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METRIC VARIABILITY IN ARCTIC SMALL TOOL TRADITION SPALLED BURINS: A PRELIMINARY SHAPE ANALYSIS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Metric Variability in Arctic Small Tool Tradition Spalled Burins: a Preliminary Shape Analysis" submitted by Ian G. Robertson in partial fulfillment of the requirments for the degree of Master of Arts.

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ABSTRACT

This thesis is concerned with documenting metric variability in a sample of Early Palaeo-Eskimo spalled burins from the eastern High Arctic of Canada.

Artifacts are described using a system of quantitative shape analysis, based on the definition of a gravitational centroid and a series of radial vectors. Multivariate statistical procedures applied to this data demonstrate that morphological characteristics of burin assemblages contain information of culture-historical significance. Patterning discerned in these artifacts demonstrates that the sequence from Independence I to Early, Middle and Late Pre-Dorset is characterized by gradual, unilineal change, and a single developmental sequence is tentatively inferred. Assemblages identified as Sarqaq are found to diverge from this pattern.

Correspondence and cluster analyses show that burin morphology may have predictive value in arctic research. These tests suggest that a number of assemblages attributed to Early and Middle Pre-Dorset may be misidentified, and an alternative culture-historical identification is tentatively offered.

The final conclusion of this work is that lithic tool analysis has the potential to provide useful information about culture change and cultural relationships in the arctic. An increased emphasis on descriptive and

classificatory studies can be expected to yield positive results, and should provide a more stable interpretive base for the writing of northern culture-history.

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CHAPTER 1

INTRODUCTION

Many facets of archaeology depend on the ability of its practitioners to document and explain variability within prehistoric material culture. Classification studies continue to fill a vital, if somewhat neglected, role in the discipline. The often preliminary task of writing culture-history is largely contingent on this stage of research, as are archaeological pursuits that, on the face of it, reflect more striking theoretical perspectives. Many practical and theoretical issues remain unresolved. Analytical techniques that aid in the discernment and explanation of formal variability must continue to be developed.

The goal of this study is to document patterns of metric variability within spalled burin assemblages of the Arctic Small Tool tradition. A secondary aim is to compare and contrast this patterning with the culture-historical context of these assemblages. The samples analyzed derive from three discrete regions in the Queen Elizabeth Islands of the Canadian arctic archipelago. Two of these, Port Refuge and the Truelove Sparbo-Hardy Lowland, are on Devon Island. The third is the Bache Peninsula region of Ellesmere Island.

While this analysis is envisioned primarily as contributive to the field of arctic archaeology, the methodology employed should prove to be more generally useful in the analysis of artifact assemblages from elsewhere in the prehistoric record. The standardized description of burins is problematic for several reasons, but one characteristic, assymetry, is shared by many other artifacts. The procedures utilized here were specifically developed so that such artifacts could be legitimately described for the purpose of comparison.

Scope of Analysis

For the sake of analytical convenience, a number of arbitary limitations have been placed on the topics addressed by this thesis.

Inquiry is focused on variability exhibited by burins viewed in two dimensions, and in plan view. Implicit in the decision to so limit the study is the belief that significant stylistic information may be recorded simply in the outline of the artifact. This in no way precludes the possibility that other facets of morphological and other variability may prove equally or more significant. Before most of these can be adequately addressed, however, detailed analyses into the lithic-technological nature of arctic burins will have to be undertaken, in conjunction with a good deal of practical experimentation. This is a field that remains largely unexplored, and this particular study makes no pretense of contributing to it.

Burins exhibiting multiple spall removal are, with a few exceptions, eliminated from analysis. Analysis is confined to the 'classic' form of arctic burin, with a single zone of spall removal. In practice, this required the removal of only a small number of artifacts, as multi-spalled burins are not particularly common in any of the regional samples.

Finally, this study was based on burins in which the working edge was created and maintained using the technique of spall removal. The effect of this restriction was to confine analysis to the Early Palaeo-Eskimo period, and to remove the ground burin of the Dorset period from consideration (see Chapter 3).

Contribution

It is probably fair to suggest that, after 60 years of more or less systematic endeavour (Collins 1984:15), arctic research continues to lack a strong empirical base. Variability within the record has simply not been adequately documented. Evidence for temporal and other distinctions are too frequently intuitive, and much of the data that has been brought to bear on arctic culture-history remains unpublished and untested. If archaeology is to continue generating interesting questions about prehistoric behaviour in the north, this will have to be rectified; this is especially true if we hope to answer these questions.

It is to this perceived gap in arctic research that this study hopes to contribute. By attempting to document variability within a single class of stone artifact, a tool for measuring culture change may be identified. In isolation, however, even positive results cannot be expected to solve the problem. It is nonetheless hoped that such would encourage other researchers to conduct detailed studies of other artifact types that have been recovered from northern sites; in consort, valuable insight may be gained.

Outline

Chapter 2 provides a focused introduction to the burin as a component of the arctic prehistoric record. Items of vocabulary used elsewhere in the study are defined, and technical considerations of manufacture and use are selectively considered. Emphasized are considerations of burin morphology that have hindered previous attempts at metric analysis. Examples of the latter are briefly described.

Chapter 3 develops the culture-historical context of the analysis. Current reconstructions of High Arctic prehistory are briefly reviewed, and culture-historic constructs of direct relevance to the analysis are summarized. Finally, a description is provided of the regions, sites, and features from which the assemblages under study are derived. These data provide the interpretive framework for statistical analyses conducted in chapters 4 and 5, and their subsequent interpretation.

The methodological component of this study is divided into two parts. Chapter 4 describes and implements an innovative technique of analysis based on a computer assisted characterization of artifact shape. The resultant data are scrutinized using principal component analysis, which in turn is used to structure the subsequent cluster analysis of individual cases. In Chapter 5, these clusters are subjected to secondary analyses designed to clarify their relationship with known culture-historical units of the arctic prehistoric record. Specifically, they are used to define a set of hypothetical type specimens, which are then subjected to a second phase of cluster analysis.

The first portion of Chapter 6 is concerned with the culture-historical implications of the results generated by the previous two chapters. A close fit is demonstrated between temporal/cultural units known from the High Arctic, and cluster type frequencies exhibited by many of the individual assemblages under investigation. This is followed by a general review of the methodology developed in the context of this thesis, and its potential for the analysis of other artifact types. Certain refinements are suggested for subsequent applications.

CHAPTER 2

BACKGROUND

The goal of the present chapter is two-fold. The first objective is to provide a functional context for the analysis of High Arctic spalled burins. While this study is explicitly **not** concerned with details of manufacture, use, curation, and so on, certain considerations inherent in these topics form the basis for methodological decisions made later in the analysis. A select review is therefore in order.

The second goal is to introduce previous attempts at burin analysis. The treatment is not exhaustive. The aim is primarily to characterize analytical approaches that have been taken in the past, and to identify areas in which improvements could be made, and perhaps better results obtained.

Definition and Terminology

In archaeological parlance, the term 'burin' describes a distinct class of stone tool used for engraving, cutting, or otherwise modifying hard organic materials such as antler, ivory, bone, and wood. These latter form the material basis for most northern food-getting technologies, and it may be inferred that tools capable of effectively working them filled a correspondingly prominent role in the technological system. They are ubiquitous in archaeological sites of the Arctic Small Tool tradition (ASTt; see Chapter 3).

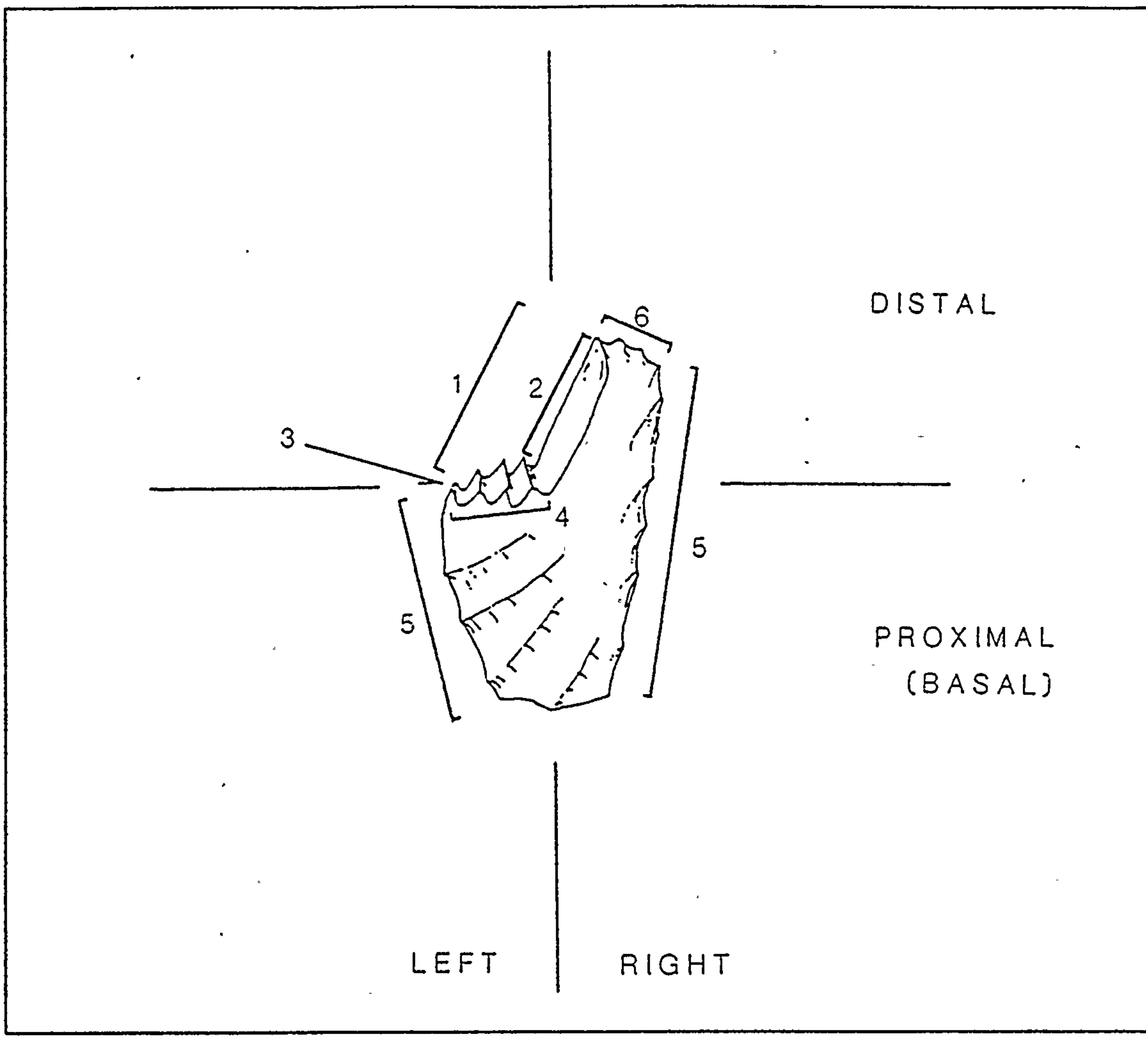
Throughout much of the period in which they were used, the working edges of burins were created through a technique of controlled spall removal (Giddings 1964:210-211). While perhaps falling short of a formal definition, the characteristic of spall removal is requisite, in the view of many researchers, to the identification of this tool.

Used primarily, then, to describe a general functional class, the term 'burin' also connotes a distinct fabrication technique. This, of course, is the rationale behind the use of the adjective 'burin-like' to describe the tool that replaced the spalled burin in later stages of the ASTt sequence (Maxwell 1985: 113-117). These artifacts are characteristically ground rather than flaked to their final form, but appear otherwise to be functionally equivalent tools used to fulfill the same general tasks (cf. Maxwell 1974). While wishing to avoid a semantic quibble, it is suggested that the definition, formal or otherwise, should be restricted to the inferred function. The modern steel burin which, through analogy, has lent its name to the prehistoric artifact, is simply a specialized form of chisel used to engrave metals; nothing about the process by which it is manufactured is implied. The fact that clearly transitional forms exist, exhibiting the features of both spall removal and grinding (Maxwell 1985:113), is indicative of a strong developmental relationship that is obfuscated by the use of the term 'burin-like' (Schledermann 1988). In this study, the term burin may refer to an artifact which simply exhibits spall removal, or equally to the ground and transitional forms.

Subsequent discussion of burin form will be facilitated through the definition of a standardized vocabulary (Figure 1). In all but a few cases, precise meanings are emphatically not implied by these terms. To anticipate an argument that will be returned to in Chapter 4, the extremes of morphological variability exhibited by burins preclude much in the way of terminological rigour. The occasional need to focus attention on specific artifact features is adequately served by the simple system described below.

Of primary importance is the **spall zone** (1). This is the portion of the burin that is altered by spall removal, and is made up of several discrete features that reflect specific components of curational activity. The first of these is the **spall edge** (2). This term is used to refer to the negative scar left by the ventral surface of the last spall flake removed. In general, its length is reduced by each event of spall removal, although this depends on the both the shape of the artifact in question, and the point of spall termination. The latter is characterized by a distinct type of hinge fracture scar. That nearest the lateral edge of the artifact, and which in most instances records the removal of the first spall, is referred to as the **primary spall termination scar** (3). The entire series

Figure 1: Terminology



1 spall zone
2 spall edge
3 primary spall termination scar
4 spall termination zone
5 lateral edges
6 distal edge

[sketch of burin taken from Giddings (1964)] of scars left by the action of repeated spall removal is described as the **spall termination zone** (4). It is not uncommon to find that both of these features have been more or less obscured by subsequent, and usually unifacial, retouch.

Having described the spall zone, a **standard orientation** may now be defined. Burins so oriented have the spall zone to the left, and **away** from the viewer, in exactly the same manner as the artifact illustrated in Figure 1. This aids in standardizing the digitization process, where it is important that all cases have comparable surfaces facing upward.

When the burin is placed in standard position, a few relative terms are useful for less precise descriptive purposes. **Left** and **right** halves are distinguished. The division between them is roughly that of the artifact's midline, as indicated in Figure 1, and no attempt at a more precise definition is practical or necessary. **Proximal** and **distal** components are defined in a similarily imprecise manner; when not serving merely as relative terms, the division is roughly at the primary spall termination zone. The combination of the these two sets of distinctions should divide a burin, at a very gross level, into quarters. The term **basal** will frequently be used as a synonym for proximal.

The last set of terms that needs to be considered here describe portions of the artifact's margins. Most critical are the **lateral edges** (5). This term is largely self explanatory, and refers to the margins that, very roughly, extend away from the viewer when the artifact is in standard orientation. Different portions of these edges can be indicated by modifying the term with one or more of the relative terms described immediately above. In some burins, a distinct edge can be discerned immediately adjacent to the spall edge; this is refered to simply as the **distal edge** (6). Even if not obscured by spall removal, it may often be impossible to distinguish objectively between a 'distal edge' and the most distal portion of the right lateral edge'. The same can be said about most marginal components, and the very distinct edges exhibited in Figure 1 represent an ideal form that many artifacts do not attain.

Manufacture and Use

Little attention has so far been focused on the processes of lithic tool manufacture in the arctic. Giddings's study of the Denbigh Flint Complex from Alaska, however, provides insight into several aspects of burin production (1964:211-219:). His observations suggest that the majority of burins are made from asymmetrical, but standardized preforms struck from some sort of prepared core. These 'mitten shape' flakes were apparently produced specifically for burin manufacture, and the amount of secondary alteration required was often minimal. The desired characteristic of asymmetry may have been invoked by manipulating both platform angle and the scars of previous flake scars; preserved dorsal ridges on finished burins indicate that cores were habitually rotated over 90 degrees between the detachment of subsequent flake series (Giddings 1964:214). Spall removal is usually restricted to a single end of the flake, and remnant platforms are normally found on the opposite (proximal) end. The vast majority of single spall burins, when placed in the standard orientation position described above, have their most planar (usually ventral) surface facing downward; this observation is thought to relate to the characteristic of handedness (Giddings 1964:218). Given the usual asymmetry of preforms, this distinction may reflect more closely the motor habits associated with core preparation and subsequent flake detachment, rather than secondary alteration and use. This distinction would be significant if specialization is ever demonstrated to have been a component of lithic tool production in the prehistoric arctic (Irving 1964:326, cited in McGhee 1980).

How well these observations describe the assemblages analyzed in this study is unknown. As will be indicated below, however, the general technological system of which they form a part includes the material described by Giddings. At the intuitive level, the assemblages appear to reflect rather deliberate motor behaviour. Opportunistic spall detachment from expediently chosen flakes is very much the exception.

Little experimental work has been published on how arctic spalled burins were actually used to alter raw materials. It is suspected, based largely on formal evidence, that two quite different functional modes may have existed (Maxwell 1985:91-92). According to this reconstruction, the tip of the burin (the point at which spall removal was initiated), was used for cutting narrow slots, often in preparation for splitting; the cutting action was thus in the plane of the tool. In a rather distinct manner, the edges of the spall scars would have been useful for modifying secondary tools through controlled shaving. These edges are both sharp and durable, and would have been entirely suited to this sort of activity. Gordon's analysis (1975:225) of use-wear striae on burins from the District of Keewatin (Canadian Barrenlands) has corroborated both modes of use, sometimes on the same artifact.

It is evident that many burins were placed in some kind of secondary haft before being used. Crushing and grinding on basal lateral edges were observed by Gordon in the analysis cited above (1975:214-217); these features, in conjunction with shallow lateral notching are good evidence for the use of a handle. Again, these characteristics were noted on many of the artifacts analyzed here, although only in passing. The handles themselves have not been preserved in the Canadian arctic, at least in contexts predating the Dorset occupation (see below); several examples are known from Early Palaeo-Eskimo sites in Greenland (cf. Meldgaard 1983). The use of handles need not be inferred for all burins, however, and it is conceivable that many were held directly in the hand.

As a burin's working edges become dulled through use, they were rejuvenated by spall removal, thought to have been effected through some form of directly applied pressure. Repeated spall removal tends to exaggerate the asymmetry of the artifact, and depending on the exact shape of its distal components, may obscure considerably the original shape of the artifact. This is a critical consideration when describing a burin for the purpose of subsequent analysis. Features that vary as a function of the degree of spall removal before discard may provide an effective measure of curational behaviour, but are likely to obfuscate research directed at stylistic variation over time and space. While curational behaviour may, of course, record significant stylistic information as well, interpreting the latter is likely to be difficult. At present there is much to recommend the use of attributes that appear to be unaltered by spall removal, at least when stylistic change is the area of interest.

Previous Analyses

While a detailed review or critique of all previous burin analyses is beyond the scope of this study, a brief summary of a few select works is in order. Several have had a hand in shaping current views both of arctic prehistory, and of the contribution to culture-history that might be expected from the analysis of artifacts such as burins. Many researchers have become quite pessimistic in regard to the latter (Maxwell 1985:92).

It is argued below that methodological considerations militate against the conclusions of these studies, and that the utility of burins as useful culture-historical tools is essentially untested.

Maxwell's analysis (1973) of ASTt materials collected in the vicinity of Lake Harbour, on the southeast coast of Baffin Island, makes extensive use of a detailed burin typology. A total of 24 types are described; of primary interest here are the 14 that deal with spalled burins.

In creating his typology, Maxwell decided not to concentrate on the shape and location of the spall scar or scars, since these features may be "more a function of use and resharpening than design" (1973:18). On the other hand, the treatment of the distal edge is described as a useful classificatory device (but which, according to Maxwell, may also reflect function). It is clear from the description of individual types, however, that other nominal level observations were incorporated, including an impressionistic description of overall shape, the nature and type of retouch, and, in spite of earlier comments to the contrary, the location of spall scars (1973:15-29). It is probable that the types are simply based on an intuitive clustering process in which attributes used to distinguish types did not actually emerge until after the fact. Maxwell observes in passing that only two 'meaningful' types may actually exist in the sample (these distinguished simply on the basis of distal edge treatment).

The system was not modified, however, and served as the basis for subsequent interpretation. Along with a number of other lithic types similarly conceived, the burin typology was compared to a seriation of sites based largely on external, radiometric data (Maxwell 1973:285-299). It was found that this seriation was not consistent with the distribution of artifact types among individual assemblages. The possibility of cultural mixing is not accepted by Maxwell, and the conclusion reached is that the ASTt sequence in the Lake Harbour region is characterized by a marked conservatism in material culture; the minor changes that can be discerned over time are better described as cultural 'drift', rather than 'change' (Maxwell 1973:285-287).

More recent comments by Maxwell indicate that he has rejected his attempt to classify the Lake Harbour burin assemblage (1985:92). This is due in part to an increased recognition of the functional nature of the criteria used to define his types, and to the general conclusions reached by McGhee (1979,1980), in his analysis of burins from Port Refuge.

McGhee's research in the Port Refuge area provides one of the samples upon which this analysis is based; a detailed account of the region and the sites discovered there is included in Chapter 3.

The first published description of the Port Refuge burins is found in McGhee (1979). Here, the typological approach of Maxwell is rejected in the belief that functional and individual variability are so great as to mask effectively higher level patterning. A number of quantitative observations are presented instead, based on such measurements as 'total length', 'maximum width', 'width at the base of the final spall', and 'angle at distal end of last spall' (McGhee 1979:99). A limited number of conclusions are derived from these observations. Notably, they are said to support the contention that the most recent burins in the assemblage (from Gull Cliff, see Chapter 3) are smaller than those from earlier sites (McGhee 1976:25, 1979:99). The former are also said to be more uniformly made, and lack ground lateral edges common in earlier forms (McGhee 1979:98-100).

McGhee's interest in the role of the individual in the ASTt record is developed further in a later article (McGhee 1980). Here it is argued that the greatest stylistic homogeneity in the Port Refuge sample is that displayed by assemblages from spatially discrete, well defined habitation features (McGhee 1980). Artifacts from the same tent ring, including burins, frequently exhibit striking similarities in raw material choice, flaking style, 'handedness' and size, thus suggesting the work of a single craftsman. In essence, a highly informal typology is proposed, and found to correlate with behaviour at the level of the individual. That this typology clearly differentiates features thought to be roughly contemporaneous is presented as an argument against the use of lithic analysis in assessing the cultural relationships of ASTt assemblages. The conclusion, in effect, is that artifact types (such as burins) which form their most salient clusters at the level of the individual cannot be expected to contribute to the solution of higher level problems.

Gordon's research on burins in Barrenland prehistory has already been cited in this chapter. To elaborate on points made previously, Gordon defines a typological system based on the recognition of six types which divide further into 23 categories. This system was based largely on Noone's study of European burins (1934). Features that figure in the recognition of burin types include the shape of the distal end, the angle formed by the intersection of the spall and distal edges, the number and placement of spall zones, and the treatment of the distal edge (Gordon 1975:200-202).

The spatial distribution of these burin types is used to support Gordon's hypothesis of discrete interaction between caribou herds and prehistoric hunter-gatherer bands in the Canadian Barrenlands. While individual caribou herding zones are not characterized by a single, distinct type, the frequency of type occurrence is felt to be reasonably distinctive (Gordon 1975:209). Measurements of burin length, width and thickness may augment the argument; burin size appears to vary in space, perhaps in a manner that reflects the distribution of discrete caribou herds (Gordon 1975:209-211).

The final example of burin analysis that will be considered is provided by Dekin (1976). Here, an ecological systems model concerning the nature of ASTt dispersion into the eastern High Arctic is tested. The hypothesized model suggests certain test implications concerning the expression of spatial variability in early ASTt artifact assemblages (Dekin 1976:156-158). Dekin attempts to test this hypothesis, in part, by a quantitative examination of a number of burin assemblages. The system of measurement is clearly illustrated, and among the observations made are 'length', 'width', 'haft length', 'spall length', and 'number of spalls' (Dekin 1975: Figure 39). The distribution of both burin width and length are thought to be generally consistent with the clinal variation predicted by the dispersion hypothesis, and the latter is tentatively supported (Dekin 1976:163).

Discussion and Summary

The four examples described above provide a fair indication of the range of strategies that have been applied to burin analysis in the arctic. A detailed critique of each of these studies is not attempted, and the following section is restricted to methodological limitations held in common. A more focused discussion of McGhee and Maxwell's work is included in Helmer and Robertson (1988).

Two approachs can be distinguished in these four studies. The first form of analysis is characterized by the use of a typological system defined on the basis of variability in the nominal scale. The types so distinguished may derive from the intuitive clustering of artifacts (an approach that appears to characterize both McGhee's and Maxwell's work), or a system largely developed in the context of a different culture-area and techno-complex (Gordon). Neither of these examples employs an explicit methodology, and the validity of the conclusions reached are correspondingly difficult to judge. It is probably fair to suggest that better results might have been obtained by first rigorously defining a set of appropriate attributes, and then subjecting them to a search for non-random association (Cowgill 1982). If the latter can be demonstrated, and types defined thereby, they are likely to represent 'natural', rather than imposed groupings in the data (Spaulding 1977). Dunnel (1978) notwithstanding, types of this sort **can** be used for analytical purposes. Their utility for solving specific culture-historical problems cannot be pre-judged, but at least they represent entities that are replicable and testable.

What constitutes an 'appropriate' attribute for analysis is a more critical problem from the perspective of this study. The answer depends, of course, on the purpose that the latter is supposed to serve; not all the features on a single artifact will have the same or even similar behavioural correlates. Unfortunately, our current understanding of material culture is too rudimentary to allow an a priori 'meaning' (Bielawski 1988) to be ascribed to many of the attributes or attribute states that might prove analytically useful. Often, the best indication of their significance is seen after the fact, in the 'behaviour' of the types constructed from them. Nevertheless, it does not require much insight to identify problematic areas in burin description. The potential effect of curational behaviour has already been noted. To reiterate, portions of a burin's outline can be expected to vary in shape simply as a function of the degree of respalling. In general, it is the distal part of the burin that is altered by this activity. More specifically, any attribute that incorporates portions of the spall zone can be expected to be influenced by differential curation. The 'meaning' of such an attribute is thus tied to a type of behaviour that is largely idiosyncratic, and probably of limited interest in the elucidation of higher level culture-historical problems. Many of the attributes used by Maxwell and Gordon fall into this category, and they are frequently combined in type definitions with those that probably do not.

As an example, many of the first 12 burin categories defined in by Gordon's system are distinguished by the angle formed between the spall and distal edge, or the spall and distal lateral edge (Gordon 1975:202). On most burins, this angle can be expected to become more obtuse with the removal of each spall; if this persists, spall removal may eventually be initiated from the distal portion of the right lateral edge. At this point, the angle in question will instantly become comparatively acute, though continued spall removal will make it less so. If individual elements in a burin assemblage are subject to differential curation, distinctions made on the basis of this angle will probably differentiate artifacts that were identical at the start of their use-life. This is not a desirable characteristic of a typology designed to reflect regionally specific patterns of burin manufacture.

A second analytical strategy employs observation on a continuous scale (McGhee, Gordon and Dekin). Instead of describing each burin in reference to discrete features or attributes, its shape is captured through direct measurement. These latter provide the basis for comparitive analysis.

While this approach appears on the surface to be quite distinct from that first described, the criticisms levied here are the same. In all three instances, many or most of the measurements recorded can be expected to be influenced by curational behaviour. All three studies, for example, incorporate the observation of burin length. Depending on the exact shape of the artifact, scores on this variable may be radically altered by respalling, and need not vary in a linear fashion with the number of spalls removed. In Dekin's analysis, 'length' is defined so that it is measured along the approximate midline of the basal portion of the artifact (Dekin 1975:255). This is not the case with Gordon's and McGhee's study, at least as far as can be determined from their published work. If this measurement is simply maximized, then not only the score itself, but the axis it is based on will vary as a function of differential spall removal. Since width is normally standardized by reference to the axis of length, it too may vary in a manner that is undesirable for many analytical purposes.

In summary, it is suggested that previous burin analyses lack methodological rigour, and incorporate attributes that vary in a manner that obfuscates culture-historical interpretation. Their conclusions then, culture-historical in nature and intent, are suspect. McGhee's pessimistic view of the utility of lithic analysis in the arctic rests largely on an informal identification of formal patterning that may be spurious (Cross 1983). It should be emphasized, however, that even if his general conclusion could be accepted, it would not negate the potential of future analyses of stone tool variability. Perhaps stylistic variability will, in fact, prove to be most visible at the level of the individual craftsman; sophisticated methodologies may identify more subtle patterning at a higher level.

CHAPTER 3

THE SAMPLES

The aim of this chapter is to provide a culture-historical framework for the assemblages that constitute the primary data base of this analysis. This framework must be viewed as highly tentative. Arctic culture-history is currently undergoing much review and this trend will likely intensify in the future.

Tentative or not, several considerations make a culture-historical framework desirable. First, it will provide a context within which metric patterning can be viewed, compared, and, at least at a very preliminary level, assessed. Second, its description will raise some of the unresolved culture-historical issues that studies such as this might be expected to shed light on in the future.

The analysis and interpretation of some of the sites contributing material to this study have been influential in the development of currently held views of High Arctic prehistory; in some cases they are associated with issues upon which there is much consensus, while in others, very little. The purpose of this chapter, however, is not to provide a critique of the views held either in general by arctic researchers, or more specifically by the three principal investigators whose fieldwork has made this analysis possible. The former are primarily used to generate useful vocabulary for subsequent discussion. The latter serve as a foil against which the results of this particular study can be contrasted. More detailed treatment can be found in McGhee (1976), Maxwell (1984:359-363, 1985) and Bielawski (1988).

The Arctic Small Tool Tradition

The prehistoric sequence in the eastern High Arctic is divided into two distinct periods. The more recent of these is characterized by a well-adapted, technologically sophisticated hunting society which entered the region around or slightly before 1100 RCYBP. The source for the Thule culture, as this society is now described, appears to have been in the Bering Sea area, and strong affinities have been demonstrated between early Thule manifestations in the eastern arctic, and Birnirk and Punuk materials in the west (Maxwell 1985:250-253; Schledermann and McCullough 1980).

It is, however, with an earlier population that this study is concerned. Frequently described by the term Palaeo-Eskimo, these people disappeared from the High Arctic at about the same time that the Thule arrived from the west. A causal relationship between these events has not been demonstrated, but direct competition, and perhaps conflict may have taken place between the two groups (see Maxwell 1985: 239-245).

Current interpretations hold that Palaeo-Eskimo populations form a component of a more widely distributed, and generally defined culture-historical unit known as the

Arctic Small Tool tradition (ASTt). This construct was initially developed to describe materials recovered from Alaska, and it is from this region that the eastern Palaeo-Eskimo hunters are thought to have originally migrated. Primarily defined on the basis of shared technological traits, assemblages that characterize ASTt sites include flaked stone burins, microblades from cuboid and tabular cores, and flaked triangular projectile points (MacNeish 1959). The spatial parameters of ASTt are extremely broad and include most of the North American arctic, including the interior barrenlands, and much of coastal Newfoundland and Labrador (Maxwell 1984:360). Asian equivalents are likely to exist, and although candidates for a North American ancestor of ASTt have been suggested, it is possible that eastern Siberia is where the distinctive elements of the techno-complex developed (Dumond 1984:74-75).

Radiocarbon dates indicate that, between about 4200 and 4000 RCYBP, ASTt peoples began to migrate into the High Arctic (Arundale 1981; McGhee and Tuck 1976; Maxwell 1985:42-45). The relatively late date for these pioneering movements is somewhat difficult to account for; hunter-gatherers had been successfully coping with the arctic, if perhaps not sea-ice, conditions of coastal and interior Alaska for as much as 7000 years years prior to this date (Dumond 1984). Glaciation in the far north appears to have been considerably less extensive than has been previously thought, and at the height of the Wisconsin advance on the southern mainland, ice-free High Arctic refugia were probably quite numerous (Andrews 1974; England 1976; Fladmark 1983). Whether such refugia contained resources sufficient to support human populations is much less certain (but see England 1976; Ives 1974). While geographical conditions may have hindered early occupation of the arctic islands, more active factors have been invoked to explain the late migration of ASTt peoples. Included among these is increased population pressure to the west, possibly coupled with improved resource potential in regions to the north and east. The latter has been attributed to a period of general climatic amelioration. A dramatic increase in biomass in regions previously covered by ice, and essentially devoid of mammalian life, has also been suggested (Maxwell 1985:45-48). Whatever causal factors may be favoured by future investigators, by 4000 RCYBP, migration into the High Arctic had certainly occurred; within only 500 years, most of the arctic islands had witnessed at least sporadic exploitation of their marine and terrestrial resources by bands of ASTt hunters.

Detail concerning economic conditions in the newly settled High Arctic remains elusive. Faunal analysis indicates reliance on a variety of marine and terrestrial mammals; the tool kits used to procure and process them appear well adapted to use in the arctic environment. Settlement was probably fluid, and populations were likely small, especially in the earliest part of the ASTt occupation (McGhee 1980:444-445; Maxwell 1985:62). Due to the low threshold of archaeological visibility in the arctic, however, sites generated by the activities of these people are very numerous, lending in some areas an impression of density that is likely misleading.

While the potential of the eastern High Arctic to sustain stable hunting populations remains a topic of some debate (see Schledermann 1978), many areas appear to have supported at least sporadic ASTt occupations for much of the next 3500 years. It is tempting to assume that significant culture change could have occured during this extended period, and much research has been directed toward the recognition of temporal, cultural, and spatial variability in the eastern ASTt record.

The first subdivision to be recognized in the eastern ASTt occupations remains the least controvertable; evidence derived from settlement patterns, material culture, and temporal context combine to indicate that a significant shift in cultural and technological orientation occured sometime between 2750 and 2450 RCYBP (Maxwell 1984:363). After that time, and until the arrival of the Thule culture, the High Arctic was occupied by a cultural manifestation now known as Dorset, named after its discovery at Cape Dorset (Jenness 1925).

The component of ASTt preceding the Dorset culture has been described by a wider variety of names, and this is due in part to uncertainty about the nature and extent of variability within it. In this study, the term Early Palaeo-Eskimo is used to refer to this period as a whole. This practice is suggested, in part, by a classificatory system developed by Helmer. In this system, the Early Palaeo-Eskimo Sub-Tradition refers to a component of the Arctic Small Tool tradition characterized by a distinct set of technologically based formal attributes, including, but not confined to spalled burins, unnotched bifacial cutting implements and projectile points, and non-toggling and open socketed harpoon heads (Helmer 1987a). In the eastern part of the arctic, this unit encompasses all occupations known to predate the Dorset period; the term favoured by Helmer for this eastern manifestation of the Early Palaeo-Eskimo Sub-Tradition is the Pre-Dorset Cultural Tradition. While this usage follows closely the original definition of Pre-Dorset (Collins 1954, 1956), the term Pre-Dorset is here reserved for the more restricted (and less precise) usage that views it as one of several conceptually equal sub-units that comprise the Early Palaeo-Eskimo period.

Whatever terminology favoured for its description, it is the period preceding the Dorset occupation that is of direct concern here; during the transitional stage leading into the Dorset Culture, spalled burins were almost entirely abandoned in favour of the ground variety (Maxwell 1985:150).

Early Palaeo-Eskimo

The search for metric patterning in Early Palaeo-Eskimo burins may reveal discontinuities that either correlate or contrast with other units defined on the basis of temporal, spatial and formal variability. A few of the latter have already been discerned, and although there is increasing disagreement as to their nature and significance (Bielawski 1988), they continue to function as important, if inconsistently applied, tools in the organization of arctic culture history. The following section describes these units, focusing on how they have figured in the interpretation of the three samples with which this study is concerned.

Independence I

Eigel Knuth's research in the extreme north of Greenland produced the first description of an apparently distinct Early Palaeo-Eskimo variant, Independence I (1958, 1967). A number of features have been used to distinguish this complex from the Pre-Dorset and Sarqaq manifestations of Early Palaeo-Eskimo; the following summary is primarily taken from McGhee (1976:25).

Lithic work in Independence I assemblages is thought to reveal an unusually high degree of skill; bifacial tool cross sections are thin, flaking is fine and regular, and margins characteristically exhibit careful serration. Projectile points are often equipped with tapered stems, frequently to the point of being bi-pointed. Burins tend to be quite large. Harpoon heads include rare non-toggling forms with tanged rather than socketed proximal ends. Habitation and other structures emphasize carefully made axial features and box hearths, frequently composed of vertical slab structures.

Independence I is early in the Palaeo-Eskimo sequence, and is generally thought to predate most or all of the Pre-Dorset occupation (McGhee 1979:123-124; Schledermann 1987). Depending on which radiocarbon dates are accepted, and what, if any, 'adjustments' are applied (McGhee and Tuck 1976), this contention may be either supported or refuted (Arundale 1981:257-259; McGhee 1976:25-26; Maxwell 1985:77). An estimation which favours a reasonable degree of antiquity, if not a clear seperation from Pre-Dorset, places Independence I between about 4000 and 3650 RCYBP (Fitzhugh 1984:529). Independence I sites are viewed by many researchers as an Early Palaeo-Eskimo variant that is confined to the more northerly regions of the arctic, especially Ellesmere and Devon Island, and northern Greenland. Probable manifestations as far south as Labrador are now known, and the spatial restriction may be eroding as a distinctive feature of Independence I (Helmer 1988; Maxwell 1985:101-102).

Pre-Dorset

To reiterate a point made above, the term Pre-Dorset was created in order to facilitate reference to the entire range of eastern arctic ASTt materials older than, and possibly ancestral to the Dorset period (Collins 1954). Its use has now become rather more restricted, and the majority of researchers contrast it with Sarqaq and Independence I, culture-historical units that it originally subsumed (cf. Helmer 1987a).

The material traits usually attributed to Pre-Dorset occupations tend to reflect those of the Early Palaeo-Eskimo period in general, after the distinctive Independence I and Sarqaq elements (see below) have been eliminated. The material culture is dominated by flaked lithic implements, and includes cutting implements, weapon points and side blades, microblades and microcores, side and end scrapers, and burins. The stems on projectile points tend to exhibit parallel lateral edges, sometimes slightly incurvate (McGhee 1976:26; Bielawski 1988:53).

Non-lithic inventories, when preserved, frequently include toggling harpoon heads, eyed needles, lance heads, and fish spears (Maxwell 1985: Figure 5.2, 84-96). Ivory, bone, and antler provide the raw material used to make all of these tools. Habitation structures are often demarcated by a ring of cobbles or boulders, and appear roughly oval in shape. They are often equipped with a central hearth feature; the latter may occasionally consist of a carefully built box-like structure, which sometimes is extended laterally into an 'axial' feature (Cox 1978: Figure 3a; Maxwell 1985: 96-98; Schledermann, personal communication 1988).

Evidence for Pre-Dorset activity is wide-spread in northern North America. Sites relating to this period have been found in most of the Arctic Islands, throughout the western and central Canadian Arctic, including the Barrenlands, and the Hudson Bay/Fox Basin region (Maxwell 1984:360; Bielawski 1988:53). Given the problematic nature of radiocarbon dating in the north (Arundale 1981), temporal parameters are more difficult to define. McGhee and Tuck estimate the beginning of the occupation at around 3700 RCYBP (1976). This date, which minimizes overlap with Independence I, requires that all radiocarbon dates derived from sea mammal remains be discarded. A second estimate based on an attempt to correct such dates for C13 and carbon reservoir effect, rather than simply ignore them, produces a radically different result. Overlap with Independence I is complete, and several sites tentatively identified as Pre-Dorset have furnished radiometric estimates in excess of 4000 RCYBP (Arundale 1981:258). The distinction between Dorset and Pre-Dorset depends in most areas on the recognition of a rather arbitrarily defined transitional period; an upper date for Pre-Dorset occupation is correspondingly arbitrary, but 2500 RCYBP may not be an unreasonable estimate (Maxwell 1985:109).

As might be expected given both its longevity and the archaeological propensity for inventing tripartite temporal schemes, the Pre-Dorset period has been informally subdivided into early, middle, and late components. The criteria by which these are supposed to be distinguished have never been critically assessed, and correlations with changes in artifact assemblages remain essentially undocumented. It is probably fair to suggest that intuition currently plays as great a role in identifying sites of these periods as does an explicit set of diagnostic formal criteria.

Sarqaq

A third variant of the Early Palaeo-Eskimo period is referred to by the term Sarqaq. First discovered in the vicinity of Disko Bay, West Greenland (Meldgaard 1952), the identification of Sarqaq sites rests primarily on features in the lithic assemblage; non-lithic artifacts, especially in earlier components are somewhat uncommon. Perhaps the most distinctive characteristic of these assemblages is an apparent preference for a distinctive silicious argillite known as 'angmaq'. This material is softer than chert, and artifacts made of it often exhibit the combined features of grinding and flake removal (Larsen and Meldgaard 1958:47-49; Maxwell 1985:103). As might be predicted, however, local availability appears to be a factor in determining the quantity of angmaq in Sarqaq tool assemblages; a site 150 km inland from the Greenland coast, in a region perhaps distant from convenient sources of angmaq, exhibits more extensive use of a white quartzite (Maxwell 1985:105).

Much of the general tool assemblage is reminiscient of Independence I. Edge serration is a common feature on projectile points, which include bi-pointed and tapered stem forms, as well as the small triangular bifaces identified as arrow points. 'Key-shaped' concave side scrapers are also known (Maxwell 1985:103-105). Harpoon heads that have been published are tanged and non-toggling, and bear a very close resemblance to the bifurcate-barb variety found at the Upper Beaches component of Port Refuge (Mohl 1986:Figure 5c; Fitzhugh 1984:Figure 12r; McGhee 1979:Plate 4q,s). Toggling harpoon heads have also been recovered from Sarqaq sites (Helmer, personal communication 1988). A common artifact in the Sarqaq tool kit is the burin. Relatively long and slender, these artifacts are rarely made of a material other than argillite, and usually exhibit grinding facets on the surfaces adjacent to the spall scar.

Structural remains include the same general sorts of features associated with both Independence I and Pre-Dorset sites, including both box hearths and axial structures (Maxwell 1985:103).

As a manifestation of Early Palaeo-Eskimo in Greenland, Sarqaq sites are primarily associated with East and West Greenland. On the west coast, occupations further north than Upernavik (south of Melville Bay), are not attested to.

Components identified as Sarqaq have been radiocarbon dated to between about 4200 and 2900 B.P. (Gullov 1986:2; Fitzhugh 1984:535-536). These dates are both corrected and calibrated (Helmer, personal communication 1988), and may thus compare to slightly more recent dates expressed in radiocarbon years; nevertheless, Sarqaq appears to have only slightly less the time depth of Independence I, and a very early divergence between the two has been suggested (Schledermann 1987). At the other end of the scale, Sarqaq has been implicated in the development of Dorset from Pre-Dorset (Taylor 1968:89-94). A cultural unit of such longevity may encompass much significant variation. Unfortunately, this is a possibility that cannot be adequately explored until more of the critical data has been published.

Summary

Just how distinct the three cultural entities described above really are is a difficult question to answer. Elements once thought to be diagnostic of one are now known to characterize the others as well (Helmer 1988). This is certainly the case with architectural features, for example; the axial structure, or 'mid-passage', once thought to be the hall-mark of Independence I, has now been identified on many sites that other criteria identify as Pre-Dorset or Sarqaq. Furthermore, the simple oval tent rings of the Pre-Dorset period have now been identified in Independence I sites (Schledermann 1988). It is possible that seasonal and functional considerations are contributing much to distinctions currently interpreted as temporal and/or cultural in nature.

It is unlikely, of course, that future research will eradicate the entire list of features that are now considered culturally diagnostic, and new ones may be discovered. As this list is modified, however, so probably will be the interpretations that derive from it. While an extremely difficult matter to quantify, the amount of variability that can be accommodated by in situ change is rather different from that associated with an influx of distinct populations. As more data is accumulated and analyzed, it can be expected that the genetic relationship between these three components of the Early Palaeo-Eskimo tradition will be clarified.

The Study Area

The samples upon which this analysis is based were obtained through research projects conducted in three discrete regions of the Queen Elizabeth Islands (Figure 2). Sizable collections identified as Early Palaeo-Eskimo were recovered in each case, and each of the three variants described above have been at least tentatively implicated in their description and interpretation.

These regions, and the Early Palaeo-Eskimo sites discovered within them are briefly described below. In each

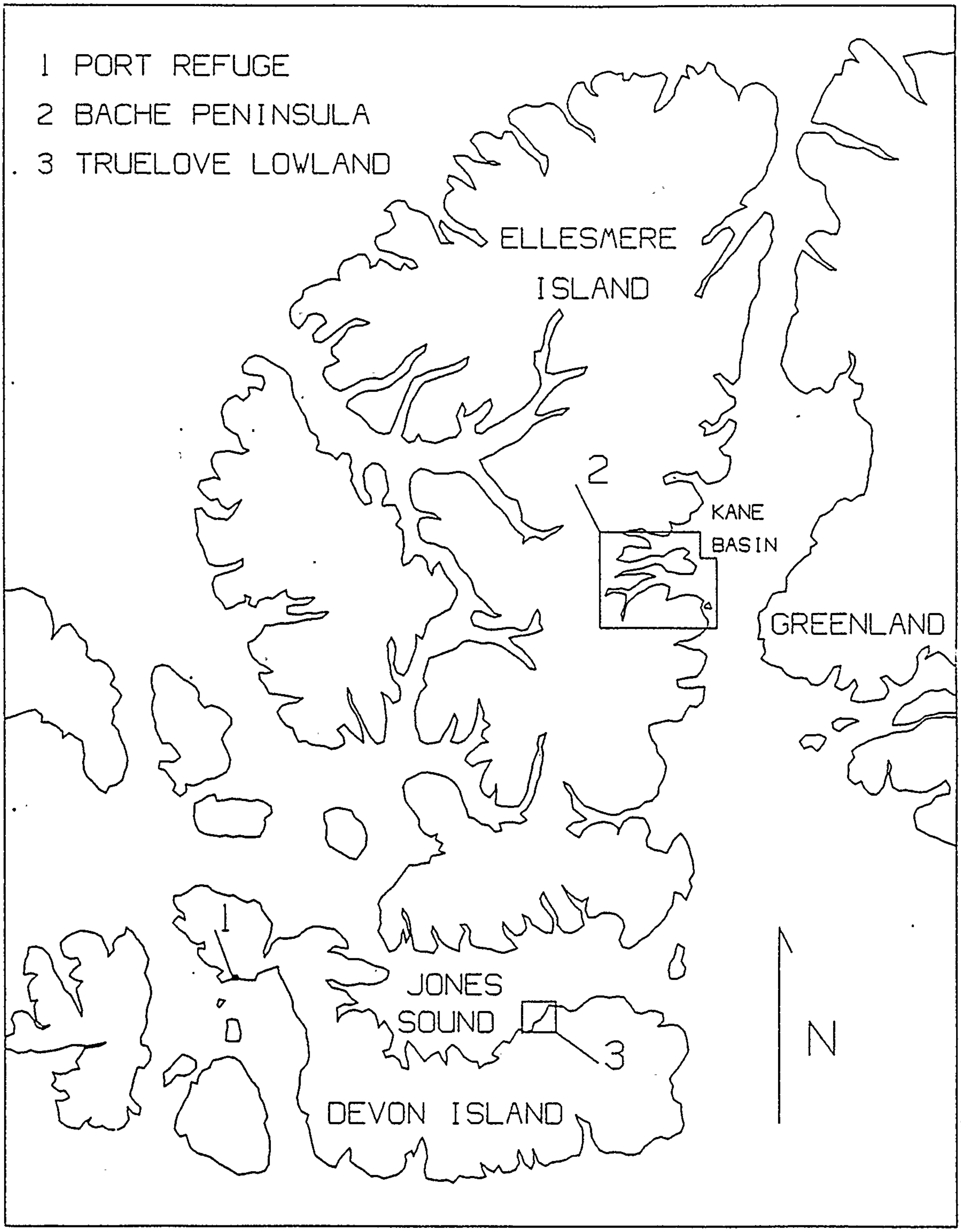


Figure 2: The Study Area

case, an attempt has been made to restrict treatment to those data that have been implicated directly in the determination of cultural and temporal affiliation.

Port Refuge

Port Refuge is located on the south side of Grinnell Peninsula, the western most segment of Devon Island (Figure 3). An important polynya, Penny's North Water, is located roughly between Port Refuge, and the neighbouring islands of Bathurst and Cornwallis (McGhee 1979:4; Schledermann 1980:297). This body of water is ice free on a permanent or semi-permanent basis, and its presence may account in part for the prehistoric population whose archaeological remains are described below. Port Refuge itself is currently quite rich in marine, and perhaps slightly less so in terrestrial, mammal resources (McGhee 1979:6). Whatever attraction the area may have held for northern hunters, local traces of Palaeo-Eskimo activity have also been attributed to the location of Port Refuge on a likely migration route between many of the southern arctic islands, and regions to the north such as Ellesmere Island and Greenland (McGhee 1979:120).

Dr. Robert McGhee of the National Museum of Man conducted survey and excavation in the vicinity of Port Refuge between 1972 and 1977. While initially interested in reports of Dorset and Thule material, early ASTt materials

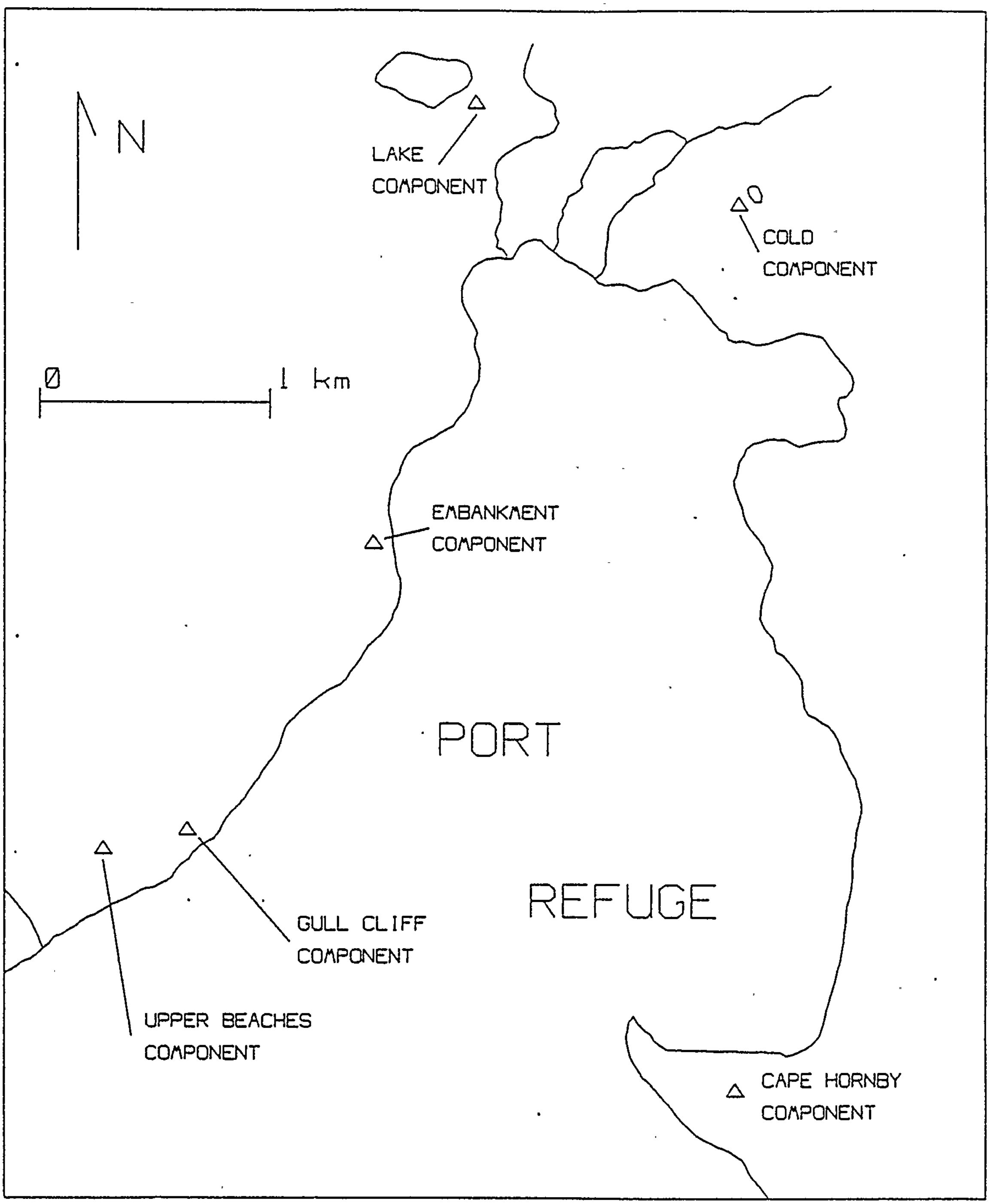


Figure 3: Port Refuge

discovered in the first season were made a focus of subsequent field research.

Fortunately, it was possible to obtain the relatively large collection of spalled burins from Port Refuge for analysis. Provenience data for these artifacts was supplied by the Archaeological Survey of Canada; this information was augmented, when necessary, by McGhee's major publication on the Early Palaeo-Eskimo components investigated by the Port Refuge Project (1979).

For reasons which will be clarified below, not all of the artifacts available for analysis were retained for the full duration of the analysis; burins were 'weeded out' at various stages for a variety of reasons. The following section briefly describes those sites represented through the entire process of analysis by at least one artifact. The rest are omitted. The information supplied here is not exhaustive, and more detail can be found in McGhee (1979).

The prehistoric remains in the Port Refuge area have been separated by McGhee into a number of units described as components; for the sake of convenience, this terminology is retained here; it should be noted that in the majority of cases, the spatial unit implied is that which in the other two regions would be refered to as a site.

RbJu-01 - Upper Beaches Component

The Upper Beaches component is located at the southwest corner of Port Refuge (Figure 2). The 26 features that make up this site extend for a distance of 700 meters along a series of fossil beach ridges, elevated 22 to 24 meters above sea level. Most are simply marked by scattered cobbles, vegetation patches, and surface concentrations of lithic artifacts. While five features were excavated, most of the artifacts that constitute the Upper Beaches collection are derived from the surface (McGhee 1979:56). Eight of 13 burins collected were included in the present analysis; five features are represented among them.

With the exception of Features 20 and 21, McGhee suggests that the Upper Beaches collection represents an early Independence I occupation. This is supported by two radiocarbon dates from Features 16 and 12 (4360 +/- 90 [GSC-1940] and 4120 +/- 120 [GSC-1931] respectively), both based on driftwood samples and apparently uncorrected for C13 fractionation (Lowdon et al. 1974:2,9), and stylistic attributes of two harpoon heads (McGhee 1979:116). The harpoon heads are tanged and non-toggling, with the type of distinctive bifurcate barbs that have been attributed to Independence I and Sarqaq assemblages elsewhere in the High Arctic.

Features 20 and 21 differ from the rest of the component in a number of respects, including amount of vegetative cover, stylistic attributes on artifacts, and a radiocarbon estimate for time of occupation (3480 +/- 140 RCYBP [GSC-1949]) (McGhee 1979:60-61,116,121). As no artifacts used in this study were recovered from either of these units, the possibility of temporal and cultural mixing can probably be ignored for the present.

RbJu-01 - Cold Component

The Cold component is located approximately 600 meters inland from the north shore of Port Refuge (Figure 2). Thirty-one features make up the site, which extends about 220 meters along a raised gravel beach ridge, at an elevation between 22 and 25 meters above sea level (McGhee 1979:10).

All of the features documented are composed of cobble and limestone slab-clusters, sometimes in association with an indistinct gravel rim. As many as one-half of them appear to relate to former habitation structures, and several of these contain internal stone features that may represent the remains of axial structures. Artifacts were recovered from as deep as 10 cm below the surface (McGhee 1979:11, 13-33, 1980:444). A total of 35 burins in this analysis derive from fieldwork carried out at the Cold component; thirteen of the 31 structures identified are represented among them.

McGhee interprets the Cold component as indicative of Independence I activity. While the criteria upon which this contention is based are not explicitly stated, a number of features in the assemblage are supportive. Bifaces with tapered stems, distinct shoulders, and edge serration are included, as are two rather early looking harpoon heads

(McGhee 1979:44,48-49). These latter, while equipped with open sockets rather than tangs, exhibit the distinctive bifurcate barb that has been noted in several Sarqaq assemblages.

RbJu-01 - Embankment Component

The Embankment component is located on the west shore of Port Refuge, half way between the Upper Beaches and Lake components (Figure 2). Four linear vertical slab arrangements make up the site, which is situated on a gravel terrace 35 meters above sea level. A single burin from this locality, collected from the surface, was used in the present study. Although little in the way of diagnostic material appears to have been recovered from the Embankment component, McGhee has tentatively identified it with the Independence I culture.

RbJu-03 - Cape Hornby

Cape Hornby defines the southeastern corner of Port Refuge, approximately 2.5 km from the opposite side of the bay, where the Upper Beaches and Gull Cliff components are located (Figure 2). Eighteen features were discovered in this area, distributed along 300 m of beach ridge at an elevation of 20 to 21 meters above sea level. Two of these features (numbers 7 and 8), are similar to those from the Cold Site, and are marked in part by low gravel depressions. The remainder are reminiscent of the more poorly defined features at the Upper Beaches component, and were identified primarily through concentrations of vegetation, stone slabs, and lithic surface scatters. Feature 7 was excavated, and others surface collected (McGhee 1979:72). Axial structures were apparently not observed in any of the eighteen features.

Eight artifacts from the Cape Hornby component were retained for full metric analysis; only one of these is from the excavated Feature 7, and none are from Feature 8. According to McGhee, these materials are related to an Independence I occupation. This opinion may be based on the single represention each of a tapered stem, and bi-pointed biface (1979:123, Plate 3f,o).

RbJu-01 - Lake Component

Approximately 1 km inland from the northwest corner of Port Refuge, and 1.5 km west of the Cold site, the Lake component is located on beach ridges elevated 21 to 24 meters above the modern sea level. Thirteen features have been noted at this locality, and 11 of these are thought to represent abandoned tent structures. All of these incorporate low gravel rims, and at least some, internal cobble features that may relate to abandoned hearth features (McGhee 1979:76).

One of the habitation structures was excavated; this, in company with general surface collection, produced an assemblage of 22 burins. Twenty of these were incorporated into the metric analysis.

While general assemblage characteristics suggest to McGhee an Independence I affiliation, technological differences from other Independence I components, such as the Cold site, were noted. The artifact assemblage appeared to be somewhat more crude, and exhibited much of the same blue-grey chert that predominated at the Gull Cliff component (McGhee 1979:118). It is possible that the Lake component shares greater affinities with the Pre-Dorset period than has been suspected. Few potentially diagnostic artifacts were recovered from this site, but one biface with an incomplete stem (McGhee 1979:Plate 3n) appears to be quite similar to artifacts recovered from Gull Cliff (ex. Plate 10d,e).

RbJu-01 - Lookout Component

A small, single-feature site 1.7 km to the northeast of the Cold site is named the Lookout component. Located 18 meters above sea level, the feature consists of a boulder and cobble concentration in association with a small quantity of musk-ox bone and a few lithic artifacts (McGhee 1979:106). Two burins collected from the surface constitute the Lookout component's contribution to this analysis.

Based on its comparatively low elevation, and the similarity of a single endscraper with specimens from the Gull Cliff site, McGhee tentatively attributes this site to the Pre-Dorset culture, rather than Independence I (McGhee 1979:106).

RbJu-01 - Gull Cliff Component

A site near the southwestern corner of Port Refuge, the Gull Cliff component overlaps slightly with the Upper Beaches component (Figure 2), and is located at an elevation 18 to 25 meters above sea level. A large number of features have been identified at the site, 20 of which are identified as dwelling remains. Several of these are associated with boulder concentrations, but obvious ring patterns are not present. In general, the features are characterized by vegetation patches, midden deposits, and scatters of artifacts, lithic debitage, and fragments of burned bone (McGhee 1979:90).

Excavation was confined to four features, and the rest of the site surface collected. Much of the artifactual material comes from Feature 9, a vague boulder structure superimposed on a large, heavily vegetated midden deposit of a presumably earlier occupation.

Lithic materials were almost entirely made of a distinctive blue-grey chert. Fifty-three burins were recovered, and of these, a total of 41 burins representing seven discrete features, were selected for metric analysis. Among other artifacts collected were stemmed bifaces, most with parallel or sub-parallel lateral edges, and two open socket harpoon heads. The latter resemble examples from the

Cold component, except that they lack the distinctive bifurcate barb (McGhee 1979:98-105, Plate 12). The most complete of these appears to be virtually identical to one illustrated by Maxwell, of a type attributed to the Early Pre-Dorset occupation (1985:86-87, Figure 5.3).

Two radiocarbon tests were conducted on a split sample of seal bone from Feature 9. The first date obtained was 3425 +/- 55 [S-1661]; the second estimate, somewhat earlier, was 3790 +/- 55 [S-1662] (McGhee 1979:121-123). These dates do not appear to have been corrected for C13 fractionation (see Rutherford et al. 1981:132). While a certain amount of cultural mixing at Feature 9 is somewhat probable, a combination of assemblage attributes, elevation, and the above noted radiocarbon estimates have led McGhee to view this component as Pre-Dorset, culturally distinct and more recent than the Upper Beaches and other Independence I components at Port Refuge.

RbJu-02 - Cape Majendie

McGhee's investigations in the vicinity of Port Refuge yielded information on a number of sites relating to the transition period between the Pre-Dorset and Dorset cultures, described by McGhee as Independence II (McGhee 1981; Knuth 1967). Transition period sites frequently contain both flaked and ground burins, and both attributes can be exhibited by the same artifact. The occupants of these particular sites, however, appear to have largely abandoned the earlier version of the tool, presumably accomplishing the same tasks with ground burins. The transitional period in Port Refuge is represented in this analysis by a single burin. The site from which the artifact was collected is RbJu-02, a site on Cape Majendie, about 10 km to the southwest of Port Refuge and immediately south of Dundas Island (McGhee 1981:Figure 2, 17). The elevation of the site is 14 to 16 meters above sea level. Its transitional status is based on a small surface collection, which includes a ground burin and a tip-fluted biface (McGhee 1981).

RbJu-05

A description of this site or component was unavailable; other than its association with the Port Refuge area, nothing is known about it. Two artifacts from this site were used in metric studies based on the regional sample in general, and eliminated from all others.

Summary

The most salient expressions of cultural patterning discerned by McGhee have been attributed to a distinction between Independence I and Pre-Dorset occupations. It is perhaps in regard to this point that the Port Refuge research has been most influential in arctic archaeology. The spatial juxtaposition of these two cultural entities at Port Refuge, coupled with their avowed cultural and temporal dissimilarities, support a dichotomy that for many researchers is now practically unassailable (c.f. Bielawski 1988; Maxwell 1985:68-75; but see Helmer 1988). In McGhee's own view, the differences are so striking that two migrations of culturally distinct populations must be posited to account for them (1979:124).

Within the Independence I period, the Upper Beaches component is thought to represent an especially early occupation of roughly 4000 RCYBP; this interpretation is based on radiocarbon estimates and harpoon head styles. Harpoon heads from the Cold component appear to combine early traits (the bifurcate barb) with later ones (the open socket), and may represent the next occupation of the area (McGhee 1979: 116, 121).

The Independence I occupation is thought to have ended by about 3800 RCYBP, at which time it was replaced by the Pre-Dorset culture. Harpoon head styles, and to a lesser extent, radiocarbon dates from Gull Cliff suggest a fairly early episode in the Pre-Dorset sequence.

The final stage of Early Palaeo-Eskimo activity in the Port Refuge area is represented by the Independence II, or Transitional Dorset period. Unfortunately, this period forms a negligible part of this particular study, and the occupation of around 2500 RCYBP (McGhee 1981:35-36) is represented by a single spalled burin.

The Port Refuge sites represented in this analysis are summarized in Table 1. Included in the summary are limited

Table 1: Port Refuge Sample

SITE	FEAT.	MASL	RC	CULT.	COMMENT	# ART.
RbJu-01 ??	??	??	0	??	No Provenience	1
RbJu-01 Cold	ALL	22-25	2	I		35
RbJu-01 Embank-ment		35	0	I?		1
RbJu-01 Gull Cliff	ALL	18-25	2	PD	EPD??	41
RbJu-01 Lake	ALL	21-24	0	I	PD??	20
RbJu-01 Lookout		18	0	PD		2
RbJu-01 Upper Beaches	ALL	22-24	2	I		8
RbJu-02		14-16	0	TD		1
RbJu-03	ALL	20-21	0	I		8
RbJu-05	ALL	??	0	??	No Provenience	2
					TOTAL	119

I = Independence I
PD = Pre-Dorset
EPD = Early Pre-Dorset
TD = Transitional Dorset

data on elevation, number of radiocarbon estimates, possible culture-historical affiliation, and the number of artifacts included in the full analysis.

Bache Peninsula

The Bache and Johan Peninsula regions are located mid-way up the east coast of Ellesmere Island, on the south western shore of Kane Basin (Figure 4). Since 1977, seven seasons of field research under the direction of Dr. Peter Schledermann have documented an extensive prehistoric occupation in this area. The region appears to have been a focus for Palaeo-Eskimo activity in the eastern High Arctic, and this may be due in part to several geographical considerations. Among them is its close proximity to Greenland. The latter is only 40 km away from this portion of the Ellesmere coast, and it is probable that prehistoric movement between the two islands was channeled through this region. Sverdrup Pass, a natural transportation route which leads directly into the Bache Peninsula region, may also have provided a convenient corridor for movement to the west coast of Ellesmere, and the other islands beyond. From a local economic perspective, this area would have been highly attractive; it is an unusually rich biotic zone, a factor which can be attributed in part to the local presence of sheltered lowland areas, and a number of large polynyas (Schledermann 1980). Both of these would have contributed

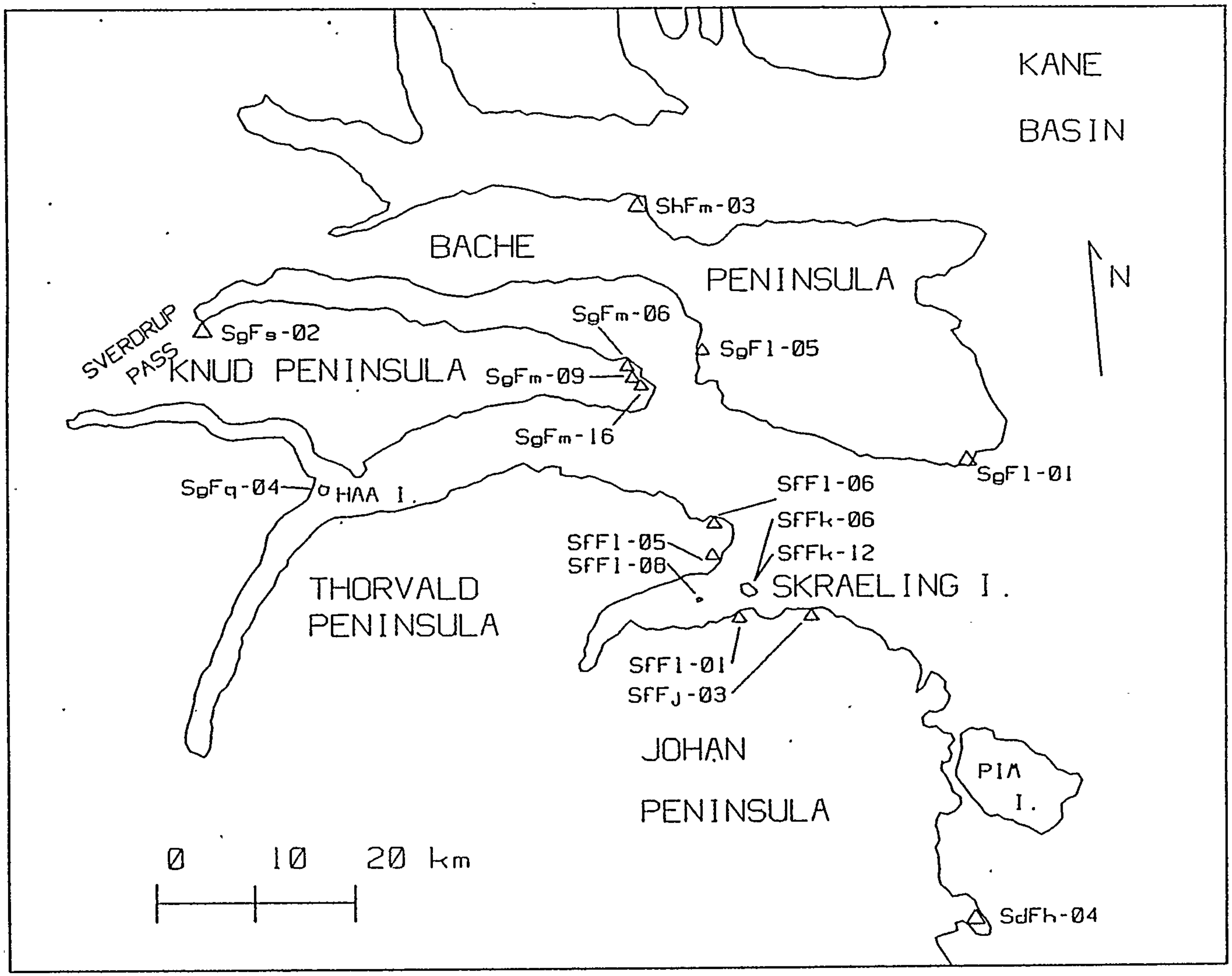


Figure 4: The Bache Peninsula Region

to a relatively stable supply of critical terrestrial and marine mammal products.

Excavation and survey in this area have recovered a large collection of Palaeo-Eskimo artifacts, and approximately 100 flaked stone burins were made available for analysis. Again, not all of these were retained for full metric analysis, and only those sites that contributed one or more artifacts are reviewed below. The data is largely derived from Schledermann's report (1988) on the ASTt investigations of the Ellesmere Island Research Project.

SdFh-04 (Blake Site)

This multi-component site is located on the coast of Cape Herschel, on the eastern-most edge of Johan Peninsula. Four features are located on a beachridge terrace 14 to 15 meters above sea level; one of these, an amorphous tent structure, contributed three burins to the present analysis. A radiocarbon sample from this feature yielded a C13 corrected age estimate of 4110 +/- 110 RCYBP [GSC-3349].

A second component containing four more features was identified at an elevation of 21 to 22 meters above sea level. Two more samples for radiocarbon testing were obtained from this component, and the means of the estimates obtained are somewhat earlier than those obtained from the lower component. The dates, both corrected for fractionation, are 4410 +/- 210 RCYBP [GSC-3355], and 4340

+/- 80 RCYBP [GSC-3310]. No burins were recovered from this component.

Schledermann suggests that the higher component relates to an early ASTt occupation, and may, presumably on the strength of the radiocarbon evidence, be indicative of Independence I movement on the east coast of Ellesmere Island (1988). While a culture-historic affiliation for the lower component is not proferred, the close proximity of the radiocarbon dates, especially considering the large sigma values, suggests that a similar interpretation may not be unreasonable.

SfFj-03 (Lakeview Site)

This site is situated on the northern coast of Johan Peninsula (Figure 4). One feature (Feature 4), an axial tent ring located at a height 14 to 15 meters above sea level, provided a single burin for analysis.

Schledermann describes the assemblage recovered from this feature as having a fairly early ASTt association, with a strong Sarqaq influence. The latter interpretation is based primarily on the high length/width ratio of the burin. Other features at the site are attributed to various Independence I and Late Pre-Dorset occupations (Schledermann 1988).

SfFk-06 (Tusk Site)

The Tusk Site is located on Skraeling Island, at the entrance to Alexandra Fjord. The upper component is situated on a terrace 27 to 30 meters above sea level, and comprises several features, including a tent structure with a box hearth, scattered boulder configurations, and one axial structure. Six burins were recovered from the surface, and four of these are analyzed here. Two radiocarbon dates were obtained from this site; one of these ([RL-834] 5390 +/- 380 RCYBP, uncorrected for isotopic fractionation) is derived from a walrus tusk exhibiting no obvious cultural modification, and is considered to be too early to reflect human activity at the site. A second date [GSC-3362], based on a material identified as driftwood charcoal (Blake 1988:82), is more acceptable with a C13 corrected date of 4250 +/- 60 RCYBP. This evidence, combined with certain attributes of the associated artifact assemblage, suggest to Schledermann an affiliation with Independence I (Schledermann 1988).

SfFk-12 (Skraeling ASTt Site #7)

This site, also on Skraeling Island, contains a single axial tent structure at 20 to 21 meters above sea level, and two box hearth features approximately 30 meters to the southwest, at an elevation approximately four meters lower. The tent feature yielded a single burin, and a C13 corrected date (sample based on *Salix* and *Larix* (Blake 1988:82)) of

4400 +/- 110 RCYBP. The date, and associated artifact assemblage suggest a possible cultural affiliation with Independence I, and an occupation comparable to that of the nearby Tusk Site (SfFk-06) (Schledermann 1988).

SfFk-22 (Campview Site)

SfFk-22 is located on Skraeling Island, roughly 150 meters south of SfFk-06. Features 1 and 2 are located at an elevation of 15 meters above sea level, and a single burin from the former was subjected to full metric analysis. This particular structure was found during excavation to be a sub-rectangular tent ring with a flagged axial feature. Although the relatively low elevation is thought to be an unusual feature of an early site, attributes on a number of artifacts are strongly indicative of an Independence I occupation (Schledermann 1988).

SfFl-01 (Baculum Site)

This site is located on a ridge 11 to 12 meters above sea level on the south coast of Alexandra Fjord, almost directly south of Skraeling Island (Figure 4). The site is culturally mixed, and exhibits the remains of both Thule culture and Arctic Small Tool tradition activities. The ASTt features consist primarily of small caches, two tent rings (one possibly an axial structure), and several concentrations of lithic reduction debris. Two of the latter features were excavated and one yielded a C13 corrected date of 2780 +/- 140 RCYBP, probably based on a sample of charred sea mammal bone [GSC-6072]. A total of 12 burins were removed from the site, and of these, two were retained for analysis. The other ten were heavily ground, and identified as Dorset. Several of these, however, appear to have had at least one conventional spall removed as well, and the juxtaposition of traits supports Schledermann's view that the site relates to a transitional Pre-Dorset/Dorset period. While the radiocarbon date is considered somewhat old, harpoon head styles reinforce its transitional nature (Schledermann 1988).

SfFl-05 (Nowra Site)

SfFl-05 is located on Thorvald Peninsula, about 2 km. south of Digarmulen Point. The site is multicomponent, and recent historic camp features are located within six meters of the current ice foot. The ASTt remains are considerably higher, situated between 26 and 27 meters above sea level. Up to nine oval tent rings may be present on this beach terrace, and one burin was recovered through surface collection. The problem of temporal placement cannot be resolved on the basis of the small collection available, but the elevation favours a fairly early placement in the ASTt continuum (Schledermann 1988).

SfFl-06 (Topo Site)

This rather complex site is located on the north shore of Thorvald Peninsula, and consists of hearth features, cache structures, lithic scatters, and a vaguely defined axial structure. It is likely that more than one component is contained within the Topo Site, which is distributed between 10 and 25 meters above sea level, and along 60 meters of coastline. Artifacts were removed from a single terrace between 14 and 15 meters above sea level, and are thought to represent a fairly cohesive assemblage. The burins from this site (nine of which were retained for full metric analysis) are among the most distinctive in the collection available for this analysis, and exhibit features that Schledermann attributes to a Sarqaq related occupation. These include the very high length/width ratio, and the carefully executed grinding facets on the distal surfaces, adjacent to the spall scars (Schledermann 1988). A radiocarbon assay has produced an age estimate of 3420 +/- 60 RCYBP for this site. The date was based on an accelerated sample of willow carbon [TO-992] (Schledermann, personal communication 1988).

SfFl-08 (Stiles Island Site I)

Stiles Island is located in Alexandra Fjord, near Skraeling Island. The ASTt component of SfFl-08 is located on the south shore of the island, on beach ridges between 19 and 27 meters above sea level. The single burin recovered from this site was associated with a camp feature located between 25 and 26 meters above sea level. While Schledermann tentatively suggests that the rather large burin **may** be indicative of an early period in the Arctic Small Tool tradition, there is little evidence to suggest either a temporal or cultural affiliation beyond that of ASTt (Schledermann 1988).

SgFh-01 (Camperdown Site)

This site is located on the southeastern tip of Bache Peninsula. Although primarily comprised of Thule culture remains, a few axial features and lithic scatters were noted. A single burin was collected from the surface of one of these. There is no evidence to support a more precise temporal or cultural affiliation for this artifact than that of ASTt (Schledermann 1988).

SgFl-05 (Bache Peninsula ASTt Site)

This site is located on the south shore of Bache Peninsula, on the eastern edge of Flagler Bay. Two sub-rectangular axial structures, one with a flag-stone floor, are located between 15 and 16 meters above sea level. An adjacent lithic scatter (possibly within a poorly delineated oval rock structure) was surface collected, and three burins were recovered. All of these were retained for full metric analysis. On the basis of associated artifacts, Schledermann suggests a tentative link to the Middle or Late

Pre-Dorset period; the axial features are thought to relate to a Late Dorset occupation (1988).

SgFm-06 (Ridge Site)

SgFm-06 is located on the north coast of Knud Peninsula, adjacent to a large seasonal polynya in Flagler Bay (Figure 4). Five features at this large and complex site are relevant to this particular study, and provide one of the largest single contributions to the Bache Peninsula sample. Feature 1 is located at an elevation of about 15 meters above sea level, and consists of a circular arrangement of boulders. The excavation of this probable tent structure yielded three burins, all of which were retained for analysis. This component of SgFm-06 is attributed, on typological grounds, to Middle or Late Pre-Dorset activity. Approximately six meters south of Feature 1 was a series of cooking hearths and small caches. While association between this food processing area and Feature 1 has not been demonstrated, excavated materials suggest that a Middle to Late Pre-Dorset occupation is also a reasonable interpretation. Designated Feature 1A, 13 burins were obtained from this area, nine of which were subjected to analysis. Feature 2 is a large circular boulder structure with a possible axial feature. Of the 20 burins recovered through excavation, 14 were selected for full metric analysis. This feature is located at an elevation roughly 20 meters above sea level, and a corrected date of 2710 +/-

60 RCYBP was obtained from a sample of charred bone [CSG-2827]. Certain features in the artifacts recovered are said to suggest a tentative association with a late stage in the Pre-Dorset period. In contrast to both SfFl-06 and SgFm-16, no particular cultural connection with Sarqaq is envisioned. Feature 3, at 23 to 24 meters above sea level, is described only briefly by Schledermann, but its elevation suggests a fairly early placement in the ASTt sequence. A single burin was analysed from this feature. Finally, Feature 9, situated between 14 and 16 meters above sea level, consists of two probable axial features; two burins collected from the surface are included in this analysis. While clearly related to an Early Palaeo-Eskimo occupation, Schledermann does not posit a culture-historical affiliation for this site.

SgFm-09

Located between 14 and 16 meters above sea level, SgFm-09 was discovered on Knud Peninsula, east of SgFm-06. Mixing is a potential impediment to a simple cultural or temporal placement, but occupations during the Late Pre-Dorset and Early Dorset phase are favoured by Schledermann (1988). One of the five burins recovered through surface collection was ground in the manner normally associated with the Dorset period; two of the remaining four were retained for metric analysis, and these can be attributed with confidence to the Early Palaeo-Eskimo period.

SgFm-16 (Bight Site)

This multicomponent site is located on the southern edge of Flagler Bay, about 1 km southeast of SgFm-06. Feature 1 is an oval structure with a low gravel wall, shallowly excavated into a beach terrace 22 meters above sea level. Excavation produced eight burins and a driftwood charcoal sample dated to 3790 +/- 360 RCYBP [GSC-3268]. Five burins were selected for full metric analysis. About 65 meters to the south, a second, more vaguely defined feature was noted at an elevation between 19 and 20 meters above sea level. Nine burins were recovered during its excavation. The Terrace Component (here designated Feature 3) is located approximately 100 meters further to the south of Feature 2, on a beach ridge 18 meters above sea level. Surface collection of boulder tent outlines and lithic scatters produced a single burin.

Schledermann attributes both Features 1 and 2 to an early ASTt occupation. It is further suggested that a mixture of Sarqaq and Independence I traits are included in their tool assemblages. Feature 3 is thought to be distinct from the other two and stylistic elements shared with nearby SgFm-06 suggest some sort of relationship with the Late Pre-Dorset period (Schledermann 1988).

SgFq-04 (Haa Island ASTt)

Haa Island is located at the mouth of Hayes Fjord. Primarily noted for a large Thule winter village, some ASTt materials are present here as well. Surface collections on a narrow beach ridge at the southwestern tip of the island yielded a small collection of eight artifacts; a single burin is included among them. While site features of ASTt affiliation are located at elevations between 19 and 25 meters above sea level, all of the artifacts analyzed here were recovered from above the 21 meter level. Based partly on the lithic material that dominates this assemblage (a white chert), and stylistic elements exhibited by the burin and a flaked bi-point, Schledermann posits a tentative link with the Topo and Bight Sites (SfFl-06 and SgFm-16), and by extension, Sarqaq 'culture' in general (1988).

SgFs-02 (Flagler Delta Site)

Flagler Delta is located at the head of Flagler Bay, near the eastern entrance to Svedrup Pass. Situated on a gravel terrace elevated 22 meters above sea level, four burins were recovered from this site; two of these were selected for analysis. Lithic artifact attributes and the height of the beach terrace suggest an affiliation with the Early or Middle Pre-Dorset period (Schledermann 1988).

ShFm-03 (Cape Hunter Site)

ShFm-03 is located on the north coast of Bache Peninsula, on the west side of Peary Bay. Materials from the Arctic Small Tool tradition proliferate in this locality, at elevations between 4 and 16 meters above sea level. Schledermann separates the Cape Hunter assemblages into two groups reflecting different elevations. The higher of the two, associated with terraces between 13 and 14 meters above sea level, provided four burins to this study. A single axial tent ring (Feature 4) was present on this beach ridge and may be associated with the artifacts in question.

Schledermann suggests that artifacts from the higher terraces share a cultural affiliation with Middle Pre-Dorset; the lower component is more likely associated with the transitional stage between early ASTt and Dorset. In general, the occupation is thought to be very roughly contemporaneous with that of SgFm-06 [Ridge Site] (1988).

Summary

The earliest sites in the Bache Peninsula region are attributed to the Independence I period of the Early Palaeo-Eskimo tradition. The period of occupation is thought to be rather brief, and appears to date between roughly 4000 and 3800 RCYBP (Schledermann 1987). Three sites included in this analysis are currently thought to be closely associated with Independence I, two others somewhat more tenuously (Table 2).

Sarqaq related occupations are next discerned in the region, and dominate for roughly the next 500 years. While a strong cultural link with Greenland is reflected in these materials, a simple migratory origin from the east appears

Table 2: Bache Peninsula Sample

SITE	FEAT.	MASL	RC	CULT.	COMMENT	# ART.
SdFh-04		14-15	1	EPE (I??)		2
SfFj-03		14-15		EPE (SQ?)		1
SfFk-06		27-30	2	I		4
SfFk-12		20-21	1	I		1
SfFk-22		15		I		1
SfFl-01		11-12	1	TD		2
SfFl-05		26-27		EPE		1
SfFl-06		14-15	1	SQ		9
SfFl-08		25-26		EPE		1
SgFh-01		??		EPE		1
SgFl-05		15-16		LPD		3

Table 2: Bache Peninsula Sample
(continued)

SITE	FEAT.	MASL	RC	CULT.	COMMENT	# ART.
SgFm-06	F01 F01A	16-17		M/LPD		12
SgFm-06	F02	20	1	LPD?		14
SgFm-06	F03	23-24		EPD??		1
SgFm-06	F09	14-16		EPE		2
SgFm-09		14-16		LPD		2
SgFm-16	F01 F02	19-20		SQ/I?		10
SgFm-16	F03	18		LPD		1
SgFq-04		21+		SQ		1
SgFs-02		22		E/MPD		2
ShFm-03		13-14		MPD		4
					TOTAL	75

EPE = Early Palaeo-Eskimo
SQ = Sarqaq
I = Independence I
EPD = Early Pre-Dorset
MPD = Middle Pre-Dorset
LPD = Late Pre-Dorset
TD = Transitional Dorset

unlikely in view of the mixture of Sarqaq and Independence I materials exhibited at SgFm-16. A High Arctic transition between the two occupations may be a better explanation for materials that heretofor were confined to sites in Greenland. Two sites identified as Sarqaq are included in the present analysis; two others may exhibit Sarqaq elements, one of these in combination with traits identified as Independence I (Schledermann 1987).

The remainder of the Bache Peninsula Early Palaeo-Eskimo sites are associated with Pre-Dorset activity. Artifact assemblages emphasize late rather than early manifestations, and are similar to those recovered by McGhee at the Gull Cliff component of Port Refuge (Schledermann 1987).

Truelove and Sparbo-Hardy Lowlands

The Truelove and Sparbo-Hardy Lowlands are located on the northeastern coast of Devon Island, south of Ellesmere Island, and almost directly opposite the modern settlement of Grise Fjord, across Jones Sound (Figure 5). Five years of active research by the Devon Island Archaeological Project, under the direction of Dr. James W. Helmer, have documented a variety of archaeological remains in this area.

While the relative importance of terrestrial and marine resources in local Palaeo-Eskimo economies remains a focus of on-going inquiry, it is likely that the unusually rich biotic zone of these lowlands was an important causal factor

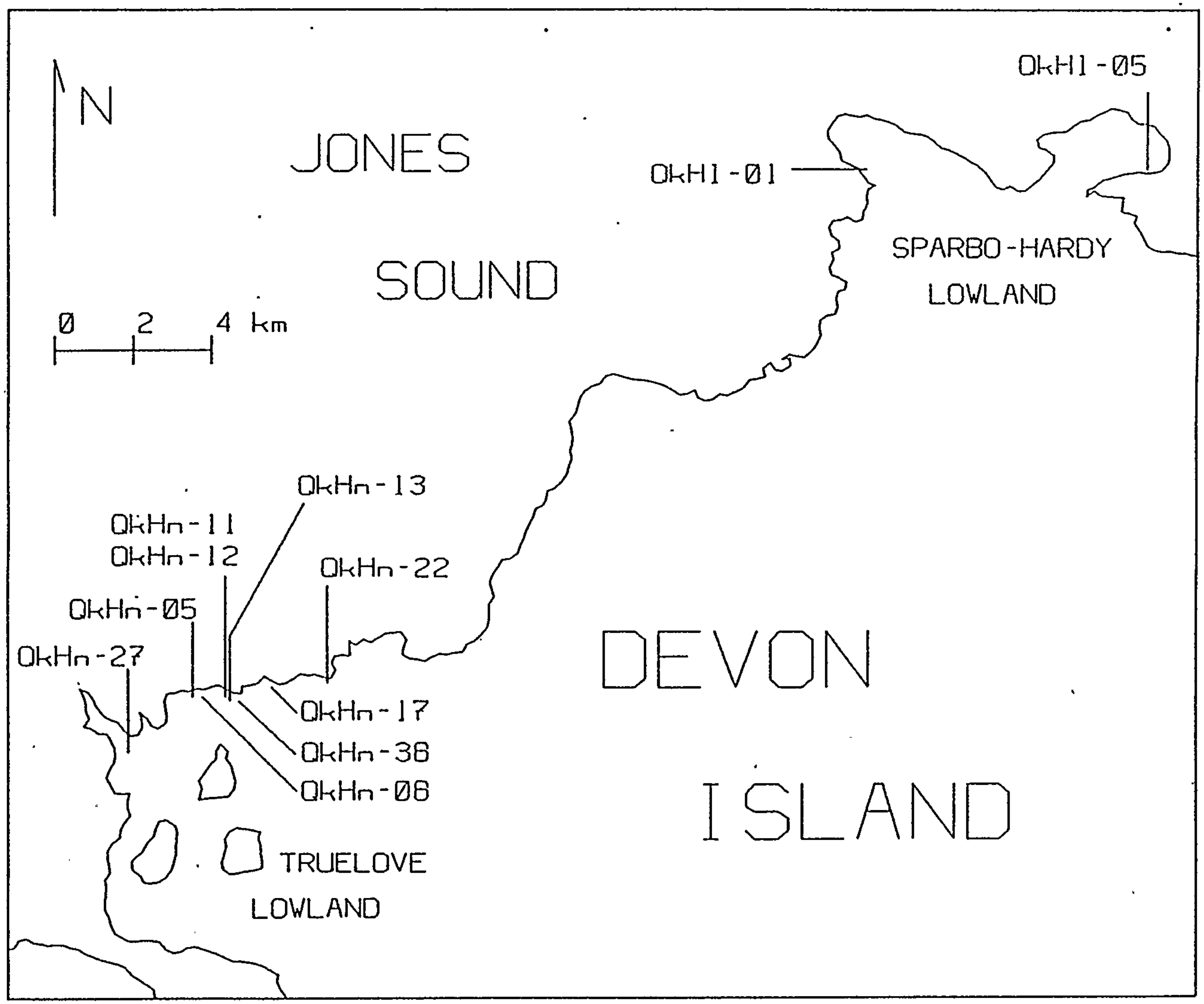


Figure 5: The Truelove and Sparbo-Hardy Lowlands

in the local concentration of sites. Caribou were present in the past, and significant populations of musk-ox, and Arctic fox and hare are still to be found in the area. These may have provided important products not easily obtained in much of the High Arctic. Lakes in the area attract numbers of waterfowl, and some contain arctic char (Bliss 1977). The currently dense populations of marine mammal species in Jones Sound suggest that the sea may also have attracted prehistoric hunters.

The largest of the three regional burin samples is derived from this area; 494 artifacts were available, and of these, 396 were selected for full analysis. The following section describes the sites and features from which these artifacts were collected. The data is taken largely from Helmer (1987b); this and other sources cited below may be consulted for complete descriptions of field activities, sites, and assemblages.

QkHl-01 (Inavik Site)

The Inavik site is located on the southwestern coast of Cape Sparbo. A multi-component site, ASTt materials appear to be confined to a beach terrace roughly four meters above sea level. Helmer's research, the second to be conducted at the site (Lowther 1962; Helmer 1985:2-3), was directed in part at the excavation of two discrete features. Feature 1 is a buried tent ring, and 15 burins associated with it form part of this analysis. Feature 2 consists of a buried boulder scatter; these may or may not represent the remains of a habitation structure, but 11 burins recovered during excavation were selected for study. Random sampling and surface collection furnished three more burins not clearly associated with either of the features so far discerned at the site (Helmer 1987b:3, 6-8).

Although cultural mixing is a potential problem at this site, both features excavated have been tentatively linked with the Early Pre-Dorset period, and share typological affinities with several sites in the Truelove and Sparbo-Hardy Lowland areas (Helmer 1987b:25-26).

QkHl-05 (Icy Bay Site)

This multi-component site is located on coastal beachs at the base of Cape Hardy, in the Sparbo-Hardy Lowlands. Nine oval tent rings have been discovered here, ranging in elevation from roughly four to nine meters above sea level. While some of the features observed relate to Neo-Eskimo activities, excavation has demonstrated that at least three tent structures can be linked to an early ASTt occupation. Burins from each of these features were used in the present analysis, and together with a single artifact recovered through surface collection, constitute a sub-collection of 61 artifacts.

Features 2 and 3 are thought to relate to Early Pre-Dorset activity at the Icy Bay site, while Feature 1 has been attributed to the Middle Pre-Dorset period. A radiocarbon sample from Feature 3 produced a corroborative date of 3770 +/- 180 RCYBP [BETA-20781]. A date from Feature 1 has been discarded; 4070 +/- 80 RCYBP [BETA-20780] is several centuries too old to support the current interpretation of cultural affinity. Dating error is attributed to the possibility that ancient driftwood made up the charcoal sample submitted for analysis (Helmer 1987b:27-28).

QkHn-08 (Gneiss Site)

The Gneiss site is located between 15 and 16 meters above sea level, on the northwest edge of the Truelove Lowland (Helmer 1985:52). Two tent ring features have been discerned here. The partial excavation of the second of these, a well defined axial structure, contributed five burins to the analysis. Feature 1 is a an oval tent ring with a central hearth; the single burin recovered from it was eliminated from study before the final stages of analysis were conducted.

A radiocarbon sample [BETA-12405] from this site yielded a C13 corrected date of 4160 +/- 180 RCYBP (Helmer 1985:115-116). In Helmer's view, QkHn-08 is typologically similar to QkHn-22 (the Far Site, below), and related to the Early Pre-Dorset component of the ASTt continuum. Diagnostic attributes include both edge serration and tapered stems on projectile points, and other bifaces (Helmer 1985:171-172; 183-185).

QkHn-11

QkHn-11 was excavated by members of the Northern Heritage Society as part of their 1985 season field school. The work was directed by Margaret Bertulli, then Executive Director of the Northern Heritage Society; details may be found in Bertulli (1987).

The site is located about 45 meters south of the more thoroughly investigated QkHn-12 (see below), on a gravel ridge about 13 meters above sea level. Structural remains are not present, the two features discerned being defined solely on the basis of lithic debris concentrations, and some bone (Bertulli 1987).

Surface collections recovered two burins from Feature 1, and these were made available for analysis. These, and the rest of the small assemblage, are attributed to a Middle Pre-Dorset occupation (Bertulli 1987), possibly the same attested to by QkHn-12.

QkHn-12 (Field School Site)

First tested by Helmer in 1983, QkHn-12 has since been intensively researched by the Northern Heritage Society field school. Detailed information about the site may be found in Bertulli and Strahlendorf (1984) and Bertulli (1987).

Located on the north central coast of the Truelove Lowland, and in close proximity to QkHn-11, the Field School Site is complex, and consists, in part, of four boulder tent rings; the site is actually multi-component, and visually dominated by semi-subterranean winter houses of the Thule culture. All materials are located at an elevation of two to seven meters above sea level (Bertulli 1987).

One of the ring structures (Feature 6) was excavated, revealing the presence of two superimposed axial features (Bertulli and Strahlendorf 1984:18). A sizable collection of burins was recovered, and 18 of these were used in the present study. Another 18 burins were obtained from Feature 10, a somewhat poorly defined ring structure about 30 meters due west of Feature 6. Twelve more burins are derived from a combination of surface collection and the excavation of random test units.

A radiocarbon date [BETA-15389] from Feature 6 provides a C13 corrected occupation estimate of 3535 +/- 90 RCYBP (Helmer 1986). This evidence, coupled with typological observation, leads Helmer to suggest that both excavated features share an affinity with the Middle Pre-Dorset period (1987b:19-21). The isolated find of a transverse edged scraper **may** be diagnostic of Late Pre-Dorset activities as well, and some possibility of multiple ASTt occupations is therefore attested (Helmer, personal communication 1988). If so, collections from random test units and surface collections may be culturally mixed.

QkHn-13 (Icebreaker Beach Site)

The Icebreaker Beach Site sits in a sheltered inlet on the central coast of the Truelove Lowland. Features were identified on beach terraces ranging in elevation from six to nine meters above sea level, and include 10 tent rings, an isolated box hearth, a midden, and several caches. Lithic artifacts are prominently scattered over the surface of this rather large site (Helmer 1987b:6).

Three of the tent ring features (1, 4, and 14), as well as the midden feature (15) were excavated, providing a total of 105 burins for metric analysis. Random excavation units and surface collection increased the QkHn-13 sample by 10 artifacts.

All four features investigated at Icebreaker Beach have been tentatively attributed to the Early Pre-Dorset period. Two radiocarbon dates have been run on samples from this site. The result of one of these, from Feature 14, is considered anomalously early at 4500 +/- 80 RCYBP [BETA-20782; C13 corrected]. A second date of 3850 +/- 95 RCYBP [NMC-1313] is in much closer agreement with the temporal assignment suggested by Helmer (1985:25).

QkHn-15 (Over Site)

Less than 0.5 km east of the QkHn-13, QkHn-15 is located on a beach ridge approximately 12 meters above sea level. Two oval tent rings are present, both exhibiting central hearth structures (Helmer 1984:49). Burins were included in the small assemblage recovered from these features, and a total of three were selected for analysis.

Both features are tentatively attributed to the Early Pre-Dorset period. No radiocarbon estimates are available for the occupation of this site, and its cultural assessment is based simply on its relatively high elevation (Helmer 1987b:18-19, personal communication 1988).

QkHn-17 (Twin Pond Site)

Seven tent ring features constitute QkHn-17, a site on the east central portion of the north coast of Truelove Lowland, located at an elevation of about nine meters above sea level. Five of these exhibit clear axial structures, three of which (Features 1, 3, and 4), have been excavated (Helmer 1985:64-84; 1986:21, 38-40). Forty of the burins used in this analysis are from this site, with each of the three tent rings represented by approximately equal numbers of artifacts.

Features 1 and 3 are attributed to the Middle Pre-Dorset period; the former has yielded a C13 corrected, radiocarbon estimate of 3680 +/- 90 RCYBP [BETA-15390] (Helmer 1987b:20). Feature 4 is probably somewhat earlier, and currently thought to relate to an Early Pre-Dorset occupation (Helmer 1987b:19).

QkHn-22 (Far Site)

On the most eastern edge of the Truelove Lowland, QkHn-22 is situated on a gravel terrace at an elevation of approximately 14 meters above sea level. Six tent rings have been identified at the site, as have three shallow, semi-subterranean features with centrally located hearths.

Excavation has contributed a total of 20 burins to this study. Twelve of these were obtained from two of the depressed features (1 and 10), and the remainder from tent ring Features 3, 4 and 8.

Helmer suggests that Features 1, 8, and 10 relate to Early Pre-Dorset activity. Two radiocarbon dates, both in close agreement with one another, support this contention. A charcoal sample from Feature 10 yielded a date of 4110 +/- 90 RCYBP [BETA-20783], and from Feature 1, an estimate of 4040 +/- 70 RCYBP [BETA-12406]. Both dates were corrected for C13 fractionation (Helmer 1987b:23). Feature 8, while of the same general cultural affiliation as the other two, appears on typological grounds to be slightly more recent than Features 1 and 10 (Helmer, personal communication 1988).

QkHn-27 (Rocky Point Site)

Rocky Point is a large peninsula on the northwestern edge of the Truelove Inlet (Figure 5). A multi-component site is located here, on a ridge elevated approximately six to seven meters above sea level. While the surface of the ridge is quite barren, a total of 13 oval tent rings have provided foci for localized organic soil development. Other features present are caches, lithic scatters, and a small oval depression. Helmer's project investigated four of the tent ring features, one of which, Feature 23, may also have an axial structure present (Helmer 1985:52,54, 1986:17-21). Burins from each of the other three features (Features 10, 15 and 17), are included in this analysis, and form a collective assemblage of 34 artifacts.

Radiocarbon dates have been obtained for two features from QkHn-27. A sample from Feature 15 has yielded a C13 corrected estimate of 4060 +/- 80 RCYBP [BETA-16554], while a date of 3800 +/- 90 RCYBP, also C13 corrected, has been obtained from Feature 17 [BETA-15391] (Helmer 1987b:21). Both dates are thought to be anomalously early, and on the strength of features exhibited by excavated collections, Helmer attributes both features to a Late Pre-Dorset occupation (Helmer 1985:196-198, 1987b:20-21).

QkHn-38 (Hind Site)

The Hind Site is located in the immediate vicinity of QkHn-15, on a beach ridge seven to eight meters above sea level. Four features have been discerned at the site, including two boulder tent rings, one with an axial structure, and a probable midden (Helmer 1986: 25). The oval tent ring (Feature 2) contributes 15 artifacts to the present study, while 22 were obtained through excavation of the midden (Feature 4).

The assemblages collected from Features 2 and 4 are thought to be quite distinct from one another. The latter appears to be the earlier of the two, and may tentatively be linked with an Early Pre-Dorset occupation. Two radiocarbon estimates are available for Feature 4, one of which has been rejected on the grounds of an anomalously recent result. The rejected date is 2880 +/- 190 RCYBP [BETA-15394, C13 corrected]; the second assay of 3700 +/- 70 RCYBP [BETA-25032, uncorrected] is considered a better estimate of the feature's age of occupation (Helmer 1986:52, 1987b:19, personal communication 1988). Feature 2 is most likely affiliated with the Middle Pre-Dorset period (Helmer 1986:51, 1987b:19).

Summary

The data described above are summarized in Table 3. Many of these sites share cultural and temporal affinities, and Helmer has grouped them into a series of complexes that are thought to reflect stages or units in a culture-historical sequence. These groups are highly tentative, especially so in that at least the earliest three complexes very probably represent an in situ developmental sequence (Helmer 1988). The boundaries currently suggested will undoubtedly be altered, and hopefully refined, as artifact collections continue to be analyzed.

Table 3: Truelove Lowland Sample

SITE	FEAT.	MASL	RC	CULT.	COMMENT	# ART.
QkHl-01	ALL	4		EPD	IBC (F01-TPC?) (F02-SQ?)	31
QkHl-05	F01	4-9	1	MPD	TPC	15
QkHl-05	F02 F03	4-9	1	EPD?	IBC	45
QkHl-05	SC	4-9		E/MPD?	IBC TPC?	1
QkHn-08	F02	15-16	1	EPD/I	FSC	5
QkHn-11	F01	13		MPD	TPC	2
QkHn-12	ALL	2-7	1	MPD	TPC	48

Table 3: Truelove Lowland Sample
(continued)

SITE	FEAT.	MASL	RC	CULT.	COMMENT	# ART.
QkHn-13	ALL	6-9	2	EPD	IBC	115
QkHn-15	ALL	12		EPD/I?	FSC?	3
QkHn-17	F01 F03	9	1	MPD	TPC	27
QkHn-17	F04	9		EPD	IBC	13
QkHn-22	ALL	14	2	EPD/I	FSC	20
QkHn-27	ALL	6-7	2	LPD	RPC	34
QkHn-38	F02	7-8		MPD? (EPD?)	TPC?	15
QkHn-38	F04	7-8	2	EPD?	IBC	22
					TOTAL	396

SQ = Sarqaq
I = Independence I
EPD = Early Pre-Dorset
MPD = Middle Pre-Dorset
LPD = Late Pre-Dorset

FCS = Far Site Complex
IBC = Ice Breaker Beach Complex
TPC = Twin Ponds Complex
RPC = Rocky Point Complex

Much of the information relevant to the formulation of these constructs has been alluded to above; the description of these complexes can therefore be brief, and confined to data of direct relevance to the assemblages analysed here. Helmer's more detailed summaries (1986,1987) can be consulted for more information.

The Far Site Complex

A number of the sites described above have been linked with the Early Pre-Dorset Culture, and be representative of both the earliest occupation of the Truelove area, and of the High Arctic in general. Within the sites so attributed, two sub-groups are distinguished. The earliest of these is named the Far Site Complex, after the site in which it was first recognized.

In addition to the Far Site (QkHn-22), this construct currently includes both QkHn-15 (Over Site) and QkHn-08 (Gneiss Site). The single most diagnostic feature of this complex is the fine edge serration frequently exhibited on bifacially flaked tools, especially those interpreted as projectile points. Radiocarbon dates from two of these sites suggest an occupation at roughly 4000 RCYBP, and they may thus be temporally comparable with sites in the Port Refuge and Bache Peninsula regions that have been attributed to the Independence I period. A number of typological elements suggest cultural as well as temporal affinities between the Far Site complex and Independence I (Helmer

1987b:18-19, 23). The significance of differences that do exist - the absence, for example, of the small bi-pointed, serrated projectile points known from the Upper Beaches component at Port Refuge (McGhee 1979:Plate 3,a-e), and SgFm-16 (Bight Site) at Knud Peninsula (Schledermann, personal communication 1988) - is not clear, and it is possible that season and functional differences may eventually account for them (Helmer 1987b:23).

The Icebreaker Beach Complex

A second, and slightly more recent component of Early Pre-Dorset has been discerned in the Truelove Lowland area, and this Helmer has designated the Icebreaker Beach Complex. Within this group are included Features 1, 4, 14 and 15 from QkHn-13, and more tentatively, Features 2 and 3 from QkHl-05, and Features 1 and 2 from QkHl-01. These sites and features are thought to represent a transitional stage between the earlier, Independence I related Far Site Complex, and somewhat more recent manifestations of Middle Pre-Dorset (1987b:19, 24-27). While a certain amount of interassemblage variability is acknowledged, the complex is characterized by the presence of small triangular, and bi-pointed projectile points and stemmed bifaces; the earlier feature of edge serration is absent. Some of the lithic artifacts exhibit grinding, so far observed on one biface (adze?) blade and several burin spalls. Non-lithic artifacts include harpoon heads of two general types: those that are tanged, unilaterally barbed, and non-toggling, and those that are self-bladed, and toggling with open sockets.

A tentative cultural association with Sarqaq related sites is seen both in the presence of tanged harpoon heads, and edge grinding on several categories of lithic artifact. Based on its perceived relationship with the Far Site Complex, as well as the radiocarbon date from QkHn-13, Feature 4, Helmer suggests that the Ice Breaker Beach Complex rests approximately in the interval between 3850 and 3600 RCYBP (1987b:25).

The Twin Ponds Complex

The Middle Pre-Dorset sites of QkHn-17, QkHn-12, and with more hesitation, QkHn-38, have been grouped together into the Twin Ponds Complex. The radiocarbon dates from QkHn-17 and QkHn-12 are believed to reflect the earliest occupation of this period, at roughly 3650 BP. An upper estimate of about 3200 RCYBP is based on dated components from the western arctic (eg. McGhee 1970:58; Mueller-Beck 1977) that contain typologically comparable artifacts, especially the small concave-based, triangular projectile points that proliferate in sites assigned to the Twin Ponds Complex. Also characteristic of these sites are small conical selfbladed harpoon heads with an open socket and single basal spur (Helmer 1987b:19-20).

It is thought that a fairly direct developmental sequence is reflected in the Twin Ponds and Ice Breaker

Beach complexes. Correspondingly, the division between them is difficult to define, and probably quite arbitrary (Helmer, personal communication 1988).

The Rocky Point Complex

The Late Pre-Dorset material collected from Rocky Point forms the final culture-historical unit to be considered here. In contrast to those discussed above, this complex is not, at present, made up of features from more than one site. Attributes that support the placement of QkHn-27 in the latest component of Pre-Dorset include broadly side-notched bifaces, a variety of small side-notched burins, and harpoon head attributes. Very early radiometric estimates notwithstanding, Helmer suggests that the occupation of this site occurred roughly between 3000 and 2700 RCYBP (Helmer 1987b:20-21).

Summary

This chapter has described the temporal and cultural context of the artifacts that are analyzed in the next two chapters. Of primary importance has been the tentative association of individual features with one or more of the culture-historical units currently recognized in arctic research. This and other critical data is recorded in Tables 1-3. A provisional chronology, based on the foregoing discussion, is provided in Figure 6. The temporal parameters implied by this chart are highly tentative, and most crucial is the relative chronological order of each culture-historical unit.

Figure 6: Regional Chronology

```
+--------+------------------------------------------------------------+
|        | PORT               BACHE               TRUELOVE            |
| RCYBP  | REFUGE             PENINSULA           LOWLAND             |
+--------+-------------------+-------------------+--------------------+
|        |                   |                   |                    |
|  4200  |                   |                   |                    |
|        |                   |                   |                    |
|  4000  | ^^^^^^^^^^^^^^    | ^^^^^^^^^^^^^^    | ^^^^^^^^^^^^^^     |
|        |      IND  I       |      IND  I       | EPD (IND I ?)      |
|  3800  | ^^^^^^^^^^^^^^    | ^^^^^^^|^^^^^^    | ^^^^^^^^^^^^^^     |
|        |        PD         |   EPD  |          |       EPD          |
|  3600  |                   |        |   SQ     | ^^^^^^^^^^^^^^     |
|        |      (EPD?)       |   MPD  ?          |                    |
|  3400  | ^^^^^^^^^^^^^^    |        ?          |       MPD          |
|        |                   | ^^^^^^^^^^^^^^    |                    |
|  3200  |                   |                   | ^^^^^^^^^^^^^^     |
|        |                   |                   |                    |
|  3000  |                   |       LPD         | ^^^^^^^^^^^^^^     |
|        |                   |                   |       LPD          |
|  2800  |                   |                   |                    |
|        |                   | ^^^^^^^^^^^^^^    | ^^^^^^^^^^^^^^     |
|  2600  | ^^^^^^TD^^^^^^    |       TD          |                    |
|        | ^^^^^^^^^^^^^^    | ^^^^^^^^^^^^^^    |                    |
|  2400  |                   |                   |                    |
|        |                   |                   |                    |
+--------+-------------------+-------------------+--------------------+
```

SQ = Sarqaq
IND I = Independence I
PD = Pre-Dorset
EPD = Early Pre-Dorset
MPD = Middle Pre-Dorset
LPD = Late Pre-Dorset
TD = Transitional Dorset

CHAPTER 4

METHODOLOGY

That fact that this analysis is exclusively concerned with continuous observation does not reflect a belief in an inherent superiority of ratio level data for archaeological taxonomic analysis. A detailed study in the nominal mode may well provide useful insight into the nature of formal variability exhibited by spalled burins; a coordinated analysis, incorporating both levels of observation might be even more illuminating. An integrated approach of this type had, in fact, been the original aim of the study. The task of standardizing metric observations was problematic, and the "traditional" approaches initially implemented proved untenable. Developing a technique appropriate to the idiosyncratic data base was time consuming, and the non-metric component of the study was accordingly abandoned.

Many prehistoric stone tools are roughly symmetrical when observed in plan view. Exact symmetry, of course, is never achieved, but does in many cases appear to represent an ideal of the craftsman; this, at least, is a convenient assumption for the lithic analyst. Depending on the tool in question, slight asymmetry can usually be attributed to material contingencies, slight variations in flaking technique, or use-damage, subsequent repair, and post-depositional breakage. Extremes aside, analysis can quite reasonably procede as if the assumption of symmetry has been fully met.

When dealing with symmetrical artifact classes, generating quantative data that are both replicable and comparable between individual artifacts and assemblages does not pose much methodological difficulty. The axis of symmetry provides a useful means of consistently orienting such frequently extracted observations as, for example, length and width. The dimension defined as 'length' is usually measured along a vector that is parallel, and very often coincident with this axis; that described as 'width' is normally perpendicular to it. The location of the latter may be defined simply so as to maximize its score, or it may be placed on some specific point, otherwise defined, along the axis of symmetry.

Exploiting an axis of symmetry is not the only strategy available to the lithic analyst, and useful quantitative measurements are often generated from artifact classes for which this property was clearly never intended. If pairs of discrete attributes or landmarks can be repeatedly identified on individual artifacts in an assemblage (or at least a subset thereof), they may define a measurement scheme that is independent of an axis of symmetry. It is assumed that a generalized artifact displaying these landmarks can be conceptualized, and that this "type" specimen will permit standardization of continuous observations on most or all of the specimens under study.

It is also assumed that the landmarks chosen are comparable between cases (i.e. they represent the same feature). It is anticipated, if not actually requisite, that the spatial relationships between attributes are non-random, and that they will reveal something of significance about the formal nature of the artifacts in question.

ASTt burins are inherently asymmetrical. This is partially due to the fact that their working edges are rejuvenated through spall removal, and this is usually focused on a single lateral edge. Additionally, and to reiterate, flakes and preforms that appear to have been destined for burin manufacture are frequently asymmetrical even before the spalls are removed; the "mitten" shape of a typical spalled burin is anticipated by the artifact's first formal manifestation (Giddings 1964: 214-215).

This being the case, initial attempts at quantification were based on the second of the two approaches outlined above. It was hoped that a set of landmarks could be identified along the edge of the artifact, and that the spatial relationships of these would capture characteristics of size and shape. Initially, this appeared to be feasible. A number of "typical" specimens exhibited points of juncture between apparently distinct marginal components; if these could be consistently identified throughout the sample, they would form the basis of a potentially useful measurement system. As the preliminary analysis progressed, however, the amount of variability observed increased substantially.

The number of junctures, the angles between them, and the shapes of the edge components varied a great deal between cases; in too many instances, a landmark on the generalized "type" artifact could be plausibly identified with several on the artifact under examination. In many cases, the opposite was true, and in still others, no convincing match could be made at all. An attempt was made to alleviate this problem by defining sub-categories of burins exhibiting comparable sets of landmarks. Success in this regard would, in itself, have represented an interesting result of the analysis, but such was not the case. Extremes were linked by a bewildering number of intermediate forms, and classes that could be objectively defined had so few members that the broad-base comparison that these samples were to afford would have been sacrificed. Perhaps the most substantive conclusion reached through preliminary analysis was that a reasonable facsimile of the sample could most readily be created by randomly manipulating a two dimensional topological puzzle. Initial attempts at quantifying the assemblage only emphasized its formal complexity, and apparent internal inconsistencies.

After failing to generate reliable metric data using the approach outlined above, a radically different method of analysis was developed. The technique, a specialized form of shape analysis, eventually formed the basis of the entire study, and this thesis is very much an experiment in its use.

As first envisioned, the technique was thought to represent a unique approach to the quantification of complex shapes. Further research, however, showed that a number of disciplines, including to a very limited extent archaeology, have developed and used comparable approaches. For general reviews of shape analytic techniques, Clark (1981) and Davis (1986) can be consulted. The two archaeological examples that I am aware of are Montet-White (1973) and Turpin and Neeley. (1977).

The technique ultimately developed uses a custom computer program (tentatively named RADSTAN) to process and standardize digitized artifact outlines. The approach is flexible, and does not depend on a priori definition of rigidly defined marginal landmarks. In the most general terms, each artifact is uniquely characterized by reducing the digitized outline to a series of truncated vectors, radiating from a gravitational centroid. The location of this centroid is weighted so as to emphasize the morphology of the basal component of the burin; while variability in the distal portion is easily recorded in this system, it does not affect the description of the artifact as a whole. The following sections describe the procedure in detail.

Artifact Description

Selection

Burins retained for preliminary analysis were subject to the following restrictions:

1) The artifact's functional role as a burin had to be the primary determinant of form. In a number of instances, it was clear that burins had been manufactured from artifacts that had previously been used for other purposes. A number of burins from the Independence I sites at Port Refuge, for example, appear to have been made of the basal portion of contracting-stem bifaces. If the degree of alteration was such that the original function, and its associated morphology was largely obscured, however, the artifact was retained. Very few burins were discarded on this basis.

2) In general, all artifacts were required to exhibit a single spall zone. As stated above, this analysis is restricted to the category of burin that exhibits one locus of spalling. There were, however, instances in which this rule was relaxed. A number of burins in the sample were made by reworking other, perhaps damaged burins. These artifacts could be identified when spall scars relating to the earlier episode of use are not totally removed by retouch. Provided, however, that its form appeared to be a primarily a function of its latest manifestation, the artifact was retained for analysis. In addition, artifacts

with double spall zones in the **distal** end were in a few instances retained. The orientation of burins (discussed below) depends to a large extent on the distinction between the spall zone, and the distal lateral edge opposite to it. If however, a comparatively limited amount of spall removal is exhibited by the latter, this distinction can still be made. The primary focus of spall removal is defined as the spall zone, and the artifact retained for analysis. The few decisions made to retain artifacts of this type were highly judgemental, and are based on a belief that the second set of spall removal reflects behaviour that is expedient in nature, and of secondary importance. Furthermore, and as will be emphasized below, descriptive variables affected by the presence of the second spall zone are identified and eliminated from analysis.

3) Burins with evidence of proximal breakage were discarded. The utility of centroid calculation depends on the degree to which basal components are intact, and thus reflecting a form that was either the product of deliberate alteration, or at least tolerated by the user. Edges that appeared to have been broken, but showed clear evidence of crushing or wear (perhaps associated with hafting) were retained. Distal breakage was not cause for elimination unless it was found to extend into the component of the artifact used in centroid calculation.

Outline Description

In order to rapidly prepare artifacts for digitization, those specimens selected for analysis were xeroxed in groups of up to twenty. The aim was to accurately record outlines, and several steps were taken to minimize distortion. Each artifact set was xeroxed with both a black and white paper background, thus providing suitable contrast for burins made of both light and dark coloured chert. Individual artifacts were placed with the least convex surface down, thus bringing their margins into as close a proximity as possible with the glass plate on the xerox copier. This reduced or eliminated shadow along the edge of most artifacts, and produced a well focussed and crisp record of the burin's shape. In some instances, it was necessary to further reduce the effect of edge shadow by varying the darkness setting on the copier.

The xerox images were used to produce a set of drawings recording the outline of each artifact. This was done simply by tracing on a light table. The outlines generated show the artifact as it appears in standard orientation. During this procedure, both the xeroxes and the line drawings derived from them were compared with the original artifacts. Inaccuracies noted were eliminated either by altering the tracing, or by re-xeroxing the artifact, and attempting a second tracing. The drawings obtained were accurate, and the amount of distortion introduced at this stage was little more than that of the width of a fine pencil lead.

The next stage in data generation involved digitizing the traced artifact outlines. In anticipation of centroid calculation (described below), it was necessary first to define a basal component for each artifact. The aim was to delineate, as objectively as possible, that portion of the burin unaltered by sequences of spall removal, task specific retouch, and reduction through use induced crushing and breakage. This portion should be morphologically quite stable, and a centroid defined within it provides a means of comparing artifacts reflecting divergent curational behaviour.

The basal portion of each artifact was defined in the following manner: First, and in consultation with the original artifact, the primary spall termination scar was identified and marked on the outline drawing. This represents the most distal point at which the spall edge can be expected to have been altered by spall removal. A wide, opaque straight edge was placed on the drawing so as to obscure from view the distal component of the artifact, and intersect the primary spall termination scar. The straight edge was then pivoted so as to maximize symmetry in the exposed, basal portion of the outline. The latter point requires some elaboration (Figure 7). At any given position of the straight edge, an imaginary axis was invisioned to emanate at right angles from the straight edge, midway

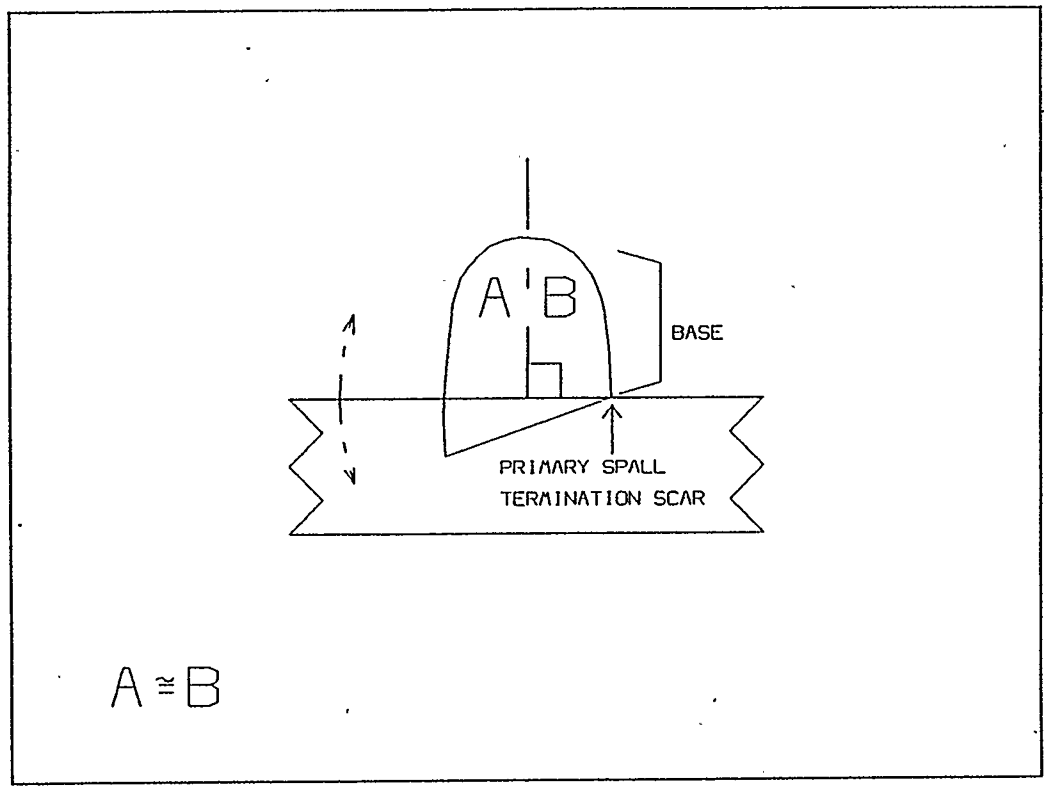


Figure 7: Defining the Basal Component

between the edges of the burin, as exposed immediately adjacent to the straight edge. The straight edge was then manipulated until the basal component of the burin appeared, as well as can be visually judged, to be bisected by the imaginary line. At this point, the intersection between the straight edge and both lateral edges of the burin were clearly marked, and the distal and basal (proximal) portions thereby delineated.

The definition of the basal component is somewhat subjective, but the results were found to be very replicable. Over the space of several days, a number of test specimens were repeatedly subjected to this procedure. Impressionistically, variation appeared to be very minor, and had little effect on the definition of artifact centroids.

Artifact outlines were manually digitized using the Calcomp 9000 digitizing table in the Geography Department, University of Calgary. The subset of data recording the shape of the basal component was delineated with a pair of character flags identifing it to RADSTAN for centroid calculation. The outline in general was collected in increment mode, starting at the most proximal spall termination scar, and moving counterclockwise around the base. The increment option allows point locations to be automatically recorded whenever movement of the digitizing puck exceeds, in either the X or Y direction, some chosen increment value. A closed shape can thus be rapidly recorded by a large number of cartesian pairs, lying at more or less regular intervals on the object's perimeter; the exact size of the data set is a function of the increment factor chosen, and the length of the perimeter traced (i.e. the size of the form digitized). In this study, a factor of 1 mm was chosen for both axes, and applied to all but a few outlines. The number of coordinate pairs recorded for each artifact varied between roughly 50 and 70; this density of marginal observations provided good shape characterization, without generating data sets so large as to make computer manipulation unwieldy. Precision levels of the digitized coordinates were limited to the nearest 0.01 mm. The margin of error introduced by drawing the artifact outlines and manipulating the digitizing puck certainly exceeds this value, and subsequent mathematical procedures rounded each figure to the nearest 0.1 mm. This reflects more closely the levels of accuracy that can be attained using this method of data recording.

In order to verify the results of the digitizing process, the raw data sets were down-loaded and processed for plotting on a dot matrix printer. A simple program written and compiled on Turbo Basic version 1.1 (Borland International, Inc. 1987) was used to prepare data sets for the PLOTCALL graphics system (Golden Software Inc. 1984). The outline of each artifact was then plotted, and compared on a light table with the tracings that were originally digitized. Discrepencies were few, and less than five percent had to be redigitized. Errors identified were primarily associated with burins having an unusually acute angle somewhere on the margin (usually, the tip). In such cases, it was possible to move the digitizing puck entirely around this angle before the increment factor was exceeded, and a new point recorded; this had the effect of truncating part of the outline. This was remedied by shifting the drawing slightly, and redigitizing. A smaller increment factor would have effectively eliminated this problem, as experiments with a factor of .05 mm indicated.

Standardization

After being reviewed for error, each data set was refined and standardized through a series of geometric manipulations. These procedures, and the conditions that neccesitated them, are described below.

During the digitization procedure, the origin for each of the individual data sets was arbitrary, and common to as many artifacts as happened to be digitized at the same time. Specimens were inconsistently oriented relative to one another, and the number of coordinates describing them varied simply as a function of their relative size. Each of these factors, in isolation, was sufficient to invalidate comparison between records.

These problems were rectified by (a) defining a unique origin for each artifact based on a common set of rules, (b) redefining marginal coordinate sets relative to this origin,

(c) orienting each artifact in a standardized manner, and (d) replacing the original coordinate pairs with a new set of equally spaced coordinates.

The mathematical calculations required to carry out the procedures described above are numerous, and a potential source of error. This, coupled with the large number of records involved, made it highly desirable to integrate a computer into this phase of data preparation. A program was developed which could rapidly standardize data and eliminate the potential for human computational error. RADSTAN was written and compiled with Turbo Basic version 1.1 (Borland International, Inc. 1987). The most important procedures carried out by it are summarized below.

Origin calculation

The origin for each individual data set was shifted to an internal point, or centroid, within each artifact. A mathematical procedure called trapezoidal approximation was used to define this point (Davis 1986:345-347). While the centroid of an object can be defined in a number of quite different ways, the advantage of this method is that it is not affected by the number or spacing of the points used to define it; whatever the density of the marginal coordinates, objects with the same outline yield identical centroids. Rather than use the outline of the entire artifact, however, only those points defining the basal portion were incorporated into this calculation. This allowed artifacts with the same basal configuration to yield equivalent gravitational centroids, regardless of how their distal components differed.

Rotation

The advantage of defining an internal origin is apparent when the problem of orientation is considered. The centroid described above provides a convenient focus for rotation, by which the position of each artifact can be shifted relative to one another. If the criterion used to control or limit rotation is applied in common, the lack of standardization inherent in the digitizing procedure can be effectively eliminated. The comparability of individual artifacts within the sample is correspondingly increased.

In order to standardize the rotation phase the position of the primary spall termination scar was exploited. After converting the cartesian pairs into polar coordinates, each artifact was rotated until the 0 degree axis extended from the centroid through this feature; the angles increase in the same direction as digitization proceeded, counterclockwise around the base. While the location of the spall termination scar is in some senses an arbitrary check on rotation, it can be consistently identified on most artifacts, and is unaffected by differential curation. In addition, it is one of the coordinates on the perimeter of the basal component used to define the centroid, or point of rotation, in the first place. Thus, none of the criteria used to standardize the data, either in centroid calculation, or rotation, are based on morphological features external to the base.

Coordinate Interpolation

The final step in data standardization required replacing the typically large data sets recorded by the digitizer with a sub-set of a standardized size, spaced at equal intervals around the gravitational centroid. This was accomplished by defining evenly spaced vectors that radiate out from the centroid and calculating all points of interception with the original marginal segments. Potential interceptions were rapidly identified by comparing the angle portion of the polar coordinates defining both these radial vectors and each of the marginal segments. These were then converted back to the cartesian system, and their points of intersection found through simultaneous solution. Precision was limited to the nearest 0.1 mm.

The amount of information retained for analysis is simply a function of the increment used to define the spacing of these vectors. As much of the original data can be eliminated as is thought appropriate. In this study, points were interpolated at 10 degree intervals, and the shape of each artifact was therefore captured by 36 discrete variables. This reduced the size of each of the original data sets by roughly 50 percent. While this is certainly a positive by-product of the procedure, the critical goal is to generate a shape description that can be validly compared between individual artifacts.

To summarize, each radial vector can be seen as a discrete variable against which individual artifacts are measured and compared. When the interpolated points are expressed in polar form, the angle component θ (theta), in a sense, becomes the name of that variable; the length r provides its standardized score, or value (Hodson 1982). For the sake of convenience, these variables were numbered sequentially, starting at zero, with the prefix 'R' (radian) added. The angle represented by each variable is simply found by multiplying the second half of the label by ten.

Analysis

While these 36 variables capture the shape of individual artifacts in some detail, simply subjecting them to multivariate analysis without modification or refinement would constitute a blatant example of 'naive empiricism'. There are two general, and rather different reasons for this. The first of these lies in the fact that, in almost all burins, one or more of the radial vectors intersect the spall edge; their length is at least partially a function of the degree of spall removal. As has been stressed above, one of the difficulties of burin analysis is minimizing the effect of differential curation, so that potential variability over time and space can be more readily discerned. A similar problem, although of a different behavioural source, was posed by artifacts exhibiting distal breakage or double spall removal in the distal end; the value of variables truncated by these zones are equally unsuitable for comparing assemblages over time and space.

These difficulties were dealt with by recording the location of broken surfaces and spall zones on the polar grid system defined by the centroid and the primary spall termination scar. Because 0 (360) degrees was set at one end of the spall zone, this critical region could usually be identified by a single maximum angle, and radii that intersected it were replaced with a missing value code. The original artifacts were used to assist in identifying the necessary landmarks; a simple template, and the computer generated artifact outlines allowed the appropriate angles to be recorded. A slight modification of the initial digitizing process, and a simple alteration to RADSTAN would have made the procedure considerably less time consuming.

A more interesting problem was posed by the way in which discrete observations were generated. Numerous, closely spaced measurements that originate in a common centroid are likely to be characterized by much redundancy (see Christenson and Read 1977; Whallon 1982:131). The chance that each of more than 25 discrete observations (the exact number depending on the number of missing values defined in the procedure described above) records a unique dimension of variability is very small. Adjacent variables, as well as those on opposite sides of the centroid may be highly correlated. Taxonomic studies based on highly redundant data are inefficient, and may differentially weigh dimensions in a manner that is not recognized, and therefore not controllable.

Fortunately, statistical techniques can identify such redundancy, which can then be 'weeded out'. One such technique was applied to this analysis; the result is a refined, and certainly much reduced set of descriptive data. The procedure used was principal components analysis (PCA).

Principal Components Analysis

Closely aligned, and often confused with factor analysis, principal components analysis (PCA) is a model free technique (Davis 1986:546; Dillon and Goldstein 1984:24) that seeks to explain metric observations in terms of a reduced number of hypothetical variables called components. Components are not directly observed, but are discovered by examining variable correlations. If data is highly structured and characterized by much redundancy, a small number of components will account for a high percentage of the observed variance and can, in effect, replace the observed variables in subsequent analyses. It is hoped that the data, through a reduction in dimensionality, will thereby be made more comprehensible. Useful descriptions of the technique are included in Davis (1986), Clifford and Stephenson (1975) and Sneath and Sokal (1973); these sources may be consulted for detail on its theory and use. Discussions of archaeological applications of PCA are included in Doran and Hudson (1975) and Orton (1980).

The extraction of principal components was carried out using the FACTOR procedure provided in release 2.1 of SPSSX (SPSS Inc. 1986). Four data sets were prepared for separate analysis; in addition to the regional samples, a combined sample composed of all three was utilized. In keeping with the exploratory nature of this analysis, it was important not to eliminate the possibility of discovering unique regional data structure, if such should exist. Given their widely disparate sizes, it is likely that dimensional characteristics of the smaller samples will, in a combined analysis, be swamped or overshadowed by those of the larger. Regionally specific analysis should offset this problem.

It is common for researchers whose data combine different scales of measurement, or observations with widely differing variances, to apply some sort of standardization procedure before carrying out multivariate analysis (Davis 1986:535-536). In this study, neither of these considerations apply, and the effect of differential character weighting is probably negligable. All observations consist of continuous measurements of length, and the variance displayed by individual variables was highly similar. The data were therefore not standardized, and component extraction was carried out on a correlation matrix calculated on raw variable scores.

Because artifacts with missing values were deleted on a listwise basis, it was highly desirable that the correlation matrix be calculated from a subset of the full 36 variable data set. The spall edge ensured that no artifacts had valid values for the last one or two variables, and most exhibited the missing values well before this point. If the analysis is restricted to less than the full complement of observations, however, a larger number of the original artifacts can be included in it. It was decided that retaining all artifacts with a valid measurement on R29 (290 degrees) represented the best trade-off between sample size and the degree of artifact description. At least 80 percent of the artifacts from each region were thus retained, providing a total sample of 590 artifacts; the correlation matrices were calculated on the basis of 30 discrete measurements.

While not reproduced here, visual inspection of the four correlation matrices indicate that strong correlations between variables do in fact exist, and that a significant reduction in data complexity can be anticipated from principal components extraction. It is widely recognized that PCA will impose an apparent structure on data sets that are randomly generated (Vierra and Carlson 1981); the unsuitability of the latter for principal components analysis will be indicated, however, by the predominence of unusually low coefficients in the correlation matrix. The large number of high correlations observed here suggest that patterning identified through principal components analysis can be attributed to structure that actually exists within the data itself.

In PCA, component extraction proceeds by finding linear combinations of variables that maximize the explanation of variance in the original data set. Each of these components is uncorrelated with all others. As higher order components are extracted, they seek to capture as much as possible of the variance remaining, subject to the restriction of orthogonality. Unless complete dependency exists between one or more variables in the correlation matrix, as many components will be extracted as there are variables. When the final component is defined, all of the variance contained in the original raw data set will have been accounted for. It is hoped, of course, that most of the variance in the sample will have been explained well before the final component is extracted. If so, the first few may provide an economical summary of the original data.

In the analyses conducted on each of the four data sets, the first four components extracted exhibit eigenvalues that exceed 1. Depending on the specific analysis, between 93 and 95 percent of the observed sample variance is accounted for by these components (Table 4). In other words, it appears that the number of analytical units could potentially be reduced by about 75 percent with a corresponding loss in sample variance of only about seven precent.

Table 4: Principal Components Analysis: Eigenvalues and Variance

COMPONENT:	EIGENVALUE:	PERCENT OF VARIANCE EXPLAINED:	CUMULATIVE:
COMBINED SAMPLE			
1	19.52	65.1	65.1
2	5.51	18.4	83.4
3	1.84	6.1	89.6
4	1.14	3.8	93.3
PORT REFUGE SAMPLE			
1	19.03	63.4	63.4
2	5.61	18.7	82.1
3	2.18	7.3	89.4
4	1.07	3.6	93.0
BACHE PENINSULA SAMPLE			
1	18.91	63.0	63.0
2	6.79	22.6	85.6
3	1.37	4.6	90.2
4	1.25	4.2	94.4
TRUELOVE LOWLAND SAMPLE			
1	19.47	64.9	64.9
2	5.28	17.6	82.5
3	1.97	6.6	89.1
4	1.20	4.0	93.1

The number of components to be incorporated into an analytical model is largely a matter of judgment. As suggested above, the trade off is between the increased simplicity that arises through the adoption of the principal component model, and the loss of information that accompanies the abandonment of lower level components. With all four samples, subsequent analysis was restricted to a three component model. Retaining a fourth component would have allowed only about four percent more of the original variance to be analyized, and it was felt that this did not justify the extra dimension of complexity. Four percent barely exceeds the amount of variance attributable to individual variables in the original data set, and thus contributes little to data reduction and simplification. Additionally, purely practical considerations favoured the use of a three component model. Two and three dimensional space can be graphically displayed, while higher order dimensions cannot. This is frequently of advantage in subsequent stages of analysis, and may allow, for example, certain cluster validation techniques to be exploited which would otherwise be impossible (Aldenderfer 1982).

The linear equations that define the relationship between components and variables are summarized in a matrix of coefficients called component loadings. If a simple solution has been achieved, most variables will load highly on, and therefore be strongly correlated with, only one component. After the initial extraction of components, this is rarely the case, and patterns of correlation between variables and components are usually relatively ambiguous.

This ambiguity can usually be alleviated by rotating the matrix of component loadings. By shifting the now reduced number of component axes, it is often possible to find positions at which formerly ambiguous loadings are replaced with those close to either 1 or 0, and hence clearly aligned with a single component. This procedure does not alter the fundamental relationship between the original data and the component model. The total amount of variance explained remains the same both for each individual variable, and for the data set in general. The amount of variance captured by each component, however, will be modified (Davies 1971).

All of the component matrices generated in this analysis were rotated to a final solution. The varimax technique was used in each case, and the orthogonality of the original component axes was therefore not altered. As anticipated, the rotated component matrices show a rather simple pattern of correlation between observed and underlying variables, or components. In all instances, variables load highly on at least one component, and in most cases, on only one. If variables are allocated to the component with which they have the strongest correlation, they can be seen to group in a manner consistent with predictions made earlier. In Table 5, for example, based on the combined data set, variables R2 to R9, and R18 to R23 are clearly associated with the first component. These variable sets represent two groups of contiguous measurements, taken from roughly opposite sides of the centroid. Similar observations apply to the other two components, and with respect to the other three samples (Tables 6-8).

Variable Selection

While rotation clarified the relationship between variables and components, its product, the rotated component matrix, was used to further streamline the analysis. Characteristics of the communalities and loadings allowed observations least compatable with the component model to be identified, and eliminated from further study. The data set retained was both smaller, and more amenable to final summary by principal components.

The degree to which a variable is accomodated by a PCA model is reflected in its correlation with the extracted and rotated components. The communality of a variable is that portion of its original variance accounted for by the combined effect of the retained components, and is found by adding together each loading after it has first been squared. The communalities calculated for each variable in each sample are listed in Tables 5-8. As will be noted, the model used here accounts for a very high percentage of variance in most variables; the implication is that their behaviour should be reflected with some accuracy in the

Table 5: Combined Sample:
Communalities

VARIABLE:	COMMUNALITY:	VARIANCE/COMMUNALITY: COMPONENT 1	2	3
* R20	0.90	0.84	0.11	0.05
* R21	0.89	0.81	0.06	0.13
* R5	0.93	0.78	0.07	0.16
* R6	0.88	0.81	0.05	0.14
* R19	0.91	0.75	0.24	0.01
R4	0.94	0.69	0.13	0.18
* R22	0.89	0.70	0.04	0.26
R7	0.76	0.80	0.08	0.13
R3	0.94	0.58	0.24	0.18
R23	0.89	0.54	0.03	0.43
R18	0.91	0.52	0.48	0.00
R2	0.95	0.46	0.38	0.16
R8	0.60	0.72	0.18	0.10
R9	0.51	0.52	0.43	0.06
* R14	0.94	0.02	0.98	0.00
* R15	0.96	0.04	0.96	0.00
* R13	0.90	0.01	0.98	0.00
* R16	0.95	0.11	0.89	0.00
R12	0.80	0.02	0.97	0.01
* R17	0.93	0.27	0.73	0.00
* R0	0.95	0.22	0.70	0.08
R11	0.67	0.08	0.91	0.01
R1	0.95	0.34	0.53	0.13
R10	0.54	0.25	0.73	0.03
* R28	0.90	0.03	0.00	0.97
* R27	0.94	0.07	0.00	0.92
* R26	0.92	0.15	0.00	0.85
R29	0.79	0.01	0.04	0.95
* R25	0.92	0.27	0.00	0.73
R24	0.91	0.40	0.02	0.59

Table 6: Port Refuge Sample:
Communalities

VARIABLE:	COMMUNALITY:	VARIANCE/COMMUNALITY: COMPONENT 1	2	3
* R20	0.88	0.90	0.08	0.02
* R19	0.89	0.83	0.17	0.00
* R21	0.87	0.82	0.07	0.12
* R6	0.85	0.74	0.05	0.21
* R5	0.90	0.70	0.06	0.25
R4	0.93	0.59	0.14	0.28
R7	0.73	0.74	0.07	0.19
R18	0.89	0.59	0.41	0.00
R22	0.88	0.59	0.06	0.34
R3	0.93	0.46	0.29	0.25
R8	0.60	0.70	0.14	0.16
R9	0.51	0.66	0.27	0.07
* R14	0.94	0.01	0.99	0.00
* R15	0.95	0.03	0.97	0.00
* R13	0.89	0.02	0.98	0.00
* R16	0.94	0.10	0.90	0.00
R12	0.79	0.05	0.95	0.01
* R0	0.94	0.20	0.73	0.07
* R17	0.91	0.28	0.71	0.00
R11	0.64	0.15	0.84	0.01
R1	0.94	0.25	0.56	0.19
R2	0.95	0.35	0.42	0.22
R10	0.52	0.41	0.56	0.03
* R27	0.96	0.02	0.00	0.98
* R28	0.92	0.01	0.00	0.99
* R26	0.95	0.05	0.00	0.94
R29	0.84	0.01	0.02	0.97
* R25	0.93	0.13	0.01	0.85
* R24	0.91	0.22	0.03	0.75
R23	0.87	0.39	0.04	0.57

Table 7: Bache Peninsula Sample:
Communalities

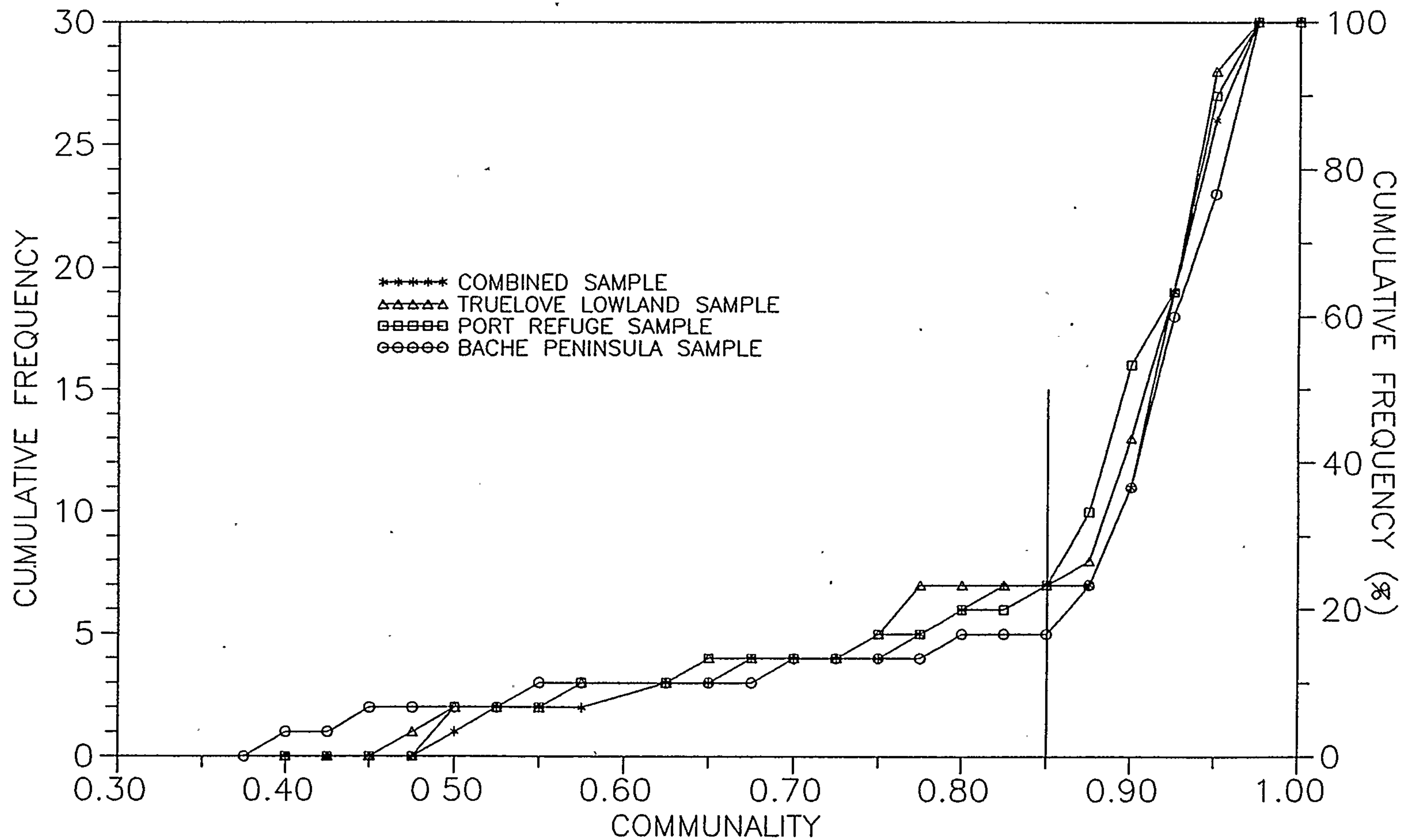
VARIABLE:	COMMUNALITY:	VARIANCE/COMMUNALITY: COMPONENT 1	2	3
* R21	0.90	0.92	0.03	0.05
* R20	0.90	0.92	0.07	0.01
* R5	0.94	0.88	0.03	0.09
* R6	0.91	0.90	0.01	0.09
* R22	0.89	0.87	0.02	0.11
* R4	0.95	0.80	0.09	0.11
* R19	0.92	0.78	0.22	0.00
* R23	0.90	0.80	0.01	0.19
R7	0.79	0.90	0.02	0.08
* R3	0.95	0.71	0.18	0.11
* R24	0.90	0.74	0.01	0.26
R25	0.90	0.67	0.00	0.33
R2	0.97	0.58	0.33	0.08
R26	0.88	0.56	0.01	0.43
R8	0.57	0.86	0.08	0.05
R1	0.97	0.48	0.47	0.04
R9	0.42	0.63	0.34	0.03
* R14	0.96	0.00	1.00	0.00
* R15	0.96	0.01	0.99	0.00
* R13	0.94	0.00	1.00	0.00
* R16	0.97	0.05	0.94	0.01
* R12	0.85	0.00	1.00	0.00
* R17	0.96	0.19	0.81	0.01
R11	0.68	0.03	0.96	0.01
R0	0.91	0.32	0.66	0.02
R18	0.92	0.48	0.52	0.00
R10	0.46	0.24	0.74	0.02
* R29	0.86	0.14	0.00	0.86
* R28	0.93	0.24	0.00	0.75
R27	0.93	0.43	0.02	0.56

Table 8: Truelove Lowland Sample:
Communalities

VARIABLE:	COMMUNALITY:	VARIANCE/COMMUNALITY: COMPONENT 1	2	3
* R5	0.94	0.81	0.07	0.12
* R20	0.91	0.83	0.12	0.05
* R21	0.89	0.82	0.06	0.12
* R6	0.87	0.84	0.06	0.10
* R4	0.94	0.74	0.13	0.14
* R19	0.91	0.75	0.24	0.01
* R22	0.88	0.73	0.03	0.23
R7	0.74	0.83	0.09	0.08
R3	0.94	0.62	0.23	0.15
R23	0.88	0.58	0.02	0.40
R18	0.91	0.53	0.47	0.00
R2	0.94	0.50	0.37	0.14
R8	0.59	0.75	0.19	0.06
R9	0.49	0.52	0.44	0.04
* R14	0.93	0.02	0.98	0.00
* R15	0.96	0.05	0.95	0.00
* R13	0.88	0.02	0.98	0.00
* R16	0.95	0.13	0.87	0.00
R12	0.77	0.03	0.96	0.01
* R17	0.93	0.30	0.70	0.00
R0	0.95	0.23	0.69	0.08
R11	0.63	0.08	0.91	0.02
R1	0.95	0.36	0.53	0.11
R10	0.51	0.23	0.74	0.03
* R28	0.89	0.03	0.00	0.97
* R27	0.93	0.07	0.00	0.92
* R26	0.92	0.16	0.00	0.84
R29	0.76	0.01	0.05	0.95
* R25	0.91	0.28	0.00	0.71
R24	0.90	0.43	0.01	0.56

three components. Variables can be identified, however, that at least in a relative sense, are less compatible with the three component model. Figure 8 illustrates ogive curves generated by plotting communalities against the cumulative variable frequencies. The marked rise in the slope suggests that two variable classes can objectively identified. The majority of variables exhibit values in excess of about .85; a much smaller subset have communalities below this. The second set of variables are viewed as expendable, and in accordance with the aim of data reduction and refinement, all those exhibiting communalities of less than .85 were eliminated from further consideration. While the remaining variables are well explained by the three component model as a whole, the possibility remains that some, even after rotation, may be highly correlated with more than one component. This is at odds with the desired end of data simplification. If the squared component loadings are expressed as percentage frequencies of each variable's communality, a simple graphical display can help identify such variables. Figures 9-12 illustrate to what extent a variable's communality can be explained by the combined effect of each of the three components. Variables that are strongly correlated with a single component lie in the corners of the graph, while those that are associated with two or three lie more towards the center. A critical value for any variable can now be defined on the basis of how much of its communality is

Figure 8: Total Variance Explained



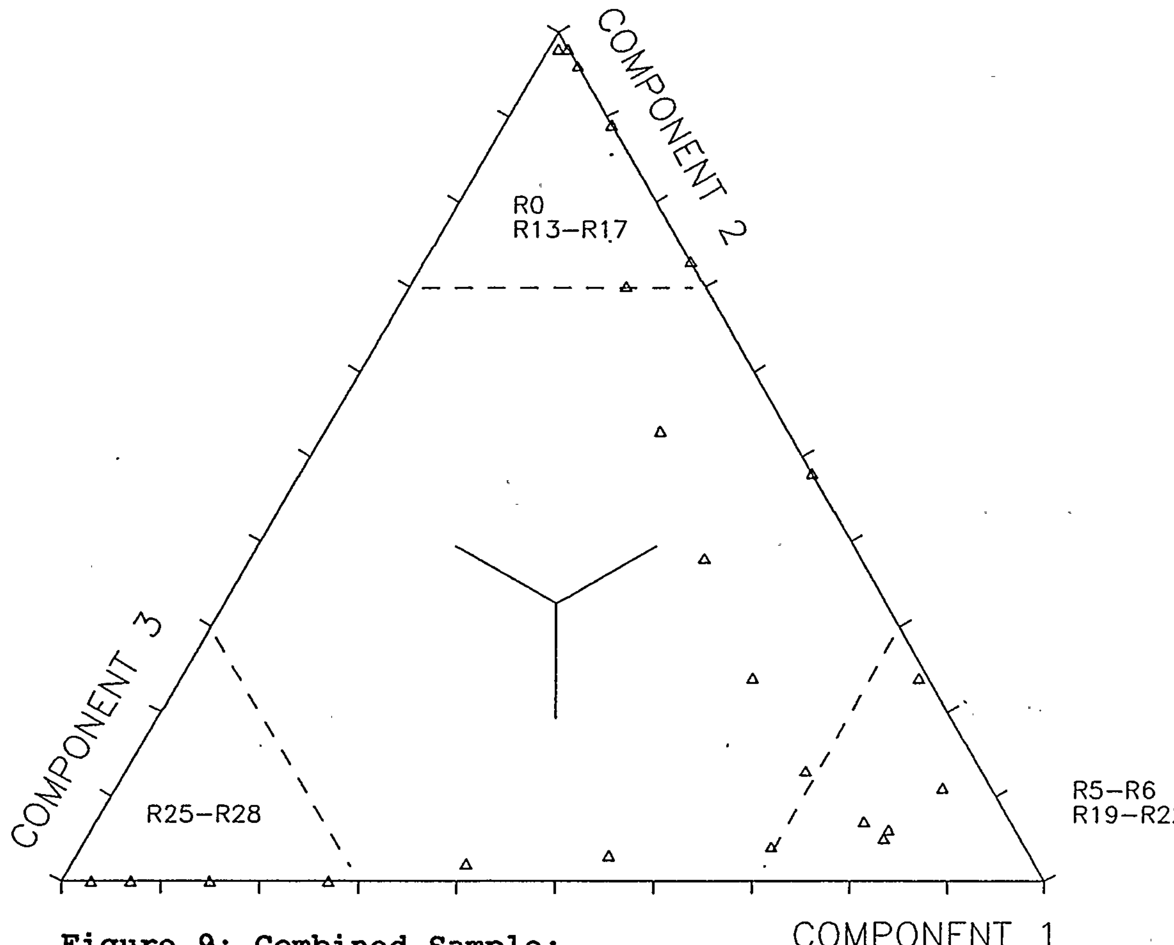


Figure 9: Combined Sample: Component Loadings

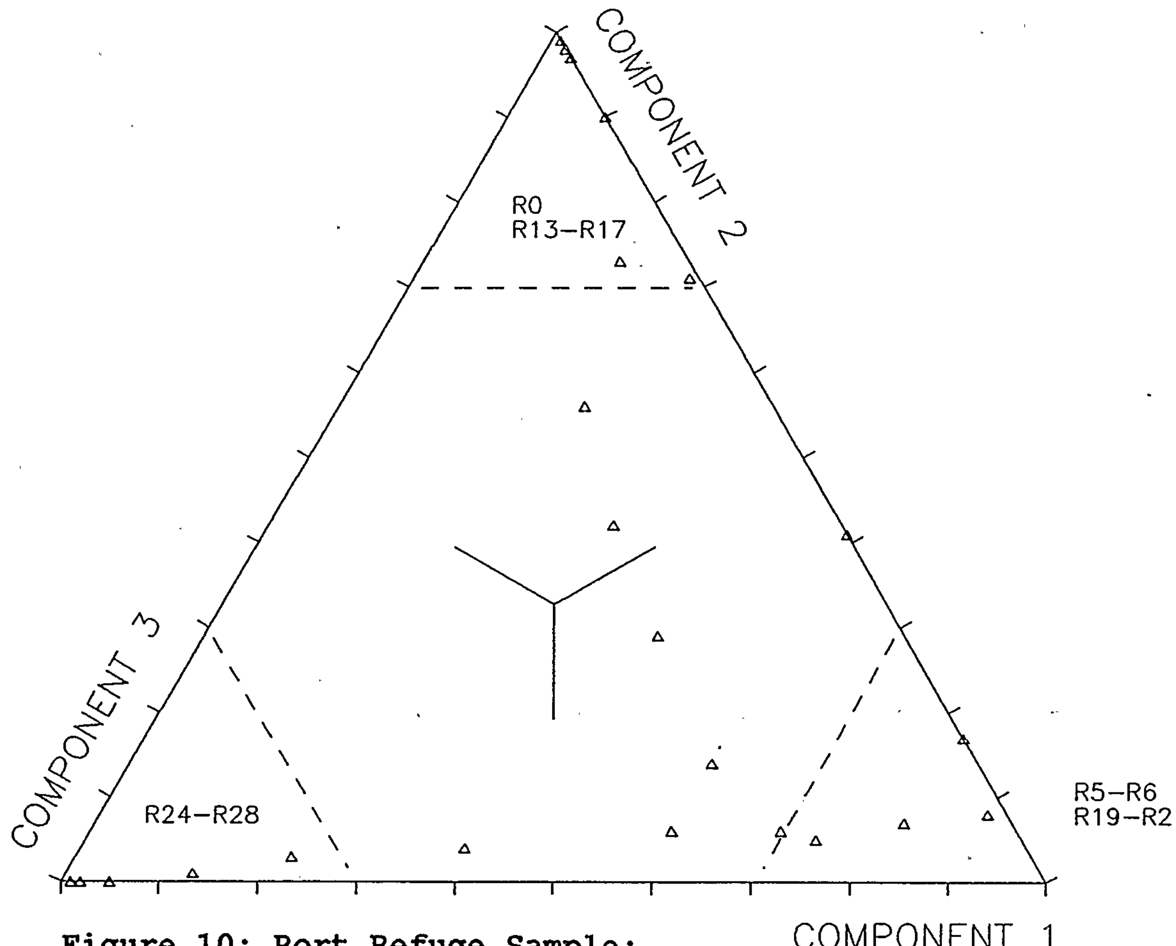


**Figure 10: Port Refuge Sample:
Component Loadings**

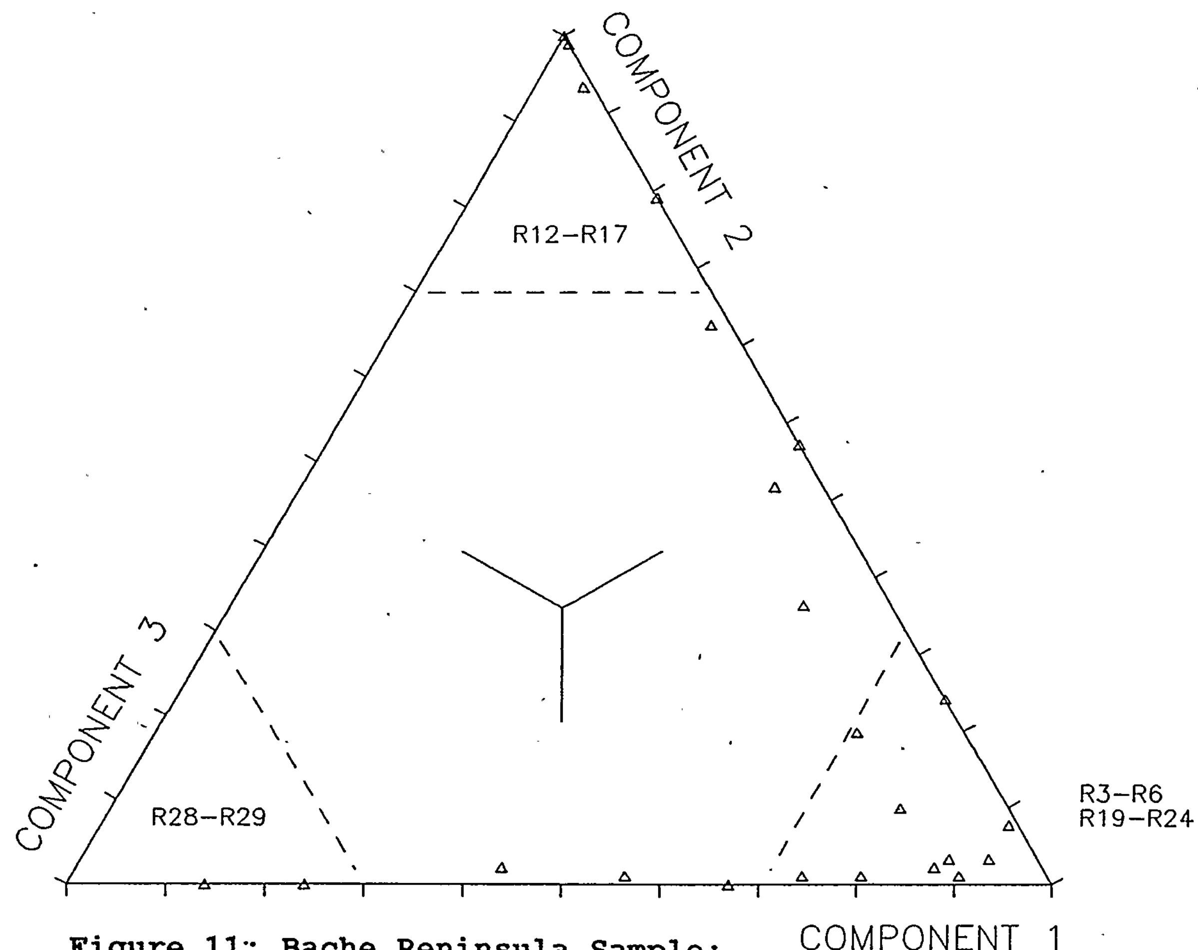


Figure 11: Bache Peninsula Sample: Component Loadings

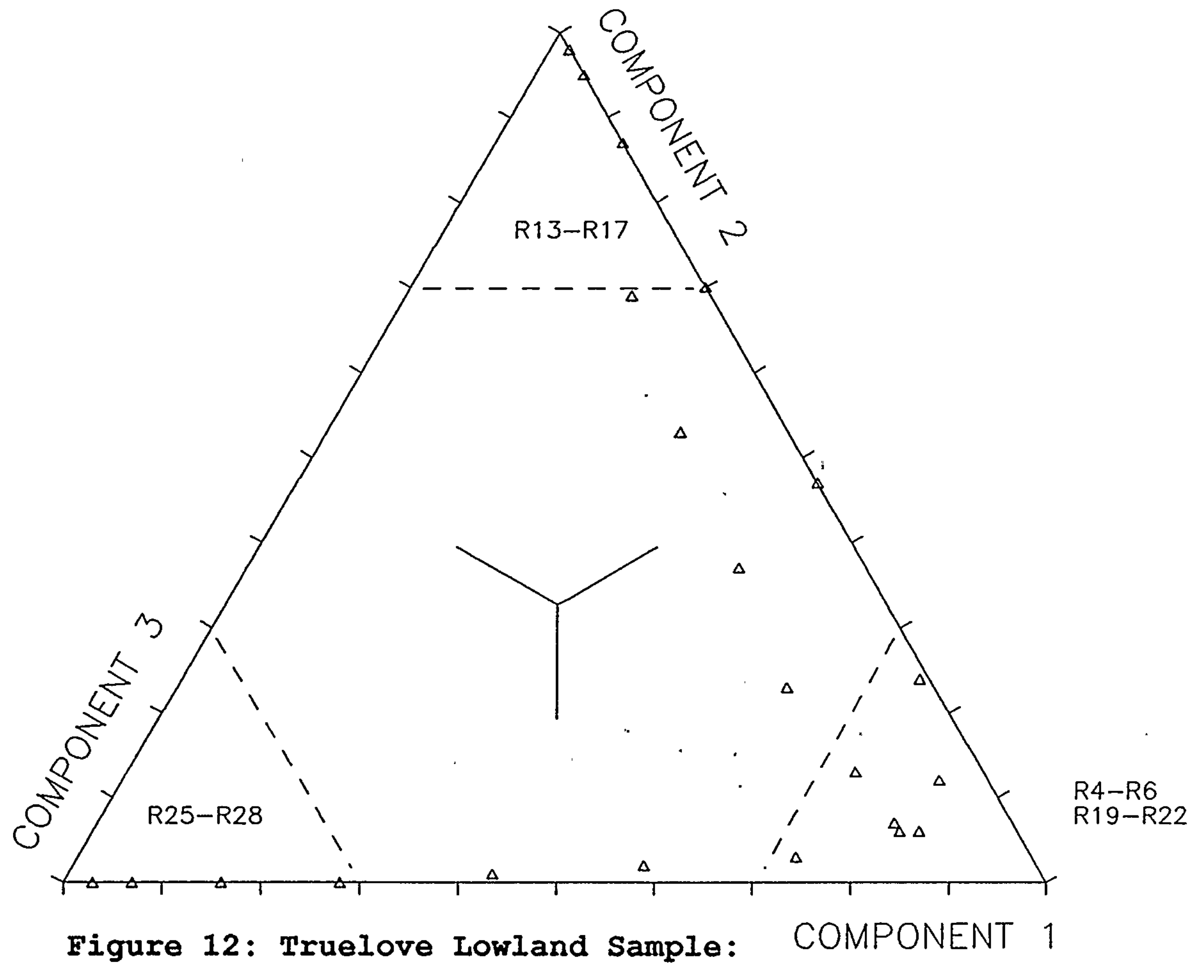


Figure 12: Truelove Lowland Sample: Component Loadings

contributed by its largest loading. An arbitrary figure of 70 percent was chosen as the cut-off for variable selection. This figure produces three sets of variables that are spatially discrete, and of roughly equal size. Variables for which the largest percent frequency is less than 70 were eliminated from further analysis.

After removing those variables that were ambiguous, or had relatively low communalities, a much reduced set of variables was generated for subsequent analysis, including description under a final principal components model. These are marked with asterisks on Tables 5-8. While the the composition of the refined data sets is fairly similar in each of the four samples, notable differences occur. Figure 13 indicates graphically which variables were represented in the final analyses. The closest agreement between the four samples occurs in the component 2 cluster lying between roughly 130 and 170 degrees (R13 and R17). In the Bache Peninsula sample, one more variable (R12) was retained than in the other three. Perhaps the greatest divergence between samples lies in the second component 2 cluster, at roughly 0 degrees (R0). While the Port Refuge and combined samples each retain a single variable in this portion of the data set, the Truelove Lowland and Bache Peninsula samples do not. Significant differences also appear among the variables associated with the distal lateral edge, opposite the spall edge. The three largest samples (combined, Truelove Lowland, and Port Refuge) are in general agreement,

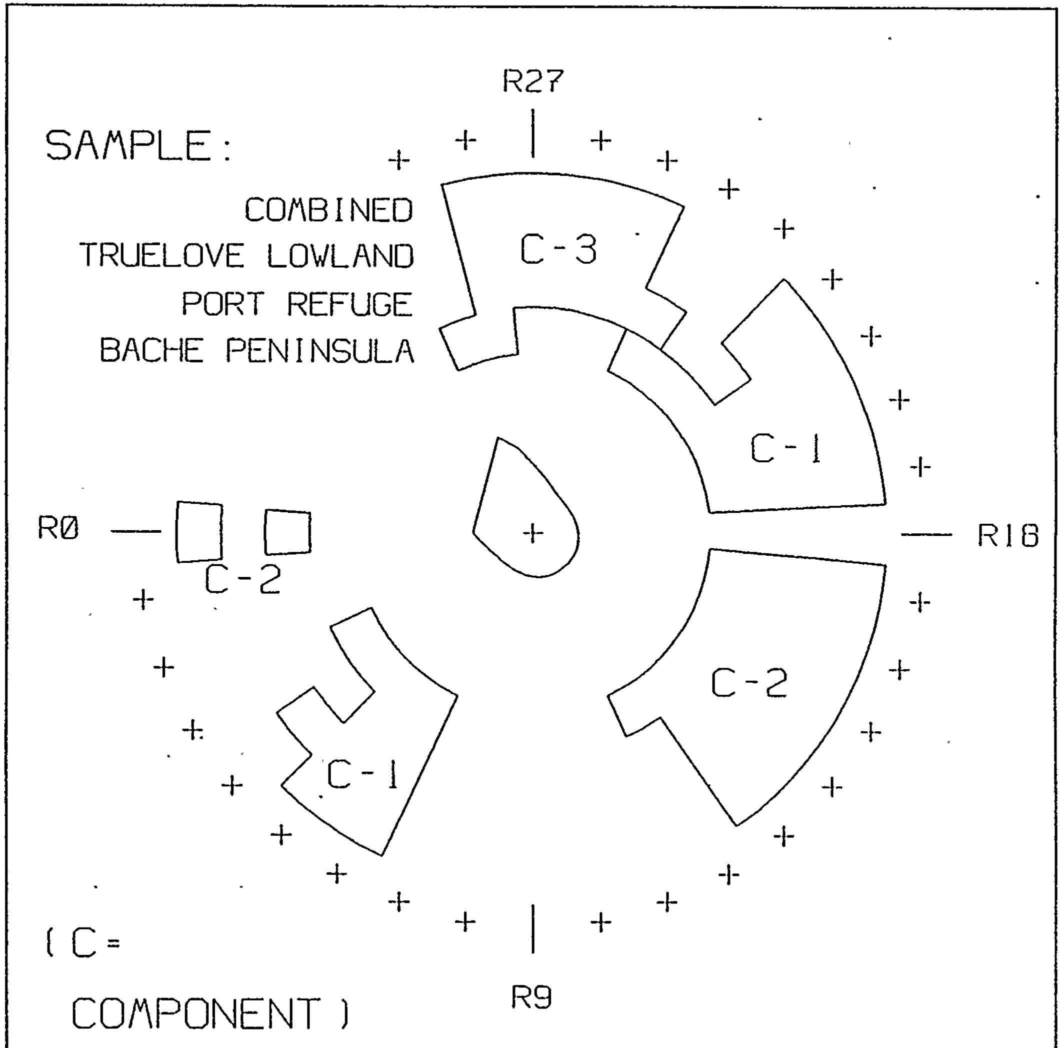


Figure 13: Variables Retained for Final Analysis

and allocate variables to component 3, and the second cluster of component 1, in a highly similar manner. The pattern of variables retained by the Bache Peninsula sample, on the other hand, is quite different. Component 3 is confined to two variables (R28 and R29) that barely overlap with those retained by the other samples, while the set of component 1 variables extends into a portion of the edge that the Port Refuge sample allocates to component 3. It is not surprizing that the combined and Truelove Lowland samples are in close agreement about variable allocation, especially before the 'weeding' process; the latter makes up 62.5 percent of the combined sample, and therefore can be expected to influence the results rather strongly. Differences and similarities in the patterns exhibited by the three isolated samples are more difficult to explain. In general the two largest samples appear to be in fairly close agreement with one another, while the Bache Peninsula sample is the most distinct. The separate and combined roles that differential sample size, data processing error, and regional data structure may play in this regard are extremely difficult to assess. The latter, most interesting possibility cannot be ruled out. The belief that variability **within** regional samples should ideally be addressed through variable sets selected specifically for that region, appears to be supported.

Cluster Analysis

While the principal components analysis is an essential step in the description of structure within the burin assemblage, the nature of higher level relationships between the artifacts themselves remains uninvestigated. The refined variable sets identified through PCA may provide a useful tool for conducting such an investigation. If the distribution of scores on these variables is discontinuous, it is possible that natural groupings of artifacts may be identified.

Associations between records, rather than the variables used to describe them, can be assessed through a number of different techniques, including a variant of principal components analysis. The option used here was cluster analysis, carried out on scores calculated on each of the three rotated components.

Cluster analysis attempts to place entities into groups that reflect a high level of shared similarity. In general, the degree of similarity exhibited within a group should exceed that exhibited between groups. Expressed somewhat differently, cluster analysis seeks to define point concentrations that are clearly separated from one another by regions of low point density. The fact that clear, cohesive concentrations do not exist in a data set does not necessarily preclude the definition of clusters; like principal components analysis, cluster analysis can impose structure where little, in fact, may really exist (Vierra and Carlson 1981; Aldenderfer 1982).

While perhaps most prominent in the field of biological taxonomy, cluster analysis has seen much application in the social sciences as well, including archaeology. Useful summaries of the technique may be found in Aldenderfer and Blashfield (1984), Sneath and Sokal (1973), Clifford and Stephenson (1975), and Davis (1986). Examples of its use in archaeology abound; useful summaries are included in Doran and Hodson (1975), and Orton (1980).

Many different approaches to cluster analysis have been developed, but all of them are characterized by two general stages of analysis. The first of these involves measuring the distance or similarity between individual entities. The second uses these measurements to group together entities so that some specified condition for cluster formation is optimized. A wide range of similarity measures and clustering algorithms have been invented and applied to cluster analysis. Different combinations of these will usually create different clusters in the same data set. The nature of the clustering technique selected appears to have a more profound effect on the outcome of the analysis than does the exact distance or similarity measure used. The differences that do occur may be reflected in the shape and size of the clusters formed, as well as in their density, and distance from other clusters (Aldenderfer and Blashfield 1984).

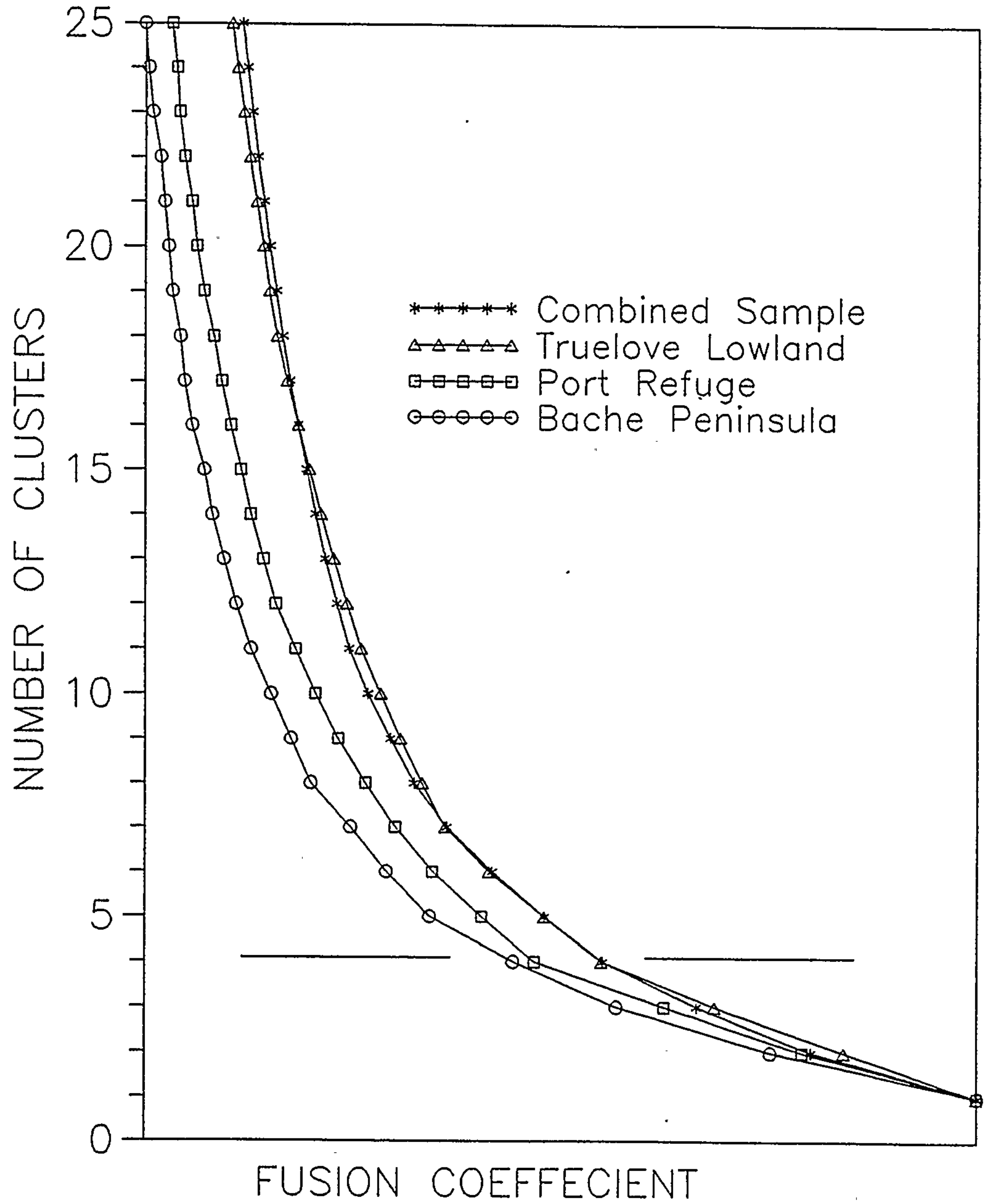
In order to prepare observations for cluster analysis, each of the variables retained in the previous phase of analysis were subjected to a second phase of principal components extraction. Component scores were calculated from the rotated component matrix using the regression option (Kim and Mueller 1978:66-67; Norusis 1985:148-150); these scores, in effect summarize the information contained in the original data, while reducing the cluster analysis to three dimensions. The advantage in reduced dimensionality may be somewhat offset by the fact that component scores are standardized, and forced to conform to a normal distribution with unity variance (Kim and Mueller 1978:72-73). Very subtle discontinuties may be slightly obscured by this procedure, and thus somewhat more difficult to identify in the analysis (Aldenderfer 1982:69).

The analysis of component scores was based on the CLUSTER procedure of release 2.1, SPSSX (SPSS Inc. 1986). A combination of Ward's (error sum of squares) clustering technique and a squared euclidean distance measure was chosen. Both of these options are biased toward the creation of clusters that emphasize elevátional over shape differences in the data profile under examination (Aldenderfer and Blashfield 1984:26,43-44). In this particular study, elevational differences equate essentially with relative size. As earlier examples suggest, size is one of the few quantitative distinctions that researchers have so far recognized in ASTt burin assemblages. Given the preliminary nature of this analysis, accepting a bias of this sort is therefore reasonable.

Figure 14 illustrates the relationship between the relative magnitude of fusion coefficients, and the cluster formation stages with which they are associated. 'Scree' plots of this sort may aid in determining how many significant groups a clustering procedure has identified. An abrupt flattening in the curve (a 'scree' zone) signals the merge of two relatively dissimilar groups, and hints at the presence of two relatively 'strong' clusters. In this particular example, interpretation is fairly subjective, and more than one cluster solution could probably be supported by the data. The horizontal line placed on Figure 14, however, is thought to represent a reasonable estimate of the start of flattening in these curves as a whole; a four cluster solution is therefore emphasized in subsequent analysis and discussion. It is possible, however, that significant groupings exist at somewhat higher levels as well, although this possibility has not been explored.

Although the ability of cluster analysis to impose groupings on homogoneous data provides a strong arguement for independent validation, this can be rather difficult to carry out. Most of the techniques that have been suggested are problematic in that they are biased in favour of certain clustering techniques, and against others. None are supported by statistical theory, and like cluster analysis

Figure 14: Artifact Cluster Analysis: Scree Plots



itself, are most appropriately viewed as heuristic devices (Aldenderfer 1982).

In this particular case, two approaches to cluster validation were attempted. The first of these, a simple examination of the cluster scree plots, has already been described. To reiterate, there are grounds for suggesting that relatively dissimilar groups begin merging at about the four cluster mark. How significant the implied clusters actually are is difficult to judge; at an intuitive level, they appear to be only moderately well defined.

In a second attempt to validate the clustering solution, scatter plots of the component scores were examined. Of course, it is extremely difficult to document three dimensional spatial discontinuities simply by examining multiple views in one or two dimensional space. Nevertheless, if clear separation exists in a lower dimension, it is very likely to persist, in some form, in higher dimensions as well.

Scatter plots (not reproduced here) were generated on each possible pair of the three sets of component scores, for each of the four samples. Possible discontinuities in point distribution were visible in only two plots; these were associated with the two smallest samples, from the Port Refuge and Bache Peninsula regions. In neither case however, was the separation especially compelling, and it is possible that apparent gaps in point distribution simply represent error associated with the relatively small sample sizes. The much larger sample from Truelove Lowland displays no hint of natural grouping, and the joint variation of each pair of component scores may approximate normality.

These limited attempts to validate the cluster solutions were not very encouraging. While the scree plots hint broadly at some sort of grouping, scatter plots offer only weak support to the possibility that these clusters reflect natural discontinuities in the data. With regard to the latter point, however, it is worth re-emphasizing the fact that a lack of modality in multiple lower dimensions does not preclude their existence at some higher dimension (Cowgill 1982:53).

A rather different type of validation procedure introduces the use of 'external' criteria (Sneath 1969). If variables not incorporated into the analysis are available, they can be compared to the cluster solution. Points of agreement and disagreement can be identified, and in some cases, the solution may be accordingly strengthened or weakened. Of course, if the adequacy of a cluster solution is judged soley on how well it conforms to external patterns, however relevant they may be to the problem at hand (Aldenderfer and Blashfield 1984:66), nothing new can be learned from it. If the comparison is approached with sufficient flexibility, however, insight into both the external and internal components, and their inter-relationship, might be gained. Partial aggreement, for example, may argue for the tentative acceptence of a solution, while at the same time suggesting a modified interpretation of either the external variables, the clusters, or both.

Whether the approach outlined above is better viewed as a validation technique per se, or simply the interpretive stage of analysis is a moot point. In this particular study, the latter view is favoured. As will be argued below, while temporal and cultural parameters, viewed as 'external variables', may provide the best arguement for the 'validity' of the cluster solution, they also, along with space, constitute exactly those dimensions of variability that this study hoped to address through quantitative artifact analysis.

CHAPTER 5

SECONDARY ANALYSIS

Interpreting a solution generated by cluster analysis can be difficult even when the groups formed prove ultimately to be both discrete and meaningful. The nature of the clusters formed, and the patterns they exhibit relative to other dimensions of variability are critical areas of inquiry that may initially appear rather opaque.

In this chapter, the interpretability of the clusters generated in Chapter 4 is increased by subjecting them to two secondary analyses. A technique for defining cluster 'type' specimens is first applied to the result of the four cluster solution. This is followed by a 'correspondence analysis', which, in conjunction with cluster analysis, generates information that clarifies the relationship between burin variability, and culture-historical units otherwise defined.

Cluster Type Specimens

It is often difficult to describe which characteristics are shared by clustered artifacts, and hence, what criteria caused the clusters to emerge in the first place. The insight gained by such a description can be considerable, however. Modes of behaviour may be implicated which in turn may allow higher level culture-historical interpretations to be significantly refined or modified.

Orton (1980:58-60) describes a graphic method for interpreting principal component solutions. A small subset of artifacts exhibiting the highest and lowest values of each of the retained components is identified, and these are then illustrated in a manner that facilitates comparisons between them. Their inspection may help contribute toward an intuitive understanding as to how dimensions identified by the principal components analysis are manifest in the original data.

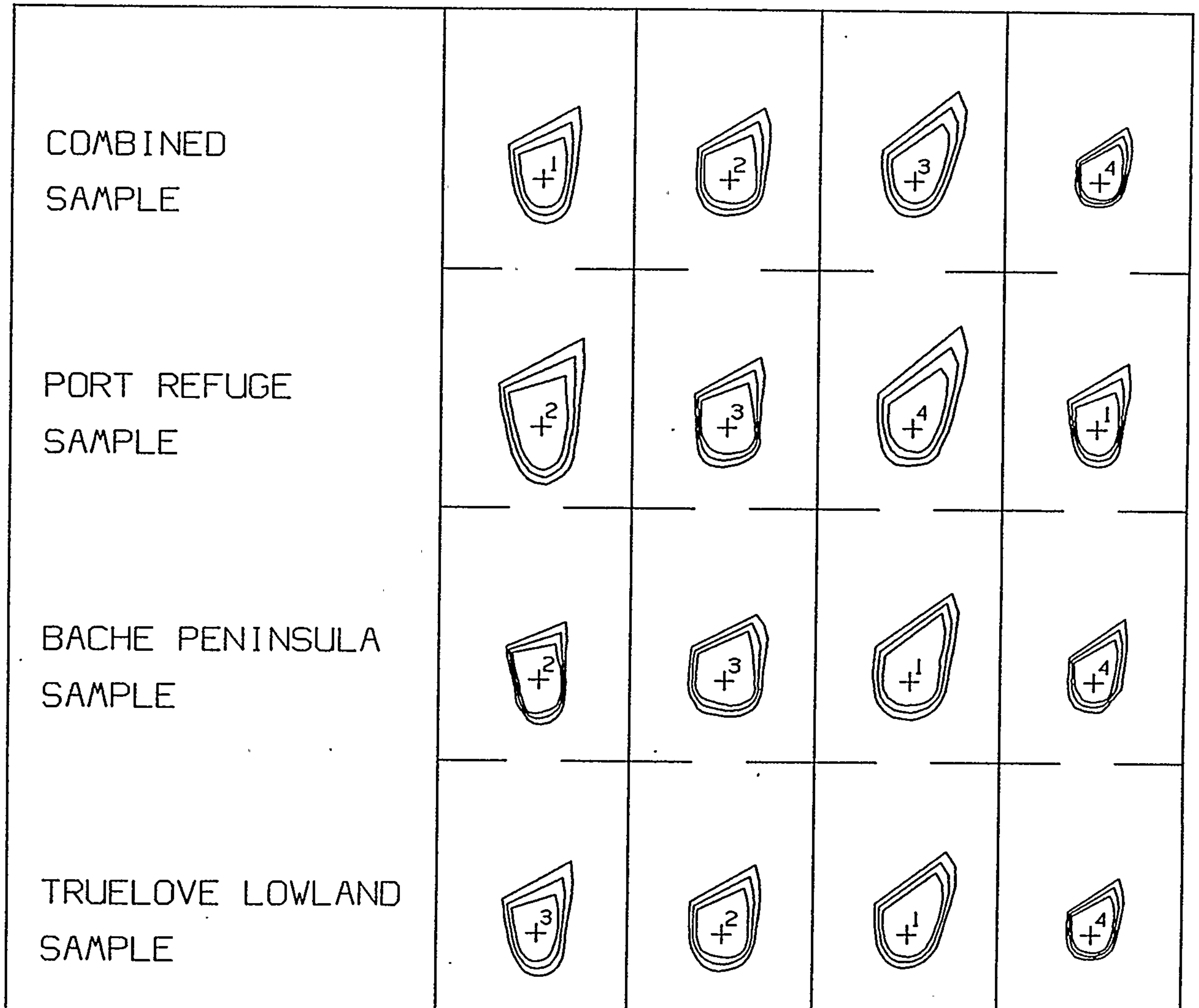
Assuming at least an ordinal level of measurement, this general approach can be applied to cluster analysis as well. Within each cluster, artifacts exhibiting the most extreme scores on the scales analyzed could be identified. Their illustration would then provide a gross visual summary of the variability within, and often between, each cluster. An adaptation of this approach, based on the definition of hypothetical 'type' burins, was used in this study, and implemented using an option written into RADSTAN. In essence, this component of the program calculates the mean and standard deviation on each of the radial variables (R0-R29) that define the standardized shapes of individual burins within each cluster. These values are then used to define an outline summarizing the distribution of descriptive variables contained within a discrete cluster. This outline, while having no exact counterpart in the actual artifact assemblage, serves as a concise expression of cluster membership, and can be viewed as a form of 'type specimen' for that cluster.

Examples of these outlines are contained in Figure 15, which is based on the four cluster solution for the combined, and three regional solutions. In each case, three concentric closed curves summarize the artifact shapes that characterize a given cluster. The middle curve is based on mean radii scores, while the inner and outermost record a single standard deviation on either side of the mean. Note that the outlines have been placed so as to emphasize concordance between regional solutions; the numbers that label each cluster are unique to the solution from which it derives, and simply reflect its position on a particular dendrogram.

The significance of these outlines is discussed more fully in Chapter 6. Here, it suffices to point out the general consistency in shape of the four cluster type specimens compared **between** regions. **Within** the regions however, each of the four clusters appears to be quite distinct.

Correspondence Analysis

In each of Tables 9-14, cursory inspection indicates that most assemblages with an appreciable sample size contribute at least some burins to most of the four clusters; few or none appear to be exclusively associated with a single cluster. Discrete burin types that correlate



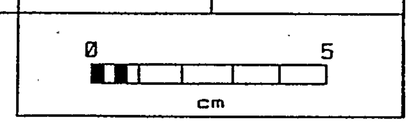


Figure 15: Cluster Type Specimens

Table 9: Cluster Type Frequencies Based on Regional Analysis: Port Refuge Sample

SITE/ COMP.	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
RbJu-01 ??	1	0	0	0	1
RbJu-01 Cold	9 (25.7%)	6 (17.1%)	10 (28.6%)	10 (28.6%)	35
RbJu-01 Embank-ment	0	1	0	0	1
RbJu-01 Gull Cliff	7 (17.1%)	3 (7.3%)	28 (68.3%)	3 (7.3%)	41
RbJu-01 Lake	2 (10.0%)	3 (15.0%)	9 (45.0%)	6 (30.0%)	20
RbJu-01 Lookout	0	0	2	0	2
RbJu-01 Upper Beaches	3	1	1	3	8
RbJu-02	1	0	0	0	1
RbJu-03	1	1	2	4	8
RbJu-05	2	0	0	0	2
TOTAL	26	15	52	26	119

Table 10: Cluster Type Frequencies Based on Regional Analysis: Bache Peninsula Sample

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
SdFh-04	2	0	0	0	2
SfFj-03	0	1	0	0	1
SfFk-06	3	0	1	0	4
SfFk-12	0	0	1	0	1
SfFk-22	1	0	0	0	1
SfFl-01	1	0	1	0	2
SfFl-05	1	0	0	0	1
SfFl-06	2 (22.2%)	6 (66.7%)	0 (0.0%)	1 (11.1%)	9
SfFl-08	1	0	0	0	1
SgFh-01	0	0	1	0	1
SgFl-05	0	1	1	1	3

Table 10: Cluster Type Frequencies Based on Regional Analysis: Bache Peninsula Sample (continued)

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
SgFm-06 1/1A	5 (41.7%)	0 (0.0%)	5 (41.7%)	2 (16.7%)	12
SgFm-06 2	11 (78.6%)	0 (0.0%)	1 (7.1%)	2 (14.3%)	14
SgFm-06 3	0	0	1	0	1
SgFm-06 9	2	0	0	0	2
SgFm-09	0	0	2	0	2
SgFm-16 1/2	0 (0.0%)	3 (30.0%)	0 (0.0%)	7 (70.0%)	10
SgFm-16 3	0	1	0	0	1
SgFq-04	0	1	0	0	1
SgFs-02	2	0	0	0	2
ShFm-03	1	0	3	0	4
TOTAL	32	13	17	13	75

Table 11: Cluster Type Frequencies Based on Regional Analysis: Truelove Lowland Sample

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
QkHl-01	3 (9.7%)	13 (41.9%)	6 (19.4%)	9 (29.0%)	31
QkHl-05 1	3 (20.0%)	7 (46.7%)	3 (20.0%)	2 (13.3%)	15
QkHl-05 2/3	6 (13.3%)	13 (28.9%)	15 (33.3%)	11 (24.4%)	45
QkHl-05 SC	1	0	0	0	1
QkHn-08 2	2	3	0	0	5
QkHn-11 1	0	0	1	1	2
QkHn-12	6 (12.5%)	18 (37.5%)	5 (10.4%)	19 (39.6%)	48

Table 11: Cluster Type Frequencies Based on Regional Analysis: Truelove Lowland Sample (continued)

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
QkHn-13	26 (22.6%)	50 (43.4%)	18 (15.7%)	21 (18.3%)	115
QkHn-15	1	1	1	0	3
QkHn-17 1/3	4 (14.8%)	12 (44.4%)	6 (22.2%)	5 (18.5%)	27
QkHn-17 4	1 (7.7%)	7 (53.8%)	3 (23.1%)	2 (15.4%)	13
QkHn-22	6 (30.0%)	9 (45.0%)	5 (25.0%)	0 (0.0%)	20
QkHn-27	2 (5.9%)	19 (55.9%)	2 (5.9%)	11 (32.4%)	34
QkHn-38 2	0 (0.0%)	5 (33.3%)	5 (33.3%)	5 (33.3%)	15
QkHn-38 4	4 (18.2%)	4 (18.2%)	5 (22.7%)	9 (40.9%)	22
TOTAL	65	161	75	95	396

Table 12: Cluster Type Frequencies Based on Combined Analysis: Port Refuge Sample

SITE/ COMP.	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
RbJu-01 ??	1	0	0	0	1
RbJu-01 Cold	18 (51.4%)	9 (25.7%)	8 (22.9%)	0 (0.0%)	35
RbJu-01 Embank-ment	1	0	0	0	1
RbJu-01 Gull Cliff	9 (22.0%)	28 (68.3%)	2 (4.9%)	2 (4.9%)	41
RbJu-01 Lake	9 (45.0%)	8 (40.0%)	3 (15.0%)	0 (0.0%)	20
RbJu-01 Lookout	0	2	0	0	2
RbJu-01 Upper Beaches	3	0	4	1	8
RbJu-02	0	0	0	1	1
RbJu-03	4	1	3	0	8
RbJu-05	2	0	0	0	2
TOTAL	47	48	20	4	119

Table 13: Cluster Type Frequencies Based on Combined Analysis: Bache Peninsula Sample

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
SdFh-04	1	1	0	0	2
SfFj-03	1	0	0	0	1
SfFk-06	0	2	2	0	4
SfFk-12	0	1	0	0	1
SfFk-22	0	1	0	0	1
SfFl-01	0	2	0	0	2
SfFl-05	0	1	0	0	1
SfFl-06	6 (66.7%)	1 (11.1%)	1 (11.1%)	1 (11.1%)	9
SfFl-08	0	0	1	0	1
SgFh-01	0	1	0	0	1
SgFl-05	1	1	0	1	3

Table 13: Cluster Type Frequencies Based on Combined Analysis: Bache Peninsula Sample (continued)

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
SgFm-06 1/1A	0 (0.0%)	11 (91.7%)	0 (0.0%)	1 (8.3%)	12
SgFm-06 2	0 (0.0%)	10 (71.4%)	4 (28.6%)	0 (0.0%)	14
SgFm-06 3	0	1	0	0	1
SgFm-06 9	0	2	0	0	2
SgFm-09	0	2	0	0	2
SgFm-16 1/2	9 (90.0%)	0 (0.0%)	0 (0.0%)	1 (10.0%)	10
SgFm-16 3	1	0	0	0	1
SgFq-04	1	0	0	0	1
SgFs-02	0	2	0	0	2
ShFm-03	0	4	0	0	4
TOTAL	20	43	8	4	75

Table 14: Cluster Type Frequencies Based on Combined Analysis: Truelove Lowland Sample

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
QkHl-01	11 (35.5%)	8 (25.8%)	3 (9.7%)	9 (29.0%)	31
QkHl-05 1	2 (13.3%)	9 (60.0%)	2 (13.3%)	2 (13.3%)	15
QkHl-05 2/3	16 (35.6%)	14 (31.1%)	5 (11.1%)	10 (22.2%)	45
QkHl-05 SC	0	1	0	0	1
QkHn-08 2	0	3	2	0	5
QkHn-11 1	1	1	0	0	2
QkHn-12	8 (16.7%)	19 (39.6%)	6 (12.5%)	15 (31.3%)	48

Table 14: Cluster Type Frequencies Based on Combined Analysis: Truelove Lowland Sample (continued)

SITE/ FEATURE	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
QkHn-13	31 (27.0%)	45 (39.1%)	22 (19.1%)	17 (14.8%)	115
QkHn-15	1	1	1	0	3
QkHn-17 1/3	12 (44.4%)	10 (37.0%)	1 (3.7%)	4 (14.8%)	27
QkHn-17 4	2 (15.4%)	8 (61.5%)	1 (7.7%)	2 (15.4%)	13
QkHn-22	9 (45.0%)	5 (25.0%)	6 (30.0%)	0 (0.0%)	20
QkHn-27	1 (2.9%)	20 (58.8%)	2 (5.9%)	11 (32.4%)	34
QkHn-38 2	6 (40.0%)	4 (26.7%)	0 (0.0%)	5 (33.3%)	15
QkHn-38 4	7 (31.8%)	3 (13.6%)	5 (22.7%)	7 (31.8%)	22
TOTAL	107	151	56	82	396

directly with culture-historical units do not appear to exist.

The large number of low expected frequencies, even after eliminating assemblages composed of small numbers of artifacts, invalidates the use of a chi-square statistic for testing the possible independence of assemblages and clusters. As an alternative way of testing the significance of the cluster results, a condensed crosstabulation between culture-historical units and cluster types was created. By reducing the number of cells relative to the marginal totals, it was hoped that a statistically valid chi-square estimation might be attainable. If a null hypothesis of independence proves untenable, it might be possible to discern some form of patterning in the cluster type frequencies displayed by each of the major culture-historical units.

In order to implement this test, assemblages were identified for which, according to their principal investigators, a sound if tentative culture-historical determination existed. These are the assemblages indicated in Tables 1-3 by the codes I, SQ, EPD, MPD, and LPD, without query marks. Frequencies were lumped according to these culture-historic units, and the latter crosstabulated with the four cluster types (Table 15). The percentage of total cells with frequencies less than 5 is 10, and none of these is less than 1; according to criteria established by Siegel (1956), a chi-square value is appropriate under these

Table 15: Cluster Type Frequencies:
Culture-Historic Units by Cluster Type

ASSEMBL. CLUSTER	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
I	44 42.7%	30 29.1%	28 27.2%	1 1.0%	103
EPD	68 28.3%	101 42.1%	33 13.8%	38 15.8%	240
MPD	22 25.3%	39 44.8%	9 10.3%	17 19.5%	87
LPD	3 7.5%	23 57.5%	2 5.0%	12 30.0%	40
SQ	16 80.0%	1 5.0%	1 5.0%	2 10.0%	20
TOTAL	153	194	73	70	487

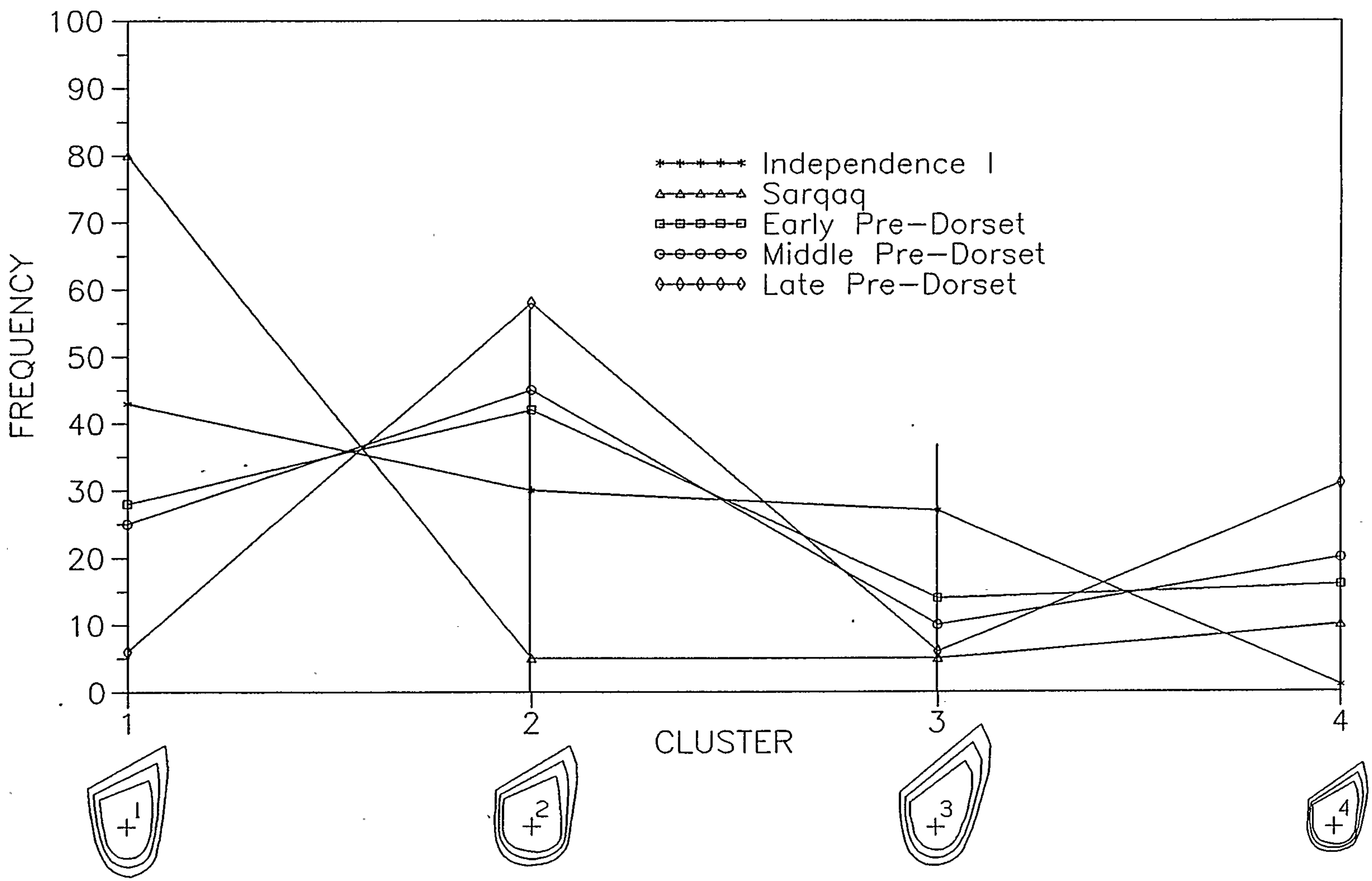
I = Independence I
EPD = Early Pre-Dorset
MPD = Middle Pre-Dorset
LPD = Late Pre-Dorset
SQ = Sarqaq

Chi-square = 79.39
DF = 12
Significance = 0.000

conditions. Given 12 degrees of freedom, the significance level of the calculated statistic is 0.000. It is thus highly improbable that the observed cell counts arise simply as a function of the probabilities implied by marginal totals. The null hypothesis of independence between culture-historic units and cluster type frequencies can be discarded with a high degree of confidence. These data are displayed graphically in Figure 16, where a clear separation exists between lines summarizing the cluster type frequencies for each culture-historical unit. The implications of these data will be discussed in the next chapter.

The possibility exists that cluster type frequencies relate in a non-random fashion to culture-historical units. This is encouraging, but does not by itself indicate whether this posited relationship would be useful, for example, for identifying assemblages of unknown culture-historical affiliation. The individual assemblages that underlie data displayed in Figure 16, for example, might overlap with those from other temporal periods; the apparent separation might to some extent be a fortuitous product of collapsed data. If, however, assemblages can be objectively grouped on the basis of cluster type frequencies, in ways that preserve their culture-historic affiliations, then the apparent correlation would be strengthened. So too would the utility of the burin as a tool for writing culture-history.

Figure 16: Cluster Type Frequencies: Combined Sample



A common technique for comparing and seriating assemblages on the basis of type frequencies involves the use of ogival curves (Jelinek 1962). The data are converted to percentage frequencies which cumulate between types, and then plotted on the same graph; the relative similarity of assemblages is reflected in the perceived degree of fit between individual curves. While this technique has seen wide application in archaeology, there are number of problems associated with its use (Kerrich and Clarke 1967). Perhaps the most glaring of these is the degree to which affinities between curves can be altered simply by changing the order of the types listed on the x-axis (Thomas 1971). When the scale implied by these types is nominal, they cannot be objectively ordered, and the resulting assemblage clusters are correspondingly arbitary. This problem aside, the difficulty of objectively defining clusters of large numbers of cumulative curves, simply by inspection, argues for the use of a different technique.

Davis (1986:579-589) describes a strategy for the analysis of frequency count data called correspondence analysis. Characteristic of this technique is the use of a data matrix in which elements represent conditional probabilities. While the relationship between rows and columns is preserved, the effects of unequal sample size is eliminated (Davis 1986:580-581). The matrix so constructed can be processed by the same range of multivariate techniques that normally assume continuous data.

In an attempt to objectively group burin assemblages based on cluster type frequencies, a form of correspondence analysis was integrated with cluster analysis. The combined sample was used, and only assemblages with more than nine artifacts were analyzed; this largely arbitrary number reflects a desire to include as many examples as possible of each culture-historical unit, and to minimize the sampling error inherent in small samples. (The cut-off value of 10 initially chosen provided only one Sarqaq sample for analysis).

The proximity measure used to generate the data matrix for correspondence analysis is one based on the chi-square statistic, available in the PROXIMITIES procedure of SPSSX, release 2.1 (SPSS Inc. 1986:737). The matrix was clustered using the error sum of squares (Ward's) technique; the dendrogram and scree plot that emerged from this analysis are illustrated in Figures 17 and 18. While the latter does not indicate any truely striking points of flattening, the best candidate is probably that associated with a three cluster solution, marked on Figure 18 with a solid line. Nevertheless, the possibility that meaningful clusters exist at higher levels was also investigated. Five culture-historical units have been distinguished in the sample, and it is possible that some or all of these may be discriminated by the cluster solution.

Table 16 lists the clustered assemblages, along with their respective culture-historical affiliations. The first

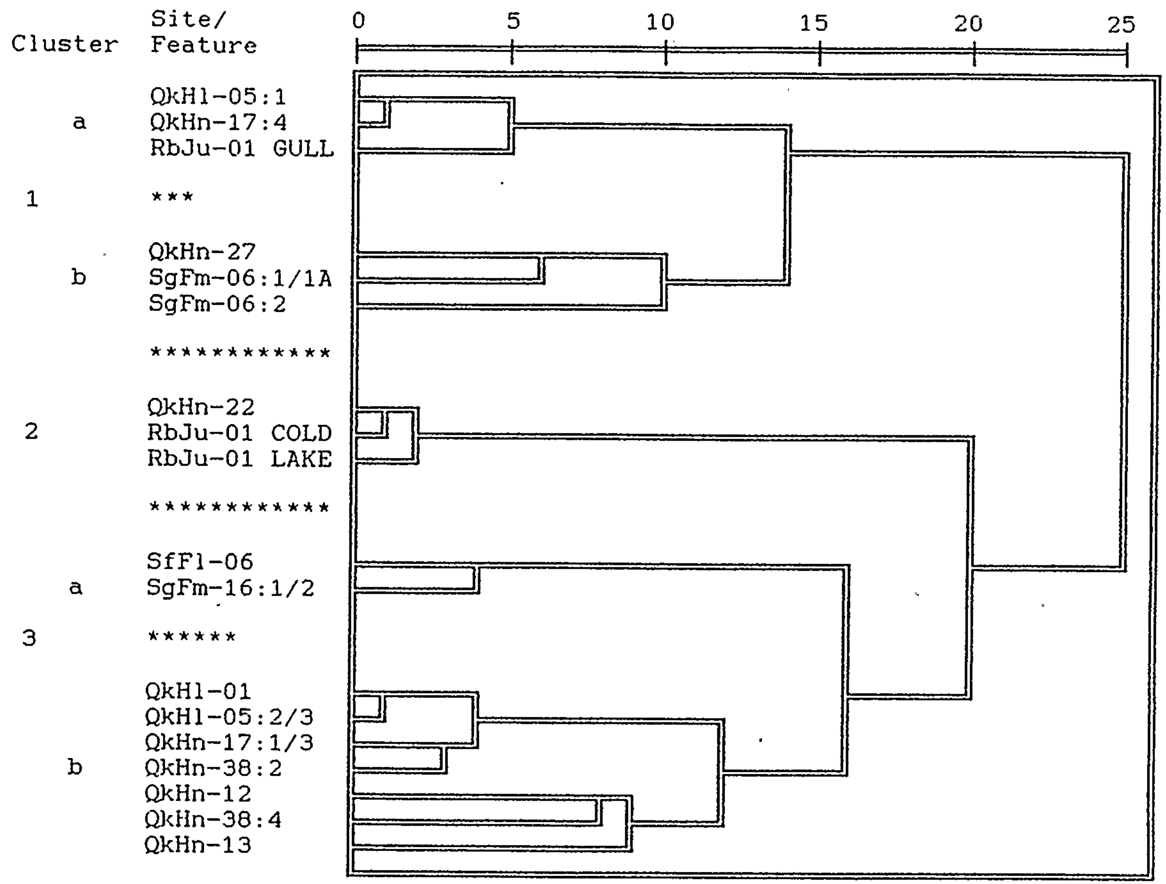


Figure 17: Assemblage Clusters Based on Cluster Type Frequencies

Figure 18: Assemblage Cluster Analysis: Scree Plot

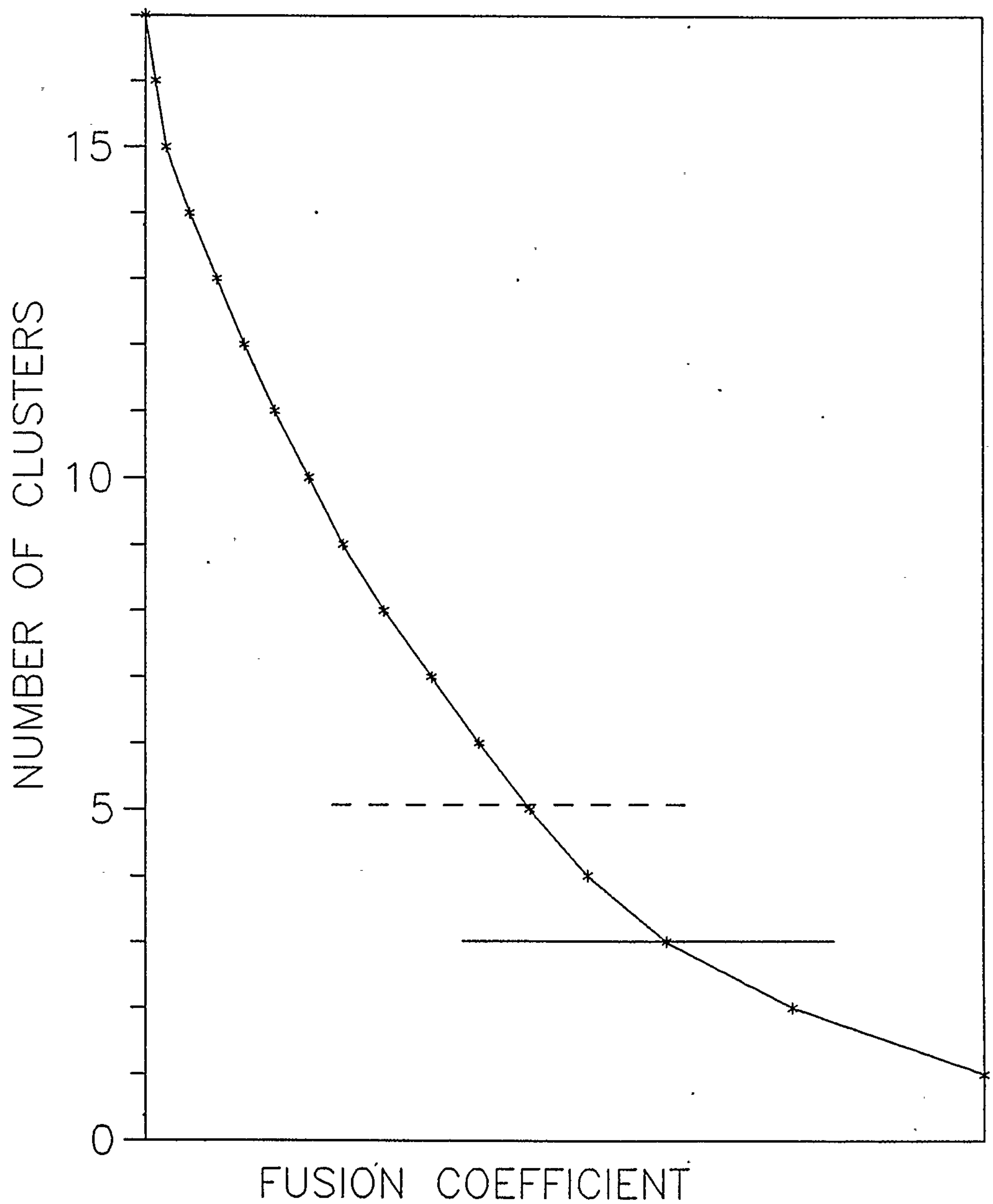


Table 16: Assemblage Clusters Based on Cluster Type Frequencies

CLUSTER	ASSEMBLAGE	CULTURAL AFFILIATION
1a	QkHl-05:1 QkHn-17:4 RbJu-01 GULL	Middle Pre-Dorset Early Pre-Dorset Early Pre-Dorset
1b	QkHn-27 SgFm-06:1/1A SgFm-06:2	Late Pre-Dorset Middle/Late Pre-Dorset Late? Pre-Dorset
2	QkHn-22 RbJu-01 COLD RbJu-01 LAKE	Independence I Independence I Independence I
3a	SfFl-06 SgFm-16:1/2	Sarqaq Sarqaq/Independence I?
3b	QkHl-01 QkHl-05:2/3 QkHn-17:1/3 QkHn-38:2 QkHn-12 QkHn-38:4 QkHn-13	Early Pre-Dorset Early? Pre-Dorset Middle Pre-Dorset Middle?/Early? Pre-Dorset Middle Pre-Dorset Early? Pre-Dorset Early Pre-Dorset

***** ********** ************************

Radiocarbon dates from clusters 1a and 3b:

1a	RCYBP	
RbJu-01 GULL	3790 +/- 55	(uncorr)
	3425 +/- 55	(uncorr)

3b	RCYBP	
QkHl-05:2/3	3770 +/- 180	
QkHn-17:1/3	3680 +/- 90	
QkHn-12	3535 +/- 90	
QkHn-38:4	3700 +/- 70	(uncorr)
QkHn-13	3850 +/- 95	(uncorr?)

three clusters are labelled 1 to 3; groups created by the four and five cluster solutions are identified as subsets of two of these. In subsequent discussion, especially where confusion may arise as to what cluster is being referred to, these will be described generically as 'assemblage clusters'; those generated in Chapter 4, and from which the latter derive, will be described as 'artifact clusters'.

Finally, Table 17 indicates the cluster type frequencies that emerge when assemblages are grouped together according to the results of the cluster analysis. The same information, based on percentage frequencies, are graphically displayed in Figure 19. The implications of these data will be discussed in the following chapter.

Summary

This chapter completes the methodological component of the study. A technique for the graphic description of artifact groups has been applied to the four cluster solution derived from the analysis of component scores. A cursory inspection of the result suggests that the regional cluster analyses produced roughly similar groups of artifacts.

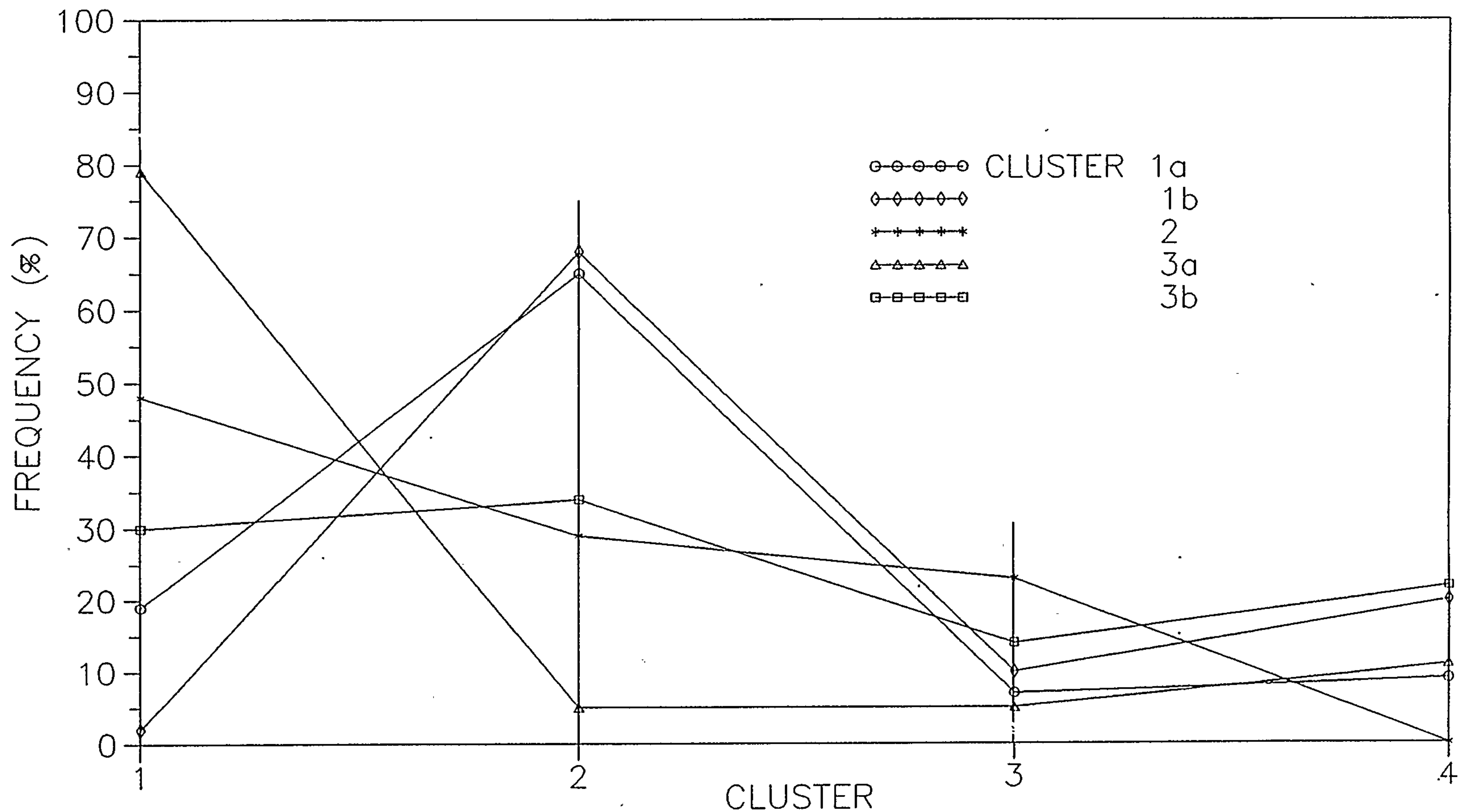
A chi-square test of independence was applied to a contingency table based on culture-historical affiliation and cluster type frequencies. While the statistic clearly favours an interpretation of dependence between the two, the nature or strength of the relationship remains untested. In order to shed more light on this possible relationship, assemblages with suitable sample sizes were grouped on the basis of cluster type frequencies, using a combination of correspondence and cluster analysis.

The implications of these procedures and their results are discussed in the next chapter.

Table 17: Cluster Type Frequencies:
Assemblage Clusters by Artifact Cluster Type

ASSEMBL. CLUSTER	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	# ART.
1a	13 (18.8%)	45 (65.2%)	5 (7.2%)	6 (8.7%)	69
1b	1 (1.7%)	41 (68.3%)	6 (10.0%)	12 (20.0%)	60
2	36 (48.0%)	22 (29.3%)	17 (22.7%)	0 (0.0%)	75
3a	15 (78.9%)	1 (5.3%)	1 (5.3%)	2 (10.5%)	19
3b	91 (30.0%)	103 (34.0%)	42 (13.9%)	67 (22.1%)	303
TOTAL	156	212	71	87	526

**Figure 19: Cluster Type Frequencies:
Clustered Assemblages**



CHAPTER 6

DISCUSSION

In this chapter, the data generated through the use of principal components, cluster, and correspondence analysis are reviewed and assessed.

Before proceeding with this discussion, a disclaimer is in order. While it is convenient to refer to the products of the cluster analysis as 'types', and to the summary outlines as 'type specimens', it is not implied that they necessarily represent discrete formal units in the burin assemblages analyzed here. As previous discussions have emphasized, the relative separation of clusters in multidimensional space is a difficult matter to assess, and in this particular study, the small amount of auxilliary evidence brought to bear on the matter was rather inconclusive. Further analysis may help resolve this matter, but at present, it is not clear that the clusters do not simply represent the dissection of largely continuous distributions. To many archaeologists, constructs so delineated will be incompatible with their concept of an archaeological type (cf. Spaulding 1982; see also Adams 1988). No such difficulty is envisioned here. Although the necessity of distinguishing different sorts of classificatory constructs in the pursuit of different culture-historical problems is quite clear, the use of the general term 'type' is justified simply by demonstrating that such a construct has the utility to address an archaeological problem. It is shown below that the cluster types defined in Chapter 4 have such utility, and are in fact relevant to the culture-history of the arctic.

Cluster Types

The first topic warranting more detailed consideration are the cluster type specimens illustrated in Figure 15. To reiterate, these provide a concise graphic summary of the shapes of artifacts grouped together by cluster analysis. Their description should clarify the nature of the clustering process, and perhaps suggest useful behavioural correlates.

Assessing similarities and differences between complex shapes is usually a subjective procedure. Except in the case of the most simple geometric forms, the distinction between size and shape is largely arbitrary and is as much an issue of semantics as logic. While the following discussion is based primarily on intuitive criteria, the general conclusions reached are nontheless thought to be valid.

The first observation suggested by Figure 15 concerns the dispersion of variable scores on the artifacts contained within the cluster types. Variables for which the variance is relatively small are identified by those portions of the outline marked by closely spaced lines. These represent points of maximum cohesiveness in the cluster, and tend to be concentrated in the basal half of the artifact, especially along the lateral edges. This can be attributed in part to procedures in the analysis designed to minimize the effects of variability contained within distal portions of the artifacts. It may also reflect constraints imposed by hafting behaviour, and the observation may be tentatively added to the other criteria (grinding and crushing) used to infer the use of handles.

It is argued that two very general shapes can be discerned within each of the four solutions, and that these can be further subdivided into two size classes. This is most clearly expressed by the cluster types contained within columns 2 and 4 of Figure 15. These outlines appear to reflect burin clusters that are characterized by short, broad bases, and roughly parallel lateral edges, the latter sometimes slightly incurvate. A large and small variety is distinguished, and these appear to be further differentiated by rather subtle differences of shape. In the case of the larger form, the lateral edges appear to expand slightly toward the base; in the smaller version, they appear to contract. The deviation from parallel orientation is slight however, and it is largely in this characteristic that they differ from the second group, illustrated by columns 1 and 3. In these two forms, lateral edges expand quite noticeably toward the distal end. Viewed in their entirety, they appear to be roughly similar in size, and are distinguished primarily by the length of the basal component, and the length and shape of the lateral edge opposite the spall scar zone. On the surface, the distal portions of these two forms appear to reflect a rather obvious difference in shape. This, however, is interpreted as being primarily a function of different base size. As the base increases in length, so must the distance between the centroid and the most proximal spall scar. This, in turn, alters the degree of artifact rotation during the standardization phase. Artifacts with short bases (column 3) are rotated less to the left (counter-clockwise), and thus, a relatively greater proportion of their distal end is captured by the 290 degree cut off (see previous chapter). The radial technique of artifact description can thus translate formal variability resulting from size distinctions into that appearing better to reflect shape.

While the functional significance of these distinctions is difficult to assess, it is tempting to argue that the shape differences relate to different hafting practices. The form with the expanding lateral edges may conceivably have been placed into the marrow cavity of a rib or other bone handle, in the manner suggested and illustrated by Gordon (1975:215), or it may not have been hafted at all. Perhaps the variety with the parallel edges was associated with a more elaborate, grooved, wooden handle of the type known to have been used by later Dorset craftsmen (Maxwell 1974). The posited size distinction may reflect differing functional requirements imposed by specific tool making activities. Interesting, and probably testable, these hypotheses should not be viewed as anything other than speculative.

Shifting attention to inter-regional differences, there is comparatively less that warrants comment. The regional analyses have produced remarkably similar clusters. It is interesting to note, however, that each of the Port Refuge outlines appear to be somewhat larger than those of the other two regional samples. The significance of this is unclear, but it is not improbable that differing characteristics of regional lithic sources may be a factor.

<u>Culture-Historical Patterning</u>

Figure 16 provides the first evidence that the frequency of cluster types within an assemblage may correlate with its relative age and culture-historic affiliation.

If the Sarqaq data is disregarded, it can be seen that the currently accepted culture-historical sequence is reflected in the magnitude of the percentage frequencies, and could be reconstructed simply by seriating the four sets of grouped data. The general trend expressed is quite simple. The quantity of burins with expanding lateral edges decreases steadily over time, and are as steadily replaced by the form with the broad base, and parallel lateral edges. This pattern holds up whether the two posited shape-variants are examined, or the four forms based on their sub-division.

It may be noted in passing that the small size-variants are generally outnumbered by the large, regardless of the period under consideration.

As a glance at Figure 16 will indicate, the Sarqaq assemblages appear quite distinct, and integrating this unit into the temporal seriation described above could not be done without ambiguity. The frequency of the first two cluster types in the Sarqaq sample would argue for a placement before Independence I. The profile of the third cluster type could support an age estimation somewhat after Late Pre-Dorset, while the fourth would suggest a position intermediate between Independence I and Early Pre-Dorset.

The Sarqaq sample is considerably smaller than the others, and the possibility of sampling error should be considered. However, the two largest assemblages contributing to the Sarqaq sample (SfFl-06, SgFm-16:1/2) are in close agreement with respect to artifact allocation, both favouring strongly the first cluster type (Table 13). If sampling error was responsible for the distinctive frequencies exhibited by the combined Sarqaq sample, it is unlikely that the two subsamples would display such similar patterns.

Of course, there is no reason to assume that a straight-forward temporal progression need be reflected in any or all of these data. The fact that such an interpretation appears to hold for the Independence I to Late Pre-Dorset sequence is an interesting analytical result that could be taken to argue for continuity within this sequence (Helmer 1988) . Divergence from this trend may support an equally interesting conclusion, i.e., that Sarqaq represents a variant of the Arctic Small Tool tradition that was distinct, and perhaps comparatively isolated from trends of cultural change in the Canadian High Arctic.

The result of the correspondence and cluster analyses summarized in Figures 17 and 19 and Tables 16 and 17 are considered next. To reiterate, the groups formed by these procedures should include assemblages with similar cluster type frequency profiles. Preliminary evidence suggests a correlation between temporal variability and the shape of these profiles. If this correlation has predictive value, these assemblage clusters should contain assemblages of similar culture-historical affiliation.

Clear homogeneity relative to culture-historic units is reflected in three of the clusters (Table 16). Cluster 2 is composed entirely of assemblages identified as Independence I. Cluster 3a includes both sites identified as Sarqaq, and cluster 1b contains all three assemblages associated with the Late Pre-Dorset period. This result is viewed as highly successful, in that the combination of cluster and correspondence analysis appears to have identified culture-historic distinctions within burins that had previously been based primarily on other, largely independent criteria. Two observations bear emphasis: first, the latter two clusters emerge with the four and five cluster solutions respectively; their existence is not indicated at higher levels in the dendrogram. The internal consistency exhibited by these clusters supports the arguement that distinct groups may exist at a level beyond that of the three cluster solution (Figure 18). Second, clusters 1b and 2 crosscut regional samples, suggesting tentatively that regional distinctions may be a less important source of variability in burin shape than temporal or cultural affiliation.

The observations that have so far been made function primarily as external validation criteria, much in the manner described by Sneath (1969) and Aldenderfer and Blashfield (1984). Perhaps somewhat tautologically, they support both the validity of the analytical techniques used, and establish the relevance of burin morphology to culture-historical research in the High Arctic. If these arguments are accepted, however, it may be possible to use the results of this study in a more generative manner.

As can be observed in Table 16, both clusters 1a and 3b are composed of a mixture of assemblages identified as Early and Middle Pre-Dorset. All but one of these is from the Truelove Lowland area, and in several instances, the culture-historical identification is uncertain. This fact has been commented on elsewhere, and has been attributed to the relatively continuous sequence of cultural development thought to be represented in these collections (Helmer 1988). Nevertheless, these two groups were separated from one another at the creation of the first two assemblage clusters, and their status as distinct clusters rests on the discernment of two other clusters (Sarqaq and Late Pre-Dorset) that are internally consistent, and appear to have clear culture-historical significance. It is tempting, then, to interpret clusters 1a and 3b in a similar light. In other words, patterning in the burin assemblages may indicate culture-historical units that have so far been difficult to objectively separate.

Retreating one level in the dendrogram, it can be seen that cluster 1a is grouped with the Late Pre-Dorset cluster (1b). In contrast, before cluster 3b forms a discrete group, it is associated with the Sarqaq (3a) and Independence I (2) clusters. On this basis alone, it could be suggested that the cluster 3b assemblages may be earlier than those of cluster 1a.

If the frequencies used to create these clusters are examined, more detail can be added to this argument. Table 17 and Figure 19 record the cluster type frequencies created by combining assemblages grouped together by correspondence analysis. In effect, these data summarize the distinct characteristics of each cluster, and by implication, reflect the differences that created them in the first place. They are thus analogous to the outline plots used to describe the data clusters created in Chapter 4. It was suggested earlier that the temporal progression from Independence I to Late Pre-Dorset is characterized by a decrease in cluster type 1 burins, and an increase in those of cluster type 2. If the Sarqaq cluster (3a) is ignored for the moment, this is seen to be the case with the first two of the artifact cluster types. In the first column of of Table 17, 30 percent of assemblage cluster 3b is composed of cluster type 1 burins, compared to only 19 percent in the assemblage cluster 1a. Conversly, only 34 percent of the assemblage group 3b is composed of cluster type 2 burins, while assemblage cluster 1a contains almost twice as many, or 65 percent. These observations are consistent with the interpretation that assemblage cluster 3b is older than assemblage cluster 1a.

This pattern does not hold in the case of cluster types 3 and 4, however, and the relative rank that might be predicted by frequencies on the first two are found to be reversed. Two points made by Figure 19, however, suggest that the hypothesis of a temporal distinction should not be too readily discarded. First, the amount of separation between the assemblage clusters is much greater when frequencies on the first two cluster types are observed. The frequencies on cluster types 3 and 4 are comparatively compressed. This, coupled with the fact that the great majority of burins fall into the first two clusters, suggests that the latter may be less affected by sampling error, and thus may serve better as tools for assemblage comparison and discrimination. (This argument is also supported by Figure 16). Second, the strong similarity in profile shape between cluster 1a and 1b (the Late Pre-Dorset group) tends to favour a late placement of the former; the same arguement, applied to the cluster 2 (Independence I) and 3b profiles suggests an early identification for the latter.

The above discussion is based entirely on data internal to this analysis. Unfortunately, it is difficult to bring much external evidence to bear on the hypothesis of a temporal distinction between clusters 3b and 1a. The second half of Table 16 lists the radiocarbon dates available from these two clusters; those that have discarded or invalidated by the investigator are not included. Taken at face value, these dates simply suggest temporal overlap. Given the fact, however, that the second group is represented by only two dates, and these from a split sample, it would be unwise to place much store in these data, and the temporal hypothesis is tentatively retained.

It was suggested in Chapter 3 that the Gull Cliff site from Port Refuge is affiliated with the Early Pre-Dorset period; this assumption was based primarily on two harpoon heads that resembled early forms from elsewhere in the arctic (see above). If this interpretation is correct, and applies equally to all materials from this site, then the ascription of cluster 1a (which includes the Gull Cliff materials) to a relatively late period is clearly not supported. The possibility of mixing at this site has already been mentioned however, and the harpoon heads (one of which came from a large midden deposit (McGhee 1979:92,158)) may be a product of an earlier occupation. This opinion was arrived at independently by Schledermann and Helmer, who consider several characteristics within the lithic assemblage to be incompatible with the undoubtedly early harpoon heads (Helmer 1988). Their view is supported by the results of this study.

It will be noted that this discussion, prompted entirely by a study of burins, has so far avoided the direct equation of these two clusters with the Early and Middle Pre-Dorset periods. These constructs, while still poorly defined, are intended to reflect variability in a constellation of artifacts and features. As much recent ethno-archaeological data reminds us, patterns of variability exhibited by one class of material culture need not correspond to that of another, even within a single society. This is equally true whether the variability is measured against space or time (Robertson 1987; Hodder 1982). While present evidence suggests that clusters 3b and 1a do, in fact, represent discrete temporal units, it is entirely probable that future analysis, based on a variety of tool types, will indicate a boundary between Early and Middle Pre-Dorset at a point that crosscuts the division suggested soley on the basis of burins. This is especially likely if the cultural continuity hypothesis proposed by Helmer holds up to future analysis. Having supplied the necessary qualifications, however, it is now suggested that the clusters identified by this analysis represent an objective means of subdividing the assemblages that appear to fall between Independence I and Late Pre-Dorset; so long as their highly tentative nature is recognized, they might as well be described as Early and Middle Pre-Dorset. More analysis is clearly called for. Hopefully, these conclusions will be challenged before too long.

CHAPTER 7

CONCLUSION

> "... one can manipulate the artifacts statistically without much concern whether one understands precisely what they originally were, exactly how they were used, and just what they meant to the ancients"
>
> (Wauchope 1966:19, in Binford 1981:196).

As research into northern prehistory continues, the need for detailed descriptive and classificatory studies becomes more and more apparent (Bielawski 1988:70). The variability manifest in Arctic Small Tool tradition sites and assemblages remains largly undocumented, and distinctions drawn between them are usually highly generalized, and frequently based on intuitive criteria. It is time to expose the full range of ASTt material culture to analytical scrutiny.

This study has contributed toward the solution of this problem by first documenting metric variability in Early Palaeo-Eskimo burin collections, and then exploring the data so generated for patterning of culture-historical significance. The results have been positive, and burins, at least when present in sufficient quantity, appear to have the potential for predicting the temporal and cultural parameters of the assemblages from which they derive.

Crucial to the analysis has been the development of a descriptive technique that allows standardized comparisons to be made within an artifact class that is inherently difficult to quantify. This technique, implemented through the use of a custom computer program, allows complicating factors such as artifact assymetry and differential curational behaviour to be eliminated from subsequent analysis. Data sets generated through this procedure, after being refined through principal components analysis, were subjected to cluster analysis. Clusters so defined were examined through a series of secondary analyses, including a second phase of clustering based on individual assemblages rather than artifacts; these exposed a relatively clear relationship between burin cluster type frequencies and temporal units defined on the basis of other criteria.

Two trends have been documented in this sample. Throughout most of the Early Palaeo-Eskimo sequence, the size of burins decreases steadily over time. Forms with expanding lateral edges dominate earlier assemblages, and are gradually replaced by a variety with parallel or sub-parallel lateral edges. Whether each of the four clusters from which these forms are interpreted represent distinct types in the Palaeo-Eskimo tool kit remains undemonstrated, and is probably unlikely. For any given period, the composition of burin assemblages appears to have been rather variable, and the former are distinguished from one another on the basis of the frequency, rather than the simple presence or absence of any of these cluster types. At present, they are best viewed as constructs with clear analytical utility, and largely unknown behavioural significance.

Assemblages clustered on the basis of cluster type-frequency are found in several instances to form surprisingly cohesive groups relative to previous estimates of age and culture-historical affiliation. Two clusters, however, appear to mix assemblages from the Early and Middle Pre-Dorset periods. Rather than view this as a failure on the part of the analytical technique, it is suggested that this presents an opportunity to objectively subdivide sites and features where it had previously been rather difficult to do so. An arguement is developed for a temporal distinction between these two groups, and tentatively, assemblages within them are identified as Early and Middle Pre-Dorset.

This analysis is viewed as being preliminary in nature, and there are undoubtedly many areas in which it could be refined. Many of the methodological procedures, for example, would benefit from further experimentation. Of particular concern here is the method used to control rotation during the phase of outline standardization. In this study, artifacts were rotated around the centroid until a common radian (0 degrees) intersected the primary spall scar. This approach was used because it was replicable and objective, but a better way may exist. A very different strategy that might prove useful is cross-correlation analysis. This technique is used to identify positions of maximum correspondence between two sets of time series data (Davis 1986:225). This approach could indicate positions at which pairs of artifacts were most similar to one another, and this provide information that could be used to standardize the rotation phase. The technique requires evenly spaced data, however, but this could easily be provided by calculating points of intersection between marginal segments and radial vectors before the rotation phase. Whether this approach would represent an improvement over the technique used in this analysis is as yet unclear. Variability injected simply as a result of the length of the first spall scar removed would probably be eliminated, however, and this might prove to be an advantage. Some procedure for reducing the effect of variability in the distal end of the artifact would still be required, but it would probably be possible to focus the cross-correlation analysis on a form of basal component, defined much in the same way as in this analysis. A final observation that favours future experimentation with this technique concerns the use of the radial method of artifact description for artifacts other than burins. Tools such as ovate bifaces are very difficult to quantify using traditional measuring techniques, and yet would be relatively easy to capture using a calculated centroid and a set of radial vectors. They generally lack features analogous to the primary spall scar of the burin, however, and a cross-correlation statistic might well prove to be the best check on degree of rotation.

In general, however, the procedures developed in the context of this analysis have served their purpose well; their best defence lies in the information they appear to have generated about change in one facet of Palaeo-Eskimo material culture. Future work with burins, however, would undoubtedly benefit by incorporating a number of well considered non-metric observations into the analysis. Patterning defined by a mixed-mode study such as principal coordinates analysis (Davis 1986) would likely be more complex than that described here, and perhaps more informative as well.

By way of a final conclusion, it may be stated that the pessimism first expressed by McGhee (1980) and subsequently adopted by Maxwell (1985) concerning the value of lithic artifact studies in High Arctic archaeological research has not been supported by this research. Burin morphology has been found to incorporate a significant amount of stylistic information that **can** be usefully applied to problems involving inter-assemblage comparison. It remains to be seen if the same generalization can be extended to other tools and artifacts that, in company with burins, allowed Palaeo-Eskimo populations to cope with their northern environment.

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