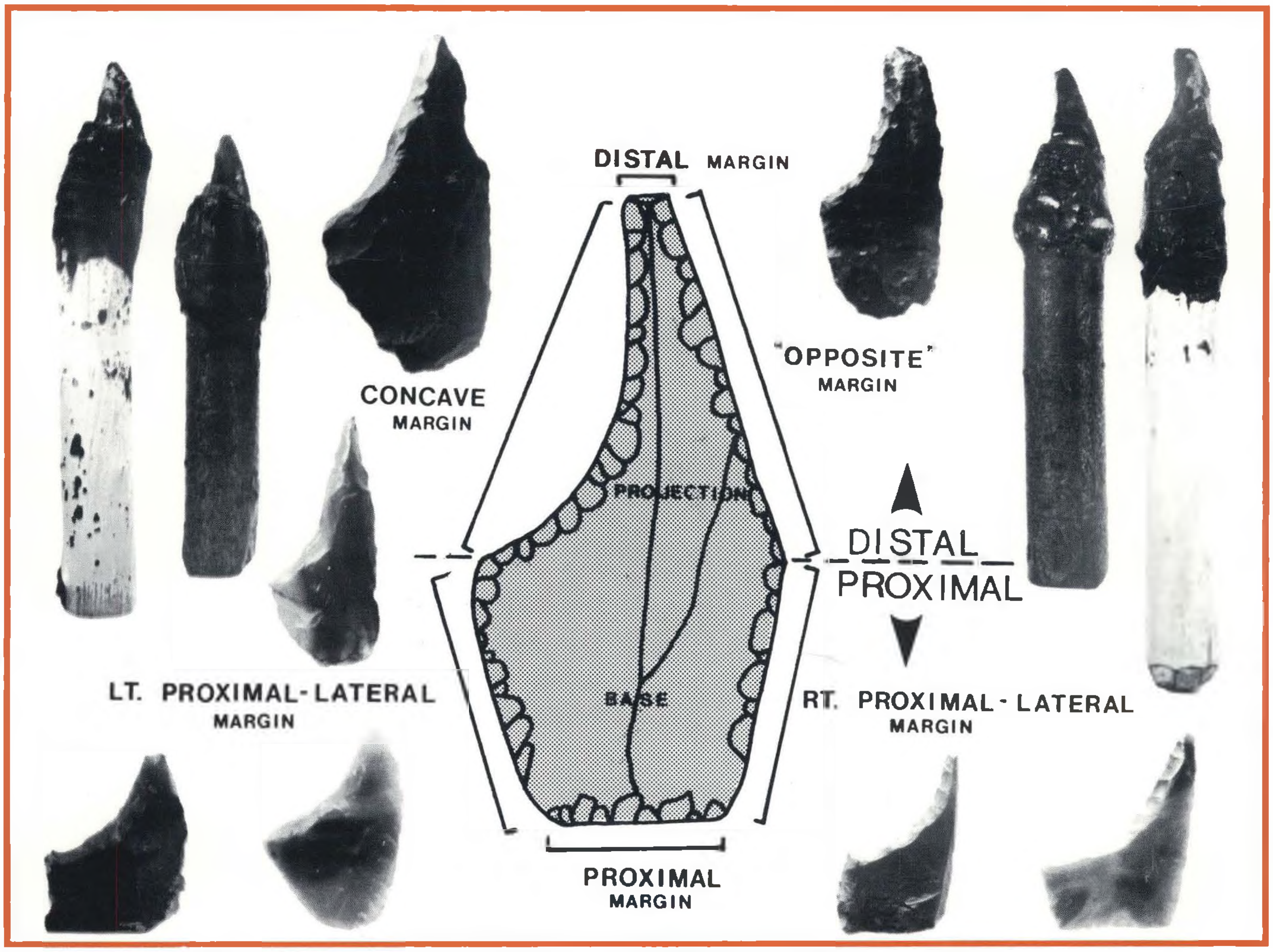
INTEGRATED LITHIC ANALYSIS: THE SIGNIFICANCE AND FUNCTION OF KEY-SHAPED FORMED UNIFACES ON THE INTERIOR PLATEAU OF NORTHWESTERN NORTH AMERICA



Department of Archaeology
Simon Fraser University
Publication Number 20

Michael Keith Rousseau
1992

Archaeology Press
Simon Fraser University
Burnaby, B. C.

ISBN 0-86491-131-9

PRINTED IN CANADA

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by

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Simon Fraser University
Publication Number 20
1992

Burnaby, British Columbia

For Eunice

ABSTRACT

Interior Plateau archaeologists have long recognized the potential for "key-shaped formed unifaces" to be formally recognized as reliable temporal horizon markers, and to provide important information concerning specific task activities performed at prehistoric sites.

The main objectives of this study are: (1) to determine the geographical distribution of key-shaped formed unifaces in the Northwest; (2) to disclose their approximate relative duration of use in areas where they have been identified; and (3) to determine their primary function on the Interior Plateau.

This tool type has been documented in two major cultural and geographic areas in the Northwest: the Interior Plateau and some of its immediately adjacent regions; and throughout most of the Arctic. Current radiocarbon age estimates suggest that they were used between ca. 3000 and 1000 BP on the Canadian Plateau. On the Columbia Plateau they have been found in contexts dating between ca. 4000 and 1000 BP. The 1000-year disparity between the appearance dates in these two contiguous culture sub-areas may be the result of sampling error, as very few sites dating between ca. 4000 and 3000 BP have been investigated on the Canadian Plateau. Very similar tools were used in the Arctic commencing sometime between ca. 4500 and 4000 BP, where they also disappeared about 1000 BP.

A study sample of 129 specimens from excavations and surface collections on the Canadian Plateau were examined to generate descriptive data, and to determine their use. Results of design theory, residue, microwear, and experimental analyses all suggest that the primary function of key-shaped formed unifaces on the Interior Plateau involved working stalks and branches of woody plants. A possible secondary function for these tools may have involved occasional shaving and smoothing of soaked or boiled antler beams and tines.

ACKNOWLEDGEMENTS

This monograph is based on a thesis submitted in partial fulfillment of the requirements for a Master of Arts degree in Archaeology at Simon Fraser University (Rousseau 1989). A few minor editorial changes have been made for this volume. I would like to extend my gratitude and sincere thanks to Dr. Brian Hayden (senior thesis supervisor) Dr. Knut Fladmark (second supervisior), and Dr. David Pokotylo (external examiner, University of British Columbia) for their guidance and useful comments during the preparation of this monograph.

Gratitude and thanks are also extended to the Museum of Archaeology and Ethnology at S.F.U., the Museum of Anthropology at U.B.C., the Anthropological Collections section of the Royal British Columbia Museum, and the Secwepemc Museum for loaning the remainder of the prehistoric key-shaped formed unifaces examined in this study.

For their time and valuable comments, I would also like to thank the many researchers who responded to my query regarding the currently known spatial and temporal distribution of key-shaped formed unifaces in the Northwest. These persons include Robert Ackerman (Washington State University), Margaret Bertulli (Prince of Wales Northern Heritage Center), Roy Carlson (S.F.U.), Raymond LeBlanc (University of Alberta), James Helmer (University of Calgary), Robert McGhee (Archaeological Survey of Canada), David Morrison (Archaeological Survey of Canada), Milton Wright (Archaeological Survey of Alberta), David Chance (University of Idaho), Robert Greengo (University of Washington), Leslie Davis (Montana State University), and John Brumley (Ethos Consultants Ltd., Alberta).

Many of my friends and/or colleagues assisted me by obliging to witness my interpretations of visual data during the residue analysis, by participating in the experimental component of the study, and/or by providing comments on various aspects of this problem. They include Dr. Paul Bakan (Psych), John Breffitt, Luke Dalabonna, Dr. Jon Driver (Arc), Rob Gargett, Geordie Howe, Gyles Iannone, Dr. Geof Lister (Biol), Ian Kuijt, Chris Knusel, Peter Merchant, Laurie Milne, Bob Muir, Dr. Erle Nelson (Arc), Murielle Nagy, Dr. Jack Nance (Arc), Tom Richards, and Dr. Arnoud Stryd (Arcas Associates). Mrs. Ruby Gay and Mr. Cliff Smith provided some of the lithic raw materials used in this study, and I am grateful for their generosity.

I thank my parents, Paul and Chris Rousseau, and Eunice's parents, George and Nancy Murakami, for all their moral and financial support over the years. It would have been very difficult to undertake this study if they had not helped us out. Lastly, I would like to thank Eunice for putting up with me while I conducted this research. For her understanding, support, patience, and love I am eternally indebted.

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CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction and Research Objectives

"Key-shaped formed unifaces" constitute a unique chipped stone tool type occasionally found at late prehistoric archaeological sites on the Interior Plateau culture area of northwestern North America. They are conspicuous by their distinctive recurrent morphological and technological attributes, and most are made of "exotic" cryptocrystalline silicates (Chapters 2.2 and 3.4).

Despite their previously acknowledged potential to be regarded as temporal horizon markers and indicators of specific task execution at sites (Fladmark 1978), the cultural, chronological, and functional significance of these tools has never been fully explored or assessed.

The main objectives of this thesis are: (1) to determine the approximate geographical extent and temporal distribution of "key-shaped" formed unifaces in northwestern North America; (2) to determine the primary function of this tool type on the Canadian Plateau by undertaking a detailed research design including design theory, microwear analysis, residue analysis, and tool replication and experimental use; and (3) to discuss the significance and implications of these considerations with respect to our current understanding of the late prehistoric period on the Interior Plateau.

Specific research questions to be addressed are:

1. What is the presently known geographic distribution of key-shaped formed unifaces in northwestern North America?

2. When did the use of these items commence and terminate in the Northwest?

3. What cultural and technological significance do the geographic and temporal distribution of these tools have with respect to late Plateau prehistory?

4. What was the primary use-behaviour (function) of this tool type, and what technological or adaptive significance does this have?

5. How did resharpening and hafting strategies influence the design of these tools?

6. On the Canadian Plateau, why were the majority of these items manufactured from relatively rare "exotic" microcrystalline and cryptocrystalline silicates rather than from the more readily available and more commonly used basalts?

This study is considered to be an important contribution to our understanding of Interior Plateau prehistory for the following reasons:

(1) determining the geographical distribution of these items will provide some insights regarding their primary function and environmental context of use;

(2) disclosing their chronological history will permit them to be used as temporal horizon markers for relative dating of components;

(3) determining their primary function will permit specific use-behaviours and related adjunct activities to be directly inferred for components bearing these tools;

(4) ascertaining why the majority (ca. 90%) of these items were produced from relatively scarce "exotic" cryptocrystalline and microcrystalline silicates on the Canadian Plateau may provide some insights into the poorly understood relationship between lithic raw material properties and functional considerations, and will permit advancement of models relating to obvious preferential selection of lithic materials on the Plateau;

(5) this study will contribute to development of "middle range theory" on the Plateau, and may serve as a model for similar studies in the future; and

(6) this study will also provide an opportunity to assess the relevance, efficacy, drawbacks, inadequacies and future potential of several methodological techniques and procedures (i.e., microwear analysis, residue analysis, and tool replication and experimentation).

1.2 Previous Research

On the Canadian Plateau (Figures 1 and 6), key-shaped formed unifaces have been previously called "curved tail end-and-side-scrapers" (Grabert 1968), "crescent scrapers" (Stryd 1974) "combined convex-concave-scrapers" (Blake 1976), "concave formed unifaces" (Turnbull 1977), "zinken-like implements" (Donahue 1975), and "concave side-scrapers" (Fladmark 1978). The term "key-shaped formed uniface" was coined by Richards and Rousseau (1982) because these tools have general formal similarity with a contemporary lock key (Figures 2, 3 and 11 to 20), and it does not infer a prejudged function (e.g., scraper), nor does it refer to inappropriate European functional analogues.

Fladmark (1978) has been the only researcher to previously discuss and draw attention to the potential importance of these items on the Plateau. In a short unpublished conference paper he remarked that:

(1) they appear to be chronologically restricted to between ca. 3300 and 1200 BP, and therefore, have potential to be regarded as reliable diagnostic temporal horizon markers;

(2) they appear to be geographically confined to the Interior Plateau culture area;

(3) the majority have been manufactured from "exotic" lithic materials (i.e., chalcedonies and cherts) rather than from the more commonly used basalt which often comprises about 90% of most chipped stone artifact classes in excavated assemblages from the Canadian Plateau;

(4) when laid dorsal face up and the projection oriented distally, they all have a left-handed concavity; and

(5) that they likely functioned as carving tools for hard organic materials, such as wood.

Fladmark's brief paper forcefully emphasized the potential for these tools to be regarded as temporal horizon markers, and also raised several important and interesting questions germane to both Plateau prehistory and lithic studies in general. Although his initial observations and preliminary interpretations were academically intriguing, a subsequent detailed study designed to explore and assess the significance and function of these distinctive tools has not been attempted until now.

CHAPTER 2

DESCRIPTION OF KEY-SHAPED FORMED UNIFACES

2.1 Study Sample Selection

A sample population of 129 prehistoric key-shaped formed unifaces was selected from excavated assemblages and surface collections recovered from ten archaeological regions in British Columbia (Appendices 1 to 3; Table 2; Figures 1 and 11 to 20). The frequency of items selected from each region is presented in Appendix 3. Eighty-eight (68.2%) of these are complete, and 41 (31.8%) are in various states of fragmentation. Fifty-eight (45%) are from excavated components of known absolute or relative age, and the remaining items are surface finds whose approximate provenience (i.e., site or nearest town) are known. Agencies that loaned the prehistoric study sample items include the Royal British Columbia Museum (Victoria), the Simon Fraser University Museum of Archaeology and Ethnology (Burnaby), the University of British Columbia Museum of Anthropology (Vancouver), the Secwepemc Museum (Kamloops), and the Westbank Indian Band (Westbank). Several items were also loaned by Dr. Knut Fladmark and Dr. Brian Hayden (S.F.U.).

The prehistoric study sample tools were judgementally selected using several morphological and technological criteria as general guidelines. In order to be selected and included in the study sample, each prospective item had to exhibit all or most of the traits falling within the following ranges of variation:

(1) an overall "key-shaped", "comma-like", or assymetric "tear-shaped" outline produced by intensive unifacial retouch initiated predominantly from the ventral face along most margins (although some margins could bear slight bifacial retouch);

(2) a maximum length between about 1.5 and 7 cm, width between about .5 and 4 cm, and thickness between about .3 and 1.8 cm;

(3) a tapering, slightly curved distal projection exhibiting a steeply retouched, slight to moderately concave edge on one lateral margin of the distal projection (most often on the left side); and a steeply retouched, or "naturally backed" margin displaying a variety of formal outlines on the opposite side; and

(4) either a trapezoidal, rhomboidal, squarish, triangular, V-shaped, or U-shaped proximal "butt" which may or may not exhibit retouch, and often bears the original flake-blank bulb of percussion on the proximal portion of the ventral face.

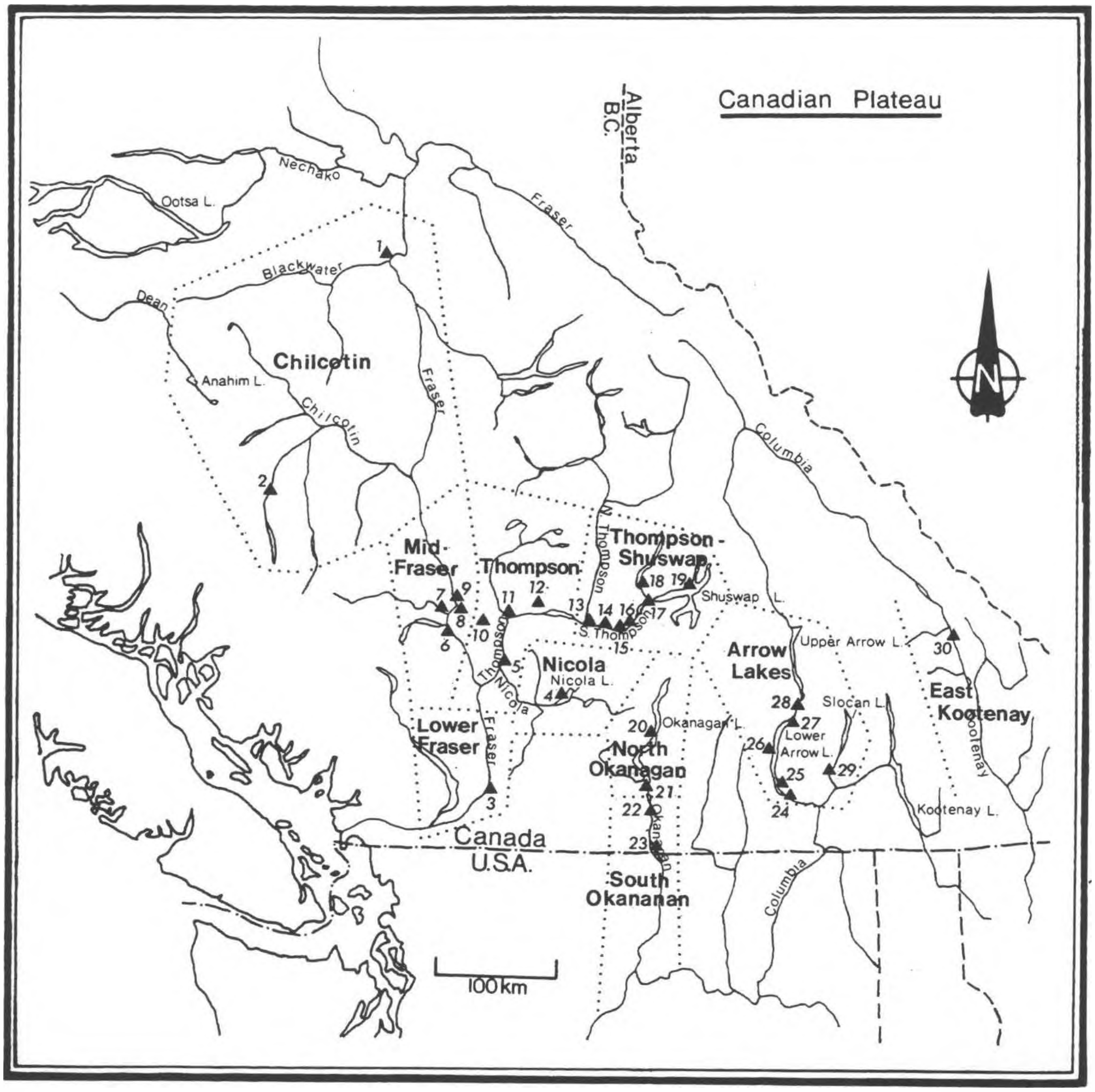

Figure 1. Archaeological regions (dotted lines) and archaeological sites (triangles) from which the 129 prehistoric key-shaped formed unifaces comprising the study sample were secured.

(1): FiRs 1
(2): EkSa 13
(3): DjRi 3, DjRi 5
(4): EbRd 3
(5): EcRh 12
(6): EdRl 13
(7): EeRl 91
(8): EeRk 4
(9): EeRl 7
(10): EeRj 63
(11): EeRh1
(12): EfRf 3
(13): EeRb 3, EeRb 10, EeRb 11, EeRb 70
(14): EdRa 9, EdRa 22
(15): EdQx 20
(16): EeQw 3, EeQw 6
(17): EfQv 2, EfQv 10
(18): EfQw 1
(19): EfQu 3, EfQu 6
(20): DlQv 37, DlQv 39
(21): DiQv 5
(22): DhQv 48
(23): DgQu 16
(24): DiQm 4
(25): DiQm 6
(26): DkQm 5
(27): DlQl 6
(28): EaQl 1, EaQl 10, EaQl 14
(29): DjQj 1
(30): EdQa 8

A degree of flexibility in type definition was maintained to allow specimens possessing some degree of "atypical" trait variability to be accomodated. Also included are several incomplete tools that demonstrate sufficient traits to permit assumption of type membership. Most such items tend to lack a portion of the distal projection that appears to have been removed by a transverse bending flexure initiation.

Because these definitive attributes can be linked to a fairly restricted range of function(s) and isochrestic stylistic variation, it was reasoned that the resulting group of items should represent an etically conceived tool "type" having both functional specificity and meaningful culture-historical significance. Chapter 3.2 presents a more detailed discussion of typological considerations.

Names have been assigned to main morphological parts or features of these tools for descriptive and analytical convenience. Major referential morphological features include the distal projection, concave margin, "opposite" margin, proximal margin, ventral face, and dorsal face (Figures 2 and 8).

A total of 57 selected continuous and discrete variables were recorded for each of the 129 tools comprising the prehistoric study sample (Appendices 1 to 3; Figures 3 and 4; Table 1). These data were coded for analysis and loaded into the Michigan Terminal System (MTS) at Simon Fraser University. Descriptive and inferential statistics were calculated using the Michigan Interactive Data Analysis System (MIDAS) programs (Appendix 3; Tables 1 and 11; Chapter 9).

2.2 Study Sample General Characteristics

This section presents a generalized description of the physical, morphological, technological, and metric attributes of key-shaped formed unifaces. It was generated through observational and statistical analyses of the 129 study sample items. The nature, frequency, and relative percentages of discrete ordinal and nominal scale variables are listed in Appendices 2 and 3. The nature of continuous variables are presented in Figure 3, and their corresponding descriptive and inferential statistics are presented in Tables 1 and 11. Several salient and/or significant attributes mentioned below are discussed in further detail in Chapter 9.

Most key-shaped formed unifaces are made on elongate, medium-sized to large flakes that were struck from cores using direct freehand hard-hammer percussion technique. Seventy-eight items, constituting 60.5% of the sample assemblage, were manufactured from cryptocrystalline chalcedonies. Thirty-six items (27.9%) were made from cryptocrystalline or microcrystalline cherts, and only 15 items (11.6%) are basalt. A total of 35 items (27%) indicate having been made from thermally altered (heat treated) flakes (see Chapter 3.3).

A total of 88 items, constituting 68.2% of the sample assemblage, are considered to be complete. Another 18 (14.0%) are regarded to be "almost" complete (i.e., a very small portion of their distal tips are missing), 16 (12.4%) lack the distal half of their projections, four (3.2%) have a large portion of their basal margins missing, one (.8%) lacks its entire distal projection, another is an entire distal projection, and the last one is a medial section.

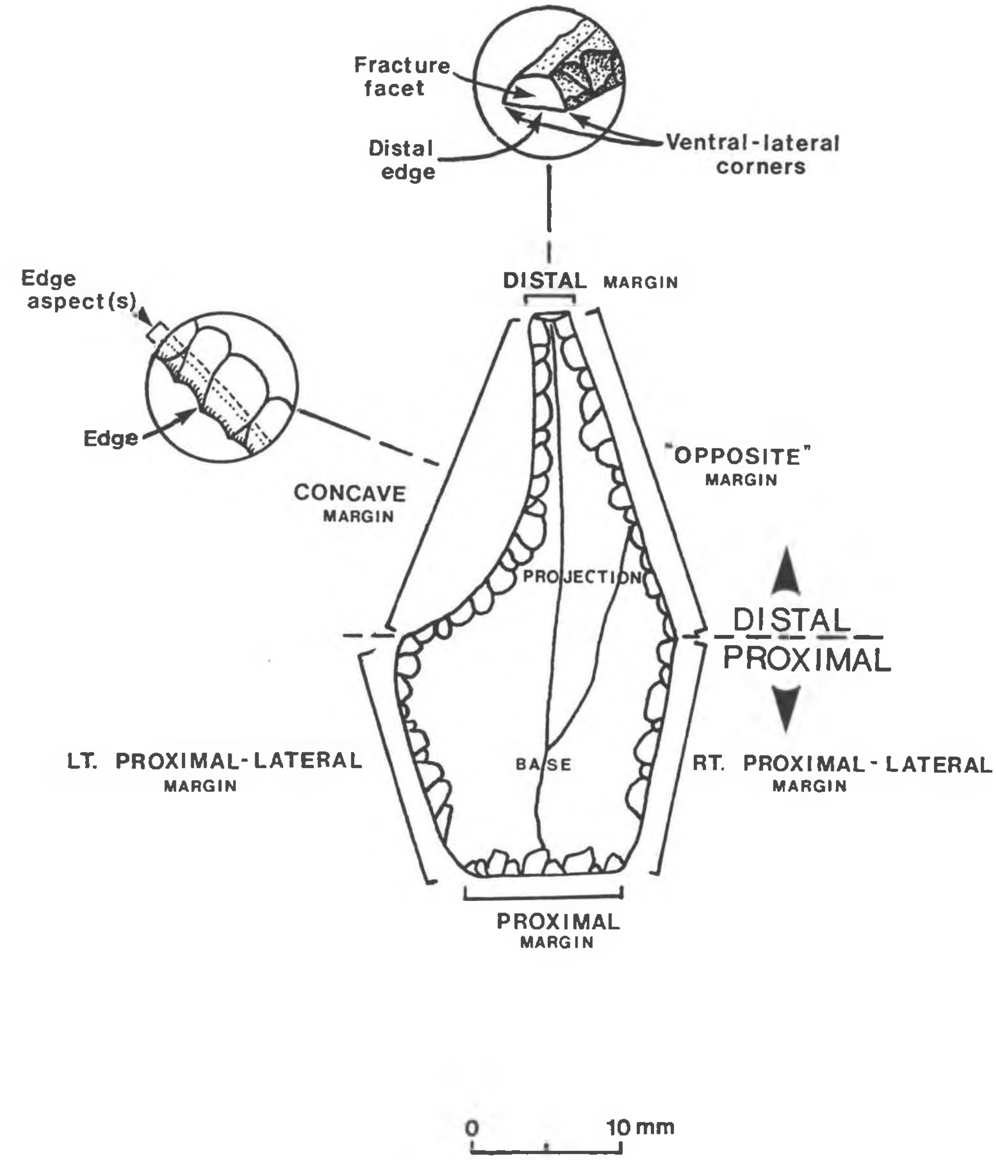

Figure 2. Morphological features and landmarks defined for key-shaped formed unifaces to facilitate description and comparison in this study.

Tool forming was executed by initiating steep retouch (i.e., 40° to 100°) from the ventral face along two or more margins to produce the characteristic "key-shaped" outline. Occasionally, fortuitous flake blank features were accomodated into the tool design with little or no subsequent modification. Examples of this include using a "naturally backed" (i.e., acutely angled) flake margin as the "opposite" margin of the distal projection, or taking advantage of an appropriately shaped proximal outline of a flake to serve as the tool's proximal margin.

The mean maximum length of complete or almost complete tools based on the prehistoric study sample data is 37.1 mm, the mean maximum width is 20.8 mm, the mean maximum thickness is 6.1 mm, and the mean ventral curvature depth is .9 mm. The average mass (weight) of complete or relatively complete items is 6.2 g.

The mean length of the distal projection on complete or almost complete specimens is 21.4 mm, the average angle of the projection outline is 32°, the mean angle of the distal tip edge is 77°, and the mean distal tip spine-plane angle is 53° (Figure 3).

When placed ventral face down and projection oriented distally, the concave margin (Figure 2) appears on the left side of the projection on 115 tools (89.1%), and for 14 items (10.9%) it is present on the right. On 125 items (96.9%) the concave margin exhibits only normally initiated unifacial retouch, and the remaining four items (3.1%) bear bifacial retouch on this margin. The concave margin mean length is 23.3 mm, its mean curvature depth is 2.9 mm, the mean edge angle is about 73°, and the mean spine-plane angle is approximately 66°.

The "opposite" margin (Figure 2) has a mean length of 21.0 mm. The most common "opposite" margin outline form is straight (n=34), comprising 26.3% of the study sample. Twenty-seven items (20.0%) have slightly convex "opposite" margins, 24 (18.6%) are moderately convex, 14 (10.8%) are slightly concave, nine (7.0%) are moderately concave, ten (7.8%) are recurved, another ten are irregular, and for one item (.8%) this margin is absent.

Ninety-five items (73.4%) indicate normally initiated unifacial retouch along the "opposite" margin, 16 (12.5%) are unretouched, 15 (11.7%) have been bifacially retouched, and three (2.3%) bear inverse unifacial retouch. The mean "opposite" margin edge angle is 69°, and the mean spine-plane angle is 60°.

The most common proximal margin outline is categorized as type "B" (Figure 4), comprising 47.3% (n=61) of the sample items bearing this margin (outline types could not be determined for five items due to their absence). Type "A" was the next most frequent category, and included 23 items (17.8%). Twelve tools (9.3%) were assigned to type "D", 11 items (8.5%) belong to type "G", five (3.9%) to type "H", three (2.3%) to type "C", another three to type "F", and one (.8%) to type "E". The remaining ten items (7.8%) were assigned to "miscellaneous irregular" (type "I"). The mean proximal margin length is 16.2 mm, and the mean width is 12.3 mm.

Fifty-seven tools lack retouch along the proximal margin, comprising 47.1% of the sample items for which the general retouch pattern could be determined (it could not be identified for eight items). Forty-eight (33.9%) specimens bear normally initiated unifacial retouch on this margin, and 23 (19.0%) are bifacially retouched.

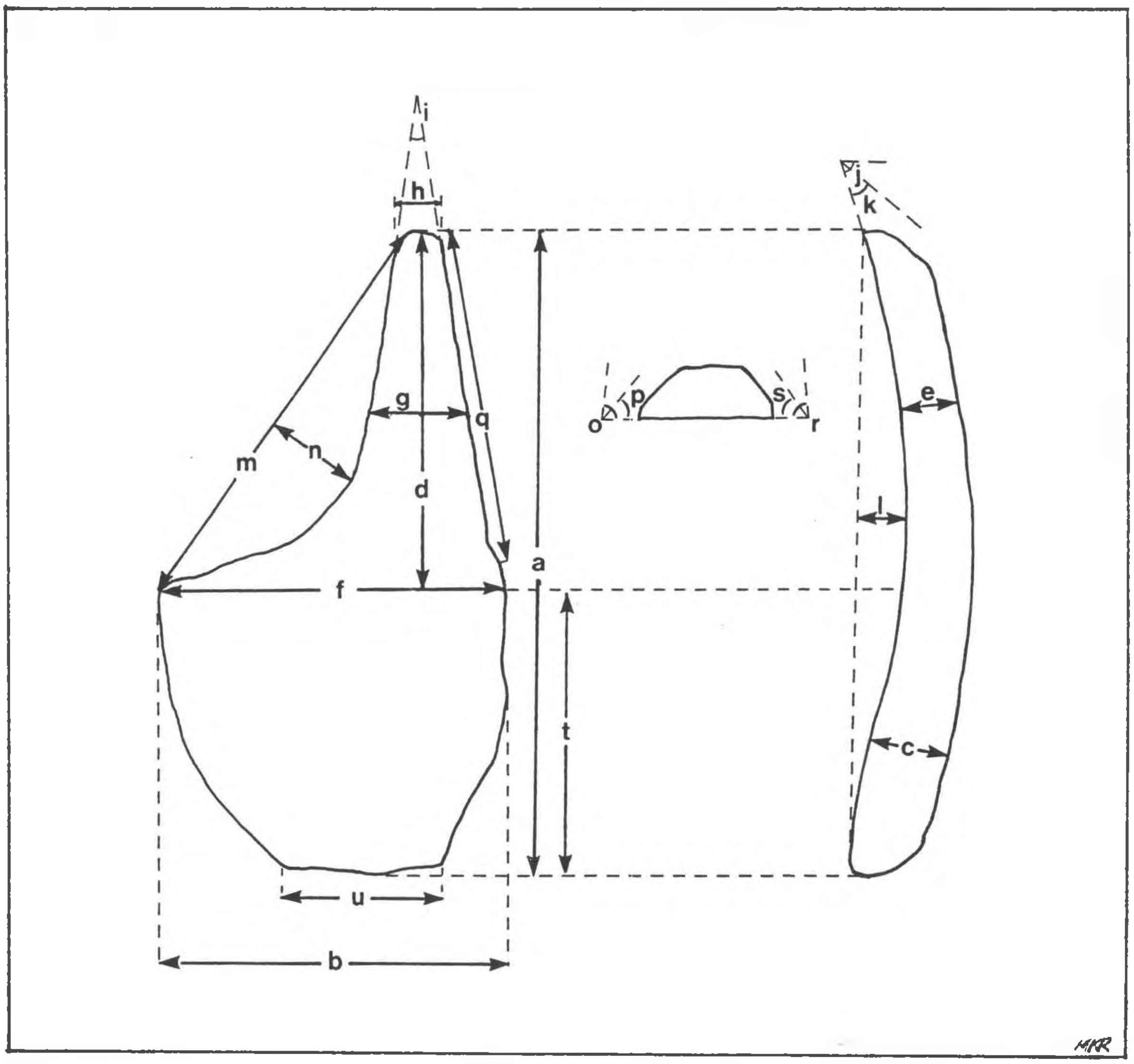

Figure 3. Continuous variables recorded for each of the 129 prehistoric key-shaped formed unifaces comprising the study sample.

(a): Maximum tool length (mm)
(b): Maximum tool width (mm)
(c): Maximum tool thickness (mm)
(d): Projection length (mm)
(e): Projection average thickness (mm)
(f): Projection basal width (mm)
(g): Projection medial width (mm)
(h): Projection distal width (mm)
(i): Projection angle (degrees)
(j): Projection tip mean edge angle (degrees)
(k): Projection tip mean spine-plane angle (degrees)
(l): Ventral curvature depth (mm)
(m): Concave margin length (mm)
(n): Concave margin maximum curvature depth (mm)
(o): Concave margin mean edge angle (degrees)
(p): Concave margin mean spine-plane angle (degrees)
(q): "Opposite" margin maximum length (mm)
(r): "Opposite" margin mean edge angle (degrees)
(s): "Opposite" margin mean spine-plane angle (degrees)
(t): Proximal margin length (mm)
(u): Proximal margin width (mm)

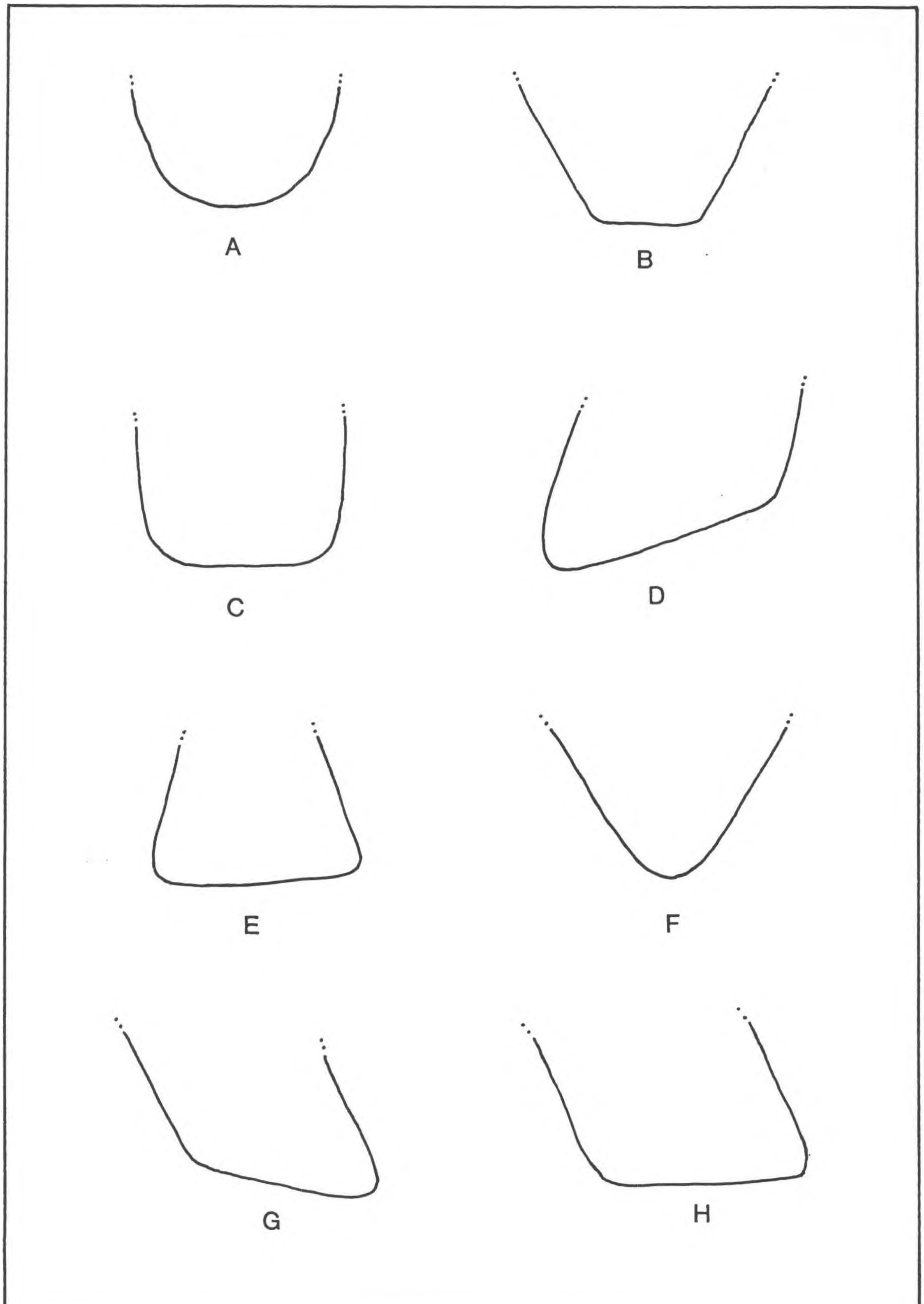

Figure 4. Proximal margin outline categories defined in this study (Types A-H). Category "I" not shown.

Fifty-three (41.1%) of the prehistoric study sample tools exhibit overall slight intensity of various types of microwear trace patterns that can be clearly observed using a stereoscopic light microscope between magnifications of 6.4 X and 40 X (Chapter 6). Another 47 items (36.4%) bear moderate microwear trace intensity, and for 19 tools (14.7%) it is pronounced. The remaining ten items lacked any detectable indication of microwear using this range of magnification.

Pronounced intentional edge resharpening is indicated on 20 items, constituting 15.5% of the sample assemblage. It is restricted primarily to the concave margin and distal projection. Resharpening practices are discussed in detail in Chapter 3.3.2. Only one item appears to have been deliberately recycled into a tool whose intended function differed markedly from that indicated for the other tools (Figures 13a and 39). Ten items (7.7%) indicate having been subjected to post-depositional mechanical or chemical weathering processes, but the remaining 98 tools (75.9%) do not appear to have experienced any such modification.

Three specimens are worthy of special mention due to their uniqueness and/or coincidential formal similarity with the key-shaped formed uniface "type" defined in this study. Specimen EeQw 6:722 (Figure 16y) differs from the "classic" typological definition of key-shaped formed unifaces in that it possesses two opposing concave margins. A possible explanation for its unique morphology is that it was made and used by an ambidextrous person. Specimen EFQs 1:75 (Figure 20f') is somewhat formally similar to typical to key-shaped formed unifaces, however, it is made of ground nephrite and lacks a sharp concave margin edge. Specimen EbRj Y:872 (Figure 20g') is also formally similar, but it is made of ground steatite. The latter two specimens are mentioned here simply because of their general morphological similarity with chipped stone key-shaped formed unifaces, and it is highly doubtful that they served the same function(s). For this reason they were excluded from the prehistoric study sample and from further consideration.

CHAPTER 3

THEORETICAL CONSIDERATIONS

3.1 Trends in Northwest Lithic Studies

The majority of past lithic studies in northwestern North America have focussed primarily on exhaustive empirical descriptions of stone tool attributes and production modes, and on defining artifact typologies for use as temporal horizon markers or for cross-cultural comparisons. As a result, very little close attention has been paid to functional aspects of various lithic tool types. Also, use-behaviours are often loosely inferred without being substantiated, or just simply ignored.

There have been, however, a few recent studies involving tool replication and experimental use that run contrary to this trend (e.g., Brink 1978a; Flenniken 1981; Magne 1985; Richards 1987). Such actualistic studies are crucial to the development of "middle range theory" as defined by Binford (1981,1982), and have contributed valuable information towards gaining a clearer understanding of prehistoric stone tool production and use in the Northwest.

Odell (1981a:339) remarks that:

> It appears from the environmentally and regionally specific nature of most lithic artifact collections that few morpho-functional equations possessing widespread validity in time or space are going to be possible. Much more work of a functional nature at a regional and cultural level is going to be required in order to establish basic regularities before attempting to interpret stone tool function in a wider context. In the recent past much of the relevant functional data have come from the analysis of use-wear damage, and it appears that this type of study will be increasingly valuable in constructing sound functional frameworks for future interpretations. I would argue that the establishment of these locally valid frameworks is a far more worthwhile and efficient expenditure of energy than attempting once again to employ morphological systems to accomplish tasks for which they are patently unsuited.

Since the present study is aimed primarily at exploring the significance and function of key-shaped formed unifaces on the Interior Plateau, several theoretical considerations must be addressed to effectively accomplish this objective. Specifically, these include various aspects of: (1) typology; (2) design theory; (3) lithic raw material properties; (4) microwear research; (5) hafting; and (6) curation.

3.2 Typology

Typologies have long been used to permit condensation of information into manageable analytical units, to facilitate culture historical reconstruction, and to allow recognition and comparison of inherent inter- and intra-assemblage variability (see Krieger 1944; Ford 1954; Hill and Evans 1972; Kleindienst 1975; Hayden 1984). Most typological schemes rely on morphological attributes as the basis for generating and defining artifact types, but the resulting tool forms are rarely correlated with specific use-behaviours through development and execution of rigorous research studies involving replication and experimentation (Odell 1981a:321).

It has often been stressed that it is methodologically unsound and potentially dangerous to infer lithic tool function on the sole basis of morphological criteria (Ahler 1971; Wylie 1975; Kay 1977; Brink 1978a; Cantwell 1979; Odell 1981a; Siegel 1984; Hayden 1984,1986). Nevertheless, attempting to understand how distinctive and morphologically complex tool types were used within their systemic context(s) can provide important insights into prehistoric human behaviour.

Two successive typological approaches were employed in this study. An "empricist" approach was first used to identify and define the key-shaped formed uniface artifact "type" based on physical, morphological, and technological attributes, and on culture-historical criteria. A "positivist" typological approach was then used exclusively to facilitate descriptions of various specific physical attributes of these tools, and to organize the data into analytic categories to help determine the functional significance of these tools (see Hill and Evans 1972; Hayden 1984).

The key-shaped formed uniface artifact "type" is essentially defined according to theoretical and methodological underpinnings propounded by Krieger (1944) and Ford (1954). They maintain that a "true" type should be a unit equatable with the ethnographic "culture trait", having proven culture-historical integrity and significance, and representing specific behaviour patterns transmitted through mechanisms of social interaction.

Acknowledging these requirements, key-shaped formed unifaces are considered to constitute an archaeological "type" based on the following characteristics. First, these tools are distinctive due to their recurrent, complex, and uniquely patterned constellation of physical, morphological, and technological attributes that permits them to be readily distinguished from all other lithic tool types similarly conceived. These include their unusual "key"-like shape, steep edge angles, an emphasis on the use of cryptocrystalline silicate materials, relatively restricted size range, and their specific temporal and geographic distribution. Second, not all membership attributes of this archaeological "type" are present on each specimen, therefore, the type definition constitutes a polythetic construct (Clarke 1968:37) which permits some degree of inherent specimen variability to be tolerated and accomodated. Third, these tools have demonstrable culture-historical significance by virtue of their temporal persistence for at least two and a half millennia throughout the Interior Plateau and most of the Arctic (Chapter 4). Lastly, they have specialized functional significance which involved an important and recurrent "primary" task, although it is acknowledged that they may have also been occasionally used for "secondary" functional purposes (Chapter 10).

Early ethnographic sources for the Plateau do not describe any tool having exactly the same characteristics outlined for this artifact type. This is not surprising since their use appears to have been discontinued about 1000 years ago (Chapter 4.2). However, a hooked, inversely retouched, unifacial knife with a vaguely similar formal outline is illustrated in Teit (1900:184,Fig. 126). Teit (1900:474) maintains that such knives were used to cut and carve antler and bone. The similarity in outline between these "crooked" knives and key-shaped formed unifaces is regarded as coincidental, since his illustrated example indicates several salient differences with respect to technological attributes and functional edge angles. Nevertheless, it provides an approximate analogue of how key-shaped formed unifaces may have been hafted and used. Also, Smith (1900:418) illustrates a classic key-shaped formed uniface from the Thompson River region which he maintains is morphologically similar to "carving-knives" used during the ethnographic period.

Once a clearly meaningful key-shaped formed uniface "type" was shown to exist, a "positivist" approach (see Hill and Evans 1972; Hayden 1984), was employed to better understand the significance of this type by generating contextual and use-related hypotheses. These in turn were used to organize and categorize attribute data observed on key-shaped formed unifaces to help generate descriptions and to create analytic units that could be used to help determine the significance and function(s) of these tools. This approach dealt exclusively with recognizing and defining specific attributes inherent to these tools, such as the kinds of lithic raw material employed, the different sorts of morphological and/or technological characteristics represented, the kinds of microwear trace patterns observed on their functional edges, etc. (see Chapters 2.2, 3.4, 6 and 8). I stress that these attribute "types" are etically conceived constructs to assist in resolving specific analytic problems related to descriptive and behavioural matters.

3.3 Design Theory

In its archaeological context, design theory collectively considers attribute characteristics of a tool (i.e., morphology, size, raw material, production mode, etc.), and integrates this information with use-analysis to permit behavioural inferences about decision-making processes relating to how the tool was conceived, made, used, and resharpened (Kleindienst 1975,1979:59-60). Design theory assumes that a tool is manufactured in order to solve a specific adaptive or functional problem, and that several constraints dictate its finished form, the material it is produced from, and its mode of manufacture. Such constraints interact dependently, and include functional efficiency related to morphological characteristics, raw material physical properties and availability, technological proficiency of the craftsperson, and economic factors related to tool production and use (Horsfall 1987:333-334). The manner and degree to which these factors interact can covary, and design theory acknowledges that a given problem may have a number of different, and equally effective solutions.

Bleed (1986) suggests that the overall design of a tool is influenced by either an explicit or implicit selection of alternative variables related to functional effectiveness, reliability, maintenance, material availability, aethestics, cost, and environmental constraints (see also Hayden 1987a). As a result, designs often vary for tools engaged in the same task, and some designs may be more reliable, more easily maintained, and/or more efficient than others. Reliability and maintainability are very prominent considerations in the design decision process, and although it is sometimes possible to isolate aspects related to either of these factors, they may often meld together to fulfill requirements of both systems.

There is ample reason to believe that key-shaped formed unifaces were designed to be reliable and easily maintained. The obvious selective preference for particularly hard and durable lithic materials (Chapter 3.3.3) considerably enhanced tool longevity and efficiency by reducing the incidence of required resharpenings (Chapter 3.3.2), and the possibility of accidental breakage. Also, the usual overall design of this tool type is such that it could be easily subjected to a series of repeated resharpenings (i.e., maintained) without significantly affecting tool performance or efficiency (Chapters 3.3.1 and 3.3.2; Figure 5).

The emphasis on optimizing the efficiency, reliability, and maintainability of key-shaped formed unifaces strongly supports the conclusion that most of these tools were curated, and they were designed to deal with a specific anticipated, important, and recurrent task. The significance associated with the curation of these tools is dicussed further in Chapters 3.6 and 9.3.

3.3.1 Morphological Considerations

The consistent dimensional and morphological attributes characterizing key-shaped formed unifaces (Appendix 3; Table 1; Figures 11 to 20) restricts their functional potential. Highly patterned, recurrent morphological and technological attributes, and microwear traces (Chapters 2.2 and 6.0) indicate that the most functionally important parts of this tool type are the concave margin edge, ventral-lateral corners of the distal projection tip, and occasionally the edge of the "opposite" margin (Figure 2).

The slightly to moderately concave outline of the "concave" margin, and its recurrently steep "scraper-type" edge angle (60°-85°) suggests that it is most effectively suited for scraping, shaving, and planing actions (Wilmsen 1970:70-71; Hayden 1979c; Cantwell 1979). Furthermore, it is argued that the concave edge outline and length range are ideal for working cylindrical contact materials having diameters ranging between about 5 and 30 mm. This would be most effectively realized by placing the ventral face of the tool against a cylindrical contact material with the concave margin facing the user, and then drawing the tool towards the body in repeated strokes (see Chapter 6.3 and Figures 43 and 44).

The very low frequency of tools exhibiting acute/invasive distal projection angles (Table 1), the common recurrence of blunted distal projection tips, and consistently curved concave margin oultines argues strongly against these tools having been used for piercing or perforating as has often been loosely inferred. Rather, the typical shape and character of the entire distal projection on relatively complete or nearly complete tools is logically suited to gouging, prying, graving or incising actions, such as would be required for removing secondary branch nodes on stalks and branches, or creating linear slots or grooves in wood, bone, or antler (see Figures 9, 48 and 50).

The high degree of variability indicated for edge angles and formal outlines of the "opposite" margin (Table 1) suggests that it may have had less functional importance than the concave margin and the distal projection. The generally steep edge angles suggest that it might be potentially effective for scraping, shaving, and planing cylindrical or elongate contact materials. However, this margin could only function well in this capacity when being pushed away from the user (see Figures 45 and 47). Microwear traces on several prehistoric microwear sub-sample specimens indicate that the "opposite" margin was indeed occasionally used in this fashion (Chapter 6.2).

The overall shape of these tools is conducive to being comfortably hand-held by placing the thumb on the proximal portion's dorsal surface, third finger on the ventral surface, and index finger on the dorsal face of the "opposite" margin. The formal outlines of the proximal half of the majority of these tools (Figures 11 to 20) are such that they are quite suitable for hafting, and three items bear obvious hafting features (Figures 12k, 12l and 16i'). The relatively low standard deviation values indicated for certain dimensions of the proximal half of these tools (Table 1) may reflect a conscious effort to standardize their basal form to accomodate hafting (see Chapters 3.5 and 7.3).

3.3.2 Resharpening

Hayden (1987a) has posited a model which suggests that on a general level, many lithic tool morphologies are directly related to effective resharpening strategies above all other reasons. He argues that "normative" ideas about shaping most tools were not held by their manufacturers (with exception of hafted tools), rather, they were made with an idea about a specific task to perform, the kind of edge best suited for that purpose, resharpening considerations, and hafting strategies. Economics of a resharpening strategy depended upon the amount of materials to be processed, and properties and availability of the lithic material used. Goodyear (1979:4) has raised a similar point in discussing the organizational "flexibility" of Paleo-Indian lithic technologies. He suggests that tool designs were partly governed by their ability to be continuously and reliably rejuvenated, and by their potential to be remodelled into functionally different tools.

Resharpening and rejuvenation strategies indicated for prehistoric key-shaped formed unifaces in the study sample are schematically illustrated in Figure 5. The initial formal design of the distal half of these tools can easily accomodate a number of minor resharpenings of the concave margin and distal projection tip without detrimentally affecting their functional efficiency. The most commonly executed resharpening strategy is indicated in Figure 5a, the next most frequent is represented in Figure 5b. Those indicated by Figure 5c-e are considered rare. I estimate that the concave margin of an average tool could have been resharpened as many as ten to fifteen times, however, the frequency would have largely depended on the initial tool form, lithic raw material, and the nature, degree, and extent of use-damage incurred to the concave margin edge and/or distal projection tip.

The predominant resharpening strategy patterns suggest that, for the most part, constant maintenence of a prominent and slightly blunted projection tip was important to the primary function and efficiency of this tool. Since the overall initial design of these tools demanded an optimal balance between conserving as much potentially resharpenable edge as possible on the concave margin while at the same time maintaining a useful projection tip, at the beginning of their use-lives, many tools probably resembled Figures 5a, 11a, 12g, 14d, 14l, 16z, 16a', 17n' and 19a'.

Preferential use of hard and durable raw materials would have significantly reduced the incidence of required resharpening episodes and

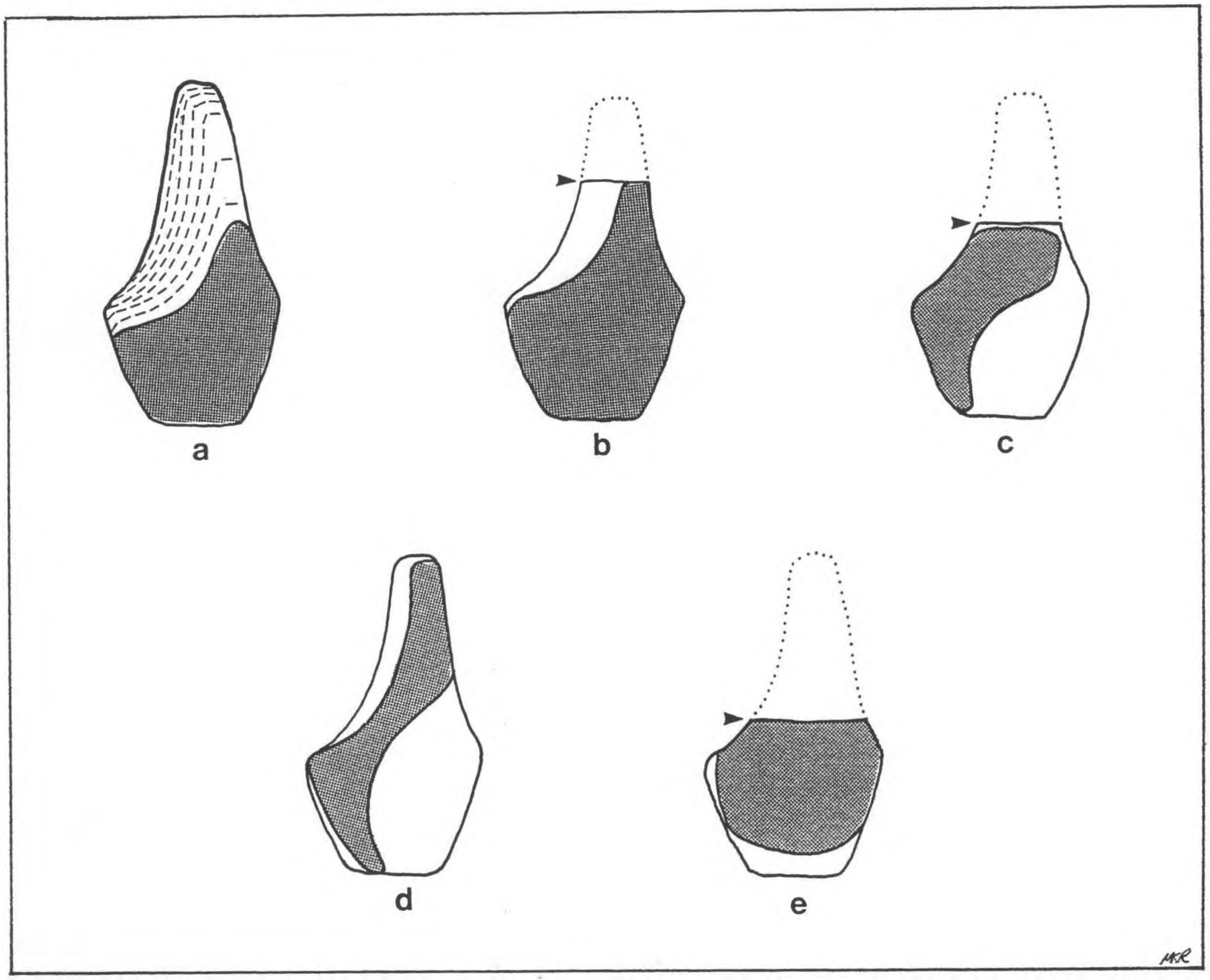

Figure 5. Resharpening, rejuvenation, and recycling strategies represented in the study sample of 129 prehistoric key-shaped formed unifaces. Shaded portions represent final exhausted tool form, solid line represents original outline, and dotted line represents a snap removal.

Strategy

(a): Typical pattern of successsive resharpenings suggested by most sample specimens.

(b): Common rejuvenation pattern for items where major portions of projection was lost to accidental removal.

(c): Relatively rare rejuvenation pattern executed when large portion of projection was lost.

(d): Rare rejuvenation pattern resulting in complete reversal of concave margin location.

(e): Rare recyling pattern where convex endscraper is produced from basal portion of exhausted or broken tool.

replacement rates, thereby affording greater tool efficiency, maintainability, and reliability (Bleed 1986). These are particularly important for curated tools designed to rapidly and effectively cope with recurrent anticipated activities undertaken by specialized task groups (Binford 1979,1980), in situations where important resource procurement scheduling and tool production conflict and create "time-stress" problems (Torrence 1983), and/or when there was a scarcity of suitable lithic raw materials for tool production (Bamforth 1986a; Hayden 1987a). The significance and implications of preferential lithic raw material selection and its relationship to the phenomenon of curation is discussed in greater detail below, and in Chapter 3.6.

3.3.3 Lithic Raw Material Properties

Raw material properties have been largely overlooked or ignored in lithic studies, although some researchers have provided a number of significant and useful insights (e.g., Goodman 1944; White and Thomas 1972; Gardener 1976; Goodyear 1979; Greiser and Sheets 1979; Kamminga 1982; Magne 1985; Gould and Saggers 1985; Horsfall 1987).

Physical and mechanical properties of lithic raw materials should be carefully considered when assessing matters concerning tool production, design, function, efficiency, resharpening and maintenence, microwear patterns, and replacement rates. Aboriginal preferential selection of certain lithic raw materials for production of specific tool types can provide some insights into why and how they were designed and used. Several important lithic raw material properties are density, relative hardness, toughness (durability), resiliency, and flakeability (Grieser and Sheets 1979:293-296). These properties usually covary between different lithic types, and are sometimes, but not always interdependent.

A salient characteristic of the prehistoric study sample of key-shaped formed unifaces is that the majority (88.4%) of items have been manufactured from a variety of relatively rare "exotic" silicates (i.e., chalcedony [60.5%] and cherts [27.9%]) rather than from more commonly available basalts which only constitute 11.6% of the study sample tools. I regard this high frequency of exotic silicates to be directly related to specific functional concerns, as about 80 to 90% of items assigned to almost all other chipped stone tool type categories on the Canadian Plateau were made from basalts. I postulate that most chalcedonies and certain types of tough cherts available on the Canadian Plateau were often selected over the more common and less durable basalts for production of tools requiring extensive edge utilization (see also Grieser and Sheets 1979:296).

Two important properties inherent to these silicates that differ from basalt are their superior hardness and toughness (durability). Using the simple Moh scale scratch test, hardness values were determined for several types of chalcedony, chert, and basalt used by prehistoric groups on the Plateau (see Appendix 7). The average hardness of tested chalcedonies varied between about 7.0 and 8.0; cherts from about 6.5 to 7.5; and basalt between about 6.0 and 6.5.

Superior hardness and toughness of chalcedony and some types of cherts have been experimentally demonstrated by the Shore Schleroscope and Paige Impact Tester (Grieser and Sheets 1979:293-294), the Los Angeles Abrasion Test (Kamminga 1982), and in the present study (Chapter 7.7). These properties suggest that the primary use-behaviour associated with key-shaped formed unifaces likely involved working of relatively hard contact materials, such as bone, antler, or dense wood (see Kamminga 1979:299). Hard and durable lithic raw materials used for working such contact materials significantly increases a tool's use-life. This reduces the incidence of required resharpening and replacement, consequently increasing tool reliability (Chapter 3.3.2).

Although many key-shaped formed unifaces are made from brightly coloured, and/or mottled polychrome cryptocrystalline silicate materials, I doubt that these materials were selected specifically for their purely "aesthetic" or "symbolic" properties. Rather, I argue that the superior hardness and durability of these materials was being sought by prehistoric lithic technicians, and that the notable aesthetic chromatic properties observed for many specimens is simply a coincidental feature of most cryptocrystalline silicates found on the Interior Plateau.

Lithic raw materials were sometimes subjected to thermal alteration to improve or enhance certain physical properties of the stone prior to secondary reduction (i.e., tool forming) (Crabtree 1964; Purdy and Brooks 1971; Purdy 1974; Mandeville 1971,1973; Solberger and Hester 1972; Hester 1972; Mandeville and Flenniken 1974; Ahler 1983; Rick and Chappel 1983). It has been suggested that thermal alteration sometimes improves flakeability by annealing flaws, and enhances tool efficiency by increasing cutting edge sharpness (Flenniken 1981:27). Other effects may be changes in raw material colour and luster, and increased brittleness.

Thermal alteration of lithic materials can usually be detected by the presence of "potlidding" or differences in luster. If a flake blank (lacking cortex) is thermally altered and subsequently retouched, the unretouched surface will often have a relatively dull waxy or pearly luster and texture, whereas retouched surfaces will have a glassy luster (Mandeville 1973; Purdy and Brooks 1971; Crabtree 1964; Rick and Chappell 1983). Using these criteria, 27% of key-shaped formed unifaces in the study sample (most of them chalcedony) had been intentionally subjected to thermal alteration (Appendix 3).

Most Plateau chalcedonies in their "raw" (i.e., unaltered) state are usually difficult to flake using direct hard hammer percussion because of their remarkable hardness and resiliency. Also, moderate to high incidence of fracture planes, large inclusions, and other flaws often hinder effective production of large flake blanks with smooth ventral faces which are required for producing key-shaped formed unifaces. I suggest that many chalcedony and some chert flake blanks were thermally altered prior to being produced into key-shaped formed unifaces -- and perhaps into other formed tool types for that matter -- to anneal internal flaws which in turn enhanced flakeability, and perhaps to improve edge sharpness. These improvements would have consequently afforded greater functional efficiency, and also enhanced the reliability and maintainability (Bleed 1986) of tools made from altered materials compared to those produced from unaltered materials of the same type. Thermal treatment of flake blanks used to produce key-shaped formed unifaces is discussed further in Chapter 9.3.

Considering all the above aspects of design theory as they relate to key-shaped formed unifaces, I conclude that:

(1) the concave margin appears to have been the primary functional edge, and its morphology is functionally suited for scraping, shaving, and planing elongate cylindrical contact materials with diameters ranging between ca. 5 and 30 mm;

(2) the relatively blunt tip of the distal projection is best suited for gouging, prying, or scraping actions rather than for piercing or perforating as has often been suggested, and the ventral-lateral corners of the projection tip are ideal for gouging, incising, and graving relatively hard contact materials such as wood, antler or bone;

(3) the "opposite" margin is also usable for scraping, shaving, and planing actions, but it is considered to have had secondary or incidental functional importance because of greater variation in edge angles, formal outlines, and retouch patterning;

(4) the proximal morphology of these tools suggests that some may have been used hand-held, whereas others were probably hafted;

(5) the morphology of the distal half of the tool is such that it can accomodate successive resharpenings of the concave margin and distal projection tip without significantly altering functional efficiency; and

(6) the obvious preferential selection of "exotic" silicates suggests that relatively hard contact materials (e.g., bone, antler, or hard wood) were worked, and by using these materials, the incidence of required edge resharpening and tool replacement was significantly reduced, and maintainability was enhanced.

3.4 Microwear Research

The primary objective of microwear (use-wear) research is to determine the function of prehistoric stone tools and thereby contribute to our understanding of certain aspects of prehistoric human behaviour. It usually involves experimental replication and use of tools, observing resulting microwear patterns, and subsequently applying these data to prehistoric artifacts to infer their probable function(s) (Semenov 1964; Tringham *et al* 1974; Keeley and Newcomer 1977; Lawrence 1979; Newcomer and Keeley 1979; Odell 1979,1980; Keeley 1980; Brink 1978a; Flenniken 1982; Kamminga 1982; Sabo 1982; Vaughan 1985; Richards 1987). Ethnographic observations have also been used to advance inferences regarding prehistoric tool functions (Gould, Koster, and Sontz 1971; Nissen and Dittemore 1974; Hester and Follett 1976; Hayden 1976a,1979b).

The experimental approach to microwear research requires an understanding of how typical wear traces (i.e., polish, rounding, striations, use-fracturing) are formed in response to specific aboriginal use-conditions (Witthoft 1967; Brink 1978a,1978b; Kamminga 1978,1979, 1982; Cotterell and Kamminga 1979,1987; Del Bene 1979; Diamond 1979; Lawn and Marshall 1979; Tsirk 1979; Odell 1981b; Mansur 1982; Meeks *et al* 1982; Unger-Hamilton 1983,1984; Bettison 1983,1985).

The physical and/or mechanical processes responsible for formation of some types of microwear traces are complex and not completely understood. As a consequence, several hypotheses regarding their formation processes exist. These, and other important aspects of microwear research have been summarized and discussed by Keeley (1974), Olausson (1980), Odell (1982), and Vaughan (1985). Current models for microwear trace formation and their potential interpretive significance are presented and discussed in Chapter 6.

3.5 Hafting

Keeley (1982) has pointed out that effects of hafting and retooling have been sorely neglected in lithic studies. He maintains that hafted tools tend to be small, extensively retouched, commonly curated, often have special features related to hafting (e.g., notches, shoulders, tangs), and are usually easily assigned to "classic" morpho-typological categories because of repeated resharpening and morphological standardization (see also Binford 1979; Ebert 1979). Keeley suggests that hafted tools also tend to be discarded at base camps within or adjacent to retooling areas such as around hearths or within shelters (Keeley 1982:802).

There is direct evidence that a few tools in the study sample were hafted. Three items in the study sample bear opposing notches on their proximal-lateral margins (Figures 12k, 12l and 16i'). Another nine exhibit typical polish and rounding microwear traces on the dorsal and ventral surfaces of their proximal aspects, which may have been caused by hafting prehension abrasion. One item is coated with a polymerized plant resin (Figure 40) which is interpreted to be hafting mastic residue. Also, 23 items in the study sample bear retouch on the ventral face along the proximal margin, a practice that increases hafting efficiency by removing all, or part of a salient bulb of percussion from a flake blank. The actual proportion of hafted tools in the prehistoric study sample cannot be determined, but it is suggested that it may have been quite large, perhaps as high as 75% to 90%.

There are at least two important behavioural implications that can be inferred from hafted items. First, hafting helps support the contention that all, or many key-shaped formed unifaces were curated as a component of personal gear (Binford 1979). Hafted/curated tools would have been particularly useful to specialized and highly moblile task groups engaged in extracting, processing, and transporting large quantities of resources (Binford 1980); during periods of "time-stress" when conflicts arose between resource procurement and processing scheduling and tool production (Torrence 1983); or when suitable lithic raw materials for tool production were scarce (Bamforth 1986a) (see also Chapter 3.6). Second, hafting must have somehow enhanced functional considerations, perhaps by permitting greater ease of manipulation and/or by increasing efficiency. Indeed, the experimental component of this study clearly demonstrated that hafted key-shaped formed unifaces functioned more effectively, efficiently, and with greater comfort than unhafted tools (Chapter 7.7; Appendix 9).

3.6 Curation

An important organizational aspect of lithic technologies is the concept of curation. Curated tools are used, maintained, and transported about for extended periods of time. They are often made of high quality materials (i.e., durable and sharp with fair-to-good flakeability), exhibit evidence for considerable investments of production time, and many are hafted.

Binford (1979,1980) regards curation as an integral component of personal gear, involving items designed to cope with anticipated and/or frequently recurring task situations. He suggests that curation is more likely to be practiced by people participating in a collector or "logistical" settlement and subsistence system, where specialized mobile task groups set out to extract and process resources from distant sources and transport them back to base camps to be consumed by larger social units. In such systems, task-specific, reliable, and easily maintainable curated tools would have been desirable, as they permitted large quantities of materials to be processed with less time and energy than would have been possible using less efficient expediently-produced tools.

On a similar bent, Torrence (1983:11-13) proposes that curation was most practical during "time-stress" situations where conflicts arose between resource extraction and processing activities and time required to produce tools to undertake these tasks. She maintains that scheduling stress could be alleviated by using curated tools manufactured prior to periods of mutually disruptive subsistence tasks when timing was not a problem. This ensured that tool production time did not directly conflict with important subsistence activities, and that the tools could be appropriately designed to help reduce the time requried to execute them.

In a review of technological efficiency and curated technologies, Bamforth (1986a) correctly points out that curation is a complex phenomenon that cannot be adequately attributed to any single factor. Although he acknowledges that subsistence and settlement systems are important, he argues that curational behaviour can also be explained as being a response to local raw material scarcity. In situations where raw materials were rare, or access to them was restricted, production of efficient and highly maintainable curated tools helped to offset stresses caused by material shortages by extending tool longevity and by reducing the incidence of required tool replacement (see also Hayden 1987a).

Identification of curated tool types and determining their related functions can assist in disclosing the nature of anticipated and recurrent task situations encountered by their aboriginal users. Exhausted items, particularly hafted ones, were often discarded at retooling stations which may or may not have been associated with their location of use (Hayden 1976b, 1987b; Keeley 1982).

It is apparent that many key-shaped formed unifaces were curated. This is suggested by the observations that: (1) they indicate reasonable amounts of time invested in their manufacture; (2) most are made of relatively rare, durable, "exotic" materials; (3) a number of excavated items are made from materials whose quarry sources are considerable distances away, and other artifacts of the same materials were not encountered at the sites; and (4) several items were clearly hafted (Chapter 3.5), a practice regarded to be highly indicative of curated tools (Keeley 1982:798-799).

That key-shaped formed unifaces appear to have been highly curated has several important implications for our understanding of Plateau prehistory. Following Binford's (1979,1980) arguments regarding curational behaviour and subsistence-settlement systems, the use of key-shaped formed unifaces during the late prehistoric period on the Plateau is consistent with the established interpretation that people participated primarily in a "collector/logistical" subsistence and settlement system that was particularly intense during the non-winter months. Large winter pithouse villages and evidence for reliance on stored salmon are also considered to be components of this type of subsistence and settlement strategy (Richards and Rousseau 1987:50; Campbell 1985:490).

The presence of key-shaped formed unifaces in components radiocarbon dated between ca. 4000 and 1000 BP on the Plateau (Chapter 4.2; Table 2) supports the conjecture that curated technologies may have been important for executing some tasks, thereby helping to alleviate time-stress problems created by mutually conflicting resource procurement activities (Torrence 1983). This may have been particularly true during non-winter months when timing of resource procurement and processing was most critical, and task conflicts were likely to have been more common. The apparently higher relative frequency of key-shaped formed unifaces at non-winter, non-housepit sites (Chapter 9.3) compared to winter pithouse village sites supports this hypothesis. During winter months when group mobility significantly decreased and pithouse villages were occupied, time-stress situations rarely occurred because of predominant reliance on stored food and lithic resources. Consequently, simple expediently produced lithic tools with high replacement rates were more commonly used since there was ample time to make them. Indeed, high proportions of expediently produced lithic tools is a consistent assemblage patterning noted at many excavated winter pithouse village sites on the Canadian Plateau (see also Parry and Kelly 1987).

It might be further speculated that use of task-specific curated technologies may have been most common during the Plateau horizon (ca. 2400 to 1200 BP) on the Canadian Plateau when it is hypothesized that salmon populations declined, and exploitation of secondary resources (e.g., upland game and plants) was intensified to offset shortages of this important storable resource (see Lawhead, Stryd, and Curtin 1986:31-32; Richards and Rousseau 1987:56-57). Because availability of many of these secondary resources was probably just as prevalent then as they were during the ethnographic period (see Teit 1900,1909; Ray 1933; Palmer 1975), extensive use of curated tools (including key-shaped formed unifaces) would have helped to relieve scheduling problems and enhance the efficiency of logistical resource extraction and processing activities.

Bamforth's (1986a) argument concerning curational technology and lithic raw material scarcity also has some value for explaining why key-shaped formed unifaces were curated on the Canadian Plateau. Cryptocrystalline silicate sources on the Canadian Plateau are relatively scarce, highly localized, and difficult to access (Leaming 1971), and production of large flake blanks from these materials was hindered by small average core size and internal flaws (Chapter 3.3.3). A considerable amount of time and energy would have been required to constantly replace expediently produced tools made from these highly prized materials, therefore, curational behaviour, efficient maintenence, and recycling (Chapter 3.3.2) were initiated as economizing measures. On most of the Columbia Plateau where cryptocrystalline silicates are more common (Campbell 1985:290-299), cost-benefits afforded by such mitigative strategies may not have been required, which may partially account for comparatively lower average frequencies of key-shaped formed unifaces at sites in this culture sub-area.

Curated chipped stone tools can easily incur incidental trauma-produced microwear traces (i.e., scratches, microflake scars, polish) caused by edges or faces of the tool coming into forceful contact with hard objects during periods of transport. However, for prehistoric key-shaped formed unifaces this type of microwear is expected to be randomly represented, and should be less intense and less frequent than microwear traces produced by use. Traumatic damage due to curation may account for at least some of the rarer types of wear observed on the 35 prehistoric microwear sub-sample specimens (Chapter 8.4). Similarly, rarely executed task activities not related to the primary function of these tools would impart microwear patterns atypical to those perceived as representing the "norm" (see also Hayden 1987b).

CHAPTER 4

GEOGRAPHICAL AND TEMPORAL ANALYSIS

4.1 Geographical Analysis Methods and Results

Fladmark (1978) previously noted that the geographical distribution of key-shaped formed unifaces appeared to be primarily restricted to the Interior Plateau culture area. He also maintained that similar items occurred in *Marpole phase* components of the South Coast, and in the *Arctic Small Tool tradition* assemblages of Alaska, the Yukon, and Northwest Territories. To his knowledge, no specimens had been found on the Plains or in the Great Basin.

By considering available radiocarbon assays from components bearing these tools, and by cross-referencing associated temporally diagnostic artifact types, Fladmark determined that they appeared to be chronologically restricted to between ca. 3300 and 1200 BP.

In the present study, the approximate geographical extent and temporal distribution of these items was estimated by considering all available published and unpublished research reports for sites throughout the Northwest, and by direct consultation with various researchers familiar with the prehistory of specific Northwestern archaeological regions. A letter including a description and photograph of the prehistoric study tools, and a brief account of the thesis goals and problems, was sent to 25 researchers. Each researcher was requested to provide any further information or insights that they, their colleagues, or associates might have regarding the geographic and temporal distribution of these tools, and what they thought their most probable function(s) might have been. Fourteen researchers responded by letter, and two others by telephone.

4.1.1 Geographic Distribution in the Southern Northwest

The results of the literature survey and researcher responses suggest that the geographical distribution of key-shaped formed unifaces in the southern part of the Northwest encompasses the entire Interior Plateau culture area and some of its immediately adjacent regions (Appendix 4; Figure 6).

The northern geographic extent of key-shaped formed unifaces in British Columbia is not presently known, although these tools have been found in the central part of the province at Punchaw Lake near Prince George (Fladmark 1976), and at Tezli Lake on the Blackwater River (Donahue 1975,1978). They may occur further north into northern B.C. and Yukon, but the relative paucity of survey or excavation data from north of 54° latitude does not permit this to be ascertained at present.

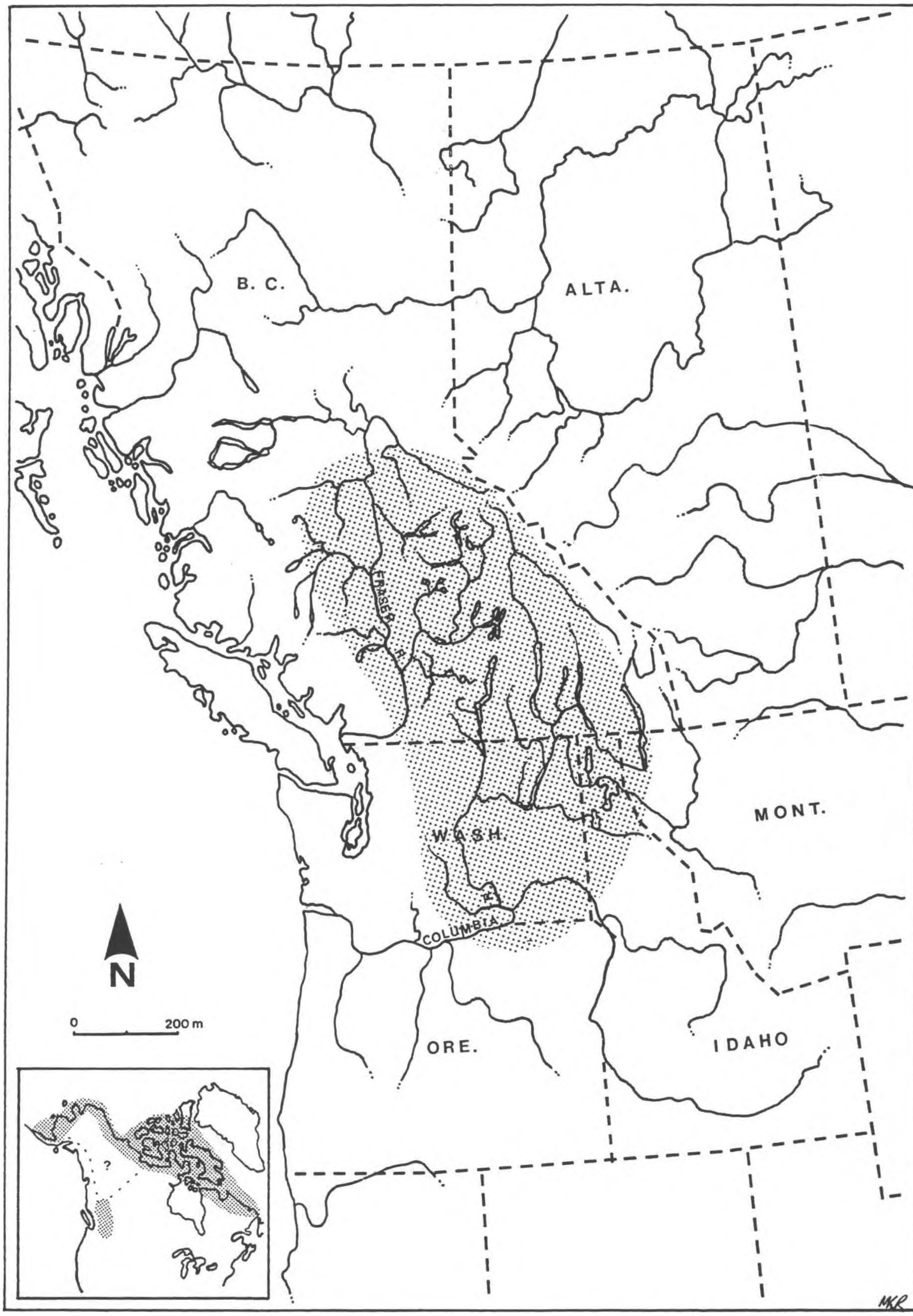

Figure 6. Presently determined geographical extent (shaded area) of key-shaped formed unifaces on the Interior Plateau and some of its immediately adjacent regions. The inset map (lower left) indicates their known distribution in the Arctic.

The western extent of these tools on the Canadian Plateau appears to be the Coast Mountains on the Fraser River (Sanger 1970; Stryd 1973). Borden (1968) recovered them in the Yale locality of the Lower Fraser Canyon, and Hanson (1973) and Von Krogh (1980) report them from the Hope locality of the Lower Fraser, which appears to have been the southwestern limit of their distribution in B.C. They have yet to be found west of the Coastal/Cascade Range on the Canadian or American portions of the southern Northwest Coast (Carlson, pers. comm. 1987; Daugherty, pers. comm. 1987).

Tools identical to key-shaped formed unifaces are not found in excavated sites east of the Rocky Mountains on the Alberta Plains. However, vaguely similar items with basal-lateral notches -- clearly hafting elements -- have been found in very small numbers in Alberta, and in northern Montana (Brumley 1975:183; pers. comm. 1988; Meyer and Beaulieu 1987:67; Wright, pers. comm. 1988). At present, the easternmost extent of key-shaped formed unifaces, as defined in this study, appears to be the Upper Columbia River valley just west of the Rocky Mountains in the East Kootenay region (Bussey 1986).

Key-shaped formed unifaces have been recovered from sites throughout the Columbia Plateau in north-central Washington (Grabert 1968; Miss *et al* 1984; Jaehnig *et al* 1985; Greengo 1986), central Washington (Gunkel 1961; Holmes 1966; Warren 1968; Nelson 1969), northeastern Washington (Rice 1968; Chance and Chance 1977,1979,1982; D. Chance, pers. comm. 1987), on the Snake River in south-eastern Washington near the Oregon/Idaho border (Caldwell and Mallory 1967; Yent 1976), and in northern Idaho (Miss and Hudson 1987). They have yet to be identified in assemblages from Montana (Davis, pers. comm. 1988), Oregon, or the Great Basin culture area.

In summary, the present data suggest that the geographical distribution of key-shaped formed unifaces in the southern Northwest is confined to the entire Interior Plateau and a few immediately adjacent regions. It is bounded on the west by the Coast/Cascade Mountains, on the south by the Washington/Oregon border, and on the east by the Rocky Mountains in both Canada and the U.S. As mentioned above, the northern boundary is not yet clear due to a paucity of archaeological data from north-central and northern B.C.

The geographical distribution of key-shaped formed unifaces on the Plateau corresponds with territories historically occupied by Interior Salish-speaking groups in the north, and several Sahaptin-speaking groups in the south. This suggests that their use was restricted predominantly to groups participating in, or being partly influenced by, a typical "Plateau" adaptive pattern.

4.1.2 Geographic Distribution in the Arctic

Communication with Arctic specialists and perusal of published information indicates that items identical to, or similar to, key-shaped formed unifaces have been found in components in the Arctic and High Arctic from Alaska to Labrador where they are called "concave side-scrapers" (Appendix 4). In coastal regions of Alaska and the Yukon, Central Arctic, High Arctic, and Eastern Arctic, identical tools have been recovered from components belonging to the *Arctic Small Tool tradition/pre-Dorset* (Ackerman, pers. comm. 1987; Bertulli, pers. comm. 1987; Giddings 1964; Helmer, pers. comm. 1988; Irving 1964; McGhee 1976,1978,1979,1980, pers. comm. 1987; Morrison, pers. comm. 1987).

In Alaska and Western Arctic they appear in *Norton* (Paleo-Eskimo) components (Ackerman, pers. comm. 1987), and in the Central and Eastern Arctic they have been found in *Dorset* components (Bertulli, pers. comm. 1987; Helmer, pers. comm. 1988; Linnamae 1975; Mary-Rousseliere 1976; Maxwell 1973,1976,1980,1984,1985; McGhee 1981; Morrison, pers. comm. 1987; Jordan 1980). The proximal morphology of Dorset concave side-scrapers strongly suggests that many were hafted during use. In discussing the techno-chronological evolution of these items, Maxwell (1973:339) remarks that:

> The concave-edged side scraper...appears as a thick flake, possibly hand-held, with a beveled notch on one margin. Through time the tool becomes narrower, more delicate, and side-notched for hafting, and at the end...becomes a uni-bevelled, oblique-edged knife -- still used as a scraper by drawing the flint edge toward the body.

Ackerman (pers. comm. 1987) maintains that similar tools have been found in the western sub-Arctic, although Morrison (pers. comm. 1987) notes that they seem to be lacking in the eastern sub-Arctic. Le Blanc (pers. comm. 1987) indicates that they are rare in the Boreal Forest of Alberta.

Arctic concave side-scrapers tend to be smaller than their Plateau analogues, averaging only about 29 mm long (McGhee 1979:102). It has been inferred that they were used to work bone, antler, ivory, and wood (Ackerman 1987; Le Blanc, pers. comm. 1987; McGhee 1979; pers. comm. 1987). Many Arctic specimens have also been intentionally burinated along the "opposite" margin; a feature not observed on any Interior Plateau specimens. Also, it should be kept in mind that this tool form may not have functioned in precisely the same capacity in both of these areas given the differences in the nature and relative abundance of raw materials available in each of these environments.

4.2 Temporal Analysis Methods and Results

The approximate chronological distribution of key-shaped formed unifaces in the Northwest was determined by: (1) considering the range of presently available radiometric dates for excavated components containing these items (Table 2); (2) inferring relative age on the basis of other associated temporally diagnostic artifact types; and (3) considering information provided by the respondent researchers (Appendix 4).

4.2.1 Temporal Distribution in the Southern Northwest

The range of radiocarbon ages associated with components bearing key-shaped formed unifaces on the Canadian Plateau (Table 2), suggests that they appeared in the archaeological record around 3000 BP, and vanished sometime around 1000 BP. This temporal span is commensurate with the latter half of the *Shuswap horizon* (ca. 3500 to 2400 BP) and all of the *Plateau horizon* (ca. 2400 to 1200 BP) (Richards and Rousseau 1987). Their use appears to have been discontinued shortly after the commencement of the *Kamloops horizon* (ca. 1200 to 200 BP). The exact reason for their disappearance is not known, although it may have been related to the complete functional replacement of atlatl technology with bow and arrow technology by about 1000 BP (see Chapter 10).

On the Columbia Plateau, key-shaped formed unifaces have been found in contexts dating between ca. 4000 and 1000 BP (Table 2). Most have been recovered from components dating between ca. 3000 and 1000 BP, but they have been found in at least two components from north-central Washington dating to ca. 4000 BP.

In north-central Washington, Grabert (1968) has assigned them to the *Chiliwist phase* (ca. 3000 to 900 BP) of the South Okanagan valley, and they also occur in the *Hudnut phase* (ca. 4000 to 2000 BP) and initial half of the *Coyote Creek phase* (ca. 2000 to 1000 BP) of the Rufus Woods Lake region (Campbell 1985). In central Washington, Nelson (1969) reports them for the *Quilomene Bar phase* (ca. 2800 to 2100 BP) and the initial half of the *Cayuse phase* (ca. 2100 to 1000 BP), Warren (1968) assigns them to his *Selah Springs pattern* (ca. 3000 to 1000 BP), and Holmes (1966) recovered a similar item from the *Schaake I* component (ca. 3300 to 2800 BP). At Kettle Falls in northeastern Washington they occur in the *Ksunku period* (ca. 4000 to 3200 BP) and the *Sinaikst period* (ca. 1700 to 600 BP) (Chance and Chance 1977,1979,1982; D. Chance, pers. comm. 1987). In the Lower Snake River region of southeastern Washington they have been attributed to the *Tucannon phase* (ca. 5000 to 2500 BP) (D. Chance, pers. comm. 1987), and to the *Harder phase* (ca. 2500 to 700 BP) (Yent 1976).

4.2.2 Temporal Distribution in the Arctic

Data for the Arctic suggest that concave side-scrapers date between ca. 4500 and 1000 BP in both western and eastern sub-areas. As previously mentioned, they are found in components belonging to the *Arctic Small Tool tradition* (ca. 4500 to 2500 BP), and to the later *Norton* and *Dorset* cultural complexes of the Paleo-Eskimo tradition, which both date between ca. 2500 and 1000 BP.

4.3 Summary and Discussion

The present data suggest that items conforming to the typological definition of "key-shaped formed uniface" as outlined in this study are occasionally found in two environmentally different and non-adjacent culture areas: the Interior Plateau and some of its neighbouring regions; and most of the Arctic. They are reportedly rare or absent in the interior of the Yukon and Northwest Territories, northern B.C., Alberta, southern Idaho, Montana, Oregon, and the Northwest Coast.

At present, the earliest appearance of these items seems to have been in the Arctic sometime around 4500 BP; at least 500 years earlier than they are known to have appeared on the Columbia Plateau. Assuming this reflects reality rather than sampling error, one model which can account for this temporal disparity is that this tool type has a single origin, and it was a technological innovation of people participating in the Arctic Small Tool tradition/pre-Dorset. Its adoption and use may have then eventually diffused rapidly southward via inland hunting groups from the Arctic to the Columbia Plateau sometime between 4500 and 4000 BP. This scenario suggests that their distribution should be more or less contiguous throughout the Northwest, and that a north-to-south cline of progressively later appearance dates might be expected.

There are a few problems with this model. First, these tools appear to be absent or very rare in the sub-Arctic culture area. Also, radiocarbon dates for components bearing these items on the Canadian Plateau (Table 2) suggest that their initial use in this sub-area was about 1000 years later than on the adjacent Columbia Plateau. Since the Canadian Plateau lies between the Arctic and Columbia Plateau, a north-to-south cline of progressively later appearance dates is logically expected; unfortunately this situation does not presently appear to exist. It is important to note, however, that only a few investigated components have been radiocarbon dated to between ca. 3000 and 4000 BP on the Canadian Plateau (Richards and Rousseau 1987; Stryd and Rousseau 1988). Therefore, the apparent absence of these tools from ca. 4000 to 3000 BP may be due to sampling problems. I predict that key-shaped formed unifaces will eventually be found in components dating to this time on the Canadian Plateau within the next few decades.

A second possible model suggests that this tool form may have been indepedently invented in two geographic centers; once in the Arctic around 4500 BP, and again on the central Columbia Plateau about 4000 BP. If this is true, I expect that this tool form might not be represented in areas lying between the Arctic and Plateau. At present, this seems to be the case. I submit that it is more parsimonius to postulate that the appearance of key-shaped formed unifaces on the Canadian Plateau is a result of a northward diffusion from the nearby and environmentally similar Columbia Plateau rather than southward diffusion from the Arctic in the distant north.

The current evidence (i.e., housepit dwellings and semi-sedentary adaptive pattern) suggests that a logistical subsistence and settlement system (Binford 1980) appeared about 4500 BP on the Columbia Plateau (Ames, Green and Pfoertner 1981; Chatters 1984,1989; Campbell 1985). This is about 1000 years earlier than the appearance of such an adaptive system on the Canadian Plateau (Richards and Rousseau 1987; Stryd and Rousseau 1988). By ca. 4000 BP, intensification of curated tool use, which included key-shaped formed unifaces, accompanied the development of a logistical strategy on the Columbia Plateau. The advantages and benefits derived from using curated technologies in a logistical subsistence and settlement system are discussed in Chapter 3.6.

CHAPTER 5

RESIDUE ANALYSIS

5.1 Residue Analysis Methods and Procedures

Using various chemical reagents, it is sometimes possible to detect the presence of minute amounts of organic residues (i.e., blood, fats, oils, resins, plant constituents) adhering to stone tools (see Briuer 1976; Broderick 1979,1984; Anderson 1980; Coughlin and Classen 1982; Loy 1983,1987; Loy and Nelson 1987; Shafer and Holloway 1979; Paull 1984; Fullagar 1986; Deal and Silk 1987; Gurfinkel 1987; Gurfinkel and Franklin 1988). Such analyses assume that there is a transferrence of plant and/or animal matter onto the surface and/or into interstices between crystalline grains of a stone tool during use, and that these deposits may persist as a residue for extended periods of time.

In the present study, tests to determine the possible presence of blood, starch, and plant lignin were performed following procedures outlined by Loy (1983), Broderick (1984), and Paull (1984). These tests were undertaken to generate data that might indicate whether the majority of key-shaped formed unifaces were used primarily on contact materials derived exclusively from animals (i.e., fresh bone), from plants (i.e., bark or wood), or both.

The first step in the analysis was to identify potential residue deposits adhering to the concave or "opposite" margins of key-shaped formed unifaces using a Nikon stereoscopic light microscope at magnifications ranging between 6.4 X and 40 X. Fortunately, the steep retouch along these margins is characterized by a preponderance of step- and hinge-terminated flake scars that are conducive to trapping and retaining residue deposits (see Chapter 5.2 and Figure 66).

During examination of the 129 prehistoric tools, residues were observed on 37 items, constituting 28.7% of the sample assemblage. It is possible that many more items initially bore residue deposits, however, some depositional contexts or recent artifact washing or brushing may have removed them.

Eighteen specimens bearing sufficient (i.e., 15 to 30 mg) residue deposits were judgementally selected and subjected to three separate reagent tests: (1) the "Hemastix" test for blood haemoglobin (Loy 1983); (2) the Iodine test for starch and plant parts; and (3) the Phloroglucinol-Hydrochloric acid test for plant lignin (Broderick 1984; Paull 1984). These simple "spot" tests were chosen because they are sensitive, relatively inexpensive, and can be performed quickly and safely with standard laboratory apparatus.

Alternate residue analysis methods such as the benzidine test for blood (Hawk *et al* 1948; Lee 1982; Broderick 1984; Paull 1984) and Sudan III and IV tests for fatty residue (Johansen 1940:63; Broderick 1983; Paull 1983) were not undertaken in this study. The benzidine test duplicates the "Hemastix" test and involves carcinogenic agents. The Sudan III and IV tests do not distinguish between plant-derived and animal-derived fatty residues, and there is some possibility of obtaining spurious results caused by fats and oils being tranferred to tool surfaces because of artifact handling during washing, cataloging, and analysis.

5.1.1 "Hemastix" Test for Blood Haemoglobin

The Hemastix test strip was devised by Ames Division, Miles Laboratories Ltd. to determine the presence of blood in urine. The strips are extremely sensitive to haemoglobin and can detect concentrations between 5000 and 20,000 molecules in one milliliter of fluid. A single mammalian red corpuscle contains approximately 70 million haemoglobin molecules, therefore, this test is considered to be an extremely sensitive indicator for blood (Loy 1983; Paull 1984).

Loy (1983,1987) is confident that blood haemoglobin can survive extended periods of time under optimum conditions. Items examined in the present study are less than 4000 years old, and most have been buried in dry silty soils. Consequently, I reasoned that if the primary function of these items involved working fresh animal bone having bits of flesh adhering, some traces of blood should be present and detectable on at least a few tools.

The test is quick, simple, and involves only the Hemastix, physiological saline solution, and the specimens to be analyzed. First, a Hemastix is dampened with physiological saline solution (distilled water and NaCl) and placed on a slide under a binocular microscope at a magnification between 10 X and 20 X. A drop of saline solution is then placed on the functional edge or surface of the tool with a glass pipette. Next, a sample of residue deposits adhering to the tool edge/surface are scraped off and agitated within the drop of saline solution with the end of the pipette and allowed to sit for between four and six minutes. The residue sample solution is then removed with a pipette, placed on the dampened Hemastix, and examined under 40 X magnification. A weak positive reaction is indicated by small flecks of green appearing over several areas of the Hemastix pad, a moderate reaction by patchy areas of medium or dark green over several areas of the pad, and a strong reaction by turning the entire pad dark green.

False reactions for the Hemastix test can be obtained by fresh fruit or vegetable peroxidases, however, peroxidases are quickly degraded and are not a concern for archaeological specimens (Broderick 1984:4). Loy (1983) also indicates that chlorophyll can produce a spurious positive reaction, which might possibly account for some weak reactions obtained in this study (see Chapter 5.2.1). Copper oxides also invoke a false positive result (Paull 1984:247), although they are not common in most soil matrices. Any tools suspected of being associated with copper compounds should be eliminated from testing. Also, residues should *not* be removed from the sample artifacts with metal implements (i.e., such as a stencil knife as suggested by Paull [1984]) to avoid a possible false reaction caused by small fragments of metal that might be dislodged into the sample solution.

5.1.2 Iodine Test for Plant Starch

Aqueous iodine (I-), is a reagent that reacts by turning starch a blue-black colour. Starch is present in many plant cells, particularly storage cells within roots, corms, bark, and stems (Esau 1953:27-28). Approximately 20% to 25% of starch is comprised of amylose, which is water soluable; the remaining 75% to 80% consists of non-soluable amylopectin (Morrison and Boyd 1967:1027). The latter may be preserved under certain conditions in the archaeological record (Broderick 1984).

The reagent is prepared by disolving 2.0 gr of Iodine (I) and 500 mg of Potassium Iodide (KI) into a mixture of 40 ml of distilled water and 20 ml of ethanol. The testing procedure is outlined in Broderick (1984) and Paull (1984). First, a small sample of residue (5 to 10 mg) is scraped from the functional edge of the tool onto a microslide at 10 X to 20 X magnification. Next, a drop of reagent is placed on the residue sample and magnification is increased to 40 X. A positive reaction is recorded if obvious organic constituents in the sample (i.e., tiny translucent particles or detritus which move freely or concentrate at the edge of the reagent drop) turn light or dark blue, violet, or black.

False positive results for the Iodine test, as well as for the Phloroglucinol-HCl Acid test (below), can also be obtained for plant parts (i.e., rootlets, decayed wood) that are a natural and incidental component of many soil matrices. Artifacts buried in such contexts might conceivably accumulate these plant parts on their surfaces or within deep flake scars. However, I argue that in the absence of a naturally occurring medium that could firmly bond or adhere these parts to the tool (e.g., calcium carbonate or ferrous precipitates), they would be very easily removed by even the slightest washing or brushing. The possibility of non-culturally derived plant part contamination was acknowledged during this study, and care was taken to ensure that this agency did not lead to misleading conclusive results. A further discussion of this potential source of error is presented below in Chapter 5.3.

5.1.3 Phloroglucinol-HCl Acid Test for Plant Lignin

Phloroglucinol saturated in concentrated Hydrochloric acid (HCl) is a reagent that reacts with lignin in plant parts, turning them reddish-purple, magenta, or red. Lignin is a durable organic substance related to cellulose, and is a component of woody plant cell walls and the cementing materials between them. The testing procedure used in this study is outlined by Paull (1984). First, a small sample of residue (5 to 10 mg) is scraped from the functional tool edge onto a microslide with a stencil knife under a magnification of between 10 X and 20 X. Next, a drop of reagent is placed on the sample, and magnification increased to 40 X. A positive reaction is indicated if any constituents of the residue sample resembling plant parts/detritus or woody fibres turn light reddish-purple, magenta, or red.

Because interpretations of the residue analyses results were subjective in nature (i.e., they relied on visual assessments of colour and quantity) and thus resercher bias was possible, several witnesses were asked to provide verification for "strong" or "moderate" reaction results. Dr. Erle Nelson, Laurie Milne, Ian Kuijt, and Chris Knusel observed many of the reactions obtained during the haeomoglobin test; Murielle Nagy and Luke Dalabonna witnessed "strong" positive results obtained for the plant lignin test; and Ian Kuijt, Chris Knusel, and Dr. Jon Driver verified "strong" and "moderate" results of the starch test.

5.2 Residue Analysis Results

5.2.1 Results of the "Hemastix" Test

Of the eighteen tools tested for blood (haemoglobin), only three produced positive reaction results (Table 3). Two tools from the Mid-Fraser River region (EeRk 4:19-2119 and EeRl 7:1000) indicated weak positive reactions. Only one tool (FiRs 1:5699 from Punchaw Lake), indicated a strong positive reaction. Indeed, dark reddish brown blotches considered typical of blood residues (Nelson, pers. comm. 1987) are evident on the functional edge and dorsal surface of this tool. The distal half of this tool's distal projection is absent, and it is possible that it might have been used for processing animal-derived materials after it had broken. Recycling of broken or worn tools was not an uncommon practice on the Plateau. Alternately, human blood may have been deposited on this tool when the distal projection snapped off during use, resulting in its user being cut (see also Chapter 7.7).

The two items that produced weak positive results may have come into contact with very small quantities of blood (particularly human [Chapter 7.7]), or perhaps other compounds known to produce false results (i.e., chlorophyll, plant peroxiodase, or iron compounds). Because of the latter possibility, they are not regarded to be conclusive indication of haemoglobin presence.

To test the possibility that chlorophyll might produce a false positive reaction for tools that were engaged in working of woody plants, the Hemastix test was performed on abundant residues adhering to the ventral face of the distal projection of experimental tool (E.T.) #8, which was used to scrape saskatoon bark and wood (Chapter 7; Appendix 9). The negative results obtained suggests that residues deposited on stone tools engaged in working woody plants do not produce a false positive reaction for the Hemastix test, and this potential source of error can be discounted. The Hemastix test was also performed on bone and antler shavings; negative results were also obtained for these materials.

5.2.2 Results of the Iodine Test

Thirteen (72%) of the eighteen tools tested for starch produced positive results (Table 3). A weak positive reaction was recorded if one to three stained particles (i.e., individual starch grains) were observed, a moderate reaction for four to six particles, and a strong reaction for more than six particles. Seven tools produced a weak positive result, four were associated with a moderate reaction, and two yielded a strong reaction. Saskatoon bark and wood shavings were tested with this reagent, and a strong positive reaction was observed. Bone and antler shavings were also tested; negative results were obtained.

5.2.3 Results of the Phloroglucinol-HCl Acid Test

Fourteen (78%) of the eighteen tools subjected to this test produced positive results for the presence of plant parts (Table 3). A weak positive reaction was observed if less than five tiny, translucent, organic-looking stained particles were apparent. Moderate results were recorded if more than five such tiny particles were observed. A strong positive result was recorded if the sample contained obvious stained plant parts (i.e., wood fibres) and five or more tiny, translucent, organic-looking stained particles. Nine tools yielded a weak positive reaction, one from Kamloops (EeRb 10:6) produced a moderate positive result, and three from the Mid-Fraser River region (EeRk 4:1-51, EeRk 4: 10-1007 and EeRl 4:364) produced strong positive results.

Tools associated with moderate or strong positive reaction results bore residues that, when scraped from step- or hinge-terminated flake scars along the functional tool edges at 20 X magnification, contained visually apparent plant fibres measuring between about .1 and 2 mm long completely embedded within a sticky resinous substrate. It was concluded that these were wood fibres because: (1) most were elongate and/or cylindrical and somewhat "kinky" in form with either frayed or invasive terminating ends; (2) they were highly cohesive and relatively resistant to mechanical pressure; and (3) they were semi-translucent, and very pale yellow or white in colour. Subsequent reagent testing confirmed their identity as plant matter. Numerous tiny (less than .1 mm) plant/wood fragments were also observed.

The sticky resinous substrate deposit containing the embedded wood fibres and plant matter observed adhering within the flake scar terminations of the prehistoric specimens was identical to residues observed on the surfaces of all experimental tools used to work wood in this study (Chapters 7.6 and 7.7; Figure 66). Loy (1983) has also observed plant residues on prehistoric stone tools from northern B.C..

Obvious wood fibres were not visually detected in residues scraped from tools producing weak positive reactions. Nevertheless, once tested, between two and five tiny fragments of stained plant parts could be easily discerned at a magnification of 40 X.

The Phloroglucinol-HCl acid reagent was used to test dried saskatoon bark and wood shavings; very strong positive results were obtained. It was also used on bone and antler shavings to determine whether a false positive reaction can occur for these materials, however, both tested negative.

5.3 Summary and Discussion

The results of the residue analyses indicate that sixteen (88%) of the eighteen tested key-shaped formed unifaces bore traces of plant lignin and/or starch in residues accumulated within step- and hinge-terminated flake scars on the dorsal surface of the tool along the concave margin. Notable concentrations of plant lignin and/or starch were detected on five items, including EeRb 10:6, EeRk 4:1-51, EeRk 4:19-1007, EeRk 4:19-2119, and EeRl 4:364. Only three tools (16%) tested positive for the presence of blood (haemoglobin), although two of them produced weak reactions that can be questioned due to other factors known to produce false positive reactions. The analyses demonstrate that the main working edges of the tested sample bore residues containing plant remains.

It might be argued that plant remains could have accumulated on these tool edges post-depositionally as a result of being buried in soils containing large quantities of naturally present plant matter. However, this hypothesis is regarded to be unlikely. As mentioned above, while mechanically removing residue samples from the dorsal surface of the concave margin of several tools with a stencil knife, it was noted that dark brown residues adhering to the immediate tool surfaces had a tacky tar-like consistency typical of hardened plant resins.

Tiny wood and plant fibres and small grains of silt and sand were readily observed embedded in this resinous substrate. Most silt and sand grains were encountered within the outer portion of the deposits, whereas the plant remains were embedded throughout. This residue deposit did not resemble, in any manner, the nature of any commonly occurring chemical precipitates (e.g., calcium carbonate and ferrous compounds) found in typical soil matrices on the Plateau that might otherwise be responsible for adhering non-culturally introduced plant remains to these tool surfaces.

I conclude that the presence of wood and plant fibres, starch, and resinous deposits on the concave margin of these tools is best explained by inferring their direct involvement in plant processing activities rather than resulting from post-depositional agencies. Identical deposits were shown to accrue on surfaces and in snap- and hinge-terminated flake scars on all key-shaped formed unifaces used to strip bark and shave, scrape, and plane wood in the experimental component of this study, even after they were extensively cleaned with acetone (Chapters 7.6 and 7.7; Figure 66).

Results of the residue analysis should not be regarded as conclusive evidence for indicating the primary function of prehistoric key-shaped formed unifaces. It is viewed as an adjunct inquiry to be considered along with, and compared to, results of the design theory analysis (Chapter 3.3), microwear analysis (Chapter 6), and experimental analysis (Chapter 7) before any definitive conclusions or inferences can be drawn.

CHAPTER 6

PREHISTORIC TOOL MICROWEAR ANALYSIS

6.1 Microwear Analysis Methodology and Procedures

Microwear analysis is regarded as a very important methodological component of this study. This is because of its previously demonstrated efficacy for helping to determine prehistoric lithic tool function with reasonable accuracy and success (e.g., Keeley and Newcomer 1977; Newcomer and Keeley 1979; Schiffer 1979; Odell and Odell-Vereecken 1980; Gendel and Pirnay 1982; Kamminga 1982; Newcomer, Grace and Unger-Hamilton 1986; Richards 1987, and many others).

A total of 35 prehistoric key-shaped formed unifaces were subjected to a detailed microwear analysis (Table 4). Using a table of random numbers, they were selected from a sub-sample of 70 items in the prehistoric study sample set that exhibited either moderate or pronounced degrees of overall microwear trace intensity (Appendix 3). Twenty (57.1%) of the 35 selected prehistoric microwear sub-sample specimens are made of chalcedony, 12 items (34.3%) are chert, and three (8.6%) are basalt. These proportions are similar to those of the 129 prehistoric study sample specimens (Appendix 3).

Each of the 35 randomly selected tools was examined under a Wild M3 stereoscopic light microscope at magnifications varying between 6.4 X and 40 X. Observed microwear traces were described qualitatively and quantitatively (Appendices 4 and 5; Tables 5, 7 and 8; Figure 8). Photographs were taken with the microscope's built-in camera and a fibre-optic light source.

The advantages and disadvantages associated with various magnification methodologies used in microwear studies have been discussed by several researchers (Keeley 1974,1981; Odell 1975,1982; Odell and Odell-Vereecken 1980; Holley and Del Bene 1981; Richards 1984,1987; Bamforth 1986b; Newcomer, Grace and Unger-Hamilton 1986). Experimental "blind tests" have also been conducted to objectively assess the accuracy of various magnification methods (see Keeley and Newcomer 1977; Newcomer and Keeley 1979; Newcomer, Grace and Unger-Hamilton 1986; Richards 1987; Shea 1987).

After considering the observations and points raised in these previous assessment studies, it was decided that a "low-power" magnification (6.4 X to 40 X) methodology was appropriate for the present study. There are several reasons why a low-power magnification analysis method was selected over high-power magnification (greater than 60 X). First, many specimens in the study sample bear intensive and extensive microwear traces that can be easily seen with the unaided eye. Therefore, it was reasoned that high-power magnification methods were not required to identify and examine the full range of microwear traces, or to determine their location, intensity, and general characteristics.

Second, low-power magnification permits large areas of a tool's surfaces to be examined, compared, and photographed within the same field of vision, whereas the high-power method permits viewing of much more restricted areas. The latter method may cause some of the more prominent microwear trace features (e.g., microflake scars or polish) to be obscured or overlooked, thus the total range of trace patterns represented may be more difficult to detect, accurately describe, and compare (see Odell 1982:19).

Third, blind tests have shown that low magnification analyses of unretouched tool edges are only slightly less accurate than high magnification methods for identifying the location of tool contact, tool movement, and relative contact material hardness (see Tringham *et al* 1974; Odell and Odell-Vereecken 1980; Odell 1982; Richards 1984). It is primarily these aspects of key-shaped formed unifaces that are of importance in this study.

Lastly, low-power magnification analysis can be undertaken rapidly and inexpensively with relatively little specialized equipment, whereas the high-power method requires access to either a specialized light microscope or scanning electron microscope (SEM). Use of a SEM requires great expenditures of time; specimen preparation involves alteration of tool surfaces which sometimes obscures certain microwear traces (see Odell 1975:230), and in some instances destruction (i.e., breaking) of specimens is required to make them fit into the scanning stage.

The location, extent, and intensity of the various microwear trace types observed in this study are described using mainly qualitative terms, as some microwear attributes are very difficult -- if not impossible -- to adequately express in any standardized quantitative manner. Location and extent were described by recording trace positions vis-a-vis ascribed parts or areas of the tool, such as the edge of the concave margin, ventral face of distal projection, ventral-lateral corners of the distal projection tip, etc. (see Chapter 2.2 and Figures 2 and 8). Definitions for each of the microwear trace types recorded in this study, and a brief discussion concerning their potential significance, are presented below.

In this study, the "edge aspect" of a margin is defined as those portions of the ventral and dorsal faces that lie about 1.5 mm back from, and along, a tool edge. The term "margin" refers to both the immediate functional edges of a tool, and their respective edge aspects (see Figure 2).

6.1.1 Polish

Polish is defined as the degree to which a use-altered edge or surface of a tool reflects light. The characteristics of various polishes are considered to vary dependently according to specific use-conditions and lithic materials being employed (see Keeley and Newcomer 1977; Keeley 1980; Moss and Newcomer 1982; Vaughan 1985).

There have been several theories advanced that attempt to explicate polish formation on edges and/or surfaces of stone tools resulting from use (Semenov 1964; Rabinowicz 1965,1968; Del Bene 1979,1980; Diamond 1979; Kamminga 1979; Anderson 1980; Meeks *et al* 1982; Unger-Hamilton 1984; Bettison 1985; Knutsson 1988). Two main types of polish formation processes have been identified and defined: (1) "additive" (also referred to as depositional or accretional); and (2) "abrasive" (also called mechanical, frictional, or attritional).

Some researchers have suggested that an additive polish results when phytoliths in plant materials and silicate components of a tool's surface are fused together in successive layers by frictional heat (Witthoft 1967; Keeley 1980; Shelley 1982), or by dissolution of the tool surface into a gel which traps plant parts on recrystallization (Anderson 1980:184; Mansur 1982). Kamminga (1979:149-151) suggests that water may be involved in the fusion process. Del Bene (1979:171, 1980) and Bettison (1983,1985) suggest that true fusion does not occur, rather, glossy layers of cohesive phytoliths adhere to a tool's surface by anchoring themselves into interstitial voids between crystals comprising the lithic material.

Abrasive polish is thought to be the more common form of polish occurring on stone tools. Two separate formation model categories for abrasive polish have been proposed; abrasional, and translocative (Del Bene 1979: 172). Abrasional polish is thought to result from loss of material from the tool surface by friction (Diamond 1979:165; Kamminga 1979:151-154; Meeks *et al* 1982). Translocative polishing occurs when materials are either removed and re-attached elsewhere on the tool's working surface, and/or are deformed in their original locations (Del Bene 1979:172-174; 1980).

Due to the considerable debate and apparent uncertainty concerning the exact nature and significance of mechanical and chemical agencies responsible for polish formation, and because the two main types (i.e., additive and abrasive) can only be adequately identified with a scanning electron microscope (SEM) (see Bettison 1985; Knutsson 1988), an attempt to conclusively differentiate between the two main polish formation types was not undertaken in this study. However, the low-power magnification analysis results (Chapters 6 and 8), suggests that both abrasive and additive polish types may be represented on many of the prehistoric and experimental tools examined.

Hayden and Kamminga (1979:8) have suggested that raw material properties have a dependent relationship with the nature of polishing or smoothing incurred on tool edges or surfaces. Therefore, different materials subjected to the same use-behaviours and conditions may develop and exhibit varying types and intensities of polish or smoothing. Because the study sample contains a wide spectrum of lithic material types, accurate monitoring of variation in polish characteristics due soley to physical property differences inherent to the lithic raw materials was not considered feasible in this study.

Polish intensities were subjectively expressed in terms of relative brightness, and were recorded as being either dull, moderately bright, or bright (see Grace, Graham and Newcomer 1985). Examples of these categories are presented in Figures 21 to 38 and 54 to 65. The location and extent of polish was also recorded. It was reasoned that these polish data were suitable for: (1) helping to determine the location of tool contact; (2) providing an approximate and comparative index for the relative duration of tool use; and (3) assisting in determining the probable nature of contact material(s) when considered along with other analysis data (see Chapters 6.3, 8.4 and 9.6).

6.1.2 Rounding and Smoothing

Rounding and smoothing refer to the reduction in angularity of a tool's protruding features (e.g., flake scar ridges and functional edges). Two processes responsible for rounding and smoothing have been identified. The first, and most common, is caused by mechanical removal of small particles by attrition or abrasion during use (Brink 1978a,1978b:47; Diamond 1979; Ahler 1979:304; Keeley 1980). It is often considered to be synonymous with abrasive polish, although Ahler (1979:308) suggests that the two may be distinguished by differences in luster and texture. Abrasive agents are usually hard and angular, and can be derived directly from the contact material; from dust, sand, silt, etc. introduced incidentally from the working environment; or from particles dislodged from the contact surfaces of a tool during use (autoabrasion) (Kamminga 1979:151-154).

The second type of rounding/smoothing is additive in nature, involving accretion of silica deposits on tool surfaces derived from contact materials (particularly plants) or the tool itself. Basically, it is characterized by a build-up of an additive polish (see above) on a tool's functional edges and immediately adjacent surfaces that reduces angularity of microtopographical features.

The degree or intensity of rounding and smoothing on prominent microtopographical features and edges of tools was described as being either slight, moderate, or pronounced. Examples of various rounding and smoothing intensity categories are presented in Figures 21 to 38 and 54 to 65. Rounding/smoothing was considered to be an important microwear trace pattern because it: (1) assists in determining tool contact areas; (2) provides an estimate for the approximate relative duration of tool use; and (3) it can indicate the relative hardness of contact material(s) being worked.

6.1.3 Striations

Striations are linear scratches, grooves, furrowed depressions, sleeks, or abraded tracks which occur on tool edges or surfaces as a result of use (Semenov 1964; Brink 1978a:47-48, 1978b; Ahler 1979:314; Del Bene 1979:167-170; Fedje 1979; Hayden 1979a:192-193; Mansur 1982; Knutsson 1988: 90-101).

Two basic discrete striation categories were observed and defined in this study. They are referred to as "scratch-groove" and "sleeked". The "scratch-groove" type is characterized by linear scratches and grooves mechanically gouged into a fresh or abrasionally smoothed tool surface during use (e.g., Figures 24, 25, 27, 28 and 35). They are formed when the tool surface is in a "solid-gel" state (Mansur 1982). Most researchers agree that this striation type is produced by abrasive agents becoming incidentally introduced between a tool and its contact material (Semenov 1964:15,88; Wilmsen 1968; Sheets 1973:217; Keeley 1974:126-127; Tringham *et al* 1974; Odell 1975: 229; Brose 1975).

"Sleeked" striations appear as linear trend lines, both raised and/or furrowed, and they seem to be most commonly associated with an additive-type polish (see Figures 24 and 30). Indeed, they are typical of what Mansur (1982) has called "additive" (i.e., built-up) and "filled-in" striations most commonly formed by dissolution of silica on a tool surface when it is in a "fluid-gel" or "intermediate" state. Del Bene (1979:169) has suggested that they may also be produced by atomic adhesion and transfer of materials between the tool and its contact material.

The relative intensity of striations were described as being either slight, moderate, or pronounced. Their orientation with respect to one another was recorded as being either parallel unidirectional, parallel bidirectional, or parallel

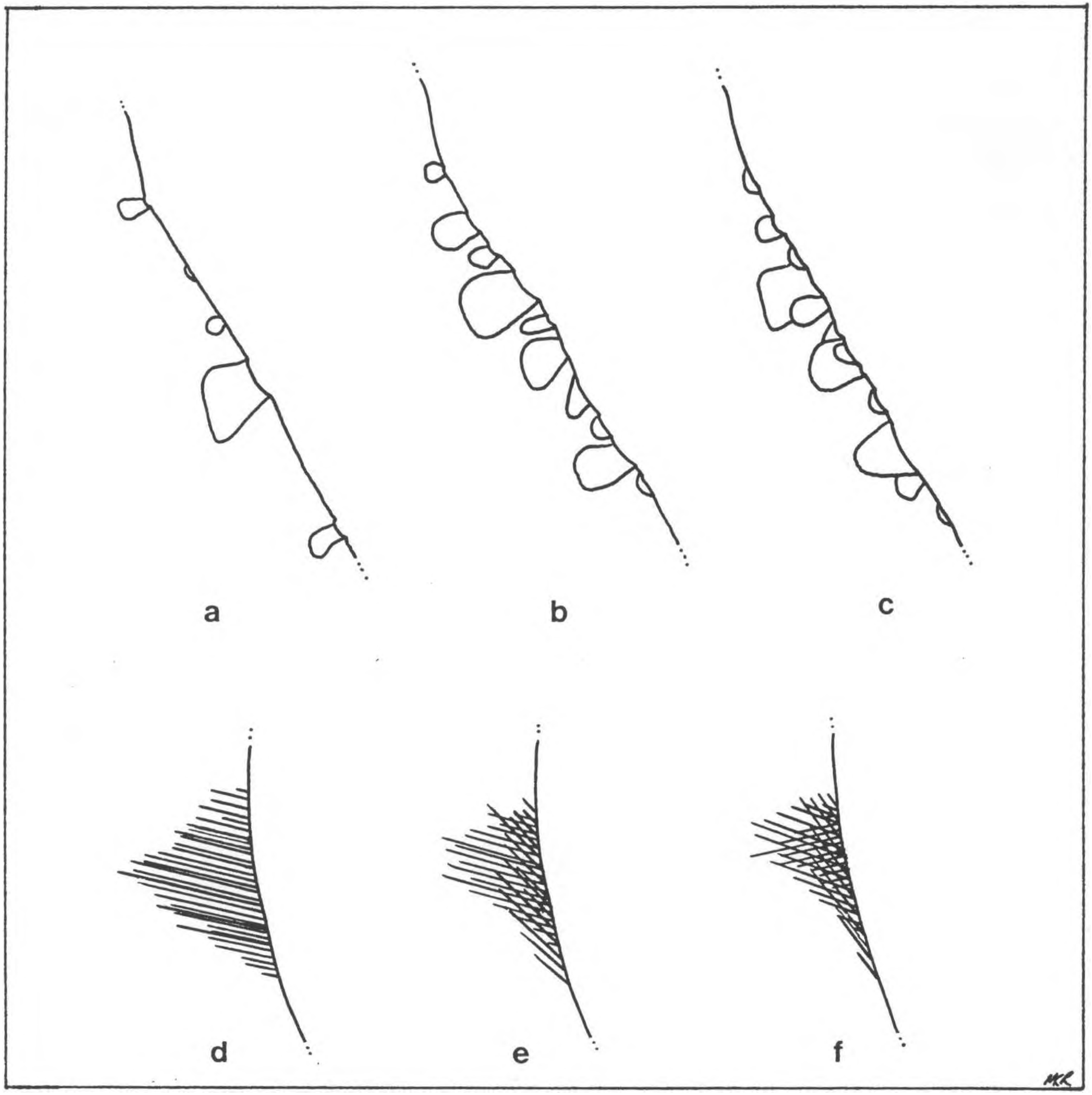

Figure 7. Typical microflake scar and striation pattern categories observed on the ventral edge aspects and ventral faces of the 35 prehistoric microwear sub-sample tools.

Edge aspect microflake scar pattern categories:

(a) random
(b) contiguous
(c) contiguous superposed

Ventral face striation pattern categories:

(d) parallel unidirectional
(e) parallel bidirectional
(f) parallel multidirectional

multidirectional (Figure 7). Certain striation attributes lend themselves to some degree of quantitative description. In this study their angular orientation vis-a-vis their respective functional edge of origin was recorded in five degree increments. "Distally" oriented striations had their "tails" pointing toward the distal end of the tool; "proximally" oriented ones had tails trending toward the butt.

Striation lengths, widths, and depths are also considered to have diagnostic value (Semenov 1964; Keeley 1980). However, an attempt to record this information was not undertaken in this study because high striation frequencies and their wide range of morphological variability would have demanded the use of high-power microscopy and enormous amounts of time to properly examine and quantify.

In this study, striations are deemed to be important data because their orientations in relation to the working edges are useful indicators of use-motion direction, and of the manner (i.e., relative working angles) that a tool was held against its contact material(s) during use. Moreover, they can also provide some information about prehistoric ambient environmental conditions in contexts where a tool was used. I have assumed that tools with a high incidence of striations were used in situations where there was an abundance of mobile abrasive agents (e.g., sand, silt, dust, grit) being introduced between the tool edges or surfaces and the material being worked. Alternately, tools with a paucity or absence of striations are regarded to have been used in contexts relatively free of abrasive materials (see Chapter 8.4).

6.1.4 Use-Fracturing

Use-fracturing refers to the manner and degree that sections of lithic materials break or shear from functional surfaces or edges of tools in direct response to applied loads of force during use. The complex laws of fracture mechanics governing use-fracturing are the same as those defined for intentional flaked tool production (Crabtree 1972:34-35; Cotterell and Kamminga 1979,1987; Lawn and Marshall 1979; Tsirk 1979; Odell 1981b).

Microflakes are commonly removed from edges of tools during use. When analogically correlated with results of experimentally generated data, their size, character, frequency, orientation, and distribution are considered to have potential diagnostic value for reconstructing motor patterns, and for helping to determine the nature of contact material(s) (Gould, Koster and Sontz 1971; Tringham *et al* 1974:188; Lawn and Marshall 1979:78; Cotterell and Kamminga 1979:110, 1987:704; Odell and Odell-Vereecken 1980:98-99; Odell 1980; Kamminga 1982).

The size, shape, and frequency of microflake scars on unretouched edge aspects of a tool can usually be easily categorized and quantified for comparative purposes (see Tringham *et al* 1974; Cotterell *et al* 1979; Hayden and Kamminga 1973; Hayden 1979a:134, 1979b; Kamminga 1982; Cotterell and Kamminga 1987; Richards 1987). In this study, only the microflake scars appearing on the ventral face edge aspects (Figure 2) of the prehistoric tool margins were examined, as it is impossible to differentiate those scars on the dorsal edge aspects that were produced by intentional retouch from ones propagated unintentionally during tool use.

Microflake scar sizes were determined by measuring their approximate diameter to the nearest .1 mm. Mean microflake scar size and range were calculated for each of the three main functional edges (i.e., the distal projection tip, concave margin, and "opposite" margin) (Table 5).

Formal attributes of microflake scars were recorded by considering their initiation types, plan outlines, and cross-section/termination types (Appendix 6; Tables 7 and 8) (see Ho Ho Classification and Nomenclature Committee Report 1979; Hayden 1979b; Tsirk 1979; Cotterell and Kamminga 1987). Use-propagated microflake initiation types were categorized as being either Hertzian (cone), or bending. Plan outlines of their scars were classified as either circular-expanding, trapezoidal-expanding, crescentic, oblique, pointed, or lamellar. Cross-section/ termination types were classified as being either invasive, shallow-stepped, deep-stepped, snapped, or retroflexed (see Tables 7 to 10). Frequencies for each of these microflake scar attributes were recorded and compared with those incurred on experimental tools (see Chapter 8).

The spatial relationship, or "pattern configuration", of microflake scars with respect to each other on the main functional margins were described as being either randomly scattered, contiguous, or contiguous-superposed (Figure 7). Examples of microflake scar formal types and their configuration patterns observed on prehistoric and experimental key-shaped formed unifaces are presented in Figures 25 to 28, 31 to 34, and 54 to 65.

Microflake scars appearing on the ventral edge aspects of key-shaped formed unifaces were important for helping to determine the location and extent of use-contact. Their initiations and terminations were useful for inferring the relative hardness of contact materials being worked, and levels of force applied (Tringham *et al* 1974:188; Ho Ho Classification and Nomenclature Committee Report 1979; Lawrence 1979:118-120; Cotterell and Kamminga 1987:686,691; Richards 1987:181). Microflake scar plan outlines were helpful for reconstructing use-motions and orientation of the working edge with respect to the material(s) being worked (Tringham *et al* 188-189; Odell and Odell-Veerecken 1980:98-99; Lawrence 1979:118) (see also Chapter 8.4).

Another category of use-fracturing occurs when substantial portions or sections of a tool are broken off due to heavy force loads being applied against a hard contact material. In such instances, the intensity and direction of the applied force can usually be inferred by considering the type of fracture involved (e.g., flexure, torsion), and/or through comparison with experimental data. For this study, understanding the nature of such use-fracturing was important for helping to determine the motor patterns associated with the apparent accidental removal of portions of the distal projection tip during use (see Chapter 6.3).

6.1.5 Crushing

Crushing is characterized by intensely microfractured sections of tool edges or prominent microtopographical features, and it is usually propagated during forceful working of hard contact materials (see Ahler 1979:309). In this study, its location and extent were described using relative descriptive terms, and its intensity was recorded as being either slight, moderate, or pronounced. An example of pronounced crushing on the concave margin of a prehistoric key-shaped formed uniface is presented in Figure 34. Crushing location and intensity was considered useful for identifying sections of tool edges that had been engaged in working reasonably hard contact materials using relatively heavy force loads.

6.1.6 Prehension Wear

Prehension wear is defined as the alteration of a tool's surface resulting from extended periods of abrasive contact with the user's hands or a hafting device. It has not been traditionally regarded as a microwear trace *per se* because it is not produced by direct contact with a material being worked. Consequently, it is sometimes referred to as "non-use" wear (see Odell 1982:22). Prehension wear can provide valuable information concerning how a tool was held, used, and/or hafted (see Odell 1977,1982; Odell and Odell-Vereecken 1980), and for this reason it was deemed important to this study. I have subsumed it under the rubric of microwear simply for descriptive convenience.

Manual or "hand-held" prehension is produced by gritty fingers repeatedly rubbing a specific location on a tool's surface during use (see Odell and Odell-Vereecken 1980; Vaughan 1985:39). Hafting prehension is formed by repeated minor side-to-side mechanical abrasion of a loose hafting device against a tool's surface during use (see Odell 1977; Moss and Newcomer 1982). Both types of prehension wear are most often manifest by localized polishing, rounding and smoothing of microtopographical features, and occasionally striations. They usually appear on non-functional portions (i.e., dorsal and ventral faces) of highly curated stone tools with long use-histories. The nature and intensity of prehension wear traces on a tool depends on the physical properties of its raw material, the abrasive characteristics of the user's fingers or hafting device, and duration of tool use. Examples of prehension wear on prehistoric key-shaped formed unifaces examined during this study are presented in Figures 36 to 38.

All microwear trace types discussed above were noted in the sub-sample of 35 prehistoric key-shaped formed unifaces selected for microwear analysis. The microwear attribute data were statistically analyzed using the Michigan Interactive Data Analysis System (MIDAS) programs to generate descriptive and inferential statistical measures (Appendices 5 and 6; Tables 5, 7, 8, 12 and 13). These measures were then compared qualitatively and quantitatively with those produced for the experimental tools (Chapters 8 and 9) to permit a judgemental assessment of their similarities and differences.

6.2 Descriptive Microwear Analysis Results

Detailed descriptive data generated for microwear traces observed on the 35 prehistoric microwear sub-sample specimens are presented in Appendix 6, and Tables 5, 7 and 8. A generalized account of salient, frequently recurring, and functionally significant microwear patterns are summarized and discussed below.

6.2.1 Distal Projection Tip

Many (45.7%) of items in the prehistoric microwear sub-sample have distal projections that are considered to be "complete" (i.e., there is no evidence to suggest intentional or accidential removal). The two most common distal projection fracture types are flexure (34%) and torsion (11.4%). Two items (5.7%) had their distal tips removed by some undetermined agency, and for one specimen (2.9%) it is severely inversely retouched (Appendix 6).

Rounding and smoothing intensity along the distal tip margin is absent for 20.6% of the sub-sample items, slight on 32.4%, moderate on 23.5%, and

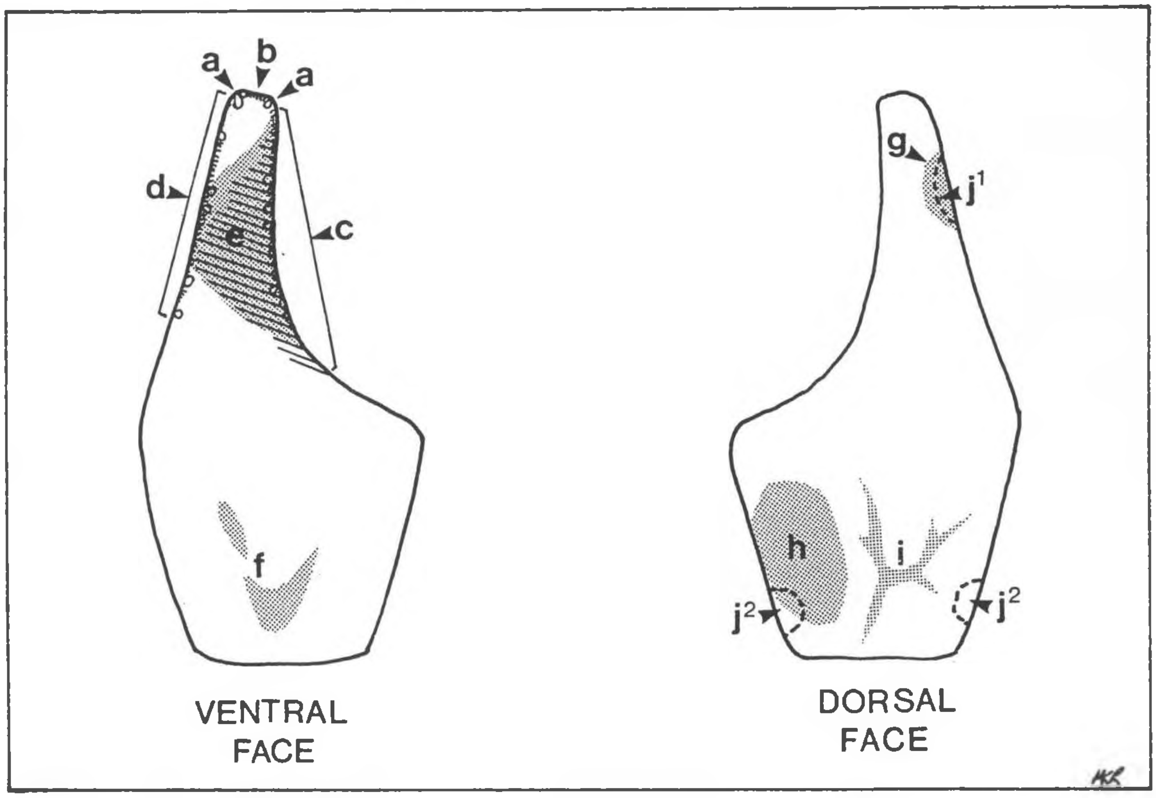

Figure 8. Typical microwear trace patterns observed on the 35 prehistoric microwear sub-sample specimens.

(a): Edge rounding and smoothing, and microflake removal on the ventral edge aspect of both ventral-lateral corners of the projection tip.

(b): Rounding and smoothing on the distal edge of the projection tip.

(c): Edge rounding and smoothing, polish, striations, and microflake removal along the ventral edge aspect of the concave margin.

(d): Edge rounding and smoothing, polish, and microflake removal along the ventral edge aspect of the "opposite" margin.

(e): Polish, striations, and smoothing on the medial or medial-distal section of the ventral face of the distal projection.

(f): Polish and smoothing on basal aspect of the ventral face caused by hafting prehension wear.

(g): Rounding, smoothing, and polish created by manual prehension resulting from the user's index finger and/or thumb rubbing on the dorsal face of the "opposite" margin.

(h): Rounding, smoothing, and polish formed by manual prehension resulting from the user's thumb rubbing on the left proximal-lateral section of the dorsal face.

(i): Polish and smoothing of ridges and microtopographical features on the proximal section of the dorsal surface caused by hafting prehension wear.

(j): Shallow indentations installed on a few specimens interpreted to have functioned as finger/thumb rests (j^1), and hafting elements (j^2).

pronounced on 23.5%. Of those exhibiting rounding/smoothing, 59.3% bear it exclusively on the ventral-lateral corners, 25.9% have it on both the distal edge and ventral-lateral corners, and only 11.1% possess it on the distal edge.

Polish intensity is dull on 17.6% of the sub-sample items, moderately bright on 55.9%, bright on 5.9%, and absent for 20.6%. Of the tools exhibiting polish, 55.6% have it on just the ventral-lateral corners, 29.6% possess it on both the distal edge and ventral-lateral corners, and 11.1% bear it on the distal edge only.

The mean number of microflake scars on the ventral edge aspect of the projection tip is 2.2, and the mean microflake scar size is 1.2 mm (Table 5). Microflakes were not observed on 48.6% of the sub-sample items. The majority (50.0%) of specimens with microflake scars have them exclusively on the ventral edge aspect of the ventral-lateral corners, 33.3% have them only along the ventral edge aspect of the distal margin, and 16.7% exhibit them on both the distal edge and ventral-lateral corners.

Crushing on the distal projection tip is absent for 64.7% of the tools in the microwear sub-sample. For items where it is present, 8.8% have slight intensity, 17.6% exhibit moderate intensity, and another 8.8% have pronounced intensity. Crushing is most common (58.3%) on the distal edge only, 25.0% of the specimens have it on just the ventral-lateral corners, and 16.7% bear them on both the distal edge and ventral-lateral corners.

Only three items in the prehistoric microwear sub-sample exhibit striations associated with the distal tip. In all cases they are parallel and unidirectional, and are oriented more or less perpendicularly in relation to the distal edge.

6.2.2 Concave Margin

Rounding and smoothing intensity on the concave margin edge is absent for 8.6% of the specimens in the prehistoric microwear sub-sample, slight on 48.6%, moderate on 25.7%, and pronounced on 17.1%. Of the items indicating edge rounding/smoothing, it is present along the medial-distal section of the edge on 50.0% of the tools, along just the medial section for 28.1%, and along the entire edge for 18.8%.

Polish is absent on 8.6% of the sub-sample specimens, dull on 31.4%, moderately bright on 48.6%, and bright on 11.4%. For tools bearing polish, it is located on the medial-distal portion of the concave edge for 53.1% of them, on just the medial section for 31.3%, and on the entire edge for 12.5%.

The mean number of microflake scars on the concave margin of each specimen in the prehistoric microwear sub-sample is 4.0 (s.d.= 1.1) (Table 5). The mean microflake scar size is 1.1 mm. It is important to note that ten items lack microflake scars on this margin. Of those that have them, 52.0% have them on just the medial section of the edge, 24.0% exhibit them along the entire edge, and 20.0% bear them on the medial-distal section.

The microflake scar configuration pattern is random on 61.1% of the items having more than two scars. They are contiguously patterned on 16.7% of the specimens, and contiguous-superposed on another 16.7%. The most common (33.3%) microflake scar formal type includes those with expanding plan outlines and invasive terminations (Table 7). The next most frequent type is expanding/shallow-stepped (16.2%), followed by trapezoidal-expanding/shallow-stepped (8.1%), expanding/deep-stepped (7.1%), trapezoidal-expanding/deep-stepped (6.1%), crescentic/shallow-stepped (5.1%), and oblique/invasive for another 5.1%.

Where possible, concave margin microflake initiation types were asssesed as being either "Hertzian" (cone) or "bending" according to criteria defined by Cotterell and Kamminga (1987:681-693). The most common (82%) initiations are the bending type, whereas the Hertzian type comprise only 18%.

Striations can be observed on the concave margin on 42.9% of the tools in the microwear sub-sample (Appendix 6). Their general characteristics are described below in the discussion of the ventral face (Chapter 6.2.5). The "heads" of the striations originate along the ventral edge aspect of this margin, and they extend onto or across the ventral face on many specimens.

Crushing on the concave margin is absent for 68.6% of the sub-sample items. Its intensity is slight on 14.3% of the specimens, moderate on 8.6%, and pronounced on another 8.6%. For those tools possessing crushing, it can be observed along the medial-distal section of the margin on 36.4% specimens, another 36.4% have it along the entire margin, 18.2% exhibit it on the medial section only, and 9.1% bear it on the distal section only.

6.2.3 "Opposite" Margin

Rounding and smoothing intensity on the "opposite" margin is slight on 41.2% of the items in the prehistoric microwear sub-sample, moderate on 32.4%, prounounced on 5.9%, and it was absent for 20.6% (Appendix 6). Of those items exhibiting rounding/smoothing, it is located on the medial-distal section of the margin for 70.4% of the tools, 14.8% have it just on the medial section, and another 14.8% possess it on the entire edge.

Polish intensity is dull on 38.21% of the specimens in the sub-sample, moderately bright on 32.4%, bright on 8.8%, and for 20.6% it is lacking. For those tools exhibiting polish on this margin, 74.1% have it on the medial-distal section, and 22.2% bear it on the medial section only.

The mean number of microflake scars appearing on the "opposite" margin for each of the items bearing them is 4.6 (s.d.= 2.8) (Table 5), indicating that they are slightly more frequent on this margin than on the concave margin. The average microflake scar size on this margin is .7 mm, indicating that they are also slightly smaller. Microflake scars are present on the medial edge sections for 43.5% of the specimens bearing them, another 43.5% have them on the medial-distal section, and 13.0% exhibit them discontinuously along the entire edge.

The most common (63.2%) microflake scar configuration pattern on the "opposite" margin is considered to be random, followed by contiguous (15.8%), and contiguous-superposed (15.8%). The most frequently represented (32.2%) microflake scar formal type on this margin has an expanding outline and invasive termination (Table 8). Coincidentally, it is also the most common type on the concave margin, and constitutes about the same proportion on both margins. Other common types include expanding/shallow-stepped (13.3%), crescentic/invasive (8.5%), and oblique/invasive (7.5%). There are also several less frequent types that are more commonly represented on this margin than on the concave margin.

Striations are present on the "opposite" margin for 14.7% of the microwear sub-sample tools. In most instances they represent the "tail" portions of striations that extend across the ventral face from the concave margin edge aspect. They are described below in the discussion for the ventral face (Chapter 6.2.5).

Crushing is considered to be absent for 73.5% of the tools, its intensity is slight on 17.6%, and moderate on 8.8% When compared to the concave margin, it is slightly less common and not as pronounced. Of the items exhibiting crushing, it is most frequently (66.7%) represented on the medial-distal section of the margin, and 33.3% have it on the entire margin.

6.2.4 Proximal Margin

Microwear traces are present on the proximal margin of only 11.4% (n=4) of the prehistoric microwear sub-sample items. For three of these specimens, the wear is characterized by very slight edge rounding, such as might be expected by intentional dulling of an edge to render it more comfortable for hand-held use. The fourth specimen exhibits pronounced edge rounding/smoothing, polish, and striations typical of "hide-scraper" microwear (Brink 1978a; Hayden 1979b) (Figure 39), indicating that it had been recycled into a tool used for this purpose.

6.2.5 Ventral Face

Polish is indicated on the ventral face of the distal projection for all items in the prehistoric microwear sub-sample. Its intensity is dull on 14.3% of the specimens, moderately bright on 51.4%, and bright on 34.3%. It is located on the medial-distal section of the distal projection for 60.0% of the specimens, and 31.4% have it on the medial section only.

Rounding and smoothing intensity on protruding microtopographical features on the distal projection's ventral face is lacking for 37.1% of the sub-sample tools, it is slight on 34.3%, moderate on 11.4%, and pronounced on 17.1%. Of those that exhibit rounding/smoothing, it is most common (50.0%) on the medial section of the distal projection, and slightly less so (36.4%) on the medial-distal section. Two specimens (5.7% of the sub-sample) exhibit slight rounding and smoothing on the medial aspect of the proximal half of the tool's ventral face which is interpreted to be related to hafting prehension wear (see below).

Striation intensity on the distal projection's ventral face is slight on 40.0% of the sub-sample items, moderate on 8.6%, pronounced on 14.3%, and for 37.1% they are absent. For tools bearing striations, they are present on the medial-distal section of the projection on 59.1% of the specimens, and 31.8% have them on the medial section only. "Scratch-groove" striations are exclusive to 63.7% of specimens exhibiting striations in the microwear sub-sample. A combination of "scratch-groove" and "sleeked" striations are evident on 22.7% items, and 13.6% have "sleeked" (see Chapter 6.3).

By far the most common striation pattern type is "parallel unidirectional", constituting 81.8% of the items possessing striations in the microwear sub-sample. This pattern is typified by minute, parallel, linear scratches or furrows on the medial-distal or medial section of the ventral face of the distal projection that originate from the concave margin edge aspect. The majority of their "tails" are oriented toward the distal projection tip at a mean angle of about 64° in relation to the concave margin (Table 5; Figure 7).

The next most frequently (13.6%) represented striation orientation pattern type is referred to as "parallel multidirectional", whose sets of tails trend in more than two directions and crosscut each other (Figure 7). The "parallel bidirectional" pattern, indicated by two separate sets of parallel crosscutting striations, constitutes only 4.5% of the tools with striations.

6.2.6 Dorsal Face

Rounding and smoothing (and sometimes polish) intensity on the dorsal surface is slight on 22.9% of the prehistoric microwear sub-sample specimens, moderate on 20.0%, and it is absent for 54.3%. Of those exhibiting rounding/smoothing (45.7% of the specimens), 37.5% have it on both the proximal half of the dorsal surface and the medial aspect of the "opposite" margin's dorsal surface; another 37.5% have it on just the proximal half of the tool's dorsal surface; 12.5% possess it on the left-proximal aspect of the tool's dorsal surface; and the remaining 12.5% exhibit it just on the dorsal surface of the "opposite" margin's medial aspect (Appendix 6). The presence of rounding and smoothing in these locations is interpeted to be wear caused by manual and hafting prehension (see below).

6.3 Summary and Discussion

The results of the descriptive microwear analysis undertaken for the 35 randomly selected key-shaped formed unifaces comprising the "prehistoric microwear sub-sample" permit several important inferences to be advanced regarding prehistoric use-behaviour associated with this tool type.

The generalized pattern of microwear traces observed on the distal projection tip (Chapter 6.2.1) indicates that the most frequently used -- and therefore most functionally important -- elements are its ventral-lateral corners. They are formed by the junctures of the concave margin, distal margin, "opposite" margin, and ventral face (Figures 2, 8a, 21 and 22). Secondary functional importance is indicated for the distal margin of the projection tip (Figures 2 and 8b). The primary motor patterns (i.e., use-motions) associated with the distal projection are a generalized burin-like gouging, prying, graving, and incising action involving both ventral-lateral corners and the distal edge (Figures 2 and 8a). Working of a relatively hard contact material is indicated by moderate to pronounced intensities of edge rounding and smoothing, polish, and crushing; and moderately high mean microflake scar frequencies and large mean microflake scar size (Table 5).

Given that the distal tip ventral-lateral corners (Figures 2 and 8a) were important functional elements of key-shaped formed unifaces, I offer that at least in some cases, flexure and torsion breaks observed on the distal ends of several items in the prehistoric microwear sub-sample (Appendix 6), (and in the larger study sample), may have been intentionally initiated during tool production and/or maintenence to create or rejuvenate acute angles on the ventral-lateral corners. This may have been executed for specimens lacking only a small portion of the original distal projection tip (e.g., Figures 12e, 13b, 13h, 14b, 14j, 15s, 16z, 16a', 18q and 20z). However, for items lacking more than 1/3 of their initial projection (e.g., Figures 11c, 11f, 11j, 11k, 13e, 15m, 16b', 16h', 18g, 18h, 19c and 19h) it seems more probable that their breaks were accidentially incurred by excessive loads of applied force during use, particularly during graving and incising activities (see Chapter 8.4; Figures 48 and 50).

The moderate to high intensity and frequency of microwear traces evident along the concave margin edge aspect and immediately adjacent ventral face (Chapter 6.2.2; Appendix 6; Tables 5 and 7; Figure 8c) clearly indicates that this margin is the most functionally important feature of key-shaped formed unifaces. The nature of these trace patterns suggests that the primary use-behaviours associated with this edge involved scraping, shaving, or planing of relatively hard cylindrical contact materials (see Chapters 5.3 and 8 for supporting data and interpretations). The high frequency (82%) of "bending"-type initiations for microflakes removed from the concave margin suggests that either wood, antler, or bone were probably being worked (Cotterell and Kamminga 1987: 690-691).

The interpretation of the microwear traces on the concave margin supports the design analysis conjecture (Chapter 3.3) that the main motor pattern associated with this edge involved placing the distal 2/3 of the ventral face of the distal projection against a cylindrical contact material with the edge facing the user's body at a slightly oblique angle such that the tip of the projection was pointing away. The tool was then drawn toward the user in repeated strokes down the length of the contact material (e.g., Figures 43 and 44).

Many specimens in the study sample testify that their concave margins were subjected to repeated resharpenings (Chapter 3.3.2; Figure 5), a maintenance practice that resulted in removal of previously incurred microwear traces along the immediate margin edge and edge aspects. This may partly explain why the mean frequency of microflake scars on the concave margin edge aspect was slightly lower than on the "opposite" margin, and why about 28% of the microwear specimens lacked microflake scars on their concave margin edge aspects altogether.

The intensity of microwear traces exhibited on the "opposite" margin indicates that it was used less frequently than the concave margin, and it also displays much greater morphological and technological variability (Chapter 6.2.3; Appendix 6; Tables 5 and 8). For these reasons I have inferred that it had less functional importance than the concave margin. This is supported by the observation that clear evidence for resharpening of this margin is rarely indicated for specimens in the prehistoric study sample. Direct evidence for resharpening is considered to include: sharply differential microwear intensities (notably rounding, smoothing, and polishing) appearing discontinuously along functional edges and/or their edge aspects; functional edge margins that are markedly indented relative to adjacent non-functional margins; and functional edges that have fairly regular (i.e., consistent or non-sinuous) outlines.

The primary reconstructed motor pattern associated with the "opposite" margin is a generalized shaving/scraping/planing action similar to that described above for the concave margin. However, for this margin, the tool would have been pushed away from the user along the length of the contact material in a "flicking" or "whittling" action (e.g., Figures 45 and 47). Working of a relatively hard contact material is also indicated by the nature and intensity of microwear trace patterns.

The microwear trace patterns appearing on the ventral face of the distal projection on the majority of the prehistoric microwear sub-sample tools (Chapter 6.2.4; Figure 8e) indicate that the distal 2/3 of the projection's ventral face was often incidentally engaged with the contact material during use of the concave margin. The character and orientation of striations, and the location and intensity of polish both reinforce the conclusion that the concave margin was the primary functional edge of prehistoric key-shaped formed unifaces.

Most striations appearing on the ventral face are classified as the "scratch-groove" type (e.g., Figures 24, 25, 27 and 35). They are linear trough-like features with "U"- or "V"-shaped cross-sections that have been gouged directly into the surface of the tool by abrasive particles (e.g., silt, sand, dust, grit) introduced between the ventral face of the tool and the contact material while the tool surface was in the "solid-gel" state (Mansur 1982) (see Chapter 6.1.3). Autoabrasion is not suspected to have been a significant contributor to striation development on most tools, as very little or no material loss is indicated along concave or "opposite" margin edges.

"Sleeked" striations occur less commonly, and appear as flowing and undulating trend lines (Figures 24 and 30). It is probable that "sleeked" striations were initially the "scratch-groove" type incurred during the early stages of a tool's use-history. During subsequent use they became mechanically smoothed, rounded, and polished while silica on the tool surfaces was in the "liquid-gel" or "intermediate" state (Mansur 1982).

Because the most common striation pattern type is classed as "parallel unidirectional", and most striations are the "scratch-groove" type displaying consistent formal regularity for their entire lengths, I conclude that the contact material being worked must have had high abrasive particle "holding" or "fixing" properties. This refers to the ability of a contact material to stabilize (i.e, trap) and maintain abrasive particles in direct contact with a tool during use (see Lawn and Marshall 1979:79-81).

Knutsson (1988:92) indicates that the high holding/fixing properties of wood, which can easily stabilize abrasive particles within and between its fibres, results in production of continuous and morphologically regular striations. In contrast, antler and bone do not readily trap abrasive grains because of their greater hardness and density. Consequently, particles are transfixed only momentarily or roll around freely, producing striations that are more likely to be morphologically irregular and discontinuous. Following these criteria, striations observed on almost all the prehistoric microwear sub-sample specimens were likely produced by contact materials with holding/fixing properties more similar to wood than those characteristic of antler and bone.

Polishes on the ventral face suggest that the most common type can be provisionally classified as "abrasive", although the "additive" type may be represented on some specimens. In general, abrasive polish was inferred when the tool surface had a worn-down appearance in relation to adjacent unaltered surfaces and microtopographical features; additive polish was provisionally identified when it appeared to be built-up. Given the mechanical and chemical processes contributing to the formation of these two main polish categories are controversial and still not completely understood, and their differentiation requires electron microscopy (see Bettison 1985; Knutsson 1988), an attempt to identify and quantify them was not undertaken in the present study. Regardless, it is clear that the contact material most commonly worked by prehistoric key-shaped formed unifaces produced predominantly moderately bright to bright intensity polishes, such as that produced by working plant parts or antler (see Chapter 8).

It is evident that the proximal margin had absolutely no functional importance with respect to the primary use-behaviour of key-shaped formed unifaces. This is indicated by the very low incidence and slight intensity of observed microwear traces; its high degree of morphological and technological variability; and since many tools appear to have been hafted, it would have been unavailable for use. Nevertheless, broken or exhausted tools were occasionally recycled into "endscrapers" by modifying and using this edge (Figures 5 and 39).

For many specimens (46%) in the microwear sub-sample, discrete areas of rounding and smoothing (and occasionally associated slight polish) on the dorsal tool surface are interpreted to be prehension wear caused by the user's hands and/or a hafting device rubbing in these locations (see Chapters 6.1.6, 6.2.6 and 8.4). Wear appearing on the left-lateral aspect of the proximal half of the dorsal surface is attributed to the user's thumb having rubbed in this location for extended periods of time while the tool was being used hand-held (Figures 8h and 36). Abrasive wear appearing on prominent features over the medial section of the tool's dorsal face (and occasionally on the ventral face) was likely caused by side-to-side movement within a loose haft (Figures 8i and 8f). Wear appearing on the medial aspect of the "opposite" margin's dorsal surface is likely the result of the user's thumb or forefinger rubbing this location for tools used either hand-held or hafted (see Figures 8g, 37, 38, 43, 44, 46 and 48).

"Atypical", random, or low frequency microwear trace pattern types (e.g., unusually large microflake scars, extensive and intensive edge crushing, multidirectional striation configuration patterns) observed on some of the specimens in the prehistoric microwear sub-sample (Appendix 6; Tables 5, 7 and 8) may be attributable to either: (1) incidental forceful contact with hard objects while being curated in prehistoric times; (2) improvisational execution of unanticipated or infrequently recurring situational tasks; (3) post-depositional trampling; and/or (4) accidental damage incurred during contemporary artifact transport, storage, and analysis.

The general microwear patterns observed on the 35 microwear sub-sample specimens described in this chapter serve as a comparative basis for attempting to infer the primary function of prehistoric key-shaped formed unifaces through a judgemental "best-fit" comparison with microwear traces observed on the ten experimental tools used in this study (Chapters 7 and 8).

CHAPTER 7

EXPERIMENTAL TOOL REPLICATION AND USE

7.1 Introduction

Experimental, "actualistic", or "imitative" studies are considered to have potentially strong explicative potency with regard to understanding and determining prehistoric behaviour (see Ascher 1961; Ingersoll, Yellen and Macdonald 1977; Tringham 1978; Stafford and Stafford 1979,1983; Kamminga 1982, and many others). They also contribute significantly to the development of "middle range theory" (Binford 1981,1982).

A component of the present study involved replication and experimental use of ten key-shaped formed unifaces in order to secure data concerning their functional efficiency and resulting microwear trace patterns. The information generated by these experiments was then compared with results obtained by the residue and microwear analyses of the prehistoric specimens (Chapters 5.3 and 6), and with tool-use data provided by other researchers. It was reasoned that once all these data were collectively considered, the primary function of prehistoric key-shaped formed unifaces on the Plateau could be inferred through a "best fit" of the comparative results.

7.2 Experimental Design

The experiments were guided by several basic empirical observations and assumptions provided by the design theory and prehistoric specimen microwear analyses (Chapters 3.3 and 6.3). First, it was assumed that the primary functional edge of these tools is the concave margin, suggested by its consistently recurrent form, and moderate to pronounced intensity of associated microwear patterns Eassociated with it (Chapter 6.2.3).

Second, the design theory analysis suggested that the main contact material(s) must have been cylindrical (i.e., tubular) in shape, with diameters ranging between about 5 mm and 30 mm, and an estimated mean diameter of approximately 12 mm.

Third, it was surmised that the primary function of these tools involved working of relatively hard contact materials. This is evidenced by the obvious selective preference for hard and durable cryptocrystalline silicates, and the general characteristics and intensity (i.e., moderate to pronounced) of most microwear trace patterns (Chapters 3.3.3 and 6.2; Appendix 6).

Fourth, it was assumed that the primary function of these tools involved two basic motor patterns (i.e., use-motions or "kinematics" [Semenov 1964]) as suggested by the design theory and microwear analyses. These include:

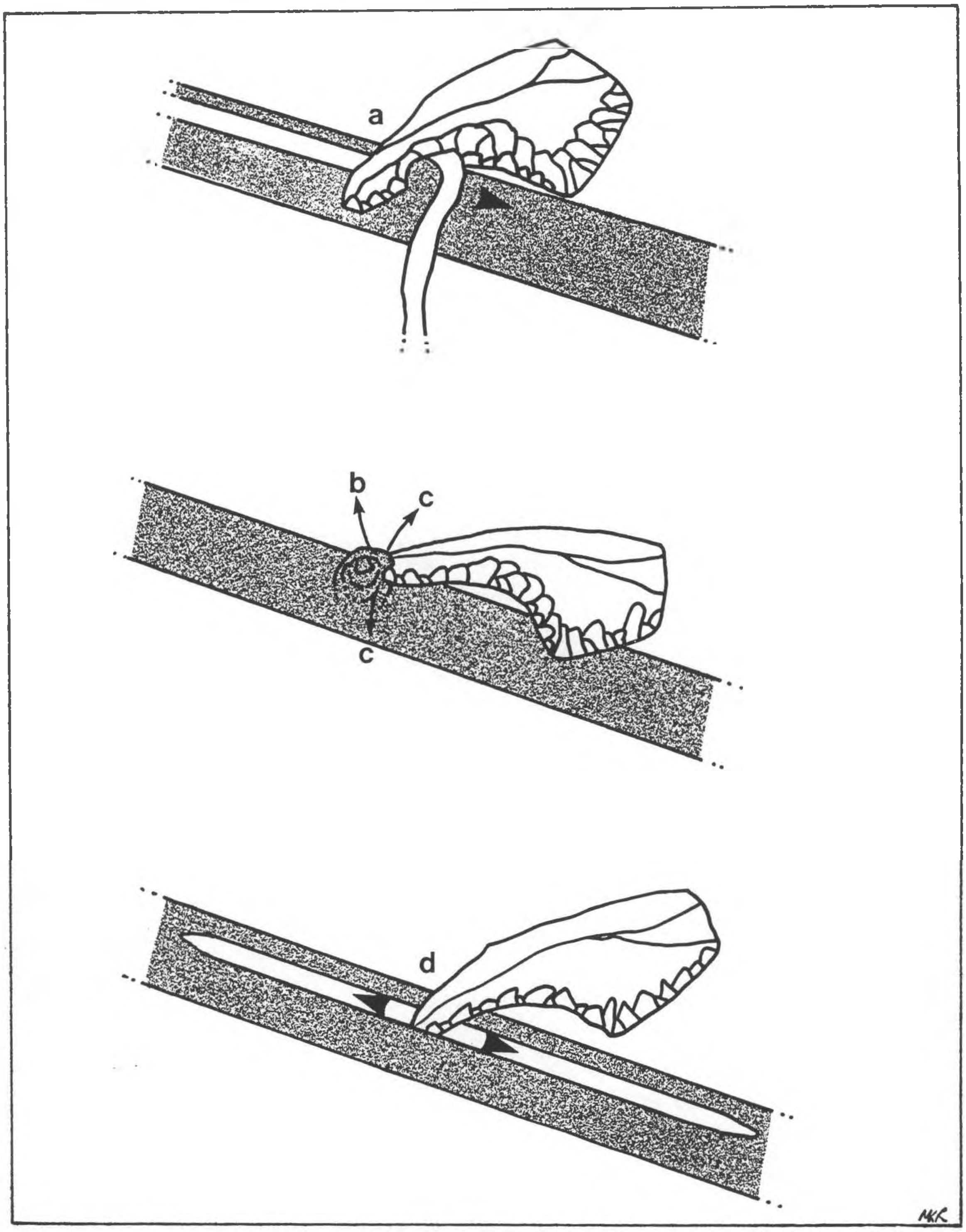

Figure 9. Specific task actions mentioned in this study.

(a): Scraping/shaving/planing using the concave margin (shown) and "opposite" margins. Executed to remove bark (shown) and scrape down wood and antler.

(b): Gouging and prying off secondary branch nodes using the distal projection tip.

(c): Lateral side-to-side "sawing" action using the distal projection tip to assist in removing secondary branch nodes.

(d): Graving/incising using the distal projection tip to create grooves in wood (shown) or antler.

(1) shaving/scraping/planing involving primarily the concave margin, and occasional secondary use of the "opposite" margin; and (2) gouging, prying, graving, and incising using the ventral-lateral corners and distal edge of the distal projection tip (Figures 2 and 9).

Fifth, it was presupposed that these items were engaged in working materials that were prehistorically important and available throughout the Interior Plateau and some of its immediately adjacent regions.

Lastly, it was also conjectured that the main reason for working these materials was to produce artifacts that were made with reasonable regularity, and were used by the prehistoric inhabitants of the Plateau for a period spanning at least 2500 years (Chapter 4.2).

Following these assumptions, and given the known range of natural raw materials used by Interior Plateau groups based on the ethnographic and archaeological records, it was deduced that the primary function of prehistoric key-shaped formed unifaces most probably involved working of either: (1) the stalks, branches, and possibly roots, of woody shrubs or small trees; (2) antler beams or tines; or (3) mammal longbone shafts. Consequently, materials from all three categories were secured and worked in the experimental component of this study.

Chalcedonies and cherts were selected to make most of the experimental tools because they have physical properties identical to, or very similar to, those possessed by the majority (88.4%) of lithic materials represented in the prehistoric study sample (Chapter 3.3.3; Appendix 3).

It was reasoned that by holding lithic material types relatively constant between the prehistoric and experimental tool samples, any variation in microwear traces observed between the two samples would not be due to significant differences in physical properties of the lithic materials. Rather, any displayed variability would be primarily attributable to how a tool was used, and on the nature of the contact material(s) worked. This is an important logical consideration of the research design. It allowed the primary function of these tools to be analogically inferred by comparing microwear traces produced on the experimental tools with those borne on the prehistoric study sample specimens without major concern for factors relating to significant differences in lithic material properties.

Cache Creek basalt was used in the experiments to attempt to gain some insights into why this more commonly available lithic material was very rarely selected by the prehistoric inhabitants of the Canadian Plateau for making key-shaped formed unifaces. As postulated in Chapter 3.3.3, this was probably because basalt is softer, less durable, and more brittle than most cherts and chalcedonies, therefore it was not as well suited for executing the primary functional activity associated with this tool type. Use of Cache Creek basalt in the experiments provided an opportunity to evaluate this hypothesis.

The experiments also used several different types of lithic raw materials on the same contact material type (Chapter 7.4; Appendix 9). Stalks and branches of saskatoon were used as the contact material "constant". By holding the contact material constant, it was reasoned that any variability in microwear pattern attributes would be more or less directly attributable to the inherent properties of the lithic raw materials, and perhaps, to the manner the tools were being used. This would provide a better understanding of the physical characteristics, functional efficiency, and relative use-lives associated with each lithic raw material type (Chapter 7.7; Appendices 7 and 9).

Another objective of the experimental design was to explore the effectiveness of traditional hafting methods, and to comparatively assess the functional and mechanical efficiency associated with using hafted and unhafted tools. Tools were used both hand-held and hafted during the experiments (Chapters 7.3, 7.6 and 7.7; Appendix 9; Figures 10 and 42 to 51).

7.3 Experimental Tool Replication

Six types of lithic raw materials from sources on both the Canadian and Columbia Plateaux (Appendix 7) were used to manufacture the ten key-shaped formed unifaces used in the experiments (Figure 41).

Lithic material "Type 1" is an opaque, wide-banded duochrome (tan and red-brown), cryptocrystalline chert obtained from northern Oregon (Smith, pers. comm. 1988), used to make experimental tools (E.T.'s) #1 and #2. Lithic Type 2 is a semi-translucent, medium grey-brown, cryptocrystalline chalcedony from somewhere in southern Washington (Smith, pers. comm. 1988). It was used to produce E.T.'s #3 and #4. Unfortunately, the exact source locations for Types 1 and 2 are not known.

Type 3 (E.T. #5) is an opaque, light brown, micro-banded chert from near the town of Falkland in the Canadian Okanagan Valley (Gay, pers. comm. 1988). Type 4 (E.T. #6) is a highly translucent, light white-grey, cryptocrystalline chalcedony found near the community of Pavilion, B.C. in the Mid-Fraser River region. Type 5 (E.T.'s #7 and #8) is a semi-translucent, light yellowish-grey, cryptocrystalline chalcedony from the Upper Hat Creek Valley in B.C.. Type 6 consists of two grades of microcrystalline basalt; fine-grained (E.T. #9), and vitreous (E.T. #10). Both basalts were obtained near the town of Cache Creek, B.C.. Additional details on these lithic materials are presented in Appendix 7.

Traditional and conventional flintknapping tools and techniques were used to manufacture the experimental tools. Direct freehand percussion was employed with a dense hammerstone to strike suitable flake blanks from large multidirectional cores. Ideal flakes were considered to be about 5 to 7 cm long, 3 to 4 cm wide, and .5 to .7 cm thick, and had ventral surfaces that were relatively smooth and flat or slightly concave.

An indenter (pressure flaker) consisting of a wooden dowel haft tipped with 5 mm diameter copper wire was used to form the typical key-shaped outline. This indenter was preferred over a traditional antler tine pressure flaker because it produced sharper, more effective, and more regularized functional edges, and it also reduced the likelihood of breaking the tools during manufacture.

The overall formal characteristics of the ten experimental tools (Figure 41) lie within the range of morphological variation exhibited by the prehistoric study sample specimens (Chapter 2.2; Appendix 3; Table 1; Figures 11 to 20). Consequently, it was reasoned that all were capable of performing activities related to the primary function of prehistoric key-shaped formed unifaces.

Four of the replicated experimental tools had pronounced bulbs of percussion and/or large initiation facets (striking platforms). These were removed using either direct freehand hard hammer percussion or pressure flaking. This permitted the tool butts to be more easily fitted into haft slots (see below and Figure 10). Similar basal thinning was noted on the prehistoric specimens, and presumably it was executed for the same reason. Removal of sharp edges and ridges associated with the flake blank initiation facet also rendered the tool more comfortable for manual (i.e., hand-held) use.

Nine experimental tools were hafted into wooden handles made from sections of green saskatoon stalks measuring about 10 to 15 cm long and 2 to 3 cm in diameter (Figures 10 and 42). The proximal end of each tool was snugly inserted into a slot cut into one end of the haft, bound tightly with raw buckskin or common household cotton string, and cemented firmly into place by dripping melted ponderosa pine *(Pinus ponderosa)* pitch over the binding (Figure 10). Pitch was commonly used as a glue and mastic by ethnographic inhabitants of the Plateau (Teit 1900:241; Ray 1933:61,89).

E.T.'s #1, #4, and #6 to #10 were hafted prior to being used. E.T.'s #2, #3 and #10 were initially used hand-held (i.e., unhafted), but they were all eventually hafted at some point early in their use-histories (see Chapter 7.6 and Appendix 9). Only one tool (E.T. #5) was used unhafted for its entire use-history.

After being manufactured, the experimental tools were placed in plastic bags to protect their edges from incidental traumatic contact with hard objects during storage and transport. This ensured that accidental damage would not be incurred to margin edges that might later be construed as being a result of use.

Prior to using the experimental tools, their distal projection tips, concave and "opposite" margins, and ventral faces were photographed at 6.4 X magnification using a Wild M3 stereoscopic light microscope's built-in camera. These photomicrographs were later compared to similar photos taken of the same features after tool-use to help identify and describe the nature and intensity of microwear trace patterns incurred (Chapter 8; Figures 54 to 65).

7.4 Experimental Contact Materials

Three types of contact materials were worked. They included the main stalks and primary branches of three types of fresh "green" woody plants, two dense mule deer antler beams, and a metacarpal from a mule deer foreleg.

It was surmised that if the primary function of prehistorically-used key-shaped formed unifaces involved working of woody plant parts, the most probable candidates would have been the main stalk (trunk) of small saplings, the primary branches of woody shrubs or trees, and perhaps tree roots. This was inferred by the fact that their diameters often range between about 5 and 30 mm, and they are relatively hard and rigid. It was also assumed that in prehistoric times, bark and wood would have been most often worked when fresh or "green", as other experimental studies have indicated that they are significantly more difficult to work when seasoned (dry) (see Keeley 1980:36; Vaughan 1985:34; Richards 1987:156).

Three types of woody plants were selected for the experiments: saskatoon *(Amelancheir alniffolia)*; Rocky Mountain juniper *(Juniperus scopulorum)*; and

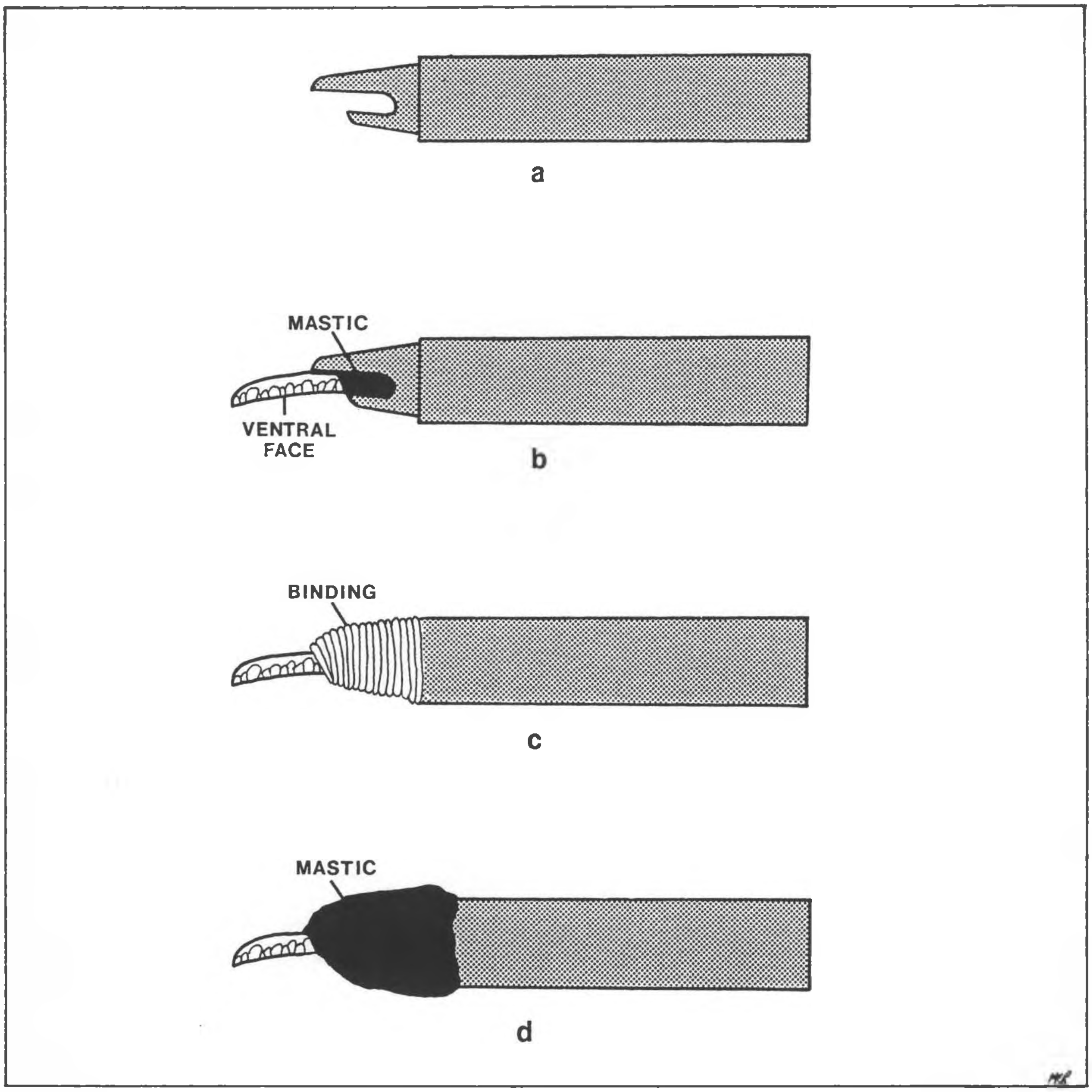

Figure 10. Hafting strategy used for nine of the ten experimental tools used in this study (side view).

(a): Handle about 2-3 cm diameter made from green saskatoon wood with one end slotted and modified;

(b): Key-shaped formed uniface was inserted and secured with ponderosa pine pitch;

(c): Binding, consisting of either leather strips or cotton cord, was wrapped tightly around the handle/tool juncture; and

(d): Mastic was applied, moulded in place by hand, and allowed to harden.

willow *(Salix* sp.). All were commonly used by inhabitants of the Plateau during the enthographic period, and are relatively abundant and ubiquitous in the Pacific Northwest today (Turner 1979:72,230,258).

Saskatoon or "service berry" wood was very important for making arrows, and for manufacturing digging stick shafts, spear and harpoon shafts, implement handles, fire drills, basket frames, and canoe frames (Teit 1900:205, 231,235,241; 1909:514,519; Turner 1979:27, 230-232).

Rocky Mountain juniper wood was used primarily to make bows, and occasionally snowshoe frames and spears. Juniper bark was used to make baskets (Teit 1900:239; 1909:519; Turner 1979:71-73).

Willow stalks and branches were employed to make fish traps and weirs, net hoops, firedrills, and tinder. Stripped and/or shredded willow bark was often used for clothing, nets, bags, basketry, cordage, diapers, wound dressings, and sanitary napkins (Teit 1909:527; Ray 1933: 62-63,67-68; Turner 1979:260-261). Detailed descriptions and additional information for the three woody plant types used in the experiments are presented in Appendix 8.

Six experimental tools (E.T.'s #1, #3, #5, #6, #8, and #10) were used on fresh green saskatoon stalks and branches; E.T. #2 was used on green juniper branches; and E.T. #4 was engaged to work green willow stalks and branches (Appendix 9). In addition, E.T. #3 was resharpened after being used on green saskatoon, and subsequently employed to briefly work seasoned saskatoon.

Green saskatoon was used most frequently in the experimental component of this study because: (1) it is readily available in most all areas of the Plateau today, and there is no reason to suspect that it would have been any less abundant or ubiquitous during the late prehistoric period; (2) ethnographic accounts indicate that it was used to manufacture several important and commonly-used artifacts and implements having moderate to high production and/or replacement rates (e.g., projectile shafts, handles, basketry); (3) its bark cannot be easily peeled off by hand, and debarking is most effectively accomplished with a sharp-edged stone tool (see Chapter 7.6.1 and Appendix 9); and (4) it was reasoned that by using several experimental key-shaped formed unifaces made of different lithic raw material types on this contact material, observed variation in resulting microwear would be primarily attributable to differences in the physical characteristics of the lithic raw materials, and to variation in motor patterns employed by individual experimenters.

Prior to working main stalks and larger primary branches of the green woody plants, their small secondary branches having diameters less than about .75 cm were usually removed manually. This involved pulling them forcefully toward the butt of the primary stalk/branch, thereby tearing them away at their "node" (i.e., juncture with the main stalk/branch). On a few occasions, these secondary branches were cut off with a steel knife so that a .5 to 1 cm-long "stub" was left attached on the nodes. These stubs and nodes were subsequently removed with the experimental tools (see below).

Seasoned (dry) saskatoon was also worked briefly to resolve whether it truly is more difficult to work than green saskatoon, and to determine if the microwear traces incurred would differ significantly from those developed on tools used to work the green woody plants.

A dense, relatively fresh, main beam of a mule deer *(Odocoileus hemionus)* antler was soaked in water for one month, as Teit (1909:474-475) indicates that the ethnographic Shuswap commonly immersed antler and bone in water for several days to soften them before being worked. A second dense mule deer antler beam was boiled in water for eight hours to see whether this rendered it any easier to work than the soaked antler.

The metacarpal longbone from the lower right foreleg of a mature mule deer killed in the fall of 1987 was defleshed, and also soaked in water for one month. The foreleg had been previously frozen, but it is unlikely that this would have had any significant effect on the outcome of the experiments. Both deer bone and antler were employed by prehistoric inhabitants of the Plateau to make a wide variety of implements. E.T. #7 was used to work both the bone shaft and two antler beams, whereas E.T. #9 was employed on the soaked antler beam only.

7.5 Experimental Conditions and Data Recording

Experiments were undertaken in both natural and laboratory contexts. Those involving green woody plants were conducted in outdoor settings at three locations: (1) the Keatley Creek archaeological site located ca. 7 km south of the community of Pavilion, B.C. in the Mid-Fraser River region; (2) the B.C. Ministry of Forestry campground at Three Sisters Creek ca. 20 km southwest of Ashcroft, B.C.; and (3) in a rural backyard setting beside the Fraser River in Delta, B.C..

There was a considerable quantity of sand, silt, dust, and grit present in the local working environment at Keatley Creek, where constant and intense pedestrian traffic within a camp kitchen area had significantly denuded local grassy vegetation. Airborne abrasive particles were commonly observed on gusty days, and these sometimes adhered to freshly exposed damp bark and wood. Sand and silt also occasionally clung to damp bark and wood when a stalk/branch was rested on unvegetated working areas between use-episodes. Very few abrasive particles were present in the immediate working environments at Three Sisters Creek campground and the residential backyard on River Road due to dense grassy vegetation cover.

Experimental tool-use on woody plants was conducted by the author and four volunteers. They included John Breffitt, Gyles Iannone, Peter Merchant, and Bob Muir. All experimenters used the tools with their right hands, and stalks and branches were held in their left hands (e.g., Figures 43, 44, and 47 to 49). Experimenters sat on the ground and/or on rocks and logs in all three use contexts to imitate prehistoric working conditions.

Experiments involving the mule deer metacarpal and antler beams were conducted by the author at Simon Fraser University in the Department of Archaeology's flintknapping pit. These contact materials were rested on a large anvil boulder located in the center of the flaking pit (Figures 50 and 51). The surface of this boulder contained a moderate amount of sand, silt, and dust which occasionally adhered to the wet bone and antler when they were rested upon it.

During the experiments, all information considered to be important or pertinent to the research problem was recorded on a prepared form. Each experimenter was responsible for documenting the following information for each tool: (1) the total number of working strokes used; (2) the average working stroke length in centimeters; (3) the approximate total use-time elapsed; (4) the approximate length and average diameter of stalks/branches processed; and (5) noting when and where significant microwear trace types could be observed with the unaided eye on tool edges or surfaces during use.

Subjective assessments concerning the suitability and relative functional efficiency of specific parts of the tools for performing certain tasks were advanced, as were details about the specific motor patterns employed. Results of these observations are summarized in Chapter 7.6 and Appendix 9.

At various experimental stages, photographs were taken using both black-and-white and colour slide film. When stored or being transported, the experimental tools were placed in plastic bags to protect their edges from coming into incidental forceful traumatic contact with hard objects. This ensured that *all* microwear traces incurred on the working edges of the experimental tools could be attributed entirely to factors related to their use-episodes or manufacture.

Following the experiments, all tools were removed from their hafts, and gently cleaned with acetone and a very dilute solution of "Pine Sol" cleanser to remove ponderosa pine pitch hafting mastic, and residues contributed by the contact materials. The main functional edges and ventral faces were re-photographed at 6.4 X and 18 X magnifications (Figures 54 to 65) using the built-in camera on a Wild M3 light microscope. The resulting photographs were compared to those taken prior to the experiments to determine the nature and extent of the microwear traces incurred.

7.6 Experimental Methods and Observations

Eight of the ten experimental tools were engaged in working stalks and branches of fresh green woody plants with diameters ranging between ca. .3 and 2.5 cm. Experimental tools (E.T.) #1, #3, #5, #6, #8 and #10 were used on green saskatoon; E.T. #2 was used on green juniper; and E.T. #4 was used on green willow. After being used on green saskatoon, E.T. #3's concave margin was retouched and subsequently used to briefly work seasoned saskatoon. One tool, (E.T. #7) was used to work soaked and boiled antler beams, and E.T. #10 was used to scrape and shave the soaked antler beam only. Details regarding experimental use-histories of these tools are presented below and summarized in Appendix 9.

Six tools (E.T.'s #1, #5 to #7, #9 and #10), were used until the experimenters felt that their concave margins required resharpening in order to restore their initial and/or optimal functional efficiency. However, the use-life potentials of the concave margins for the remaining four tools (E.T.'s #2 to #4 and #8) were not fully realized. Nevertheless, they were all used for many thousands of strokes over considerable periods of time, and plainly indicated very extensive use-life potential.

7.6.1 Bark Stripping and Woodworking

Hafting Efficiency

During woodworking experiments, one tool (E.T. #5) was used unhafted throughout its entire use-history. Another three tools (E.T.'s #2, #3 and #10) were also intitially used unhafted. This was done purposefully to assess the relative functional efficiency of unhafted tools for performing the tasks undertaken.

All five experimenters agreed that unhafted tools functioned reasonably well for bark stripping and woodworking activities. However, after about 3000 to 4000 strokes of continued use applying moderate to heavy pressure, several experimenters noted that their hands became cramped, and occasionally small cuts and abrasions developed on the right thumb and index finger where they contacted sharp edges and flake ridges. It was also noted that it was difficult to fully realize and assess the maximum functional efficiency of the "opposite" margin when using a hand-held tool because the heavy pressure needed to attain it could not be applied comfortably for very long.

Prior to being used, several tools (E.T.'s #1, #4, #6, #8 and #10) were hafted into short thick sections of saskatoon stalks measuring ca. 10 to 15 cm long by ca. 2 to 3 cm in diameter. All five experimenters unanimously agreed that hafted tools were functionally superior to hand-held ones because they: (1) afforded greater levels of mechanical and functional efficiency; (2) improved manipulation and significantly enhanced the ability to comfortably apply heavy pressure; (3) markedly reduced and/or eliminated the incidence of hand muscle cramping during extended periods of use; and (4) did not invoke any trauma to the thumb and forefinger because the incidence of manual contact with sharp edges and ridges was greatly reduced.

The hafting strategy employed during the experiments lent an important and unpredicted element of mechanical efficiency to the design and use of the tool. The juncture of the binding/mastic and the ventral face of the tool (Figure 10) functioned as a very effective "guide", allowing the tool to be accurately and rapidly drawn along the stalks/branches (see Figures 43 and 47). Because of the overwhelming functional advantages afforded by hafting, four of the initially unhafted tools (E.T.'s #2, #3, #6 and #10) were secured in saskatoon hafts at some early point in their use-histories (Appendix 9).

Generally, the ponderosa pine pitch mastic functioned very well for keeping the tools secure in their hafts, but it was noted to be somewhat sensitive to ambient temperatures. When left directly in the sun it became soft and tacky, and when the tool was used in this condition it sometimes loosened a bit in the haft, and pitch often stuck to the fingers. Between 10° and 30° C in the shade, the pitch mastic was fairly hard and held the tool firmly in place even under heavy pressure loads. Below about 10° C the mastic became quite brittle and prone to cracking. Only two experimental tools required haft repairs because of mastic cracking, and both cases occurred on fairly cool evenings. They were simply and quickly restored by retightening the binding and reapplying melted pitch.

Contact Material Positioning

During the experiments, stalks and branches of the woody plants were held in several ways. In most instances they were oriented more or less perpendicularly to the transverse plane of the body (i.e., pointing away), at a horizontal or slightly inclined position (Figures 43 to 49). Usually, one end of the stalk/branch was steadied by bracing it against the body with the left arm. The left hand was most always placed above (i.e., distally) the section of the stalk/branch being worked when using the concave margin, but when engaging the "opposite" margin or distal tip the hand grasped below the section being worked.

Occasionally the proximal end or "butt" of a stalk/branch was placed perpendicularly on the ground surface and braced with the soles of both feet. Removal of bark and wood was then assumed using the concave margin in downward vertical strokes. Rarely, the distal end of a long (greater than 1.5 m) stalk or branch was steadied by placing it between the soles of both feet, or between the big toe and second toe of either foot while in a sitting position on the ground.

Distal Projection Motor Patterns and Efficiency

The distal projection was employed for two main tasks during woodworking. The foremost of these was removal of bark and wood comprising the secondary branch nodes in order to regularize and smooth the objective primary stalks and branches. For this task, the dominant motor pattern involved grasping the haft, placing the index finger on the dorsal surface of the distal projection, and using the distal edge and ventral-lateral corners of the distal projection tip with moderate to heavy levels of applied pressure to repeatedly gouge, pry, scrape, and shave the bark and wood away from the nodes (Figure 9a and 9b). Sometimes, the distal edge of the projection was used in a lateral side-to-side "sawing" motion to help remove the central woody portions of the nodes (Figure 9c). The distal projection tip was considered to be quite effective for removing secondary branch nodes using these techniques.

A second important and highly effective capability of the distal projection tip was incising and engraving linear grooves into stalks and branches. This entailed grasping the tool in the same manner described above, placing the distal edge or a ventral-lateral corner of the projection tip against the wood so that the ventral face of the tool inclined proximally between about 30° and 60°, and then using very heavy pressure to engrave/incise linear scores or grooves using a repeated "back-and-forth" motion (Figure 48).

The width of the incisions and grooves depended on which parts of the distal tip were used. The ventral-lateral corners of the distal projection were used to initiate narrow incisions, and for starting larger grooves. Once an incision was sufficiently widened with the ventral-lateral corners, the distal edge of the tip could be inserted to widen it further and create substantial grooves. Groove/incision depths depended on how long a tool was used, and the amount of force being applied.

Concave Margin Motor Patterns and Efficiency

For all experimental tools engaged in woodworking, the concave margin edge was the most commonly used and most functionally effective feature. The primary motor pattern associated with the concave margin for hafted tools involved: (1) grasping the haft and placing either the index finger or thumb on the medial aspect of the "opposite" margin's dorsal face; (2) placing the ventral face of the distal projection against the stalk/branch with the concave margin facing the user's body, and the projection tip pointed away at a slightly oblique angle; and (3) drawing the tool toward the body using moderate to heavy pressure in repeated strokes varying between 5 and 20 cm long (Figures 43, 44 and 46). The heavy force loads required to remove thick bark and secondary branch nodes, and to significantly modify (i.e., "carve") wood were easily and comfortably applied using the hafted tools in this manner.

When working branches with diameters less than about .5 cm, the thumb of the right hand was sometimes used to brace and support them against the ventral face of the tool. This was found to be particularly useful for working small willow branches, which are typically quite pliable.

When used unhafted, the concave margins of the experimental tools were used in generally the same manner as for hafted tools. The proximal portion of unhafted tools was gripped between the thumb and third finger of the hand of preference, and the index finger was placed on the medial aspect of the "opposite" margin's dorsal surface. Moderate to heavy force loads were then applied to remove bark and/or work wood. Heavy force loads were usually required to remove secondary branch nodes or thick bark and to work wood. For these situations, force loading and mechanical efficiency were slightly enhanced by holding the proximal portion of the tool between the thumb and third finger of the hand of preference and placing the thumb of the other hand on the dorsal surface of the "opposite" margin (Figure 46).

The experiments demonstrated that the concave margins of the tools functioned effectively for swift mechanical removal of bark from all three types of green wood in long (5-20 cm), narrow (ca. 3 mm), fibrous strips (Figure 52). However, it was noted that juniper and willow bark could be more easily and quickly removed by simply peeling off large strips and sections by hand. Conversely, saskatoon bark could not be manually peeled from its wood very well at all, rather, it came off in small patchy pieces, and took considerable time to remove in this manner. Heating and scorching green saskatoon branches for several minutes in a bed of campfire coals significantly improved the ability to remove the bark manually. However, once the branch cooled the bark again became difficult to peel off. Removal of saskatoon bark by scorching required several reheatings of the branch, and the resulting soot made it a rather messy task. Removal of green saskatoon bark using the concave and "opposite" margins of the experimental tools was just as effective, much cleaner, and required slightly less time.

The concave margin was also considered to be very effective for shaving, scraping, and planing down the "green" woody portions of stalks and branches of all three types of tree plants used in the experiments. It worked well for regularizing and smoothing primary stalks and branches, such as are required to make atlatls and bows, and shafts for spears, atlatl darts, arrows, etc. It also functioned moderately well for removing woody portions associated with secondary branch nodes using short scraping and planing strokes (although the distal projection tip was more efficient for this purpose), and for significantly altering (carving) green wood.

During use on green woody plants, the concave margin often clogged up with accumulations of plant resins and small bark and wood fibres. These "wads" of matted sticky fibres commonly invoked temporary loss of tool efficiency by coming between the concave margin edge and the bark/wood being worked. The wads were easily removed with a downward flick of the thumb, thereby restoring edge efficiency. It was usual to have to flick them off about every 5 to 10 strokes when working saskatoon, and about every 15 to 20 strokes for juniper and willow.

After being used on green saskatoon, the concave margin of E.T. #3 was resharpened and briefly used on seasoned saskatoon for about 1000 strokes (Appendix 9). This was done to assess how much more difficult dried saskatoon was to work than when it was green, and to determine whether microwear traces resulting from working these two materials would differ in any significant manner. A great deal of effort and pressure was required to remove the bark, and it was extremely difficult to modify the wood in any manner. It was also noted that the tool edge dulled quite rapidly (after 1000 strokes), and at least two large microflakes were removed from the ventral edge aspect. As predicted, seasoned saskatoon is definitely far more difficult to work than green saskatoon, and this is probably true for most all other woody plant types.

"Opposite" Margin Motor Patterns and Efficiency

The "opposite" margins of the experimental tools were used much less frequently than the concave margins during woodworking activities. It was most often used to strip bark and/or to shave and plane down wood at the ends of stalks or branches. The primary use-pattern for hafted tools entailed: (1) grasping the haft and placing the thumb on the medial aspect of the concave margin's dorsal surface; (2) placing the ventral face of the tool against the stalk/branch so that the "opposite" margin edge was perpendicular or slightly oblique to the long axis of the stalk/branch; and (3) pushing the tool away from the body using moderate to heavy pressure to strip bark and/or to shave, scrape, and plane down green wood in repeated "whittling" strokes varying between about 5 and 15 cm in length (see Figure 47).

The experimenters noted that while working green wood with the "opposite" margin in this "whittling" fashion it functioned rather effectively, but often there was a tendency for the tool to "chatter" one to three times during an average stroke. This produced transverse or slighly oblique linear gouges or "chattermarks" that snagged the working edge and intensified the chattering effect. This was particularly common problem when working stalks/branches greater than 1 cm in diameter. Chattering commonly interupted attempts to maintain a steady cadence to the working strokes, and was thus viewed to be both a nuisance and functional liability.

The "opposite" margin also functioned reasonably well for removing bark and woody portions associated with secondary branch nodes. This technique involved placing both thumbs on the dorsal aspect of the concave margin to exert the heavy force loads required to shave, gouge, and/or "pry" them off using very short strokes between about .5 and 1 cm long (Figure 45).

In general, the "opposite" margin was a bit more mechanically awkward to use than the concave margin for bark stripping and woodworking, and the associated working strokes tended to be shorter and were more prone to being disrupted by chattering. It was primarily for these reasons that the concave margin was preferred over the "opposite" margin for executing most bark and woodworking tasks.

Again, matted wads of sticky plant resins and bark and wood fibres sometimes adhered to the dorsal and ventral surfaces of the "opposite" margin, clogging its working edge. As with the concave margin, these wads were quite easily flicked off using the index finger, thereby restoring edge efficiency.

Lithic Raw Material Efficiency

The experiments indicated that tool efficiency and longevity varied between lithic raw material types used to make the experimental tools employed in bark removal and woodworking. This assessment is based on a collective consideration of the total number of working strokes, time elapsed, and relative degree and intensity of wear incurred by each of the different lithic materials employed (Appendices 7 and 9; Tables 6, 9 and 10).

The experimental data suggest that the most durable lithic material is Type 2 chalcedony from southern Washington, which was used to work green juniper and saskatoon. It demonstrated a long use-life and a high resistance to edge dulling. Its high level of efficiency and longevity are attributed directly to its hardness and toughness, as it has a Moh hardness value of about 8.0 (Appendix 7). High density and resiliency were also noted when it was being flaked.

The next most durable lithic materials are Type 1 chert from northern Oregon, and Type 5 chalcedony from Upper Hat Creek (Appendix 7). They too indicate relatively long use-life potential which can be directly attributed to their hardness (Moh value = 8.0), high density, and superior toughness and resiliency.

Type 3 chert was considered to be a very poor lithic material for working bark and wood. It indicated a rapid rate of acute edge deterioration and dulling manifest by intensive and extensive microflake removal and crushing. These were particularly accelerated when attempting to remove bark and wood associated with secondary branch nodes. The poor functional efficiency associated with this lithic type was not surprising, since its Moh hardness value is only 6.5, and it was noted to be quite brittle when being flaked.

The relatively short use-life (ca. 5250 strokes) of the concave margin of E.T. #6, made of Type 4 chalcedony, was surprising. Since it has a Moh hardness value of about 7.5, it was expected to have a use-life nearly as comparable as tools made of Type 1 chert, and Type 2 and Type 5 chalcedonies with Moh hardness values of 8.0. I postulate that the relatively rapid dulling rate of the concave margin on E.T. #6 may be partly due to idiosyncratic experimenter motor patterns, as the tool was used fairly aggressively (i.e., quickly and with very heavy pressure), and the ventral face of the tool was often held at a relatively steep angle (i.e., greater than 45°) relative to the wood (see Appendix 9). Edge dulling may have particularly accelerated when secondary branch nodes were being removed in this manner.

Alternately, it may be that translucent chalcedonies (such as Type 4 chalcedony) are less durable than are other types of chromatic chalcedonies, and some cherts. Translucent chalcedonies consist primarily of pure colloidal silica or "silica gel" and occasionally include some crystalline silica, and very few mineral or organic (fossiliferous) impurities. Although they too are comprised mostly of colloidal and crystalline silica, chromatic chalcedonies and all cherts also contain varying amounts of other minerals and/or organic impurities that impart their colour and opaqueness. It may be that chromatic chalcedonies and some cherts are more durable than translucent chalcedonies because their included minerals and other impurities serve to strengthen inter-molecular and/or inter-granular bonds. Regrettably, the scope of the present study does not allow this possibility to be examined.

E.T. #10 is made of Type 6 vitreous basalt, and in the initial part of its use-history, the concave margin of the tool functioned quite well for bark stripping and woodworking. However, continuous pronounced microflake removal, rounding, and crushing along the concave margin edge rendered it dull after about 6000 strokes (Appendix 9). This was not surprising, since this material has a Moh hardness value of only 6.5, and it was noted to be quite brittle when it was flaked -- a suspected result of its microcrystalline groundmass.

7.6.2 Results of Working Deer Antler

Experimental tools #7 and #9 were used to work two dense antler beams. One beam was from a mature mule deer, and measured approximately 25 cm long by 3 cm in diameter. It was soaked in water for one month prior to being worked. The second beam was from a two-year old mule deer and measured about 15 cm long by 2 cm in diameter. It was boiled in water for eight hours before being worked (Appendix 9).

E.T. #7 was made from Type 5 chalcedony, and was used to scrape and shave the soaked antler beam. Most of the experimental and microwear data mentioned for antler in this section, and in Chapter 8, are related to working the soaked beam with this tool. After being used on the soaked antler, the concave margin of E.T. #7 was resharpened and used very briefly on the boiled beam simply to determine whether boiling increased the workability of antler in any manner. E.T. #9 (Type 6 fine-grained basalt) was used only on the soaked beam (Appendices 7 and 9).

Hafting Efficiency

Both tools engaged in working antler were hafted prior to use. As was observed during woodworking, hafting served to markedly reduce muscular stress in the hand, allowed effective tool manipulation, and permitted heavy levels of pressure to be applied with relative ease.

Even though E.T. #7 was hafted securely following the same procedure used to haft the woodworking tools, it became quite loose after about 1200 strokes on the soaked beam. Very heavy pressure loads were required to effectively work this contact material, consequently, great stress was directed through, and absorbed by, the juncture of the tool and its haft. E.T. #9 remained rigid in its haft for the duration of it's short use-life.

Contact Material Positioning

The soaked antler was held in two basic positions while being shaved and scraped with the concave margin. The first involved resting one end of the beam on a large anvil boulder and holding the "opposite" end with the left hand so that its shaft was either oriented vertically or slightly inclined (e.g., Figure 51). For this method, stroke direction was from top to bottom. The second technique involved simply resting the beam horizontally on a boulder anvil with the shaft oriented perpendicular to the transverse plane of the body, and strokes were initiated in a distal-to-proximal direction. The beam was placed horizontally on the boulder when incising or engraving (Figure 50).

Distal Projection Motor Patterns and Efficiency

The distal projection tip was used to incise longitudinal linear grooves into the soaked antler beam following the "groove and splinter" technique used to manufacture elongate antler tool blanks. This was accomplished by: firmly grasping the tool haft and putting the index finger on the dorsal surface of the distal projection; placing either the distal edge or one of the ventral-lateral corners of the projection tip against the antler so that the tool was inclined at about a 45° angle relative to the beam; and pushing the tool back-and-forth with considerable pressure in repeated strokes measuring about 10 to 15 cm long (see Figures 9d and 50). As was the case for stalks and branches of green woody plants, incision/groove widths could be controlled by using different parts of the distal tip edges and/or by altering the working angle of the tool. Groove depth depended on the pressure exerted and amount of working time elapsed.

The distal projection tip functioned moderately well for incising and engraving linear scores and grooves into the antler beam parallel to its longitudinal axis, but it was much more awkward for incising lines accross the beam because of its roundness. The upper 1 to 2 mm of outer antler cortex softened by soaking was removed with moderate ease, and produced antler shavings measuring between 1 and 4 cm long, and about 1 to 5 mm wide. Incising/engraving became much more difficult and significantly less effective once the softened cortex had been penetrated.

Concave Margin Motor Patterns and Efficiency

The concave margins on both experimental tools were used to scrape and shave down the main "shaft" portion of the soaked antler beam by: firmly grasping the tool haft and placing the thumb on the medial aspect of the distal projections's dorsal surface; placing the ventral surface of the distal projection against the beam so that the projection tip was oriented away from the user at a slightly oblique angle; and drawing the tool toward the user using very heavy levels of applied pressure in repeated strokes about 10 cm long.

During initial use on both the soaked and boiled antler beams, the concave margin of E.T. #7 was sharp, and it was considered to function reasonably well for shaving and scraping down the outer 1 to 2 mm of their softened cortex. This was also observed for E.T. #9, which was used on the soaked antler only. Small shavings ranging between about .5 and 4 cm long, and about 2 to 3 mm wide were removed (Figure 53). However, once the softened outer 1 to 2 mm of the antler beams had been penetrated, the shavings were significantly smaller and much more difficult to remove.

The functional efficiency associated with scraping and shaving the soaked antler beam with the concave margin edge was about the same as that noted for the boiled antler beam. Therefore, it was concluded that boiling does not render antler significantly easier to work than soaking it, at least as far as using key-shaped formed unifaces is concerned.

When compared to the use-lives of experimental tools used for woodworking, both tools used on antler dulled much more rapidly. This is attributed to the obvious superior hardness of antler compared to the three types of green woody plants, and to the greater levels of applied force required to work it.

"Opposite" Margin Motor Patterns and Efficiency

The "opposite" margin of E.T. #9 was very rarely used to scrape and shave the soaked antler beam. When used, it involved grasping the haft and putting the thumb on the dorsal surface of the concave margin, placing the ventral face of the tool on the antler shaft so that the "opposite" margin edge was roughly perpendicular to the long axis of the beam, and pushing the tool away from the body in a shaving and scraping "whittling" motion. The "opposite" margin of E.T. #7 was not used to work antler.

It was concluded that shaving and planing of the soaked antler beam with the "opposite" margin was not a very successful endeavour. The concave margin was considered to be much easier to manipulate, and functioned far more efficiently for this task.

Lithic Raw Material Efficiency

The two lithic raw material types employed to work antler performed quite differently with regard to functional efficiency and use-life potential (Appendix 9). The concave margin edge of E.T. #7, made from type 5 chalcedony, required resharpening after about 1,700 strokes on soaked antler, and after resharpening, it became noticably dull after about 250 strokes on the boiled antler. E.T. #9's edge (Type 6 fine-grained basalt) lasted only 400 strokes on soaked antler. This clearly indicates that chalcedony is far more durable than basalt for working antler, a pattern that was also observed during the woodworking experiments. Again, the inferior hardness and greater brittleness of microcrystalline basalt is blamed. Heavy loads of applied force required to scrape, shave, and groove antler quickly dulled the working edge of the basalt tool by invoking pronounced crushing and extensive microflake removal along both ventral and dorsal edges.

7.6.3 Results of Working Deer Bone

Experimental Tool #7 (lithic Type 5) was initially used to attempt to scrape a longbone (metacarpal) from the foreleg of an adult mule deer. The bone measured ca. 20 cm long by 2.25 cm diameter, and had been soaked in water for one month (Chapter 7.4; Figure 51). The tool was used initially to work the deer bone for 500 strokes, and was subsequently used on soaked antler (see above).

Motor Patterns and Functional Efficiency

Use of a hafted tool was considered to be highly effective for working either soaked (or unsoaked) bone because it enabled heavy pressure to be applied that could not otherwise be exerted using an unhafted tool.

The bone was held using the same two basic methods described above for the antler beam. The first of these involved placing one end on a large boulder and holding the opposite end so that the shaft was either vertical, or slightly inclined (Figure 51). The concave margin was used for scraping and shaving, and stroke direction was from top to bottom. The second method involved resting the bone horizontally on a boulder with the shaft oriented perpendicular to the lateral plane of the body, and scraping and shaving was executed in a distal-to-proximal direction.

A brief attempt was made to incise a linear groove along the longitudinal axis of the bone using the distal projection tip following the procedure and motor patterns described above for grooving antler. This task was associated with a low level of success and efficiency because the bone was very difficult to penetrate, and the tip of the tool repeatedly slipped off (see also Lynott 1975). Nevertheless, a small incision was created with one of the projection's ventral-lateral corners, but not without considerable effort.

The concave margin on E.T. #7 was used to try to scrape and shave down the shaft of the soaked metacarpal using the same technique described above for scraping and shaving the soaked antler shaft. Attempting to work soaked bone in this manner was associated with a very low level of success. Despite the tool's sharp edge and use of heavy pressure, it only succeeded in scratching or slightly smoothing the surface of the bone, or occasionally removing minute shavings measuring about 2 to 5 mm long by about .5 mm wide. Soaking the bone for one month did not appear to have softened it significantly. Not surprisingly, the concave margin functioned well for removing residual soft tissue. The "opposite" margin was not used to work bone, as it was plainly evident that there was no task that this margin could have been used for that the concave margin could not have accomplished as well or better.

7.7 Summary and Discussion of Experimental Results

<u>Bark and Wood Working</u>

The experimental results indicate that key-shaped formed unifaces functioned quite successfully and effectively for stripping bark and shaving, scraping, and planing down stalks and branches of all three types of green woody plants worked. For all eight tools, the concave margin edge was used most frequently for these tasks, and consequently it was always the first edge to become dull. The "opposite" margin was used much less frequently, and was usually engaged for removing bark and wood from the ends of stalks/branches, and from secondary branch nodes. The distal tip was very effective for removing secondary branch nodes, and for incising and engraving linear scores and grooves of various widths and depths.

There was unanimous consensus among the experimenters that hafted tools were more efficient and easier to use than hand-held tools. Hafting significantly enhanced tool comfort, manipulability, and effectiveness, and allowed much greater loads of force to be applied. During the experiments, either the thumb or forefinger was commonly placed on the dorsal surface of the distal projection. This increased the amount of force that could be applied to, and/or be absorbed by, the tool. It also helped to relieve stress that would otherwise be directed into, and completely absorbed by, the hafting joint which could result in loosening a tool from its handle.

Overall, the concave margins of E.T.'s #1 and #2 (Type 1 chert), E.T.'s #3 and #4 (Type 2 chalcedony), and E.T. #8 (Type 5 chalcedony) all indicated fairly long use-lives before requiring resharpening. In contrast, E.T. #5 (Type 3 chert), E.T. #6 (Type 4 chalcedony) and E.T. #10 (Type 6 basalt) dulled much more quickly. This lends strong support to the hypothesis that chalcedonies and some cherts are more durable than other types of cherts and basalts, and this was the primary reason that they were purposefully selected for production of prehistoric key-shaped formed unifaces. From this it can be inferred that these tools were intended to be used most often on relatively hard contact materials (Chapter 3.3.3), and that functional longevity was also deemed to be an important feature of this tool type.

Because juniper and willow bark were more quickly and effectively removed by hand than with the experimental tools, I suggest that the prehistoric incidence of using these tools to remove bark from these woody plants -- and others with bark like them -- would have been low. Saskatoon bark could not be removed very easily by hand, but it could be swiftly and efficiently removed using the concave or "opposite" margin edges.

Bark strips and shavings produced as a by-product of working green saskatoon bark and wood are fibrous, strong, very flexible, and can sometimes be quite long (Figures 43 and 52). Freshly stripped saskatoon bark and wood have a pungent but pleasant almond-like fragrance. When dry, a subtle hint of this odor is retained. Dried shreddings are absorbant, relatively soft, and very supportive when densely packed. It is conceivable that they may have occasionally been used for bedding. Dried bark and wood strips were also determined to be effective tinder (i.e., it combusted easily and quickly) for starting fires. Twisted strands of fibres about 3 to 5 mm in diameter were braid-woven to make a strong piece of cordage about 15 cm long and 8-10 mm wide, and it is possible that similar cordage or rope was made in prehistoric times. Unfortunately there are no ethnographic or archaeological data to support any of these postulated potential uses for saskatoon bark and wood shreddings.

While working green bark and wood, it was noted that the incidence of microflake scar formation increased significantly along edges when removing and smoothing down secondary branch nodes. This phenomenon has been documented previously during other woodworking experiments (Odell 1981b:202). It was also observed that polish developed more rapidly when working woody parts of green stalks and branches compared to removing the bark only.

Although it was noted that the distal tips of many (45.7%) items in the study sample of prehistoric key-shaped formed unifaces had been removed by either flexure (34.3%) or torsion (11.4%) fractures, no such breakage occurred during the experiments. Nevertheless, a consideration of the experimental results indicate that at least four possible explanations can be advanced to account for this phenomenon. First, a small portion (e.g., the distal 1/4) of a projection tip may have been intentionally removed by flexure breaks by direct freehand hard hammer retouch to rejuvenate worn ventral-lateral corners and distal edge. Second, larger portions (e.g., more than 1/3) of the projection may have been accidentally removed by such fractures while the concave margin or distal projection tip were being resharpened or rejuvenated. Third, flexure or torsion fractures might have been initated when heavy pressure was being applied to the projection during use -- especially during incising and graving actions. Lastly, flexure fracturing could have possibly resulted when excessive force was exerted by either the thumb or forefinger on the dorsal surface of the distal projection when it was engaged in rigorous scraping, planing, shaving actions, causing the distal 1/2 to 1/4 of the projection to snap in a ventral direction.

In the latter two scenerios, trauma to the thumb or forefinger would have been very probable, resulting in cuts and/or abrasions. In such cases, human blood may have been deposited on the tool surface. The strong positive reaction results obtained for blood (haemoglobin) on specimen FiRs 1:5699 from Punchaw Lake (Table 3; Figure 11k) may be owing to this agency.

Extended use of hand-held key-shaped formed unifaces could also possibly result in transfer of small quantities of human blood to the surface of a tool originating from cuts and/or abrasions on the thumb and fingers caused by prolonged forceful contact with sharp margin edges and flake ridges. Also, during the woodworking experiments, the tools sometimes slipped off the stalks/branches when heavy pressure was being applied, and occasionally the tip of the distal projection would accidentally slash or gouge the anterior part of an experimenter's left forearm, or more rarely, left thigh or calf.

Therefore, it is quite possible for human blood residues to be transfered to the surfaces of these tools during use (see also Loy 1983; Gurfinkel 1987; Gurfinkel and Franklin 1988). Blood cells could also be introduced to the tool when refurbishing tools previously coated with animal blood, particularly hunting tools and weaponry. Study specimens EeRk 4:19-2119 (Figure 12k) and EeRl 7:1000 (Figure 12n) from the Mid-Fraser River region both produced weak positive reactions for blood, which may be due to any of the possibilities mentioned above.

E.T. #8 has a short distal projection that frequently slipped off saskatoon stalks and branches during use, even when using the "guide" formed by the juncture of the hafting mastic and ventral face of the tool (Figures 10 and 43). This tool is morphologically similar to what might be expected for prehistoric tools whose concave margins and/or distal projection tips had been subjected to several resharpenings (see Figure 5a) and was nearing the point of being functionally exhausted. Although E.T. #8 functioned very well for stripping bark and woodworking, occasional slipping disrupted the cadence of the strokes, and constituted both a nuisance and potential hazard (see above). Consequently, it was concluded that tools with short projections were considered to have slightly less overall functional efficiency than those with longer projections.

All experimenters developed distinct individual motor pattern "styles" shortly after they became familiar with the features and capabilities of their tools, and the nature of the woody plant types being worked. For example, some preferred to place their index finger on the medial aspect of the "opposite" margin's dorsal surface when engaging the concave margin, whereas others opted to use their thumb. Sometimes both thumb and index finger were used alternately. Conspicuous shallow indentations created on the medial, or medial-distal sections of the "opposite" margin on several specimens in the prehistoric microwear sub-sample (e.g., Figures 8j, 12a, 12g, 15n, 18e and 19d) suggests that these features were intentionally installed to comfortably accomodate the digit of preference (see also Odell 1981b:207).

Stalks and branches were held in a variety of ways for both reasons of functional efficiency and/or personal preference (Chapter 7.6). Average pressure loadings and working speeds also varied between experimenters. Some always worked slowly, methodically, and gently, whereas others preferred to work more quickly, erratically, and aggressively (see Appendix 9). Motor patterns and working rates also depended on the mood of the experimenters, and often varied between use-episodes. All experimenters remarked that when a tool was used unhafted, it was used differently than when hafted, and hafted tools were much more efficient.

These idiosyncratic behaviour modes are regarded to have contributed to at least some of the microwear trace variability observed on the experimental sample of key-shaped formed unifaces (Chapter 8), and also on the 129 prehistoric study sample specimens (Chapter 6).

Deer Antler Working

The experiments suggest that the concave margin edge was moderately effective for scraping and shaving the softened outer 1 to 2 mm of cortex on antler beams that had been either soaked or boiled. However, it did not function well for working the unaltered antler beneath the softened cortex, and thus did not permit any substantial alteration of the beams. Rapid deterioration and dulling of the concave margin edge occurred when unaltered antler was worked.

The "opposite" margin was not very effective for scraping and shaving soaked antler, as it required a rather awkward and forceful motor pattern that afforded poor mechanical efficiency. The distal projection tip functioned quite well for incising and engraving the soaked outer cortex, but not without incurring severe damage and attrition to the distal edge and ventral-lateral corners.

Because soaked and boiled antler were significantly harder to work with key-shaped formed unifaces once the softened outer 1 to 2 mm of the beams had been exposed and/or penetrated, it is obvious that any attempt to significantly modify antler using this technique would necessitate repeated soakings or boilings over long periods of time. Overall, soaking and boiling do not allow antler to be very easily modified by chipped stone tools. Similar observations and conclusions were made by Richards (1987:132) during experiments involving Cache Creek basalt (lithic Type 6) tools used on soaked deer antler.

Given the types of substantially modified antler artifacts found in late prehistoric components on the Plateau (e.g., digging stick handles, wedges, harpoon valves, barbed points, sap scrapers, figurines, etc. [see Richards and Rousseau 1987:91]), I argue that there are several other techniques that could have been used to manufacture such items more efficiently. Unifacial "spurred" gravers -- which are formally distinct from key-shaped formed unifaces, but are often made of similar lithic raw materials -- can very effectively create elongate antler tool blanks by implementing the "groove and splinter" technique. They can also be used to install fine functional details (e.g., barbs), and to incise linear decorative elements. Abraders made of sandstone, siltstone, or other raspy lithic materials are effective for rapidly wearing down substantial portions of antler beams and tines for shaping blanks, and further modifying blanks into finished tools. Large cobble choppers, hammerstones, and stone wedges can be used to remove large unwanted sections of beams, create large blanks, or make small splinter-like blanks. Numerous gravers, abraders, hammerstones, and small stone wedges have been found in late prehistoric components on the Plateau, suggesting that some, or perhaps all, of these antler working techniques may have been commonly employed.

All considered, I conclude that the primary function of prehistoric key-shaped formed unifaces did not likely involve significant modification of soaked or boiled antler. This inference is based on: (1) the overall low to moderate functional efficiency and relatively rapid rate of tool edge dulling associated with undertaking this task; (2) the great amount of time that would have been required to significantly alter antler using this technique; and (3) there are several other methods that are far more efficient for executing this task, and there is ample artifactual evidence for them.

Moreover, it is significant to note that key-shaped formed unifaces disappear from the archaeological record after about 1000 BP (Chapter 4.2), whereas a wide variety and abundance of highly sophisticated antler artifacts persisted, and even seem to have increased in frequency, after this date (see Richards and Rousseau 1987:45-46).

However, since the experimental component of this study indicates that key shaped formed unifaces can be used to minimally modify (i.e., scrape and incise/engrave) soaked and boiled antler with some success, it cannot be concluded that these tools were *never* employed for this purpose. Yet given the overall low to moderate level of efficiency associated with performing these tasks, I maintain that they were probably only very rarely executed, and consitute a possible secondary function of these tools.

Deer Bone Working

Scraping and shaving soaked deer bone was associated with a low level of functional efficiency and success. This is attributed primarily to the fact that bone is a very dense, hard, and resistant contact material, and these properties do not appear to be significantly mitigated by soaking in water for extended periods. Significant alteration of bone could be more effectively accomplished using several, or possibly all, of the alternate methods described above for working antler. From a functional perspective, I am compelled to conclude that key-shaped formed unifaces were probably engaged very rarely, if ever, to work bone in prehistoric times.

In sum, the experimental component of this study indicates that key-shaped formed unifaces functioned most efficiently and effectively for working green woody plants. Seasoned wood was determined to be significantly more difficult to work than green wood. Soaked and boiled antler were harder to work than seasoned wood, and could be minimally, but not significantly altered. Soaked bone was the most difficult material to work, and could barely be modified in any manner.

CHAPTER 8

EXPERIMENTAL TOOL MICROWEAR ANALYSIS

8.1 Introduction

Subsequent to the experimental component of this study (Chapter 7), all ten experimental tools were subjected to a descriptive, comparative, and interpretive microwear analysis according to the same procedures and methods outlined in Chapter 6.1. Detailed descriptive analysis results are presented in Appendix 9 and Tables 6, 9 and 10. In this chapter, the experimental tool microwear data are judgementally and inferentially compared with results obtained during analysis of the 35 prehistoric microwear sub-sample specimens (Chapter 6). Further detailed statistical analyses of the prehistoric microwear sub-sample specimens and the eight experimental woodworking tools are presented in Chapter 9.

8.2 Descriptive Comparison of Experimental Woodworking Tool Microwear Patterns

The eight experimental tools used for bark stripping and woodworking activities (Chapter 7; Appendix 9) were collectively analyzed as a sample. A general description and comparison of their salient microwear trace patterns with those of the prehistoric microwear sub-sample specimens, and with results documented in previous microwear studies, are presented in this section. Additional detailed descriptive and comparative data are presented in Appendix 6, Tables 6, 9 and 10, and Figures 54 to 61, 63 and 65. The microwear traces observed on the two experimental tools used on antler and bone are described separately in Chapter 8.3 (below).

This descriptive and judgemental comparison of microwear trace patterns between the experimental woodworking tools and the microwear sub-sample specimens was undertaken to test the hypothesis that the primary function of prehistoric key-shaped formed unifaces involved mainly woodworking activities. It was reasoned that woodworking could be inferred if the majority of microwear trace patterns on the experimental woodworking tools closely matched, or were notably similar to, those observed on the majority of the prehistoric microwear sub-sample specimens. If the dominant microwear traces represented for these two samples were observed to be notably dissimilar, then the woodworking hypothesis would be rejected.

All eight experimental tools engaged in bark removal and woodworking activities developed microwear that can be easily seen by the unaided eye (see Figures 54 to 61, 63 and 65). Variability in dulling rates, and slight differences in microwear traces were noted for the six tools used exclusively on green saskatoon stalks and branches. The observed variation is probably due to physical property differences inherent in each lithic raw material type, and/or to idiosyncratic motor pattern behaviours (Chapter 7.7; Appendix 9).

The relative percentages of specific lithic material types comprising the experimental woodworking tool sample are very similar to those represented for the prehistoric microwear sub-sample. Therefore, when both samples are compared, any significant statistical or observational variation for microwear trace patterns indicated between the two samples cannot be directly attributed to factors relating to disproportionate representation of specific lithic raw material types.

One of the woodworking tools (E.T. #10) was made of fine-grained "Cache Creek" basalt (Lithic Type 6). In a previous study, Odell (1980:40) concluded that the basic fracture properties of Cache Creek basalts are similar enough to cryptocrystalline silicates (e.g., flint) to permit identification of specific tool activities (see also Richards 1987,1988). Given this, I reasoned that the basalt and silicate tools should develop similar microwear traces when engaged in woodworking, and consequently, data contributed by the basalt tool would not appreciably affect or distort the general qualitative and quantitative character of microwear trace patterns representing the collectively analyzed experimental woodworking tool sample.

It could be argued that the eight experimental woodworking tools constitute an uncomfortably small sample size for the purposes of generating descriptive statistics, and that ideally, a larger sample would have been more desirable to ensure greater representative accuracy. However, a great deal of time and effort would have been required to increase the experimental tool sample size and satisfy this consideration. Also, it could be questioned as to whether statistical measures generated from a larger sample would have been significantly different from those obtained, given the overall high level of microwear trace pattern similarity shared between the eight experimental woodworking tools.

Although it is acknowledged that some minor degree of sampling error undoubtedly exists, frequencies and percentages generated for attribute variables indicated on the eight experimental woodworking tools are regarded to generally represent the general salient characteristics of the sample. Consequently, they were used as indices for comparison with the same statistical measures generated for the 35 prehistoric microwear sub-sample specimens (Appendix 6; Tables 6, 9 and 10).

Distal Projection Tip

All eight expermimental woodworking tools retained their distal projections. It appears that if the primary function of prehistoric key-shaped formed unifaces *did* involve woodworking activities, accidental removal of distal projections during use was probably a relatively rare occurrence. Several possible scenarios for accidental distal tip removal are discussed in Chapter 7.7.

The distal tips of most experimental woodworking tools were used to remove secondary branch nodes employing gouging, prying, and lateral side-to-side sawing motions (Figure 9b and 9c); and to incise and engrave grooves into primary stalks and branches (Figure 9d) (Chapter 7.6.1; Appendix 9).

For experimental woodworking tools, distal projection tip mean microflake scar frequency, mean microflake scar size, and mean microflake scar maximum size are about half as large as those represented in the prehistoric microwear study sub-sample (Tables 5 and 6). The mean minimum microflake scar size on the distal tip was much smaller than that represented in the prehistoric microwear sub-sample specimens. A similar pattern was noted for the "opposite" margin (see below).

Both samples indicate comparable similarities for percentages representing the categories for rounding and smoothing intensity, polish intensity, and crushing intensity; and for tools bearing striations (Appendix 6). Slightly similar percentages are represented for distal tip polish location, microflake scar location, and microflake scar configuration pattern categories. Percentages for rounding and smoothing location, and crushing location categories are proportionately dissimilar between the two samples.

Concave Margin

The experimental woodworking sample and prehistoric microwear sub-sample both indicate close metric similarities for the concave margin mean maximum microflake scar size, and concave margin mean edge angle (Tables 5 and 6). The experimental tool concave margin mean microflake scar size is about .3 mm smaller than that for the prehistoric microwear sub-sample specimens. This difference is relatively minor, and a close similarity is inferred. The concave margin mean minimum microflake scar size is about half as large as that determined for the prehistoric microwear sub-sample. The most notable dissimilarity is indicated for the mean concave margin microflake scar frequency per tool; experimental tools have about three times as many more microflake scars than those in the prehistoric microwear sub-sample.

With respect to nomimal and ordinal scale attribute variables represented in the two samples (Appendix 6), there are moderate percentile similarities indicated for for concave margin edge rounding and smoothing intensity, edge rounding and smoothing location, and edge polish location categories, as well as for the frequencies of tools bearing striations. Slight percentile similarities are noted for microflake scar configuration pattern, edge crushing intensity, and edge crushing location categories. The two samples are dissimilar with respect to the percentages in edge polish intensity and microflake scar location pattern categories.

Microflakes are considered to be important in this study because many researchers have demonstrated that they have diagnostic value that can be used to infer prehistoric tool function(s) through comparison with experimental tools (Tringham *et al* 1974; Keeley and Newcomer 1977; Odell 1977,1981b; Odell and Odell-Vereecken 1980; Keeley 1980). A total of 99 microflake scars were observed on the concave margin ventral edge aspects of 25 prehistoric microwear sub-sample specimens; 108 were noted on the eight experimental woodworking tools. The number of microflake scars represented in the prehistoric and experimental samples are sufficiently large and comparable in size to assume that they constitute samples from which representatively accurate statistics can be derived.

Frequencies and relative percentages for the most common microflake scar types represented on the concave margin edge aspect of tools bearing microflake scars in the prehistoric microwear sub-sample were compared with those for the experimental woodworking tools (Tables 7 to 10). In both samples, the most commonly represented microflake scars are those with circular-expanding plan outlines and invasive terminations, followed by those with circular-expanding outlines and shallow-stepped terminations. Indeed, the relative proportions for the latter type are identical in both samples.

Approximately similar percentages are indicated for microflake scar types represented in moderate frequencies. They include those having: (1) circular-expanding outlines and deep-stepped terminations; (2) trapezoidal-expanding outlines with shallow-stepped terminations; (3) crescentic oultines and shallow-steped terminations; (4) oblique outlines and invasive terminations; and (5) oblique outlines with shallow-stepped terminations.

At least two obvious microflake scar type frequency differences exist between the two samples. First, there are at least six times as many microflake scars with crescentic outlines and deep-stepped terminations represented in the experimental tool sample than in the prehistoric microwear sub-sample specimens. However, it is important to note that most (70%) of these are associated with E.T.'s #3 and #4, which are both made of Type 2 chalcedony, a material conducive to "hingeing-out" abruptly at flake terminations (see Appendix 7).

Second, microflake scars with lamellar outlines and invasive terminations are six times more common in the experimental sample than in the prehistoric microwear sub-sample. However, all were observed on E.T. #5, which is made of Type 3 chert, which is softer and far more brittle than the majority of lithic materials represented in the prehistoric microwear sub-sample or experimental woodworking tool sample (Chapter 7.6.1; Appendices 7 and 9).

There are a few low frequency "outlier" microflake scar types represented in the prehistoric microwear sub-sample (Table 9). They exhibit five outline categories, and terminate mostly in snaps or retroflexed steps or hinges. These "atypical" forms may have been accidentally incurred by forceful traumatic contact with hard objects during tool transport, and/or as a result of being employed in a "secondary" functional capacity on contact materials other than green wood.

Where possible, concave margin microflake scar initiation types for the experimental woodworking tools were classified as being either "Hertzian" (cone) or "bending" using criteria defined by Cotterell and Kamminga (1987: 682-691). The most commonly represented initiations (81%) were determined to be the bending type, while Hertzian initiations constituted only 19%. These percentages are virtually identical to those determined for the microflake scar initiation types identified on the concave margin edge aspects of specimens in the prehistoric microwear sub-sample.

"Opposite" Margin

The "opposite" margin mean microflake scar frequency, mean microflake scar size, and mean maximum microflake scar size for the experimental woodworking tools are about half that observed on the prehistoric microwear sub-sample specimens (Table 6). The mean minimum microflake scar size on the "opposite" margins are about a third as large as that represented on the prehistoric microwear sub-sample specimens. The mean "opposite" margin edge angle for the experimental tool sample is about 10° greater than that determined for the prehistoric microwear sub-sample. However, this slight edge angle difference is not deemed to be great enough to have contributed any microwear trace pattern variations evident between the two samples.

In considering relative frequencies and percentages of various discrete variables for each of the two samples (Appendix 6), there are notable percentile similarities indicated for edge polish location and edge crushing intensity categories, and for frequencies of specimens exhibiting striations. Some weak similarities are indicated for percentages representing each of the polish intensity, microflake scar location, and edge crushing location categories. Percentile dissimilarities for the "opposite" margin are indicated for edge rounding and smoothing intensity, and edge rounding and smoothing location categories.

A total of 106 microflake scars were observed on the "opposite" margin of 23 specimens in the prehistoric microwear sub-sample. The eight woodworking tools bear only 19. The latter sample size is viewed as being uncomfortably small, consequently the validity of interpretations drawn from it could easily be open to some question. Nevertheless, the resulting measures suggest that there are a few obvious general similarities shared between the two samples.

Comparison of the relative percentages of microflake scar formal types (Tables 7 to 10) between the two samples indicate that the most commonly shared configurations are those with: (1) circular-expanding outlines and invasive terminations; (2) circular-expanding outlines and shallow-stepped terminations; (3) crescentic outlines and invasive terminations; and (4) oblique outlines with invasive terminations. Percentages for most of the less frequently represented microflake scar types in the experimental tool sample are similar to those represented in the prehistoric microwear sub-sample.

Ventral Face

Frequencies and relative percentages of nominal and ordinal scale microwear attribute variables represented on the ventral faces of the specimens in the two samples (Appendix 6), indicate that strong similarities exist for percentiles representing the categories for polish intensity, polish location, rounding and smoothing intensity, and rounding and smoothing location. Only one specimen in the experimental woodworking tool sample bears striations that extended beyond the concave margin edge aspect onto the ventral face. Consequently, striation types and patterns cannot be properly compared or used as diagnostic functional indices between samples.

General Comparisons and Observations

Some variation in polish types and intensities are evident between the eight experimental woodworking tools and the prehistoric microwear sub-sample. However, the polishes on E.T.'s #1- #4, #6, and #10 are either identical to, or very similar to, those observed on many of the specimens in the prehistoric microwear sub-sample, and on other cryptocrystalline silicate experimental and ethnographic woodworking tools (e.g., Keeley 1977:4; Keeley and Newcomer 1977:39,50; Newcomer and Keeley 1979:201; Keeley 1980:35; Kamminga 1977:207,210; Dumont 1982:214; Sabo 1982:69; Vaughan 1985:33-34,114-115,124).

Polishing on the experimental woodworking tools is very distinctive, intense, and most pronounced along the immediate working edge (Figures 54, 56, 58, 59, 61, 63 and 65). The extent and intensity of polish development along the concave and "opposite" margins varied somewhat between lithic raw material types, and with the manner and duration of tool use. Intensity and locational extent of polish on the concave margin edge aspects was noted to have increased more or less incrementally with tool use. The extent of the polished area on the ventral face back from the concave margin edge aspect depended how often, and how forcefully the ventral face contacted the wood during use.

A moderate proportional dissimilarity is indicated between the prehistoric microwear sub-sample and experimental woodworking tool sample for categories representing concave margin edge polish brightness (Appendix 6). On average, most of the experimental tools exhibit brighter polish. This is compatible with previous observations that polish formed by working green wood is usually very bright (Keeley and Newcomer 1977:39; Keeley 1980:35; Vaughan 1985:33). This difference in average polish brightness intensity between samples could be due to several reasons. Foremost of these are physical differences in lithic raw material types, and/or post-depositional factors that have reduced original polish intensity of the prehistoric specimens through chemical and/or mechanical processes (see Keeley 1980; Plisson 1983; Unger-Hamilton 1984). Also, Hayden and Kamminga (1973:4) and Kamminga (1977:207) have observed that polish produced by hard woods can be qualitatively different from those associated with soft woods. Similarly, polish developed when working seasoned wood has been noted to be less intense than that produced by working green wood (Hayden and Kamminga 1973:6; Keeley 1980:36).

Only three experimental woodworking tools exhibited striations. The mean distally-oriented striation angle vis-a-vis the average concave margin edge was determined to be identical in both samples (Tables 5 and 6). They suggest that prehistoric and experimental motor patterns were similarly executed.

Minute "sleeked" type striations appear on the concave margin ventral edge aspects of E.T.s #1, #2 and #10 (e.g., Figure 54c). They resemble those observed on several prehistoric microwear sub-sample specimens (e.g., Figures 24 and 30), and on other experimental tools used to work green wood (see Keeley and Newcomer 1977:39; Newcomer and Keeley 1979:201; Kamminga 1982:210; Mansur 1982:233). "Scratch groove" type striations are indicated on the "opposite" margin of E.T. #1 (Figure 57b), which was the only tool used on juniper. These are also similar to some examples represented in the prehistoric microwear sub-sample (e.g., Figures 24, 25, 27 and 35), and to those exhibited on experimental tools used on green wood by other researchers (see Dumont 1982:214; Kamminga 1982: 205,207; Mansur 1982:231).

The notable paucity of striations on the eight experimental woodworking tools can be attributed to at least two important factors. First, many of the tools were used primarily in contexts where abrasive particles (i.e., sand, silt, dust, and grit) were not very prevalent in the immediate work areas (Chapter 7.5). Therefore, the possibility of abrasive particles being incidentally introduced between a tool's working edge or surface and its contact material was significantly reduced. Second, none of the experimental tools were used until their use-life potential had expired (Appendix 9). This would have entailed using each tool until its concave margin had been repeatedly subjected to numerous use-episodes and subsequent resharpenings to the point of tool exhaustion. As a result, the experimental tools did not have the same opportunity to develop striations as did prehistoric tools, which were undoubtedly used for much longer periods of time. It is significant to note that E.T.'s #1 and #2, which bore striations, were both used at Keatley Creek for relatively long periods. There, sand, silt, dust, and grit were relatively abundant in the immediate working environment.

A notable difference in the mean size of microflake scars on the edge aspects of the ventral face is apparent between the experimental woodworking tools and the prehistoric microwear sub-sample specimens. On average, those on the experimental tools are about half the size of those on the prehistoric microwear sub-sample items. This suggests that many of the prehistoric specimens were probably used on contact materials that were slightly harder than the green woods used in the experiments, and/or possibly that greater levels of applied force may have been used prehistorically to work green woods than was used experimentally. The former explanation seems more likely, as very heavy pressure was often exerted by the experimenters, and these force loadings were likely comparable to those applied prehistorically.

It is important to note that of the three microflake scars removed from the concave margin ventral edge aspect of E.T. #3 when it was used to work seasoned saskatoon wood for about 1000 strokes, two scars were exceptionally large (1.5 mm and 2.0 mm diameter) (Chapter 7.6.1; Appendix 9). When this tool had been used previously on fresh green saskatoon for 15,400 strokes, eight microflakes were removed, having a size range of .3 mm to 1.5 mm, and mean diameter of .5 mm. These results support previous observations that working seasoned wood creates larger microflakes than working green wood of the same type. Therefore, the slightly larger mean microflake size indicated for the prehistoric microwear sub-sample specimens compared to the experimental tools used on green wood can be explained by the fact that the former may have been occasionally used to work seasoned wood. Working of seasoned wood would have been common during the refurbishing or repairing of dried-out wooden artifacts, notably hunting weaponry. Occasional working of antler, or possibly bone, could have also contributed to the larger mean microflake scar size represented in the prehistoric microwear sub-sample (Chapter 7.6.2.).

Microflake scar configuration pattern categories represented on the concave margin edge aspects of the eight experimental woodworking tools (Tables 9 and 10; Figures 54 to 56, 58 to 61, 63 and 65) are simlar to those exhibited on many of the prehistoric microwear sub-sample specimens (Tables 7 and 8; Figures 23, and 25 to 34), and on edges of experimental tools used by other researchers to scrape and plane soft and hard woods (e.g., Tringham *et al* 1974:187-188; Keeley and Newcomer 1977:49; Cotterell and Kamminga 1979:105; 1982:180; Odell and Odell-Vereecken 1980:101; Odell 1981b:200-203).

The majority of the microflake scars on the experimental woodworking tools and the prehistoric microwear sub-sample items exhibit invasive and shallow-stepped termination types (Tables 9 and 10). When related to contact material relative hardness categories defined by Odell (1981b) and Odell and Odell-Vereecken (1980:101), they suggest having been used on predominantly "medium-soft" and/or "medium-hard" contact materials. Woods are included in both of these categories, however, bone and antler are relegated to the "hard" category.

The high percentage of "bending"-type microflake initiations on the concave margin edge aspects of the experimental woodworking tools and prehistoric microwear sub-sample specimens (81% and 82% respectively) are virtually identical in both cases. The proportion of "Hertzian" initiations are also very similar (19% and 18% respectively). Cotterell and Kamminga (1987:682-691) maintain that bending initiations are commonly produced by working wood, bone, and antler. "Hertzian" initiations are more likely to result from much harder materials such as stone, but they can sometimes be created by bone and antler indenters if very heavy levels of force are applied. Most woods are considered to be too soft to create Hertzian initiations by pressure, although they can occasionally be produced by percussion (Cotterell and Kamminga 1979:686). The experimental results of the present study indicates that these generalized rules are not hard and fast, since both types were produced by working green bark and wood. Albiet, the bending type is clearly dominant.

8.3 Descriptive Comparison of Antler and Bone Microwear

Two experimental tools were used to work antler and bone. E.T. #7 was used on soaked antler, boiled antler, and soaked bone; E.T. #9 was used exclusively on soaked antler (Chapters 7.6.2 and 7.6.3; Appendix 9). Resulting microwear traces observed on each of these two tools are summarized and discussed below, and corresponding photomicrographs are presented in Figures 62 and 64.

E.T. #7

Microwear trace patterns described for E.T. #7 in this section refer to those incurred after this tool was used to work soaked antler for 1,700 strokes (Chapter 7.6.2; Appendix 9). Microwear on the projection tip is characterized by moderate edge rounding and smoothing on the distal edge and ventral-lateral corners (Figure 62). Polish intensity is moderately bright, and it appears on the distal edge, ventral-lateral corners, and their adjacent edge aspects. Four microflake scars were removed from the distal tip; their mean diameter size is 2.0 mm and they range between .5 and 3.0 mm. Crushing is pronounced, and appears along the entire distal tip margin.

The concave margin bears pronounced rounding and smoothing, pronounced crushing, and moderately bright polish along its entire working edge. Six microflake scars are randomly distributed along the ventral edge aspect. Their mean size is 2.0 mm, and they range between .3 and 3.0 mm. Striations were not observed. The most common microflake scar outline category is trapezoidal (n=3), followed by expanding-circular (n=2), and expanding-oblique (n=1). The most common microflake scar termination types are deep-stepped (n=2) and snapped (n=2), followed by invasive (n=1), and shallow-stepped (n=1). All six microflake initiations are the "bending" type.

The "opposite" margin was used for a very short time on soaked antler, and it did not incur any microwear that could be observed using magnifications less than 40 X. The ventral face of the distal projection bears moderately bright polish on its medial-distal aspect. Striations were not detected. Rounding and smoothing is slight, and appears on microtopographical features on the medial aspect of the distal projection.

E.T. #9

E.T. #9 was used exclusively to work soaked antler. Its distal projection margin exhibits pronounced edge rounding and smoothing on both the distal edge and ventral-lateral corners. Polish is absent, and only one microflake scar (.2 mm) is present. Edge crushing is pronounced, and appears along the entire distal tip margin. A small burin-like spall was also removed from the right ventral-lateral corner along the very distal aspect of the "opposite" margin (Figure 64).

For the concave margin, moderate edge rounding and smoothing, and pronounced crushing appear along the entire edge. Polish or striations are not indicated. Six microflake scars, averaging .8 mm in size, and ranging between .4 and 1.2 mm, appear randomly along the entire edge. The most common microflake scar plan type is circular-expanding (n=3), followed by crescentic (n=2), and one is pointed. The most frequent termination type is deep-stepped (n=4), followed by snapped (n=2). All six microflake initiations are the "bending" type.

Comparison of Figures 64a and 64b indicate that considerable portions of the edges on the distal projection tip and concave margin were lost during use. This is attributed entirely to acute edge crushing and microflake removal from the dorsal edge aspects of these margins (see below).

The "opposite" margin was used very briefly, and bears slight edge rounding and smoothing along its medial aspect. Polish, striations, or crushing were not observed. One microflake scar about 1.5 mm in diameter is present on the medial-distal edge aspect. It has a trapezoidal outline and deep-stepped termination.

Descriptive Comparison and Observations

Comparison of combined microwear trace patterns observed on E.T.'s #7 and #9, which were used on soaked antler, with the most frequently represented patterns observed on the prehistoric microwear sub-sample specimens and the eight experimental wood-working tools, display some similarities and a number of salient differences.

Major differences are apparent by: (1) the unusually acute degree of edge crushing on the distal tip; (2) the significantly larger mean microflake scar size on the distal tip margin; (3) the notably larger mean microflake scar size on the concave margin; (4) the very high incidence of deep-stepped and snap terminated microflake scars on the concave margin; and (5) the pronounced intensity and location of crushing on the concave margin.

When compared to other experimental results involving bone and antler conducted by other researchers, the microwear traces on E.T.'s #7 and #9 are noted to be quite similar. The pronounced edge damage and microwear traces exhibited on the distal projection of E.T. #7, used to engrave soaked antler, is identical to that incurred on experimental chert graving tools used on antler by Lynott (1975) and Moss and Newcomer (1982:309). The nature, intensity, and location of polish on the ventral edge aspects and ventral face of E.T. #7 is very similar to that observed on experimental tools used on bone and antler by Keeley and Newcomer (1977:39,42-44), Keeley (1980:56), and Vaughan (1985:31-33). The intensity and location of polish represented on E.T. #7 is also similar to one of the more frequent microwear pattern types represented in the sample of 35 prehistoric microwear sub-sample specimens.

There is some similarity in the degree and location of edge rounding, smoothing, and edge polish on the concave margin with those of the prehistoric microwear sub-sample. Unfortunately, in its early stages of development, antler polish has been noted to be almost indistinguishable from wood polish (Keeley 1980:56). Therefore, that polish can be regarded as a reliable diagnostic trait for distinguishing between working wood and antler is rendered suspect in this study.

One major difference between polishes represented in both contact material categories was that the intensity of bone/antler polish along the immediate edges was not as bright as was noted for many of the woodworking tools, and it tends to have more of an "even" intensity over the polished area (compare Figure 62 with Figures 54, 56, 58, 59, 61 and 63). Even though the bone/antler polish formed much more rapidly than woodworking polish, it appears that the rapid rate of attrition and edge loss along the concave margin did not permit development of bright polish in this area.

Severe edge damage and removal of considerable portions of working edges on both E.T.'s #7 and #9 is a phenomenon that has also been noted by other researchers for experimental tools engaged in working bone and antler (Brink 1978b:367; Keely and Newcomer 1977:44; Keeley 1980:44,56; Vaughan 1985:32; Richards 1987:117-130). This pronounced degree and rapid rate of edge deterioration was not observed on the eight experimental woodworking tools, nor is it commonly indicated for the prehistoric microwear sub-sample specimens (Appendix 6).

As mentioned above, one of the most striking differences between the microwear trace patterns on the two experimental tools used on bone and antler compared to those on the eight woodworking tools and the prehistoric microwear sub-sample specimens is the significantly higher preponderance of deep-stepped and snap terminated microflake scars on the working edges. They are either very rare or absent in the latter two samples (see Tables 7 to 10). This is commensurate with observations made by other researchers that such termination types are commonly associated with working "hard" contact materials, notably antler and bone (Tringham *et al* 1974:188; Keeley 1980:56; Odell and Odell-Vereecken 1980:101; Vaughan 1985:21).

8.4 Summary and Discussion of Descriptive Comparisons

Microwear trace patterns observed on the eight experimental woodworking tools are somewhat varied, although most are either identical to, or very similar to, the spectrum of attributes recorded for the prehistoric microwear sub-sample, and for other experimental and/or ethnographic woodworking tools made from cryptocrystalline silicates.

The woodworking tool sample clearly possesses higher microflake scar frequencies per tool compared to the prehistoric microwear sub-sample specimens. There are at least three reasons for this. First, three of the experimental tools were made from lithic raw materials *not* commonly used to produce prehistoric key-shaped formed unifaces. Because these materials are softer and more brittle than the other lithic types used, they are more prone to microflake removal, pronounced rounding, smoothing, and crushing (see Chapters 3.3.3; Appendix 7;

Figures 60, 64 and 65).

Second, many of the experimental tools were used until they became quite dull (Appendix 9). I argue that prehistoric resharpening practices would most likely have been initiated fairly regularly to restore optimal edge efficiency (Chapter 3.3.2), resulting in microflake scars -- and other trace types -- being regularly removed from the edge aspects of tools. Therefore, microflake scar frequencies on prehistoric specimens are logically expected to display variability owing directly to resharpening practices.

Lastly, idiosyncratic motor patterns are considered to have played an important part in the development of some microwear traces (Chapter 7.7; Appendix 9). Persons adopting aggressive motor pattern styles involving inordinately heavy loads of applied pressure were observed to be more apt to produce greater microflake scar frequencies than persons executing passive motor patterns.

Most of the other mean values for continuous microwear attribute variables observed on the experimental woodworking tools suggest that they are about half as large as those represented in the prehistoric microwear sub-sample (Tables 5 and 6). I suggest that these disparities in size can be attributed to several reasons.

First, as previously indicated, differences in the mean size of microflake scars on experimentally used lithic tools have been previously correlated with the relative hardnesses of contact materials being worked (see Odell and Odell-Vereecken 1980:101; Richards 1987:181). I maintain that on occasion, the relative hardness of contact materials worked by many of the key-shaped formed unifaces comprising the prehistoric microwear sub-sample were harder than the green woody plants used in the experimental component of this study. The significantly larger mean microflake scar size obtained by working seasoned saskatoon with E.T. #3 compared to when it was used on green saskatoon suggests that working seasoned wood can account for this size disparity. Indeed, it seems inevitable that seasoned wood must have been occasionally worked in prehistoric times, particularly when refurbishing or repairing dried-out wooden implements.

Second, incidental forceful contact of tool edges against hard objects can often produce large microflake scars. I suggest that edges of prehistoric tools probably incurred at least some degree of accidental traumatic edge damage during prehistoric transport and storage, and perhaps post-depositionally by contemporary artifact transport, handling, and storage.

Third, for prehistoric tools, the distal projection tip margin and the "opposite" margin would most probably have been resharpened much less frequently than the concave margin because of their lesser functional importance. Therefore, these margins were more likely to have retained evidence of microwear traces incurred during use, and from incidental traumatic episodes.

The intensity and magnitude of striations indicated on the ventral faces of prehistoric key-shaped formed unifaces are interpreted to be an indication of the amount of abrasive particles (e.g., sand, silt, dust, and grit) represented in the immediate working environment. Striation intensity also provides a relative index of how long tools were were used in such contexts. Those used for long periods where abrasive particles were abundant display very high striation frequencies (e.g., Figures 23 to 28). Prehistoric tools displaying moderate to pronounced microwear intensities, but lacking or having very few striations, were likely used in working contexts were abrasive particles were absent or relatively rare. That very few striations were observed on the experimental tools, despite having been used for substantial periods, suggests that many prehistoric key-shaped formed unifaces must have been used for very long periods in use-contexts where abrasive particles were far more abundant than in the experimental settings.

The relatively high incidence of striations evident on many of the prehistoric key-shaped formed unifaces has at least three other important potential implications. First, it suggests that these tools were most commonly used during drier, or non-winter months of the year, since abrasive particles are more likely to be introduced between a tool edge and contact material when they are most mobile and can be readily transported and/or transferred to contact materials by natural or cultural agencies (e.g., wind, pedestrian traffic, or resting materials on the ground). Frozen ground and snow cover during the winter, and moist ground conditions during the late fall and spring, would have severely restricted environmental exposure and mobility of abrasive agents, thereby minimizing striation development. The apparently higher recovery frequencies of key-shaped formed unifaces at non-housepit sites compared to winter pithouse village sites lends further support to this conjecture (see Chapters 3.6 and 9.2).

Second, the high incidence of striations on prehistoric specimens suggests that many were probably frequently used at residential and/or resource extraction sites located in valley bottom contexts. Because environmental conditions appear to have changed relatively little over the last 4000 years on the Plateau (Hebda 1982; Mathewes 1985; Campbell 1985:149-178; Richards and Rousseau 1987:23) I have assumed that lowland vegetation cover was typically as sparse during this period as it is today. Therefore, abrasive particles derived from exposed soils and sediments could have been readily introduced to the surfaces of contact materials. Conversely, mid-altitude and upland contexts were more likely to have had much greater vegetation and littermat cover, which would have significantly reduced the availability of abrasive agents in immediate working environments.

Lastly, and most importantly, the character and intensity of striations appearing on many of the prehistoric tools indicate that the primary contact material being worked had highly efficient abrasive particle "holding" or "fixing" properties. This refers to the ability of a contact material to transfix, stabilize, and maintain abrasive agents in direct contact with a tool during use (see Lawn and Marshall 1979:79-81; Knutsson 1988:92).

Green wood is regarded to be a very proficient fixer because when freshly exposed, its relatively yielding and moist surface can easily trap and hold abrasive particles within and between wood fibres. When green wood containing fixed abrasive particles is worked, continuous and morphologically regular striations are produced on the edges and surfaces of the stone tools used (see Knutsson 1988:92). In contrast, seasoned wood, antler, and bone do not readily trap abrasive grains because of their greater hardness and density, and particles are transfixed only momentarily or roll around freely. This produces striations that are more likely to be morphologically irregular and discontinuous. Following these criteria, it would appear that striations produced on almost all of the specimens in the prehistoric microwear sub-sample were produced by a contact material with holding/fixing properties more similar to that of green wood than with those characteristic of seasoned wood, antler, or bone.

Prehension wear resulting from contact with the experimenter's fingers (Chapters 6.1.6 and 6.3) was *not* observed on the dorsal surfaces of any of the experimental tools. I posit that such wear can only develop when appreciable amounts of abrasive agents adhering to fingers are repeatedly rubbed in specific areas of a tool's surface for very long periods of time (see also Vaughan 1985:39). This further supports the conjecture that many key-shaped formed unifaces certainly must have had exceptionally long use-lives. It can be further argued that if the primary function of key-shaped formed unifaces involved working soaked bone or antler, the resulting rapid edge loss and severe edge damage on the concave marign would have exhausted the use-life potential of most all key-shaped formed unifaces long before any finger prehension polish could develop.

Prehension wear resulting from loose hafts was also lacking in the experimental tool sample. However, this is not surprising since all experimental tools remained relatively secure in their hafts throughout most of their use-lives. The very low incidence of haft-type prehension wear represented on prehistoric specimens suggests that most hafted tools were probably also rigidly secured.

Sampling problems aside, qualitative and quantitative comparisons of microwear trace patterns exhibited on the eight experimental woodworking tools indicate that they are either identical to, very similar to, and/or are within the range of variation of characteristics exhibited by, the majority of specimens comprising the prehistoric microwear sub-sample.

Microwear trace patterns incurred on the two experimental tools used on soaked bone and/or antler display some similarities with those observed on the prehistoric microwear sub-sample specimens. Soaked bone and soaked antler polish is somewhat similar to polish resulting from working green wood. Also, the larger average microflake scar size observed on E.T. #7, used on soaked antler, is closer to that indicated for the prehistoric microwear sub-sample than it is for the experimental tools used on green woods. However, it was determined that working seasoned saskatoon also produces larger mean microflake scar sizes than was obtained working green woods.

Experimental tools used on soaked antler and bone display several salient differences when compared with most of prehistoric microwear sub-sample specimens and the experimental tools engaged in working green wood. These differences include: (1) a more homogeneous (i.e., non-differential) polish intensity on the ventral face which appeared most commonly on prominent microtopographical features; (2) slightly less polish intensity along the immediate concave margin ventral edge aspect, probably because of rapid edge deterioration rates; (3) severe edge damage in the form of pronounced crushing and rounding, and intensive dorsal microflake removal; and (4) most microflake scars terminate in deep-stepped and snap terminations, whereas these termination types are very rare or completely absent on prehistoric microwear sub-sample specimens and experimental woodworking tools.

After a collective and judgemental assessment and comparison of the microwear trace patters exhibited by the experimental tools and the prehistoric microwear sub-sample specimens, I conclude that there is greater overall similarity between microwear trace patterns observed on the eight experimental woodworking tools with those on the prehistoric specimens than there is with those represented on the two experimental tools used on bone and antler. It seems then, that the most parsimonius explanation to account for this similarity is that the primary function of prehistoric key-shaped formed unifaces involved the working of green woody plants, and on occasion, seasoned wood. Thus, the hypothesis that they functioned mainly in a woodworking capacity is accepted.

However, it should be noted that there is a modicum of similarity indicated between microwear traces exhibited on the experimental tools used on soaked antler and those noted on a few specimens in the prehistoric microwear sub-sample. Therefore, that key-shaped formed unifaces may have been used prehistorically to occasionally work soaked or boiled antler cannot be confidently negated, and it is quite possible that this may have been a "secondary" function associated with this tool type.

CHAPTER 9

STATISTICAL ANALYSIS

9.1 Introduction

A simple statistical analysis of data derived from key-shaped formed unifaces was conducted at Simon Fraser University using the Michigan Interactive Data Analysis System (MIDAS) programs (Fox and Guire 1976). The resulting statistical measures were used to help describe and compare various selected qualitative and quantitative attribute variables possessed by: (1) the 129 specimens comprising the prehistoric study sample; (2) the 35 items representing the prehistoric microwear sub-sample; and (3) the eight replicated experimental woodworking tools (Chapters 2.2, 6 and 8; Appendices 3 and 6; Tables 1 and 5 to 13).

9.2 Statistical Methods and Procedures

Descriptive Statistics

The objective of the descriptive statistical analysis was to generate measures that could be used to help describe and compare attribute variables between sample specimens, and between sample sets.

Common measures of central tendency and dispersion (e.g., mean, mode, standard deviation, minimum and maximum values) were calculated for continuous variables. These are presented in Tables 1, 5 and 6. Continuous variable data were recorded and described using common units of measurement (i.e., grams, millimeters, and angles). Nominal and ordinal scale variable data are presented in Appendices 3 and 6.

Frequency histograms for individual continuous and discrete variables were produced using several different interval widths. They provided visual impressions of frequency distributions that were useful for detecting significant data clustering and/or skewness.

Inferential Statistics

Use of inferential statistical procedures to assist in interpreting data derived from microwear studies is not a common practice despite their previously acknowledged potential (see Nance 1979; Stafford and Stafford 1979). Nevertheless, some studies have successfully employed statistical methods to solve a number of problems (Chandler and Ware 1976; Nance 1977; Stafford 1977; Odell 1977; Siegel 1984,1985; Vaughan 1985; Schutt 1982; Lewenstein 1981; Richards 1987).

The Pearson Product-Moment correlation coefficient (Blalock 1972:376-395; Freedman, Pisani, and Purves 1978: 116-120; Thomas 1986:383-387) was calculated for selected pairs of continuous variables exhibited on the prehistoric tools in order to determine the strength and direction of any linear relationships between them. A value of +1.00 is obtained when the case values for two variables are correlated in a positive direction (i.e., as the value of one variable increases, the other also increases proportionately). A value of -1.00 indicates that the case values are perfectly negatively correlated (i.e., as one variable increases, the other decreases proportionately). Correlation was assessed at the .05 significance level (Tables 11 and 12).

The strength and direction of relationships indicated between selected pairs of ordinal scale variables represented for the prehistoric microwear sub-sample specimens was determined using the Spearman Rank Order correlation coefficient (Leach 1979:190-194; Thomas 1986:395-405). This statistical test is the standard product-moment correlation coefficient for case values of two ranked variables being compared. A value of +1.00 is obtained when the rankings are identical in a positive direction (i.e., as the frequency or intensity of one variable increases, so does the other). A value of -1.00 indicates that the rankings are perfectly negatively correlated (i.e., when one variable increases in frequency or intensity, and the other decreases proportionately).

For this calculation, each ordinal variable was ranked according to ascending value or level of degree. Microflake frequencies for the primary functional edges were ranked using a four-part scale. For the distal projection tip: (1) = absence of microflakes; (2) = 1 microflake; (3) = 2 microflakes; and (4) = more than 3 microflakes. For the concave and "opposite" margins: (1) = 0 to 2 microflakes; (2) = 3 to 5 microflakes; (3) = 6 to 8 microflakes; and (4) = 9 to 11 microflakes. Mean edge angles for all three margins were also ranked using a four part scale: (1) = 30° to 55°; (2) = 60° to 75°; (3) = 80° to 95°; and (4) = 100° to 115°.

Four-part scales were also used to rank relative degrees of edge rounding and smoothing intensity, crushing intensity, and striation intensity (1) = absent; (2) = slight; (3) = moderate; and (4) = pronounced); and polish intensity, (1) = absent; (2) = dull; (3) = moderately bright; and (4) = bright. Again, correlation strength was assessed at the .05 significance level. Values for Spearman's rank-order correlation coefficients for selected pairs of variables are presented in Table 13 and their interpreted significance is discussed below.

Scatter plots for selected pairs of variables were also generated to provide a visual supplement to the correlation coefficients to detect clustering, linear relationships, and outliers.

9.3 Study Sample Statistical Analysis Results

High frequencies of certain variables represented in the 129 prehistoric study sample specimens were considered to be indicative of certain important and deliberate decisions made by prehistoric people during the manufacture of key-shaped formed unifaces, and they also reflect recurrent and predominant behaviour patterns associated with their use. Several traits are rather obvious because of their high frequencies, and are worthy of mention and discussion here.

The majority (54.3%) of the 129 key-shaped formed unifaces comprising the prehistoric study sample were recovered from housepit sites (i.e., winter pithouse villages), and (34.9%) were found at lithic scatter sites (i.e., non-housepit encampments and/or resource extraction and processing locations). Thus, at first glance it appears that these tools are more commonly represented at winter pithouse villages than at lithic scatter sites. However, the sample population from which the tools were drawn is very heavily biased in favour of housepit sites because most Canadian Plateau researchers have chosen to conduct large-scale excavations at pithouse villages, and past resource management policy has relegated high priority status to this site type. Indeed, about 70% of *all* excavated components on the Canadian Plateau are from housepit sites, and many have been extensively and intensively investigated. Only about 15% of components excavated on the Canadian Plateau belong to non-housepit lithic scatter sites (see Richards and Rousseau 1987: Tables 1-3). This is unfortunate, since it is my experienced impression that lithic scatter sites on the Canadian Plateau dating between ca. 3500 and 1000 BP are far more numerous than housepit sites belonging to the same period.

If key-shaped formed unifaces were made, used, and discarded just as frequently at housepit sites as they were at large non-housepit lithic scatter sites between ca. 3500 and 1000 BP, it follows that the relative frequencies of these items should be more or less similar in tool assemblages of comparable size from both site types. However, this pattern does not seem to be the rule. Notably high frequencies of key-shaped formed unifaces compared to other chipped stone tool types have been recovered from several excavated and surface collected non-housepit residential base camp sites dating between ca. 3500 and 1000 BP. These sites include EaQl 10 and EaQl 14 in the Arrow Lakes region, DhQv 48 (Copp 1979) and DlQv 39 (Rousseau 1984) in the Okanagan Valley, and FiRs 1 in the Chilcotin region (Fladmark 1976; Montgomery 1978).

Although numerous key-shaped formed unifaces have been recovered from housepit sites EeQw 3 and EeQw 6 in the South Thompson - Shuswap region (Fladmark pers. comm. 1988), they represent only a small proportion of thousands of artifacts surface collected from these two very large pithouse villages. Several extensively excavated housepit sites on the Canadian Plateau have also yielded very large assemblages of chipped stone tools from components predating ca. 1000 BP, but these sites have all produced comparatively low frequencies of key-shaped formed unifaces (see Borden 1968; Stryd 1973; Turnbull 1977; Wilson 1980; Richards and Rousseau 1982; Hayden pers. comm. 1988).

As I have previously suggested and discussed in Chapters 3.3, 3.6 and 8.4, it seems that key-shaped formed unifaces were used most frequently during non-winter months of the year. Given the increased group and residential mobility practiced by most Interior Plateau groups during the non-winter months to exploit and process seasonally available and widely distributed resources (see Teit 1900,1909; Ray 1933; Palmer 1975), adoption and extensive implementation of task-specific curated tool technologies would have helped to mitigate the severity of logistical problems presented directly by, or associated with, these subsistence activities. Highly reliable and maintainable curated tools (Bleed 1986) were often used by aboriginal hunter-gatherer groups participating in a logistical subsistence and settlement system because: (1) they allowed mobile task groups to "gear up" with task-specific tools prior to leaving base camps on subsistence forays so that extraction and processing activities could be quickly and effectively dispatched at resource locations (Binford 1979); (2) they helped to alleviate "time-stress" problems arising from mutually conflicting resource procurement and processing activites and the time required to produce tools needed to undertake them (Torrence 1983); and (3) they helped to extend tool use-lives and accomodate recycling, which helped to offset critical shortages of raw materials required for tool production (Bamforth 1986a). Since key-shaped formed unifaces are plainly efficient, reliable, and maintainable, and constitute a task-specific component of a curated technological system (Chapter 3.6), I suggest it is realistic to expect that they would have been commonly used and discarded at sites occupied during non-winter months of the year (i.e., large "lithic scatter" residential base camp sites) when logistical subsistence practices were most intense.

In contrast, heavy reliance on stored resources during the winter months was accompanied by a marked reduction in group mobility and scheduling stress, and ample raw materials for tool production were most probably collected and stored at pithouse villages prior to the onset of inclement weather. Therefore, high frequencies of "expediently" produced lithic tools (i.e., utilized flakes, unformed unifaces) compared to other well-made formed/curated tools (i.e., endscrapers, knives, drills, perforators, gravers, etc.) observed in many excavated assemblages from winter housepit sites is a commonly observed pattern that should be neither surprising or unexpected (see also Parry and Kelly 1987).

In conclusion, I submit that the currently held impression that key-shaped formed unifaces constitute a relatively "rare" tool type on the Plateau might be more correctly attributable to biases related to researcher interest and heritage resource management policy which have both long emphasized a priority for investigation of winter housepit sites. Future excavations conducted at non-winter residential base camps sites with components dating between ca. 3500 and 1000 BP will likely indicate that these tools are indeed more common at this site type than at housepit sites, and that they are really not as rare as currently perceived. Unfortunately, the presently small sample of excavated non-winter residential base camp sites from the Canadian Plateau does not allow this hypothesis to be adequately assessed.

Large, non-winter, base camps and aggregation sites might be expected to contain a greater frequency of key-shaped formed unifaces because retooling and discard of curated tools were likely common practices at such sites (see also Keeley 1982). Alternately, I expect that key-shaped formed unifaces will be relatively rare at small, short-term, task-specific, resource extraction and/or processing locations (i.e., root roasting sites, hunting lookouts, small hunting camps, fishing stations, etc.) which are associated with a high degree of mobility and curational behaviour. The notable paucity of key-shaped formed unifaces at many intensively investigated sites of these types in Upper Hat Creek Valley (Pokotylo pers. comm. 1989) supports this hypothesis.

Descriptive statistical analysis of the 129 key-shaped formed unifaces comprising the prehistoric study sample also indicates high frequencies for items produced from chalcedonies (60.5%) and cherts (27.9%). Together they constitute 88.4% of the tools in the study sample, whereas basalt tools include only 11.6%. This is highly conspicuous and significant since basalt usually comprises between 70% and 90% of tools and debitage in most assemblages on the Canadian Plateau. There was clearly a strong selective preference for using cryptorystalline silicates to manufacture key-shaped formed unifaces, presumably to effectively satisfy needs relating to tool efficiency, reliability, and maintainability (see Chapters 3.3, 3.5 and 3.6). This raw material predilection might not be so obvious for sites on the Columbia Plateau where good quality basalts are usually rare, and silicate tools and debitage typically constitute large proportions of most assemblages.

Evidence for thermal alteration was observed on 27.1% of the specimens in the study sample (Appendix 3). Of these, 85.7% are chalcedony and 15.3% are chert. Chalcedony tools are slightly more than twice as common than chert specimens (68.4% and 31.6% respectively). If the relative incidence of thermal alteration was more or less similar for both these lithic material categories, the expected proportion of thermally altered chalcedony items vs. thermally altered chert specimens should be about 2.16 to 1, or 24 and 11 items respectively, but actual frequencies are 30 and 5 respectively.

The relative frequencies of thermally altered chalcedony and chert specimens reveal that chalcedony flake blanks used to make key-shaped formed unifaces were about three times more likely to have been thermally altered than those of chert. The reason for this disparity is probably due to the fact that most "raw" (i.e., unaltered) chalcedonies usually display a high incidence of internal groundmass flawing, they are less abundant than most types of cherts, and on average, cobbles and chunks of chalcedony tend to be smaller. Given that the hardness and durability properties inherent in most chalcedonies were considered to be optimally suited for satisying functional and technological demands associated with the use and maintenence of key-shaped formed unifaces, thermal treatment would have partially rectified problems relating to internal flawing, scarcity, and small core size. Experimental thermal treatment of silicates has shown that it can often significantly improve the potential to reliably produce large flake blanks and enhance overall flakability by annealing internal flawing. In some instances it may have also increased edge sharpness (see Chapter 3.3.3). Alternately, it appears that most cherts were considered to be suitable for producing key-shaped formed unifaces in an unaltered state, probably because the incidence of flawing is generally less frequent for this material type category, and large cores from which suitable flake blanks could be derived were more abundant.

About 45.0% of the specimens in the study sample can be assigned to either of three late prehistoric cultural horizons defined by Richards and Rousseau (1987) through absolute and/or relative dating methods. Of the items with known age affiliation, 15.5% belong to the Shuswap horizon (ca. 3500 to 2400 BP), 82.7% relate to the Plateau horizon (ca. 2400 to 1200 BP), and only 1.7% date to the Kamloops horizon (ca. 1200 to 200 BP).

At present, the number of excavated Shuswap horizon components ($n \simeq 25$) is slightly less than half the number of investigated Plateau horizon components ($n \simeq 60$), and about a third the number of investigated Kamloops horizon components ($n \simeq 75$) (see Richards and Rousseau 1987:Tables 1-3). A sampling bias is strongly suspected with respect to the relative proportions of components representing each of these three horizons, particularly with regard to Shuswap horizon occupations.

The number of excavated Shuswap horizon components relative to the numbers of excavated components belonging to the following Plateau and Kamloops horizons is most certainly underrepresented with respect to the true (i.e., actual) proportions of components belonging to each of these horizons on the Canadian Plateau. There appears to be at least two important reasons for this situation. First, because Shuswap horizon non-housepit lithic scatter components are usually more deeply buried than those dating to the later Plateau and Kamloops horizons, they have been more difficult to detect during site surveys, and consequently have escaped being investigated.

Second, many Shuswap horizon pithouse villages were established in locations that were also favoured by people participating in the following two horizons. Numerous housepit site investigations indicate that aboriginal reconstruction and reoccupation of abandoned house depressions was a common practice that often involved removal of unwanted floor deposits from previous occupations and/or enlargement of a house depression. Both these activities resulted in earlier artifactual materials being redeposited outside the house floors onto the surrounding house rims (see Blake 1974; Fladmark 1982:123; Hayden *et al* 1986,1987). Therefore, as a general rule, most investigations of housepit floors indicate that they usually contain evidence of the last, or most recent occupation(s). Since the majority of investigations conducted at multicomponent pithouse villages have focussed primarily on sampling house floor deposits, and not house rims, materials belonging to earlier occupations (e.g., a Shuswap horizon component) have often been missed, or are significantly underrepresented in excavated assemblages.

Considering the abovementioned factors, it is really not surprising that very few sites dating between ca. 3500 and 2400 BP have been identified or investigated on the Canadian Plateau. I suspect that once a larger sample of Shuswap horizon sites are examined, -- particularly non-winter residential base camps -- it will probably be revealed that key-shaped formed unifaces are more commonly represented in components belonging to this period than is suggested by the results of the present study.

The very high frequency (82.7%) of study sample specimens assigned to the Plateau horizon (ca. 2400 to 1200 BP) indicates that key-shaped formed unifaces were used quite regularly during this period. Despite the apparent sampling problems perceived to be associated with investigation of Shuswap horizon components, I suggest that in general, these tools were probably used more frequently during the Plateau horizon than during the Shuswap horizon. However, a larger sample of Shuswap horizon components would be required to adequately assess the veracity of this postulate.

Interestingly, the high frequency of key-shaped formed unifaces represented in Plateau horizon components corresponds with a period when logistical subsistence practices were significantly intensified relative to the previous Shuswap horizon (Chapter 3.6; Lawhead, Stryd and Curtin 1986:31-32; Richards and Rousseau 1987:56-57). That curated technologies were often engaged to increase resource procurement and processing efficiency and to mitigate problems associated with scheduling stress and raw material shortages, it seems logical that key-shaped formed unifaces (and other task-specific curated tools), would have been more commonly used during this time.

Only one specimen in the study sample was recovered from a context belonging to the Kamloops horizon (ca. 1200 to 200 BP). It is associated with a radiocarbon age and diagnostic artifacts that place it solidly within the first 200 years of this horizon (Table 2). The apparent absence of this tool type between ca. 1000 to 200 BP is considered highly significant given the exceptionally large number of excavated Kamloops horizon components. A ca. 1000 BP termination date is also indicated for the Columbia Plateau and Arctic (see Chapter 4.2 and Table 2). A suspected primary reason for discontinued use of this tool type at about this time is offered in Chapter 10.

When the 129 study sample specimens are laid ventral face down with their projections oriented distally, 89.1% have the concave margin on their left side, and 10.9% have it on their right. Right-handed persons typically comprise

88% to 90% of any contemporary population, whereas left-handed people make up the other 10% to 12% (Bakan, pers. comm. 1987). Assuming that key-shaped formed unifaces were always used with the hand of preference, as they were in the experimental component of this study (Chapter 7), it follows that right-handed aboriginal people used tools with concave margins on the left side of the tool, and for left-handed people it was on the right. This proportionality again supports the conclusion that the concave margin was the primary functional edge of key-shaped formed unifaces, and that it was engaged primarily by drawing it toward the user.

Residue deposits derived from contact materials were observed adhering to the surfaces of 28.7% of the study sample specimens. These residues had survived for one to three millennia (Chapter 5.3). The actual number of tools initially bearing residue deposits may have been greater, but depositional conditions and the common practice of thoroughly washing lithic artifacts prior to analysis may have resulted in removing them from many specimens.

Although sample sizes of key-shaped formed unifaces from five of the ten archaeological regions on the Canadian Plateau are too small to be statistically reliable or significant (Appendix 4), a preliminary inter-regional comparison of selected characteristics was undertaken for regional samples with greater than ten specimens. These regions include the Chilcotin (n=12 items), Mid-Fraser (n=16), South Thompson - Shuswap (n=42), South Okanagan (n=11), and Arrow Lakes (n=30).

Relative percentages of the three main lithic raw material type categories (chalcedony, chert, basalt) represented in these five regional samples suggests that approximate proportional similarity exists between the Mid-Fraser and Chilcotin regions where chalcedony constitutes about 75-80% of the specimens, chert 6-8%, and basalt 12-17%. This is not surprising since both regions are geographically juxtaposed, and they share similar geologic and physical environments. Chalcedony is also the dominant (57%) raw material in the Arrow Lakes sample, whereas chert comprises 40%, and basalt 3%. This pattern probably reflects a greater local availability of chalcedonies relative to cherts. For the South Thompson - Shuswap region, most of the specimens (ca. 45%) are made of chert, 33% are chalcedony, and 22% are basalt. This likely indicates that cherts are slightly more naturally abundant than chalcedonies in this region. The greater proportion of basalt tools compared to other regional samples is not entirely surprising, since there is an abundance of good quality basalts in the nearby Arrowstone Hills, and basalts almost invariably comprise about 80% to 90% of all lithic assemblages in this region. Chalcedony is the dominant (91%) lithic material type category represented in the South Okanagan regional sample, and basalts comprise the remaining 9%. Here, a regional scarcity of good quality cherts is suggested. Generally, the proportions of lithic raw material type categories repesented in these five regional samples again emphasize the preferential exploitation of local cryptocrystalline silicates over more abundant and readily available basalts, and also reflects the relative local natural abundance and availability of chaledonies and cherts.

The Chilcotin regional sample indicates that about 50% of its specimens have been made from thermally altered flake blanks, the Mid-Fraser region sample indicates 25%, South Thompson - Shuswap 10%, South Okanagan 36%,and the Arrow Lakes 24%. Thermal alteration of silicates may have been more commonly practiced in the Chilcotin region than in the Mid-Fraser River region, since both regional samples have similar raw material type category proportions (see above). The very low incidence of thermal alteration indicated for the South Thompson Shuswap region specimens is likely owing to greater local availability of cherts, since collective analysis of the 129 study sample specimens indicates that chalcedony tools are about three times more likely to have been thermally altered than those produced from cherts (see above). The percentages of thermally altered specimens from the South Okanagan and adjacent Arrow Lakes are somewhat similar, and not unexpectedly, these samples both contain relatively high proportions of chalcedony tools. In sum, lithic material thermal alteration practices appear to have been most common in regions where abundance and availability of chalcedonies dominate that of cherts.

All of the key-shaped formed unifaces with known age affiliation in the Chilcotin and South Okanagan regional samples belong to the Plateau horizon (ca. 2400 to 1200 BP). For the Mid-Fraser region 4% are from Shuswap horizon (ca. 3500 to 1200 BP) contexts, 82% belong to the Plateau horizon, and the remaining 4% date to the early Kamloops horizon (ca. 1200 to 1000 BP). For the South Thompson - Shuswap regional sample, 8% are affiliated with the Shuswap horizon, and 92% belong to the Plateau horizon. The high frequency of these tools in Plateau horizon contexts in these regions is commensurate with the expected pattern determined for the 129 study sample specimens (see above). About 60% of the Arrow Lakes region sample specimens date to the Shuswap horizon, and the remaining 40% relate to the Plateau horzion. This pattern is attributed to sampling bias, since most of the excavated components from which the Arrow Lakes specimens were drawn date to the Shuswap horizon.

Inferential Analysis

Results of the Pearson Product-Moment correlation coefficient analysis for selected pairs of continuous variables represented in the 129 study sample specimens produced fairly predictable results (Table 11). Moderately strong positive correlations are indicated for the relationship between margin edge angles and their respective spine-plane angles. This is not surprising, since both measures are sometimes the same measurement, or usually differ only slightly from each other.

Moderately strong positive correlations are also evident between the maximum tool length and maximum width, and between maximum tool width and proximal margin length. Moderately weak positive correlations are noted between: (1) maximum tool length and maximum thickness; (2) maximum tool length and projection medial width; (3) maximum tool width and maximum tool thickness; and (4) concave margin curvature depth and concave margin length. Again, these general relationships are expected. They simply reflect typical dimensional attributes of a flake blank and aspects related to overall formal tool design.

9.4 Microwear Sub-sample Statistical Analysis Results

Descriptive and inferential statistics were also calculated to provide a comparative basis for microwear traces observed on the 35 prehistoric microwear sub-sample specimens with those exhibited on the eight experimental tools used to work green wood (Chapters 6, 7 and 8; Appendices 5 and 6; Tables 5 to 13).

Descriptive Analysis

Standard measures of central tendency and dispersion for discrete and continuous variables represented in the 35 prehistoric microwear sub-sample specimens and eight woodworking tools are presented in Tables 5 to 10. Their mean and variance values are considered to provide a "normative" account of recurrent attribute patternings related directly to the design of key-shaped formed unifaces, and to the predominant use-behaviours associated with their prehistoric use.

Frequencies and relative percentages of discrete nominal and ordinal scale variables are presented in Appendix 6. The most frequently represented attribute variables (i.e., highest percentages) are also taken to be strongly indicative of, and related to, the basic design of key-shaped formed unifaces and the most commonly executed use-behaviours associated with them. A summary of the descriptive statistical analysis results and comparison of the prehistoric microwear sub-sample with the replicated experimental tools has already been presented and discussed in Chapters 6 to 8, and thus need not be repeated here.

Inferential Analysis

Pearson product-moment correlation coefficients calculated for selected pairs of continuous and discrete variables observed on the 35 prehistoric microwear sub-sample items are presented in Table 12. The results indicate that there is very little or no significant correlation between most of the paired variables. This indicates that microwear trace patterns incurred on various parts of the tools often vary within and between specimens comprising the prehistoric microwear sub-sample. Nevertheless, a weak positive correlation is indicated between the concave margin mean microflake size and the "opposite" margin mean microflake size. This is likely due to both of these margins having been used on the same or similar contact materials with comparable levels of applied force.

For selected ordinal scale variables represented in the prehistoric microwear sub-sample, Spearman's rank-order correlation coefficients (Table 13) indicate moderately strong positive correlations between: (1) distal projection edge rounding intensity and distal tip polish intensity; (2) concave margin edge rounding intensity and concave margin polish intensity; and (3) "opposite" margin microflake scar frequency and "opposite" margin crushing intensity. Not surprisingly, these correlation results indicate that an increase in edge rounding on the distal projection tip and concave margin is quite often associated with a concomitant increase in polish intensity. Also, an increase in "opposite" margin microflake scar frequency is quite often associated with an increase in crushing intensity.

Moderately weak positive correlations are indicated between: (1) edge rounding intensities on the distal projection tip and concave margin; (2) polish intensities on the distal projection tip and concave margin; (3) concave margin edge rounding intensity and "opposite" margin edge rounding intensity; (4) concave margin microflake scar frequency and concave margin crushing intensity; (5) "opposite" margin rounding intensity and "opposite" margin polish intensity; (6) ventral face polish intensity and ventral face striation intensity; and (7) ventral face striation intensity and ventral face rounding intensity.

In general, the Spearman rank-order correlation coefficient results suggest that: (1) increases in edge rounding and polishing on the projection tip are often associated with corresponding increases of the same on the concave margin, supporting the conjecture that these two morphological features played a related and important role in the primary function of key-shaped formed unifaces; (2) an increase in edge rounding is often associated with an increase in edge polish on the distal projection tip, concave, and "opposite" margins; (3) an increase in microflake scar frequency often corresponds with an increase in edge crushing for the concave margin; and (4) an increase in ventral face striation intensity is often accompanied by an increase in ventral face polish and rounding intensity. Most of these correlations were self-evident during the microwear analyses (Chapters 6 and 8), and they are compatible with generalized patterns of various recurrent microwear trace associations observed by many previous researchers.

A moderately weak negative correlation is indicated between the concave margin mean edge angle and the concave margin edge rounding intensity. This suggests that as the concave margin edge angle increases, the edge rounding intensity decreases. This makes logical sense since an obtuse edge is much stronger and therefore less prone to being damaged or dulled under duress than an invasive edge (see also Wilmsen 1970; Hayden and Kamminga 1973; Cantwell 1979). Given that key-shaped formed unifaces were designed in an attempt to strike a optimal balance between functional efficiency, reliability, and longevity, it comes as no suprise that steep concave margin edge angles are a prominent and recurrent feature of these tools.

9.5 Experimental Tool Statistical Analysis

The eight experimental tools (E.T.'s #1- #6, #8 and #10), used to strip bark and work green wood, were analyzed collectively as a sub-sample. They were subjected to the same descriptive statistical analyses of microwear trace variables conducted for the 35 prehistoric microwear sub-sample specimens (Appendix 6; Table 6, 9 and 10). Detailed results of this comparative analysis are presented in Chapter 8, and thus are not repeated here. Meaningful inferential statistics could not be calculated for the eight woodworking tools because of small sample size.

A judgemental comparison of the descriptive statistical results generated for the eight woodworking tools and the prehistoric microwear sub-sample specimens suggests that microwear traces exhibited on both sample sets are quite similar, and the hypothesis that prehistoric key-shaped formed unifaces functioned primarily as woodworking tools was accepted. The few salient disparities displayed between the sample sets were potentially attributed to: (1) small sample size, (2) use of soft and/or brittle lithic raw materials to make the experimental tools; (3) that prehistorically, seasoned wood was very likely sometimes worked using this tool type, whereas the eight experimental tools used to generate the statistical analysis results were used exclusively on significantly softer green woods; and (4) that prehistoric tools may have been occasionally used in a secondary capacity to also work soaked or boiled antler.

CHAPTER 10

SUMMARY AND CONCLUSIONS

A study sample of 129 prehistoric "key-shaped" formed unifaces selected from excavated assemblages and surface collections from ten archaeological regions in British Columbia were examined in this study. The primary research objectives were: (1) to determine the approximate geographic extent and chronological distribution of key-shaped formed unifaces in northwestern North America; (2) to determine the primary function of this tool type on the Interior Plateau by undertaking a detailed research design that included design theory, microwear analyses, residue analyses, experimental tool replication and use; and (3) to interpret and discuss the cultural and technological ramifications of these results with respect to the later prehistoric period on the Interior Plateau.

The results have made several important contributions to our present understanding of Interior Plateau later prehistory from culture-historical, technological, and behavioural perspectives. The nature and implications of these contributions are briefly summarized and discussed below.

Current data suggest that chipped stone tools fitting the description of "key-shaped formed unifaces" as outlined in this study are commonly found in two environmentally different and non-adjacent culture areas: the Interior Plateau and some of its neighboring regions; and most of the Arctic.

On the Interior Plateau the northern geographic extent of key-shaped formed unifaces is not presently known due to a relative paucity of archaeological data from north-central and northern B.C., although they have been found in central British Columbia at Punchaw Lake near Prince George, and at Tezli Lake on the Blackwater River. Their western geographic extent is marked by the Coast Mountain range in B.C. and Cascade Mountains in Washington, the southern boundary appears to correspond approximately with the Washington/Oregon border, and the eastern limit corresponds with the western slopes of the Rocky Mountains in both Canada and the United States.

The known geographic distribution of key-shaped formed unifaces on the Plateau corresponds primarily with territories historically occupied by Interior Salish groups in the north, and several Sahaptin-speaking groups to the south. This indicates that these tools were used predominantly by people participating in typical "Plateau" adaptive patterns. It may eventually be determined that this tool type represents a culture trait unique to Salish-speaking groups. If this is so, it may have some interesting implications for group interaction and territorial displacement between 4000 and 1000 BP on the southern Columbia Plateau.

In the Arctic, tools morphologically similar to key-shaped formed unifaces have been found in components from Alaska to Labrador where they are known as "concave side-scrapers". It has been loosely inferred that they were used to work bone, antler, ivory, and wood. The high incidence of burination on the "opposite" margins on Arctic specimens is a salient feature that is lacking on the Plateau tools. It is possible that the Arctic analogues may have functioned in the same capacity as they did on the Plateau. However, I caution that this can only be corroborated by conducting a detailed study similar to that undertaken here, as it is potentially dangerous to infer functional parity simply on the basis of general morphological and technological similarity.

The chronological duration (i.e., temporal distribution) for the use of key-shaped formed unifaces on the Plateau was determined by documenting their association with radiocarbon dated components. Dates for the Canadian Plateau suggest that they appeared around 3000 years BP, and their use was discontinued after about 1000 BP. On the Columbia Plateau, the majority of key-shaped formed unifaces have been found in contexts dating to the same temporal range, but at least two dated components attest to their use around 4000 BP. They can now be formally recognized as being diagnostic temporal horizon markers that can be used to provide relative age estimates for Plateau components lacking other types of temporally diagnostic artifact types or datable organic materials. Eventually, it may be shown that they also appeared on the Canadian Plateau around 4000 BP (or shortly thereafter), but at present there are very few investigated components dated between 3000 and 4000 BP.

Arctic "concave side-scrapers" date between about 4500 and 1000 BP in both western and eastern sub-areas. They have been found in components belonging to the Arctic Small Tool tradition, and the later Norton and Dorset cultural complexes of the Paleo-Eskimo tradition.

The present spatial and temporal data allow that two models be advanced regarding the appearance and distribution of key-shaped formed unifaces in the Northwest. The first model suggests this tool type was initially invented in the Arctic around 4500 BP, and then their use spread rapidly southward via inland hunting groups to appear on the Plateau by about 4000 BP. The second model suggests that these tools may have been independently invented in two centers; first in the Arctic around 4500 BP, and again on the Columbia Plateau around 4000 BP. Parsimony and the current data suggest that the latter scenario is more likely. Adequate resolution of either model will require: (1) confirmation that the Arctic and Plateau tools functioned in the same general capacity; (2) determining if they are represented in late prehistoric components lying between the Plateau and the Arctic, thus indicating geographic contiguity; and (3) detailed investigation of a greater sample of components dating between ca. 4000 and 3000 BP on the Canadian Plateau.

Several theoretical and methodological approaches were used to determine the primary function of Interior Plateau key-shaped formed unifaces. They included design theory, residue analysis, microwear analysis, and experimental tool replication and use. This study provided an opportunity to assess the relevance, efficacy, drawbacks, and future potential of these approaches for solving a problem related to lithic tool function.

The design theory analysis was considered to be one of the more powerful approaches used in the study. It permitted several "primary" and "secondary" potential functions for key-shaped formed unifaces to be realized and subsequently explored. Design analysis should always be a component of any study aimed at assessing stone tool function(s).

The residue analysis was relatively cheap, easy to undertake, and provided very clear and useful results. I conclude that all three methods employed in this study appear to have good potential for assisting in determining the function(s) of some stone tools. However, I warn that conclusions regarding tool function(s) should not be drawn on the basis of residue analysis results alone, rather, residue analysis should be conducted as an adjunct inquiry to compliment several other analytic procedures. Best results were obtained for artifacts that had been washed poorly, or not at all. As some researchers have already emphasized, the common practice of thoroughly washing lithic artifacts should be strictly avoided in situations where residue analyses may be useful for solving specific functional problems.

Although very time consuming, microwear analyses of the prehistoric microwear sub-sample specimens and the experimentally used tools were extremely important and useful components of this study. They helped to reconstruct the motor patterns associated with the primary use of prehistoric Plateau key-shaped formed unifaces, and assisted in disclosing the general nature of the contact material being worked. Most importantly, the microwear analyses permitted the primary function of these tools to be inferred through a judgemental comparison of microwear traces observed on the prehistoric microwear sub-sample specimens with those on the experimental tools. The power, advantages, and benefits of microwear studies are numerous, and they need not be recounted here.

Replication and experimental use of ten key-shaped formed unifaces provided a great deal of important information and many valuable insights regarding the functional potential of this tool type, and contributed to the development of "middle range" theory on the Plateau. The experimental component of the study allowed the efficiency and motor patterns associated with this tool type to be realized while working three different categories of contact materials. It also permitted several different types of lithic raw materials to be evaluated with respect to how their physical properties were related to functional efficiency and tool-use longevity, and how they responded to microwear trace pattern development. This enabled the lithic material types to be ranked according to their relative overall functional and technological superiority. This ranking allowed a critical assessment of the hypothesis that the obvious prehistoric preferential selection of durable cryptocrystalline silicates for the production of key-shaped formed unifaces represented a decision to exploit their superior hardness and durability. The experimental component also allowed the effects and advantages of traditional hafting methods to be examined.

The statistical analyses were most important for providing measures used to generate the descriptions presented in this study, and they were also useful for quantifying data which revealed several significant behavioural patterns that might have otherwise not been realized.

The microwear and experimental analyses also indicated that most Plateau key-shaped formed unifaces were hafted. The experimental tool-use results suggests that hafted tools afforded greater overall tool manipulability, permitted heavy loads of pressure to be accurately applied during tool-use, and they reduced hand straining that is commonly associated with unhafted (i.e., hand-held) tools.

Key-shaped formed unifaces were also probably highly curated, as suggested by several important facts. Reasonable amounts of time were invested to produce these tools, and their recurrent formal outline indicates they were intended to be task-specific. Also, almost 90% are made from hard, resilient, and durable (tough) cryptocrystalline silicates that demonstrate exceptional functional use-life potential and resharpening capabilities. This indicates that they were designed to be highly efficient, reliable, maintainable, and they were also intended to have long use-lives. These characteristics are typical of most curated tools. Basalt, although commonly available, was rarely employed to make key-shaped formed unifaces because of its inferior hardness and durability, and much greater brittleness. Basalt dulls very rapidly compared to silicates when used on moderately hard and hard contact materials, and thus has much shorter tool use-life potential. Also, because basalt is quite brittle, it is more prone to breaking while being used or resharpened. Overall, basalt is less efficient, less reliable, and less maintainable, and these are highly undesirable characteristics for a lithic material intended to be employed to produce curated tools.

Use of key-shaped formed unifaces and other curated tools during the late prehistoric period on the Plateau is consistent with the established interpetation that people participated in primarily a "collector" or "logistical" subsistence and settlement system at that time. Use of task-specific curated tools, such as key-shaped formed unifaces, would have helped to attenuate time-stress problems created by mutually conflicting resource procurement and processing activities, which were further compounded by the time required to secure lithic raw materials and produce tools.

These scheduling problems would have been particularly prominent during the non-winter months (notably late spring and summer) when logistically organized subsistence activities were most intense. That many of the key-shaped formed unifaces examined in this study exhibit moderate to pronounced striation intensities lends support to this hypothesis, since mobile abrasive particles (i.e., sand, silt, dust, etc.) are most abundant in the environment during the drier non-winter months of the year. This suspected pattern is also evidenced by the observation that these tools are found in comparatively low frequencies at winter pithouse villages. An examination of the available excavation data, and my previous field experience, leads me to conclude that key-shaped formed unifaces are probably most commonly represented at non-winter residential base camp sites dating between ca. 3500 and 1200 BP. Unfortunately, only a few sites of this type have been investigated, and the scant data from them does not permit this hypothesis to be adequately assessed at this time. I believe that the apparent perception that these tools are relatively rare on the Canadian Plateau is due to past researcher and heritage resource management policy emphasis on investigating primarily pithouse sites.

The small number of specimens determined to belong to the Shuswap horizon (ca. 3500 to 2400 BP) is also attributed to sampling bias. There is little doubt that the proportion of investigated Shuswap horizon components relative to the number of excavated components belonging to the later Plateau and Kamloops horizons is underrepresented with respect to the actual (i.e., true existing) proportions of components belonging to each of these three horizons. This is because Shuswap horizon components are associated with less archaeological visibility than those belonging to the later two horizons. Once a larger sample of Shuswap horizon components have been investigated (notably non-winter lithic scatters), it will probably be revealed these tools were more commonly used during this period than is suggested by the results of this study.

Regardless of sampling problems, use of key-shaped formed unifaces appears to have been most intense during the Plateau horizon (ca. 2400 to 1200 BP). This corresponds with a period when it seems that logistically organized subsistence and settlement practices were significantly intensifed relative to the previous Shuswap horizon. As mentioned above, curated task-specific tools would have been advantageous in such adaptive contexts, and this is supported by the high frequency of key-shaped formed unifaces and other types of well-made curated tools used during this time (see Richards and Rousseau 1987:34-36).

Collectively assessed, the results of the analyses and approaches used in this study strongly suggest that the primary function of key-shaped formed unifaces on the Plateau involved working stalks and branches of small woody shrubs and trees. Specific tasks included bark stripping, removal of secondary branch nodes, and smoothing and significantly altering the primary stalk/branch shafts by scraping, shaving, planing, whittling, carving, and/or engraving actions.

This supports Fladmark's (1978) initial contention concerning the probable primary function of these tools. Henceforth, I suggest that transpiration of woodworking activities can, and should be, directly inferred for prehistoric Plateau occupations where these tools are commonly represented. Henceforth, an appropriate functional moniker such as "key-shaped woodworking tools" should be used to refer to this tool category. However, I must caution that inferring that these tools were used *exclusively* to work wood may not always be entirely correct, as the experimental and microwear analyses provide sufficient data and reason to suggest that it is quite possible that they could have also been occasionally used in a secondary functional capacity to scrape soaked or boiled deer antler. Nevertheless, I am quite confident that unsoaked antler, unsoaked bone, or soaked bone were very rarely, if ever, worked with these tools.

Ethnographic accounts indicate that modified stalks and branches of small trees and woody shrubs were used to manufacture projectile shafts, fish traps and weirs, basketry, wooden handles, and snowshoes. I suggest that key-shaped formed unifaces would have functioned well for working wood used to produce any of these items.

It is intriguing that there is an apparent decline in the frequency of key-shaped formed unifaces after about 1500 BP, and that their use was completely discontinued by about 1000 BP. The begining of this decline is coincident with the appearance of bow and arrow technology around 1500 BP (Richards and Rousseau 1987:34), and is also concurrent with the 500-year period when it was used along with atlatl and spear technology. After 1000 BP, bow and arrow technology appears to have functionally replaced the atlatl, thereby becoming the dominant hunting weapon.

The experimental component of this study indicated that key-shaped formed unifaces function very effectively for removing bark and working stalks and branches of woody plants ranging between about 1 and 3 cm in diameter. I maintain that it is not unrealistic to speculate that key-shaped formed unifaces may have been used very commonly to manufacture and maintain wooden elements of hunting weaponry; notably spear and atlatl dart shafts, and perhaps even atlatls themselves.

Because arrow shaft diameters are estimated to have been typically between about .7 and 1 cm in diameter (Richards and Rousseau 1987:86), prehistoric technicians may have observed that stalks and branches of these diameters could be more easily and effectively worked using sandstone arrowshaft smoothers and/or simple notched flakes, or "spokeshaves" (see Teit 1930:218). These latter artifact types are argued to have been less efficient for working stalks and branches having diameters greater than 1 cm owing to greater edge and surface contact with bark and wood, producing high levels of frictional drag that would have required very heavy force loads to effectively overcome. This scenario is supported by the fact that I have observed simple notched flakes to be far more common in Kamloops horizon components than those belonging to the previous Plateau and Shuswap horizons, and arrow-sized sandstone shaft smoothers are restricted almost exclusively to the Kamloops horizon.

Finally, I submit that on the Plateau, saskatoon was probably one of the most common types of wood used prehistorically to produce atlatl and spear weaponry, and for manufacturing many other types of implements. Ethnographic accounts indicate that it was the preferred wood used for production of arrow shafts by Native groups on the Plateau. Moreover, its physical properties are ideal for this purpose (i.e., straightness, durability, inertial mass), and it was most probabably as ubiquitous throughout the Plateau culture area during the late prehistoric period as it is today.

REFERENCES CITED

Ahler, Stanley A.

1971 Projectile Point Form and Function at Rodgers Shelter, Missouri. *Missouri Archaeological Society Research Series* 8. Columbia.

1979 Functional Analysis of Non-obsidian Chipped Stone Artifacts: Terms, Variables, and Quantification. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 301-328. Academic Press, New York.

1983 Heat Treatment of Knife River Flint. *Lithic Technology* 12(1):1-8.

Ames, Kenneth M., J.P. Green and M. Pfoertner

1981 *Hatwai (10NP143) Interim Report.* Archeological Reports No. 9, Boise State University, Boise Idaho.

Anderson, Patricia C.

1980 A Testimony of Prehistoric Tasks: Diagnostic Residues on Stone Tool Working Edges. *World Archaeology* 12(2):181-194.

Archer, David J.W.

1980 Analysis of Spatial Patterns At A Prehistoric Settlement in the Lower Fraser Canyon, B.C. Unpublished M.A. thesis, Department of Anthropology, University of British Columbia, Vancouver.

Ascher, Robert

1961 Experimental Archaeology. *American Anthropologist* 63:973-816.

Bamforth, Douglas B.

1986a Technological Efficiency And Tool Curation. *American Antiquity* 51(1):38-50.

1986b A Comment on "Functional Variability in An Assemblage of Endscrapers". *Lithic Technology* 15(2):61-64.

Bettison, Cynthia Ann

1983 An Experimental Approach to Sickle Sheen Deposition And Archaeological Interpretation. Unpublished M.A. Thesis, Department of Anthropology, Eastern New Mexico University, Portales, New Mexico.

1985 An experimental Approach To Sickle Sheen Deposition And Archaeological Interpretation. *Lithic Technology* 14(1):26-32.

Binford, Lewis R.

1979 Organization And Formation Processes: Looking At Curated Technologies. *Journal of Anthropological Research* 3:255-273.

1980 Willow Smoke And Dog's Tails: Hunter-gatherer Settlement Systems And Archaeological Site Formation. *American Antiquity* 45:4-20.

1981 *Bones: Ancient Men and Modern Myths.* Academic Press, New York.

Binford (cont'd)

1982 Objectivity--Explanation--Archaeology--1981. In *Theory and Explanation in Archaeology*, edited by C. Renfrew, M.J. Rowlands, and B.A. Segraves, pp. 125-138. Academic Press, New York.

Blake, Michael T.

1974 The Explanation of Late Prehistoric Settlement Pattern Variation in the Thompson and Fraser River Valleys, British Columbia. *BC Perspectives* 5:1-17.

1976 *The Rocky Point Site (EdQx 20): Spatial Analysis and Descriptive Report*. Occasional Papers of the Archaeological Sites Advisory Board of British Columbia, Victoria.

Blalock, Hubert M. Jr.

1972 *Social Statistics*. McGraw-Hill Series in Sociology, New York.

Bleed, Peter

1986 The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51(4):737-747.

Borden, Charles E.

1968 Prehistory of the Lower Mainland. In *Lower Fraser Valley: Evolution of a Cultural Landscape*, edited by A. Siemens, pp. 9-26. B.C. Geographical Series 9, Department of Geography, University of B.C.

1975 *Origins and Development of Early Northwest Coast Culture from about 3000 BC*. National Museum of Man Mercury Series, Archaeological Survey of Canada Paper No. 45.

Brink, John W.

1978a *An Experimental Study of Microwear Formation on Endscrapers*. National Museum of Man, Mercury Series, Archaeological Survey of Canada Paper No. 83.

Brink, John W.

1978b The Role of Abrasives in the Formation of Lithic Use-wear. *Journal of Archaeological Science* 5:363-371.

Briuer, Frederick L.

1976 New Clues to Stone Tool Function: Plant and Animal Residues. *American Antiquity* 41(4):478-484.

Broderick, Michael

1979 Ascending Paper Chromatographic Technique in Archaeology. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 375-384. Academic Press. New York.

1984 Blood, Fat, Resin, and Starch from Stone Tools. Manuscript on file, Laboratory of Archaeology, University of British Columbia. Vancouver.

Brose, David S.
1975 Functional Analysis of Stone Tools: A Cautionary note on the Role of Animal Fats. *American Antiquity* 40(1):86-94.

Brumley, John. H.
1975 *The Cactus Flower Site in Southeastern Alberta: 1972-1974 Excavations*. National Museum Museum of Man Mercury Series, Archaeological Survey of Canada Paper No. 46. Ottawa.

Bussey, Barbara Jean
1986 Salvage Excavations EdQx 8, near Invermere, B.C. A Late Middle Prehistoric Camp. Report on file, Heritage Conservation Branch, Victoria.

Caldwell, Warren W. and O.L. Mallory
1967 *Hells Canyon Archaeology*. River Basin Surveys, Museum of Natural History, Smithsonian Institution, Publications in Salvage Archaeology 6. Lincoln, Nebraska.

Campbell, Sarah K.
1985 *Summary of Results, Chief Joseph Dam Cultural Resources Project, Washington*, edited by S. Campbell. Office of Public Archaeology, Institute for Environmental Studies, University of Washington, Seattle.

Cantwell, A. M.
1979 The Functional Analysis of Scrapers: Problems, new Techniques and Cautions. *Lithic Technology* 8(1):5-11.

Chance, David H. and J.V. Chance
1977 *Kettle Falls 1976: Salvage Excavations in Lake Roosevelt*. University of Idaho Anthropological Research Manuscript Series 39.

1979 *Kettle Falls 1977*. University of Idaho Anthropological Research Manuscript Series 69.

1982 *Kettle Falls 1971/1974*. University of Idaho Anthropological Research Manuscript Series 69.

Chandler, Susan M. and J.A. Ware
1976 Replication and Empirical Multivariate Analysis. *Newsletter of Lithic Technology* 5(3):24-26.

Chatters, James C.
1984 *Human Adaptation Along the Columbia River, 4700-1600 BP. A Report on the Test Excavations at River Mile 590, North Central Washington*. Central Washington University, Graduate Studies and Research, Research Reports, 84-1, Ellensburg.

1989 Resource Intensification and Sedentism on the Southern Plateau. *Archaeology In Washington* 1:3-19.

Clarke, David L.
1968 *Analytical Archaeology*. Methuen and Co. Ltd., London.

Copp, Stanley A.
1979 Archaeological Excavations at the McCall Site, South Okanagan Valley, British Columbia. Unpublished M.A. thesis, Department of Archaeology, Simon Fraser University.

Cotterell, Brian and J. Kamminga
1979 The Mechanics of Flaking. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 97-112. Academic Press, New York.

1987 The Formation of Flakes. *American Antiquity* 52(4):675-708.

Coughlin, Elizabeth and C. Claassen
1982 Siliceous and Microfossil Residues on Stone Tools: A new Methodology for Indentification and Analysis. Paper Presented at the 1982 Annual Meetings of the Society of American Archaeologists, Minneapolis.

Crabtree, Don
1964 Heat Treatment of Silica Materials. *Tebiwa* 7:1-6.

1972 The Cone Fracture Principle and the Manufacture of Lithic Materials. *Tebiwa* 15:29-36.

Deal, Michael and P. Silk
1987 Absorption Residues and Vessel Function: a Case Study from the Maine-Maritimes Region. *Ceramica de Cultura Maya* (in press).

Del Bene, Terry A.
1979 Once Upon a Striation: Current Models of Striation and Polish Formation. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 167-177. Academic Press, New York.

1980 An X-Ray Analysis of Depositional Polish. *Lithic Technology* 9(2):36-37.

Diamond, George
1979 The Nature of So-called Polished Surfaces on Stone Artifacts. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 159-166. Academic Press, New York.

Donahue, Paul F.
1975 Concerning Athapaskan Prehistory in British Columbia. *The Western Canadian Journal of Anthropology* 5(3-4):21-63.

1978 4500 Years of Cultural Continuity on the Central Interior Plateau of British Columbia. Unpublished Ph.D. dissertation, University of Wisconsin, Madison.

Dumont, John V.
1982 The Quantification of Microwear Traces: A New Use for Interfoerometry. *World Archaeology* 14(2):206-217.

Ebert, J.
1979 An Ethnoarchaeological Approach to Reassessing the Meaning of Variability in Stone tool Assemblages. In *Ethnoarchaeology: Implications of Ethnography for Archaeology*, edited by C. Kramer, pp. 59-73. Columbia University Press, New York.

Eldridge, Morley and A.H. Stryd
1983 CN Rail Railyard Expansion Project Heritage Mitigation Study, Kamloops Junction, B.C. Report on file, Heritage Conservation Branch, Victoria.

Esau, K.
1953 *Plant Anatomy*. John Wiley and Sons, New York.

Fedje, Daryl
1979 Scanning Electron Microscopy Analysis of Use-striae. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 179-187. Academic Press, New York.

Fladmark, Knut F.
1976 Punchaw Village: A Preliminary Report. The Archaeology of a Prehistoric Settlement. In *Current Research Reports*, edited by R.L. Carlson, pp. 19-32. Department of Archaeology, Simon Fraser University, Publication 3.

1978 Concave Side-scrapers: Possible Horizon Markers in the Intermontane West. Paper Presented at the 11th Annual Meeting of the Canadian Archaeological Association, Quebec.

1982 An Introduction to the Prehistory of British Columbia. *Canadian Journal of Archaeology* 6:95-156.

Flenniken, Jeffrey
1981 Replicative Systems analysis: A Model Applied to the Vein Quartz Artifacts from the Hoko River site. *Washington State University Laboratory of Anthropology Reports of Investigations* 59.

Ford, James
1954 On the Concept of types; the type Concept Revisited. *American Anthropologist* 56:42-57.

Fox, D.J. and K.E. Guire
1976 Documentation for MIDAS, 3rd Edition, Statistical Research Laboratory, Ann Arbor, Michigan.

Freedman, David, R. Pisani, and R. Purves
1978 *Statistics*. W.W. Norton and Company, New York.

Fullagar, R.
1986 Use Wear and Residues on Stone Tools. Unpublished Ph.D. dissertation, Department of Prehistory, LaTrobe University, Melbourne, Victoria, Australia.

Gardener, W.M.
1976 Paleo-Indian to Early Archaic: Continuity and Change in Eastern North America During the Late Pleistocene and Early Holocene. *Proceedings of the IXth International Congress of Prehistoric and Protohistoric Scientists*. Colloque XVIII, pp. 20-46, Nice.

Gendel, Peter A. and L. Pirnay
1982 Microwear Analysis of Experimental Stone Tools: Further Test Results. *Studia Praehistorica Belgica* 2:251-265.

Giddings, J.L.
1964 *The Archaeology of Cape Denbigh*. Brown University Press, Providence RI.

Goodman, Mary Ellen
1944 The Physical Properties of Stone Tool Materials. *American Antiquity* 9:415-433.

Goodyear, Albert C.
1979 A Hypothesis for the Use of Cryptocrystalline Raw Materials Among Paleo-Indian Groups of North America. *Institute of Archaeology and Anthropology Research Manuscript Series* 56. University of South Carolina.

Gould, Richard A., D.A. Koster, and A.H.L. Sontz
1971 The Lithic Assemblage of the Western Desert Aboriginies of Australia. *American Antiquity* 36(2):149-169.

Gould, Richard A. and S. Saggers
1985 Lithic Procurement in Central Australia: A Closer Look at Binford's idea of Embeddedness in Archaeology. *American Antiquity* 50(1):117-136.

Grabert, Garland F.
1968 *North-Central Washington Prehistory*. University of Washington, Department of Anthropology, Reports in Archaeology 1.

Grace, R., I.D.G. Graham and M.H. Newcomer
1985 The Quantification of Microwear Polishes. *World Archaeology* 17(1):112-120.

Greengo, Robert E.
1986 *Prehistory of the Priest Rapids-Wanapum Region, Columbia River, Washington*. BAR International Series 290.

Greiser, Sally T., and P.D. Sheets
1979 Raw Material as a Functional Variable in Use-wear Studies. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 289-296. Academic Press, New York.

Gunkel, Alexander
1961 *A Comparative Cultural Analysis of Four Archaeological Sites in the Rocky Reach Reservoir Region, Washington.* Washington State University Theses in Anthropology 1.

Gurfinkel, D.M.
1987 The Analysis of Blood on Artifacts, or did the Tool Maker Need a Bandage? *Archaeological Newsletter of the Royal Ontario Museum*, Series II(21):1-4.

Gurfinkel, D.M. and U.M. Franklin
1988 A Study of the Feasibility of Detecting Blood Residues on Artifacts. *Journal of Archaeological Science* 15:83-97.

Hanson, Gordon W.
1973 The Katz Site: A Prehistoric Pithouse Settlement in the Lower Fraser Valley, British Columbia. Unpublished M.A. thesis, Department of Anthropology and Sociology, University of British Columbia.

Hawk, P.B., B.L. Osler, and W.H. Summerson
1947 *Practical Physiological Chemistry.* The Blackiston Company, Toronto.

Hayden, Brian
1976a Australian Western Desert Technology: An Ethno-Archaeological Study of Variability in Material Culture. Unpublished Ph.D. dissertation, University of Toronto.

1976b Curation: old and New. In *Primitive Art and Technology.* Archaeological Association, Dept. of Archaeology, University of Calgary.

1979a (Ed.) *Lithic Use-Wear Analysis*, Academic Press, New York.

1979b Snap, Shatter, and Superfractures: Use-wear of Stone Skin Scrapers. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 207-229. Academic Press, New York.

1979c *Palaeolithic Reflections: Lithic Technology and Ethnographic Excavations Among Australian Aboriginies.* Australian Institute of Aboriginal Studies, Canberra, Australia.

1984 Are Emic Types Relevant to Archaeology? *Ethnohistory* 29(4).

1986 Use and Misuse: the Analysis of Endscrapers. *Lithic Technology* 15(2):65-70.

Hayden (cont'd)
1987a From Chopper to Celt: the Evolution of Resharpening Techniques. *Lithic Technology* 16(2-3):33-43.

1987b Past to Present Uses of Stone Tools in the Maya Highlands. In *Lithic Studies Among the Contemporary Highland Maya*, edited by B. Hayden, pp. 160-234. University of Arizona Press, Tuscon.

Hayden, Brian, D. Alexander, K. Kusmer, D. Lepofsky, D. Martin, M. Rousseau and P. Friele
1986 Report on the 1986 Excavations at Keatley Creek. Report on file, Heritage Conservation Branch, Victoria.

Hayden, Brian, J. Breffitt, P. Friele, R. Gargett, M. Greene, W.K. Hutchings, D. Jolly, I. Kuijt, K. Kusmer D. Lepofsky, B. Muir, M. Rousseau, and D. Martin
1987 Report on the 1987 Excavations at Keatley Creek. Report on file, Heritage Conservation Branch, Victoria.

Hayden, Brian and J. Kamminga
1973 Gould, Koster, and Sontz on 'microwear': a Critical Review. *Newsletter of Lithic Technology* 2(1-2):3-8.

1979 An Introduction to Use-wear: the First CLUW. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 1-14. Academic Press, New York.

Hebda, Richard J.
1982 Postglacial History of Grasslands of Southern British Columbia and Adjacent Regions. In *Grassland Ecology and Classification Syposium Proceedings June 1982*, pp. 157-192.

Hester, Thomas R.
1972 Ethnographic Evidence for the Thermal Alteration of Siliceous Stone. *Tebiwa* 15(2):63-65.

Hester, Thomas R. and W.I. Follett
1976 Yurok Fish Knives: a Study of Wear Patterns and Adhering Salmon Scales. In *Experiment and Function: Four California Studies*, pp. 2-23. Contributions of the University of California Archaeological Research Facility, No. 33. University of California, Berekely.

Hill, J.N. and R.K. Evans
1972 A Model for Classification and Typology. In *Models in Archaeology*, pp.231-273, edited by D.L. Clarke, Metheun, London.

HoHo Report
1979 In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 133-136. Academic Press, New York.

Holley, Gerald A. and T.A. Del Bene
1981 An Evaluation of Keeley's Microwear approach. *Journal of Archaeological Science* 8:337-352.

Holmes, Brian G.
1966 The Shaake Site - A New Study. Unpublished M.A. thesis, University of Washington, Seattle.

Horsfall, Gayel A.
1987 Design Theory and Grinding Stones. In *Lithic Studies Among the Contemporary Highland Maya*, edited by B. Hayden, pp. 332-377. University of Arizona Press, Tucson.

Ilkjaer, Jorgen
1979 A New Method for observation and Recording of Use-wear. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 345-350. Academic Press, New York.

Ingersoll, Daniel, J.E. Yellen and W. Macdonald
1977 *Experimental Archaeology*, edited by D. Ingersoll, J.E. Yellen, and W. Macdonald. Columbia University Press, New York.

Irving, William N.
1964 Punyik Point and the Arctic Small Tool Tradition. Ph.D. dissertation, University of Wisconsin, Ann Arbor.

Jaehnig, Manfred E.W., N. Crozier, S. Livingston, and N. Stenholm
1985 *Archaeological Investigations at Site 45-OK-258, Chief Joseph Dam Project, Washington.* Office of Public Archaeology, Institute for Environmental Studies, University of Washington, Seattle.

Johansen, D.A.
1940 *Plant Microtechnique*. McGraw-Hill, New York.

Jordan, Richard H.
1980 Preliminary Results from Archaeological Investigations on Avayalik Island, Extreme Northern Labrador. *Arctic* 33(3):607-627.

Kamminga, Johan
1977 A Functional Study of Use-polished Eloueras. In *Stone Tools as Cultural Markers: Change, Evolution and Complexity*, edited by R.V.S. Wright, pp. 205-212. Humanities Press, New Jersey.

1978 *Journey into the Microcosms: A Functional Analysis of Certain Classes of Prehistoric Australian Tools*. Unpublished Ph.D. dissertation, Univeristy of Sydney.

1979 The Nature of Use-polish and Abrasive Smoothing on Stone Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 143-157. Academic Press, New York.

Kamminga (cont'd)

1982 *Over the Edge: Functional Analysis of Australian Stone Tools.* Occasional Papers in Anthropology Number 12, University of Queensland.

Kay, M.
1977 Wear Analysis and Unifacial Scraping Tool Morphology: Implications for Studying Individual Use. In *The Individual in Prehistory: Studies of Variability in Style in Prehistoric Technologies*, edited by J.N. Hill and J. Gunn, pp. 231-245. Academic Press, New York.

Keeley, Lawrence H.
1974 Technique and Methodology in Microwear Studies: a Critical Review. *World Archaeology* 5:323-336.

1977 The Functions of Paleolithic Flint Tools. *Scientific American* 237(5):108-126.

1978 Microwear Polishes on Flint: Some Experimental Results. In *Lithics and Subsistence: The Analysis of Stone Tool Use in Prehistoric Economies*, edited by D.D. Davis, pp. 163-178. Vanderbuilt University Publications in Anthropology 20.

1980 *Experimental Determination of Stone Tool Uses: A microwear Analysis.* University of Chicago Press, Chicago.

1981 Reply to Holley and Del Bene. *Journal of Archaeological Science* 8:348-352.

1982 Hafting and Retooling: Effects on the Archaeological Record. *American Antiquity* 47:798-809.

Keeley, Lawrence H. and M.H. Newcomer
1977 Microwear Analysis of Experimental Flint Tools: A Test Case. *Journal of Archaeological Science* 4:29-64.

Kleindienst, Maxine R.
1975 Comment. *Current Anthropology* 16:382-383.

1979 Design Theory. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 59-60. Academic Press, New York.

Knutsson, Kjel
1988 *Patterns of Tool Use: Scanning Electron Microscopy of Experimental Quartz Tools.* Societas Archaeologica Upsaliensis. Uppsala.

Krieger, Alex D.
1944 The Typological Concept. *American Antiquity* 9(3):271-288.

Lawhead, Stephen, A.H. Stryd and A.J. Curtin
1986 Archaeological Excavations at Valley Mine, Highland Valley, B.C. Report on file, Heritage Conservation Branch, Victoria.

Lawn, B.R. and D.B. Marshall
1979 Mechanisms of Microcontact Fractures in Brittle Solids. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 63-82. Academic Press, New York.

Lawrence, Robert A.
1979 Experimental Evidence for the Significance of Attributes Used in Edge-damaged Analysis. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 113-121. Academic Press, New York.

Leach, Chris
1979 *Introduction to Statistics: A Nonparametric Approach for the Social Sciences*. John Wiley and Sons, New York.

Leaming, S.
1971 *Rock and Mineral Collecting in British Columbia*. Geological Survey of Canada Paper 72-53.

Lee, H.C.
1982 Identification and Grouping of Bloodstains. In *Forensic Science Handbook*, edited by R. Saferstein. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Lewenstein, Suzanne
1981 Mesoamerican Obsidian Blades: An Experimental Approach to Function. *Journal of Field Archaeology* 8(2):175-188.

Linnamae, Urve
1975 *The Dorset Culture: A Comparative Study in Newfoundland and the Arctic*. Technical Papers of the Newfoundland Museum, 1.

Loy, Thomas H.
1983 Prehistoric Blood Residues: Detection on Tool Surfaces and Identification of Species Origin. *Science* 220:1269-1271.

1987 Recent Advances in blood Residue Analysis. In *Archaeometry: Further Australasian Studies*, edited by W.R. Ambrose and J.M.J. Mummery, pp. 57-65. The Australian National University, Canberra.

Loy, Thomas H. and D.E. Nelson
1987 Potential Applications of Organic Residues on Ancient Tools. In *Proceedings of the 23rd International Archaeometry Symposium*, edited by J. Olin and J. Blackmun, pp. 179-185. Smithsonian Institution, Washington.

Lynott, Mark J.
1975 Explanation of Microwear Patterns on Gravers. *Plains Anthropologist* 20(68):121-128.

Magne, Martin P.R.
1985 *Lithics and Livelihood: Stone Tool Technologies of Central and Southern Interior British Columbia.* National Museum of Man Mercury Series Archaeological Survey Paper No. 133.

Mandeville, M.
1971 *The Baked and the Half Baked: A Consideration of the Thermal Pretreatment of Chert.* Unpublished M.A. thesis, Department of Anthropology, University of Missouri, Columbia.

1973 A Consideration of the Thermal Pretreatment of Chert. *Plains Anthropologist* 18:146-148.

Mandeville, M. and J. Flenniken
1974 A Comparison of the Flaking Qualities of Nehawka Chert Before and after Thermal Pretreatment. *Plains Anthropologist* 19:146-148.

Mansur, M. E.
1982 Microwear Analysis of Natural and Use Striations: new Clues to the Mechanisms of Striation Formation. In Tailler! Pour Quoi Faire: Prehistoire et Technologie Lithique II. Recent Progress in Microwear Studies, edited by D. Cahen. *Studia Praehistorica Belgica* 2:213-233. Musee Royal De L'Afrique Centrale, Tervuren.

Mary-Rousseliere, Guy
1976 The Paleoeskimo in Northern Baffinland. *Memoirs of the Society for American Archaeology* 31:40-57.

Mathewes, Rolf W.
1985 Paleobotanical Evidence for Climatic Change in Southern British Columbia During the Late-glacial and Holocene Times. In Climatic Change in Canada 5, edited by C.R. Harrington. *Syllogeus* 55:397-422.

Maxwell, Moreau S.
1973 *Archaeology of the Lake Harbour District, Baffin Island.* National Museum of Man Mercury Series, Archaeological Survey of Canada Paper No. 6.

1976 Pre-Dorset and Dorset Artifacts: the View from Lake Harbour. *Memoirs of the Society for American Archaeology* 31:58-78.

1980 Dorset Site Variation on the Southeast Coast of Baffin Island. *Arctic* 33(3):505-516.

1984 Pre-Dorset and Dorset Prehistory of Canada. In *Handbook of North American Indians*, Vol. 5, Arctic, edited by D. Damas, pp. 359-368. Smithsonian Institution, Washington D.C.

1985 *Prehistory of the Eastern Arctic.* Academic Press, Orlando.

McGhee, Robert

1976 Paleoeskimo Occupations of Central and High Arctic. *Memoirs of the Society for American Archaeology* 31:15-39.

1978 *Canadian Arctic Prehistory*. National Museum of Man Canadian Prehistory Series. Van Nostrand Reinhold Ltd., Sarborough, Ontario.

1979 *The Palaeoeskimo Occupations at Port Refuge, High Arctic Canada.* National Museum of Man Mercury Series, Archaeological Survey of Canada Paper No. 92. Ottawa.

1980 Individual Stylistic Variability in Independence I Stone Tool Assemblages from Port Refuge, N.W.T. *Arctic* 33(3):443-453.

1981 *The Dorset Occupation in the Vicinity of Port Refuge, High Arctic Canada*. National Museum of Man Mercury Series, Archaeological Survey of Canada Paper No. 105.

Meeks, N.D., G. de G. Sieveking, M.S. Tite and J. Cook

1982 Gloss and Use-wear Traces on Flint Sickles and Similar Phenomena. *Journal of Archaeological Science* 9(4):317-340.

Miss, C.J., S. Campbell, S. Livingston, D. Sammons-Lohse, and N.A. Stenholm

1984 *Archaeological Investigations at Sites 45-0K-287 and 45-0K-288, Chief Joseph Dam Project, Washington.* Office of Public Archaeology, Institute for Environmental Studies, University of Washington, Seattle.

Miss, C.J. and L. Hudson

1987 *Cultural Resources Collection Analysis, Albeni Falls Project, Northern Idaho.* Technical Report Prepared for the U.S. Army Corps of Engineers, Seattle District.

Mohs, Gordon

1982 Final Report on Excavations at DjQj 1, Slocan Valley, British Columbia. Report on file Heritage Conservation Branch, Victoria.

Montgomery, Pamela

1978 Stone Artifacts from the Punchaw Lake Site (Area C): A Late Prehistoric Occupation in Central British Columbia. Unpublished M.A. thesis, Department of Archaeology, Simon Fraser University, Burnaby.

Morrison, R.T. and R.N. Boyd

1967 *Organic Chemistry*. Allyn and Bacon Ltd., Boston.

Moss, Emily H. and M.H. Newcomer

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

Nance, Jack D.
1977 Numerical Taxonomy Studies of Microwear on the Los Tapiales Artifacts. *Proceedings of the American Philosophical Society*, 121:267-271.

1979 Fundamental Statistical Considerations in the Study of Microwear. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 351-364. Academic Press, New York.

Nelson, Charles M.
1969 *The Sunset Creek Site (45-KT-28) and its Place in Plateau Prehistory*. Laboratory of Anthropology, Washington State University, Report of Investigations 47, Pullman.

Newcomer, Mark H. and L.H. Keeley
1979 Testing a Method of Microwear Analysis with Experimental Flint Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 195-205. Academic Press, New York.

Newcomer, Mark H., R. Grace, and R. Unger-Hamilton
1986 Investigating Microwear Polishes with blind Tests. *Journal of Archaeological Science* 13:203-217.

Nissen, Karen and M. Dittemore
1974 Ethnographic data and Wear Pattern analysis: a Study of Socketed Eskimo Scrapers. *Tebiwa* 17:67-88.

Odell, George H.
1975 Micro-wear in Perspective: A Sympathetic Response to Lawrence H. Keeley. *World Archaeology* 7:226-240.

1977 *The Application of Micro-Wear Analysis to the Lithic Component of an Entire Prehistoric Settlement: Methods, Problems and Functional Reconstructions*. Unpublished Ph.D. dissertation, Department of Anthropology, Harvard University.

1979 A New Improved System for the Retrieval of Functional Information from Microscopic Observations of Chipped Stone Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 329-344. Academic Press, New York.

1980 Butchering with Stone Tools: Some Experimental Results. *Lithic Technology* 9:39-48.

1981a The Morphological Express at Function Junction: Searching for Meaning in Lithic Tool Types. *Journal of Anthropological Research* 37(4):319-342.

1981b The Mechanics of Use-breakage of Stone Tools: Some Testable Hypotheses. *Journal of Field Archaeology* 8:197-209.

1982 Emerging Directions in the Analysis of Prehistoric Stone Tool Use. *Reviews in Anthropology* 9:17-33.

Odell, George H., and F. Odell-Vereecken
1980 Verifying the Reliability of Lithic Use-wear Assessments by "Blind Tests": the Low-power Approach. *Journal of Field Archaeology* 7:87-120.

Olausson, Deborah S.
1980 Starting from Scratch: the History of Edge-wear Research from 1883 to 1978. *Lithic Technology* 9(2):48-60.

Palmer, Gary B.
1975 Cultural Ecology in the Canadian Plateau: Pre-Contact to the Early Contact Period in the Territory of the Southern Shuswap Indians of British Columbia. *Northwest Anthropological Research Notes* 9(2):199-245.

Parry, William J. and R.L. Kelly
1987 Expedient Core Technology and Sedentism. In *The Organization of Core Technology*, edited by J.K. Johnson and C.A. Morrow, pp. 285-304. Westview Press, London.

Patterson, L. W.
1981 Comments on Wear Rates of Lithic Tool Edges. *Lithic Technology* 10(1):11-12.

Paull, William
1984 Research Report on Organic Residue Analysis Based on Artifacts from Eagle Lake. Manuscript on file, Laboratory of Archaeology, University of British Columbia, Vancouver.

Plisson, Hugues
1983 An Application of Casting Techniques for Observing and Recording Microwear. *Lithic Technology* 12(1):17-21.

Purdy, Barbara A.
1974 Investigations Concerning the Thermal Alterations of Silica Minerals: An Archaeological Approach. *Tebiwa* 17:37-66.

Purdy, Barbara A. and H.K. Brooks
1971 Thermal Alteration of Silica Minerals: An Archaeological Approach. *Science* 173:322-325.

Rabinowicz, E.
1965 *Friction and Wear of Materials*. Wiley, New York.

1968 Polishing. *Scientific American* 218:99-109.

Ray, Verne F.
1933 *The Sanpoil and Nespelem: Salishan Peoples of Northeastern Washington*. University of Washington Publications in Anthropology, Seattle.

Rice, David G.
1968 *Archaeological Investigations in the Coulee Dam National Recreation Area, Spring 1968*. Washington State University Laboratory of Anthropology Report of Investigations No. 45, Pullman.

Richards Thomas H.
1984 Searching High and Low: A Review and Comparison of Microwear Analytical Methodologies. *The Western Canadian Anthropologist* 1:18-25.

1987 Microwear Patterns on Experimental Cache Creek Basalt Tools. Unpublished M.A. thesis, Department of Anthropology and Archaeology, University of Saskatchewan, Saskatoon.

1988 *Microwear Patterns on Experimental Basalt Tools*. BAR International Series 460.

Richards Thomas H. and M.K. Rousseau
1982 Archaeological Investigations on Kamloops Indian Reserve No. 1, Kamloops, British Columbia. Manuscript on file, Heritage Conservation Branch, Victoria.

1987 *Late Prehistoric Cultural Horizons on the Canadian Plateau*. Simon Fraser University Department of Archaeology Publication No. 16.

Rick, John W. and S. Chappell
1983 Thermal Alteration of Silica Materials in Technological and Functional Perspective. *Lithic Technology* 12(3):69-80.

Rousseau, Mike K.
1984 Heritage Investigations on Tsinstikeptum Indian Reserve No. 10, Westside Locality, North Okanagan Valley, British Columbia. Report on file, Heritage Conservation Branch, Victoria.

1989 The Significance and Function of Key-Shaped Formed Unifaces on the Interior Plateau of Northwestern North America. Unpublished M.A. Thesis, Simon Fraser University, Burnaby.

Sabo, Deborah R.
1982 Preliminary Use-wear Analysis of a Michigan Chert. *The Michigan Archaeologist* 28(3):55-72.

Sanger, David
1970 The Archaeology of the Lochnore-Nesikep Locality, British Columbia. *Syesis* 3, Supp. 1:1-129.

Semenov, Sergei A.
1984 *Prehistoric Technology*. Translated by M.W. Thompson. Cory, Adams and McKay, London.

Schiffer, Michael B.
1979 The Place of Lithic Use-wear Studies in Behavioral Archaeology. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 15-26. Academic Press, New York.

Schutt, Jeanne Ann
1982 A Comparative Analysis of Wear Patterns on Experimental Lithic Flake Tools: the Re-examination of Current Concepts in Tool Utilization. Unpublished M.A. thesis, University of New Mexico.

Shafer, Harry J. and R.G. Holloway
1979 Organic Residue Analysis in Determining Stone Tool Function. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 385-400. Academic Press, New York.

Shea, John
1987 On Accuracy and Relevance in Lithic Use-wear Analysis. *Lithic Technology* 16(2-3):44-50.

Sheets, P.
1973 Edge Abrasion During Biface Manufacture. *American Antiquity* 38:215-218.

Shelley, P.
1982 Research into Processes of Phytolith Deposition. *Phytolitharian Newsletter* 1(2):3-4.

Siegel, Peter E.
1984 Functional Variability Within an Assemblage of Endscrapers. *Lithic Technology* 13(2):35-51.

1985 Edge Angle as a Functional Indicator: a Test. *Lithic Technology* 14(2):90-94.

Smith, Harlan I.
1900 *Archaeology of the Thompson River Region*. Memoirs of the American Museum of Natural History 2:6. New York.

Solberger, J.B. and T.R. Hester
1972 Some Additional data on the Thermal Alteration of Siliceous Stone. *Bulletin of the Oklahoma Anthropological Society* 21.

Spaulding, Albert
1953 Statistical Techniques for the Discovery of Artifact Types. *American Antiquity* 18:305-313.

Stafford, Barbara D.
1977 Burin Manufacture and Utilization: An Experimental Study. *Journal of Field Archaeology* 4: 235-246.

Stafford, Russel C. and B.D. Stafford
1979 Some Issues Concerning the Design of Lithic Experiments. *Lithic Technology* 8:21-24.

1983 The Functional Hypothesis: A Formal Approach to Use-wear Experiments and Settlement-subsistence. *Journal of Anthropological Research* 39(4):351-375.

Stryd, Arnoud H.
1973 The Later Prehistory of the Lillooet Area, British Columbia. Unpublished Ph.D. dissertation, University of Calgary, Calgary.

1974 *Lillooet Archaeological Project: 1974 Field Season.* Cariboo College Papers in Archaeology 1. Kamloops.

1980 A Review of the Recent Activities Undertaken by the Lillooet Archaeological Project. *The Midden* 12(2):5-20.

Stryd, Arnoud H. and M.K. Rousseau
1988 The Early Prehistory of the Mid Fraser - Thompson River Area of British Columbia. Paper Presented at the 21st Annual Meeting of the Canadian Archaeological Association, Whistler, B.C. (presently being reviewed for publication).

Teit, James A.
1900 The Thompson Indians. *American Museum of Natural History Memoirs* 2(4):163-392, New York.

1909 The Shuswap. *American Museum of Natural History Memoirs* 2(7):447-758, New York.

1930 The Salishan Tribes of the Western Plateaus. *Annual Reports of the Bureau of American Ethnology* 45:295-396, Washington.

Thomas, David H.
1986 *Refiguring Anthropology: First Principles of Probability and Statistics.* Waveland Press Inc., Prospect Heights, Illinois.

Torrence, Robin
1983 Time Budgeting and Hunter-gatherer Technology. In *Hunter-Gatherer Economy in Prehistory: A European Perspective*, edited by G. Bailey, pp.11-22. Cambridge University Press, Cambridge.

Tringham, Ruth
1978 Experimentation, Ethnoarchaeology, and the Leapfrogs in Archaeological Methodology. In *Explorations in Ethnoarchaeology*, edited by R.A. Gould, pp. 169-199. University of New Mexico Press, Albuquerque.

Tringham, R., G. Cooper, G. Odell, B. Voytek, & A. Whitman
1974 Experimentation in the Formation of Edge Damage: a New Approach to Lithic Analysis. *Journal of Field Archaeology* 1:171-196.

Tsirk, Are
1979 Regarding Fracture Initiations. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 83-96. Academic Press, New York.

Turnbull, Christopher J.
1977 *Archaeology and Ethnohistory in the Arrow Lake, Southeastern British Columbia*. National Museum of Man Mercury Series, Archaeological Survey of Canada Paper No. 65, Ottawa.

Turner, Nancy J.
1979 *Plants in British Columbia Indian Technology*. British Columbia Provincial Museum Handbook 38, Victoria.

Unger-Hamilton, Romana
1983 An Investigation into the Variables Affecting the Development and Appearance of Plant Polish on Flint Blades. In *Traces d'Utilization sur les Outils Neolithiques du Proche Orient*, edited by M.C. Cauvin, pp. 243-250. Travaux de la Maison de L'Orient No. 5. Maison de L'Orient, Lyon.

1984 The Formation of Use-wear polish on Flint: Beyond the "deposit Versus Abrasion" Controversy. *Journal of Archaeological Science* 11:91-98.

Vaughan, P. C.
1985 *Use-Wear Analysis of Flaked Stone Tools*. University of Arizona Press, Tuscon.

Von Krogh, Henning
1980 *Archaeological Investigations at the Flood and Pipeline Sites, near Hope, British Columbia*. Occasional Papers of the Heritage Conservation Branch 4, Victoria.

Warren, Claude N.
1968 *The View from Wenas: A Study of Plateau Prehistory*. Occasional Papers of the Idaho Sate University Museum 24.

White, J.P. and D. Thomas
1972 What Mean These Stones? In *Models in Archaeology*, edited by D.L. Clarke, pp. 275-308. Methuen, London.

Wilmsen, Edwin
1968 Functional Analysis of Flaked Stone Artifacts. *American Antiquity* 33:156-161.

1970 *Lithic Analysis and Cultural Inference: A Paleo-Indian Case*. Univeristy of Arizona Press, Tucson, Arizona.

Wilson, Robert L.
1980 Archaeological Investigations Near Kamloops. In *The Archaeology of Kamloops*, by R. Wilson and C. Carlson, pp.1-83. Department of Archaeology, Simon Fraser University, Publication 7.

Witthoft, J.
1967 Glazed Polish on Flint Tools. *American Antiquity* 32(2):383-388.

Wylie, H.
1975 Tool Microwear and Functional Types from Hogup Cave, Utah. *Tebiwa* 17(2):1-30.

Yent, Martha E.
1976 *The Cultural Sequence at Wawawai (45WT39), Lower Snake River Region, Southeastern Washington*. Washington State University Department of Anthropology Publication, Pullman.

Appendix 1. Code legend for the 37 continuous and nominal scale variables examined in the 129 prehistoric study sample specimens.

Variable Number and Description

1. REGION OF ORIGIN:
1: Chilcotin
2: Mid-Fraser
3: Lower Fraser
4: Thompson River
5: South Thompson - Shuswap
6: Nicola
7: North Okanagan
8: South Okanagan
9: Arrow Lakes
10: East Kootenay

2. SITE TYPE:
0: Unknown
1: Housepit
2: Buried lithic scatter
3: Cachepit
4: Dwelling platform

3. LITHIC RAW MATERIAL:
1: Chalcedony
2: Chert
3: Basalt

4. THERMAL ALTERATION:
0: No
1: Yes

5. RELATIVE AGE:
0: Unknown
1: 3500 to 2400 BP (Shuswap horizon)
2: 2400 to 1200 BP (Plateau horizon)
3: 1200 to 200 BP (Kamloops horizon)

6. FRAGMENTATION STATE:
1: Complete
2: Almost complete (tip gone)
3: Distal half of projection absent
4: Basal portion (proximal half)
5: Entire distal projection
6: Distal tip
7: Medial section
8: Part of basal aspect missing
9: Resharpened/Remodelled

Continued...

Appendix 1 (continued).

7. MODIFICATION STATE:
- O: Absent
- 1: Resharpened/Remodelled
- 2: Recycled
- 3: Weathered
- 4: Water worn.

8. MAXIMUM TOOL LENGTH (in mm)

9. MAXIMUM WIDTH (in mm)

10. MAXIMUM THICKNESS (in mm)

11. WEIGHT (in grams)

12. PROJECTION LENGTH (in mm)

13. PROJECTION AVERAGE THICKNESS (in mm)

14. PROJECTION BASAL WIDTH (in mm)

15. PROJECTION MEDIAL WIDTH (in mm)

16. PROJECTION DISTAL WIDTH (in mm)

17. PROJECTION ANGLE (in degrees)

18. PROJECTION DISTAL TIP EDGE ANGLE (in degrees)

19. PROJECTION DISTAL TIP SPINE PLANE ANGLE (in deg.)

20. VENTRAL CURVATURE DEPTH (in mm)

21. CONCAVE MARGIN SIDE: 1: Left 2: Right.

22. CONCAVE MARGIN LENGTH (in mm)

23. CONCAVE MARGIN CURVATURE DEPTH (in mm)

24. CONCAVE MARGIN RETOUCH:
- 0: No margin
- 1: Unifacial
- 2: Bifacial

25. CONCAVE MARGIN MEAN EDGE ANGLE (in degrees)

Continued...

Appendix 1 (continued).

26. CONCAVE MARGIN SPINE PLANE ANGLE (in degrees)

27. OPPOSITE MARGIN LENGTH (in mm)

28. OPPOSITE MARGIN OUTLINE:

0: Margin absent
1: Concave
2: Moderately concave
3: Convex
4: Moderately convex
5: Straight
6: Recurved
7: Irregular

29. OPPOSITE MARGIN RETOUCH:

0: Margin absent
1: Unifacial
2: Bifacial
3: None present
4: Inverse unifacial
5: Ground

30. OPPOSITE MARGIN MEAN EDGE ANGLE (in degrees)

31. OPPOSITE MARGIN SPINE PLANE ANGLE (in degrees)

32. PROXIMAL MARGIN EDGE OUTLINE:

1:Type A; 2:B; 3:C; 4:D; 5:E; 6:F; 7:G;
8:H; 9:Miscellaneous Irregular
(see Figure 4 for outline definitions).

33. PROXIMAL MARGIN LENGTH (in mm)

34. PROXIMAL MARGIN WIDTH (in mm)

35. PROXIMAL MARGIN RETOUCH:

0: Margin absent
1: Unifacial
2: Bifacial
3: None present

36. OVERALL MICROWEAR TRACE INTENSITY:

0: No use wear evident
1: Slight
2: Moderate
3: Pronounced

37. RESIDUE: 0: Absent 1: Present.

Appendix 2. Values for the 37 continuous and nominal scale variables recorded for the 129 study sample specimens. Codes descriptions are presented in Appendix 1. The symbol " -- " indicates a missing value.

DgQu16:129

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	1	1	1	0	1	0	33.9	24.2	6.2	4.1	1.9	3.5	22.2	6.5	1.3	45	75	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.2	1	22.9	2.3	1	75	60	20.0	6	1	60	60	1	16.5	14.5	2	1	0

DhQv48:865

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	1	0	4	0	--	17.6	4.5	--	--	3.2	17.5	--	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	65	55	--	0	0	--	--	2	15.0	11.1	1	1	0

DhQv48:1386

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	1	2	3	0	--	16.4	4.4	---	---	2.8	16.3	10.0	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	70	60	--	3	1	65	65	2	13.0	9.0	2	0	0

DhQv48:1479

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	0	2	1	0	42.9	25.3	7.3	6.4	20.0	4.8	20.5	6.6	4.7	15	85	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.5	1	21.2	3.6	1	80	80	20.9	1	1	90	70	2	22.0	6.8	1	0	0

DhQv48:1572

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	0	2	1	1	28.8	20.1	7.3	3.5	16.5	5.7	28.9	7.8	5.2	25	115	115

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.7	1	20.3	2.0	1	85	75	17.6	2	2	75	55	1	12.0	7.2	2	2	1

DhQv48:1646

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	3	0	2	1	0	34.4	21.7	8.2	4.0	20.2	3.0	20.6	7.6	3.9	25	85	75

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	22.5	4.5	2	80	80	14.2	7	1	85	75	4	17.0	18.1	1	0	0

DhQv48:1932

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	0	2	5	0	--	--	--	--	23.3	3.1	18.2	6.1	5.0	15	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	23.5	4.1	1	55	55	23.3	3	1	60	45	0	--	--	0	1	0

DhQv48:1997

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	0	2	1	0	30.7	15.6	6.1	2.0	21.0	2.6	14.6	5.2	1.5	20	85	15

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.8	1	20.5	4.5	1	75	65	16.0	6	1	80	65	2	10.2	8.1	3	1	0

Continued ...

Appendix 2 (continued).

DhQv48:2021

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	0	0	1	1	36.0	23.0	6.5	4.9	17.4	3.5	22.3	6.6	3.3	30	90	90

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	28.8	4.0	1	75	65	16.1	5	1	60	45	1	21.0	12.0	1	0	0

DhQv48:2097

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	1	2	1	0	17.7	1.5	4.4	.7	9.5	2.2	10.2	3.3	.5	30	10	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	13.3	1.6	1	70	65	10.0	5	1	60	60	2	8.6	4.8	3	1	0

DhQv48:2478

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
8	2	1	0	0	1	1	31.0	21.1	6.3	3.5	17.5	5.5	21.0	10.0	3.5	40	80	80

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	21.5	2.2	2	85	80	20.0	3	2	90	90	1	16.0	7.0	1	2	1

DiQm4:183

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	2	0	1	1	0	31.0	15.1	5.1	1.9	16.5	2.5	15.0	3.1	1.6	15	65	65

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.8	1	19.7	4.2	1	60	60	17.0	4	3	80	80	4	12.0	13.0	3	3	0

DiQm4:205

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	1	0	1	1	0	25.6	15.4	3.4	1.6	14.5	3.1	15.1	7.7	4.0	30	100	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.5	1	16.3	2.0	1	50	50	17.7	7	1	70	70	1	12.0	6.5	3	2	0

DiQm6:13

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	1	1	0	3	0	--	22.9	5.3	--	--	5.3	21.6	--	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	70	60	--	3	1	55	35	1	15.0	10.1	1	1	0

DiQm6:16

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	1	0	0	1	0	49.0	16.3	4.0	3.2	27.5	3.5	18.9	9.3	2.2	25	30	30

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.7	1	27.2	3.5	1	80	65	32.0	7	1	70	40	2	21.5	11.3	3	2	0

DiQv5:247

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7	1	1	1	0	7	0	--	22.8	3.9	--	--	3.4	22.5	11.7	--	25	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	60	60	--	4	1	65	40	0	--	--	0	0	0

Continued ...

Appendix 2 (continued).

DiQv5:273

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7	1	1	1	0	1	0	44.6	16.1	3.7	3.3	15.5	3.4	14.7	7.4	4.7	15	110	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.3	1	24.0	2.3	1	70	50	28.0	5	3	80	80	2	19.5	12.9	2	1	0

DjQj1:19

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	2	0	2	1	3	35.2	21.3	4.6	3.2	20.0	3.0	20.5	8.7	5.5	30	30	30

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	21.5	2.5	1	55	55	20.5	7	1	75	75	1	16.0	14.0	1	2	1

DjQj1:200

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	1	0	0	1	3	39.0	21.3	3.7	3.1	21.5	2.8	20.0	9.6	6.5	10	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.7	1	21.8	3.7	2	40	40	17.5	5	1	50	50	3	19.0	18.3	3	2	0

DjQj1:324

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	2	0	2	1	3	29.1	21.7	6.2	4.5	15.5	14.9	13.1	9.8	8.2	10	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.8	1	18.5	.8	1	65	65	28.3	5	1	55	55	5	20.0	21.6	3	2	1

DjRi3:4629

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	1	1	0	1	1	0	36.8	25.9	11.5	9.9	17.2	5.9	22.7	8.2	2.8	45	70	65

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.2	1	18.9	1.9	1	120	60	19.5	5	1	70	55	1	20.0	25.0	1	3	1

DjRi5:2164

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	1	1	0	3	2	0	29.9	16.2	4.0	1.9	22.5	2.4	16.4	7.3	--	15	80	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.5	2	19.5	2.0	1	75	65	19.2	5	1	75	75	2	9.0	8.3	1	1	0

DjRi5:10722

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	1	1	1	1	1	0	31.3	19.2	9.5	5.1	23.1	5.5	19.2	7.2	2.0	40	70	40

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	23.1	1.5	1	100	85	12.9	6	1	75	60	2	9.0	12.9	4	2	1

DjRi5:11637

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	1	1	1	2	1	0	23.4	15.9	5.0	1.9	13.8	3.4	15.9	7.5	5.3	30	80	80

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.2	1	15.2	2.6	1	80	65	16.6	6	1	75	30	4	12.0	15.0	0	3	1

Continued ...

Appendix 2 (continued).

DjRi5:12423

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	1	1	1	2	3	0	--	27.2	6.1	--	--	4.9	25.1	12.4	--	30	95	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	65	65	--	2	1	75	60	1	21.0	15.7	2	2	0

DjRi5:12820

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	1	1	1	2	1	1	26.8	16.8	4.4	1.9	14.1	3.9	14.3	7.5	2.6	40	95	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	2	15.2	1.8	1	80	70	19.0	5	1	80	70	4	9.2	16.0	1	2	0

DkQm5:273

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	1	1	1	1	3	0	--	21.7	8.5	--	--	7.4	19.9	11.1	--	35	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	2	--	--	1	65	65	--	5	1	90	90	2	11.5	10.5	1	2	0

DlQ16:41

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	2	3	31.4	14.0	4.4	1.9	15.2	3.3	3.8	7.0	3.0	35	65	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	16.0	2.2	1	80	65	21.6	3	4	50	50	7	17.0	--	3	1	0

DlQv37:56

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7	2	1	1	2	1	0	27.7	20.5	3.2	1.7	20.0	3.2	21.0	6.1	2.2	25	95	50

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.5	1	22.0	5.0	1	75	50	18.0	3	1	60	60	2	9.7	16.2	2	1	0

DlQv39:11

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7	2	1	0	1	1	0	32.7	8.8	6.2	2.5	22.0	5.0	12.7	7.7	.7	50	75	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	22.2	2.9	1	70	70	18.2	3	2	55	55	1	11.5	4.8	1	1	1

DlQv39:27

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
7	2	2	0	1	1	0	49.5	25.7	10.2	9.4	28.5	6.6	23.2	9.5	2.6	45	45	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.5	1	30.7	3.0	1	85	85	19.6	7	1	70	55	2	23.0	11.0	1	3	1

EaQl1:137

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	1	0	1	0	30.3	22.0	3.4	1.9	16.1	2.0	18.5	6.5	.8	55	70	35

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	7	20.4	2.0	1	45	45	14.9	1	1	55	55	2	12.5	16.7	3	1	0

Continued ...

Appendix 2 (continued).

EaQl1:244

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	0	0	1	1	31.0	20.8	4.7	2.7	19.0	3.3	19.8	7.5	1.2	45	95	40

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.7	1	24.7	1.9	1	80	65	20.5	5	1	60	60	2	10.0	18.2	3	2	0

EaQl1:405

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	1	0	1	1	33.4	24.2	8.5	4.9	18.0	4.5	22.8	6.5	1.7	35	85	25

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	22.2	3.1	1	85	70	11.0	1	1	80	80	2	17.0	8.9	3	1	0

EaQl1:416

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	0	28.8	20.0	7.2	2.5	15.5	3.0	19.3	6.5	3.0	45	60	40

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.7	1	19.7	3.1	1	70	70	11.2	4	3	40	40	4	11.5	16.8	3	2	0

EaQl10:71

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	0	0	2	0	40.6	20.1	8.9	5.5	26.5	7.1	20.1	11.5	6.5	10	55	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.6	1	25.0	0	1	60	60	20.8	2	3	65	65	2	12.5	12.5	1	3	1

EaQl10:59

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	3	0	0	1	3	50.8	21.5	6.4	4.7	31.0	4.0	8.6	8.9	7.5	15	40	40

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	2	29.7	3.1	1	70	70	20.3	1	1	80	80	7	21.0	13.8	3	2	0

EaQl10:139

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	0	36.8	15.9	5.2	2.5	23.0	7.0	13.8	8.7	2.5	25	105	35

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.5	1	24.1	2.7	1	70	70	24.0	3	3	75	75	8	13.0	10.5	3	1	0

EaQl10:141

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	1	0	1	0	23.8	15.5	3.9	1.3	76.0	2.2	13.7	4.1	2.9	25	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	6.4	2.5	1	55	50	15.6	4	1	50	50	4	7.5	8.9	3	2	0

EaQl14:55

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	1	0	1	0	41.4	18.3	4.2	2.9	24.0	3.4	18.2	8.4	6.0	15	50	50

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.8	1	23.2	3.9	1	65	65	22.0	3	1	70	45	2	18.0	10.8	3	1	0

Continued ...

Appendix 2 (continued).

EaQl14:56

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	0	0	1	0	27.9	18.7	5.2	2.3	14.0	2.6	21.8	7.6	3.5	30	15	15

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.5	2	16.6	2.3	1	60	60	24.8	4	1	80	55	2	13.3	5.4	1	1	0

EaQl14:57

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	1	35.6	20.6	6.5	5.0	23.8	4.6	20.1	7.0	1.6	45	80	80

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.2	2	24.0	1.7	1	80	80	19.2	2	1	90	90	2	1.4	17.8	1	1	0

EaQl14:58

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	1	32.9	19.1	7.7	4.3	12.5	4.0	18.4	6.6	1.7	60	95	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	19.0	1.3	1	90	70	13.5	3	2	65	65	1	22.2	7.0	1	2	0

EaQl14:59

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	1	0	1	0	30.7	20.6	5.9	3.0	20.0	3.9	19.9	7.8	2.0	45	90	90

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	22.5	3.5	1	60	60	22.5	3	2	45	40	1	14.5	9.0	2	2	0

EaQl14:60

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	0	33.7	18.0	4.5	2.3	34.0	3.3	16.0	5.5	3.2	15	40	30

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2.6	1	23.9	3.1	1	65	60	23.1	1	1	50	50	8	9.0	15.3	2	2	0

EaQl14:61

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	0	40.7	22.1	5.7	5.1	20.0	3.8	18.3	7.9	2.2	35	85	50

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
3.9	2	20.7	3.1	1	85	70	21.0	5	1	80	70	2	23.0	14.5	3	2	1

EaQl14:62

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	0	34.7	18.5	6.0	3.6	18.3	3.2	18.2	6.8	2.0	40	75	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.9	1	23.0	3.1	1	70	55	25.0	3	1	65	65	2	17.0	12.1	3	2	0

EaQl14:65

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	0	0	2	3	25.5	19.2	4.1	1.9	15.0	2.4	19.1	7.3	--	40	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	2	13.9	--	1	60	60	--	2	1	75	75	2	11.0	7.0	3	1	0

Continued ...

Appendix 2 (continued).

EaQl14:736

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	0	0	1	0	48.8	22.9	7.1	6.9	21.5	5.5	19.6	6.7	2.7	25	80	60

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.6	2	22.7	2.2	1	80	75	25.5	5	1	80	80	7	27.0	--	1	1	1

EaQl14:737

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	1	0	0	1	1	33.6	21.5	8.2	4.0	19.5	3.3	15.6	7.7	2.5	40	50	40

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	21.5	2.7	1	75	65	18.9	5	1	60	60	4	15.0	20.0	1	2	0

EaQl14:825

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	0	0	2	0	34.3	16.8	5.7	3.5	15.0	3.5	16.6	6.5	2.2	40	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	29.0	2.0	1	75	60	25.8	5	2	80	55	2	18.0	11.8	3	3	0

EaQl14:826

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
9	2	2	0	0	1	0	31.4	19.8	5.2	2.6	14.0	2.8	19.0	5.5	2.5	45	90	30

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.4	1	18.6	2.3	1	60	60	14.7	4	1	55	45	4	15.0	15.5	3	2	0

EbRd3:18

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
6	1	2	1	0	2	0	--	17.5	3.5	--	--	3.5	7.5	8.6	--	25	95	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	85	65	--	4	1	70	60	7	2.0	5.4	3	2	0

EbRj-y:618

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	0	1	1	0	2	0	37.5	27.2	6.3	4.1	28.0	4.6	17.2	8.5	--	20	95	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	18.0	4.4	1	65	65	27.0	7	1	75	50	2	21.0	8.0	3	2	1

EcRh12:55

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	3	1	1	2	1	0	26.8	18.0	5.0	2.1	15.2	4.3	16.7	5.5	3.5	50	85	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.8	1	18.5	1.8	1	70	70	9.7	5	1	65	65	2	11.5	9.2	3	1	0

EcRh12:56

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	3	1	1	2	3	0	--	20.5	7.3	3.3	--	5.0	20.9	8.4	--	40	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	65	65	--	5	3	55	55	2	14.5	13.3	1	1	0

Continued ...

Appendix 2 (continued).

EdQa8:32

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
10	2	1	0	2	3	0	--	23.9	6.4	--	--	5.0	23.5	16.3	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	55	55	--	4	1	25	25	2	12.0	6.3	3	1	0

EdQx20:A-7001

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	2	1	0	0	1	0	49.9	21.6	17.9	13.0	29.5	9.0	20.7	7.2	2.1	20	95	95

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.5	2	28.5	2.9	1	90	90	22.5	6	1	85	85	8	29.0	25.8	3	1	0

EdQx20:B1-100

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	2	0	30.9	14.9	6.8	2.8	18.5	6.1	14.3	7.8	--	30	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	9.1	1.0	1	85	85	21.0	5	3	55	55	2	11.0	10.4	2	2	0

EdRa9:350

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	2	1	0	34.3	17.0	4.3	2.5	22.0	2.5	16.8	9.4	5.0	30	65	65

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.7	1	22.5	2.9	1	65	65	24.5	3	1	70	70	1	10.3	7.5	3	2	0

EdRa9:378

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	2	8	3	--	24.4	4.5	4.0	30.1	3.8	23.2	13.5	1.5	45	40	40

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	7	30.6	2.5	1	80	70	11.7	3	1	80	45	0	--	--	0	2	1

EdRa22:1-31

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	2	1	1	27.6	21.7	6.1	3.2	19.0	5.2	21.0	8.8	3.2	40	90	90

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	22.5	1.7	1	80	80	18.7	2	1	85	85	4	1.7	18.0	1	1	0

EdRa22:1-37

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	2	1	0	26.3	16.7	3.6	1.6	12.5	2.0	15.8	5.6	2.7	40	110	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.3	1	15.1	2.0	1	75	75	15.4	5	1	60	60	7	14.5	8.0	3	1	0

EdRa22:2-105

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	2	1	0	49.0	25.5	9.6	12.6	26.0	7.5	21.6	6.6	3.5	35	95	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	26.5	2.7	1	85	85	21.5	4	1	65	65	7	28.0	14.8	3	1	0

Continued ...

Appendix 2 (continued).

EdR113:5

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	2	1	0	0	1	0	33.3	17.2	6.3	3.4	16.5	4.3	16.4	4.5	1.9	20	55	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.1	1	19.2	40	1	75	75	25.0	6	1	85	65	1	19.0	6.4	2	1	1

EeQw3:565

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	1	0	50.5	21.6	7.4	6.5	23.0	3.9	7.8	4.2	2.7	25	90	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.2	2	2.2	2.5	1	90	80	26.6	1	1	110	90	4	29.0	--	3	1	0

EeQw3:588

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	0	2	1	24.8	16.5	5.0	3.0	13.3	3.8	16.1	6.5	--	25	70	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	27.5	2.4	1	60	60	14.5	5	1	75	65	2	12.0	8.9	1	1	0

EeQw3:594

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	0	1	1	33.5	22.8	4.7	3.9	18.5	3.3	24.0	5.0	1.0	60	110	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.3	1	24.2	2.1	1	70	60	18.1	6	1	80	75	2	17.5	4.5	3	1	0

EeQw3:596

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	1	3	49.7	27.2	7.1	7.4	25.0	4.6	25.0	10.5	3.9	50	60	50

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.2	1	25.7	4.1	1	75	60	31.5	4	1	65	65	2	26.5	10.0	3	0	0

EeQw3:618

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	0	3	0	--	29.5	6.3	5.5	--	3.5	25.2	11.2	--	45	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	90	50	--	5	1	80	60	1	17.0	18.3	1	1	0

EeQw3:692

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	1	0	52.5	31.1	9.5	15.1	35.5	4.9	29.7	15.5	4.1	35	90	15

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.7	7	38.8	3.7	1	85	65	37.0	3	2	65	65	2	20.0	21.9	3	2	1

EeQw3:811

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	0	1	0	28.9	19.1	4.9	3.2	16.0	3.0	8.6	5.8	2.4	20	55	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	20.4	4.0	2	85	85	13.5	5	2	85	70	2	11.5	8.0	2	1	0

Continued ...

Appendix 2 (continued).

EeQw6:197

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	1	0	1	0	37.2	19.8	4.8	3.2	20.0	3.8	19.2	10.1	3.7	20	90	20

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	20.5	4.0	1	65	65	19.0	3	1	60	45	9	17.5	9.0	3	0	0

EeQw6:203

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	0	1	0	45.4	27.5	10.0	11.0	24.0	9.6	25.0	9.0	4.2	30	90	90

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	29.5	3.6	1	95	75	20.0	4	2	80	55	7	22.0	19.6	3	0	0

EeQw6:313

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	0	1	3	41.0	22.7	7.5	1.9	19.5	5.4	22.5	11.2	--	25	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.3	1	22.0	3.0	1	65	65	30.0	5	1	75	45	2	19.5	19.5	3	1	0

EeQw6:365

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	9	1	--	--	6.4	--	22.5	4.0	--	8.6	.5	25	50	20

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.9	1	26.5	3.7	1	85	60	--	6	1	60	50	0	--	--	0	2	0

EeQw6:511

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	1	0	1	0	39.4	17.1	6.0	3.0	27.5	4.2	16.3	7.0	1.3	25	85	75

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
3.7	1	27.4	2.2	1	85	85	20.4	2	1	70	70	1	12.0	8.0	1	2	1

EeQw6:516

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	0	9	2	--	--	4.8	--	--	4.5	--	6.9	--	30	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	95	65	--	5	2	75	50	9	--	--	1	1	0

EeQw6:555

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	0	1	0	40.5	25.3	6.8	5.3	18.5	4.4	25.8	8.7	6.2	20	70	70

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.9	2	20.0	3.1	1	60	60	11.2	5	1	80	80	2	21.0	7.2	3	1	0

EeQw6:633

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	0	1	0	37.0	17.4	5.6	3.5	19.0	4.0	16.7	9.5	2.7	50	30	30

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.3	1	20.9	1.4	1	65	65	17.7	3	3	40	35	2	18.5	18.4	3	2	0

Continued ...

Appendix 2 (continued).

EeQw6:722

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	1	0	50.3	42.8	8.8	11.8	27.5	4.5	42.5	8.3	2.3	25	70	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.5	7	30.8	5.5	1	90	90	30.5	1	1	90	90	1	23.0	18.3	3	1	0

EeQw6:773

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	2	0	57.0	29.6	10.3	17.4	30.0	6.5	29.3	17.5	--	35	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.9	1	30.5	1.0	1	60	60	26.7	4	1	65	30	2	17.0	22.1	2	2	0

EeQw6:779

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	2	0	68.8	24.6	8.5	16.9	3.5	7.5	22.2	14.3	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.6	1	33.7	4.5	1	80	80	35.7	2	3	80	80	2	29.5	12.5	3	3	1

EeRb3:52

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	2	3	0	--	25.8	7.7	7.5	--	4.6	23.7	14.0	--	35	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	80	70	--	1	1	75	65	1	5.0	9.5	1	1	0

EeRb3:875

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	2	1	0	33.3	19.9	6.1	3.0	13.5	3.3	18.3	7.2	4.1	40	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.8	1	18.3	3.0	1	65	55	12.5	2	3	35	35	2	20.5	12.6	1	2	0

EeRb3:910

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	1	2	1	1	35.4	18.3	17.0	4.1	18.0	5.7	17.5	5.6	.6	35	75	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.7	1	17.2	1.9	1	70	70	18.0	5	1	70	70	2	2.3	11.4	2	1	0

EeRb3:1181

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	2	1	0	38.3	19.6	5.8	3.0	26.5	2.5	19.5	8.3	5.2	20	15	15

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.7	2	27.2	3.1	1	55	55	23.0	2	1	50	50	2	9.0	11.8	1	1	0

EeRb3:1184

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	2	3	0	--	17.6	3.7	--	--	3.7	17.1	7.6	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	80	80	--	4	1	70	50	4	6.0	11.5	3	0	0

Continued ...

Appendix 2 (continued).

EeRb10:6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	1	1	0	36.6	16.0	5.4	2.3	25.0	4.1	15.6	7.0	1.6	30	75	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	26.4	1.4	1	75	60	24.6	4	1	70	55	2	12.5	8.6	1	3	1

EeRb11:72

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	0	3	0	--	18.9	4.6	2.5	--	3.1	17.8	9.8	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	70	65	--	5	1	60	40	1	17.0	9.0	2	3	0

EeRb70:6490

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	2	1	0	33.5	21.3	3.7	2.5	16.5	1.9	19.8	7.0	2.6	25	90	60

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	20.1	3.0	1	40	40	17.7	7	2	45	45	6	17.5	18.5	2	3	0

EeRh1:33

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	2	2	0	0	1	0	48.8	21.1	7.3	8.1	28.0	4.1	21.2	7.0	4.3	20	100	35

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.4	1	30.4	4.6	1	85	70	29.0	4	2	70	70	2	21.0	15.7	3	2	1

EeRj63:327

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	2	1	0	0	1	1	37.4	16.9	10.2	5.0	20.9	4.0	15.2	7.5	5.0	25	80	60

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.3	1	17.7	1.3	1	55	55	19.0	4	1	70	70	9	17.0	--	3	2	0

EeRk4:1-51

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	1	1	0	16.4	16.2	5.0	2.1	16.0	3.2	15.5	4.6	1.5	30	50	15

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	16.2	2.2	1	90	80	21.5	6	3	60	60	1	13.0	16.3	3	2	1

EeRk4:6-403

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	2	2	0	31.2	20.5	6.2	4.7	23.0	4.9	20.4	9.9	3.6	40	105	105

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.4	1	18.8	2.6	1	80	65	16.0	3	1	75	60	1	9.5	10.0	1	1	0

EeRk4:6-407

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	1	2	3	0	--	18.9	6.5	4.0	--	4.0	22.1	9.5	--	50	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	70	60	--	7	1	45	35	7	13.0	19.7	1	2	0

Continued ...

Appendix 2 (continued).

EeRk4:6-462

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	2	1	0	34.9	16.6	5.6	2.4	25.0	5.0	16.0	5.6	3.5	15	60	55

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.4	1	20.5	3.4	1	75	75	21.5	5	1	75	60	2	9.5	9.1	1	3	0

EeRk4:6-1043

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	2	1	2	1	0	53.9	22.9	10.2	10.0	28.5	5.2	22.7	13.7	3.3	20	45	40

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.1	1	30.0	3.1	1	60	55	27.5	4	3	35	35	9	27.0	15.0	3	2	0

EeRk4:6-1124

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	3	0	2	3	0	--	23.6	6.1	5.1	--	4.1	23.4	10.8	--	30	110	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	90	90	--	3	2	50	50	2	19.5	13.3	2	3	1

EeRk4:19-1007

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	2	1	0	33.7	15.9	5.6	2.5	21.5	4.3	5.5	6.7	4.5	20	75	65

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.6	1	22.6	3.2	1	75	70	18.8	4	1	85	65	4	13.0	13.0	3	3	1

EeRk4:19-1253

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	2	1	0	46.5	29.5	8.5	7.2	24.0	3.5	22.8	7.5	3.3	25	50	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.5	1	24.4	5.0	1	55	55	24.3	2	4	60	60	8	22.5	23.2	3	1	0

EeRk4:19-2119

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	3	0	2	1	0	64.7	29.6	7.5	11.4	43.0	5.1	29.6	10.7	4.4	25	50	50

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
5.2	1	45.2	8.0	1	70	55	31.9	7	1	70	45	6	22.0	16.3	3	3	1

EeRk4:20-372

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	0	1	0	30.5	15.6	5.1	2.3	14.0	3.4	3.1	5.5	.8	30	60	20

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.7	1	15.8	2.1	1	75	65	13.0	4	3	60	60	6	17.5	9.7	3	2	1

EeRl4:364

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	0	1	0	26.0	19.8	4.2	2.2	19.4	2.7	19.8	12.5	4.0	50	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	21.7	.3	1	65	65	20.0	4	1	60	60	2	7.0	6.0	1	1	1

Continued ...

Appendix 2 (continued).

EeR17:1000

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	0	1	1	22.2	14.2	4.3	1.3	1.0	1.7	14.0	4.2	1.1	50	55	20

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	13.0	2.4	1	80	50	12.5	4	3	55	30	2	10.1	6.0	2	1	1

EeR17:1107

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	1	1	0	2	2	1	24.3	17.2	4.4	2.1	8.8	3.0	16.9	7.0	3.3	55	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.6	1	14.5	1.1	1	75	55	9.0	7	1	65	65	7	18.0	4.5	2	1	1

EeR191:7

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	2	1	1	0	1	1	31.1	19.7	6.9	4.1	17.0	4.2	19.5	6.2	2.5	45	75	75

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.9	1	20.9	2.9	1	95	95	13.0	5	1	75	80	2	15.5	13.6	2	2	0

EfQu3:55

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	0	2	8	0	--	--	9.4	--	21.5	6.4	--	7.7	1.5	30	85	60

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
2.1	1	21.0	--	1	100	80	21.0	5	1	90	85	0	--	--	0	2	1

EfQu3:308

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	0	2	0	53.5	27.3	6.5	7.3	28.0	4.3	27.2	8.6	2.3	40	90	30

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	35.2	2.9	1	70	60	33.4	6	1	75	65	7	20.0	17.0	3	1	1

EfQu6:126

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	0	1	0	60.5	34.5	8.1	12.0	31.5	4.4	33.8	7.3	3.3	35	65	65

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.8	1	36.5	6.4	1	80	65	30.9	4	1	80	65	7	27.0	11.0	1	2	0

EfQv2:187

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	3	0	0	1	3	43.3	21.6	9.3	8.1	2.7	6.2	21.2	10.1	4.4	40	80	80

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	29.1	.9	1	75	75	24.0	4	2	70	60	2	19.5	6.4	2	3	0

EfQv10:114

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	2	1	0	1	0	56.2	27.7	7.7	10.0	36.5	6.8	26.7	13.5	6.9	25	45	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.9	1	39.4	4.0	1	90	90	40.0	4	1	80	60	2	21.0	14.1	3	3	0

Continued ...

Appendix 2 (continued).

EfQv10:186

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	1	1	0	0	1	1	25.2	17.7	6.6	2.0	16.5	3.5	15.0	4.7	3.0	25	80	60

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	21.3	2.6	1	65	65	18.2	5	1	90	60	2	14.5	5.5	1	1	0

EfQw1:437

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	2	2	0	0	2	0	42.1	25.6	6.1	5.5	21.5	3.4	25.6	9.8	--	20	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.4	1	25.9	2.4	1	80	50	24.0	1	4	60	60	2	20.5	14.0	3	2	1

EfQw1:563

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	2	2	0	0	2	0	38.2	20.5	6.5	5.7	20.2	5.4	19.6	10.1	--	20	100	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.5	1	23.5	3.1	1	75	65	--	3	2	50	50	3	17.5	18.7	3	3	1

EfQw1:564

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
5	2	2	0	0	2	0	49.7	28.3	5.9	8.1	29.5	5.0	28.0	10.8	4.6	30	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.7	1	35.0	5.1	1	85	75	35.0	3	1	80	60	2	21.5	13.8	3	3	1

EfRf3:77

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
4	2	1	0	0	1	0	42.2	21.9	10.6	7.0	26.0	5.0	21.5	7.2	3.2	30	95	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.9	1	26.6	1.9	1	50	50	26.7	2	3	85	85	8	15.5	14.5	3	1	0

EkSa13:3039

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	1	3	0	0	1	0	50.3	22.3	5.1	5.1	30.0	3.5	20.7	6.4	2.6	25	25	25

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.1	2	30.4	3.1	1	75	50	31.0	2	1	80	50	3	25.0	16.5	3	1	1

FiRs1:361

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	3	0	2	1	1	47.1	21.7	6.2	6.6	22.5	4.4	20.9	13.4	4.5	55	105	105

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
0	1	23.0	3.1	1	85	60	17.8	4	1	50	50	9	24.0	12.0	1	3	1

FiRs1:539

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	1	2	1	0	37.5	27.1	3.2	2.8	25.1	3.0	25.0	5.3	4.2	10	75	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	28.7	6.0	1	65	40	24.0	3	1	60	40	2	15.0	7.7	2	1	0

Continued ...

Appendix 2 (continued).

FiRs1:1352

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	2	0	2	3	0	--	19.1	3.4	--	--	3.4	19.1	--	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	50	50	--	5	1	--	--	2	16.5	10.5	2	1	0

FiRs1:1587

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	1	2	1	0	37.3	15.4	6.1	3.2	24.5	4.7	15.3	4.1	1.4	20	105	45

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.3	1	26.0	30	1	90	90	22.2	5	1	100	100	2	15.0	15.3	1	1	0

FiRs1:2028

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	1	2	1	0	29.6	17.6	4.8	2.4	1.5	4.2	15.3	16.8	5.5	30	90	80

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.5	1	15.9	1.8	1	85	75	18.8	2	1	60	60	1	15.0	8.7	1	2	0

FiRs1:3496

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	0	2	3	0	--	15.1	4.0	--	--	2.9	15.0	--	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	75	75	--	3	1	--	--	2	17.0	8.3	1	0	0

FiRs1:3818

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	1	2	1	0	36.1	20.4	7.9	3.8	28.0	3.6	20.2	8.7	2.8	25	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	28.1	3.9	1	55	55	25.5	4	1	80	40	2	13.0	10.7	2	1	0

FiRs1:4413

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	1	2	1	0	37.3	21.6	3.7	3.2	21.5	3.6	21.2	6.4	1.5	25	100	70

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1.0	1	25.7	5.1	1	70	55	20.0	5	3	65	65	2	16.0	15.1	3	2	1

FiRs1:5340

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	0	2	2	0	37.0	20.5	6.4	4.5	25.0	4.7	19.2	8.2	--	15	90	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
.8	1	27.0	5.0	1	70	70	16.5	4	1	60	50	2	13.5	6.7	1	2	0

FiRs1:5493

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	0	2	3	0	--	20.7	4.2	--	--	3.2	20.7	--	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	65	65	--	3	1	70	40	1	22.0	5.2	1	1	0

Continued ...

Appendix 2 (continued).

FiRs1:5699

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4	1	1	2	3	0	--	21.0	3.5	--	--	2.7	20.9	12.7	--	--	--	--

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
--	1	--	--	1	80	65	--	5	1	80	70	2	14.0	10.5	0	2	1

Appendix 3. Frequencies and relative percentages for ordinal and nominal scale attribute variables for the 129 prehistoric key-shaped formed unifaces in the study sample.

REGION OF ORIGIN:

	Chilcotin	Mid-Fraser	Lower Fraser	Thompson	S. Thompson-Shuswap	Nicola	North Okanagan	South Okanagan	Arrow Lakes	East Kootenay
n:	12	16	6	5	42	1	5	11	30	1
%:	9.3	12.4	4.7	3.9	32.6	.8	3.9	8.5	23.3	.8

SITE TYPE:

	Housepit	Lithic Scatter	Dwelling Platform	Cachepit	Unknown
n:	70	45	11	2	1
%:	54.3	34.9	8.5	1.5	.8

LITHIC RAW MATERIAL TYPE:

	Chalcedony	Chert	Basalt
n:	78	36	15
%:	60.5	27.9	11.6

EVIDENCE FOR THERMAL ALTERATION:

	Present	Absent
n:	35	94
%:	27.1	72.9

RELATIVE AGE:*

	Shuswap horizon	Plateau horizon	Kamloops horizon	Unknown
n:	9	48	1	71
%:	7.0	37.2	.8	55.0

CONCAVE MARGIN SIDE:

	Left	Right
n:	115	14
%:	89.1	10.9

CONCAVE MARGIN RETOUCH TYPE:

	Unifacial	Bifacial
n:	125	4
%:	96.9	3.1

OPPOSITE MARGIN OUTLINE:

	Moderately concave	Slightly concave	Moderately convex	Slightly convex	Straight	Recurved	Irregular	Margin absent
n:	9	14	24	27	34	10	10	1
%:	7.0	10.8	18.6	20.9	26.3	7.8	7.8	.8

Continued ...

Appendix 3 (continued).

OPPOSITE MARGIN RETOUCH TYPE:

	Unifacial	Bifacial	Inverse Unifacial	None	Margin Absent
n:	94	15	3	16	1
%:	72.9	11.6	2.3	12.4	.8

PROXIMAL MARGIN FORMAL OUTLINE TYPE:

	A	B	C	D	E	F	G	H	Miscell. Irregular
n:	23	61	3	12	1	3	11	5	10
%:	17.8	47.3	2.3	9.3	.8	2.3	8.5	3.9	7.8

PROXIMAL MARGIN RETOUCH TYPE:

	Unifacial	Bifacial	None	Unknown
n:	41	23	57	8
%:	31.8	17.8	44.2	6.2

OVERALL MICROWEAR TRACE INTENSITY:

	Absent	Slight	Moderate	Pronounced
n:	10	53	47	19
%:	7.8	41.1	36.4	14.7

FRAGMENTATION STATE:

	Complete	Almost complete	Distal 1/2 of proj. absent	Proximal portion only	Entire distal projection	Medial section	Portion of Proximal section absent
n:	88	18	16	1	1	1	4
%:	68.2	13.9	12.4	.8	.8	.8	3.1

MODIFICATION STATE:

	Relatively unmodified	Significantly resharpened	Recycled	Weathered
n:	98	20	1	10
%:	75.9	15.5	.8	7.8

EVIDENCE FOR RESIDUES:

	Present	Absent
n:	37	92
%:	28.7	71.3

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* Shuswap horizon: ca. 4000/3500 to 2400 BP; Plateau horizon: ca. 2400 to 1200 BP;
Kamloops horizon: ca. 1200 to 200 BP.

Appendix 4. Information concerning key-shaped formed unifaces provided by various Northwest researchers who responded by mail.

Researcher: Robert Ackerman
Affiliation: Washington State University
Research Area: Arctic and Subarctic
Comments: "Such tool forms are common in the Arctic and Subarctic Sub-Arctic ... These flake tools are called flakeknives and occur in the Norton and Denbigh phases of the Bering Sea region. Norton dates from roughly 500 BC to AD 1000. Denbigh dates ca. 2200-1000 BC. Some of your objects also appear to be similar to the mitten-shaped burin of the Denbigh phase. ... The Arctic is a bit far off, but there could be similarity of function that is responsible for the cultural convergence. The form is rather widespread throughout the Arctic and Subarctic zones. I do not know about the boreal forest. I would suspect that the tool form is rather generalized and one that is utilized in working organic materials such as bone." (Letter dated December 21, 1987).

Researcher: Margaret Bertulli
Affiliation: Prince of Wales Northern Heritage Center, Northwest Territories
Research Area: Arctic
Comments: "The artifacts you describe seem similar to what have been called concave sidescrapers in the Arctic region. They have appeared in Pre-Dorset, Dorset Independence I and Independence II components in the Arctic." (Letter dated December 23, 1987).

Researcher: Raymond LeBlanc
Affiliation: University of Alberta
Research Area: Arctic and Subarctic
Comments: "... it is my impression that such objects are rare in sites in the boreal forest region of Northern Alberta. The same appears to be true for the late prehistoric period (last 2500 years or so) in the Northern Yukon. ... As to the function of these objects, my guess is that they were used for scraping wood, bone, or antler shafts. This is a fairly standard interpretation, however, and it would be certainly desirable to verify this with some experimentation, followed by use-wear analysis of archaeological examples." (Letter dated December, 1987).

Continued...

Appendix 4 (continued).

Researcher: James Helmer
Affiliation: University of Calgary
Research Area: Arctic
Comments: "I am familiar with the "key-shaped" formed unifaces that you mention from my own experience in the Plateau quite a few years ago. You will be interested to know that very similar artefacts occur in Early Palaeo-Eskimo assemblages dating from circa 4500-3000 BP. In Arctic assemblages these tools are referred to as concave sidescrapers (though sometimes this type of tool has been included in the generic class of flake knife too). ... They never make up a very large percentage of any assemblage but nonetheless are common. No one that I know of has done a typological analysis of these objects. Based on my own material from Devon Island I suspect that there have been some stylistic changes through time. But, this is purely a subjective determination based on a small sample. According to Moreau Maxwell (1973, 1985) these concave sidescrapers may persist into Late Palaeo-Eskimo complexes but they certainly aren't common after circa 3000 B.P. I do not know for sure what the functional replacement was though it may well have been the ground burin (burin-like tool in the literature)." (Letter dated February 4, 1988).

Researcher: Robert McGhee
Affiliation: Archaeological Survey of Canada
Research Area: Canadian Museum of Civilization
Comments: "... very similar objects occur in the Arctic regions where they are associated with the ASTt. Although they occur throughout the Paleoeskimo tradition, they are characteristic only of the earlier stages -- what in Arctic Canada is known as Independence and Pre-Dorset. Here they are known as "concave sidescrapers", with the implied but unverified function of having been used as spokeshaves in working wood or harder organic materials. They are also identified as burin blanks ... left-handed people used ones which were reversed in plan from the tools used by right handers. ... the frequencies for my Port Refuge sites, and for the three components which had adequate numbers, came up with the following: Cold Component (about 2000 BC?): 7/532 formed artifacts; Upper Beaches component (about 1500 BC?): 14/472. After about 500 BC, they occur only rarely ..." (Letter dated December 17, 1987).

Continued...

Appendix 4 (continued).

Researcher: David Morrison
Affiliation: Archaeological Survey of Canada
Research Area: Arctic
Comments: "... they occur in the Arctic. Specifically, they are a Palaeoeskimo tool type, normally called "concave sidescrapers". They occur in Independence I, Pre-Dorset and Dorset (i.e. 2000 B.C. to A.D. 1000), but seem to be particularly common in Independence I and Pre-Dorset. I've always assumed (like most others I think) that they were used primarily for shaping wood, antler and ivory. Nothing like these occur in the Subarctic as far as I know, at least not as a well-defined "type". Nor do they occur in the late prehistoric Thule culture of the Arctic." (Letter dated December 22, 1987).

Researcher: Milton Wright
Affiliation: Archaeological Survey of Alberta
Research Area: Northern Alberta
Comments: "The items you describe are what I have termed crescentic knives or scrapers in sites ranging from Late Woodland in Ontario to undated contexts in the northern parklands of Alberta. The major problem with this "class" of lithic tool is the extreme variability that I see in formal properties. To be sure the outline form of the tool is relatively consistent, but they can appear on reworked bifaces, unifaces, and utilized flakes. While you may be able to identify a particular sub-set of "key-shaped unifaces" I think the functional aspect of these tools is also mirrored in the reworked bifaces and unifaces that I term crescentic tools. It seems most reasonable that such tools would be associated with wood working - presumably shaft preparation for thrusting spears, arrow shafts, etc." (Letter dated February 2, 1988).

Researcher: David Chance
Affiliation: University of Idaho
Research Area: Eastern Columbia Plateau
Comments: "The artifacts are called by us "Right Perforators" at Kettle Falls where they are an important marker, in large size, of the Ksunku period. Shorter ones, termed "Short Right Perforators" were found to be diagnostic of the Sinaikst period at Kettle Falls. In the southern Plateau they have not been recognized except by myself. They seem to characterize the Tucannon phase (5000 - 2500 BP). ... My belief, based on cursory examination, is that they are probably leather punches. Note that "left-handed" ones are virtually unknown." (Letter dated December 16, 1987).

Continued...

Appendix 4 (continued).

Researcher: Robert Greengo
Affiliation: University of Washington
Research Area: Central Columbia Plateau
Comments: "... that class occurred rarely if at all, in the Priest Rapids-Wanapum region of the Middle Columbia. Similar forms occurred infrequently in the Chief Joseph region, farther up the Columbia." (Letter dated January 18, 1988).

Researcher: Leslie Davis
Affiliation: Montana State University
Research Area: Montana
Comments: "I have shown your letter to two other experienced archaeologists active in this part of the world and they, like myself, do not recognize such an artifact class. From the photocopied illustration, one gets the (perhaps unfortunate) impression that the class includes objects which are superficially morphologically similar, but which may actually combine functionally dissimilar or diverse subclasses." (Letter dated January 6, 1988).

Researcher: John Brumley
Affiliation: Ethos Consultants Ltd., Medicine Hat, Alberta
Research Area: Northern Plains
Comments: "I am not aware of any tools closely similar to the ones you illustrate in your letter. A somewhat similar tool which I refer to as a hafted spokeshave was recovered from the Cactus Flower site in association with McKean Complex materials. The distal working end of that hafted spokeshave seems closely analogous to the specimens you described. ... I have seen two similar hafted spokeshave specimens from a surface context in the Bear Paw Mountains of northern Montana; and one from a surface context in south central Saskatchewan." (Letter dated March 4, 1988).

Appendix 5. Code legend for the 55 attribute variables examined in the 35 specimens comprising the microwear study sub-sample.

Variable Number
and Description

DISTAL PROJECTION:

1. **Fracture Type:**
   1:none 2:flexure 3:torsion 4:crushed/heat spalled 5:inversely retouched

2. **Edge rounding and smoothing intensity:**
   1:absent 2:slight 3:moderate 4:pronounced

3. **Edge rounding and smoothing location:**
   1:corners 2:distal edge 3:distal edge and corners 4:distal edge corners and faces

4. **Polish intensity:**
   1:absent 2:dull 3:moderately bright 4:bright

5. **Polish location:**
   1:corners 2:distal edge 3:distal edge and corners 4:distal edge corners and faces

6. **Microflake frequency**

7. **Microflake mean size (in mm)**

8. **Microflake size minimum value (in mm)**

9. **Microflake size maximum value (in mm)**

10. **Microflake location:**
    1:distal edge 2:corner(s) 3:both

11. **Microflake orientation:**
    1:perpendicular 2:oblique 3:both

12. **Crushing intensity:**
    1:absent 2:slight 3:moderate 4:pronounced

13. **Crushing location:**
    1:corners 2:distal edge 3:distal edge and corners 4:distal edge corners and faces

14. **Striations:**
    1:absent 2:present

Continued ...

Appendix 5 (continued).

CONCAVE MARGIN AND VENTRAL EDGE ASPECT

15. **Edge rounding and smoothing intensity:**
1:absent 2:slight 3:moderate 4:pronounced

16. **Edge rounding and smoothing location:**
1:medial 2:medial-distal 3:medial-proximal
4:entire edge 5:distal edge

17. **Polish intensity:**
1:absent 2:dull 3:moderately bright 4:bright

18. **Polish location:**
1:medial 2:medial-distal 3:medial-proximal
4:entire edge 5:distal edge

19. **Microflake frequency**

20. **Microflake mean size (in mm)**

21. **Microflake size minimum value (in mm)**

22. **Microflake size maximum value (in mm)**

23. **Microflake location:**
1:medial 2:medial-distal 3:medial-proximal
4:entire edge

24. **Microflake configuration pattern:**
1:random 2:contiguous 3:contiguous superposed

25. **Striations:**
1:absent 2:present

26. **Crushing intensity:**
1:absent 2:slight 3:moderate 4:pronounced

27. **Crushing location:**
1:medial 2:medial-distal 3:medial-proximal
4:entire edge 5:distal

Continued ...

Appendix 5 (continued).

OPPOSITE MARGIN AND VENTRAL EDGE ASPECT

28. **Edge rounding and smoothing intensity:**
    1:absent 2:slight 3:moderate 4:pronounced

29. **Edge rounding and smoothing location:**
    1:medial 2:medial-distal 3:medial-proximal 4:entire edge

30. **Polish intensity:**
    1:absent 2:dull 3:moderately bright 4:bright

31. **Polish location:**
    1:medial 2:medial-distal 3:medial-proximal
    4:entire edge

32. **Microflake frequency**

33. **Microflake mean size (in mm)**

34. **Microflake size minimum value (in mm)**

35. **Microflake size maximum value (in mm)**

36. **Microflake location:**
    1:medial 2:medial-distal 3:medial-proximal
    4:entire edge 5:dorsal edge aspect

37. **Microflake configuration pattern:**
    1:random 2:contiguous 3:contiguous superposed

38. **Striations:**
    1:absent 2:present

39. **Crushing intensity:**
    1:absent 2:slight 3:moderate 4:pronounced

40. **Crushing location:**
    1:medial 2:medial-distal 3:medial-proximal 4:entire edge

PROXIMAL MARGIN AND VENTRAL EDGE ASPECT

41. **Microwear trace:**
    1:absent 2:present

Continued ...

Appendix 5 (continued).

VENTRAL FACE

42. **Polish intensity:**
 1:absent 2:dull 3:moderately bright 4:bright

43. **Polish location on projection:**
 1:medial 2:medial-distal 3:medial-proximal
 4:entire face 5:distal

44. **Striation intensity:**
 1:absent 2:slight 3:moderate 4:pronounced

45. **Striation location:**
 1:medial 2:medial-distal 3:medial-proximal
 4:entire face

46. **Striation respective orientation:**
 1:parallel unidirectional: 2:parallel bidirectional
 3:parallel multidirectional

47. **Striation orientation with respect to edge:**
 1:perpendicular 2:distal 3:proximal
 4:perpendicular and distal

48. **Angle of proximally oriented striations relative to the concave margin (in degrees)**

49. **Microtopographic rounding and smoothing intensity:**
 1:absent 2:slight 3:moderate 4:pronounced

50. **Microtopographic rounding and smoothing location:**
 1:medial 2:medial-distal 3:medial-proximal
 4:entire face

DORSAL FACE

51. **Microtopographic rounding and smoothing intensity:**
 1:absent 2:slight 3:moderate 4:pronounced

52. **Microtopographic rounding and smoothing location:**
 1:proximal half 2:left side of proximal half
 3:dorsal surface of opposite margin 4:both 2&3

53. **Projection tip mean distal edge angle (in degrees)**

54. **Concave margin mean edge angle (in degrees)**

55. **Opposite margin mean edge angle (in degrees)**

Appendix 6. Frequencies and relative percentages of discrete nominal and ordinal scale microwear variables for the 35 prehistoric microwear sub-sample specimens, and eight experimental tools engaged in bark stripping and woodworking activities.

LITHIC RAW MATERIAL TYPES:

		Chalcedony	Chert	Basalt
Microwear Sub-sample*	n:	20	12	3
	%:	57.1	34.3	8.6
Experimental Tools**	n:	4	3	1
	%:	50.0	37.5	12.5

DISTAL PROJECTION TIP FRACTURE STATE:

		Complete	Flexure	Torsion	Indetermin.	Inversely retouched
Microwear Sub-sample	n:	16	12	4	2	1
	%:	45.7	34.3	11.4	5.7	2.9
Experimental Tools	n:	8				
	%:	100.0				

DISTAL PROJECTION TIP ROUNDING AND SMOOTHING INTENSITY:

		Absent	Slight	Moderate	Pronounced	Tip missing
Microwear Sub-sample	n:	7	11	8	8	1
	%:	20.6	32.4	23.5	23.5	-
Experimental Tools	n:	2	5	1		
	%:	25.0	62.5	12.5		

DISTAL PROJECTION TIP ROUNDING AND SMOOTHING LOCATION:

		Corners only	Distal edge only	Distal edge and corners	All	Missing/ absent
Microwear Sub-sample	n:	16	3	7	1	8
	%:	59.3	11.1	25.9	3.7	-
Experimental Tools	n:	2		4		2
	%:	33.3		66.7		-

DISTAL PROJECTION TIP POLISH INTENSITY:

		Dull	Moderately Bright	Bright	Absent	Tip missing
Microwear Sub-sample	n:	6	19	2	7	1
	%:	17.6	55.9	5.9	20.6	-
Experimental Tools	n:	2	2	2	2	
	%:	25.0	25.0	25.0	25.0	

Continued ...

Appendix 6 (continued).

DISTAL PROJECTION TIP POLISH LOCATION:

		Corners only	Distal edge only	Distal edge and corners	All	Missing/ absent
Microwear Sub-sample	n:	15	3	8	1	8
	%:	55.6	11.1	29.6	3.7	-
Experimental Tools	n:	1	2	3		2
	%	16.7	33.3	50.0		-

MICROFLAKE LOCATION ON DISTAL PROJECTION TIP:

		Corners only	Distal edge only	Distal edge and corners	Missing/ absent
Microwear Sub-sample	n:	9	6	3	17
	%:	50.0	33.3	16.7	-
Experimental Tools	n:	5	1		2
	%:	83.3	16.7		-

ORIENTATION OF MICROFLAKES ON DISTAL PROJECTION TIP:

		Perpen-dicular	Oblique	Both	Missing/ absent
Microwear Sub-sample	n:	5	8	5	17
	%:	27.8	44.4	27.8	-
Experimental Tools	n:	3	3		2
	%:	50.0	50.0		-

CRUSHING INTENSITY ON DISTAL PROJECTION TIP:

		Absent	Slight	Moderate	Pronounced	Tip missing
Microwear Sub-sample	n:	22	3	6	3	1
	%:	64.7	8.8	17.6	8.8	-
Experimental Tools	n:	6	1	1		
	%:	75.0	12.5	12.5		

CRUSHING LOCATION ON DISTAL PROJECTION TIP:

		Corners only	Distal edge only	Distal edge and corners	Missing/ absent
Microwear Sub-Sample	n:	3	7	2	23
	%:	25.0	58.3	16.7	-
Experimental Tools	n:	1		1	6
	%:	50.0		50.0	

Continued ...

Appendix 6 (continued).

EVIDENCE FOR STRIATIONS ON DISTAL PROJECTION TIP:

		Absent	Present	Tip missing
Microwear Sub-sample	n:	31	3	1
	%:	91.2	8.8	-
Experimental Tools	n:	8		

CONCAVE MARGIN EDGE ROUNDING AND SMOOTHING INTENSITY:

		Slight	Moderate	Pronounced	Absent
Microwear Sub-sample	n:	17	9	6	3
	%:	48.6	25.7	17.1	8.6
Experimental Tools	n:	2	4	2	
	%:	25.0	50.0	25.0	

CONCAVE MARGIN EDGE ROUNDING AND SMOOTHING LOCATION:

		Medial	Medial-distal	Entire	Distal	Missed/ absent
Microwear Sub-sample	n:	9	16	6	1	3
	%:	28.1	50.0	18.8	3.1	-
Experimental Tools	n:	1	7			
	%:	12.5	87.0			

CONCAVE MARGIN EDGE POLISH INTENSITY:

		Dull	Moderately Bright	Bright	Absent
Microwear Sub-sample	n:	11	17	4	3
	%:	31.4	48.6	11.4	8.6
Experimental Tools	n:		1	6	1
	%:		12.5	75.0	12.5

CONCAVE MARGIN EDGE POLISH LOCATION:

		Medial	Medial-distal	Entire	Distal	Missed/ absent
Microwear Sub-sample	n:	10	17	4	1	3
	%:	31.3	53.1	12.5	3.1	-
Experimental Tools	n:	1	6			1
	%:	14.3	85.7			-

Continued ...

Appendix 6 (continued).

LOCATION OF MICROFLAKES ON CONCAVE MARGIN VENTRAL EDGE ASPECT:

		Medial	Medial-distal	Medial-proximal	Entire	Missed/absent
Microwear Sub-sample	n:	13	5	1	6	10
	%:	52.0	20.0	4.0	24.0	-
Experimental Tools	n:		5		3	
	%:		62.5		37.5	

MICROFLAKE CONFIGURATION PATTERN ON CONCAVE MARGIN VENTRAL EDGE ASPECT:

		Random	Contiguous	Contiguous-superposed	Missed/absent
Microwear Sub-sample	n:	11	3	4	17
	%:	61.0	16.7	22.3	-
Experimental Tools	n:	2	2	4	
	%:	25.0	25.0	49.7	

EVIDENCE FOR STRIATIONS ON CONCAVE MARGIN VENTRAL EDGE ASPECT:

		Absent	Present
Microwear Sub-sample	n:	20	15
	%:	57.1	42.9
Experimental Tools	n:	5	3
	%:	62.5	37.5

CONCAVE MARGIN EDGE CRUSHING INTENSITY:

		Slight	Moderate	Pronounced	Absent
Microwear Sub-sample	n:	5	3	3	24
	%:	14.3	8.6	8.6	68.6
Experimental Tools	n:	4		1	3
	%:	50.0		12.5	37.5

CONCAVE MARGIN EDGE CRUSHING LOCATION:

		Medial	Medial-distal	Entire	Distal	Missed/absent
Microwear Sub-sample	n:	2	4	4	1	24
	%:	18.2	36.4	36.4	9.1	-
Experimental Tools	n:	3	3			2
	%:	50.0	50.0			-

Continued ...

Appendix 6 (continued).

OPPOSITE MARGIN EDGE ROUNDING AND SMOOTHING INTENSITY:

		Slight	Moderate	Pronounced	Absent	Margin missing
Microwear Sub-sample	n:	14	11	2	7	1
	%:	41.2	32.3	5.9	20.6	-
Experimental Tools	n:	1			7	
	%:	12.5			87.5	

OPPOSITE MARGIN EDGE ROUNDING AND SMOOTHING LOCATION:

		Medial	Medial-distal	Entire	Missing/absent
Microwear Sub-sample	n:	4	19	4	8
	%:	14.8	70.4	14.8	-
Experimental Tools	n:	1			7
	%:	100.0			-

OPPOSITE MARGIN EDGE POLISH INTENSITY:

		Dull	Moderately Bright	Bright	Absent	Margin missing
Microwear Sub-sample	n:	13	11	3	7	1
	%:	38.2	32.4	8.8	20.6	-
Experimental Tools	n:		3		5	
	%:		37.5		62.0	

OPPOSITE MARGIN EDGE POLISH LOCATION:

		Medial	Medial-distal	Entire	Missing/absent
Microwear Sub-sample	n:	6	20	1	8
	%:	22.2	74.1	3.7	-
Experimental Tools	n:	1	2		5
	%:	33.3	66.7		-

MICROFLAKE LOCATION ON OPPOSITE MARGIN VENTRAL EDGE ASPECT:

		Medial	Medial-distal	Entire	Missed/absent
Microwear Sub-sample	n:	10	10	3	12
	%:	43.5	43.5	13.0	-
Experimental Tools	n:	1	5		2
	%:	16.7	83.3		-

Continued ...

Appendix 6 (continued).

MICROFLAKE CONFIGURATION PATTERN ON OPPOSITE MARGIN VENTRAL EDGE ASPECT:

		Random	Contiguous	Contiguous superposed	Missed/ absent
Microwear Sub-sample	n:	12	3	4	16
	%:	63.2	15.8	21.1	-
Experimental Tools	n:	1		1	6
	%:	50.0		50.0	-

EVIDENCE FOR STRIATIONS ON OPPOSITE MARGIN VENTRAL EDGE ASPECT:

		Absent	Present	Margin missing
Microwear Sub-sample	n:	29	5	1
	%:	85.3	14.7	-
Experimental Tools	n:	7	1	
	%:	87.5	12.5	

OPPOSITE MARGIN EDGE CRUSHING INTENSITY:

		Slight	Moderate	Absent	Margin missing
Microwear Sub-sample	n:	6	3	25	1
	%:	17.6	8.8	73.5	-
Experimental Tools	n:	1		7	
	%:	12.5		87.5	

OPPOSITE MARGIN EDGE CRUSHING LOCATION:

		Medial-distal	Entire	Missing/ absent
Microwear Sub-sample	n:	6	3	26
	%:	66.7	33.3	-
Experimental Tools	n:	1		7
	%:	100.0		-

EVIDENCE FOR MICROWEAR ON PROXIMAL MARGIN EDGE:

		Absent	Present
Microwear Sub-sample	n:	31	4
	%:	88.6	11.4
Experimental Tools	n:	8	

Continued ...

Appendix 6 (continued).

VENTRAL FACE POLISH INTENSITY:

		Dull	Moderately Bright	Bright
Microwear Sub-sample	n:	5	18	12
	%:	14.3	51.4	34.3
Experimental Tools	n:	1	2	4
	%:	12.5	25.0	50.0

VENTRAL FACE POLISH LOCATION:

		Medial	Medial-distal	Entire	Distal	Absent
Microwear Sub-sample	n:	11	21	2	1	
	%:	31.4	60.0	5.7	2.9	
Experimental Tools	n:	1	6			1
	%:	12.5	75.0			12.5

VENTRAL FACE STRIATION INTENSITY:

		Slight	Moderate	Pronounced	Absent
Microwear Sub-sample	n:	14	3	5	13
	%:	40.0	8.6	14.3	37.1
Experimental Tools	n:	1			7
	%:	12.5			87.5

VENTRAL FACE STRIATION LOCATION:

		Medial	Medial-distal	Entire	Missed/absent
Microwear Sub-sample	n:	7	13	2	13
	%:	31.8	59.1	9.1	-
Experimental Tools	n:	1			7

VENTRAL FACE STRIATION TYPE:

		Scratched groove	Sleek	Scratched and sleek	Missing/absent
Microwear Sub-sample	n:	14	3	5	13
	%:	63.7	13.6	22.7	-
Experimental Tools	n:		1		7

Continued ...

Appendix 6 (continued).

VENTRAL FACE STRIATION ORIENTATION PATTERN TYPE:

		Parallel uni-directional	Parallel bi-directional	Parallel multi-directional	Missing/absent
Microwear Sub-sample	n:	18	1	3	13
	%:	81.8	4.5	13.6	-
Experimental Tools	n:	1			7

VENTRAL FACE STRIATION ORIENTATION PATTERN WITH RESPECT TO THE CONCAVE MARGIN:

		Distally	Proximally	Perpendicular	Missing/absent
Microwear Sub-sample	n:	19	1	2	13
	%:	86.4	4.5	9.1	-
Experimental Tools	n:	1			7

VENTRAL FACE SURFACE TOPOGRAPHY ROUNDING AND SMOOTHING INTENSITY:

		Slight	Moderate	Pronounced	Absent
Microwear Sub-sample	n:	12	4	6	13
	%:	34.3	11.4	17.1	37.1
Experimental Tools	n:	3			5
	%:	37.5			62.5

VENTRAL FACE SURFACE TOPOGRAPHY ROUNDING AND SMOOTHING LOCATION:

		Medial	Medial-distal	Entire	Proximal	Missed/absent
Microwear Sub-sample	n:	11	8	2	1	13
	%:	50.0	36.4	9.1	4.5	-
Experimental Tools	n:	2	1			5
	%:	66.7	33.3			-

DORSAL FACE SURFACE TOPOGRAPHY ROUNDING INTENSITY:

		Slight	Moderate	Pronounced	Absent
Microwear Sub-sample	n:	8	7	1	19
	%:	22.9	20.0	2.9	54.3
Experimental Tools	n:				8

Continued ...

Appendix 6 (continued).

DORSAL FACE SURFACE TOPOGRAPHY ROUNDING LOCATION:

		Entire proximal aspect	Left-proximal aspect	Medial aspect of opposite margin	Left-proximal aspect & medial aspect of opposite margin	Absent
Microwear Sub-sample	n:	6	2	2	6	19
	%:	37.5	12.5	12.5	37.5	-
Experimental Tools	n:					8

* Includes the 35 randomly sampled specimens in the prehistoric microwear sub-sample.

** Includes the eight experimental tools (ET.#'s 1-6,8,10) used exclusively on bark and wood.

Appendix 7. Summary description of physical properties of lithic raw materials used to make experimental tools (E.T.'s) #1 to #10.

Type 1 Chert.
Quarry Source: Northern Oregon; exact location and geologic context unknown.
General Description: Duochrome cryptocrystalline with wide bands of opaque dull buff vis-a-vis slightly translucent, medium red-brown with dull to waxy luster; Moh hardness is 8.0; flakability is generally considered be good to excellent, large flake blanks are easily produced and it lends itself very well to pressure flaking; used to make Experimental Tools (E.T.'s) #1 and #2 (Figures 41-49, and 54-57). Reference: Mr Cliff Smith, 4071 Lillooet Street, Burnaby, B.C..

Type 2 Chalcedony.
Quarry Source: Southern Washington; exact location and geologic context unknown.
General Description: Slightly mottled, varying between medium brown, brownish-grey, medium grey; and slightly translucent; cryptocrystalline with waxy luster; Moh hardness value is 8.0; flakeability is fair to good, with control being slightly hampered by the hardness of the material, affecting success in producing large flakes and making pressure flaking a bit difficult; tends to "hinge" at terminations; used to make E.T.'s #3 and #4 (Figures 41, 42, 58 and 59). Reference: Mr Cliff Smith, 4071 Lillooet Street, Burnaby, B.C..

Type 3 Chert.
Quarry Source: Falkland, B.C.; float pebbles in local glacio-fluvial deposits.
General Description: Overall light-brown with thin, alternating tan and light brown to medium brown bands; cryptocrystalline with waxyluster; Moh hardness value is 6.5; generally poor to fair flakability. Tends to contain a high incidence of internal perverse fracturing, and it is very brittle. This detrimentally affects production of suitable flake blanks. Flake blanks often snap when being pressure flaked. Used to make E.T. #5 (Figures 41, 42 and 60). Reference: Mrs. Ruby Gay, Vernon, B.C.

Continued ...

Appendix 7 (continued).

Type 4 Chalcedony.
Quarry Source: Pavilion B.C.; fLoat pebble found in glacio-fluvial deposits.
General Description: Highly translucent light white-grey with occasional crystalline inclusions; cryptocrystalline with waxy luster; Moh hardness value is 7.5; flakability is generally fair, but its toughness and presence of occasional internal flaws hinders large flake blank production and renders pressure flaking a bit difficult; used to produce E.T. #6 (Figures 41, 42 and 61). Found by the author during a hike.

Type 5 Chalcedony.
Quarry Source: Hat Creek Valley, B.C.; from float deposits in the Medicine Creek locality.
General Description: Generally light yellow brown, moderately translucent with an occasional inclusion of opaque white or highly translucent white-grey; cryptocrystalline with waxy luster; MOH hardness value is 8.0. Fair flakeability due to its toughness and high incidence of internal flaws. Used to make E.T.'s #7 and #8 (Figures 41, 50, 51 and 62). This material is widely known to B.C. Interior archaeologists and rockhounds, and is commonly referred to as "Hat Creek Chert". However, the example used in this study is a chalcedony.

Type 6 Basalt.
Quarry Source: Cache Creek B.C.; float pebbles in local glacio-fluvial and fluvial deposits.
General Description: Opaque black, microcrystalline with the occasional crystalline inclusion; Moh value is 6.5; flakeability is considered to be fair to excellent although the presence of occasional internal flaws and inclusions sometimes hinders effective large flake blank production and pressure flaking. Used to make E.T.'s #9 and #10 (Figures 41, 42, 64 and 65). Reference: Richards (1987). E.T. #9 was made from fine-grained basalt; E.T. #10 from fairly glassy basalt.

Appendix 8. Summary descriptions of woody plant contact materials used in the experiments.

Saskatoon bark and wood:

Saskatoon is a deciduous shrub belonging to the Rose family. It is also sometimes referred to as service berry, and commonly grows as a bush consisting of several primary stalks that vary between 1 and 7 m high. It is common throughout British Columbia and Washington, particularly in dry forests and open hillsides of the Interior Plateau. The stalks and branches are relatively straight or slightly curved, and their diameters usually differ only slightly along their lengths. The wood is quite hard, rigid, and durable, particularly when dry. The bark is relatively thin, tough, and fibrous, and cannot be easily peeled away from the wood by hand. Ethnographically, it was most commonly used to make arrows by all of the Interior Salish groups, and the Kootenay, Carrier, Upper Stalo, and Flathead. Other items produced from saskatoon wood that required bark removal and/or woodworking include digging stick shafts, spear and harpoon shafts, fire drills, implement handles, basket frames, and canoe frames (see Teit 1900:231,235,241, 1909:514,519; Turner 1979:230-232). Experimental Tools (E.T.'s) # 1, #3, #5, #6, #8, and #10 were used in the experimental component of the study to strip bark and shave, scrape, plane, incise, and engrave green saskatoon bark and wood (Appendix 8). E.T. #3 was also resharpened after being used on green sasakatoon, and was then used to work seasoned saskatoon. The saskatoon used in the study was obtained in proximity to the Keatley Creek archaeological site near the community of Pavilion in the Mid-Fraser River region of British Columbia, near Three Sisters Creek British Columbia Forestry campground about 20 km southwest of Ashcroft, B.C., and beside the Trans-Canada highway in the Thompson River Valley about 10 km north of Lytton, B.C.

Rocky Mountain juniper bark and wood:

Rocky Mountain juniper is a tree belonging to the Cypress Family that varies from low spreading shrubs about 1 m high to densely branched trees about 10 m high. It is common throughout southern British Columbia and Washington in dry environments on plains, valleys, and lower mountains. The branches are usually slightly to moderately curved, and they taper markedly along their lengths. The wood is quite hard, rigid, and durable, particularly when dry. When the outer bark is removed, the surface of the wood contains numerous small bumps, nodes, and other irregularities. The bark is quite tough, fibrous, and moderately thick, and can be easily peeled away from the wood in large strips by hand. The wood was used by the ethnographic Interior Salish groups primarily for making bows, although snowshoe frames and spear shafts were also sometimes made by the Shuswap. The Thompson also made juniper bark baskets (see Teit 1900:239; 1909:519; Turner 1979:71-73). E.T. #2 was used in the experimental component of this study to strip bark and scrape, shave, plane juniper branches (Appendix 8). The juniper was obtained in proximity to the Keatley Creek archaeological site near the community of Pavilion in the Mid-Fraser River region of British Columbia, and near Three Sisters Creek British Columbia Forestry campground about 20 km southwest of Ashcroft, B.C.

Continued...

Appendix 8 (continued).

Willow bark and wood:

There are as many as 50 species of willows indigenous to British Columbia and Washington. These occur as small shrubs measuring about .5 m high to trees 10 m high. Some characteristics, particularly bark and leaves, can vary widely between species. At least three unidentified species were used in the experimental component of this study. Their stalks and branches were long and slender with fairly consistent diameters along their lengths. When green, the wood is soft and very pliable, however, when dried it becomes stiff and brittle. The bark is moderately thick, and can be peeled away from the wood very easily by hand in long even strips. Ethnographic data indicate that debarked and worked stalks and branches of willow were commonly used by the Interior Salish groups to make fish traps, fish weirs, fire drills and tinder. Shredded willow bark was often used to make articles of clothing, cordage, nets, basketry, bags, diapers, wound dressings, and sanitary napkins (see Teit 1909:527; Turner 1979:258-265). E.T. #4 was used exclusively to strip bark and shave, scrape, and plane fresh green willow stalks and branches (Appendix 8). These were obtained in proximity to the Keatley Creek archaeological site near the community of Pavilion in the Mid-Fraser River region of British Columbia, and near Three Sisters Creek British Columbia Forestry campground about 20 km southwest of Ashcroft, B.C.

Appendix 9. Summary description of experimental tool use results.

E.T. #1
Lithic Type: Type 1 Chert
Contact Material: Saskatoon stalks and branches
Total No. of Strokes: 12,500
Mean Stroke Length: 15 cm
Total Time Elapsed: 317 min
Location of Use: Camp Kitchen area at Keatley Creek
Experimenter: Mike Rousseau
Witnesses: Bob Muir, Gyles Iannone, Peter Merchant

Comments: The concave and opposite margin edges were used in a shaving, scraping, planing action to strip bark, and modify and smooth irregularities (e.g., branch nodes, bumps, bends) of green saskatoon stalks and branches using moderate to heavy levels of applied force. The concave margin was used far more often than the opposite margin for these activities. The tip of the distal projection was used to remove bark around the branch nodes by primarily scraping and prying, and to incise linear grooves into the wood. A total of 13.2 m of fresh green stalks/branches having a mean diameter of 1.10 cm were processed. On average, 5.90 m of bark and/or wood were removed per minute, suggesting a comparatively average working rate. The tool was hafted throughout its entire use-life, and was considered to be quite effective for performing all the tasks outlined above. A slight polish and a few microflakes were evident on the concave margin edge after about 5000 strokes; a moderate polish developed and a few more microflakes had developed after about 9000 strokes; and the concave margin edge would have required resharpening to restore optimal functional efficiency at about 11,000 strokes. Polish development and microflake formation were noted to be most frequent during woodworking activities rather than with bark removal. Plant resin and fibre residues accumulated on the dorsal aspects of the concave and lateral margin, and on the ventral face of the tool.

Continued...

Appendix 9 (continued).

E.T. #2
Lithic Type: Type 1 Chert
Contact Material: Juniper branches
Total No. of Strokes: 7,700
Mean Stroke Length: 12 cm
Total Time Elapsed: 340 min
Location of Use: Keatley Creek and Three Sisters Creek Campground
Experimenter: Gyles Iannone
Witnesses: John Breffitt, Peter Merchant, Bob Muir, Mike Rousseau

Comments: The concave and opposite margin edges were used to strip bark, shave/scrape/plane down wood, and smooth irregularities in the wood (e.g., branch nodes, bumps, bends) using moderate levels of applied force. The concave margin was used most frequently for these activities. The tool was used hand-held for the first 3500 strokes, and then hafted for the remainder of its use-life. Hafting was noted to improve efficiency and manipulation of the tool. It was observed that when used unhafted, the opposite margin was used about as often as the concave margin for scraping and shaving wood. Once hafted, the concave margin was used more often and was more effective for this task. Bark removal was easier using the hafted tool. The opposite margin was often used to remove the secondary branch nodes. The distal projection was rarely used, but assisted in removing secondary branch nodes. In general, the tool was considered to be fairly effective for executing the above tasks. A total of 7.60 m of fresh green juniper branches having a mean diameter of .8 cm was processed. On average, 2.70 m of bark and/or wood were being removed per minute, suggesting a comparatively slow working rate. At about 800 strokes a few tiny microflakes were visible on the ventral edge aspects of the concave and opposite margins; by about 1200 strokes some slight polish had begun to develop in the same locations; and by about 6000 strokes several tiny microflakes were present on the medial aspects of these margins. **Note:** Use of the tool was discontinued after ca. 7,700 strokes, but it was estimated that it could have continued to have functioned quite effectively for another estimated 5000 strokes before it would have required resharpening. During use, some plant resins and fibres were deposited on the dorsal aspects of the concave and opposite margins.

Continued...

Appendix 9 (continued).

E.T. #3
Lithic Type: Type 2 Chalcedony
Contact Material: Saskatoon stalks and branches
Total No. of Strokes: 15,400
Mean Stroke Length: 15 cm
Total Time Elapsed: 415 min
Location of Use: Three Sisters Campground
Experimenter: Mike Rousseau
Witnesses: John Breffitt, Gyles Iannone, Peter Merchant, Bob Muir

Comments: The concave and opposite edges were used to strip bark, shave/scrape/plane down wood, and smooth irregularities (e.g., branch nodes, bumps, bends) using moderate to heavy applications of force. The concave margin was favoured for executing these tasks. The distal tip was used to remove bark around the branch nodes and to incise linear grooves into the wood using heavy force loads. A total of 13.8 m of fresh green saskatoon having a mean diameter of .93 cm was processed. On average, 5.55 m of bark and/or wood were being removed per minute, indicating a moderate working rate. Initially the tool was used hand-held, however, after about 3500 strokes it was decided to haft the tool to improve manipulation, enhance effectiveness by permitting greater loads of applied force. At about 6500 strokes a slight polish appeared along the medial ventral edge aspect of the concave margin; at about 9000 strokes the tool became slightly dull, and a large microflake was removed from the medial ventral edge aspect. It was still very effective after 12,000 strokes, and was still moderately sharp at the conclusion of its use episode. It is probable that the tool could have been used for at least another 4000 to 5000 strokes on green saskatoon before requiring resharpening. During use, plant resins and fibres became adhered to the dorsal aspects of the concave and opposite margins, and the ventral face. **Note:** This tool's concave margin was subsequently resharpened and used to scrape and shave seasoned (dry) saskatoon for 1000 strokes. The bark was very difficult to remove, and the wood was almost impossible to modify in any manner. Two large microflakes were removed; one at 450 strokes, and the other at 650 strokes. A third smaller microflake was also noted. No polish development was noted.

Continued...

Appendix 9 (continued).

E.T. #4
Lithic Type: Type 2 Chalcedony
Contact Material: Willow stalks and branches
Total No. of Strokes: 17,650
Mean Stroke Length: 10 cm
Total Time Elapsed: 410 min
Location of Use: Keatley Creek
Experimenter: Bob Muir
Witnesses: Rob Gargett, Gyles Iannone, Peter Merchant, Mike Rousseau

Comments: The concave and opposite margin edges were used primarily to shave and plane irregularities on the woody portions of stalks and branches (e.g., branch nodes, bumps) and occasionally to remove bark from branches. Both were undertaken using moderate levels of applied force. The concave margin was preferred for these activities. Most of the bark was removed by hand, as it was a bit easier than stripping it off with the tool. The distal tip of the projection was used to assist in removing branch nodes and the bark surrounding them. A total of 30.3 m of fresh green willow stalks and branches averaging .77 cm in thickness were processed. On average, 4.30 m of bark and/or wood were being removed per minute, indicating a slow to moderate working rate. The tool was used hafted throughout its use-life, and was considered to be quite effective at performing the tasks outlined above. It was most efficient for working mature branches. Very small twigs and branches were best stripped using strokes about 50 cm in length while "pinching" them between the thumb and ventral face of the tool. A few small microflakes were observed on the ventral edge aspect of the concave margin after about 5000 strokes. After about 10,000 strokes several more minute microflakes and a very slight polish had developed. At about 15,000 strokes the polish had become slightly more intense. **Note:** although the tool was used for 17,650 strokes, it was estimated that it could have been used for several thousand more strokes before it would have required resharpening. During use, plant resins and fibres accumulated on the dorsal aspects of the concave and opposite margins, and to the ventral face.

Continued...

Appendix 9 (continued).

E.T. #5
Lithic Type: Type 3 Chert
Contact Material: Saskatoon stalks and branches
Total No. of Strokes: 600
Mean Stroke Length: 12 cm
Total Time Elapsed: 10 min
Location of Use: Keatley Creek
Experimenter: Peter Merchant
Witnesses: Gyles Iannone, Bob Muir, Mike Rousseau

Comments: The concave and opposite edges were used to strip bark, shave/scrape/plane down wood, and smooth irregularities in the wood (e.g., branch nodes, bumps, bends) of green saskatoon using fairly heavy force load applications. The concave margin was used more frequently, and was considered to be quite effective for stripping bark, but was not very effective for shaving and scraping wood and removal of woody portions of the secondary branch nodes. The opposite margin was sometimes used to assist in the removal of the branch nodes. The distal tip was often used to assist in the removal of secondary branch nodes using heavy force loads. The tool was used unhafted throughout its entire use-life. A total of 1.57 m of fresh green branches having a mean diameter of about 2.0 cm were processed. On average, 7.20 m of bark and/or wood were being removed per minute, indicating a rather rapid working rate. By about 100 strokes, the concave margin developed several microflakes along the medial-ventral aspect of the concave margin, and by the end of its use-life, the entire edge had been subjected to moderate crushing and intense microflake removal along the entire concave margin. By about 500 strokes it was noted that the concave margin was in need of resharpening. During use, some plant resins and fibres were deposited on the dorsal aspects of the concave and opposite margins.

Continued...

Appendix 9 (continued).

E.T. #6
Lithic Type: Type 4 Chalcedony
Contact Material: Saskatoon stalks and branches
Total No. of Strokes: 5,250
Mean Stroke Length: 15 cm
Total Time Elapsed: 130 min
Location of Use: Three Sisters Creek Campground
Experimenter: Peter Merchant
Witnesses: John Breffitt, Gyles Iannone, Mike Rousseau

Comments: The concave and opposite edges were used to strip bark, shave/scrape/plane down wood, and smooth irregularities in the wood (e.g., branch nodes, bumps, bends), using heavy loads of applied force. The concave margin was used most frequently, and was regarded to have greater functional efficiency than the opposite margin for stripping bark and shaving/planing wood. The opposite margin was used occasionally to assist in removal of the seconardy branch nodes. The distal tip was used to remove bark around the branch nodes. A total of 7.60 m of fresh green saskatoon having an average diameter of .80 cm was processed. On average, 6.05 m of bark and/or wood were being removed per minute, indicating a moderate work rate. The tool was used hafted throughout its entire use-life. Initially, it was very effective at performing the above tasks. After about 2000 strokes several small microflakes had been removed from the ventral aspect of the concave margin edge, and a slight polish developed along the medial portion of the concave margin. Heavy pressure was used to remove the bark and shave wood, and this appears to have contributed to rapid appearance of microflakes and slight edge dulling. After about 4000 strokes the concave margin edge had become moderately dull, more pressure was required to shave the wood, and several more microflakes had appeared on the ventral portion of the concave margin edge aspect. The opposite margin edge was still very effective and displayed no visible microwear. At 5000 strokes the concave margin edge was quite dull and required resharpening. During use, some plant resins and fibres were deposited as residues on the dorsal aspects of the concave and opposite margins. **Note:** As with E.T. #4, Peter tended to be fairly aggressive with the tool, particularly when removing branch nodes. He also held the concave margin edge at a fairly acute angle (about 45°) with respect to the branches which may account for the high incidence of microflake removal (Mike Rousseau).

Continued...

Appendix 9 (continued).

E.T. #7
Lithic Type: Type 5 Chalcedony
Contact Material: Mule deer longbone shaft and antler (both soaked)
Total No. of Strokes: 2,200
Mean Stroke Length: 10 cm
Total Time Elapsed: 36 min
Location of Use: SFU Flintknapping pit (Dept. Arch.)
Experimenter: Mike Rousseau
Witnesses: Gyles Iannone

Comments: This tool was used hafted thoughout its use-life. Initially, the concave margin edge was used to scrape a soaked mule deer metacarpal for 500 strokes for about five minutes. Despite its sharpness and considerable pressure applied, the concave edge was totally useless for this task. However, it did effectively remove residual soft tissue adhering to the bone. It was then used to scrape and shave the beam of a mule deer antler. For this task, it was relatively effective for scraping small shavings from the outermost 1-2 mm of the surface, but after about 1000 strokes the concave margin edge became notably duller. After about 1250 strokes a great deal of force was required to remove the shavings due to increased dulling of the edge by crushing, and greater hardness of the antler beneath the outer 1-2 mm. After 1700 strokes the tool was completely ineffective for removing shavings from even the soaked portions of the antler, and the tool required resharpening. Linear grooves were incised and graved into the antler using the left ventral-lateral corner of the distal projection. This task was mostly effective for the outermost 1-2 mm, but again it became rather difficult once the soaked outer portion had been penetrated. On average, 6.10 m of antler and/or bone was being shaved/scraped per minute, suggesting a moderate to relatively fast working rate. Only very small bits and shavings of antler were observed adhering to the immediate dorsal edge aspect of the concave margin, and these were easily removed. **Note:** This tool's concave margin was resharpened and subsequently used to scrape and shave a deer antler beam that had been boiled for eight hours. About 250 strokes were executed. The outer 1-2 mm of softened cortex was removed with moderate ease, however, once this had been penetrated, tool efficiency reduced markedly. Generally, it appears that working of boiled antler with key-shaped formed unifaces is associated with about the same level of functional efficiency as working soaked antler.

Continued...

Appendix 9 (continued).

E.T. #8
Lithic Type: Type 5 Chalcedony
Contact Material: Saskatoon stalks and branches
Total No. of Strokes: 11,200
Mean Stroke Length: 15 cm
Total Time Elapsed: 232 min
Location of Use: Backyard on River Road, Delta, BC.
Experimenter: Mike Rousseau
Witnesses: None

Comments: The concave and opposite edges were used to strip bark, shave/scrape/plane down wood, and smooth irregularities in the wood (e.g., branch nodes, bumps, bends) of green saskatoon using moderate to heavy loads of applied force. The concave margin was used most frequently, and was deemed to be most efficient. The distal tip was used to remove bark around the secondary branch nodes and to incise linear grooves into the wood. A total of 13.7 m of stems and branches of fresh green saskatoon having a mean diameter of 1.1 cm was processed. On average, 7.25 m of bark and/or wood were removed per minute, indicating a relatively rapid work rate. The tool was used hafted during its entire use-life. Initially it was very effective at performing the above tasks, and a single large microflake was removed from the ventral portion of the concave margin edge aspect at about 1500 strokes, however, it was associated with an inclusion which may have been a weakened section of the tool edge. At about 5000 strokes a slight polish had developed on the medial-ventral section of the concave margin, and the tool was still very effective. By about 9000 strokes it had dulled slightly, but still functioned quite effectively. At 9500 strokes another large microflake had been removed from the medial-ventral portion of the concave margin edge aspect. **Note:** Although tool use was discontinued at 11,200 strokes, it could have been used for several thousand additional strokes before it would have required resharpening. During use, some plant resins and fibres were deposited on the dorsal aspects of the concave and opposite margins.

Continued...

Appendix 9 (continued).

E.T. #9
Lithic Type: Type 6 Basalt (fine grained)
Contact Material: Mule Deer Antler (soaked)
Total No. of Strokes: 400
Mean Stroke Length: 10 cm
Total Time Elapsed: 5 min
Location of Use: SFU Flintknapping pit (Dept. Arch.)
Experimenter: Mike Rousseau
Witnesses: Gyles Iannone

Comments: The concave margin edge was used to scrape and shave the beam of a mule deer antler, and the distal tip was used to incise and grave linear grooves in the beam. The tool was used hafted during its entire use-life. Initially the tool was effective at removing small antler shavings, but after 200 strokes large microflakes had been removed from both the dorsal and ventral portions of the concave margin edge, and several sections of the concave margin had been completely removed. At 300 strokes the tool became moderately dull, and large microflakes continued to be removed. It became completely dull and required resharpening at 400 strokes. When attempting to incise grooves, the distal margin also partially collapsed and dulled rapidly. Some small antler particles and shavings adhered loosely to the dorsal edge aspect of the concave margin during use, but these were easily removed.

Continued...

Appendix 9 (continued).

E.T. #10
Lithic Type: Type 6 Basalt (glassy)
Contact Material: Saskatoon stalks and branches
Total No. of Strokes: 7,050
Mean Stroke Length: 10 cm
Total Time Elapsed: 95 min
Location of Use: Three Sisters Creek Campground
Experimenter: John Breffitt
Witnesses: Gyles Iannone, Peter Merchant, Mike Rousseau

Comments: The concave and opposite edges were used to strip bark, shave/scrape/plane down wood, and smooth irregularities in the wood (e.g., branch nodes, bumps, bends) using moderate to heavy loads of applied force. The concave margin was considered to be most effective for performing these tasks, and was used most frequently. The distal projection tip was used to remove bark around the branch nodes and to incise linear grooves into wood. A total of 8.10 m of stalks and branches of fresh green sakatoon having a mean thickness of 1.0 cm were processed. On average, 7.40 m of bark and/or wood were being removed per minute, indicating a relatively rapid work rate. This tool was hafted during its entire use-life. Initially the tool was very effective for performing the above tasks, however, after about 3000 strokes several large microflakes were evident along the ventral portion of the concave margin edge aspect, and the edge had become moderately dull. After about 4000 strokes, microflaking along the concave margin edge was pronounced, and by 6000 strokes the concave margin edge was very dull and required resharpening. During use, some plant resins and fibres were deposited on the dorsal aspects of the concave and opposite margins.

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* Descriptions for lithic raw materials are presented in Appendix 7.
** Descriptions of the working environments are presented in Chapter 7.5.

Table 1. Descriptive statistics for complete continuous variables possessed by the 129 prehistoric study sample key-shaped formed unifaces.

Attribute*	n	Minimum Value	Maximum Value	Mean	Standard Deviation	Skewness	Kurtosis
Maximum length	105	16.40	68.80	37.13	9.89	.73	.42
Maximum width	125	8.80	42.80	20.84	4.67	1.14	3.22
Maximum thickness	128	3.20	17.90	6.20	2.15	1.60	5.52
Mass (weight)	112	.70	17.40	4.71	3.34	1.78	3.05
Ventral maximum curvature depth	102	.00	5.20	.87	.87	1.98	6.42
Projection length	109	8.80	43.00	21.46	6.21	.59	.46
Projection mean thickness	129	1.70	14.90	4.24	1.69	2.52	11.60
Projection basal width	126	3.10	42.50	19.25	5.45	.22	2.87
Projection medial width	124	3.10	17.50	8.29	2.78	1.01	1.18
Projection distal width	98	.50	8.20	3.16	1.63	.68	.24
Projection margin outline angle	118	10.00	60.00	31.80	11.80	.36	-.57
Projection tip mean edge angle	115	10.00	115.00	77.26	22.39	-.98	.47
Projection tip mean spine-plane angle	79	15.00	115.00	52.59	23.26	.44	-.21
Concave margin length	109	9.10	45.20	23.28	5.99	.76	1.23
Concave margin maximum curvature depth	107	.00	8.00	2.91	1.29	.80	1.60
Concave margin mean edge angle	129	40.00	120.00	73.33	12.90	.08	.64
Concave margin mean spine-plane angle	129	40.00	95.00	65.77	11.34	.29	-.10
Opposite margin length	106	9.00	40.00	21.03	6.31	.55	.19
Opposite margin mean edge angle	126	25.00	110.00	68.73	14.04	-.29	.34
Opposite margin mean spine-plane angle	126	25.00	100.00	59.92	15.14	.12	-.29
Proximal margin length	122	1.70	29.50	16.19	5.61	.13	-.11
Proximal margin width	119	4.50	25.80	12.27	4.83	.49	-.36

* All dimension measurements are in millimeters; all angle measurements are in degrees. Definitions for these variables are presented in Figure 3. Values are determined for the number of complete measurements (n).

Table 2. Radiocarbon dates associated with components bearing key-shaped formed unifaces on the Plateau.

CANADIAN PLATEAU:

Region	Site No.	14-C Age (BP)	Lab Number	Reference
Mid-Fraser	EeRk 4	2965±95	(S 762)	Stryd 1980
	"	1515±90	(I 6076)	" "
	"	1420±200	(I 6077c)	" "
	"	1250±200	(I 6076c)	" "
	EeRl 7	1070±70	(SFU 1001)	Hayden, pers. comm. 1988
Lower Fraser	DiRi 38	2310±150	(Gak 5430)	Von Krogh 1980
	DjRi 3	2630±60	(S 112)	Borden 1975
	"	2790±130	(M 1512)	" "
	"	2860±130	(M 1513)	" "
	DjRi 5	2000±120	(M 1543)	" " ; Archer 1980
	"	2080±130	(GSC 444)	" " " "
	"	2640±140	(GSC 448)	" " " "
Chilcotin	FgSd 1	2335±120	(S 770)	Donahue 1975,1978
South Thompson-Shuswap	EdRa 9	1950±130	(Gak 4915)	Wilson 1980
	EeRb 3	1920±100	(Gak 3902)	" "
	EeRb 10	2950±150	(SFU 76)	Richards and Rousseau 1982
	EeRb 70	1300±160	(SFU 303)	Eldridge and Stryd 1983
	"	1180±100	(SFU 315)	" " "
North Okanagan	DlQv 39	2370±80	(WSU 3032)	Rousseau 1984
Arrow Lakes	DiQm 4	2530±220	(Gak 2898)	Turnbull 1977
	"	2870±100	(Gak 2897)	" "
	DjQj 1	1250±120	(SFU 177)	Mohs 1982
	DkQm 5	3090±200	(Gak 2895)	Turnbull 1977
East Kootenay	EdQa 8	2360±80	(Beta 16903)	Bussey 1986
	"	2130±70	(Beta 16902)	" "

COLUMBIA PLATEAU:

Region	Site No.	14-C Age (BP)	Lab Number	Reference
South Okanagan	DhQv 48	2050±80	(Har 1654)	Copp 1979
Rufus Woods Lake	45OK258	2260±80	(TX 3385)	Jaehnig <u>et al</u> 1985
	"	2460±90	(Beta 4303)	" " "
	"	2690±90	(Beta 4299)	" " "
	"	2750±90	(Beta 4298)	" " "
	"	3050±60	(Beta 4297)	" " "
	45OK288	1560±90	(TX 4029)	Miss <u>et al</u> 1984
	"	3980±80	(TX 4027)	" " "
	"	4070±110	(TX 3800)	" " "
Lower Snake River	45-WT-39	910±90	(WSU 1621)	Yent 1976
	"	1030±90	(WSU 1620)	" "
	"	1190±110	(WSU 1043)	" "

Table 3. Residue analysis reagent reaction results.*

Artifact No.	Blood	Plant Lignin	Plant Starch
DhQv 48:2478	-	+	-
EbRj Y:618	-	+	++
EdRa 9:378	-	+	+
EeQw 3:692	-	+	+
EeRb 10:6	-	++	++
EeRk 4:1-51	-	+++	++
EeRk 4:6-1124	-	+	+
EeRk 4:19-1007	-	+++	+++
EeRk 4:19-2119	+	+	+++
EeRk 4:20-372	-	+	-
EeRl 4:364	-	+++	++
EeRl 7:1000	+	-	+
EeRl 7:1107	-	-	-
EfQw 1:437	-	+	-
EfQw 1:563	-	-	-
EfQw 1:564	-	+	+
FiRs 1:5699	+++	-	+
Y-1	-	+	+

* A negative reagent reaction is indicated by " - ". A weak positive reagent reaction is indicated by " + "; moderate positive reaction by " ++ "; and a strong positive reaction by " +++ ".

Table 4. The 35 randomly selected key-shaped formed unifaces comprising the prehistoric microwear sub-sample.

Artifact Number	Figure(s)
DhQv 48:1572	18j
DhQv 48:2478	18p
DiQm 4:183	19a, 27, 28
DjQj 1:19	19e
DjQj 1:200	19f
DjRi 3:4629	13a, 24, 39
DjRi 5:12423	13e
DkQm 5:273	19h
DlQv 39:27	18e
EaQl 1:416	19m
EaQl 14:58	20u
EaQl 14:61	20x, 22
EaQl 14:62	20y
EaQl 14:737	20b'
EaQl 14:825	20c'
EaQl 14:826	20d'
EbRj Y:618	12a
EdQx 20:B1-100	14b
EeQw 6:511	15u
EeRb 3:875	16c'
EeRb 10:6	16g', 25, 26
EeRb 11:72	16h'
EeRb 70:6490	16i', 30
EeRh 1:33	13i, 29, 36
EeRk 4:6-407	12e, 33
EeRk 4:6-1043	12g
EeRk 4:19-1007	12i, 31
EeRk 4:19-2119	12k
EeRk 4:20-372	12l, 32
EeRl 91:7	12p
EfQv 10:114	17n', 35, 38
EfQw 1:563	17q'
FiRs 1:2028	11e, 34
FiRs 1:5699	11k
Y-1	17s', 21, 23, 37

Table 5. Descriptive statistics for continuous microwear variables for the 35 key-shaped formed unifaces comprising the prehistoric microwear sub-sample.

Attribute*	n	Minimum Value	Maximum Value	Mean	Standard Deviation	Skewness	Kurtosis
Projection tip microflake frequency	18	1.00	4.00	2.22	1.21	.73	-1.38
Projection tip mean microflake size	18	.20	3.00	1.16	.76	1.07	.18
Projection tip minimum microflake size	11	.20	2.50	.77	.62	2.17	3.88
Projection tip maximum microflake size	11	.75	3.50	1.50	.88	1.42	.63
Projection tip mean edge angle	32	30.00	115.00	77.81	20.48		
Concave margin microflake frequency	25	1.00	11.00	4.00	2.74	.67	-.23
Concave margin mean microflake size	25	2.00	4.00	1.06	.86	2.08	4.23
Concave margin minimum microflake size	18	.10	1.00	.46	.26	.46	-.94
Concave margin maximum microflake size	18	.50	7.00	1.56	1.48	2.91	8.22
Concave margin mean edge angle	32	40.00	120.00	74.68	15.65		
Opposite margin microflake frequency	23	1.00	10.00	4.65	2.77	.26	-1.09
Opposite margin mean microflake size	23	.30	1.50	.73	.29	.64	.10
Opposite margin minimum microflake size	19	.20	.80	.38	.19	.77	-.31
Opposite margin maximum microflake size	19	.40	2.50	1.18	.53	.80	.35
Opposite margin mean edge angle	32	35.00	90.00	65.31	14.75		
Ventral distal-oriented striation angle	21	45.00	80.00	63.95	10.75	-.12	-1.20

* All microflake size measurements are in millimeters. Microflake size refers to approximate mean flake scar diameter. Distal-oriented striation angle measurements are in degrees with respect to the concave margin. Values are calculated from the number of complete measurements (n).

Table 6. Descriptive statistics for continuous microwear variables for the eight experimental tools engaged in bark stripping and woodworking.

Attribute*	n	Minimum Value	Maximum Value	Mean	Standard Deviation	Skewness	Kurtosis
Projection tip microflake frequency	8	.00	2.00	1.12	.83	- .22	-1.33
Projection tip mean microflake size	6	.80	1.00	.50	.29	.46	- .02
Projection tip minimum microflake size	3	.50	.20	.15	.87	- .71	-1.50
Projection tip maximum microflake size	3	.60	1.00	.80	.20	.00	-1.50
Concave margin microflake frequency	8	5.00	22.00	13.62	5.95	- .06	-1.29
Concave margin mean microflake size	8	.30	1.10	.67	.28	.32	-1.14
Concave margin minimum microflake size	8	.10	.60	.24	.16	1.59	1.50
Concave margin maximum microflake size	8	.70	2.50	1.41	.55	.65	.30
Concave margin mean edge angle	8	70.00	90.00	78.12	5.94	.78	.22
Opposite margin microflake frequency	8	.00	14.00	2.50	4.69	2.18	2.93
Opposite margin mean microflake size	6	.20	.50	.33	.14	.38	-1.50
Opposite margin minimum microflake size	2	.10	.10	.10			
Opposite margin maximum microflake size	2	.50	1.00	.75	.35	.00	-2.00
Opposite margin mean edge angle	8	70.00	90.00	77.50	7.56	.40	-1.14
Ventral distal-oriented striation angle	2	60.00	70.00	65.00			

* All microflake size measurements are in millimeters. Microflake size refers to approximate mean flake scar diameter. Distal-oriented striation angle measurements are in degrees with respect to the concave margin. Values are calculated from the number of complete measurements (n).

Table 7. Frequencies and relative percentages of microflake scar types on the concave margin ventral edge aspect for specimens bearing microflakes in the prehistoric microwear sub-sample.

		GENERAL MICROFLAKE OUTLINE TYPE					
							
MICROFLAKE CROSS-SECTION TYPE		Circular Expanding	Trapezoidal expanding	Crescentic	Oblique	Pointed	Lamellar
 Invasive	n=	33	1	2	5	1	1
	%=	(33.3)	(1.0)	(2.0)	(5.1)	(1.0)	(1.0)
 Shallow stepped		16	8	5	3		
		(16.2)	(8.1)	(5.1)	(3.0)		
 Deep stepped		7	6	2			
		(7.1)	(6.1)	(2.0)			
 Snapped		2	3	1			
		(2.0)	(3.0)	(1.0)			
 Retroflexed				1	1	1	
				(1.0)	(1.0)	(1.0)	

* Total number of microflake scars is 99.

Table 8. Frequencies and relative percentages of microflake types on the opposite margin ventral edge aspect for specimens bearing microflakes in the prehistoric microwear sub-sample.

	GENERAL MICROFLAKE OUTLINE TYPE					
MICROFLAKE CROSS-SECTION TYPE	Circular Expanding	Trapezoidal expanding	Crescentic	Oblique	Pointed	Lamellar
Invasive	n= 34 %= (32.2)	1 (.9)	9 (8.5)	8 (7.5)	4 (3.8)	2 (1.9)
Shallow stepped	14 (13.3)	4 (3.8)	4 (3.8)	3 (2.8)		
Deep stepped	7 (6.6)	1 (.9)	1 (.9)	5 (4.7)		1 (.9)
Snapped	2 (1.9)	1 (.9)			1 (.9)	
Retroflexed						
Shatter	2 (1.9)		2 (1.9)			

* Total number of microflakes is 106.

Table 9. Frequencies and relative percentages of microflake types on the concave margin ventral edge aspect for the eight experimental tools engaged in bark stripping and woodworking.

MICROFLAKE CROSS-SECTION TYPE		GENERAL MICROFLAKE OUTLINE TYPE					
		Circular Expanding	Trapezoidal expanding	Crescentic	Oblique	Pointed	Lamellar
Invasive	n=	20	1	7	8	3	6
	%=	(18.6)	(.9)	(6.5)	(7.4)	(2.7)	(5.6)
Shallow stepped		17	4	11	7		
		(15.8)	(3.7)	(10.2)	(6.5)		
Deep stepped		5	2	13	4		
		(4.6)	(1.8)	(12.0)	(3.7)		

‡ Total number of microflake scars is 108.

Table 10. Frequencies and relative percentages of microflake types on the opposite margin ventral edge aspect for the eight experimental tools engaged in bark stripping and woodworking.

MICROFLAKE CROSS-SECTION TYPE		GENERAL MICROFLAKE OUTLINE TYPE				
		Circular Expanding	Trapezoidal expanding	Crescentic	Oblique	Pointed
Invasive	n=	3		4	3	
	%=	(15.8)		(21.0)	(15.8)	
Shallow stepped		4	1	1	1	1
		(21.0)	(5.3)	(5.3)	(5.3)	(5.3)
Deep stepped					1	
					(5.3)	

‡ Total number of microflake scars is 19.

Table 11. Pearson Product-Moment correlation coefficients for selected continuous variables possessed by the 129 prehistoric study sample specimens.

Variable*	vs Variable	n	Correlation Coefficient	Signif. Level r@ .05
Maximum length	Maximum width	104	.6552	.1927
	Maximum thickness	104	.4988	.1927
	Projection medial width	104	.5024	.1927
	Proximal margin width	101	.3605	.1956
Maximum width	Maximum thickness	118	.4505	.1809
	Proximal margin length	118	.5246	.1809
	Proximal margin width	118	.4005	.1809
Projection length	Projection tip width	98	.2135	.1986
	Projection outline angle	108	-.3004	.1891
Projection basal width	Projection medial width	99	.3961	.1975
	Opposite margin length	99	.4671	.1975
	Proximal margin width	99	.2858	.1975
Projection distal width	Projection outline angle	98	-.4260	.1986
Concave margin curvature depth	Maximum length	104	.4469	.1927
	Projection length	107	.4599	.1900
	Projection basal width	106	.3763	.1909
	Projection medial width	107	-.0258	.1900
	Concave margin length	107	.5027	.1900
	Concave margin edge angle	107	.0026	.1882
Concave margin mean edge angle	Concave margin length	109	.1084	.1882
	Concave margin spine-plane angle	129	.6661	.1729
	Opposite margin edge angle	126	.3645	.1750
Opposite margin mean edge angle	Opposite margin length	106	.2057	.1909
	Opposite margin spine-plane angle	126	.7098	.1750

* Continuous variable definitions are presented in Figure 3.

** Positive coefficients indicate positive relationships between variable pairs (i.e., when the value of one variable increases the other variable value also increases); negative ones (-) indicate negative relationships (i.e, as one value increases, the other corresponding value decreases).

Table 12. Pearson Product-Moment correlation coefficients for selected continuous and discrete variables possessed by the 35 prehistoric microwear sub-sample specimens.

Variable* vs	Variable	n	Corr. Coeff.	Signif. Level r@ .05
Projection tip microflake frequency	Projection tip microflake mean size	11	-.2264	.6021
	Concave margin microflake frequency	10	.1114	.6319
	Opposite margin microflake frequency	10	-.4009	.6319
Projection tip microflake mean size	Concave margin microflake mean size	10	-.0485	.6319
	Opposite margin microflake mean size	10	.4372	.6319
Projection tip mean edge angle	Projection tip microflake mean size	10	.5610	.6319
	Concave margin mean edge angle	10	.2067	.6319
	Opposite margin mean edge angle	10	.1393	.6319
Concave margin microflake frequency	Concave margin microflake mean size	18	-.0259	.4683
	Opposite margin microflake frequency	18	-.1353	.4683
Concave margin microflake mean size	Opposite margin microflake mean size	18	.5554	.4683
Concave margin mean edge angle	Concave margin microlake frequency	18	-.0549	.4683
	Concave margin microflake mean size	18	-.0366	.4683
	Opposite margin mean edge angle	18	.3252	.4683
	Ventral face striation angle	21	.2071	.4329
Opposite margin microflake frequency	Opposite margin microflake mean size	19	.3544	.4556
Opposite margin mean edge angle	Opposite margin microflake frequency	19	-.4127	.4555
	Opposite margin microflake mean size	19	.2060	.4555

Table 13. Spearman's Rank-Order correlation coefficients for selected ordinal scale variables possessed by the 35 prehistoric microwear sub-sample specimens.

Variable‡	vs Variable	n	Corr. Coeff.	Signif. Level r@ .05
Projection tip edge rounding intensity	Projection tip polish intensity	34	.6620	.3412
	Projection tip crushing intensity	34	.1519	.3412
	Concave margin edge rounding intensity	34	.4770	.3465
	Opposite margin edge rounding intensity	34	.2808	.3465
Projection tip polish intensity	Projection tip microflake frequency	30	.1622	.3640
	Projection tip crushing intensity	34	.2747	.3412
	Concave margin polish intensity	33	.4640	.3465
	Opposite margin polish intensity	33	.3351	.3465
	Ventral face polish intensity	33	.1228	.3465
Projection tip microflake frequency	Projection tip crushing intensity	30	.3129	.3640
	Projection tip edge rounding intensity	33	.3879	.3465
	Concave margin edge rounding intensity	33	.0281	.3465
	Concave margin microflake frequency	30	-.1441	.3640
	Concave margin polish intensity	30	-.0317	.3640
	Opposite margin microflake frequency	30	-.0441	.3640
	Opposite margin polish intensity	30	.1616	.3640
	Ventral face polish intensity	30	.1603	.3640
Projection tip crushing intensity	Concave margin crushing intensity	33	.2747	.3465
	Opposite margin crushing intensity	33	.2539	.3455
Projection tip mean edge angle	Projection tip edge rounding intensity	31	.1178	.3578
	Projection tip polish intensity	31	.1717	.3578
	Projection tip crushing intensity	31	.0943	.3578
Concave margin edge rounding intensity	Concave margin polish intensity	18	.6191	-
	Concave margin microflake frequency	35	.2011	.3361
	Concave margin crushing intensity	18	-.0012	-
	Opposite margin edge rounding intensity	34	.4667	.3412
Concave margin polish intensity	Concave margin microflake frequency	35	.1056	.3361
	Concave margin crushing intensity	18	-.0279	-
	Opposite margin polish intensity	34	.4349	.3412
	Ventral face polish intensity	34	.1130	.3412
Concave margin microflake frequency	Concave margin crushing intensity	35	.4621	.3361
	Concave margin mean edge angle	35	-.1800	.3361
	Opposite margin microflake frequency	35	.1186	.3361
Concave margin crushing intensity	Opposite margin crushing intensity	34	.1038	.3412

Continued ...

Table 13 (continued).

Variable*	vs Variable	n	Corr. Coeff.	Signif. Level r@ .05
Concave margin mean edge angle	Concave margin edge rounding intensity	35	-.4517	.3361
	Concave margin polish intensity	35	-.2944	.3361
	Concave margin crushing intensity	35	.0169	.3361
	Opposite margin mean edge angle	35	.3022	.3361
	Ventral face striation intensity	35	-.0065	.3361
Opposite margin rounding intensity	Opposite margin polish intensity	19	.4943	-
	Opposite margin microflake frequency	34	.3230	.3412
	Opposite margin crushing intensity	19	.2701	-
Opposite margin polish intensity	Opposite margin microflake frequency	34	.2172	.3412
	Opposite margin crushing intensity	19	-.1812	-
	Ventral face polish intensity	34	.2899	.3412
Opposite margin microflake frequency	Opposite margin crushing intensity	34	.6193	.3412
	Opposite margin mean edge angle	34	-.3567	.3412
Opposite margin mean edge angle	Opposite margin edge rounding intensity	34	.0656	.3412
	Opposite margin polish intensity	34	-.0955	.3412
	Opposite margin crushing intensity	34	-.2960	.3412
Ventral face polish intensity	Ventral face striation intensity	35	.4671	.3361
	Ventral face rounding intensity	35	.2677	.3361
Ventral face striation intensity	Concave margin edge rounding intensity	25	.2933	.4001
	Concave margin polish intensity	25	.0564	.4001
	Concave margin microflake frequency	35	.2748	.3361
	Concave margin crushing intensity	25	-.2296	.4001
	Opposite margin edge rounding intensity	23	.1505	.4179
	Opposite margin polish intensity	23	-.1590	.4179
	Opposite margin microflake frequency	23	-.2163	.4179
	Opposite margin crushing intensity	23	-.1469	.4179
	Ventral face rounding intensity	35	.4705	.3361

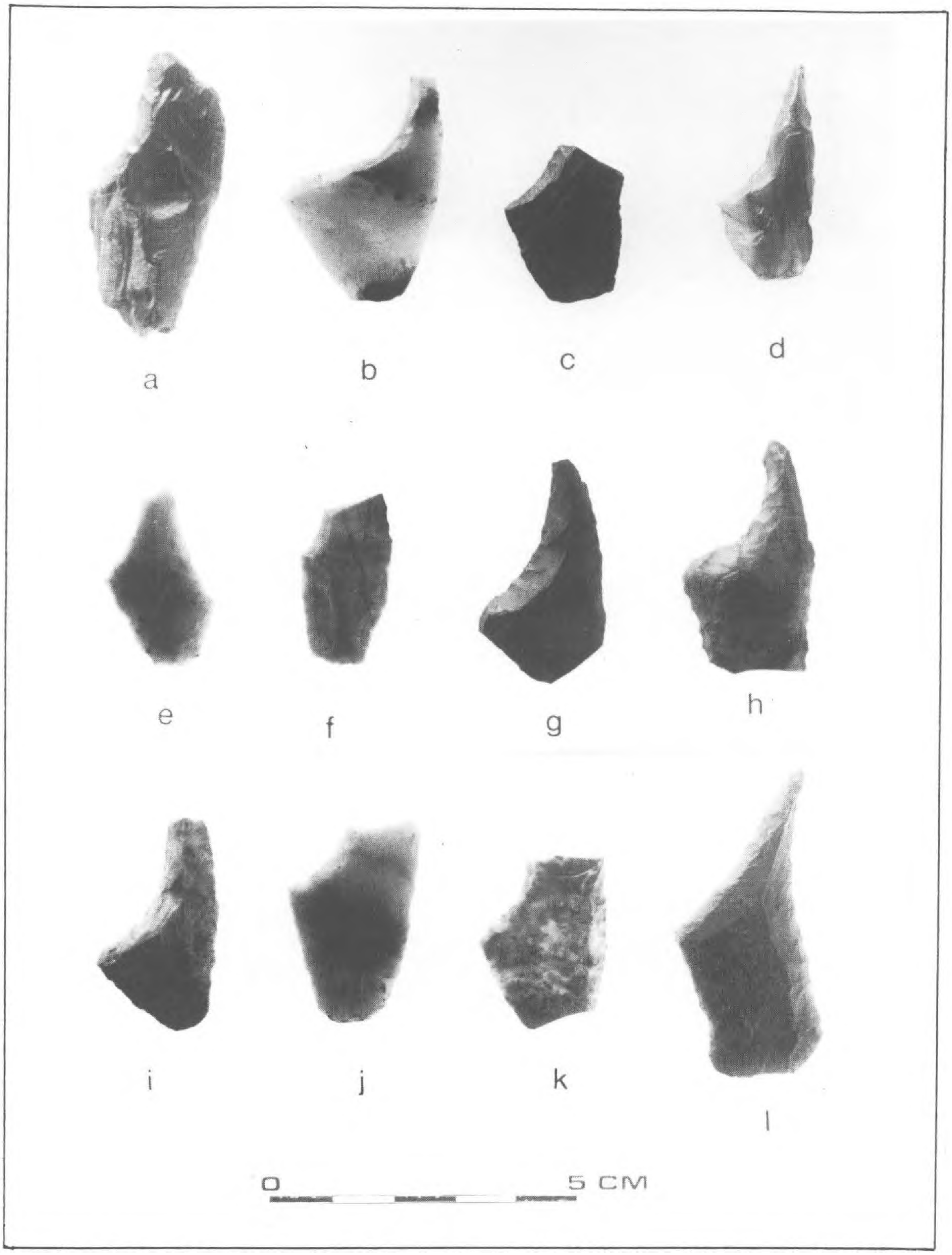

Figure 11. Prehistoric study sample key-shaped formed unifaces from the Chilcotin region.

Specimen	(a): FiRs 1:361	(g): FiRs 1:3818
	(b): FiRs 2:539	(h): FiRs 1:4413
	(c): FiRs 1:1352	(i): FiRs 1:5340
	(d): FiRs 1:1587	(j): FiRs 1:5493
	(e): FiRs 1:2028	(k): FiRs 1:5699
	(f): FiRs 1:3496	(l): EkSa 13:3039

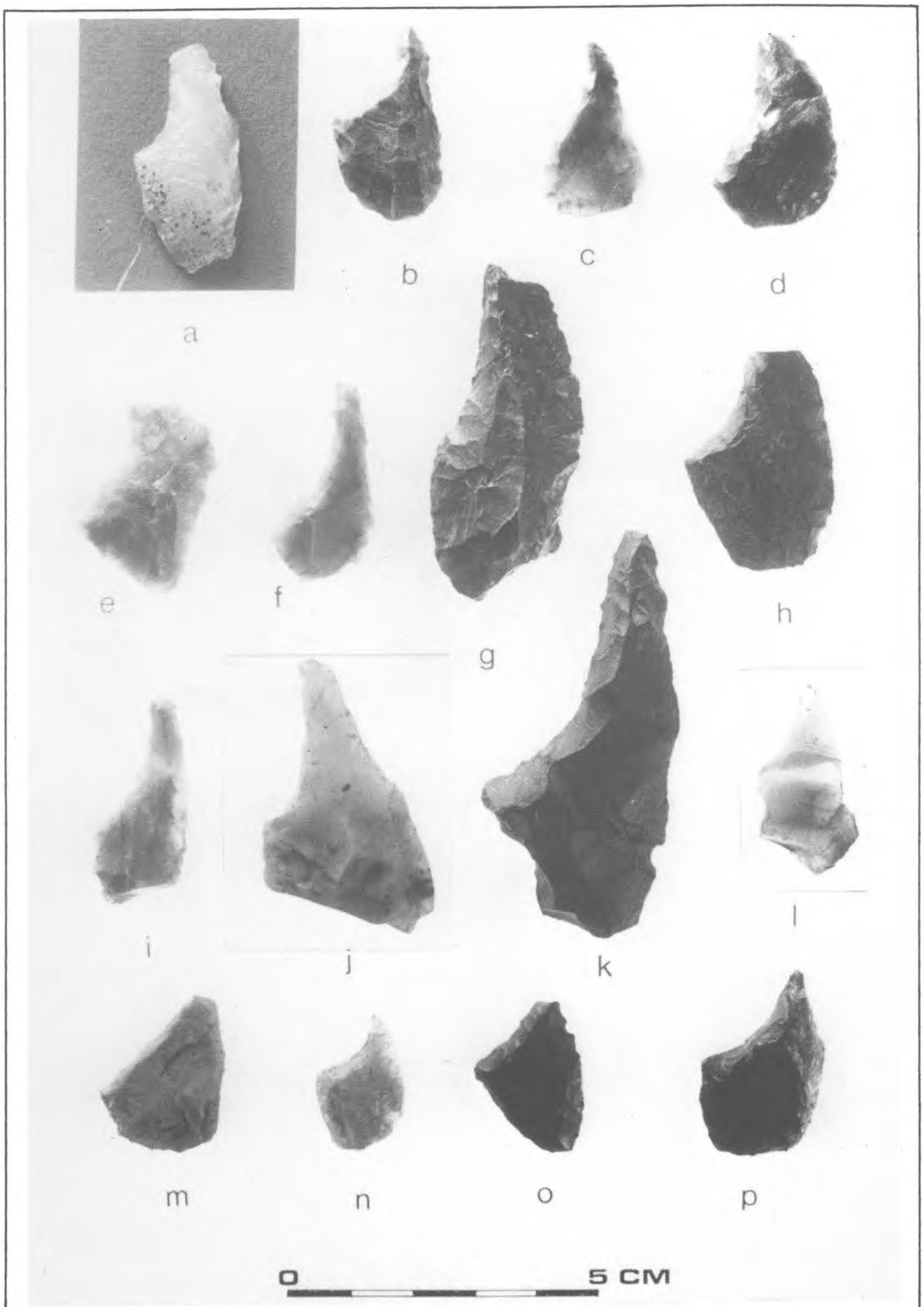

Figure 12. Prehistoric study sample key-shaped formed unifaces from the Mid-Fraser River region.

Specimen
(a): EbRj y:618
(b): EdRl 13:5
(c): EeRk 4:1-51
(d): EeRk 4:6-403
(e): EeRk 4:6-407
(f): EeRk 4:6-462
(g): EeRk 4:6-1043
(h): EeRk 4:6-1124
(i): EeRk 4:19-1007
(j): EeRk 4:19-1253
(k): EeRk 4:19-2119
(l): EeRk 4:20-372
(m): EeRl 4:364
(n): EeRl 7:1000
(o): EeRl 7:1107
(p): EeRl 91:7

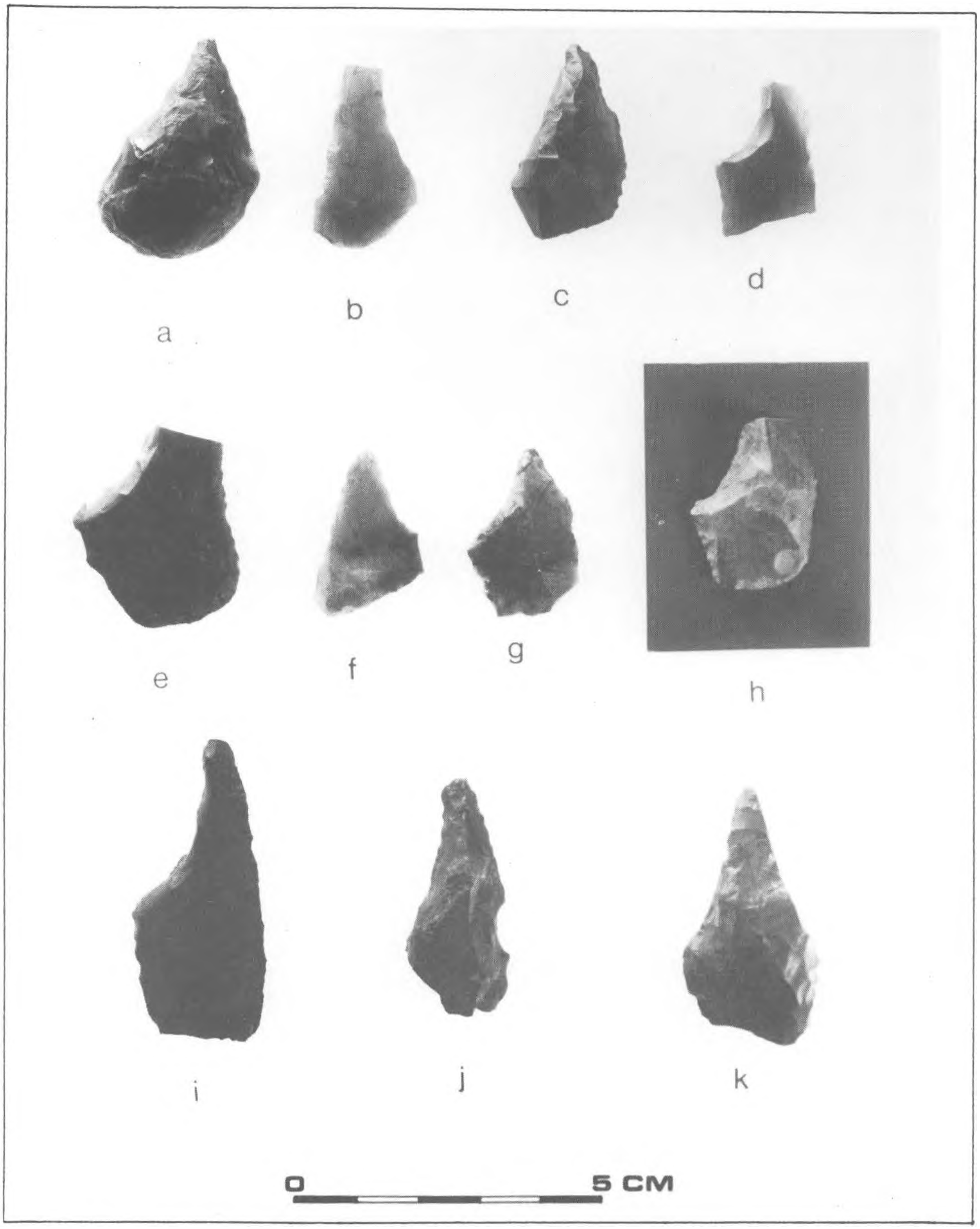

Figure 13. Prehistoric study sample key-shaped formed unifaces from the Lower Fraser and Thompson River regions.

Lower Fraser specimens:

(a): DjRi 3:4629
(b): DjRi 5:2164
(c): DjRi 5:10722
(d): DjRi 5:11637
(e): DjRi 5:12423
(f): DjRi 5:12820

Thompson River specimens:

(g): EcRh 12:55
(h): EcRh 12:56
(i): EeRh 1:33
(j): EeRj 63:327
(k): EfRf 3:77

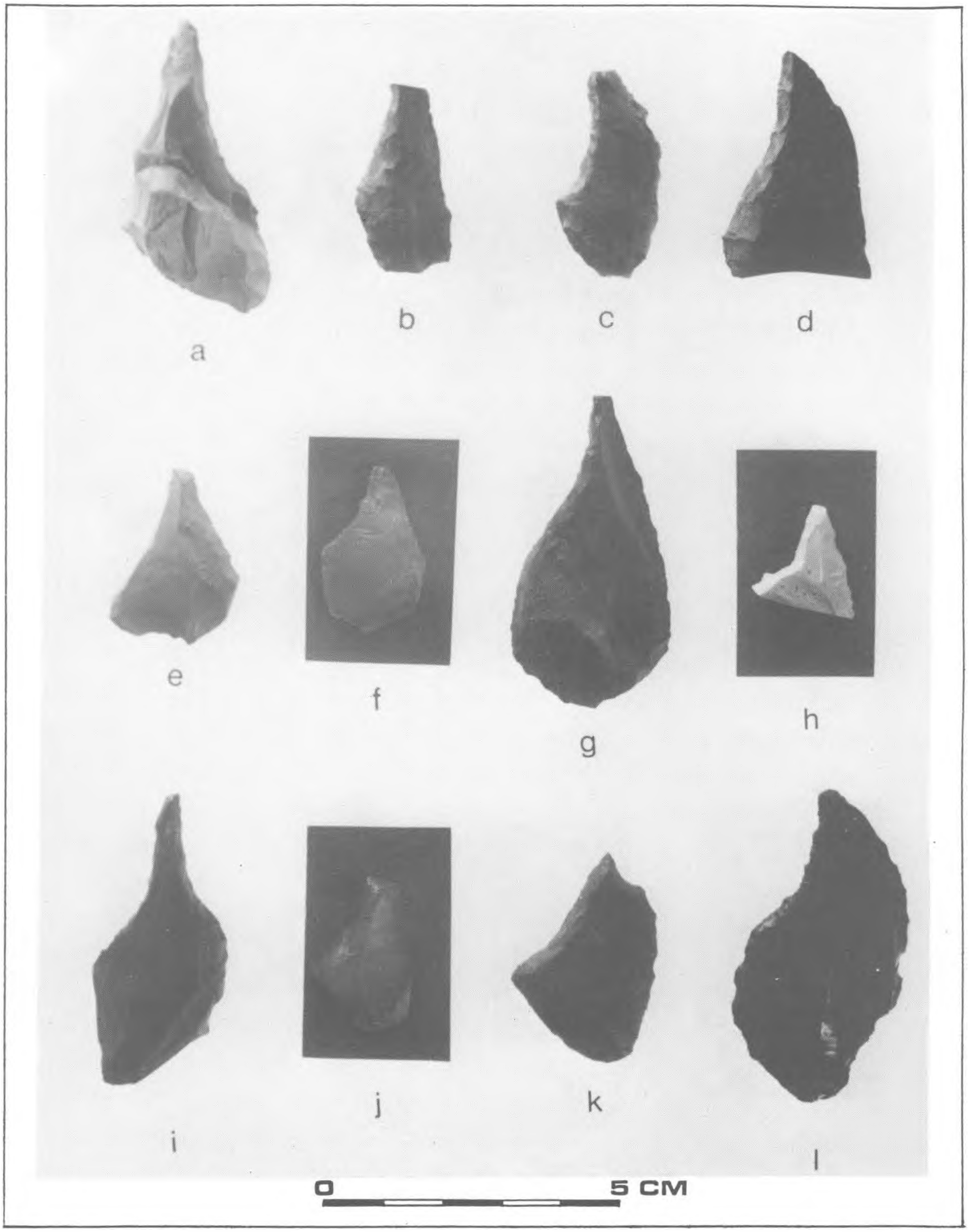

Figure 14. Prehistoric study sample key-shaped formed unifaces from the South Thompson - Shuswap region (sites EdQx 20 to EeQw 3).

Specimen	(a): EdQx 20:A-7001	(g): EdRa 22:2-105
	(b): EdQx 20:B1-100	(h): EeQw 3:517
	(c): EdRa 9:350	(i): EeQw 3:565
	(d): EdRa 9:378	(j): EeQw 3:588
	(e): EdRa 22:1-31	(k): EeQw 3:594
	(f): EdRa 22:1-37	(l): EeQw 3:596

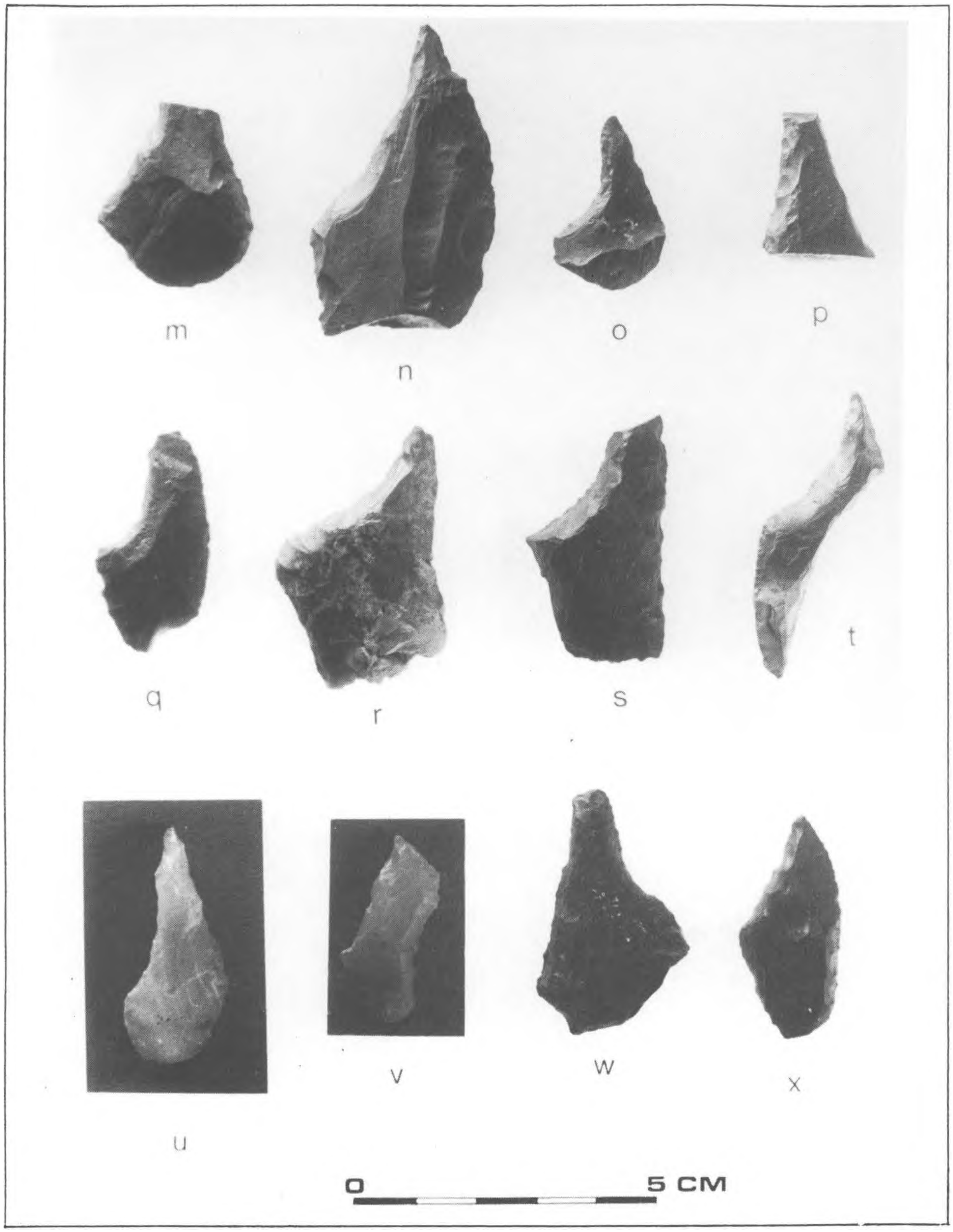

Figure 15. Prehistoric study sample key-shaped formed unifaces from the South Thompson - Shuswap region (sites EeQw 3 [continued] to EeQw 6).

Specimen (m): EeQw 3:618
(n): EeQw 3:692
(o): EeQw 3:811
(p): EeQw 3:863
(q): EeQw 6:197
(r): EeQw 6:203
(s): EeQw 6:313
(t): EeQw 6:365
(u): EeQw 6:511
(v): EeQw 6:516
(w): EeQw 6:555
(x): EeQw 6:633

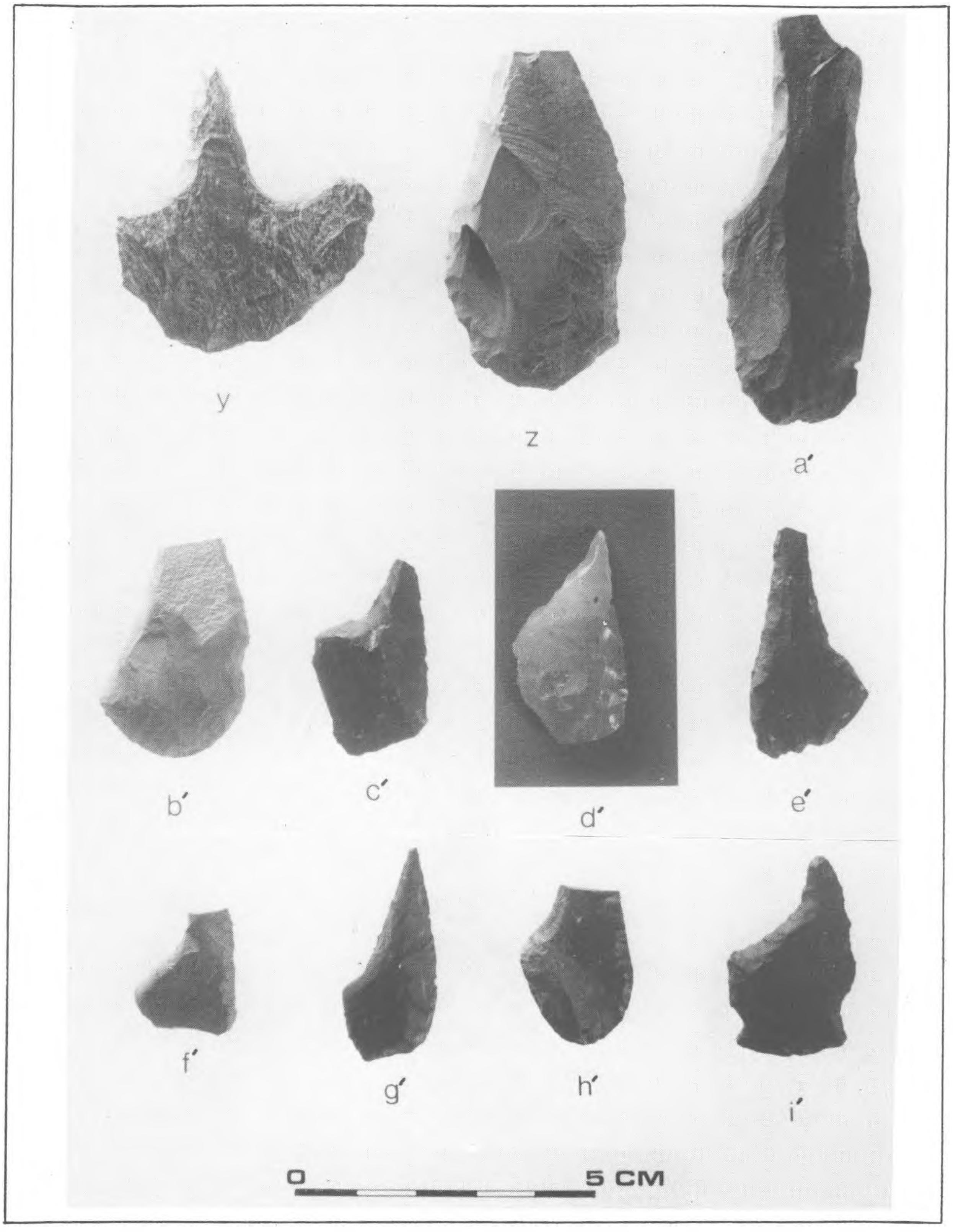

Figure 16. Prehistoric study sample key-shaped formed unifaces from the South Thompson - Shuswap region (sites EeQw 6 [continued] to EeRb 70).

Specimen
(y): EeQw 6:722
(z): EeQw 6:773
(a'): EeQw 6:779
(b'): EeRb 3:52
(c'): EeRb 3:875
(d'): EeRb 3:910
(e'): EeRb 3:1181
(f'): EeRb 3:1184
(g'): EeRb 10:6
(h'): EeRb 11:72
(i'): EeRb 70:6490

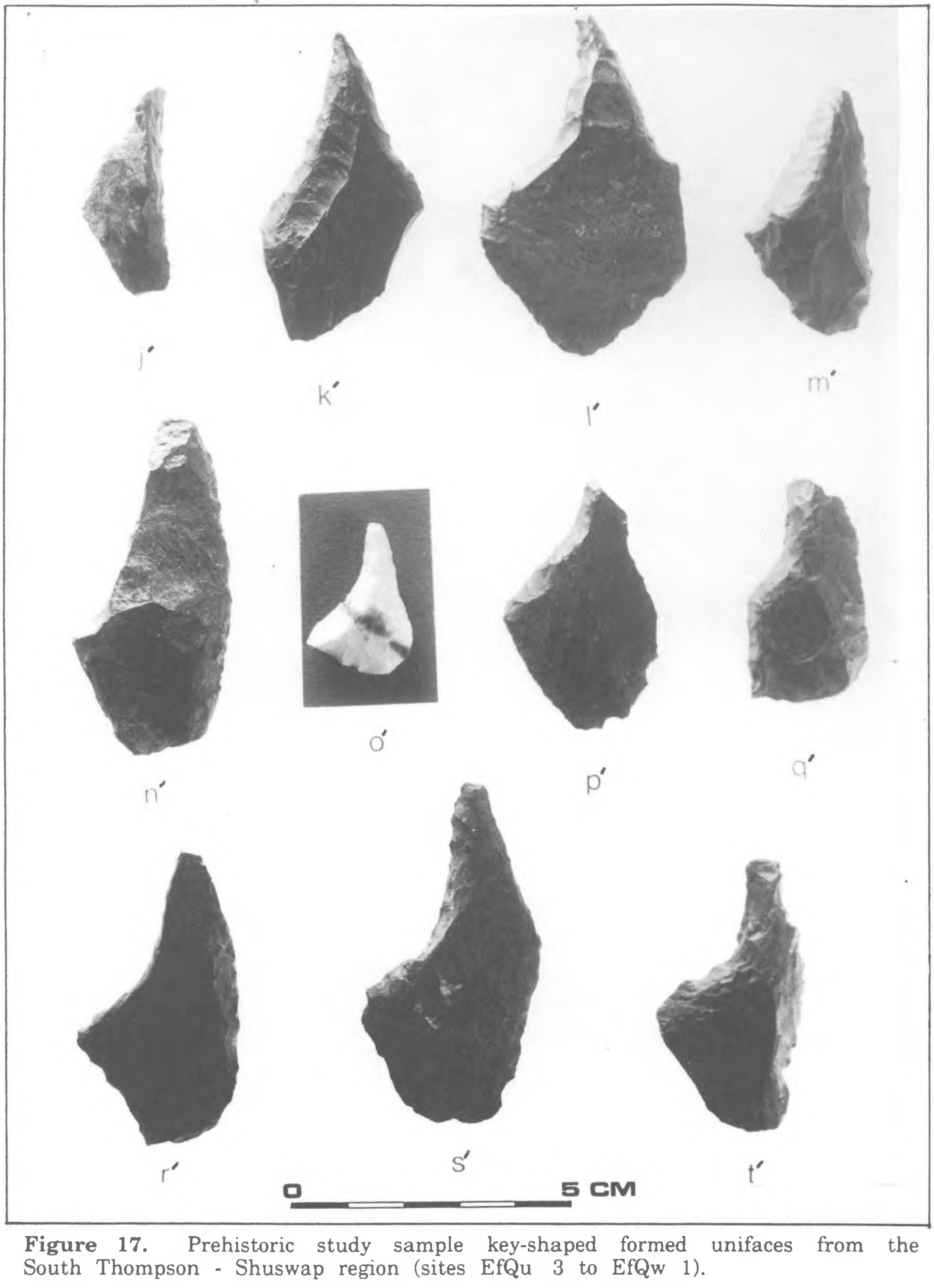

Figure 17. Prehistoric study sample key-shaped formed unifaces from the South Thompson - Shuswap region (sites EfQu 3 to EfQw 1).

Specimen

(j'): EfQu 3:55
(k'): EfQu 3:308
(l'): EfQu 6:126
(m'): EfQv 2:187
(n'): EfQv 10:114
(o'): EfQv 10:186
(p'): EfQw 1:437
(q'): EfQw 1:563
(r'): EfQw 1:564
(s'): Y-1 (site unknown)
(t'): 7376 (site unknown)

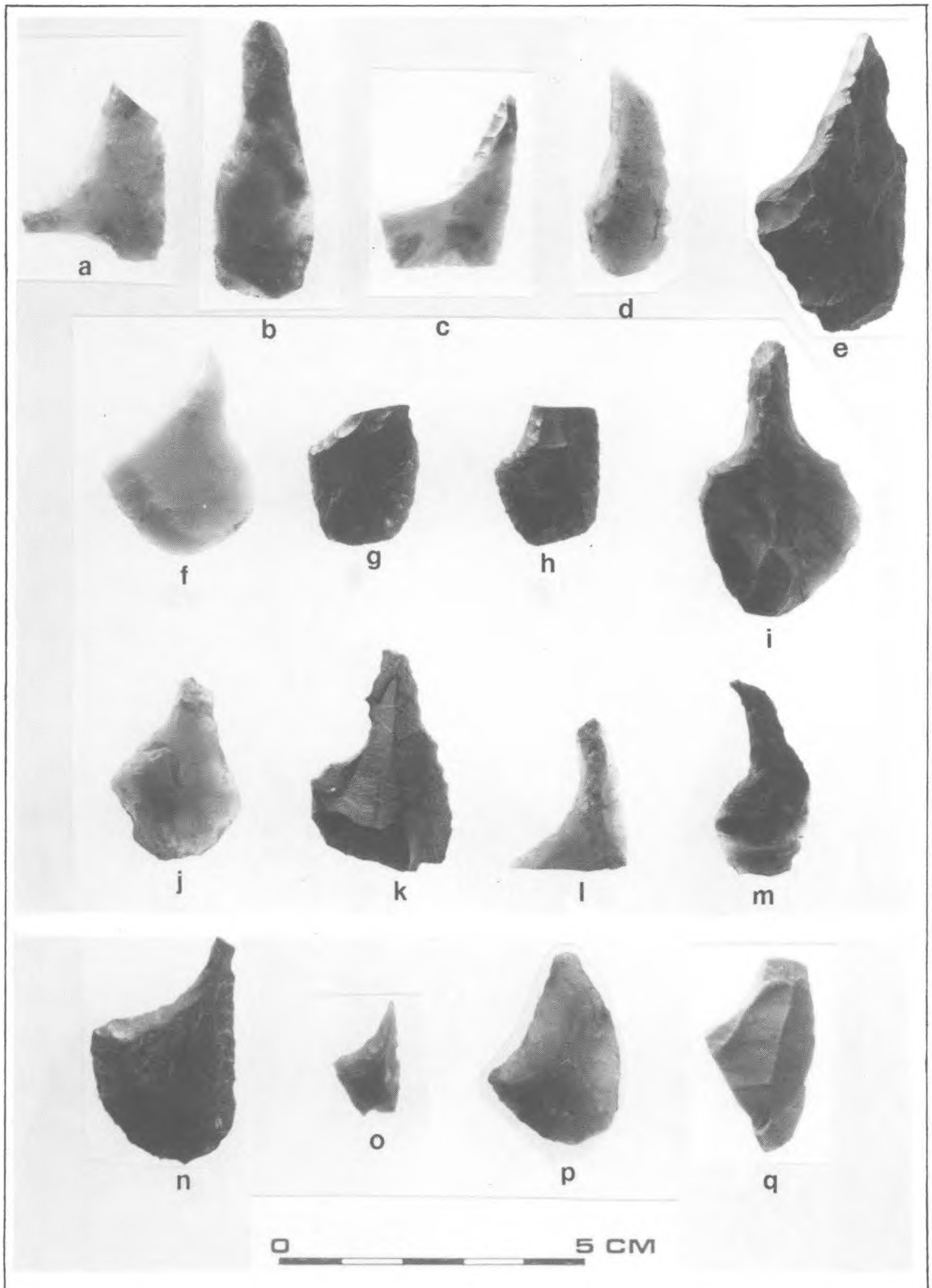

Figure 18. Prehistoric study sample key-shaped formed unifaces from the North Okanagan, South Okanagan, and Nicola regions.

North Okanagan specimens:

(a): DiQv 5:247
(b): DiQv 5:273
(c): DlQv 37:56
(d): DlQv 39:11
(e): DlQv 39:27

South Okanagan specimens:

(f): DgQu 16:129
(g): DhQv 48:865
(h): DhQv 48:1386
(i): DhQv 48:1479
(j): DhQv 48:1572
(k): DhQv 48:1646
(l): DhQv 48:1932
(m): DhQv 48:1997
(n): DhQv 48:2021
(o): DhQv 48:2097
(p): DhQv 48:2478

Nicola specimen:

(q): EbRd 3:18

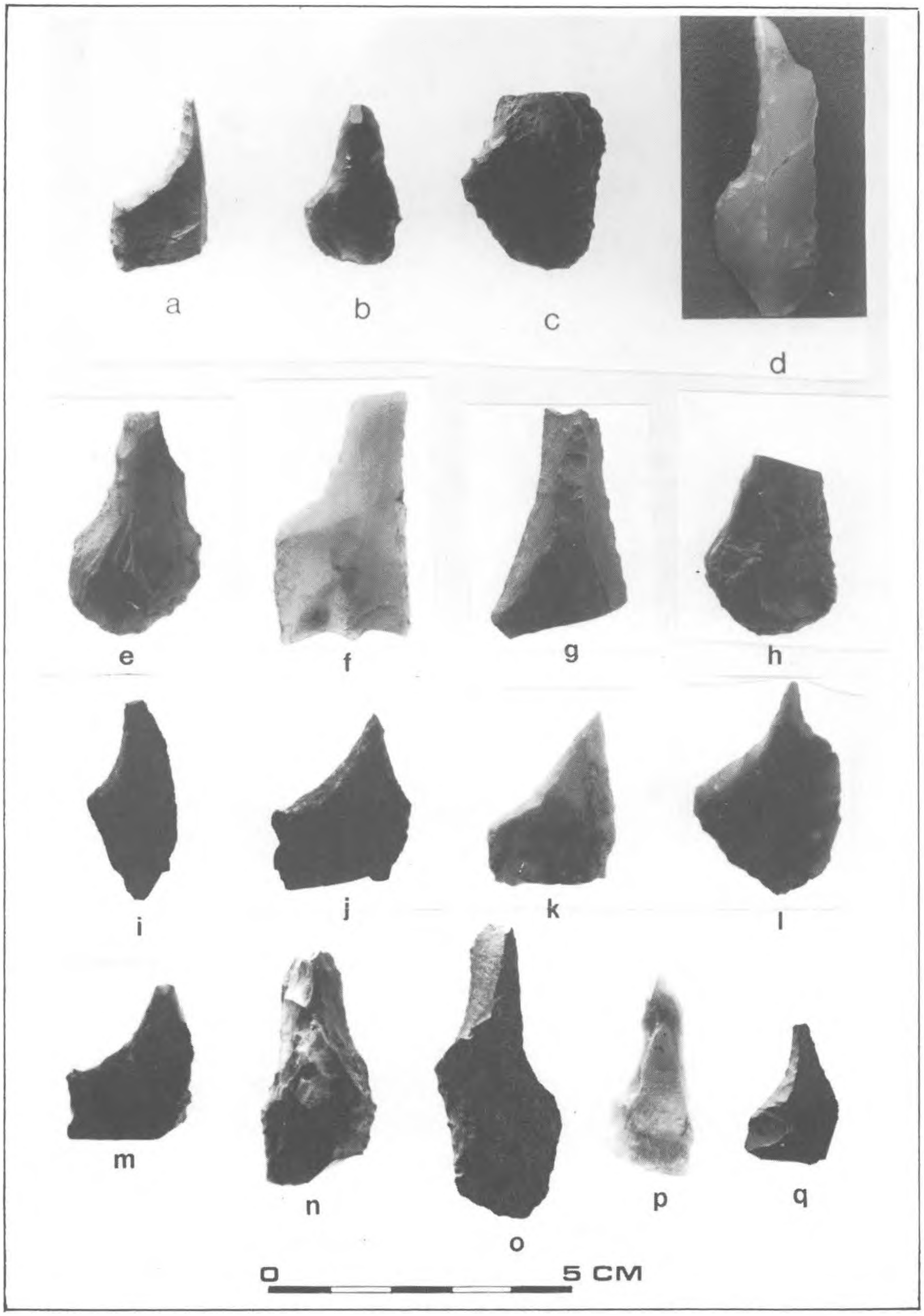

Figure 19. Prehistoric study sample key-shaped formed unifaces from the Arrow Lakes region (sites DiQm 4 to EaQl 10).

Specimen

(a): DiQm 4:183
(b): DiQm 4:205
(c): DiQm 6:13
(d): DiQm 6:16
(e): DjQj 1:19
(f): DjQj 1:200
(g): DjQj 1:324
(h): DkQm 5:273
(i): DlQl 6:41
(j): EaQl 1:137
(k): EaQl 1:244
(l): EaQl 1:405
(m): EaQl 1:416
(n): EaQl 10:71
(o): EaQl 10:59
(p): EaQl 10:139
(q): EaQl 10:141

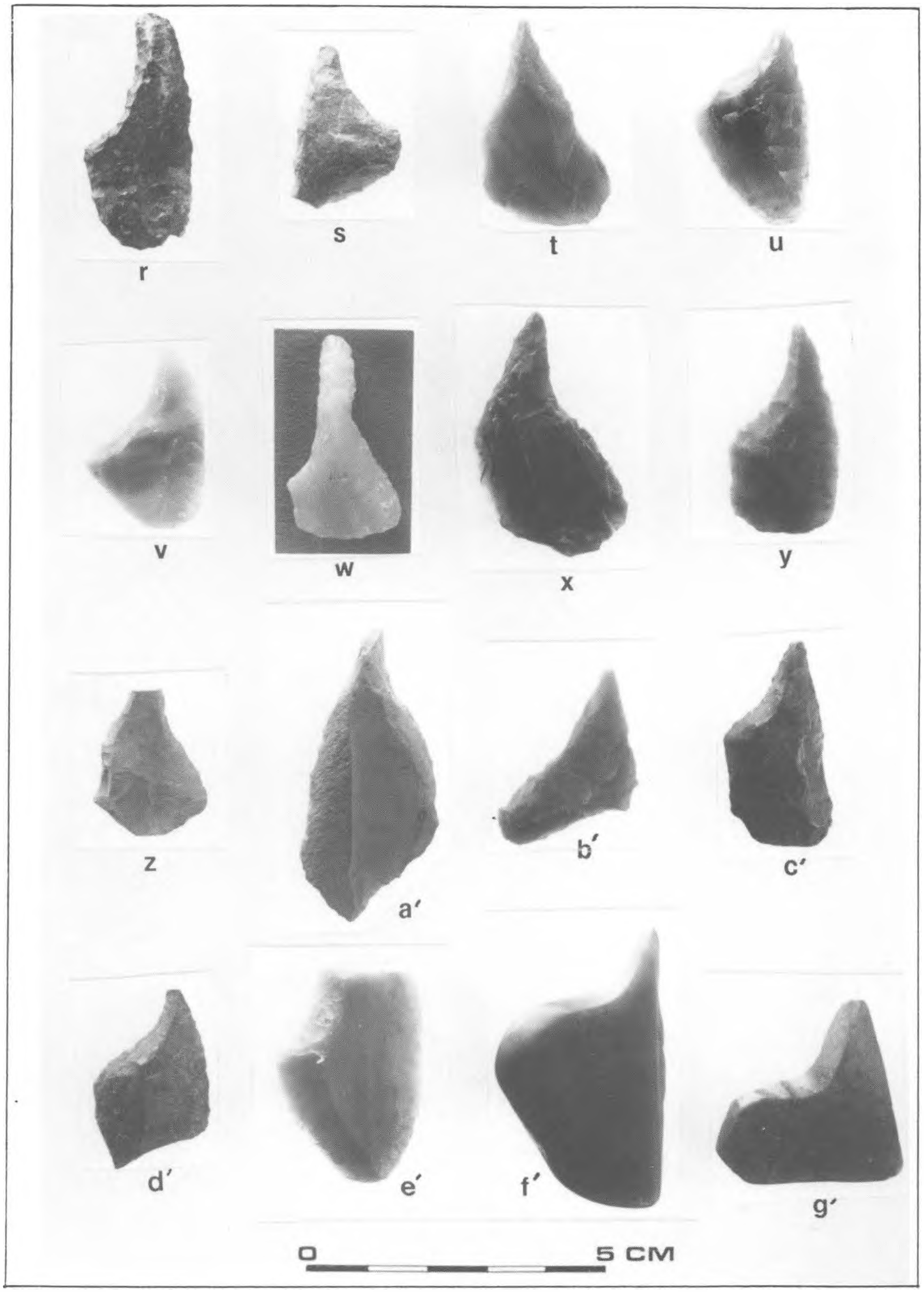

Figure 20. Prehistoric study sample key-shaped formed unifaces from the Arrow Lakes (site EaQl 14 [continued]), and East Kootenay regions. Item f' is a nephrite tool resembling key-shaped formed unifaces from the South Thompson - Shuswap region; g' is made of steatite and is from the Mid-Fraser river region.

Specimen

(r): EaQl 14:55
(s): EaQl 14:56
(t): EaQl 14:57
(u): EaQl 14:58
(v): EaQl 14:59
(w): EaQl 14:60
(x): EaQl 14:61
(y): EaQl 14:62
(z): EaQl 14:65
(a'): EaQl 14:736
(b'): EaQl 14:737
(c'): EaQl 14:825
(d'): EaQl 14:826

East Kootenay specimen: (e'): EdQa 8:32

Miscellaneous: (f'): EfQs 1:75
(g'): EbRj y:872

Figure 21. Pronounced rounding and moderately bright polish on the distal tip of prehistoric specimen "Y-1". Magnified 8 X.

Figure 22. Pronounced rounding and smoothing, and moderately bright polish on the distal tip of prehistoric specimen EaQl 14:61. Magnified 8 X.

Figure 23. Pronounced smoothing and rounding, and dull polish on the ventral face of the distal projection of prehistoric specimen "Y-1". Note the "pitted" appearance (dark areas) and very extensive pronounced parallel multidirectional "scratch-groove" type striations. Magnified 8 X.

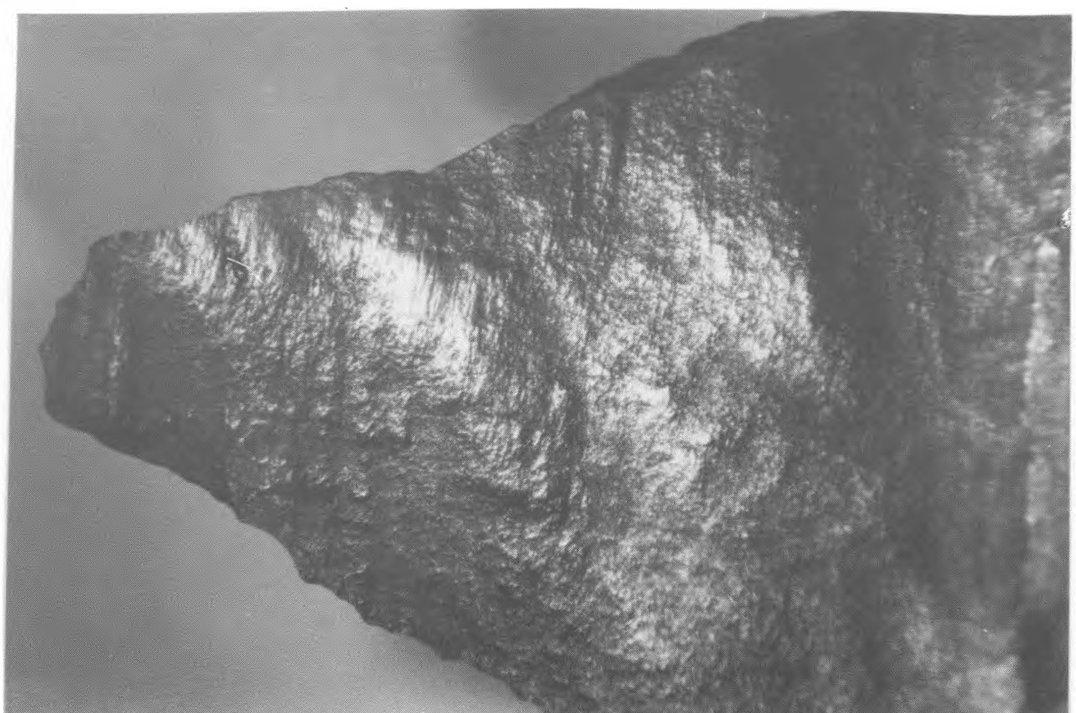

Figure 24. Pronounced rounding and smoothing, and bright polish associated with both "scratch-groove" and "sleeked" striations on the ventral face of prehistoric specimen DjRi 3:4629. Magnified 8 X.

Figure 25. Pronounced smoothing and rounding, moderately bright polish, random microflake scar pattern, and pronounced parallel multidirectional "scratch-groove" striations on the ventral face and concave margin edge aspect (top) of prehistoric specimen EeRb 10:6. Magnified 8 X. Arrows indicate edge section shown in Figure 26 (below).

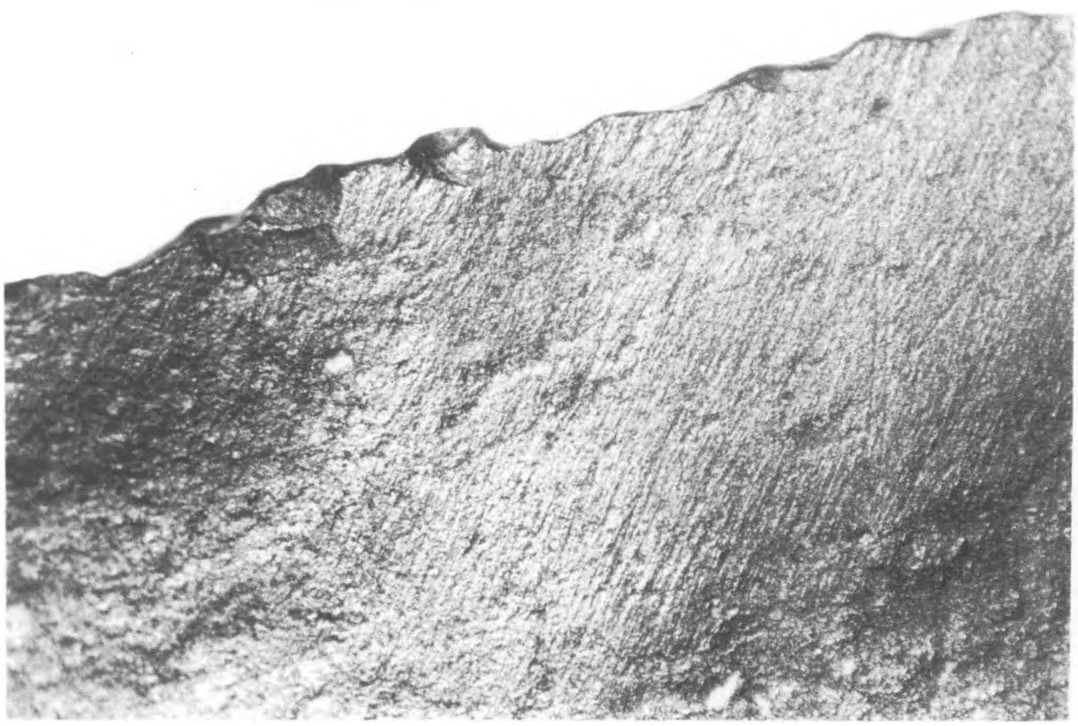

Figure 26. Detail of smoothing, polish, microflake scars, and striations on the ventral face of prehistoric specimen EeRb 10:6 (see also Figure 25). Magnified 20 X.

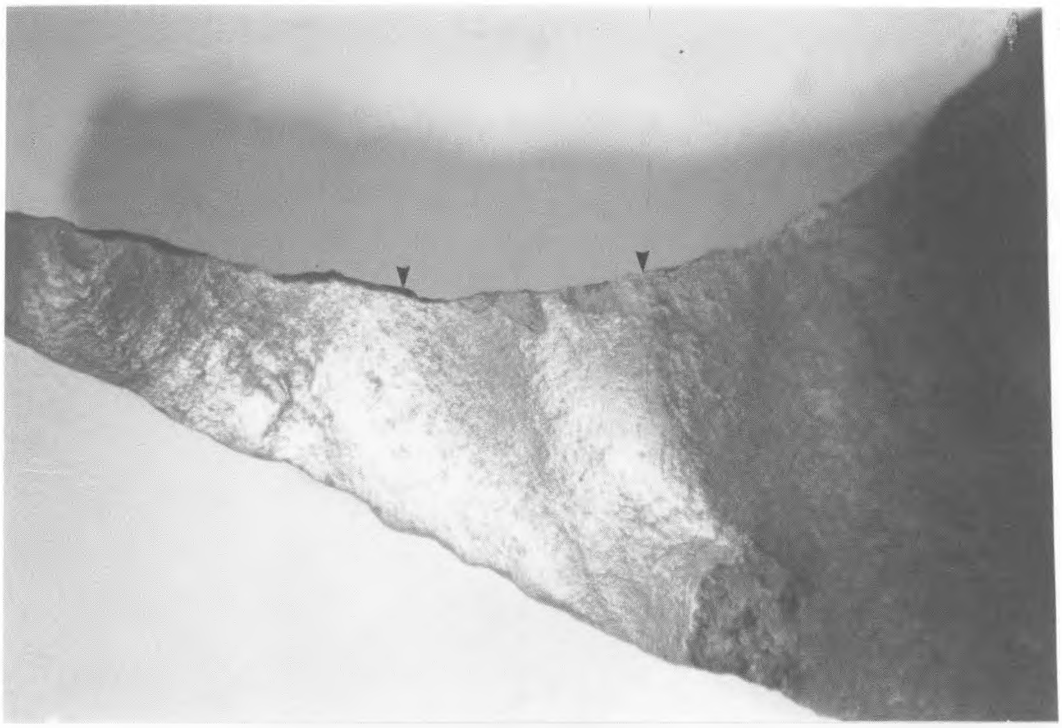

Figure 27. Moderate rounding and smoothing, bright polish, moderate intensity parallel unidirectional "scratch-groove" striations, and typical random microflake scar pattern on the ventral face of prehistoric specimen DiQm 4:183. Magnified 7.5 X. Arrows indicate edge section shown in Figure 28 (below).

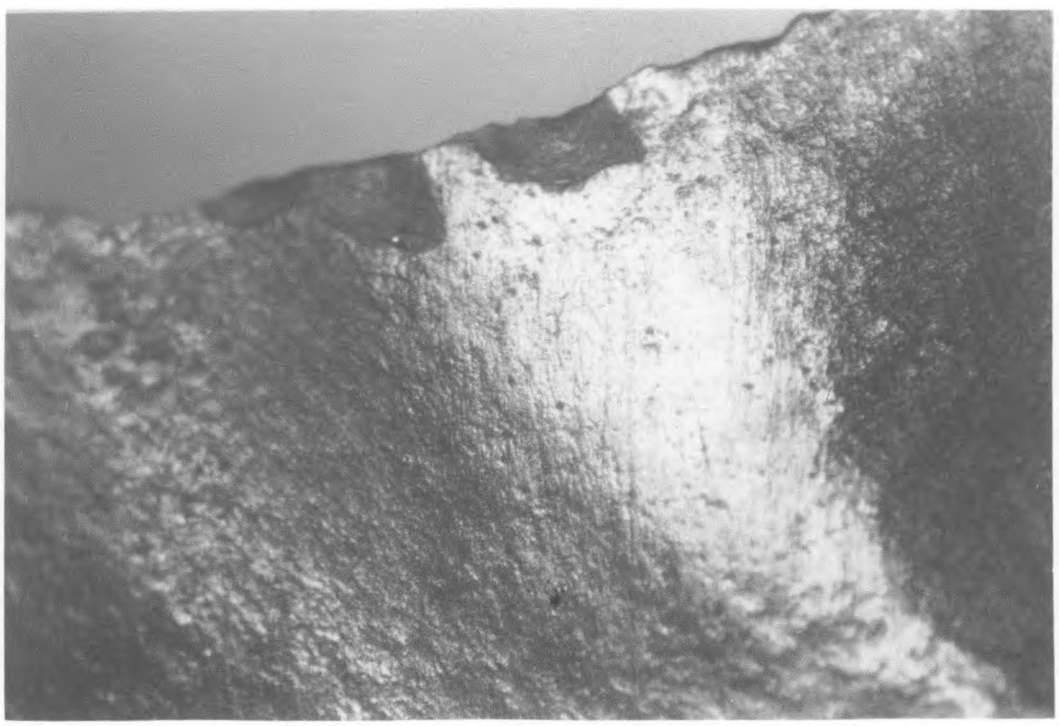

Figure 28. Detail of rounding, smoothing, polish, striations, and microflake removals on the ventral face of prehistoric specimen DiQm 4:183 (see also Figure 27). Magnified 20 X.

Figure 29. Moderate smoothing and rounding, and bright polish on the ventral face of prehistoric specimen EeRh 1:33. Note atypical inverse retouch along the "opposite" margin. Magnified 8.5 X.

Figure 30. Pronounced smoothing and rounding, and associated "sleeked" type striations on the ventral face of prehistoric specimen EeRb 70:6490. Magnified 8.5 X.

Figure 31. Moderate smoothing and rounding, bright polish, and random microflake scar pattern on the ventral face of prehistoric specimen EeRk 4:19-1007. Magnified 8 X.

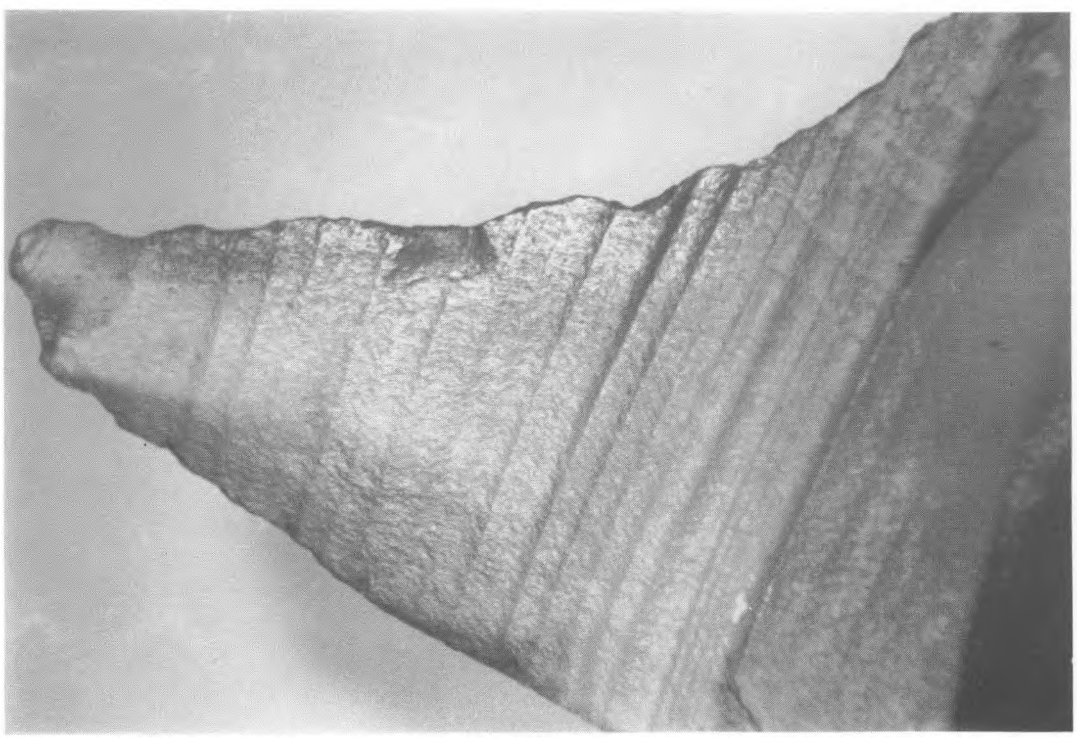

Figure 32. Slight smoothing and rounding, bright polish, and random microflake scar pattern on the ventral face of prehistoric specimen EeRk 4:20-372. Magnified 8 X.

Figure 33. Slight rounding and smoothing, bright polish, and contiguous-superposed microflake scar pattern on the ventral face of prehistoric specimen EeRk 4:6-407. Magnified 10 X.

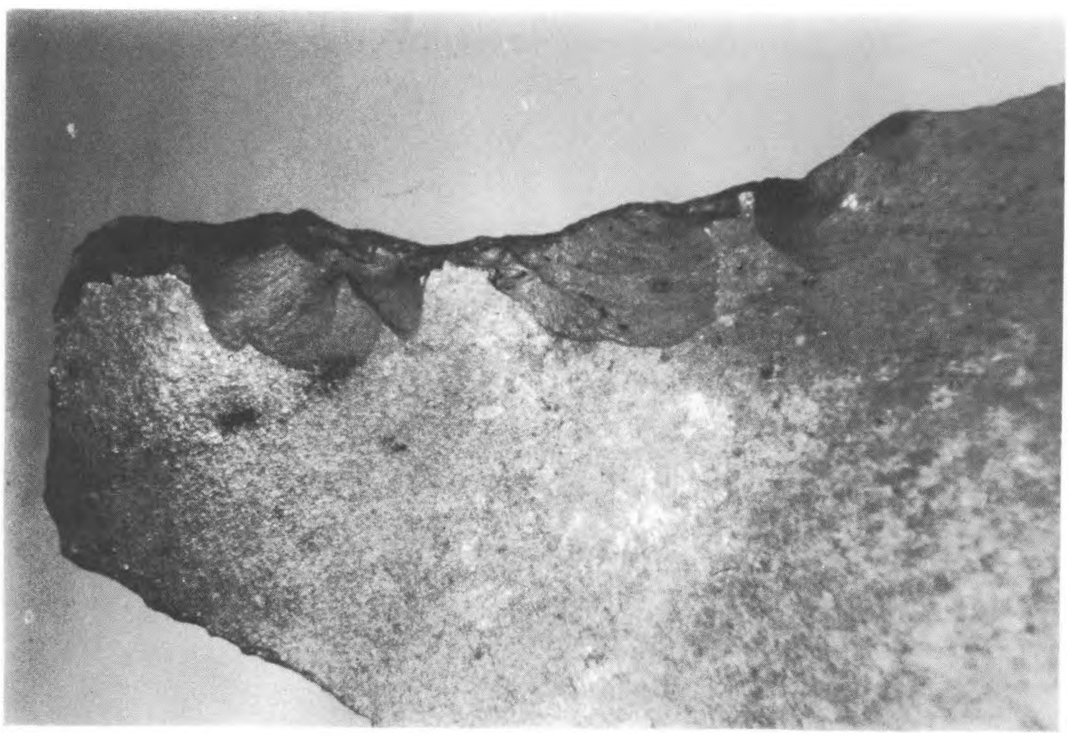

Figure 34. Moderately bright polish and pronounced contiguous superposed microflake scar pattern on the ventral face, and pronounced edge rounding and crushing along the concave margin of prehistoric specimen FiRs 1:2028. Magnified 8 X.

Figure 35. Pronounced smoothing, bright polish, and parallel multidirectional "scratch-groove" type striations on the ventral face of prehistoric specimen EfQv 10:114. Magnified 20 X.

Figure 36. Slight rounding and bright polish appearing on microtopographical features (arrows) apparently caused by long-term rubbing of the user's thumb on the left proximal-lateral section of the dorsal surface of prehistoric specimen EeRh 1:33. Magnified 20 X.

Figure 37. Pronounced smoothing and moderately bright polish on the dorsal aspect of the "opposite" margin of prehistoric specimen "Y-1" apparently caused by long-term rubbing of the user's forefinger and/or thumb in this location. Magnified 16 X.

Figure 38. Slight smoothing and moderately bright polish apparently caused by long-term rubbing of the user's forefinger on the dorsal aspect of the "opposite" margin of prehistoric specimen EfQv 10:114. Magnified 16 X.

Figure 39. Typical "hide scraper"-type microwear trace pattern along the proximal margin edge of prehistoric specimen DjRi 3:4629. Magnified 8 X.

Figure 40. Polymerized resin hafting mastic residues (dark specks) adhering to the proximal half of the dorsal surface of prehistoric specimen EeRl 7:1107. Magnified 16 X.

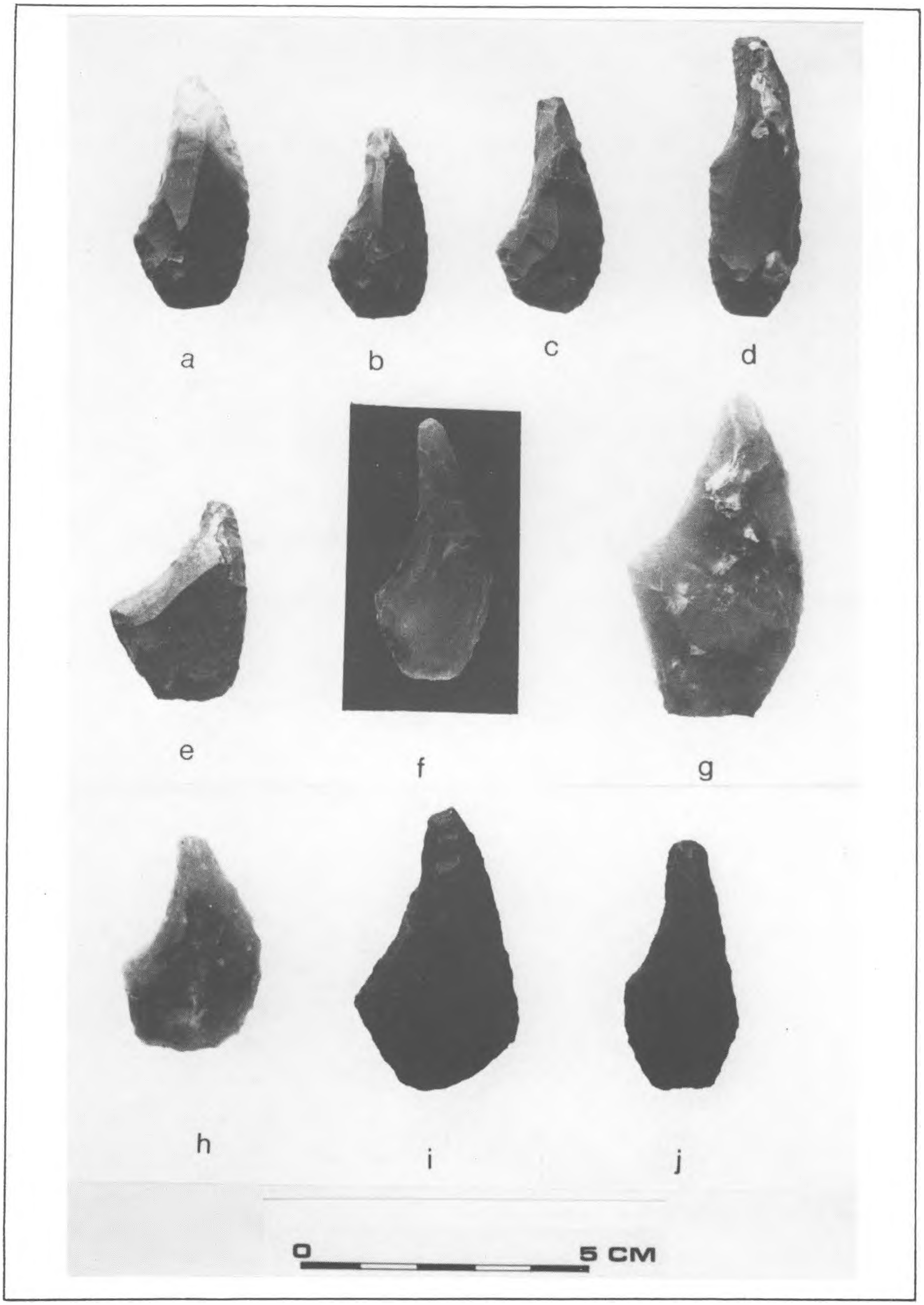

Figure 41. The ten replicated key-shaped formed unifaces (in order from #1-#10) used in the experimental component of this study.

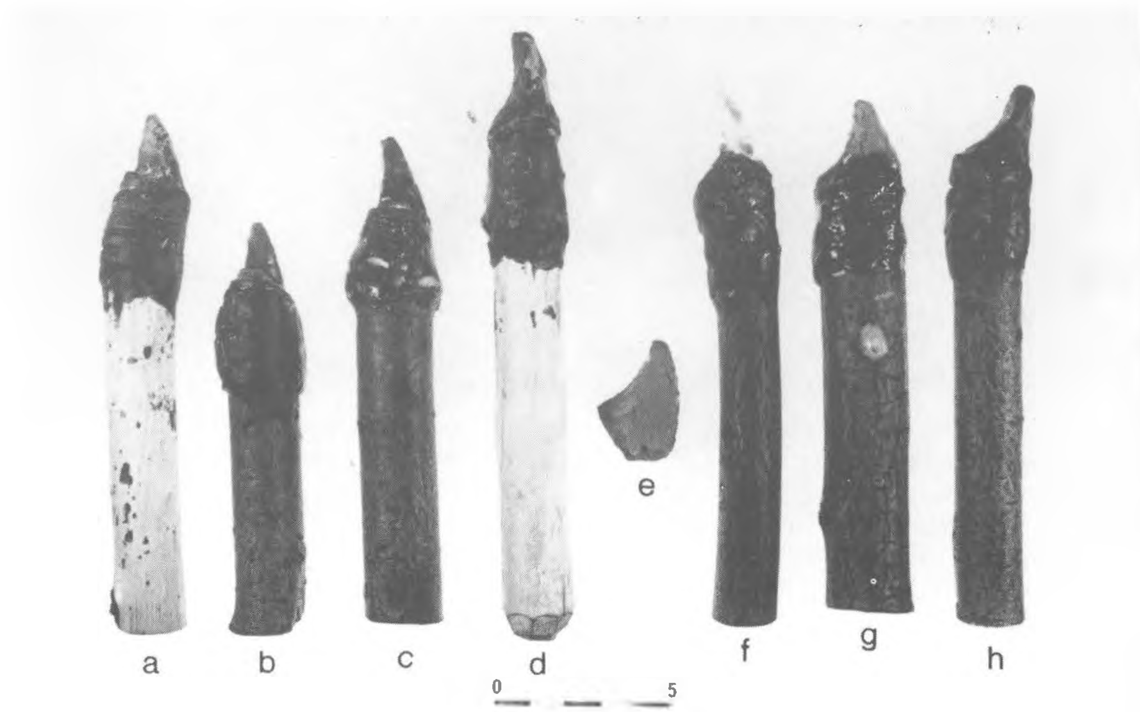

Figure 42. The eight experimental tools used to work branches and stalks of woody plants in this study. E.T.'s #1-#4, #6, #8, and #10 (a-d,f-h) were hafted during all, or most of their use-histories; E.T. #5 was used entirely hand-held.

Figure 43. Stripping bark and shaving, scraping, and planing a saskatoon stalk with the concave margin of E.T. #1 employing one of the most commonly used motor patterns. Arrow indicates direction of working stroke. Note that the index finger is placed on the dorsal face of the "opposite" margin for support, and the juncture of the ventral face of the tool with the haft acts as an effective guide.

Figure 44. Shaving, scraping, and planing a saskatoon stalk with the concave margin of E.T. #1. This motor pattern is similar to that depicted in Figure 43 (above), but note that the thumb is placed on the dorsal face of the "opposite" margin for support.

Figure 45. Using the "opposite" margin of E.T. #2 to remove and smooth down a secondary branch node on a juniper branch. Note that the tool is being used hand-held (unhafted).

Figure 46. Shaving, scraping, and planing down a juniper branch with the concave margin of E.T. #2 (used unhafted).

Figure 47. Stripping bark and shaving, scraping, and planing a juniper stalk using the "opposite" margin of E.T. #1. Note placement of thumb on the dorsal aspect of concave margin for support.

Figure 48. Incising a large groove into a saskatoon stalk using the distal projection tip of E.T. #1. Note that the index finger is placed on the dorsal surface of the projection for support.

Figure 49. Using the concave margin of E.T. #1 to significantly modify (carve) the proximal end of a saskatoon stalk. Note placement of index finger on dorsal aspect of "opposite" margin for support.

Figure 50. Using the distal projection tip of E.T. #7 (hafted) to incise a linear groove into the shaft of a soaked deer antler beam.

Figure 51. Using the concave margin of E.T. #7 (hafted) to attempt to scrape a soaked deer metacarpal. The tool was effective at removing remaining fleshy tissue, but had very little effect on the bone.

Figure 52. Saskatoon bark and wood shavings produced using key-shaped formed unifaces.

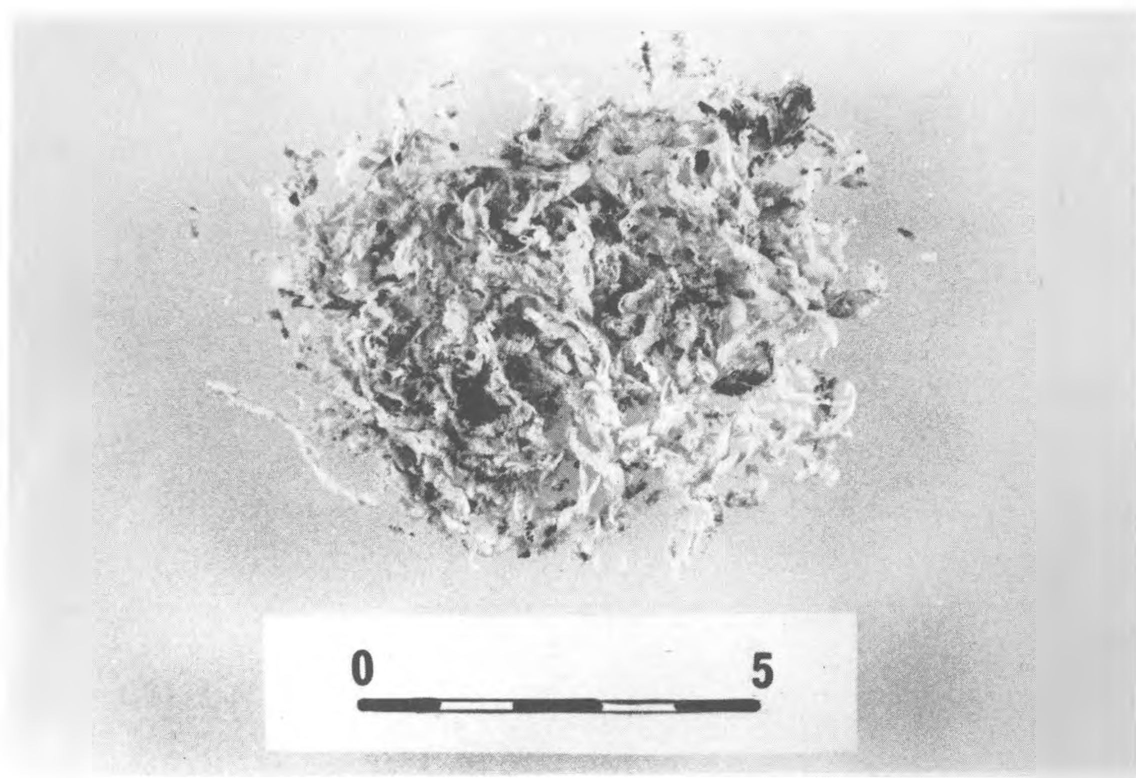

Figure 53. Soaked deer antler shavings and scrapings produced using key-shaped formed unifaces.

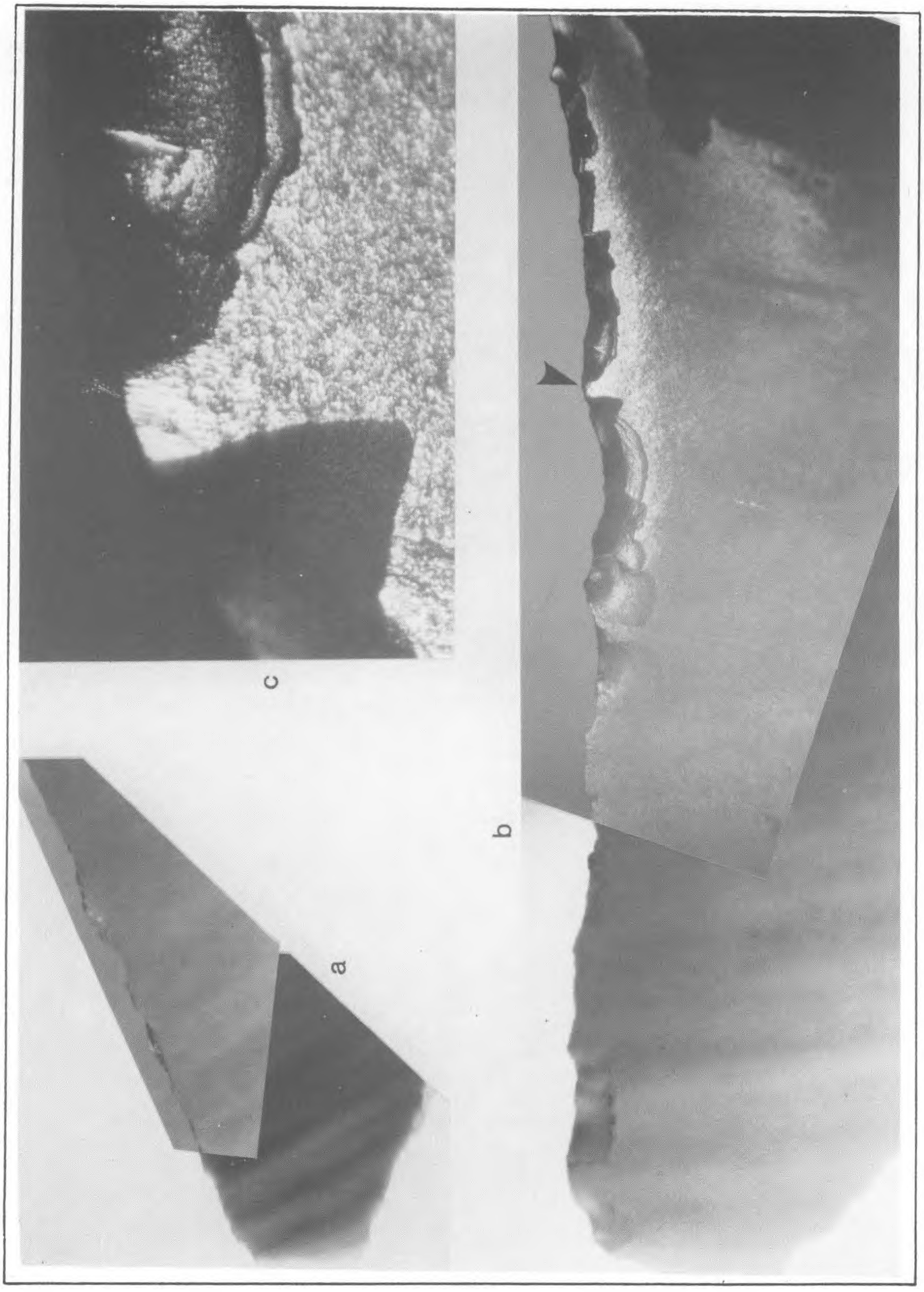

Figure 54. Pre- and post-use photomicrographs of E.T. #1, used to work saskatoon (12,500 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #1 showing concave margin (top) and distal projection tip (magnified 5.5 X);

(b): Post-use photo mosaic indicating microflake scars on the distal tip, and contiguous superposed microflake scars and bright polish on the medial section of the concave margin edge aspect and ventral face (magnified 9.5 X). Arrow indicates location of edge segment depicted in (c).

(c): "Sleeked" type striations (arrows), moderate rounding, and bright polish, on a prominent feature on the ventral edge aspect of the concave margin (see [b]; magnified 40 X).

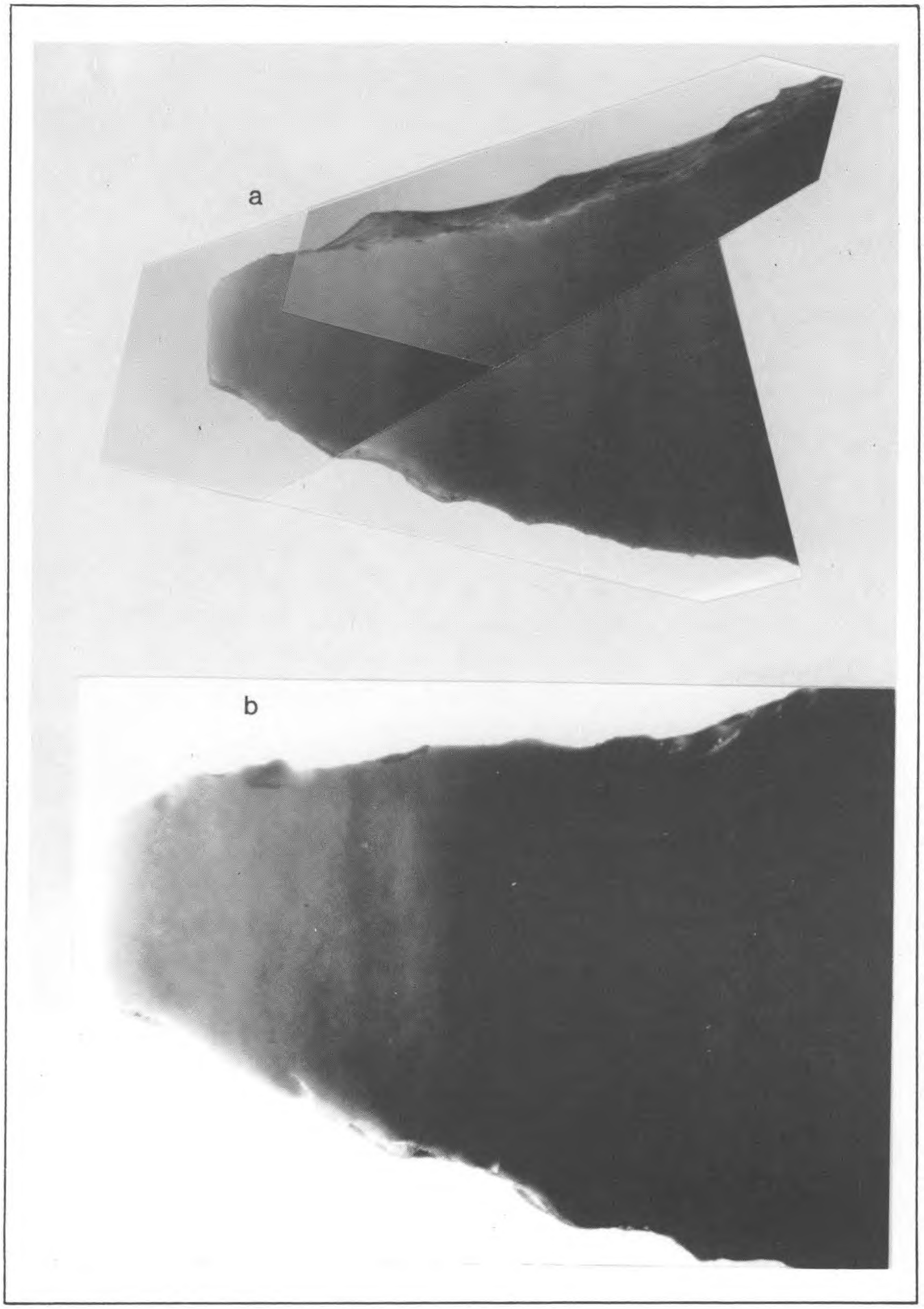

Figure 55. Pre- and post-use photomicrographs of E.T. #2, used to work juniper (7,700 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #2 showing concave margin (top) and distal projection tip (left) (magnified 4.5 X);

(b): Post-use photo mosaic indicating random microflake removal along the ventral edge aspects (magnified 7.5 X).

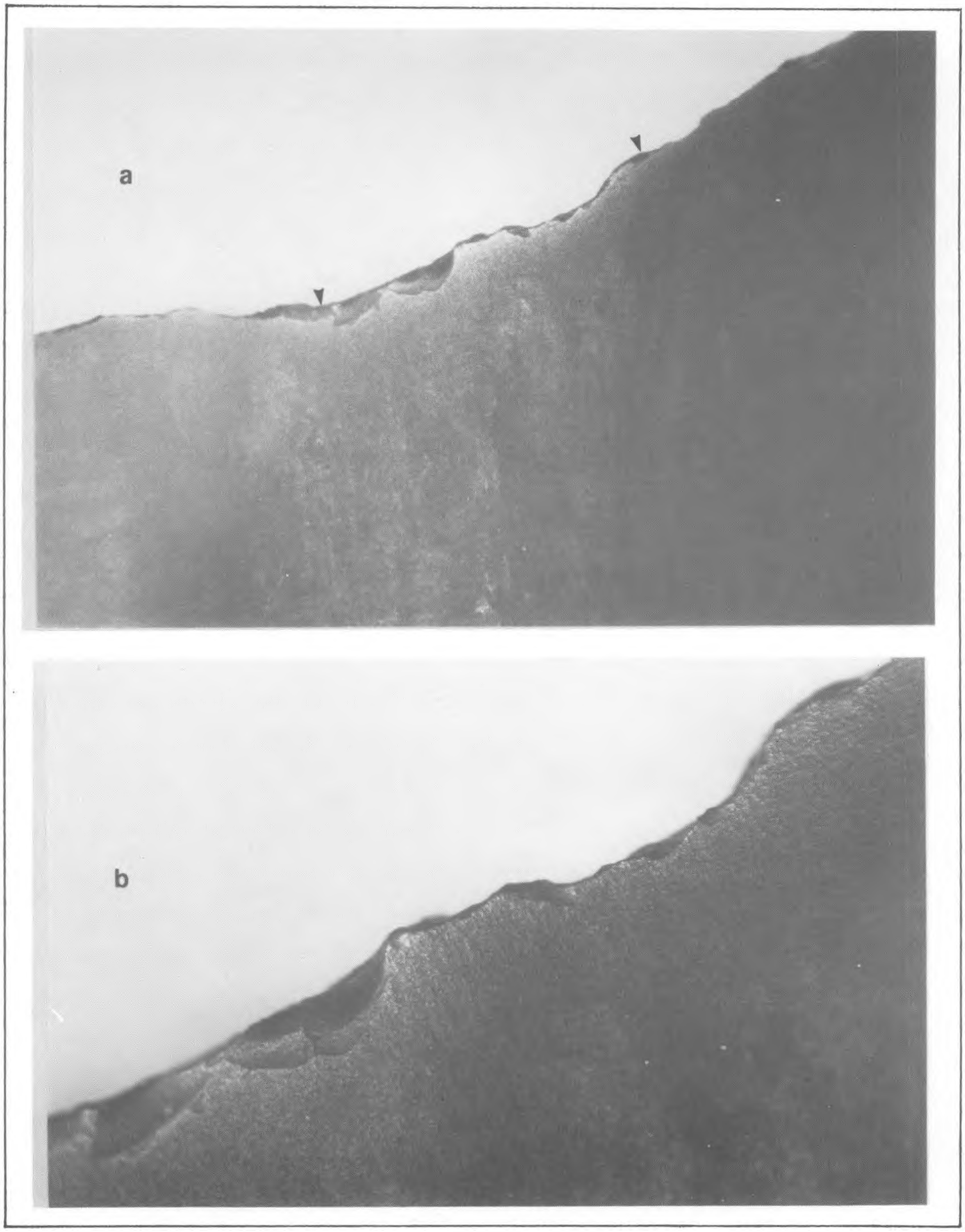

Figure 56. Post-use photomicrographs of the medial section of the concave edge aspect of E.T. #2, used to work juniper (7,700 strokes).

(a): Contiguously patterned microflake scars and bright polish (magnified 10 X). Arrows indicate location of edge segment depicted in (b).

(b): Detail of microflake scars, polish, and moderate rounding (see [a]; magnified 35 X).

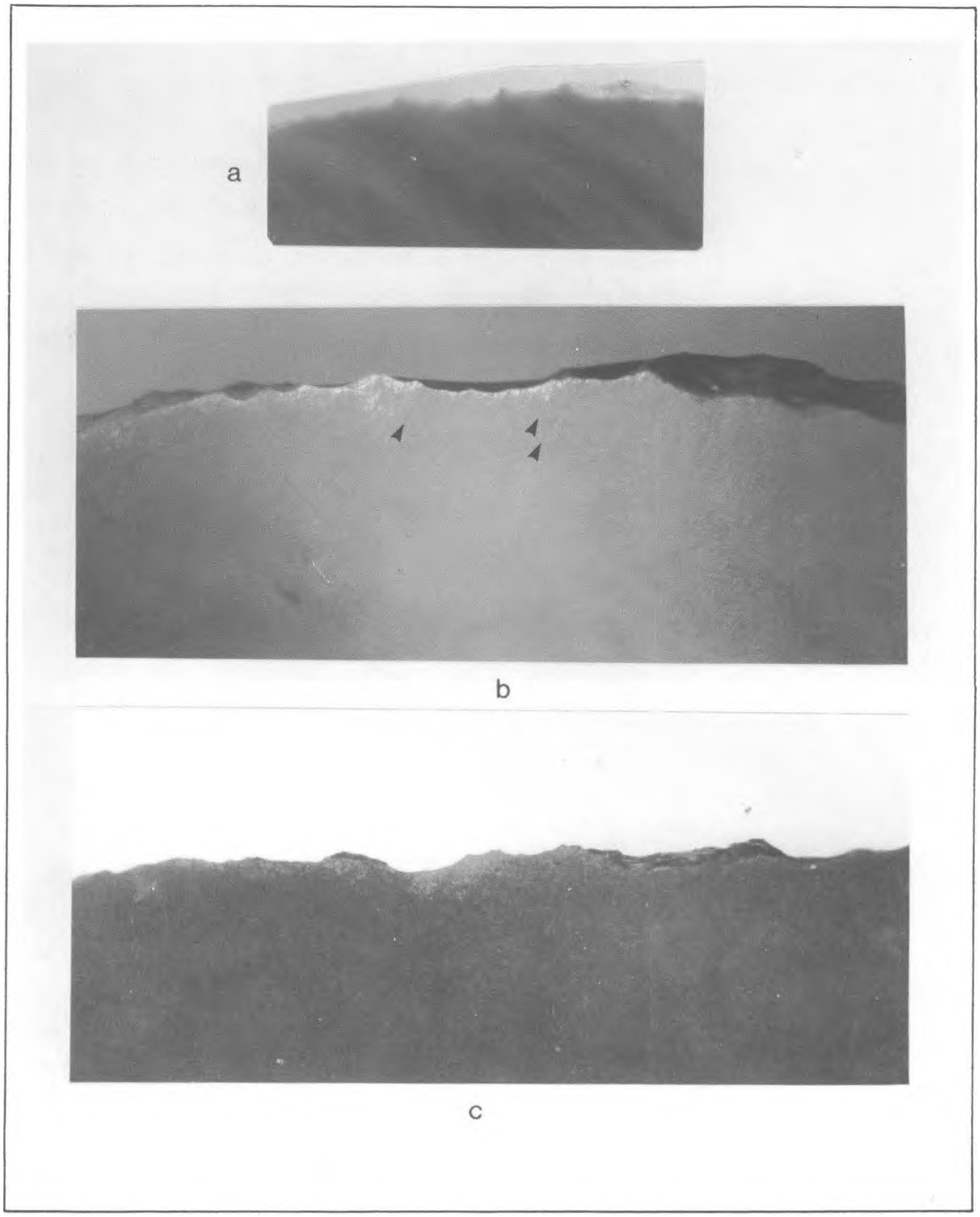

Figure 57. Microphotographs of the "opposite" margins of E.T.'s #1 and #2.

(a): Pre-use photo of medial section of the "opposite" margin of E.T. #1 (magnified 5 X).

(b): Post-use photo of medial section of the "opposite" margin of E.T. #1 indicating "scratch-groove" striations (arrows) and moderately bright polish (magnified 9 X).

(c): Post-use phto of E.T. #2 indicating moderately bright edge polish on the medial edge aspect of the "opposite" margin (magnified 10 X).

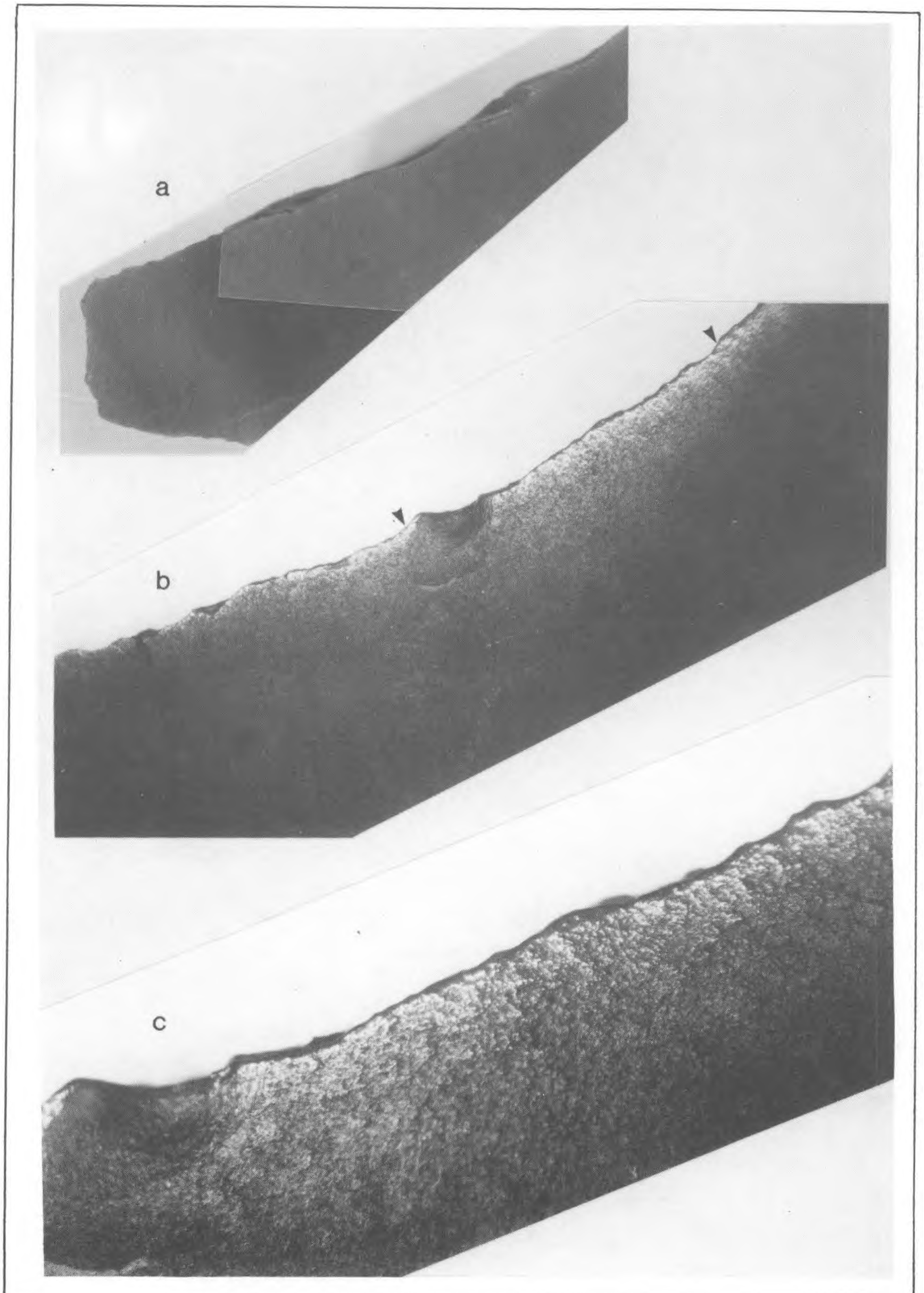

Figure 58. Pre- and post-use photomicrographs of E.T. #3, used to work saskatoon (15,400 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #3 showing concave margin (top) and distal projection tip (magnified 5 X);

(b): Post-use photo of the medial-distal section of the concave margin edge aspect indicating random microflake scar removal and bright polish (magnified 10 X). Arrows indicate edge segment depicted in (

(c): Detail of polish and slight edge rounding for the edge segment indicated in (b) (magnified 40 X).

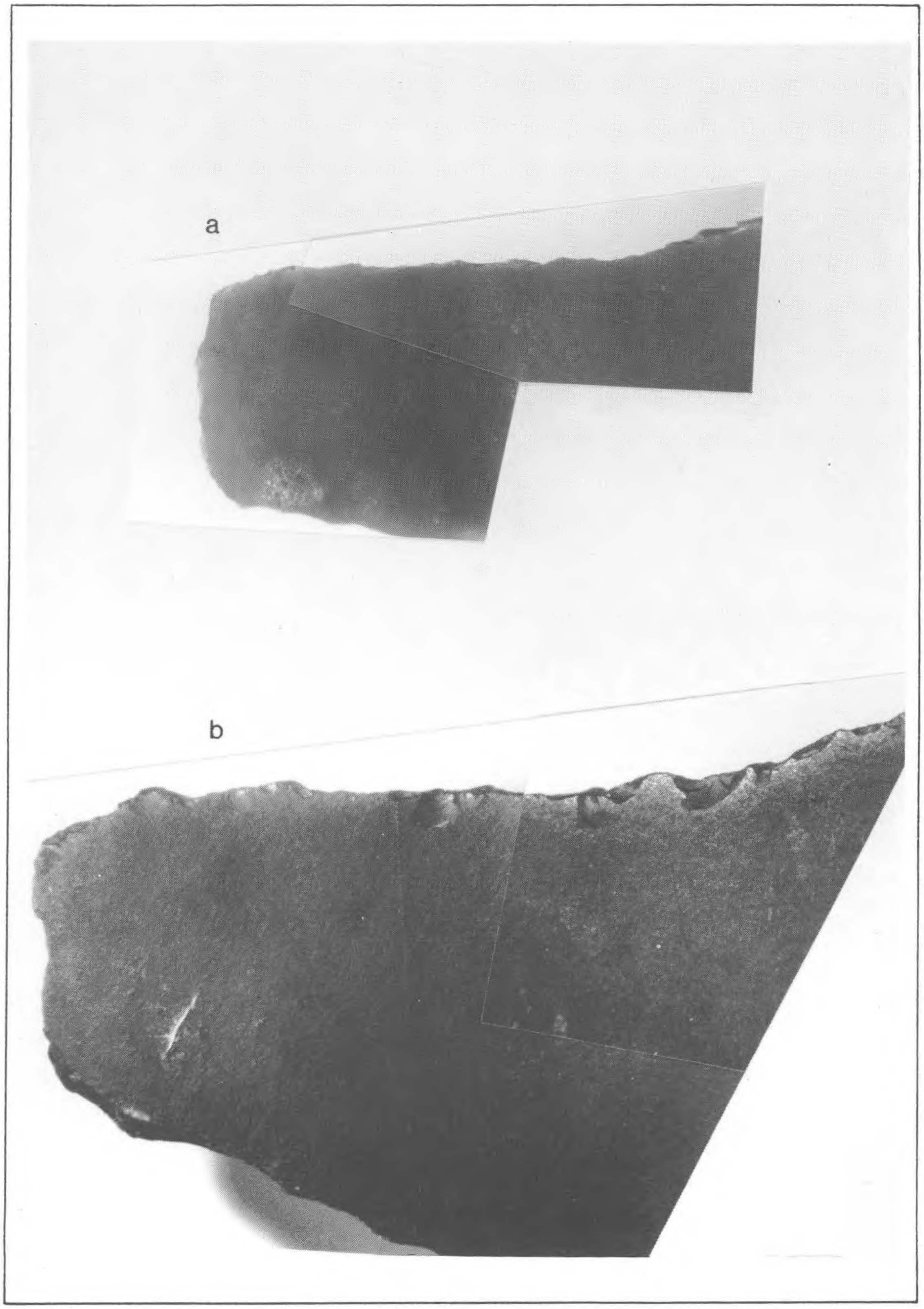

Figure 59. Pre- and post-use photomicrographs of E.T. #4, used to work willow (17,650 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #4 showing concave margin (top) and distal projection tip (magnified 5.5 X);

(b): Post-use photo mosaic indicating contiguous superposed microflake scar pattern, bright polish, moderate rounding, and slight crushing on the medial-distal section of the concave margin; and moderate crushing on distal tip edge (magnified 9 X).

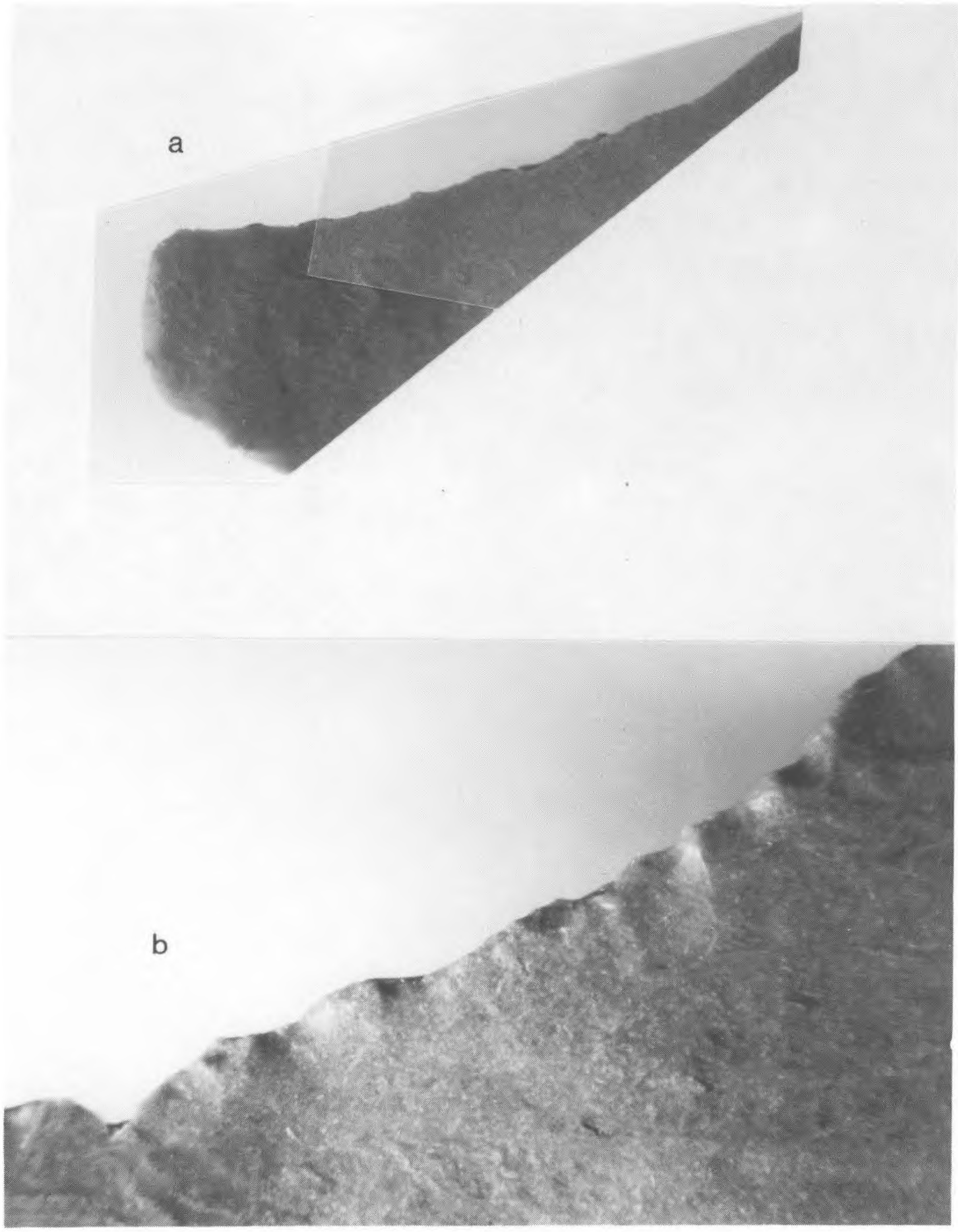

Figure 60. Pre- and post-use photomicrographs of E.T. #5, used to work saskatoon (600 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #5 showing concave margin (top) and distal projection tip (magnified 5 X);

(b): Post-use photo of the medial-distal section of the concave margin edge aspect indicating contiguous superposed microflake scar removal pattern, pronounced edge rounding and smoothing, and pronounced crushing (magnified 10 X).

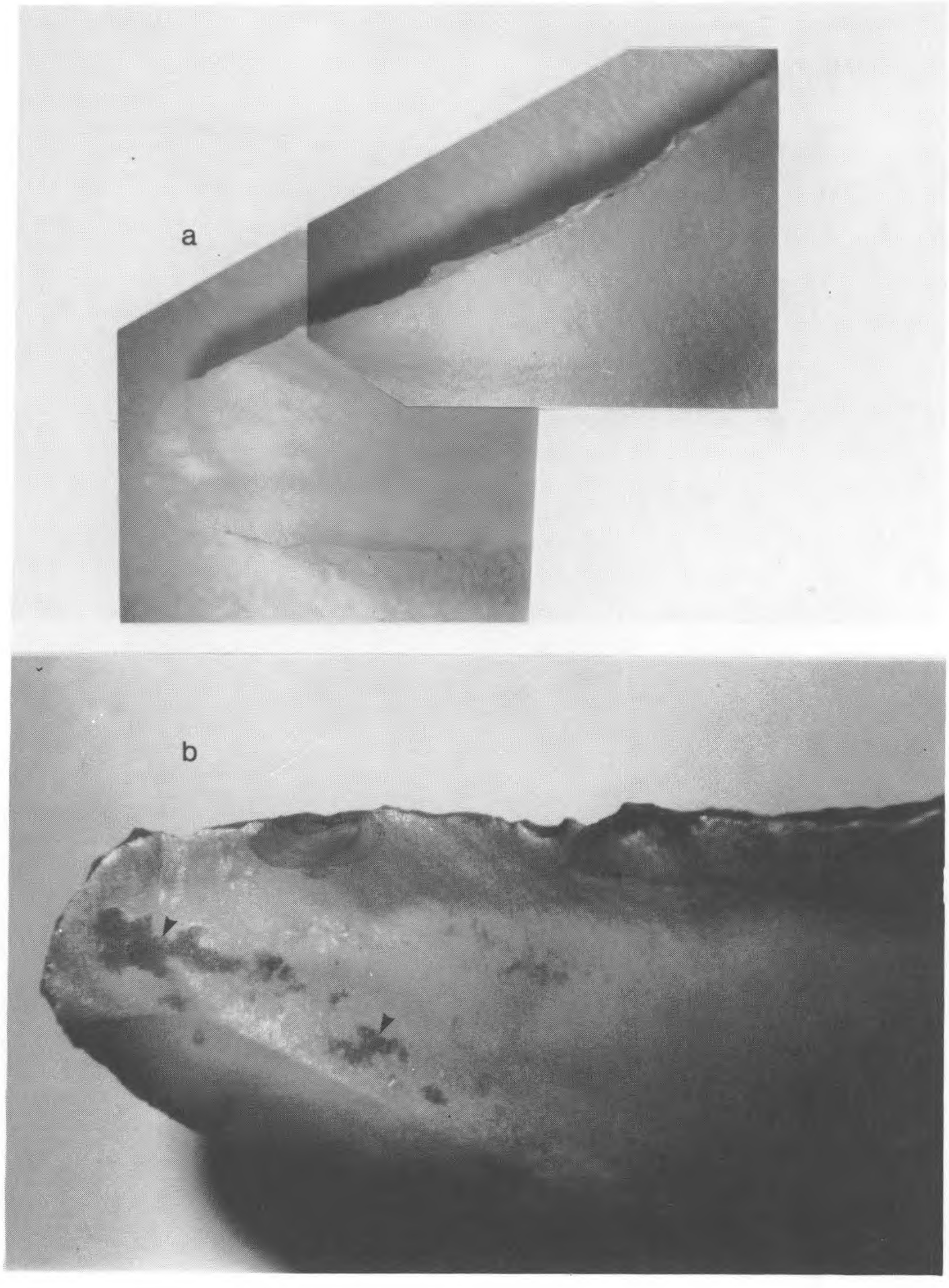

Figure 61. Pre- and post-use photomicrographs of E.T. #6, used to work saskatoon (5,250 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #6 showing concave margin (top) and distal projection tip (magnified 5 X);

(b): Post-use photo indicating: random microflake scar pattern, bright polish, moderate rounding and smoothing, and slight crushing along the concave margin; and bright polish and slight edge rounding on the distal projection tip (magnified 8.5 X). Arrows indicate plant resin residue deposits adhering in slight depression on ventral face.

Figure 62. Pre- and post-use photomicrographs of E.T. #7, used to work deer bone and antler (2,200 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #7 showing concave margin (top) and distal projection tip (left) (magnified 5 X);

(b): Post-use photo mosaic indicating: pronounced crushing, moderate edge rounding, and extensive microflake removal on the distal projection tip; and random microflake pattern, pronounced edge rounding and smoothing, moderately bright polish, and pronounced edge crushing on the medial-distal section of the concave margin (magnified 9 X).

Figure 63. Pre- and post-use photomicrographs of E.T. #8, used to work saskatoon (11,200 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #8 showing concave margin (top) and distal projection tip (magnified 5 X);

(b): Post-use photo mosaic indicating moderately bright polish adjacent to the distal projection tip; and randomly patterned microflakes, slight edge rounding and smoothing, bright polish on some edge aspect segments, and slight crushing on the concave margin (magnified 10 X).

Figure 64. Pre- and post-use photomicrographs of E.T. #9, used to work deer antler (400 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #9 showing concave margin (top) and distal projection tip (magnified 5.5 X);

(b): Post-use photo mosaic indicating extensive edge loss due to severe crushing on the distal tip and concave margins. Circles mark same microtopographic landmarks indicating amount of edge loss (magnified 9 X).

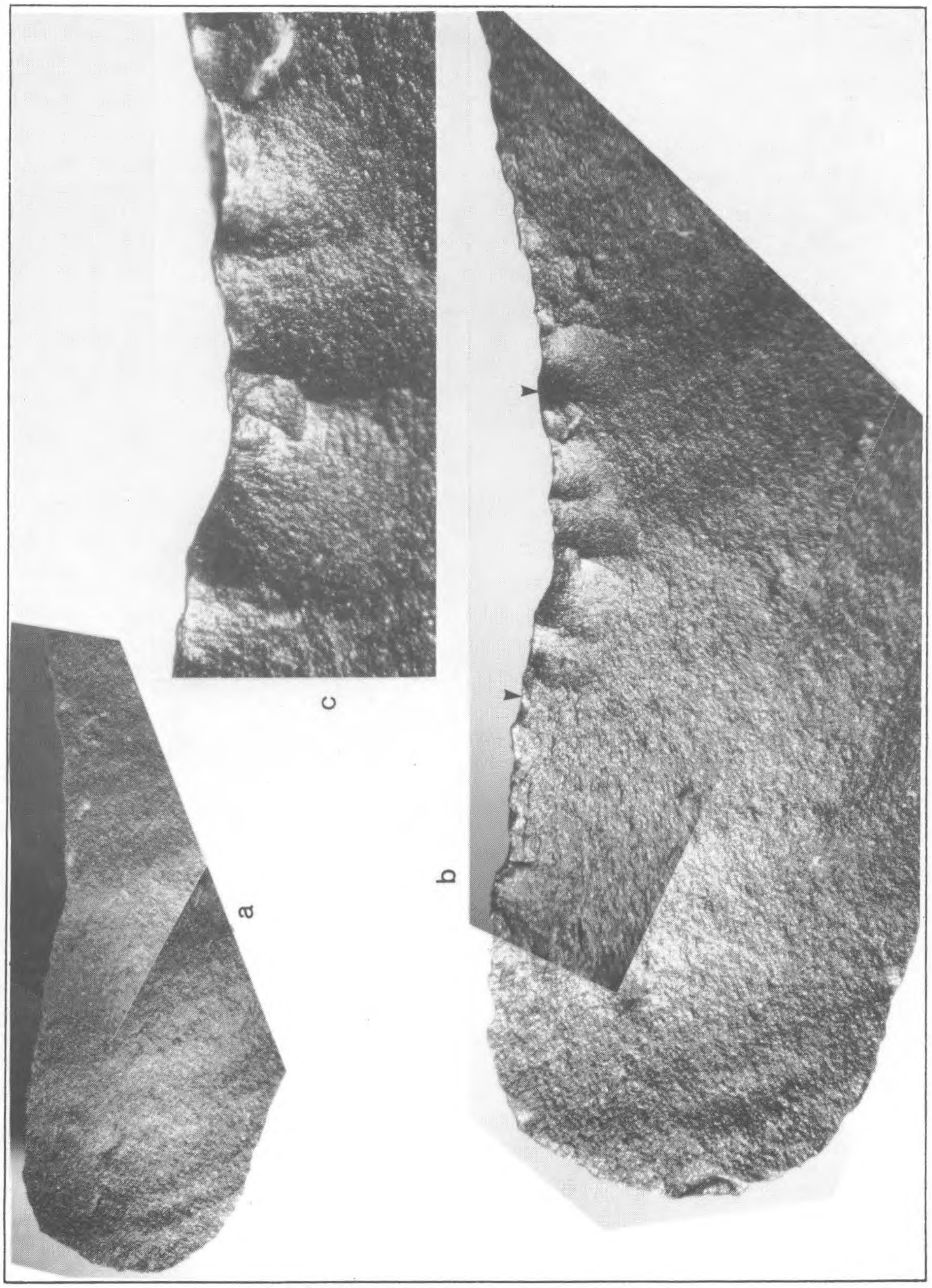

Figure 65. Pre- and post-use photomicrographs of E.T. #10, used to work saskatoon (7,050 strokes).

(a): Pre-use photo mosaic of the ventral face of E.T. #10 showing concave margin (top) and distal projection tip (magnified 5.5 X);

(b): Post-use photo mosaic indicating contiguous superposed microflake scar pattern, moderately bright polish, and slight crushing along the medial-distal section of the concave margin edge (magnified 10 X). Arrows indicate edge segment depicted in (c).

(c): Detail of pronounced edge rounding and smoothing, and polish on the edge segment indicated in (b) (magnified 22 X).

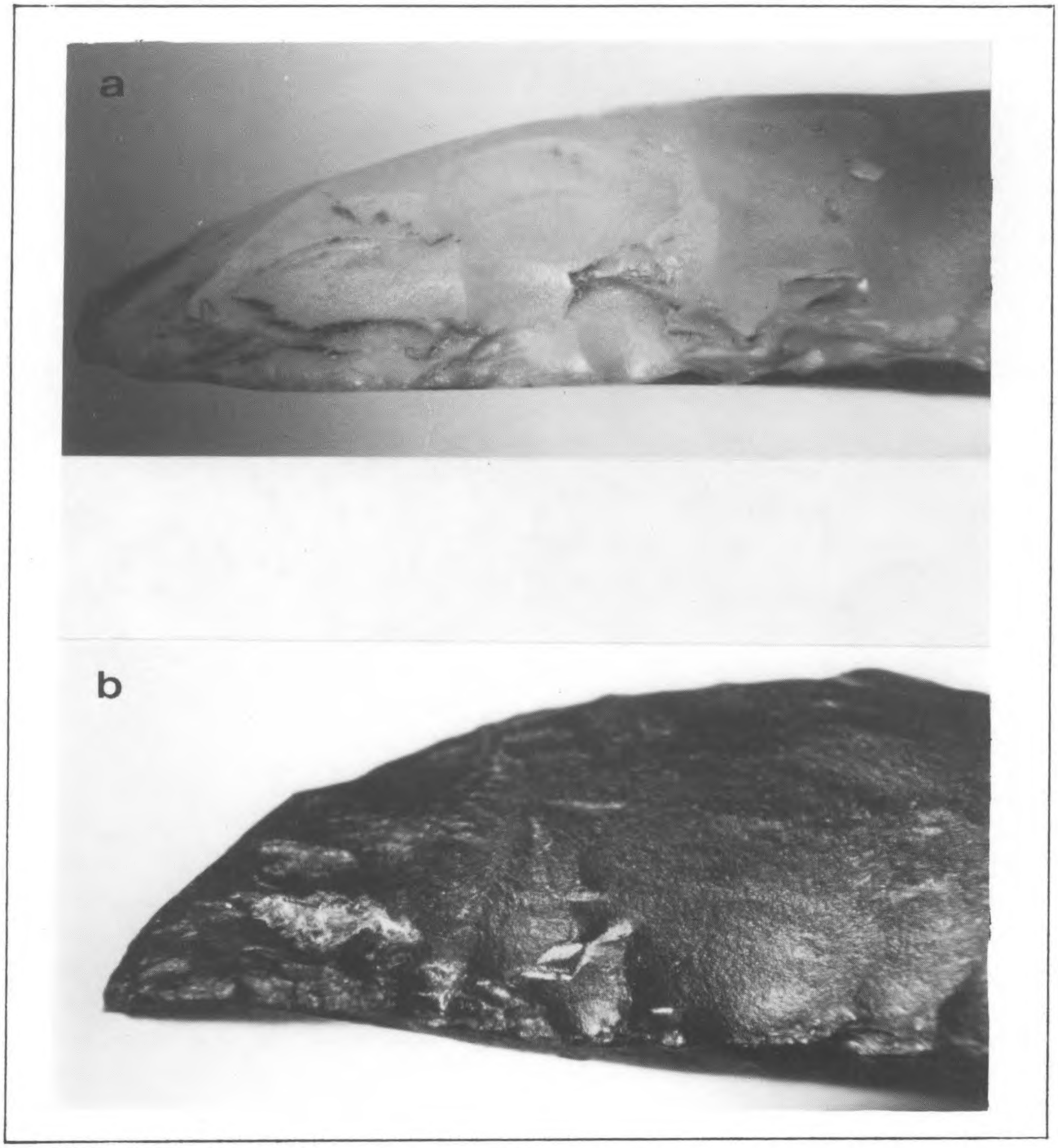

Figure 66. Plant resin residue deposits trapped in flake scars on the dorsal face of E.T. #1 (a) and E.T. #10 (b) after having been cleaned thoroughly with acetone. These residue deposits are identical to those observed on most of the prehistoric specimens examined during the residue analysis. Magnified 9.5 X.