. I could not ever discern whether these tools were used or unused. The remaining quartzite tool is very fine grained and I was able to suggest a function for this specimen. The single tool made of pure quartz (#621) was also amenable to microscopic analysis and will be discussed shortly. Examination of the twenty chert endscrapers suggested that five of these were unused, and of the remaining fifteen I was able to identify the probable function of twelve tools. Thus, out of a sample of twenty-seven tools, specific functions are advanced for fourteen (12 chert, 1 quartzite, and 1 pure quartz).

The chert tools interpreted as being "unused" (#574, 79, 24, 203 and 720) do not exhibit any signs of rounding or polish on either the working edge or the remainder of the tool. The macro and microflake scars visible on these tools cannot be distinguished from manufacture scars. However, the possibility cannot be ruled out that these tools were used for short periods of time on a hard substance, such as bone, which caused flaking of the edge and prevented the development of the other wear types. It may be significant that three of these five tools are distal fragments only, and one tool (#574) was recovered in three pieces but is reassembled in Plate 48. The fact that four of the five apparently unused tools are broken may indicate breakage during manufacture, accounting for the absence of use-wear. The possibility cannot be ruled out that these tools were originally used, then resharpened and then lost or discarded.

One quartzite and five chert tools are believed to have been used on hide in a soft condition (#701, 373, 152, 531, 85 and 117). The specific stage of hide working cannot be identified. These tools may have been used to de-hair or flesh a hide, or perhaps for some hide working activity which I did not attempt, such as a post-tanning softening process. Whatever the case, the wear patterns on these tools match very closely those found on the experimental de-hairing and fleshing tools. The two prehistoric specimens illustrated in Plate 50a and b exhibit the typical use-wear associated with soft hide working --- an extremely fine rounding found only at the immediate edge and accompanied by a very bright polish. One of the six tools (#152) may have been used on wood. Typical of wood working, the extent of rounding and polish on the dorsal face was greater than on the other five tools. However, the smoothness and brightness of the edge still suggested soft hide working activities.

Two chert tools (#630 and 115) are suspected to have been used on wood. As indicated above, this judgement rests on the observation of a bright polish and very smooth surface extending up the dorsal face, well beyond the range for soft hide working use-wear. Micro-flaking was not as common on these wood working tools as was found to be the case experimentally. This conclusion may only reflect uncertainties over what constitutes manufacture as opposed to utilization scarring.

Two chert tools (#48 and 52) are believed to have been used to scrape bone. These tools exhibited heavy scarring on the working edge yet lacked rounding or polish. Plate 51a and b illustrates one of these tools. Note the presence of ventral scarring adjacent to the distal end. This was the only prehistoric specimen which exhibited ventral use-wear. Another tool which may have been used on bone is #621. This tool, made of pure quartz, exhibited very heavy scarring all along the distal end (Plate 52a, b). Again, rounding and polish were absent. However, because I am not familiar with the fracture tendencies of this exotic material, a more positive assessment cannot be made. I would suspect that the pure quartz behaves more like glass or obsidian and thus may be more brittle than chert. This could mean that the heavy scarring on the working edge is the result of some less strenuous task than bone scraping. Assuming this to be true I have included this tool in the following group of tools believed to have been used on antler.

Four tools may be assigned as antler scraping implements (#621, 628, 486 and 402). Unlike the functional categories discussed above, the tools in this category do not all share the same wear patterns. Two of the tools (#628 and 486) displayed use-wear very similar to that produced on the experimental antler scraping tools; that is, a rough pitted edge with a scattered and discontinuous polish. While the possibility that these tools were used to scrape a dried hide cannot be ruled out, the spatial distribution of the use-wear on tools 628 and 486 most closely paralleled that of the antler scraping experimental tools. Tool 621 as discussed above, did not exhibit the typical antler use-wear, but was assigned to this group on the basis of an assumption regarding the fracture properties of pure quartz. The remaining tool (402) has almost certainly been used on a gritty surface, and I am speculating this was antler. As seen in Plate 49a, b the very edge of the tool shows fine linear abrasion marks running perpendicular to the tool edge. This use-wear was found only near the immediate edge, suggesting use on a hard, unyielding surface. This form of use-wear was very similar to the wear produced experimentally on tools used to scrape silty bone. In the case of tool #402 I would argue that antler is a more likely choice because of the lack of evidence of heavy scarring which was characteristic of tools used on both clean and silty bone.

Three tools (#98, 523 and 487) from the Smoky site exhibited wear patterns which I could not interpret. There is no question that the tools were used. In fact, tool #523 displayed the most pronounced use-wear of any of the prehistoric specimens. Yet these wear patterns did not compare well with any of the experimentally produced use-wear patterns. The three tools had two use-wear features in common: 1) they were well rounded at the distal edge; and 2) they lacked both a bright and matte type polish in that the reflectivity of the rounded areas was the same as the unaffected portions of the tools (Plates 53a, b; 54a, b).

One explanation for these unknown wear patterns is that some material other than those I tested was being worked by the prehistoric craftsmen. Certainly my tests were not an exhaustive coverage of materials available to prehistoric inhabitants. The wear patterns on these three tools may be the result of scraping some vegetal matter, or some aspect of food preparation. Or it may be that these tools were used on a material that I tested, only they were used in a different manner, or for different lengths of time. Because the distal ends are well rounded it is unlikely that the tools were resharpened. Finally, the tools may have been used on several materials, thus the wear patterns are conglomerations and not task specific. Interpreting tools used in this manner promises to be extremely complex and will require more controlled testing.

As mentioned in the first section of this chapter, no other portions of the experimental tools except the working edges developed use-wear. This contrasts sharply with the prehistoric sample where fifteen of the twenty-seven endscrapers exhibited use-wear on either the proximal ends, the lateral sides or both (Plate 53a, b). This use-wear on the prehistoric specimens was interpreted as being the result of hafting. If the tool is not hafted securely it will move against the handle and the lashing. Although I have not seen it documented experimentally, this movement would likely cause a rounding and polishing of the hafted end of the tool. The absence of "haft wear" on the experimental tools may be due to the conscious effort I made to keep the tools tightly lashed. Tools which became loose in their handles were difficult to work with and were immediately retied. Aboriginal craftsmen may have tolerated less stringent hafting arrangements because of the frequent need to resharpen the tools. As Gould et al. (1971) point out, Australian aborigines are repeatedly removing the scraping tools from their handles in order to resharpen the working edge. Given these circumstances prehistoric hafting may have been less rigorous than in my experiments where easy access to the tool for the purpose of resharpening was not a concern.

As an alternative, it is possible that the proximal end and lateral side use-wear seen on the fifteen prehistoric tools was the result of some entirely different use of the tools while out of the handles, or a result of the reversal of the tools in the handles as Gould et al. (1971) document among the Australians.

The tool using experiments did not help solve the puzzle of why so many of the prehistoric specimens were transversely snapped just proximal to the distal ends (Plate 48). None of the experimental tools experienced similar breakage. It is impossible to say whether or not the prehistoric specimens were broken while in their handles or at some other time. The fact that three of the specimens show no signs of use-wear may indicate breakage during manufacture. The other twelve specimens may have been broken in a variety of ways while not in the handles.

A final issue to be raised in the interpretation of the end-scrapers from the Smoky site concerns the possible influence of deposition and burial on the observed wear patterns. Several authors have claimed that artifacts may acquire "wear-like" alterations while buried. Bordes, for example, claims that artifacts buried in moving sediments or under pressure are more likely to experience a striating effect than are tools used on a gritty material (1969:20). Likewise, Keeley and Newcomer describe in detail the nature of tool alterations they believe to be caused by settling or shifting soils, or soils under pressure (1977:35). None of these authors make it clear how they have come to know these processes are in effect. No literature is cited which purports to demonstrate the reality of these events. What must be regarded as conjecture is presented as fact. The Smoky site affords an excellent opportunity to test some of these conjectures.

All of the cultural material at the site was buried. Depth of burial ranged between 10-15 cm. All of the material was recovered within a single homogeneous depositional unit --- the loess layer. These silt deposits, having settled slowly out of the air, are very compact. Thus every artifact from the site was encased in a matrix of fine quartz-based silt and very fine sand. The tool using experiments which included silt have shown quite conclusively the high abrasive potential of this silt. Frost-heave experiments conducted at the site have demonstrated that objects buried in the soil experienced considerable upward movement over a two year period (Brink 1976). Thus, the artifacts from the Smoky site are prime subjects to examine in search of wear caused by movement in an abrasive soil. Examination of all recovered prehistoric tools (not just the endscrapers) has failed to reveal evidence of any such alteration. An argument could be made that the three tools I have interpreted as being used on an unknown material were in fact worn by soil movement. If it can be assumed that wear caused by soil movement would be similar to wear caused by tools used on a material with a covering of this soil, then the argument can be rejected: the wear patterns on the experimental tools used on silty surfaces were not similar to those found on the prehistoric specimens of unidentified function. Furthermore, if wearing of the tools by soil movement was in operation, one would expect more than three tools to have been affected.

I cannot refute the possibility that the results would be different if the soils were under greater pressure. I would argue, however, that this pressure load would have to be far more substantial than will be found at the majority of archaeological sites.

## Concluding Remarks

I regard the results of both the experimental microwear analysis and the prehistoric interpretations as encouraging but not fully convincing. It may be some time yet before microwear research offers convincing answers to archaeological problems. The fact that experimentally produced wear patterns correspond closely with some of the wear patterns seen on prehistoric material suggests that the functions of certain tools may have been correctly inferred. While it is unlikely that functional determinations will ever take the form of dogmatic statements, still the confidence placed on our interpretations will undoubtedly increase as more information concerning use-wear is obtained. Above all else, continuing experimentation is needed to clarify the limits of the resolving power of microwear analysis. As the significant factors become better known, as we gain a fuller understanding of use-wear phenomena --- its causes and its wide range of expressions --- we become better equipped to predict and explain the events and processes of prehistory.

The application of microwear information to the solving of archaeological puzzles is in many ways the most exciting and challenging aspect of the study. Utilizing the data produced by my own experiments and those of others, a nearly limitless number of questions may be posed. My examination of the endscrapers from the Smoky site has only scratched the surface of the interpretive potential of microwear analysis. The assertion of my study, that we may correctly identify the material a tool was used on could, by itself, lead to important inferences concerning prehistoric resource utilization, diet and subsistence. Given the perishable nature of many of the substances these tools were used on, the analysis of the wear patterns which persist on these tools may well be our best link to fuller cultural reconstruction.

Ideally, the initial identification of tool function would be followed by a complete functional analysis. Pursuant to this goal, the analyst might refer back to artifact provenience at the site a search for associations or clusterings of artifacts with similar o dissimilar wear patterns. Distributional maps of all cultural material may reveal contextual relationships between task specific tools and other artifacts, tool types, features, faunal remains, and so on. In this manner activity areas may be delineated and identified. Wear patterns may be typically observed on particular lithic materials, as seems to be the case with the Smoky endscrapers. This may indicate preferential selection of certain raw materials for certain tasks.

The list of possible applications of microwear data to prehistoric reconstruction could be greatly expanded. The important point to be made is that the set of information derived from microwear analysis represents a powerful new tool for the archaeologist. New perspectives on archaeological data may be gained through use-wear application. For example, several authors have suggested that our very way of thinking about and organizing archaeological data should be transformed from the current emphasis on formal attributes to a new emphasis on the intended or actual function of stone tools (Ahler and McMillan 1976; Semenov 1970; White 1967; White and Thomas 1972). Wear patterns may well emerge as the basic analytical unit of this still hypothetical "new systematics." Artifacts could be viewed from the perspective of shared or differing forms of use-wear, and based on these criteria new groups of data could be generated which would presumably cross-cut already established formal typologies.

Equally important, wear pattern analysis allows us to examine some older, long standing archaeological assumptions. For example, the presence of "projectile points" at a site almost invariably leads to the conclusion that the prehistoric inhabitants were engaged in hunting activities. Yet mounting evidence from use-wear analysis argues that many of these artifacts were used for purposes other than spear or arrow points (Ahler 1971; Gibson 1977; Nance 1971). Similar investigations of other morphological types with functional names promise to be equally enlightening.

The scope of interest in the practical applications of micro-wear research is not limited to a few individuals actually involved in this research. The growing number of archaeological reports which include some form of functional analysis attests to the general desire to incorporate the information use-wear studies have to offer.

TABLE 1

METRIC AND EXPERIMENTAL FEATURES OF MODERN ENDSCRAPERS

| TOOL NO. | MAX. LENGTH | MAX. WIDTH | DISTAL THICK.[1] | MAX. THICK. | EDGE ANGLE[2] RANGE | EDGE ANGLE[2] CENTER | MANUF.[3] | MATERIAL USED ON[4] | WEIGHT CHANGE |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 36.5mm | 26.2mm | 7.2mm | | 62-90° | 73° | D | FS | - 1mg |
| 2 | 23.5 | 23.5 | 10.9 | | 80-90 | 80 | D | B | -17 |
| 3 | 31.7 | 30.5 | 10.0 | 13.3mm | 65-82 | 65 | D | B | -33 |
| 4 | 22.9 | 17.5 | 5.1 | 5.7 | 68-84 | 72 | D | HF | - 5 |
| 5 | 41.0 | 30.5 | 8.1 | 11.0 | 64-86 | 67 | D | BS | -28 |
| 6 | 42.1 | 26.9 | 5.0 | 12.0 | 55-70 | 56 | D | HF | - 2 |
| 7 | 27.8 | 21.8 | 7.7 | | 62-72 | 63 | D | A | - 2 |
| 8 | 21.9 | 24.5 | 8.7 | | 74-88 | 80 | D | HS | -17 |
| 9 | 36.7 | 24.8 | 5.1 | 7.7 | 65-88 | 66 | D | HD | - 1 |
| 10 | 25.5 | 20.0 | 6.2 | | 62-88 | 62 | D | FA | 0 |
| 11 | 27.5 | 23.5 | 7.7 | | 60-72 | 60 | D | BS | + 1 |
| 12 | 34.6 | 22.1 | 7.0 | | 60-65 | 60 | D | HD | - 2 |
| 13 | 26.2 | 18.5 | 8.3 | | 69-80 | 70 | D | FS | + 2 |
| 14 | 24.2 | 20.9 | 8.2 | | 62-70 | 63 | D | HD | - 3 |
| 15 | 30.0 | 25.0 | 6.9 | | 62-87 | 62 | D | HS | - 2 |
| 16 | 20.0 | 23.0 | 5.2 | 6.2 | 65-75 | 78 | D | A | |
| 17 | 27.0 | 48.5 | 3.8 | 4.7 | 52-60 | 53 | D | A | - 4 |
| 18 | 23.0 | 21.2 | 4.0 | | 60-73 | 63 | P | DE | - 2 |

TABLE 1

(CONTINUED)

| TOOL NO. | MAX. LENGTH | MAX. WIDTH | DISTAL THICK.[1] | MAX. THICK. | EDGE ANGLE[2] RANGE | EDGE ANGLE[2] CENTER | MANUF.[3] | MATERIAL USED ON[4] | WEIGHT CHANGE |
|---|---|---|---|---|---|---|---|---|---|
| 20 | 16.1mm | 15.5mm | 5.1mm | | 72-82 | 80 | P | A | - 3mg |
| 21 | 30.5 | 21.1 | 9.0 | | 68-105 | 68 | D | BS | + 6 |
| 22 | 36.0 | 23.0 | 12.0 | | 80-88 | 82 | D | FS | -10 |
| 23 | • 30.0 | 23.0 | 10.0 | | 84-88 | 84 | D | BS | -132 |
| 24 | 41.5 | 21.5 | 8.5 | 9.5mm | 72-81 | 74 | D | FA | - 4 |
| 25 | 18.5 | 18.0 | 7.0 | | 67-73 | 69 | D | HF | - 1 |
| 26 | 23.8 | 19.5 | 7.0 | | 61-62 | 61 | D | FA | - 3 |
| 27 | 22.1 | 18.2 | 5.6 | | 65-72 | 68 | P | B | -29 |
| 28 | 18.2 | 27.5 | 3.2 | 4.5 | 60-74 | 71 | P | SS | - 3 |
| 29 | 20.9 | 20.5 | 4.9 | 6.0 | 62-75 | 65 | H | SS | -27 |
| 30 | 37.2 | 32.0 | 7.0 | | 61-80 | 62 | D | B | -20 |
| 31 | 36.5 | 27.5 | 7.3 | 8.5 | 58-70 | 60 | D | SS | -14 |
| MEAN | 28.6 | 22.9 | 6.9 | 7.7 | | 67 | | | -11.6 |

1. Maximum thickness measured at the distal end.

2. Edge angle measured with goniometer. Range designates angles measured across the distal end. Center is edge angle measured at the center of the distal end.

3. Manufacture techniques:
   D = direct percussion, soft hammer
   P = pressure with copper percussor
   H = hard hammer

TABLE 1

(CONTINUED)

4. Material used on:
   - FS = fresh spruce
   - SS = seasoned spruce
   - FA = fresh aspen
   - A = antler
   - BS = bone with silt
   - B = bone
   - HF = hide flesh
   - HD = dry hide
   - DE = de-hair
   - HS = dry hide with silt

TABLE 2

METRIC DATA ON PREHISTORIC ENDSCRAPERS

| TOOL NO. | MAX. LENGTH | MAX. WIDTH | DISTAL THICK. | MAX. THICK. | EDGE ANGLE RANGE | EDGE ANGLE CENTER | MATERIAL[1] |
|---|---|---|---|---|---|---|---|
| 486 | 23.7 | 15.0 | 3.9 | 4.3 | 65-70 | 68 | C |
| 485 | 38.1 | 24.1 | 8.9 | 9.1 | 50-55 | 50 | Q |
| 621 | 35.7 | 18.0 | 6.1 | | 55-74 | 72 | PQ |
| 1 | 35.2 | 19.5 | 8.2 | 11.0 | 50-75 | 74 | Q |
| 720 | * | 28.0 | 7.2 | 9.0 | 56-90 | 85 | C |
| 574 | 34.9 | 28.7 | 8.5 | 12.9 | 55-75 | 70 | C |
| 152 | 23.0 | 28.1 | 4.0 | 5.2 | 45-72 | 70 | C |
| 52 | 21.8 | 26.2 | 5.9 | | 64-71 | 68 | C |
| 84 | 25.0 | 22.1 | 7.2 | | 63-75 | 68 | Q |
| 2 | 21.1 | 20.5 | 7.7 | 9.0 | 60-73 | 67 | Q |
| 48 | * | 21.5 | 4.5 | | 55-80 | 78 | C |
| 630 | 33.0 | 16.1 | 6.5 | | 48-70 | 65 | C |
| 373 | * | 17.5 | 4.9 | 5.0 | 55-65 | 65 | C |
| 402 | 42.2 | 27.9 | 8.9 | | 60-72 | 68 | C |
| 323 | 20.5 | 29.0 | 7.2 | | 56-63 | 57 | Q |
| 177 | 40.5 | 26.0 | 9.5 | | 61-68 | 62 | Q |
| 98 | 40.5 | 21.5 | 4.5 | 6.1 | 50-61 | 53 | C |
| 85 | 23.5 | 19.5 | 7.2 | | 60-68 | 60 | C |
| 523 | 31.2 | 17.9 | 6.8 | | 65-70 | 68 | C |
| 531 | * | 21.0 | 3.9 | 5.1 | 57-62 | 65 | C |
| 703 | * | 21.5 | 4.0 | | 65-75 | 66 | C |
| 628 | * | 17.0 | 1.9 | | 55-58 | 58 | C |
| 487 | 17.0 | 13.0 | 2.8 | | 55-64 | 59 | C |
| 79 | * | 15.0 | 1.9 | | 37-50 | 45 | C |
| 629 | * | 18.0 | 2.9 | | 48-55 | 49 | C |
| 24 | * | 15.5 | 4.5 | | 55-66 | 63 | C |
| 115 | * | 18.9 | 5.0 | | 62-66 | 63 | C |
| MEAN | 28.2 | 20.3 | 6.3 | 7.6 | | 64 | |

* = Broken specimen, distal fragment present

1 = Material: C = chert
Q = quartzite
PQ = pure quartz

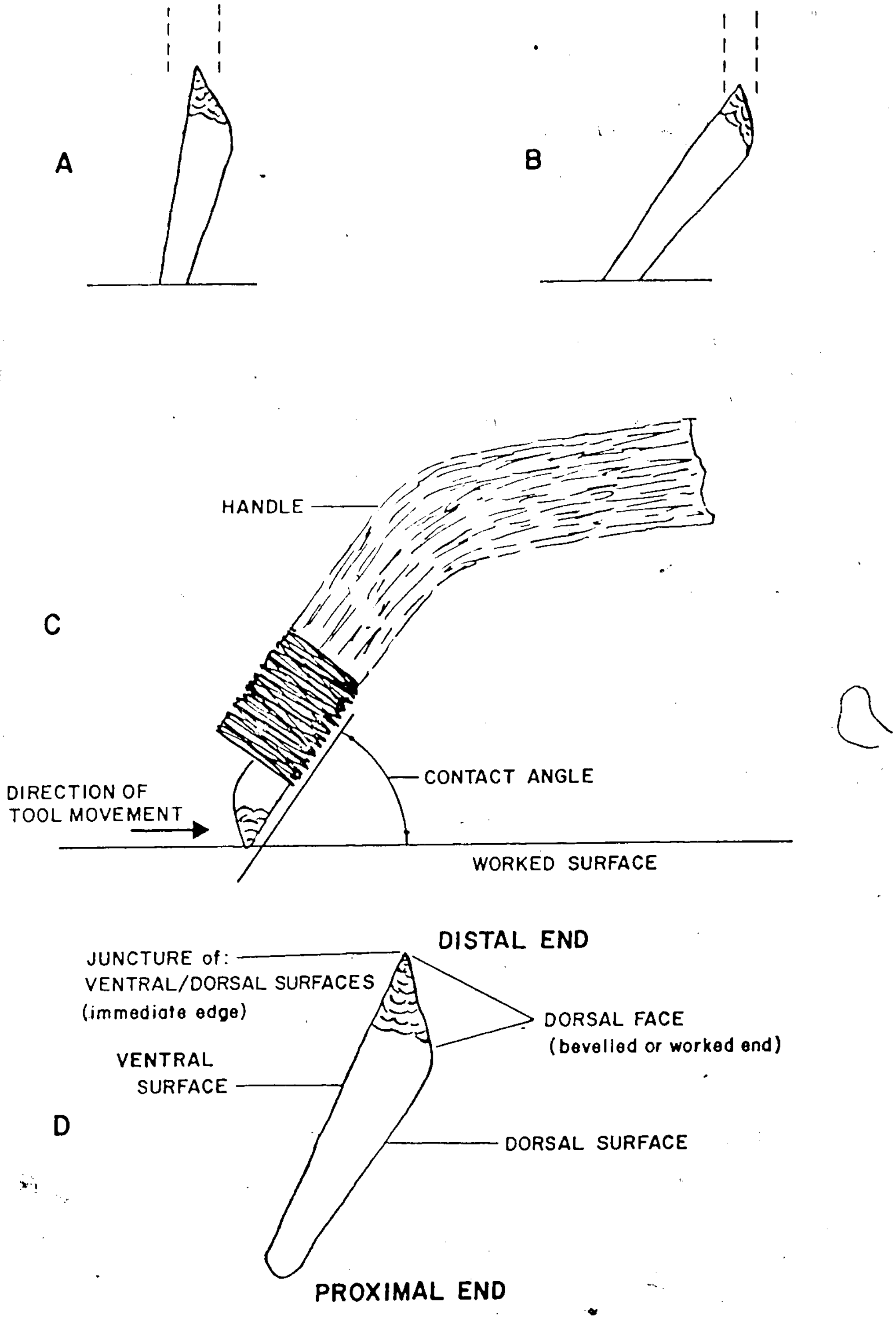


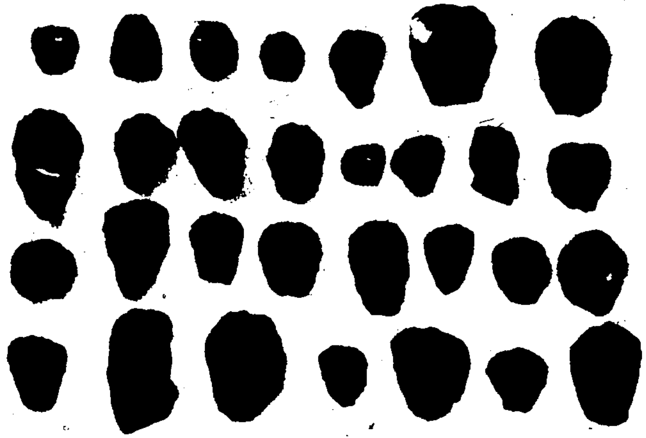

Figure 1. Profile of endscraper in first (A) and second (B) photographic positions. C; example of the direction of endscraper use and the angle of tool use on the worked surface. D; endscraper terminology as mentioned in the text.

PLATE 1. Sample of experimental tools used in this study. Tools numbered consecutively from 1 at lower right to 31 at upper right. There is no tool #19.

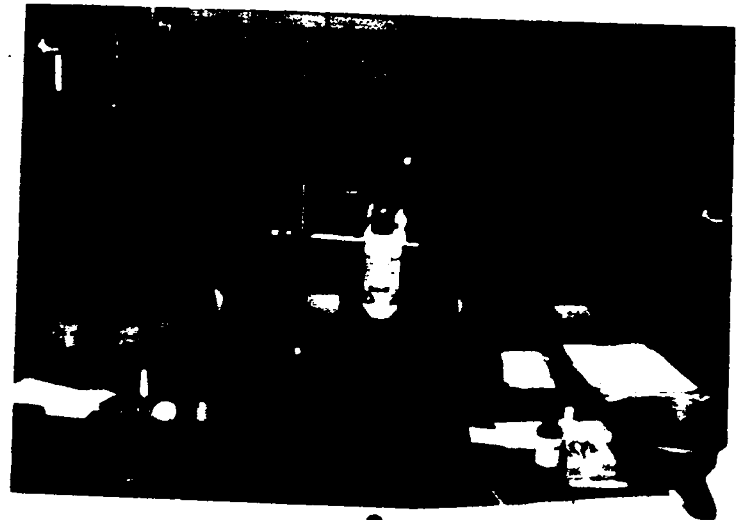
PLATE 2. Wild M5 microscope, camera and lighting set up used in microwear analysis.

PLATE 3. Distal end (dorsal face) of scraper showing dotting reference system. Tool is standing straight up on proximal end.

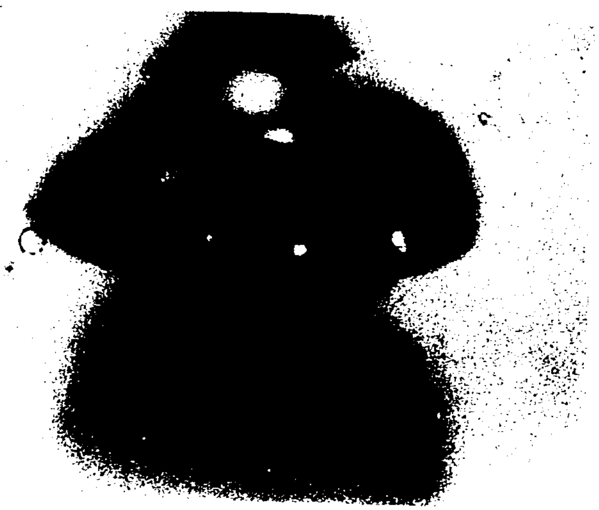
PLATE 4. Set of seven handles used in the experiments.



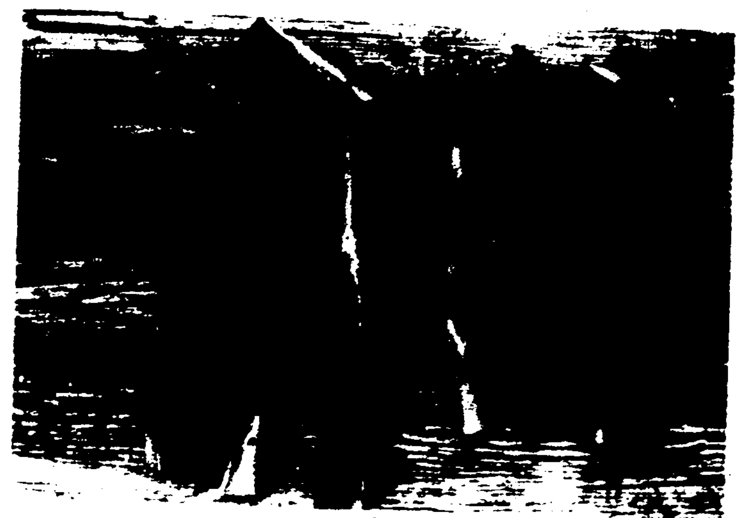
1



2



3



4

PLATE 5. 10X. Tiny chips of chert are visible on the surface of the scraped bone. This was a common occurence during the bone scraping sessions. Also note the grooves in the bone surface.

PLATE 6. Example of tool being used to scrape soaked bone.

PLATE 7. Example of tool being used to de-hair a cow hide. Tool is being pushed downward with the edge nearly perpendicular to the hide surface.

PLATE 8. 25X. Example of manufacture damage on unused edge. Distal end of tool shows "crushing" from the immediate edge to 0.48 mm up the dorsal face. Repeated flake initiation in this area has made individual scar identification difficult. The base of the dot is 0.99 mm from the edge. Coated.

5

6

7

8

PLATE 9. Examples of manufacture damage on unused edges.

a. 12X. Exp 2. Numerous step and hinge fractures are clearly discernable from the edge 0.50 mm up the dorsal face. "Crushing" is evident at the immediate edge area. The total edge across measures 4.16 mm. Coated.

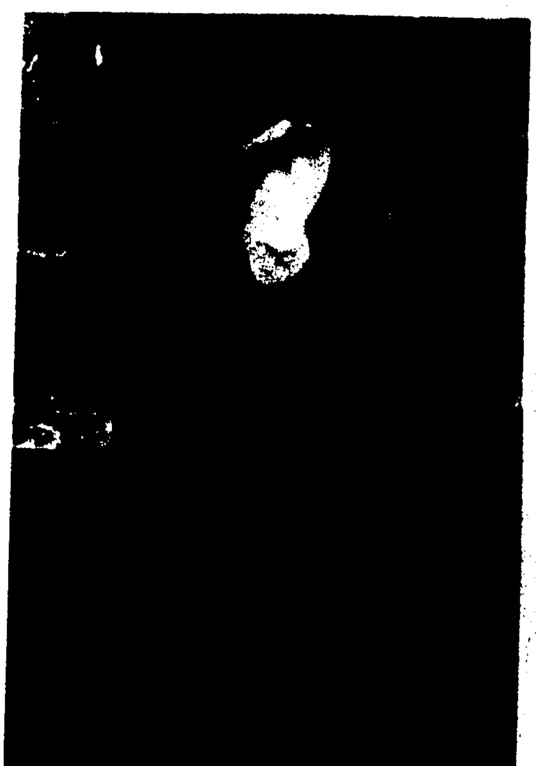
b. 25X. Exp 5. A relatively "clean" unused edge. Large feather scar left of center and overhanging projection of hinge scar at right. Feather scar at edge is 0.75 mm across.

c. 12X. Exp 13. Numerous step and/or hinge scars extend from edge to 0.60 mm up the dorsal face. On both sides of dot are much larger manufacture scars. Base of dot is 1.10 mm from the edge. Coated. See next photo.

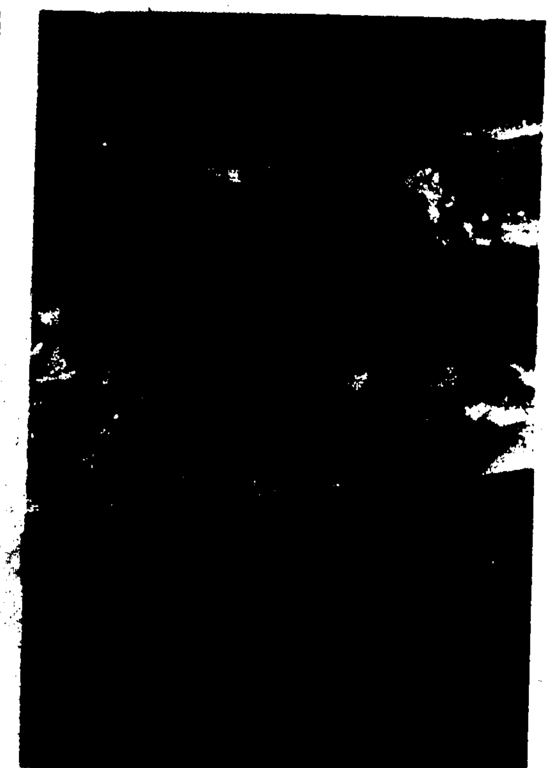
d. 50X. Exp 13. Higher power magnification of the area to lower right of dot in 9c. Note that step and hinge scars are clearly discernable, not crushed. Total edge across is 1.07 mm. Coated.

9a

9b



9c



9d

PLATE 10. Example of spontaneous retouch. Exp 24. Unused.

a. 12X. Edge in view is lateral side of scraper. Dot is in center of large semi-circular scar which terminates in a step fracture. Around periphery of flake terminus are multiple tiny scars, enlarged in next photo. Base of dot is 1.26 mm from edge. This tool was made by direct percussion with an antler billet.

b. 25X. Small parallel feather scars have apparently been initiated by a transmission of force from the removal of the larger step flake. Scars directly above dot are 0.12 mm across and 0.14 mm long.

PLATE 11. Probable examples of spontaneous retouch.

a. 25X. Exp 31. Distal end of unused experimental tool. Parallel, oblique feather scars are a maximum of 0.37 mm long, and 0.27 mm across. Tool was made by direct percussion with an antler billet.

b. 25X. Exp 8. Distal end of unused tool also made with antler billet. Mostly feather scars at edge. Expanding scar at far right is 0.31 mm long and 0.16 mm across at the edge.

10a

10b

11a

11b

PLATE 12. Exp 24. Dot 2. Tool used on fresh aspen.

a. 12X. Unused edge. Note cone-shaped feather manufacture scars. Base of dot is 2.05 mm from edge.

b. 25X. Unused edge at higher magnification. Feather scar at far right is 0.35 mm high.

c. 25X. After 500 strokes. New rectangular step scars extend a maximum of 0.71 mm up dorsal face. Base of dot 2 is just visible at top of photo. Coated.

d. 25X. After 3500 strokes. New feather scar to right of center is 0.30 mm high. Coated.

12a

12b

12c

12d

PLATE 12. (Continued)

e. 12X. After 7000 strokes. Large new scar in center. This step scar is 1.58 mm wide at widest point and 0.99 mm high. A few ink fragments are visible. Coated.

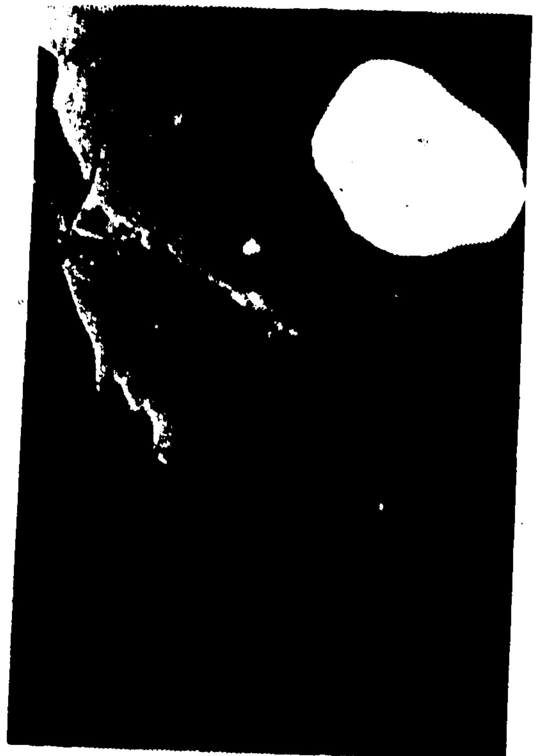
PLATE 13. Exp 31. Dot 2. Tool used on dry spruce.

a. 25X. Unused.

b. 25X. Used 500 strokes. Note numerous new scars. Rectangular shaped feather scar in center is 0.35 mm high. Coated.

c. 12X. After 1500 strokes. Large use flake with dot is laid back in place on tool surface. Flake extends off photo to right. Base of dot to tool edge is about 1.05 mm.

12e



13a

13b

13c

PLATE 14. Exp 31. Dot 3. Tool used on dry spruce.

a. 12X. Unused. Coated.

b. 12X. At least 3 new sequential [illegible]p scars can be seen on the ridge to the right of the dot. All of these scars occurred during the second use of the tool (between 500-1500 strokes). The three scars together extend 1.16 mm up the tool face. Coated.

PLATE 15. Exp 22. Dot 2. Tool used on fresh spruce.

a. 25X. During the third u[illegible] (750-1750 strokes) a large new feather scar was produced. Scar extends maximum of 1.66 mm up dorsal face.

b. 25X. View of the ventral surface of this tool where this flake was struck.

14a

14b

15a

15b

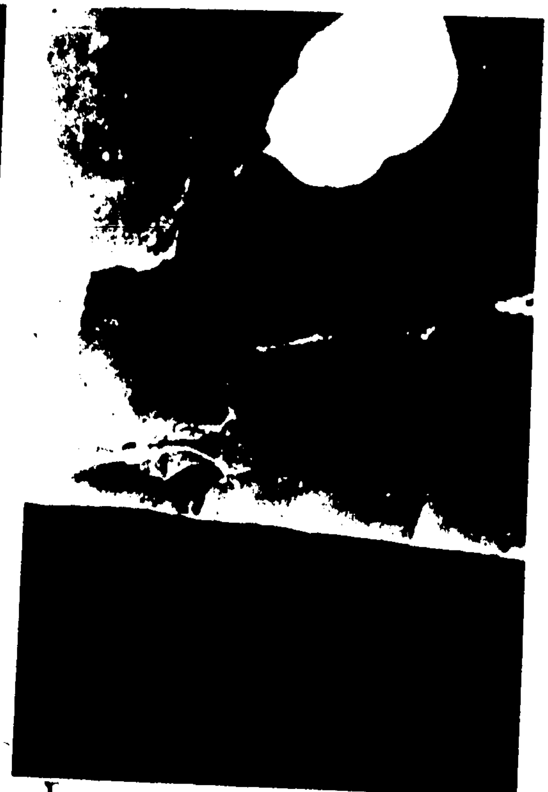
PLATE 16. Exp 31. Dot 1. Tool used on dry spruce.

a. 12X. Unused. Coated.

b. 25X. After 500 strokes; note several rectangular step scars directly below dot, as well as crescent-shaped scars at the left edge. Rectangular scars are 0.75 mm high. Coated.

c. 25X. After 1500 strokes; previous scars eliminated and new scars added. Coated.

16a



16b

16c

PLATE 17. Exp 10. Dot 1. Tool used on fresh aspen.

a. 25X. Unused. Coated.

b. 25X. After 9000 strokes. Dot is 1.58 mm from the edge. Coated.

PLATE 18. Projections on the edges of wood working tools.

a. 25X. Exp 24. Dot 3. After 1500 strokes on aspen. Area in focus is roughly 0.35 mm high.

b. 25X. Exp 10. After 3000 strokes on aspen. Two rounded and polished projections. Distance between them is about 1.38 mm.

17a

17b

18a

18b

PLATE 19. Rounded and polished edge on wood working tools.

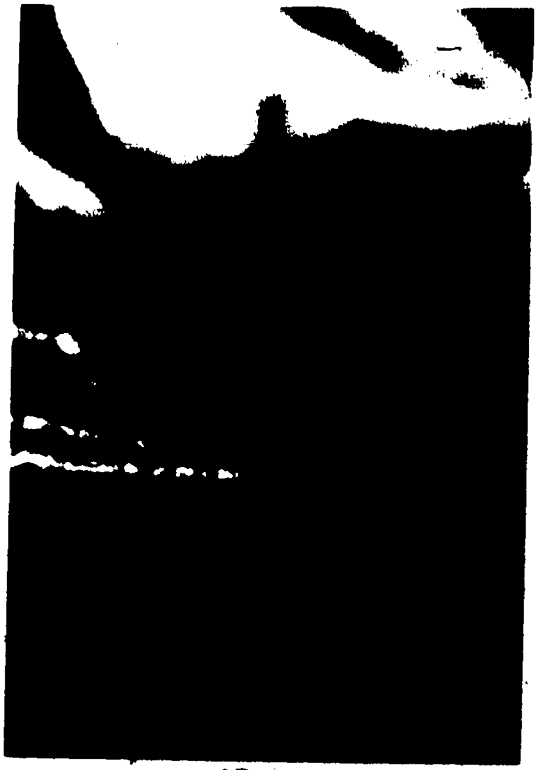
a. 25X. Exp 13. Dot 1. After 3500 strokes on fresh spruce. Length of edge in photo is 2.18 mm.

b. 25X. Exp 24. Dot 1. After 7000 strokes on aspen. Edge in photo is 2.18 mm long.

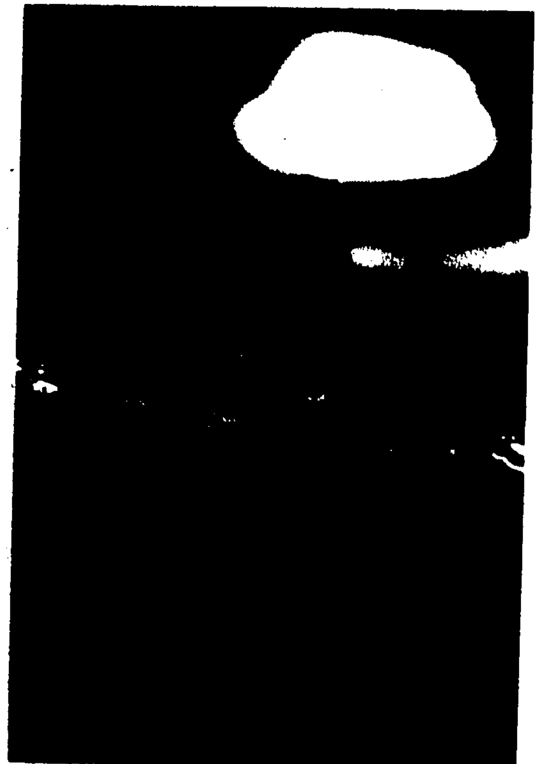
PLATE 20. Exp 1. Dot 1. Tool used on fresh spruce.

a. 12X. Unused edge and dorsal face. Coated.

b. 25X. Unused edge, ventral surface in bottom half of photo.



19a



19b

20a

20b

PLATE 20. (Continued)

c. 12X. After 1000 strokes. Base of dot is 3.05 mm from edge. Coated.

d. 25X. After 3000 strokes. Entire edge is 3.17 mm long.

e. 12X. After 5900 strokes. Base of new dot is 2.49 mm from edge. Coated.

f. 25X. After 5900 strokes. Edge in view is 1.98 mm long. Note rounding of flake scars near edge.

20c

20d

20e

20f

PLATE 21. Exp 22. Dot 1. Tool used on fresh spruce.

a. 25X. After 250 strokes. Base of dot is 2.06 mm from edge. Coated.

b. 25X. After 1750 strokes. Coated.

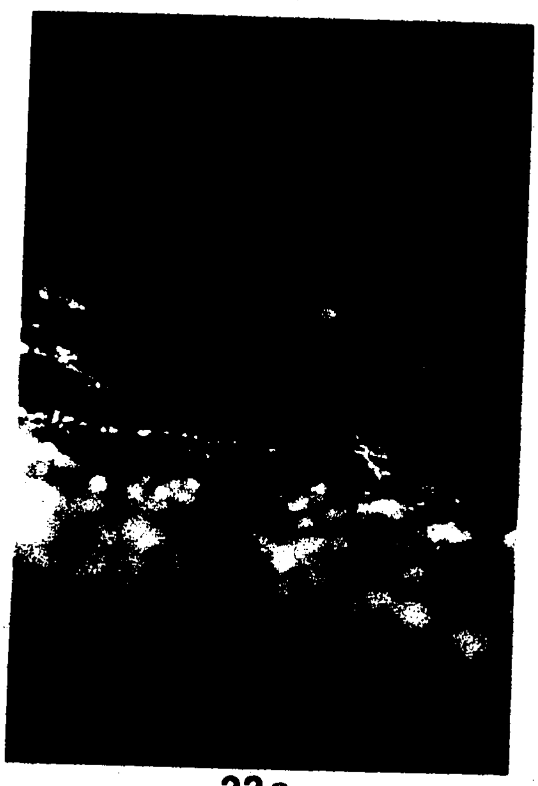
PLATE 22. Exp 24. Tool used on aspen.

a. 25X. After 7000 strokes. Edge is 2.18 mm long.

b. 25X. After 7000 strokes. Same part of tool as Plate 22a, showing extreme rounding and polish of dorsal surface. Edge is 2.18 mm long.

21a

21b



22a

22b

PLATE 23. Rounded and polished wood working tools.

a. 25X. Exp 1. After 5900 strokes on fresh spruce. Total edge in photo is 2.18 mm long.

b. 25X. Exp 22. Dot 1. After 1750 strokes on fresh spruce. Polished areas in photo are maximum of 0.75 mm high.

PLATE 24. Exp 17. Dot 3. Tool used on antler.

a. 25X. Unused. Height of semi-circular scar ~~at~~ left is 0.40 mm. Coated.

b. 25X. After 1000 strokes. Note new step s[illegible]s below and left of dot. Highest point of new scars is 0.51 mm up the dorsal face. Note sharpness of newly exposed edge to left, in contrast to right side. Coated.

23a

23b

24a

24b

PLATE 24. (Continued)

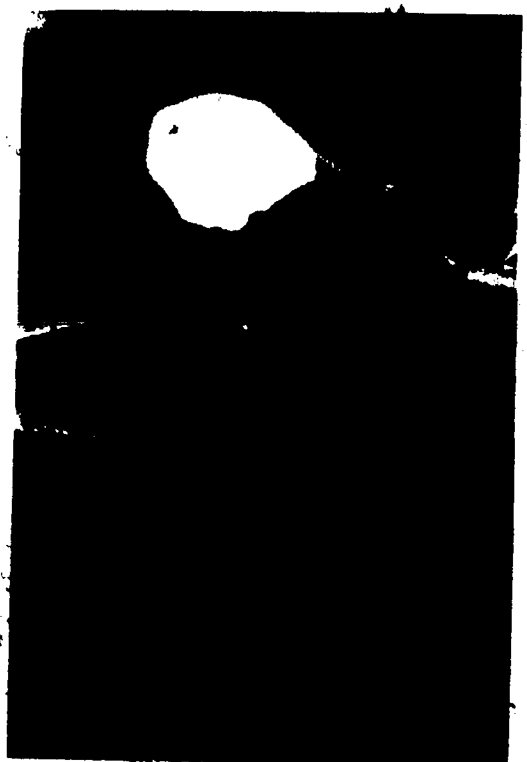
c. 25X. After 1600 strokes. Little change from Plate 24b, but note how edge at left is becoming dulled by process of edge breakdown similar to that at right. These tiny new scars at left are less than 0.039 mm high, (39 ). Coated.

d. 25X. After 1600 strokes. Total length of edge in view is 2.10 mm.

PLATE 25. Exp 17. Dot 1. Tool used on antler.

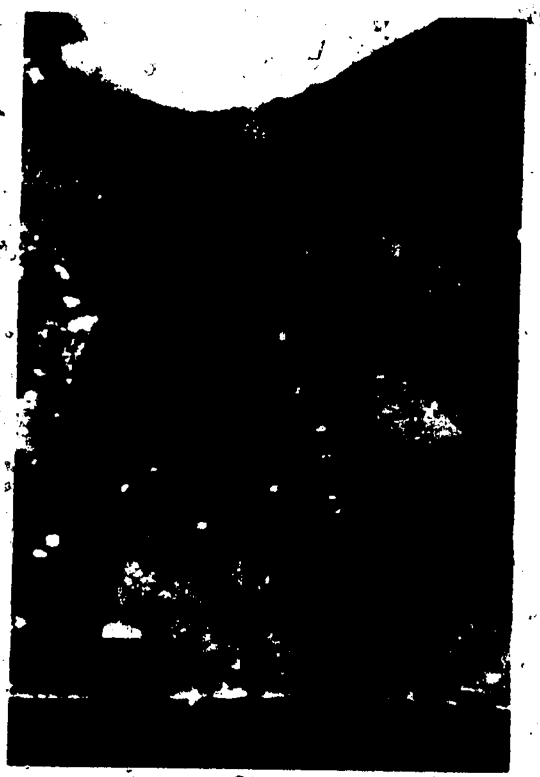
a. 50X. Unused. Edge in view is 1.07 mm across. Coated.

b. 25X. After 1000 strokes. Step scars at edge directly below dot are from use and are a maximum of 0.15 mm high. Scalar scars at right are from manufacture and highest scar is 0.25 mm from edge. Coated.

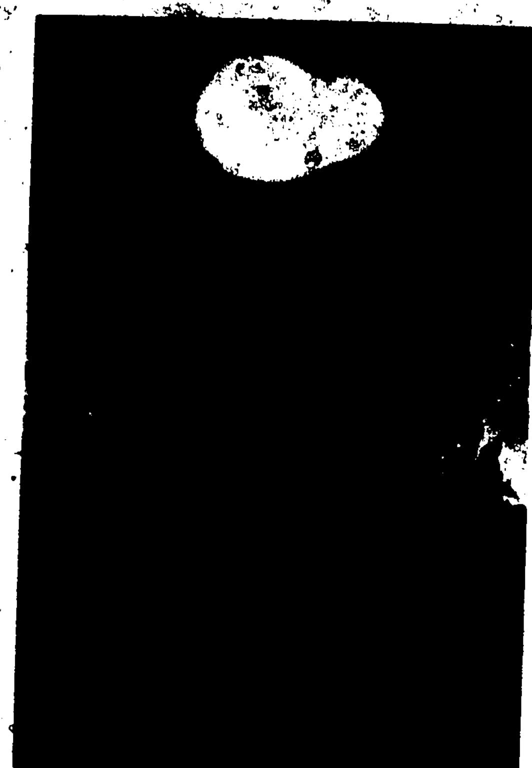


24c

24d



25a



25b

PLATE 25. (Continued)

c. 25X. After 1000 strokes. Edge in view is 2.18 mm across.

d. 50X. After 1000 strokes. Close up of edge near dot 1. Edge is 1.09 mm across.

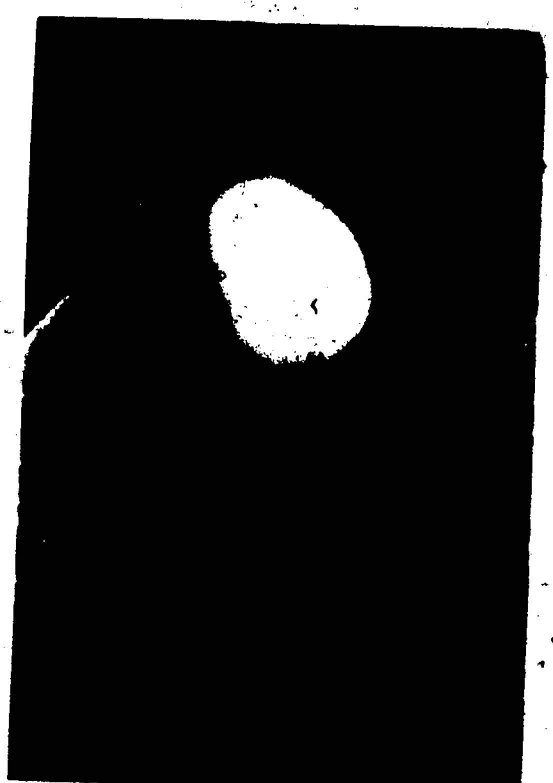
PLATE 26. Exp 7. Dot 1. Tool used on antler.

a. 25X. Unused. Note angularity of lower dorsal face. Base of dot is 1.19 mm from edge. Coated.

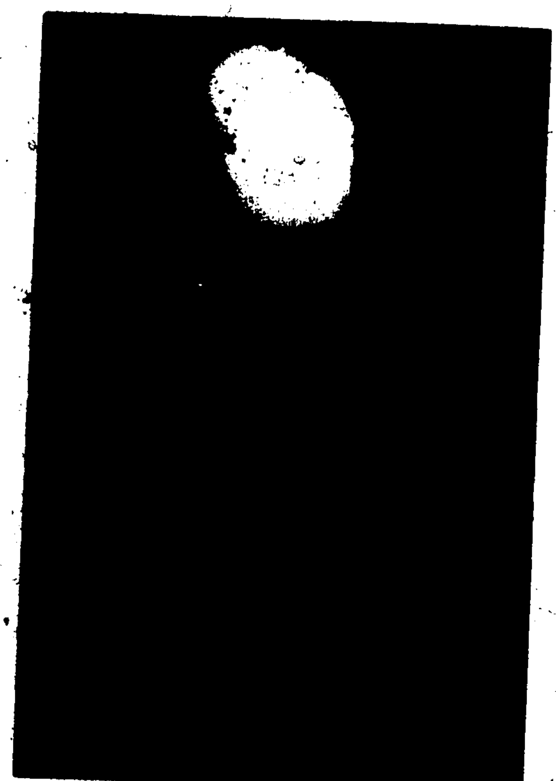
b. 25X. After 1250 strokes on antler. Note general lack of additional microflaking. Also note that the angularity of the manufacture scars is maintained. Coated.

25c

25d



26a



26b

PLATE 27. Polished and rounded edges on antler working tools.

a. 25X. Exp 16. Dot 2. After 2000 strokes on antler. Edge is ca. 2.18 mm across.

b. 50X. Exp 17. After 1600 strokes on antler. Band of smoothed and polished edge at right is 0.16 mm thick.

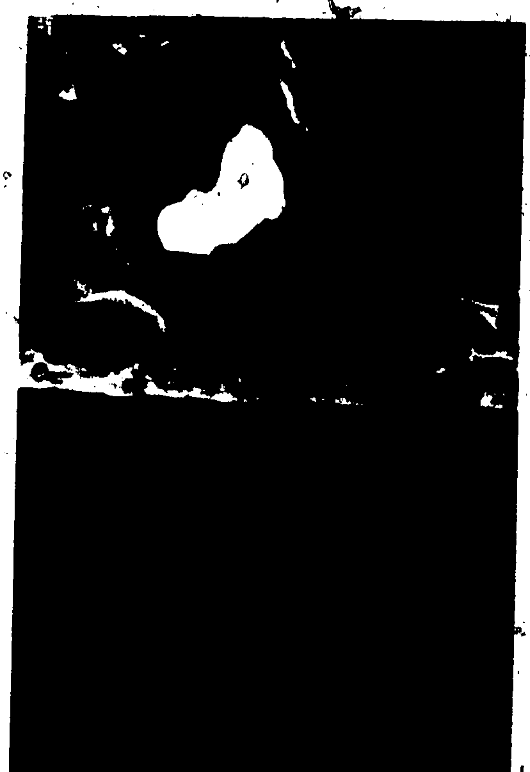
PLATE 28. Exp 30. Dot 1. Tool used on bone.

a. 12X. Unused. Coated.

b. 12X. After 250 strokes. Dorsal and ventral flaking at left. Base of dot is 1.20 mm from edge.

27a

27b



28a

28b

PLATE 28. (Continued)

c. 25X. After 250 strokes. View of scars extending onto ventral surface. Dot on dorsal face is visible at upper right. Edge is about 2.18 mm across. Coated.

d. 50X. After 1750 strokes. Slightly smoothed and polished edge area below dot 1. Edge in view is about 1.09 mm across.

PLATE 29. Exp 30. Dot 2. Tool used on bone.

a. 12X. Unused. Coated.

b. 12X. After 250 strokes. Numerous new scars, mostly of irregular shape and step termination. Note irregularity of edge. New scars have traveled about 1.10 mm up the dorsal face. Coated.

28c

28d

29a

29b

PLATE 29. (Continued)

c. 12X. After 750 strokes. Extensive flaking continues, note scar which has removed half of ink dot is about 1.54 mm long. Coated.

d. 12X. After 1750 strokes. Dot was removed by last use and the one seen here is new. Much of lower dorsal face has been totally altered. Parts of ventral surface are visible below the edge. Coated.

e. 25X. After 1750 strokes. View of microflaked ventral surface. Scarred area is about 1.98 mm across. Dot from 29d can be seen at upper left. Coated.

29c

29d

29e

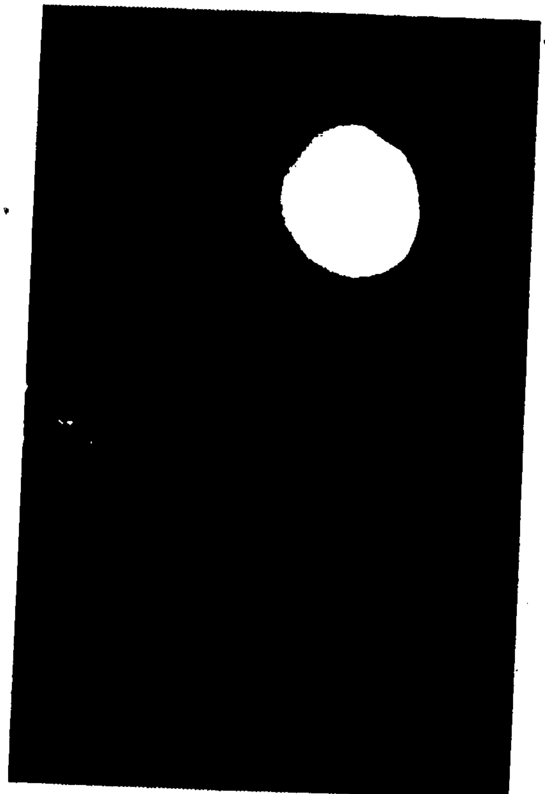
PLATE 30. Exp 30. Dot 3. Tool used on bone.

a. 25X. Unused. Base of dot is 0.83 mm from edge. Coated.

b. 25X. After 250 strokes. New dot. Surface and previous dot are completely flaked away. Base of new dot is about 1.07 mm from edge.

c. 25X. After 750 strokes. Virtually all visible scars are new. Large scars have traveled 1.38 mm up dorsal face. Small overlapping scars at edge are within a distance of 0.12 mm of edge. Coated.

d. 50X. After 1750 strokes. Smoothing and polishing of edge area below dot. Edge in view is about 1.09 mm across.



30a

30b

30c

30d

PLATE 31. Exp 3. Dot 2. Tool used on bone.

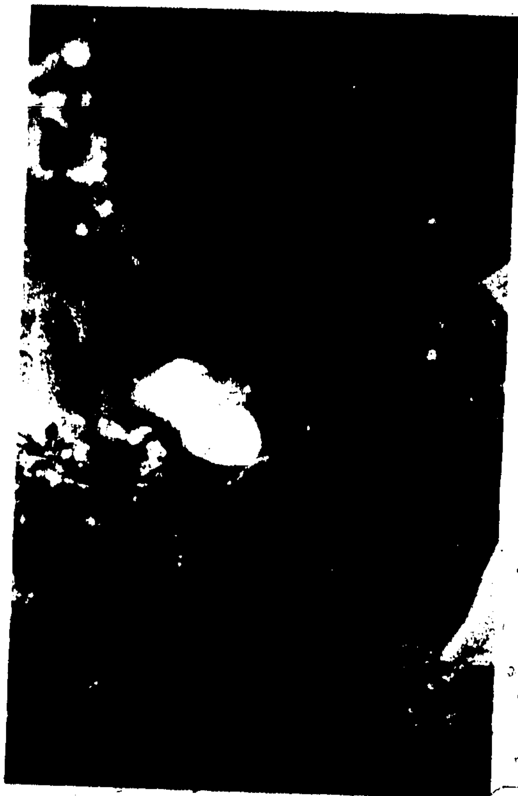
a. 12X. Unused. Base of dot is about 2.0 mm from edge. Coated.

b. 12X. After 1000 strokes. Extensive flaking in a crushing fashion along edge, and larger step and hinge scars below dot. Note long V-shaped scar below dot going off of right side of photo. Visible portion of this scar is 2.90 mm long. Coated.

PLATE 32. Exp 3. Dot 3. Tool used on bone.

a. 25X. Unused. Dot at very upper right. Edge across is about 2.05 mm. Note a few small nibble scars at edge to left of central ridge. Channels on either side of this ridge are long manufacture scars.

b. 25X. After 1000 strokes. Step scars have occurred along most of edge but only to a maximum of 0.20 mm up the dorsal face. Note the beginning of smoothing and polishing processes at the very edge.



31a

31b

32a

32b

PLATE 32. (Continued)

c. 25X. After 4000 strokes. Same edge as 32a, b. Dot at bottom of photo is on ventral surface. Note how flake scars have retained sharp appearance. Coated.

d. 25X. After 4000 strokes. Some smoothing of edge can be seen. Edge in view is about 2.05 mm across.

e. 50X. After 4000 strokes. Well developed rounding of a projection at the distal end. Projection is about 0.12 mm high.

f. 50X. After 4000 strokes. Well rounded edge. Area in view is about 2.05 mm across.

32c

32d

32e

32 f

PLATE 33. Exp 2. Dot 3. Tool used on bone.

a. 25X. Unused. Base of dot is about 1.20 mm from edge. Coated.

b. 25X. After 2000 strokes. Note small microflaking at edge to left of center. Also note somewhat smoothed appearance of immediate edge area. Also notice striations etched into enamel.

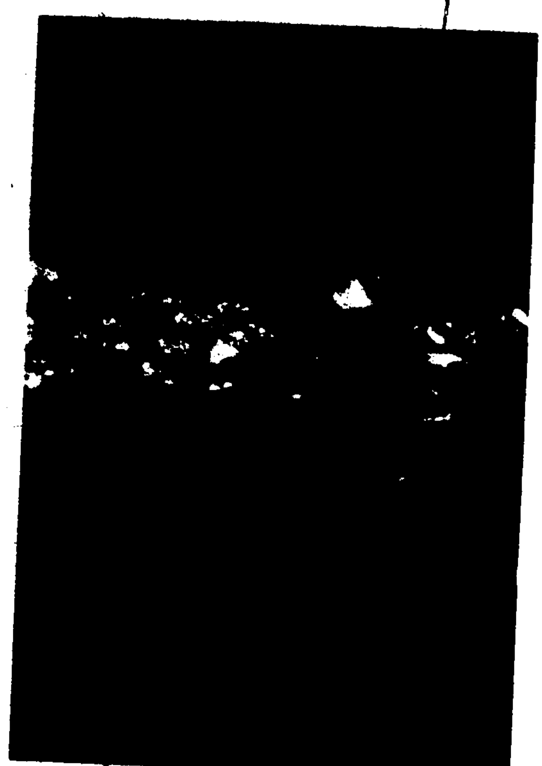
c. 25X. After 5000 strokes. Well developed rounding of edge area. Band of smoothed and polished area is about 0.28 mm thick.

d. 50X. Close up of 33c.

33a

33b

33c



33d

PLATE 34. Exp 21. Dot 1. Tool used on bone with silt.

a. 12X. Unused. Base of dot is 1.78 mm from edge.

b. 12X. After 500 strokes on silty bone. Note rounding and increased luster at edge. Same scale as 34a.

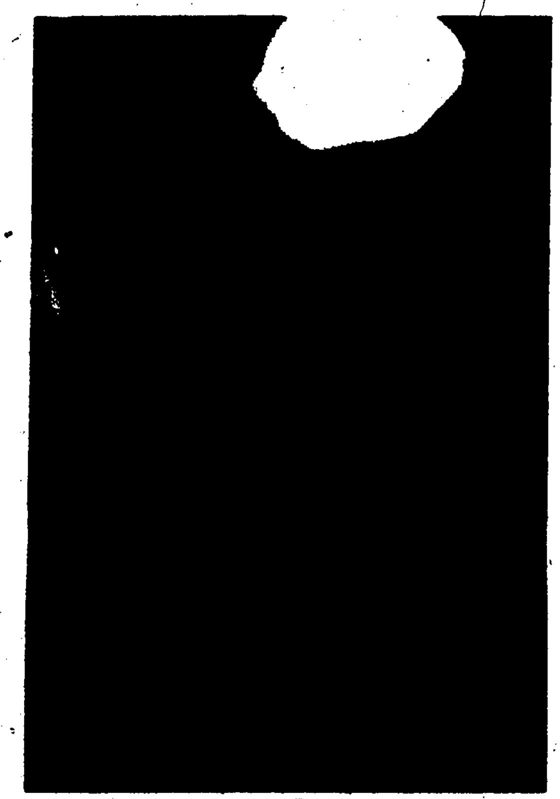
c. 12X. After 1500 strokes. Note enhanced damage to projectior at ends of ridges. Abraded projection at left is 1.10 mm high.

d. 25X. After 1500 strokes. Note how even with coating the abraded areas are easily identified. Also note faceted appearance to this abraded area.

34a

34b

34c



34d

PLATE 34. (Continued)

e. 25X. After 1500 strokes. Close up of abraded projection to left of dot. Note the linear gouging of the rock surface. Polish is scattered or discontinuous.

f. 50X. After 1500 strokes. Same area as 34e. Individual striations are not quite discernable. Note scattered, discontinuous polish.

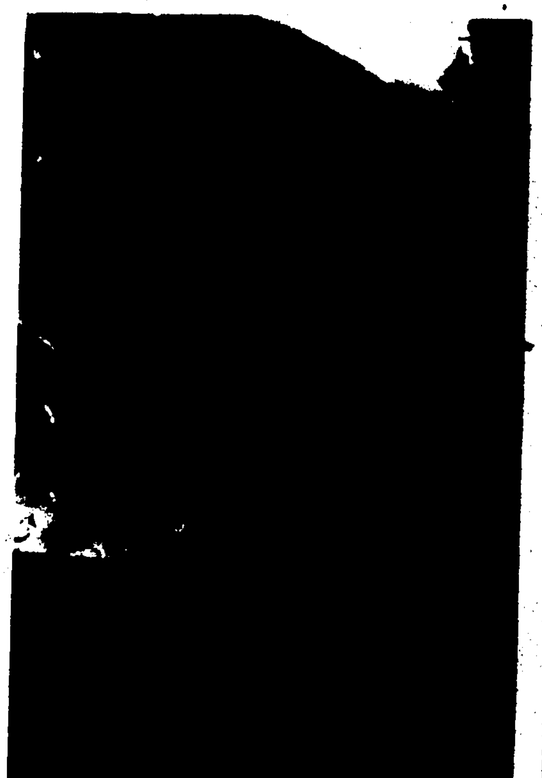
PLATE 35. Exp 23. Dot 1. Tool used on bone with silt.

a. 25X. Unused. Base of dot is 2.14 mm from edge. Coated.

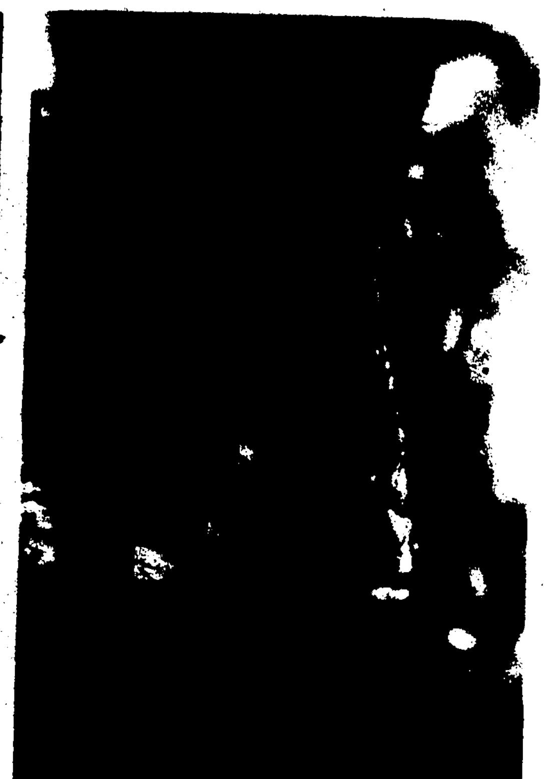
b. 25X. After 2000 strokes on bone with silt. Brightly polished flake ridge is 1.50 mm high. Dot is visible at upper left.

34e

34f



35a



35b

PLATE 35. (Continued)

c. 50X. After 2000 strokes. Striations visible in enamel over ink dot (Visible at upper right).

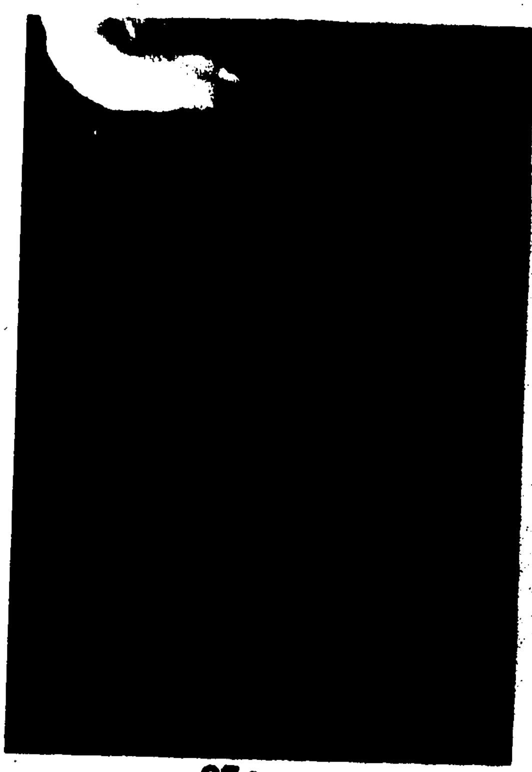
d. 25X. After 2000 strokes. Note greatly reduced angularity of flake scars near edge. Base of dot is 1.94 mm from edge. Coated.

e. 25X. After 2500 strokes. Flake scars near edge are even more rounded; some to the right of center are nearly obliterated. Coated.

f. 25X. After 2500 strokes. Same ridge as 35b. Rounding and polish are more extensive than in 35b. Polish is somewhat smooth, but still pitted in appearance.

35c

35d



35e

35f

PLATE 36. Exp 11. Dot 2. Tool used on bone with silt.

a. 25X. Unused. Base of dot is about 1.95 mm from edge.

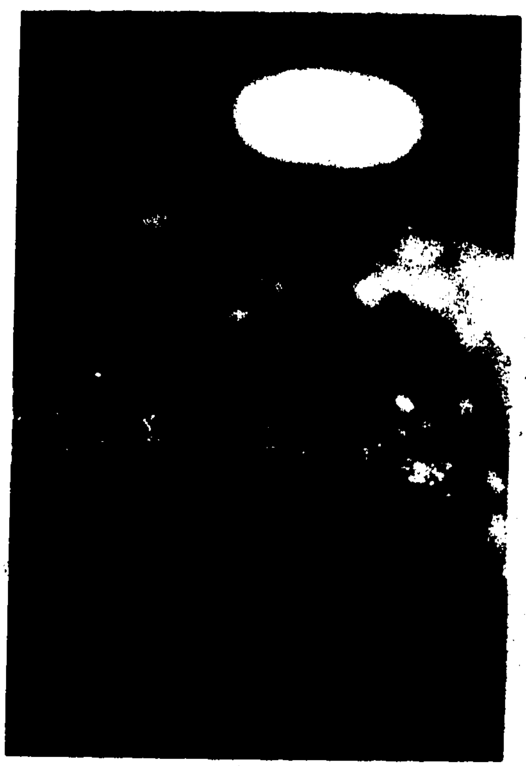
b. 25X. After 250 strokes. Some small step scars can be seen within 0.15 mm of the edge. Also note slight rounding and polish of the immediate edge area.

c. 25X. After 750 strokes. Smoothing and polishing of the working end. See 36d for scale.

d. 50X. After 750 strokes. Band of smoothed and polished rock along the edge is about 0.14 mm thick.

36a

36b



36c

36d

PLATE 37. Exp 25. Dot 2. Tool used to flesh hides.

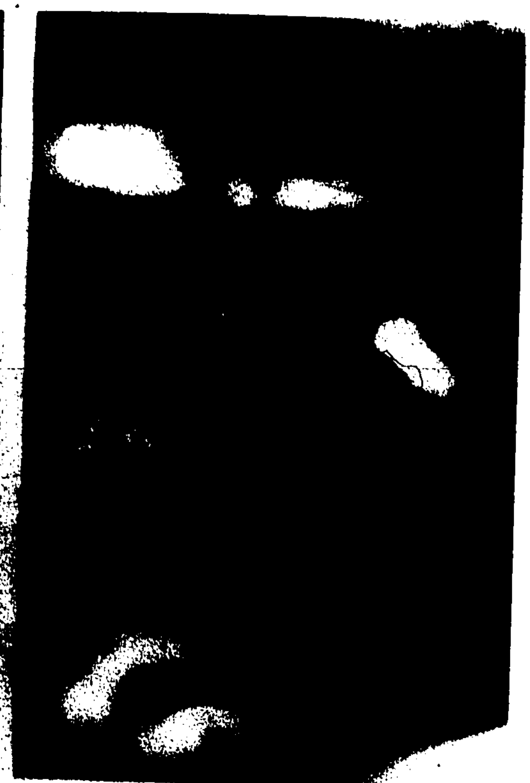
a. 25X. Unused. Base of dot is 0.[illegible] mm from edge. Coated.

b. 12X. After 1000 strokes. Little change from 37a, but note slightly smoothed and polished edge.

c. 25X. After 1000 strokes. Higher magnification of 37b. Note projecting areas are most affected. Band of polish at edge is about 0.28 mm thick.

d. 50X. Striations etched into enamel over dot. Lines run perpendicular to tool edge.

37a



37b

37c

37d

PLATE 38. Exp 9. Dot 2. Tool used on dry hide.

a. 12X. Unused. Base of dot is about 1.50 mm from edge. Coated.

b. 25X. After 1500 strokes. Note new semi-circular step scar below dot. Scar is a maximum of 0.47 mm high. Coated.

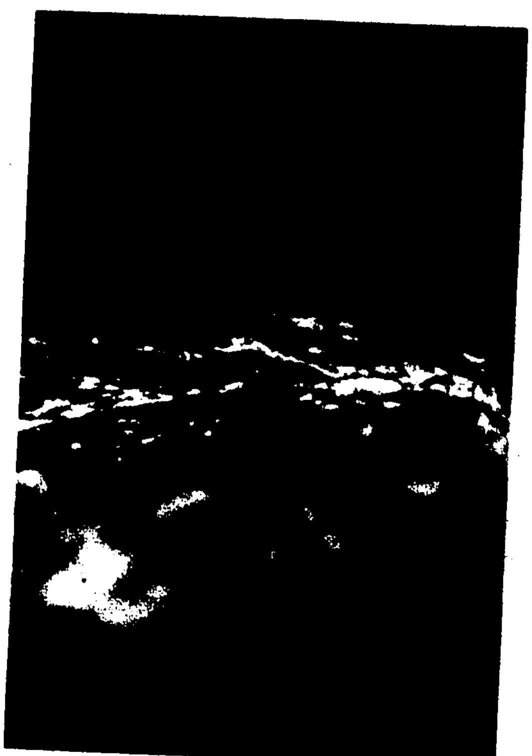
PLATE 39. Exp 9. Tool used on dry hide.

a. 12X. Unused.

b. 25X. After 1500 strokes. Rounding and polishing of edge and adjacent dorsal face. Rounded edge at far right is about 0.28 mm thick. Rounded edge at left is about 0.35 mm thick.

38a

38b



39a

39b

PLATE 40. Exp 12. Dot 2. Tool used on dry hide.

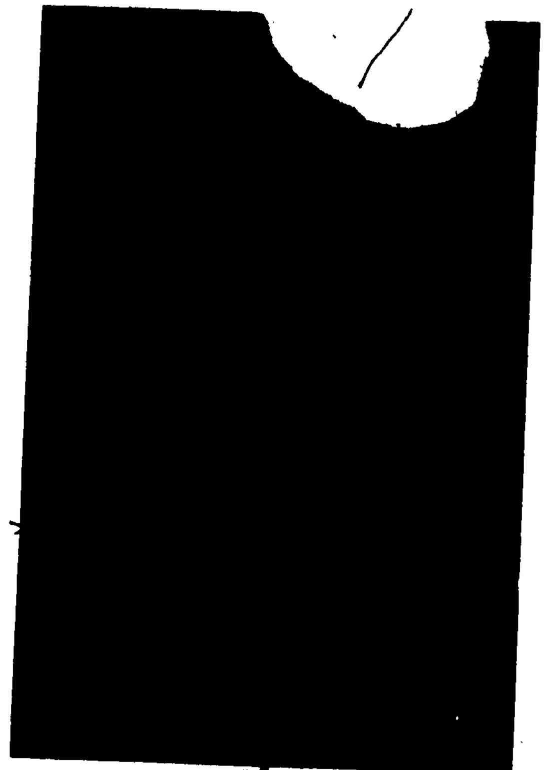
a. 25X. Unused. Manufacture scar at right extends a maximum of 0.63 mm up dorsal face. Coated.

b. 25X. After 6000 strokes. Several new microflake scars at right, in center and to left side of edge. Largest new scar at left extends 0.71 mm up dorsal face. Note sharpness of edge in center of photo. This is a concavity along the edge and has been protected from the effects of rounding as seen on the extreme right and left of the photo. Coated.

c. 25X. After 6000 strokes. The fairly sharp edge at center and left is same concavity mentioned in 40b. Note rounded and polished projection at right. Next plate shows this projection and area to the right. Whole edge in view is about 2.18 mm across.

d. 25X. After 6000 strokes. Same projection seen in 40c. Thickness of smoothed and polished area is about 0.35 mm. Trace of dot in upper left.

40a



40b

40c

40d

PLATE 40. (Continued)

e. 25X. After 6000 strokes. Rounded and polished projection to the left side of concavity seen in 40c. Note trace of dot at upper right. Thickness of smoothed area at edge is about 0.40 mm.

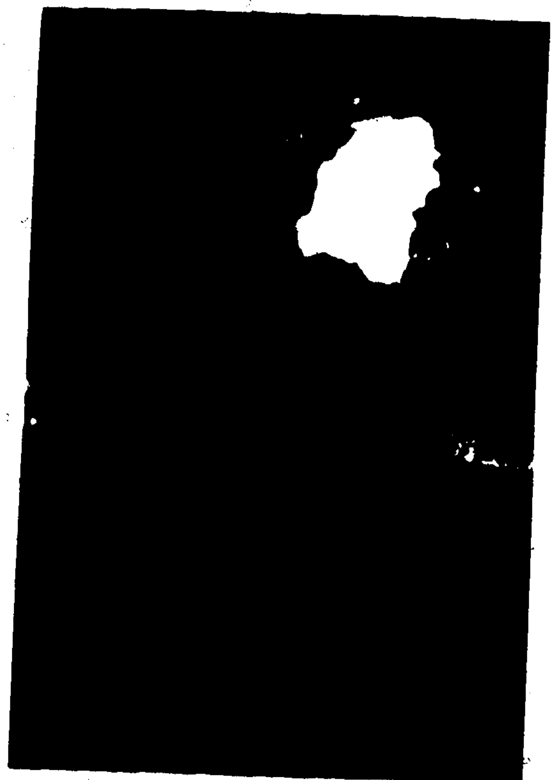
PLATE 41. Exp 14. Dot 1. Tool used on dry hide.

a. 12X. Unused. Base of dot is about 1.27 mm from edge. Coated.

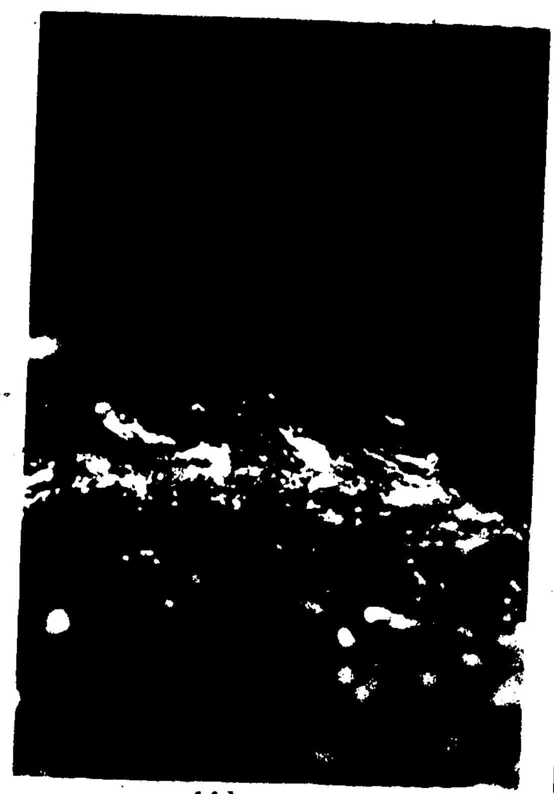
b. 25X. After 3000 strokes. Rounded and polished edge beneath dot (visible in upper half of photo). Smoothed area is about 0.40 mm thick.

c. 50X. After 3000 strokes. Same area as 41b.

40e



41a



41b

41c

PLATE 42. Exp 15. Dot 1. Tool used on dry hide with silt.

a. 12X. Unused. Base of dot is about 1.10 mm from edge. Notice numerous manufacture scars. Coated.

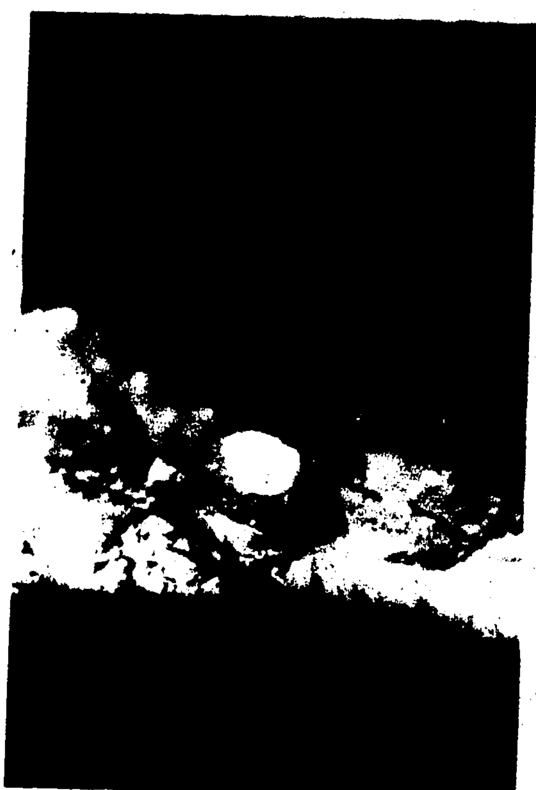
b. 25X. After 500 strokes. Abrasion of edge is well under way. Band of abraded edge is about 0.45 mm thick.

c. 12X. After 1500 strokes. Band of abraded edge at right is about 1.00 mm thick.

d. 25X. After 1500 strokes. Same area as in the right of 42c. (Note part of dot at upper left.) Lineality of abrasion is apparent in spots. Also note flat, dull appearance of abraded edge.

42a

42b



42c

42d

PLATE 43. Exp 15. Dot 3. Tool used on dry hide with silt.

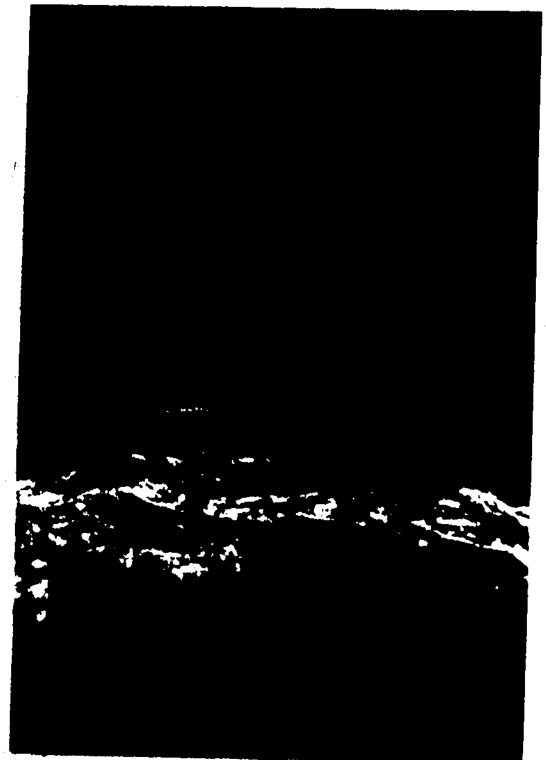
a. 12X. Unused. Note dot is on a near vertical face of rock about 3.50 mm from the edge. First elongated step scar below dot is about 1.26 mm long.

b. 12X. After 500 strokes. Same area as 43a, dot has been removed. Note two slightly projecting areas on either side of elongated step scar. These projecting areas show earliest development of abrasion. Distance between these projections is about 2.38 mm.

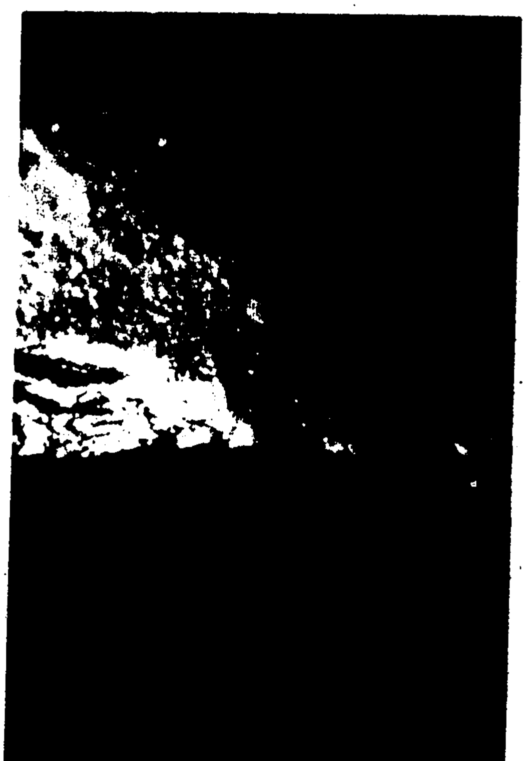
c. 12X. After 500 strokes. Center of photo is projection from the right side of 43b. Linear abrasion can be seen on blocky face of tool about 2.00 mm from edge.

d. 25X. After 500 strokes. Higher magnification of 43c.

43a



43b



43c

43d

PLATE 43. (Continued)

e. 50X. After 500 strokes. Same area as 43c and 43d. Individual striations can almost be identified. Distance from edge of tool at bottom to top of photo is about 1.40 mm.

f. 12X. After 1500 strokes. Entire edge is rounded. Projections seen in 43a and b are nearly gone. Also, elongated step scar is smoothed down. Top of this dorsal face (out of focus) is also rounded.

g. 25X. After 1500 strokes. Close up of area at right of 43f. Note matte appearance of smoothed area.

PLATE 44. Exp 8. Dot 2. Tool used on dry hide with silt.

a. 25X. Unused. Base of dot is about 1.23 mm from edge. Note angularity of edge and dorsal face area. Coated.

43e

43f

43g

44a

PLATE 44. (Continued)

b. 12X. After 250 strokes. Elongated portion of dot can be seen in upper center of photo. Beginnings of rounding process can be seen, especially at lower right. Whole edge is about 4.30 mm across.

c. 12X. After 750 strokes. Most of dorsal face shows rounding and moderately bright polish. Note ridge which runs diagonally down face of tool to right of remaining dot has been extensively smoothed. From edge to top of smoothed area is about 3.00 mm.

PLATE 45. Exp 15. Dot 2. Tool used on dry hide with silt.

a. 12X. Unused. Rectangular scar at center of photo is about 0.55 mm high and 0.33 mm wide. Coated.

b. 12X. After 500 strokes. Several small step scars have been initiated at edge below dot. Rectangular manufacture scar has been removed.

44b

44c

45a

45b

PLATE 46. Exp 18. Tool used to de-hair hide.

a. 12X. After 250 strokes. Projecting ridge at distal end of scraper. Note that the apex of the ridge is taking on a bright polish and a somewhat smoothed appearance. Dot at very top of photo is 3.76 mm from edge.

b. 25X. After 250 strokes. Edge at distal end shows faint trace of polish but little or no rounding or smoothing. Edge is 2.18 mm across.

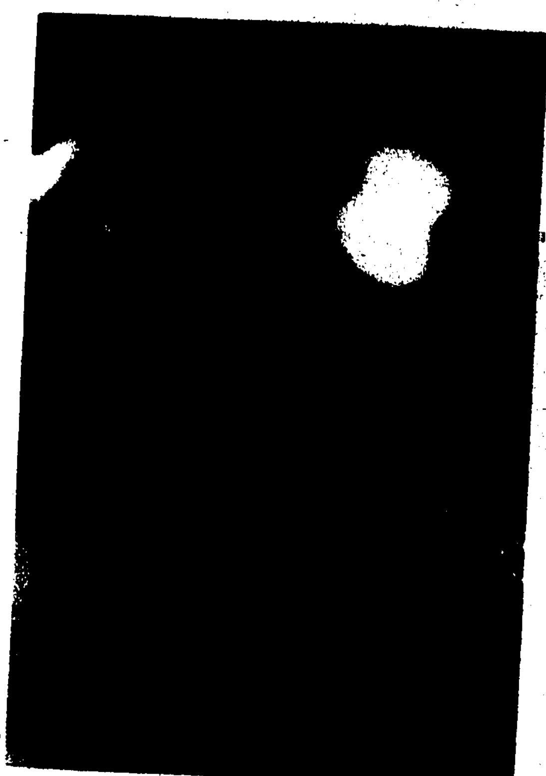
PLATE 47. Exp 18. Tool used to de-hair hide.

a. 25X. After 1250 strokes. Same edge as 46b, bright polish is established and edge is considerably rounded or smoothed. Edge is 2.18 mm across.

b. 50X. After 1250 strokes. Close up of center of 47a, bright, smooth band of polish associated with a fine smoothing of the edge. Edge is 1.09 mm across.

46a

46b



47a

47b

PLATE 47. (Continued)

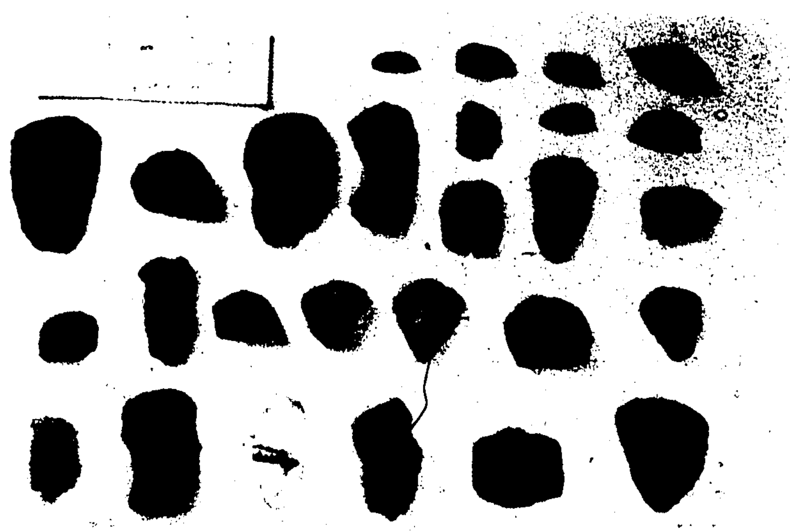
c. 50X. Long, continuous band of smoothed, polished edge surface. Note regularity of the edge at this part of the tool. At left side of photo, just above polished edge, dorsal face seems to exhibit some smoothing. Edge is 1.09 mm across.

d. 50X. Small projection along distal end of tool. High degree of rounding and polish are found on these extended areas of the edge. Projection is about 0.12 mm high.

PLATE 48. Prehistoric endscrapers from the Smoky Site.

Artifact numbers from left to right: Bottom row 486, 485, 621, 1, 720, 574; second row 152, 52, 84, 2, 48, 630, 373; third row 402, 323, 177, 98, 85, 523, 531; lower row of distal fragments 703, 628, 487; top row of distal fragments 79, 629, 24, and 115.

47c 47d



48

PLATE 49. Distal end of prehistoric scraper #402.

a. 25X. Finely rounded edge with apparent abrasion lines perpendicular to edge.

b. 50X. Short, striae-like abrasion marks along very edge. Approximate thickness of this rounded band is 0.11 mm.

PLATE 50. Distal end of prehistoric scrapers #701 and 117.

a. 50X. Scraper #701 showing very faint development of a bright, smooth polish along very edge. Total edge across is 1.05 mm. This tool is made of chert.

b. 50X. Scraper #117 showing more pronounced smoothing and bright polish along very edge. Edge across is 1.05 mm. This tool is made of quartzite.

PLATE 51. Distal end of prehistoric scraper #52.

a. 12X. Heavily flaked edge of tool. Base of dot is 2.30 mm from edge.

b. 12X. Ventral view of the same area as 51a. Notice the ventral flake scar and the generally sharp appearance of the edge. Edge across is 4.36 mm.

49a

49b

50a

50b

51a

51b

PLATE 52. Distal end of prehistoric scraper #621.

a. 25X. This tool is made of pure quartz. Edge is heavily damaged by breakage and fracture of the edge area. Few identifiable scars. Edge is 2.18 mm across. Damage area extends a maximum of 0.35 mm up dorsal face.

b. 25X. Another part of the working end. Similar breakage pattern as in 52a. Damaged area extends 0.71 mm up dorsal face. Note absence of rounding at very edge.

PLATE 53. Lateral edge and proximal end of prehistoric scraper #523.

a. 12X. Extremely rounded proximal end. Polish is light and of moderate brightness. Top to bottom of photo is about 3.49 mm.

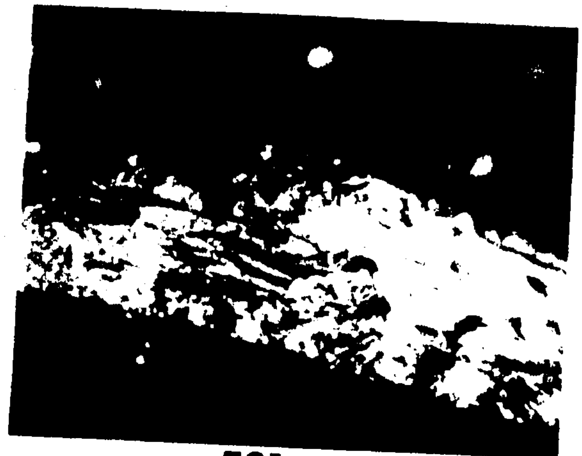
b. 12X. Extremely rounded lateral edge of same tool as above. Again polish is only weakly developed. Edge across is about 4.36 mm.

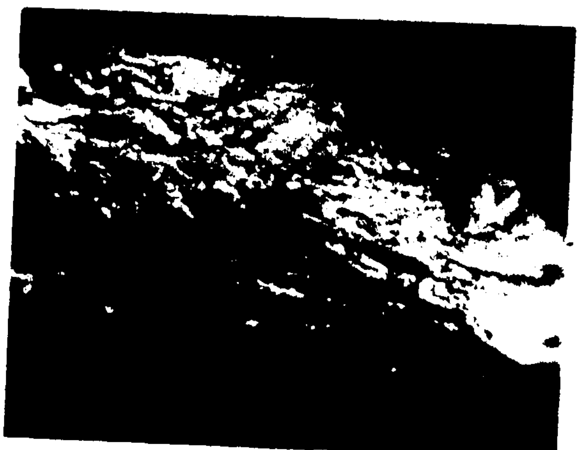
PLATE 54. Distal end of prehistoric scraper #98.

a. 25X. Note rounded edge but little polish. No apparent microflaking. Edge across is about 2.18 mm.

b. 50X. Same area as above. Rounding of tool surface extends about 0.22 mm up dorsal face.

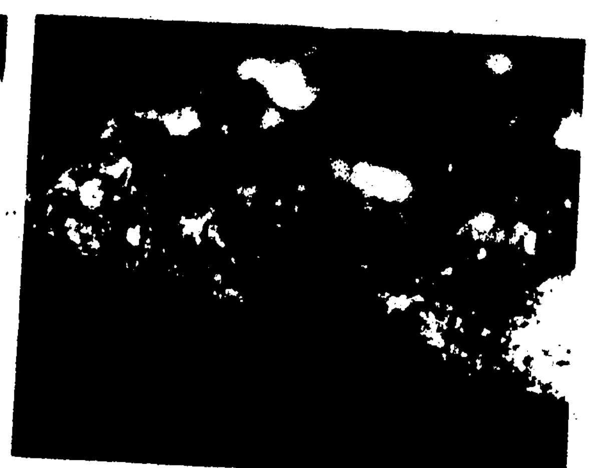

52a


52b


53a


53b


54a


54b

## REFERENCES


Ahler, S.
1971 Projectile point form and function at Rodgers rockshelter, Missouri. Missouri Archaeological Society Research Series, No. 8.

Ahler, S. and R. B. McMillan
1976 Material culture at Rodgers shelter: a reflection of past human activities. Prehistoric Man and His Environments, A Case Study in the Ozark Highland, W. R. Wood and R. B. McMillan (eds.), pp. 163-199. Academic Press, New York.

Asher, R.
1961 Experimental archaeology. American Anthropologist 63:793-816.

Barnes, A.
1932 Modes of prehension of some forms of upper paleolithic implements. Proceedings of the Prehistoric Society of E. Anglia, 7:34-56.

Bordes, F.
1969 Reflections on typology and techniques in the paleolithic. Arctic Anthropology VI (1):1-21.

Brink, J.
1976 Archaeology and pedology at the Smoky site, Grande Cache, Alberta. Paper presented at the IX meeting of the Canadian Archaeological Association, Winnipeg.

Broadbent, N. and K. Knutsson
1975 An experimental analysis of quartz scrapers, results and applications. Fornvannen 70:113-128.

Brose, D.
1975 Functional analysis of stone tools: a cautionary note on the role of animal fats. American Antiquity 40:86-93.

Clouse, R.
1977 Wear patterns, scanning electron microscopy, x-rays and amino acid residue analysis for determining tool function. Paper presented at the Conference on Lithic Use-Wear, Vancouver.

Cox, I.
1936 The Indian spoon. American Antiquity 1:317-320.

Conaty, G.
n.d. The Karpinsky site. Unpublished B. A. honours thesis, Department of Anthropology, University of Alberta.

Crabtree, D.
1964 Heat treatment of silica minerals. Tebiwa 7:1-6.

1972a The cone fracture principle and the manufacture of lithic materials. Tebiwa 15:29-36.

1972b An introduction to flintworking. Occasional Papers of the Idaho State University Museum, No. 28.

Del Bene, T.
1977 Once upon a striation: current models of striation and polish formation. Paper presented at the Conference on Lithic Use-Wear, Vancouver.

Dodd, W.
1977 Battered implements from Armijo rockshelter: an investigation of tool function. Paper presented at the Conference on Lithic Use-Wear, Vancouver.

Fedje, D.
1977 S. E. M. analysis of use-striae. Paper presented at the Conference on Lithic Use-Wear, Vancouver.

Frison, G.
1968 A functional analysis of certain chipped stone tools. American Antiquity 33:149-155.

Gibson, Douglas
1977 Use-wear on Sandia points. Paper presented at the Conference on Lithic Use-Wear, Vancouver.

Goddard, P. E.
1916 The Beaver Indians. American Museum of Natural History, Anthropological Papers X, Part IV.

Gould, R., D. Koster and A. Sontz
1971 The lithic assemblage of the Western Desert aborigines of Australia. American Antiquity 36:149-169.

Greiser, S. and P. Sheets
1977 Raw material as a functional variable in use-wear studies. Paper presented at the Conference on Lithic Use-Wear, Vancouver.

Hayden, B. and J. Kamminga
1973 Gould, Koster and Sontz on 'microwear': a critical review. Newsletter of Lithic Technology II:3-8.

Hester, T.
1970 A study of wear patterns on hafted and unhafted bifaces from two Nevada caves. Contributions to the University of California Archaeological Research Facility, No. 7, pp. 44-54.

1971 Hafted unifaces from Southwestern Coahuila, Mexico. The Kiva 36:36-41.

Hester, T., D. Gilbow and A. Albee
1973 A functional analysis of Clear Forks artifacts from the Rio Grande Plain, Texas. American Antiquity 31:90-96.

Hester, T. and R. Heizer
1972 Problems in the functional interpretation of artifacts: scraper planes from Mitla and Yagul, Oaxaca. Contribution to the University of California Archaeological Research Facility, No. 14, pp. 107-123.

Kamminga, J.
1977 The nature of use-polish on stone tools. Paper presented at the Conference on Lithic Use-Wear, Vancouver.

Keeley, L.
1974 Technique and methodology in microwear studies: a critical review. World Archaeology 5:323-336.

Keeley, L. and M. Newcomer
1977 Microwear analysis of experimental flint tools: a test case. Journal of Archaeological Science 4:29-62.

Keller, C.
1966 The development of edge damage patterns on stone tools. Man 1:501-511.

Kinsaul, R.
1972 Microscopic analysis of certain stone tools from 1Mg74. Unpublished Masters Thesis, Department of Anthropology, University of Alabama.

Lawrence, R.
1976 Microanalysis of edge damage on utilized flakes. The APE Experimental Archaeology Papers 4:90-127.

Levitt, J.
1976 The traceological method: an introduction and case study analysis of some late prehistoric hide-scraping tools from the Northwestern Plains. Unpublished Masters Thesis, University of Calgary, Department of Archaeology, Calgary, Alberta.

Mandeville, M.
1973 A consideration of the thermal properties of chert. Plains Anthropologist 18:177-202.

Mason, O.
1890 Aboriginal skin dressing --- a study based on material in the U.S. National Museum. Smithsonian Report of the National Museum for 1889, Section III, pp. 553-589.

Metcalf, G.
1970 Some wooden scraper handles from the Great Plains and Southwest. Plains Anthropologist 15:46-53

Morwood, M.J.
1975 Analogy and the acceptance of theory in archaeology. American Antiquity 40: 111-116.

Nance, J.
1969 Lithic technology of 4-5AC-43: microscopic examination. Unpublished Masters Thesis, Department of Anthropology, University of California, Davis.

1971 Functional interpretations from microscopic analysis. American Antiquity 36:361-366.

n.d. Numerical taxonomy studies of microwear on the Los Tapiales artifacts. Appendix in Los Tapiales: a paleo-Indian campsite in Guatemala Highlands. R. Gruhn and A. Bryan, Proceedings of the American Philosophical Society, in press.

Newcomer, M.
1976 Spontaneous retouch. Second International Symposium on Flint. F.H.G. Engelen, (ed.), pp.62-64, Staringia No. 3, Nederlandse Geologrsche Vereniging Maastricht.

Nissen, K. and M. Dittemore
1974 Ethnographic data and wear pattern analysis: a study of socketed Eskimo scrapers. Tebiwa 17:67-88.

Odell, G.
1975 Microwear in perspective: a sympathetic response to Lawrence H. Keeley. World Archaeology 7:226-240.

Osgood, C.
1940 Ingalik material culture. Yale University Publications in Anthropology, No. 22.

Over, W.
1937 The use of the thumb-scraper. American Antiquity 2:208-209.

Purdy, B.
1974 Investigations concerning the thermal alteration of silica minerals. Tebiwa 17:37-66.

Purdy, B. and H. Brooks
1971 Thermal alteration of silica minerals: an archaeological approach. Science 173:322-325.

Rabinowicz, E.
1968 Polishing. Scientific American 218 (6):99-109.

Ranere, A.
1975 Tool making and tool use among the preceramic peoples of Panama. Lithic Technology, Making and Using Stone Tools, E. Swanson (ed.), pp. 173-209. Mouton, The Hague.

Ray, C.
1937 Probable uses of flint end-scrapers. American Antiquity 2:303-306.

Rosenfeld, A.
1971 Examination of use-marks on some Magdalenian end scrapers. British Museum Quarterly XXXV:176-182.

Semenov, S.
1964 Prehistoric Technology. Translated by M. Thompson, Barnes and Noble, New York.

1970 The forms and funktions of the oldest tools. Quartar 21:1-20.

Sheets, P.
1973 Edge abrasion during biface manufacture. American Antiquity 38:215-218.

Sollberger, J. B.
1969 The basic tool kit required to make and notch arrow shafts for stone points. Bulletin, Texas Archaeological Society No. 40, pp. 231-240.

Sonnenfeld, T.
1962 Interpreting the function of primitive implements. American Antiquity 28:56-65.

Thompson, M.
1964 Translator's preface in Prehistoric Technology. S. Semenov, pp. ix-xii.

Tindale, N.
1965 Stone implement making among the Nakaka, Ngadajara and Pitjandjara of the Great Western Desert. Records of the South Australian Museum 15:131-164.

Tixier, J.
1974 Glossary for th[e d]escription of stone tools with special reference to the epipaleolithic of the Maghreb. Newsletter of Lithic Technology: Special Publication No. 1. Translation by M. H. Newcomer.

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 1:170-196.

U.S.F.P.L.
1974 (United States Forest Products Laboratory). U. S. Department of Agriculture.

Walcott, C.
1965 Significance of wear on chipped implements. Bulletin, Massachusets Archaeological Society 27:12-14.

Wedel, W.
1970 Antler tine scraper handles in the central Plains. Plains Anthropologist 15:36-45.

White, J.
1967 Ethno-archaeology in New Guinea: two examples. Mankind 6:409-414.

1969 Typologies for some flaked stone artifacts of the Australian New Guinea Highlands. Archaeology and Physical Anthropology in Oceania 4:18-46.

White, J. and D. Thomas
1972 What mean these stones? Ethno-taxonomic models and archaeological interpretations in the New Guinea Highlands. Models in Archaeology, D. L. Clark (ed.), pp. 275-308, University of Pittsburgh.

Wilmsen, E.
1968 Functional analysis of flaked stone artifacts. American Antiquity 33:156-161.

1970 Lithic analysis and cultural inference: a paleo-Indian case. Anthropological Papers of the University of Arizona, No. 16.

Wissler, C.
1910 Material culture of the Blackfoot Indians. American Museum of Natural History, Anthropological Papers V, Part I.

Witthoft, J.
1955 Worn stone tools from southeastern Pennsylvania. Pennsylvania Archaeologist XXV:16-31.

1967 Glazed polish on flint tools. American Antiquity 32:383-388.

Wylie, H.
1973 Microanalysis and functional typology of the Hogup cave chipped stone tools. Unpublished Masters Thesis, Department of Anthropology, University of Utah.

1975 Too[illegible] icrowear and functional types from Hogup cave, Utah. Tebiwa [illegible] (2):1-30.