VARIABILITY AMONG FOUR ARCHAIC LITHIC ASSEMBLAGES IN THE PORCUPINE MOUNTAIN REGION, MANITOBA

by

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ABSTRACT

Collins' (1975) model of lithic technology is adapted to the investigation of quantitative variability among four Archaic lithic assemblages from the Porcupine Mountain region, Manitoba. The modifications involve the formation of 60 classes of lithic implements and debitage by which lithic technological behavior can be inferred.

The patterns observed through the initial application of the model are tested and refined using cluster and non-metric multidimensional scaling procedures. More detail in technological behavior is achieved when the results of all the analyses are combined.

Two of the assemblages exhibit a great deal of similarity, and their composition is seen to result from activities focusing of the manufacture of tools intended for export to other sites. The other two assemblages are not so similar to each other, and their contents were probably produced through activities primarily related to tool use.

The derived behavioral inferences as well as geographical information are used to propose technological factors that account for variability in Archaic lithic assemblages in the Porcupine Mountain region. These factors include precision in lithic reduction, utilisation of debitage, removal of cortex, amount of debitage produced, amount of

secondarily trimmed bifaces produced, and these are all related to the proximity of sites to Lake Agassiz shoreline features.

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This thesis is dedicated to my parents.

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CHAPTER 1

INTRODUCTION

The aim of this thesis is to investigate factors responsible for quantitative variability among four Archaic lithic assemblages from the Porcupine Mountain region, Manitoba. This is done by considering stone artifacts in a technological framework that incorporates the by-products as well as the end-products of stone tool manufacturing activities. As is discussed in Chapter 2, the Archaic period in Manitoba has been previously examined primarily in culture-historical terms. The chronology and origins of certain prehistoric cultures have been studied, but the processual aspects of technological adaptations of Archaic peoples has not until recently received much treatment.

Within contemporary culture-ecological theory, technology is a suitable conceptual base through which ecological patterning may be examined, as is aptly stated by Harris (1975: 156):

> The ecological adaptation of a particular culture depends upon the technology it has for obtaining, transforming, and distributing energy. Thus at the base of every culture are the tools, machines, techniques, and practices relating human existence to the material conditions of specific habitats.

Archaeologists' data consists largely of the remains of material culture, and it is our task to reconstruct and explain the cultural context of those remains. It is important to understand that all archaeological materials are ultimately products of disposal activities, and that many kinds of behavior may result in the desposition of artifacts. Schiffer (1972: 1976) has approached this issue using a set of research strategies known as Behavioral Archaeology. The methodology of Behavioral Archaeology treats artifact assemblages and their spatial occurrences as end-results of activities responsible for their production, use, maintenance, and disposal. Schiffer's definition of activity is congruent with Harris' (1975) definition of the "ecological sector" of culture

> An activity is a transformation of energy, minimally involving an energy source, often human, acting on one or more proximate material elements. (Schiffer 1972: 157).

Archaeologists observe the material results of behavior, in what Schiffer (1972) calls the archaeological context of research. The aim of research is to reconstruct the systemic context, or the cultural reasons for the artifacts' morphological and spatial variability. It is also necessary to detail the influence post-depositional processes may have on the nature of variability.

While technological variability is the central concern of this thesis, variability is produced in many other cultural contexts. Binford (1962) has provided a general way of approaching other sources of artifact variation. This thesis deals primarily with "technomic artifacts", which "have their primary functional context in coping directly with the physical environment". Socio-technic artifacts express variability as a result of their participation in the "social subsystem of the total cultural system", and ideotechnic artifacts "signify and symbolize the ideological rationalizations for the social system" (Binford 1962: 218-220). In this approach and others (eg. Binford 1965), Binford's main point seems to be that archaeologists will not be able to explain artifact variability generated through the social or ideological systems, until the variability exhibited through participation in the ecological system has been accounted for.

Schiffer's (1972) general approach has been used by Collins (1975) to produce a model of lithic technology that outlines the kinds of behavior responsible for the formation of certain lithic artifact classes. Collins (1975: 25) states that his model is a specific example of Schiffer's methodology, in which the linear process of lithic reduction (systemic context) is archaeologically observable as seven artifact groups. Analysis of the artifacts identified as belonging to the "product groups" results in inferences about the nature of the activities which produced them. Collins' model is presented in detail in Chapter 5, where two problems with the model are addressed. The first of these concerns a lack of explicitness in tool classification, which is resolved by presenting morphological criteria for the assignment of tools to specific reduction stages. The second problem is that the analytical importance of lithic debitage is not fully realised in Collins' general model. Following Collins' (1975: 15) stricture that lithic analysts should "... be capable of extracting the maximum possible understanding of human behavior from the limited data", attributes of lithic debitage are presented as indicators of lithic reduction activities.

Lithic artifacts here include all stone items produced in past human activities. Thus the by-products of stone tool manufacture as well as the tools themselves should figure prominently in inferring the behaviors responsible for the observed inter-assemblage variabilities. This last point is important to lithic analysis in general. Although it has been pointed out that tool manufacturing wastes generally comprise "... from 50 to 90 percent of the total specimens" of Paleolithic assemblages (Bordaz 1970: 45), archaeologists have not until recently considered debitage to be as significant in analyses as the tools.

For archaeologists interested in the reconstruction of site activities, and the explanation of behavioral relationships among prehistoric sites, lithic debitage is a material product with at least two distinct advantages: a) The debitage retains the attributes relevant to reconstructing artifact reduction sequences as readily as the artifacts themselves (Sheets 1975: 369); and b) Debitage is far less subject to relocation or curation than are tools (Collins 1975: 19). By constructing a set of lithic debitage classes this study permits refinement of descriptions of lithic technological systems.

Technological comparisons of the four assemblages are made with reference to 60 implement and debitage classes constructed within Collins' general model. General similarities and differences among the sites are examined in terms of lithic reduction activities using raw counts, relative frequencies and densities of more than 12,000 artifacts.

The usefulness of the general patterns observed through the initial application of the model is examined using Q-mode hierarchical clustering. Cluster analysis is applied to three sets of data: a) total artifact frequencies; b) implement frequencies only; and c) debitage frequencies. The cluster groups obtained support the previous interpretations and furnish further insights. The behavior responsible for inter-assemblage variability is thus better understood, but certain problems become apparent when the results of the three cluster analyses do not completely agree. Also, the utility of the artifact classification is somewhat obscured by the grouping effects of the cluster analyses.

Greater detail in behavioral inferences is made possible through the use of non-metric multidimensional scaling. This technique aligns the assemblages along dimensions or vectors that are subject to interpretation with reference to individual and grouped artifact frequencies, densities, and ratios. To enable accuracy in the final interpretations of inter-assemblage variability, the results of both statistical procedures are compared and combined.

In the concluding chapter, cultural and environmental factors are proposed which account for quantitative inter-assemblage variability, and these are also presented as being relevant to the entire Porcupine Mountain Archaic.

CHAPTER 2

THE ARCHAIC IN MANITOBA

Nearly all of the archaeological research undertaken in the Porcupine Mountain Region is a direct result of the Glacial Lake Agassiz Survey initiated in 1965. The GLAS crews had recorded the existence of more than 400 sites in the province by 1968, with the western portions yielding the highest density of sites (Hill 1965; Tamplin 1966, 1967).

As presented mainly in the works of Pettipas (1967, 1969, 1970), the Campbell Beach of Glacial Lake Agassiz was first occupied by Paleo-Indian peoples around 8000 years ago. Pettipas' data consisted of surface finds only, and none of the materials have been absolutely dated. It is reasonably certain, however, that the area was not occupied while the beaches were active, and the frequent occurrence of Paleo-Indian materials within the Lake Agassiz basin provides a maximum date only. Haug (1977) reports on a Paleo-Indian living floor near Duck River (ElMb-10). Excavations there also failed to produce datable materials, but Haug was able to isolate tool kits and activity areas using statistical techniques of cluster and spatial analyses. Other Paleo-Indian remains have been uncovered in controlled excavation and survey in the Caribou Lake area in eastern Manitoba (Wheeler 1978: 11).

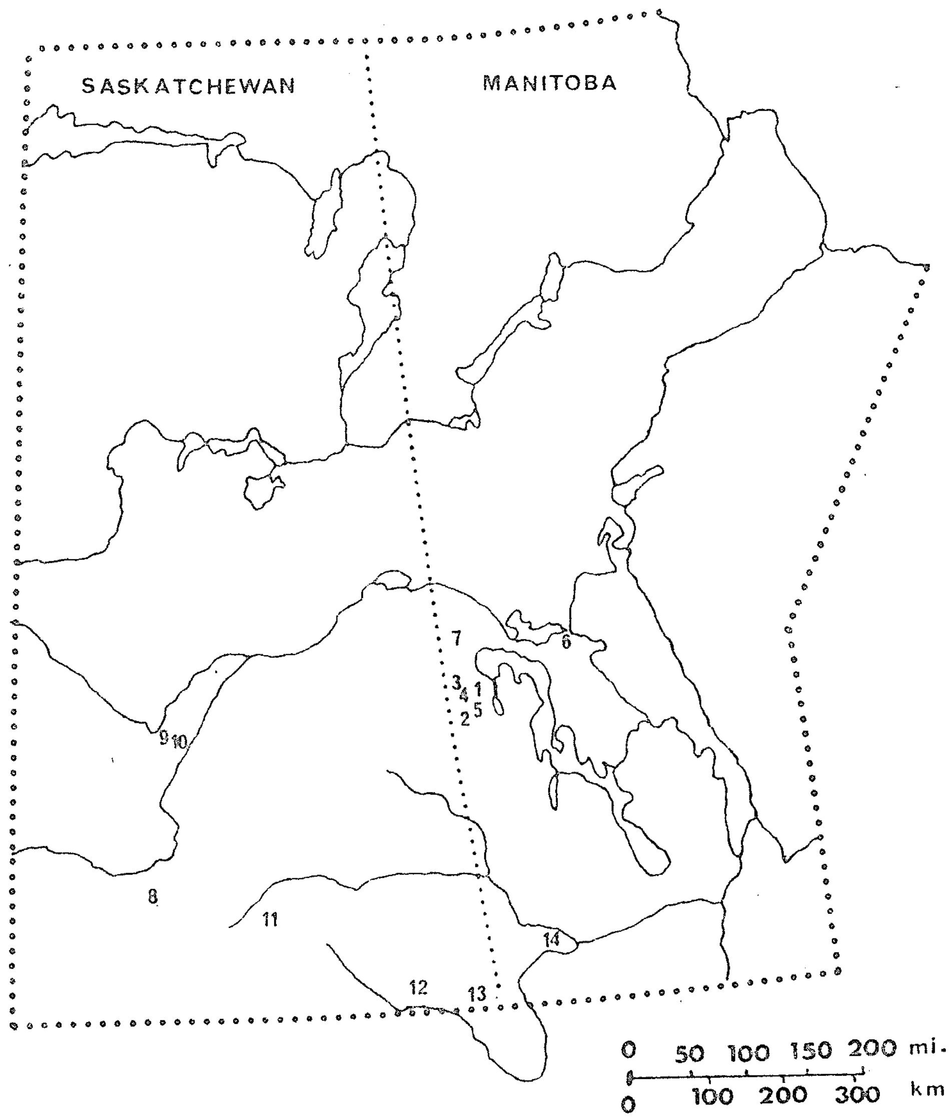
The lack of a chronology for Paleo-Indian occupations in the region results in a puzzling absence of cultural materials that can be typologically assigned to ca. 6000 to 4000 years BP. This apparent cultural hiatus on the northern plains may be a product of several independent factors, such as incomplete sampling, post-depositional disturbance, and a lack of recognition of diagnostic artifact forms (Reeves 1973: 1221).

The occurrence of Archaic or Middle Prehistoric Period assemblages in south and central Manitoba has been more thoroughly documented than Paleo-Indian remains (Colwill 1973; Gryba 1976, 1977; Haug 1976; Magne 1978; Mayer-Oakes 1967, 1970; Simpson 1970 a, b; Syms 1969, 1970, Figure 1). The most complete study of Archaic sites in Manitoba is that of Syms (1969, 1970), who synthesised the then available data relevant to the development of the McKean Complex in Manitoba. At the time of his study, Syms placed a terminal date of 1000 to 600 BC for the McKean Complex on the "marginal Canadian Plains" (1970: 131). Recent research at sites producing Archaic assemblages has resulted in more temporal data, and Haug (1976: 54) would extend the duration of the Archaic to as far as "the tenth century AD".

Often found in association with McKean lanceolate points are distinct, eared, concave-based projectile points known as Oxbow (Nero and McCorquodale 1958). Assemblages with Oxbow points are considered by many researchers to belong to a separate complex (Haug 1976; Mulloy 1958; Syms 1969, 1970). The co-occurrence of McKean and Oxbow points has been noted for a series of surface sites in the Swan River Valley (Gryba 1976, 1977), and two of the assemblages analysed here, AG19 and UN55, contain both Oxbow and McKean specimens. It should be noted here that the occurrence of Duncan and Hanna points is far less understood than the relationship between McKean and Oxbow, although both Duncan and Hanna points have been found in McKean and Oxbow assemblages.

The conclusion reached by Dyck (1977: 5-6) that "... too little is known about the Oxbow Complex and its neighbours for the establishment of either spatial and temporal connections", seems to be overstated. The occurrence of a large McKean/Oxbow component at the Tailrace Bay site suggests a northern range for the complexes (Mayer-Oakes 1970; Tamplin 1977, Figure 1). A compilation of 26 radio-carbon dates for McKean-Oxbow components in Manitoba and Saskatchewan demonstrates some temporal range, but it is interesting to note that the range of dates for Oxbow components overlaps the range of dates for McKean components (Table 1; cf. Syms 1969: 171).

Mulloy (1958) and Syms (1969, 1970) place the origins of the McKean Complex in the foothill and basin regions of



1 PH1
2 AG15
3 AG19
4 UN55
5 FbMi-5
6 Tailrace Bay
7 The Pas
8 Grey Site
9 Harder
10 Moon Lake
11 Mortlatch
12 Long Creek
13 Oxbow Dam
14 Cherry Point

Figure 1. Locations of Archaic Sites Referred To In The Text

Wyoming and Montana. A developmental relationship between late Plano cultures and McKean has been suggested in the high-altitude regions of Colorado (Benedict and Olson 1973). The Oxbow Complex, however, is seen as developing out of several early Archaic side-notched point traditions in the more northerly foothills of the Rockies (Reeves 1973: 1245).

A somewhat different view is taken by Mayer-Oakes (1970: 368) who suggests that Archaic cultures from the east and southeast moved into Manitoba prior to the McKean-Oxbow complexes. Resolution of these problems of spatial and temporal overlap is not crucial here, but the discussion above has shown that the archaeology of the Archaic in Manitoba has emphasised description and culture-history.

The temporal range of this part of the Archaic in the Porcupine Mountain region is approximately 5000 years BP (Oxbow Dam site) to as recently as 2000 years BP (Cherry Point site, Occupation B; Table 1). Haug's (1976) estimate of 1000 BP for an upper temporal range of the Archaic is based on a Pelican Lake component, for which no diagnostic materials have yet been uncovered in the Porcupine Mountain region.

The approach taken here requires simply that the peoples who manufactured McKean, Oxbow, and Duncan projectile points be regarded as roughly contemporaneous in the Porcupine Mountain region. It is possible that their

RADIOCARBON DATES BEFORE PRESENT (UNCALIBRATED)	SITE	LEVEL	CULTURAL COMPONENT	REFERENCE
1015 ± 105	Cherry Point	A	Pelican Lake	Haug (1976)
1040 ± 185	Cherry Point	A		
1580 ± 325	Mortlatch	4B	Besant	Wettlaufer (1955)
1850 ± 100	Cherry Point	B	Oxbow	Haug (1976)
2060 ± 130	Cherry Point	B	Oxbow	
2243 ± 100	Long Creek	4	Pelican Lake	Wettlaufer & Mayer-Oakes (1960)
2330 ± 130	FbMi - 5		Archaic	Colwill (1973)
2400 ± 290	Mortlatch	4E	Oxbow	Wettlaufer (1955)
2830 ± 260	Cherry Point	C	Oxbow	Haug (1976)
2860 ± 205	Cherry Point	C	Oxbow	
3190 ± 60	The Pas		Duncan-Hanna	Tamplin (1977)
3360 ± 120	Harder		Oxbow	Dyck (1977)
3363 ± 115	Long Creek	5	Hanna	Wettlaufer & Mayer-Oakes (1960)
3400 ± 200	Mortlatch	8	McKean-Duncan	Wettlaufer (1955)
3425 ± 105	Harder		Oxbow	Dyck (1977)
3485 ± 195	Gray Site		Oxbow	So and Wade (1975)
3550 ± 295				
3750 ± 180				
3755 ± 100				
4100 ± 90	Moon Lake		Oxbow	Dyck (1970)
4613 ± 150	Long Creek	7	Oxbow	Wettlaufer & Mayer-Oakes (1960)
4643 ± 159	Long Creek	8		
4955 ± 165	Grey Site		Oxbow	Millar et al (1972)
4995 ± 130	Long Creek	9	Long Creek Culture	Wettlaufer & Mayer-Oakes (1960)
5100 ± 390	Gray Site		Oxbow	So and Wade (1975)
5200 ± 130	Oxbow Dam		Oxbow	Nero & McCorquodale (1958)

Table 1. Radiocarbon Dates For Archaic Sites In Manitoba and Saskatchewan

co-occurrence means that the people who manufactured these point forms co-existed and exploited the same local environments (cf. Brumley 1975). For the time stated above, similar ecological adaptations are assumed for the complexes.

CHAPTER 3

ENVIRONMENTAL SETTING

The area in this study defined as comprising the Porcupine Mountain region includes that segment of the Manitoba escarpment and associated areas situated approximately within 52 to 53 degrees north latitude and 101 to 102 degrees west longitude (Figures 2 and 3).

Present vegetation in the Porcupine Mountain Forest Reserve is best described as mixed coniferous-deciduous forest, with the deciduous species largely confined to the lower-altitude, dry areas. The Swan River Valley to the south of the reserve is now extensively cultivated, but was an aspen parkland. In the present study, the assumption is made that the natural environment at the time the four sites were occupied was similar to that of today.

Deciduous species began to expand at the expense of conifer species in the region around 3000 years ago (Ritchie 1977; Shay 1976). Nichols' (1969) pollen diagram from Porcupine Mountain seems to demonstrate moisture fluctuations in the area, but it is presently impossible to fit the ages of the four sites in question to Nichols' chronology.

The nature of prehistoric faunal populations in the Porcupine Mountain region is not well known. None of the

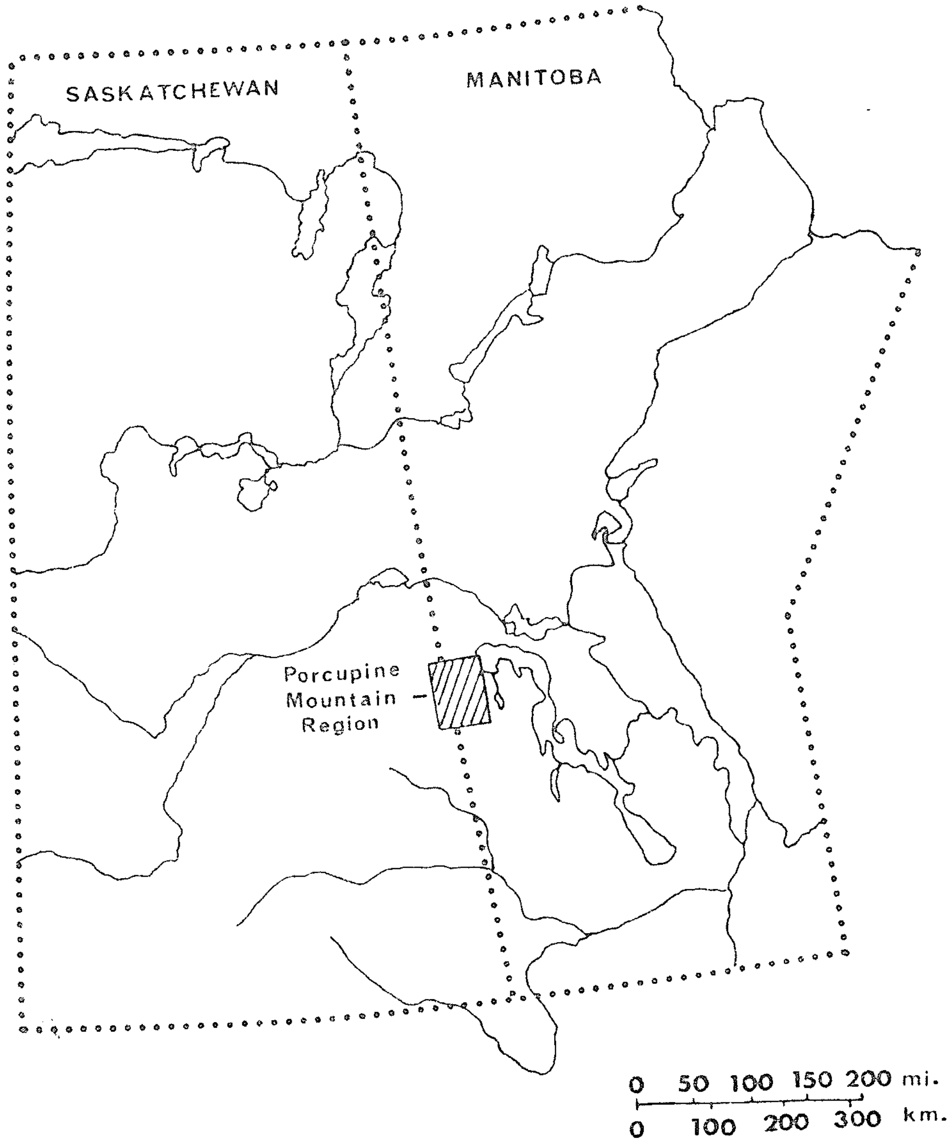


Figure 2. Location of the Porcupine Mountain Region

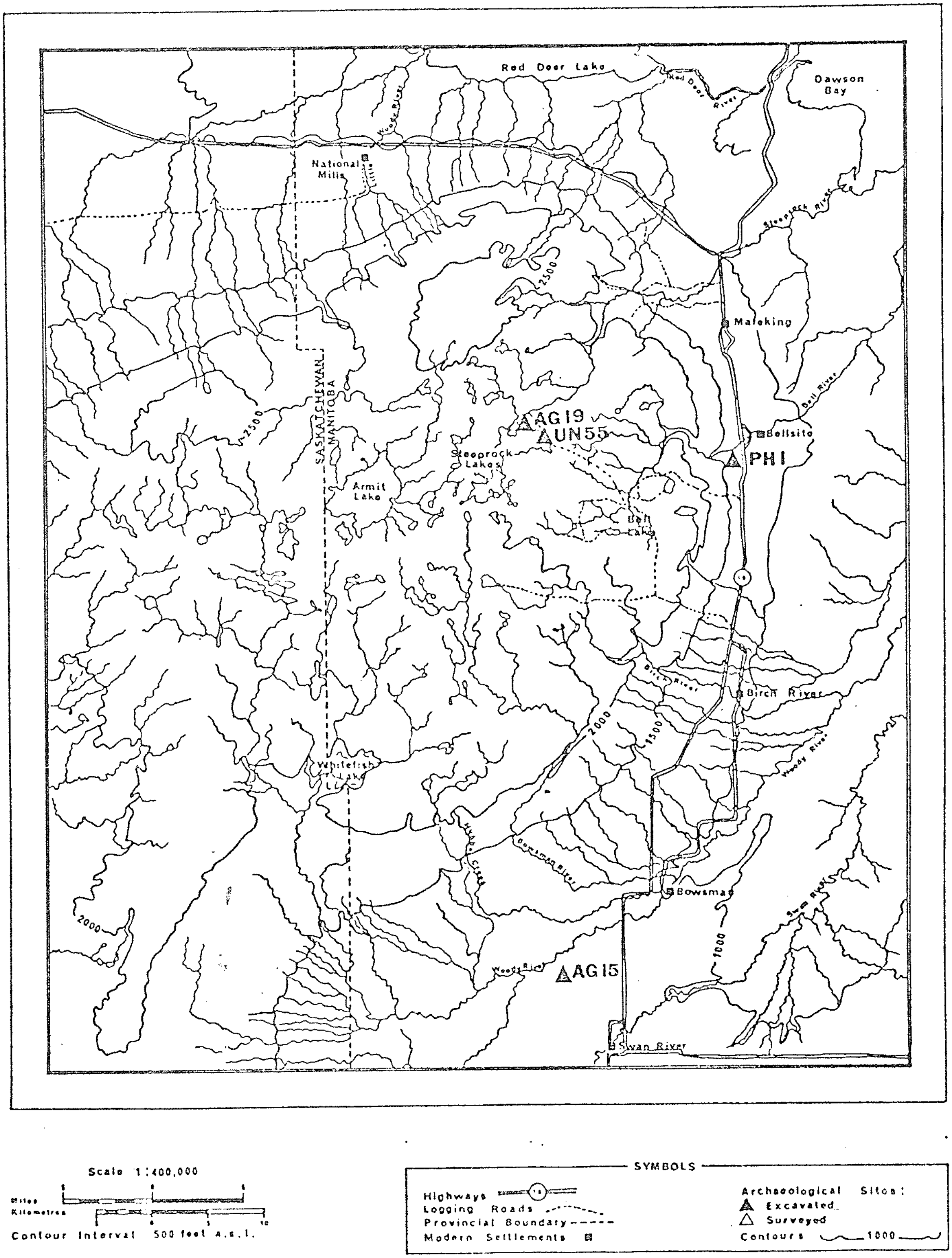


Figure 3. Map of the Porcupine Mountain Region Showing the Locations of the Four Sites Analysed in the Study

four sites here studied yielded faunal remains, but another Archaic site in the Swan River Valley (FbMi-5) produced bones of *Bison bison*, *Lepus americanus*, and possibly *Canis lupus* (Colwill 1973: 82). Colwill's conclusion based upon 4,870 bone fragments is that "... there has been (no) marked environmental change at the site since prehistoric occupations" (1973: 82). This is supported by similar findings by Lukens (1970: 330) at the Tailrace Bay site near Grand Rapids 150 km. to the northeast. Tamplin (1977: 8) also finds no evidence for environmental change in the last 5000 years from reexamination of the Tailrace Bay materials. Major big game species in the region include bear, moose, elk, deer and until recent times, bison.

The Manitoba Escarpment itself is essentially a product of pre-Wisconsinan geological processes (Teller 1976). Cretaceous shales of differential hardness have been eroded away leaving a northwest-southeast topographical rise of up to 2000 feet above the Lake Agassiz basin.

Shoreline features were formed against the lower slopes of the escarpment in response to fluctuations in the level of Lake Agassiz (Ehrlich, Pratt and LeClaire 1962). While it is unlikely that prehistoric populations occupied the active shores of Lake Agassiz (Pettipas 1967), these features have received a great deal of archaeological attention. During the Glacial Lake Agassiz Surveys, the strandlines, spits and deltas of Lake Agassiz were extensively surveyed because it was thought that these would make good camping places, providing good drainage characteristics, as well as sources of lithic raw materials. The precise geological processes by which these features were formed are discussed in more detail by Elson (1967, 1971), Pettipas (1967), and Teller (1976).

There is ethnographic evidence that the beach and other deposits flanking the lower areas of the escarpment were used aboriginally as routes of travel (Tyrell 1892: 90; Colwill 1973: 114), because of their superior drainage qualities. These areas were not occupied exclusively, however, and in this study two of the assemblages under examination are from sites on the top of the Porcupine Mountain in the hummocky terrain produced by the melting of stagnant ice covered with supra-glacial tills (Elson 1967: 65; Pettipas 1967).

Both AG19 and UN55 are located near Steeprock Lake, and the other two sites are situated near strandlines (Figure 3). PH1 is found on a former delta of the Bell River at the eastern base of Porcupine Mountain (Elson 1967: 67, Ehrlich, Pratt, and LeClaire 1962); and AG15 is situated on a morainic ridge in the Swan River Valley (Syms 1969: 25).

The type of rock employed predominantly by prehistoric peoples in the Porcupine Mountain region is known to Manitoba archaeologists as Swan River Chert. This highly variable material with an unknown geological origin occurs in glacial tills, strandlines, and stream gravels as cobbles and pebbles that range in quality from cryptocrystalline siliceous rocks to quartzite. Both extremes are often observable on a single specimen. Colour is rarely homogenous in the cobble-size range, with multiple combinations of white, orange, grey, green, blue, brown and red often occurring. Attempts to classify the material have been successful in specific archaeological cases only. Haug's (1977) six-type classification was found to be inadequate for the materials here analysed. Thin sections of 17 samples of Swan River Chert revealed that the rock is a silicified siltstone, with chalcedony forming the cementing medium of granoblastic quartz grains (Campling 1976). Campling's study also demonstrated that Swan River Chert cobbles can be reliably identified macroscopically on the basis of its spongy or vuggy texture (1976: 4), although not all specimens exhibit this.

It has been suggested that Swan River Chert was formed in a now-eroded dolomite-limestone formation similar to the existing Paleocene Turtle Mountain Formation (Syms 1977: 28; cf. Davies _et al_ 1962: 145). The processes of glaciation, especially those associated with glacial Lake Agassiz, resulted in concentrations of Swan River Chert as lag cobbles in shoreline features. Further exposure was probably produced by post-glacial fluvial and lacustrine processes. This lithic raw material is not highly concentrated, but the supply is very widespread, being nearly continuous around the base of Porcupine Mountain, as well as occurring with less frequency in tills in the upper reaches of the region.

The environmental factor that appears to have most relevance to the present analysis is the location of readily-available raw materials. It seems that the lower reaches of the Porcupine Mountain region in the range of the 1500 ft. to 1000 ft. contour intervals have a high probability of containing cobbles of Swan River Chert suitable for the manufacture of stone tools. A casual survey of the bed of the Bell River near the 1000 ft. contour produced approximately 15 kilograms of suitable material per hour of search. While some of the cobbles obtained in this fashion were extensively water-rounded, others exhibited flat facets which would have served as excellent platforms for the initiation of core reduction. Data on pebble roundness has been discussed by Elson (1971), and the indications are that those beaches occupied for the longest times by Lake Agassiz produce the roundest cobbles, although there is variability within any sample.

The differential distribution of raw materials is the most important point to be made here, since it can be expected that different kinds of technological behavior will be observable in areas where raw materials are readily attained as opposed to areas where these are not a prime environmental resource.

CHAPTER 4

SOURCES OF DATA

The lithic remains to be analysed here originate from four sites in the Porcupine Mountain region (Figure 3). Two (AG19 and UN55) are from the Porcupine Mountain Forest Reserve near the northernmost of the Steeprock Lakes, one is from just outside the reserve boundary at the eastern base of the escarpment (PH1), and the fourth is in the Swan River Valley just south of the Woody River (AG15).

Each site contains at least one McKean lanceolate projectile point. AG19 and UN55 also produced Oxbow points. All are considered to be Archaic components of the McKean-Oxbow complexes. No differentiation is made within the sites because of stratigraphic and sampling described below.

The effects of frost heaving may be serious in the region. Flakes were often observed in vertical positions during the excavation of PH1, and Pettipas (1977: personal communication) observed similar conditions at AG19. Johnson et al (1977) have conducted experiments to determine the precise effects of frost action of artifacts, although the experiments have yet to control for different soil types.

Other factors which would tend to obscure the vertical separation of components include animal burrowing as well as erosion and redeposition.

Site Descriptions

For ease of identification the original site designations have been retained here and are used throughout the text rather than the Borden designations. The site layout maps are for purposes of illustration only. Artifacts are not shown to scale, and their positions within the excavation sub-units are approximate. (Figures 4-8)

PH1 (FdMg-3) (Figure 5.)

PH1 is situated on the uplands adjacent to the Bell River delta on a logging access road near to Public Highway 10. A total area of 9.5 square meters were excavated in the summer of 1977 (Magne and Shay 1977; Magne 1978). The matrix of each unit was trowelled and screened through ¼ inch mesh. The total artifact count is 17 implements and fragments, and more than 11,000 debitage items, of which 25 are uniface and biface reduction flakes. One flake of Knife River Flint was recovered but the remainder of the materials have been produced from cobbles of Swan River Chert presumably obtained from the bed of the Bell River. The Knife River Flint flake is significant since this material has its geological source in North Dakota, some 300 miles to the south of PH1. Excavations reached depths of 25 cm and proceeded in 50 cm X 50 cm sampling units until the density of artifacts declined sharply. Parts of the site have been slightly disturbed through forestry ploughing, but in the worked area it is believed that the recovered artifacts were more or less in situ.

AG15 (FaMb-6; Figure 6)

This site is situated on a morainic ridge in the Swan River Valley and is referred to by Syms as "Campbell Island" (1969: 25, 28). Thirty-two square meters in 2 m X 2 m units and one 1 m X 1 m unit were excavated by Pettipas in 1968 in an undisturbed area (Pettipas 1968). The following year Syms escavated another 1 m X 1 m unit next to Pettipas' area for a total of 34 square meters of opened area (Syms 1969: 25-33). AG15 is the designation assigned the site by Pettipas, although it is referred to by Syms as the Filuk site in his thesis (1969) and published work (1970). The AG15 collection comprises the largest assemblage in this study with a total of 95 implements and fragments, 31 implement reduction flakes, and approximately 15,000 debitage items. Three McKean lanceolate projectile points were recovered. The precise criteria for location of the units is unknown, but it is assumed that the assemblage represents a single occupation.

AG19 (FdMi-1; Figure 7)

Situated on the north shore of Steeprock Lake, AG19 was also excavated by Pettipas in 1968. A total of 12 m^2

in 1 m X 1 m units and one 2 m X 2 m unit yielded 82 implements, 25 implement reduction flakes, and approximately 3500 debitage items. The site produced one specimen each of McKean and Duncan points, and two Oxbow points, as well as three flakes of Knife River Flint, and one fine uniface (end scraper) of brown chalcedony. Although the excavation units are spatially discrete, the assemblage is treated here as a single Archaic component.

UN55 (FdMi-4; Figure 8)

UN55 is the largest site examined in this study in terms of square meters of opened soil. Located near to AG19 on the campgrounds at Steeprock Lake, the site was excavated by Simpson (1966, 1970a, 1970b) under the auspices of the Manitoba Archaeological Society.

In the early stages of this reanalysis of the UN55 materials it was realised that the site has two components. The Archaic component is separated from a Late Woodland component by a horizontal distance of 70 meters, and only the Archaic materials are discussed here. The dates obtained for the site by Simpson 3130 ± 110 BP, 3795 ± 130 BP and 2480 ± 120 BP (1974: 3-6) are not relevant here because the radiocarbon samples were obtained from units in the Woodland component. Independent dating of materials from the site produced dates of 5600 ± 200 BP and 4650 ± 80 BP (Syms 1970: 130).

Reconstruction of the excavated portions of the site from field notes was difficult. The notes (1966) record a total of 93 m^2 of opened units, but examination of the materials revealed that they had been derived from only 72 m^2. The excavated area yielded one McKean and one Oxbow point, five implement reduction flakes, and a total of more than 3600 debitage products.

Arbitrary levels excavated within units at the sites have been combined in the following analysis to facilitate assemblage comparisons. In spite of the variations in excavation procedures, it is believed that the samples are sufficiently comparable for the purposes of this study.

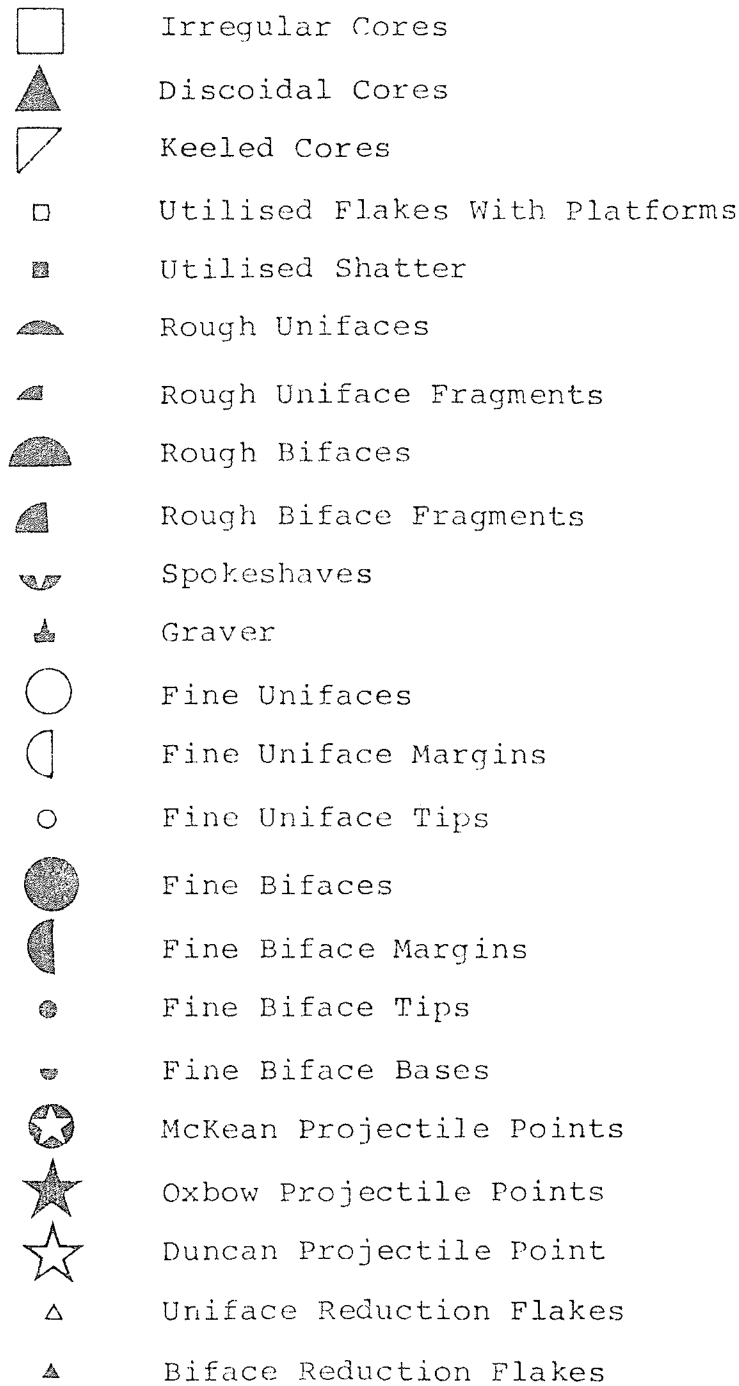


Figure 4. Legend For Accompanying Site Maps

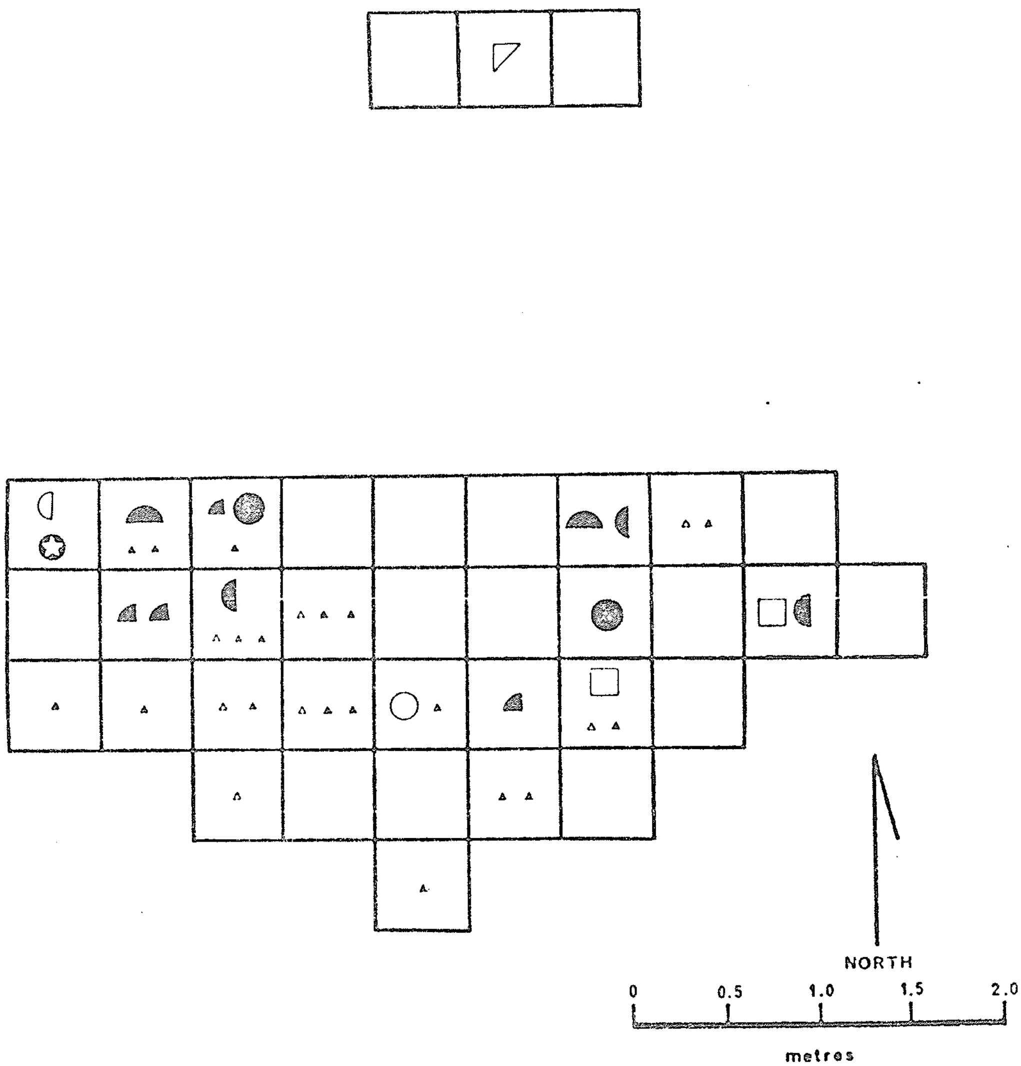


Figure 5. PH1 Excavation Units Showing Approximate Artifact Locations

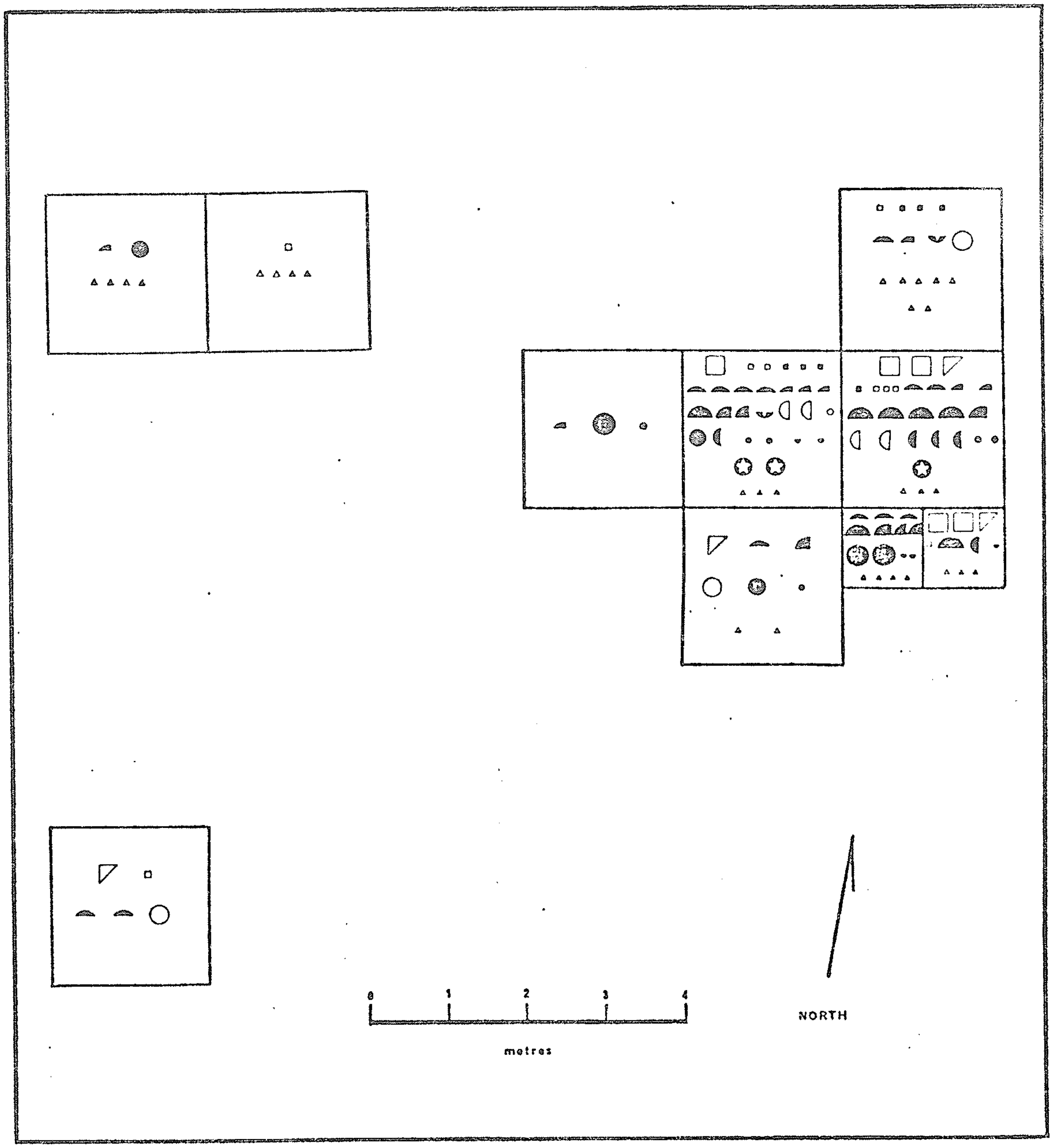


Figure 6. AG15 Excavation Units
Showing Approximate Artifact Locations

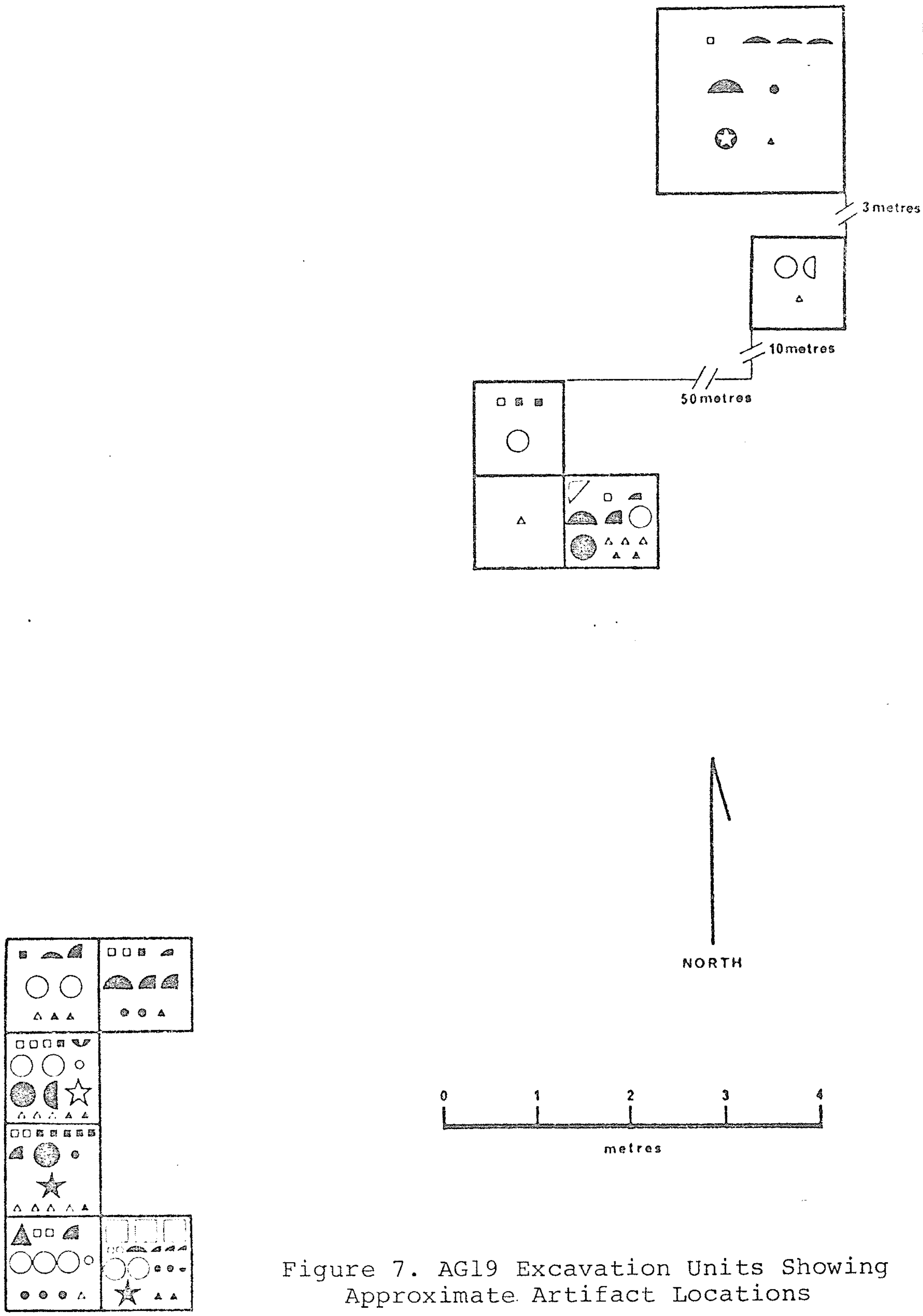


Figure 7. AG19 Excavation Units Showing Approximate Artifact Locations

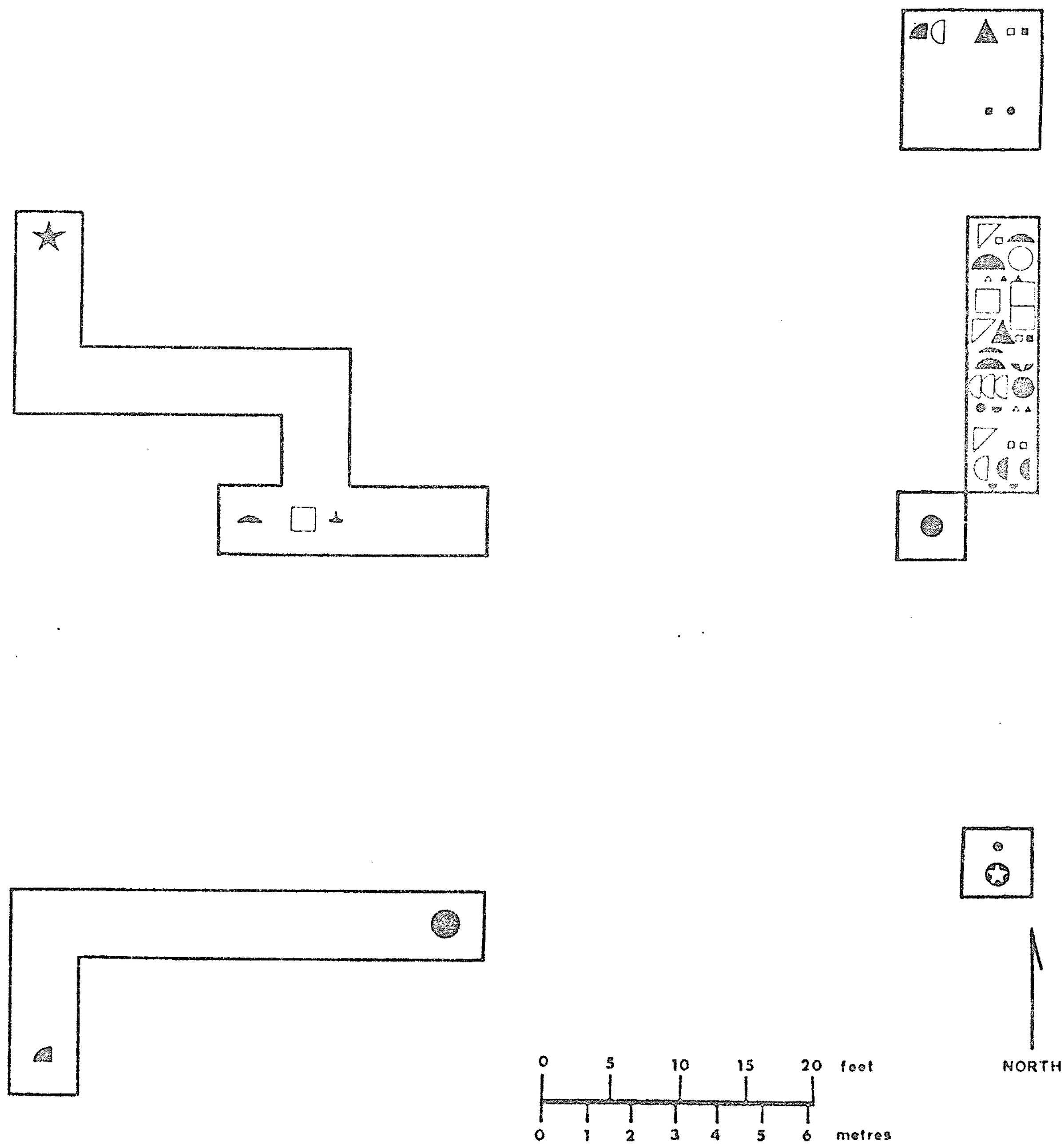


Figure 8. UN55 Excavation Units Showing Approximate Artifact Locations

CHAPTER 5

A MODEL OF LITHIC TECHNOLOGY AND THE INTERPRETIVE VALUE OF LITHIC DEBITAGE

Several versions of the stages involved in the reduction of stone tools are presently available. These isolate morphological attributes based on reduction strategies which are useful towards the interpretation of lithic technological activities. Sheets (1975), Muto (1971), Schiffer (1976), and Singer and Erickson (1977) have presented such models with respect to specific problems such as blade manufacture, early reduction stages, single sites, or specific kinds of sites.

Collins' Model of Lithic Technology

Collins (1975) has produced a useful model of lithic technology that outlines the kinds of behavior that result in the formation of certain lithic artifact classes. This model is comprised of five steps which account for most lithic reduction sequences (1975: 16-19):

1. Aquisition of the raw material
2. Core preparation and initial reduction
3. Optional primary trimming
4. Optional secondary trimming
5. Optional maintenance and modification

Collins' model has its theoretical base in Behavioral Archaeology (Schiffer 1972, 1976), which is mainly concerned with defining processes of formation of the archaeological record. Collins explicitly applies this kind of methodology to stone tool production, the value of his model is its generality (cf. Kliendienst 1975; Johnson 1978; Hester 1978). The five steps are potentially observable in any functioning or extinct lithic technological system (Collins 1975: 17-18, 25).

Another feature of Collins' model is its simplicity. The redundancy often encountered in other lithic technological models has been reduced by presenting a linear system which requires the output of one stem as the input for the following steps (excepting the initial procurement of materials). Feedback of sorts may occur within the system if "... changes in the output requirements of one step... necessitate changes in earlier steps" (Collins 1975: 17).

One or more sets of activities is involved in each step, and the material resulting from each step is termed a product group. Both wastes and materials suitable for use or further modification are included in the product groups. For ease of comprehension in the ensuing presentation of Collins' model, the reader is referred to Figure 9.

Product group I materials are the results of raw material procurement. The acquisition of river cobbles, weathered nodules of flint or chert in calcareous formations, or blocks obtained from igneous or metamorphic deposits may vary in complexity from opportunistic gathering to systematic quarrying. These activities may be inferred from product group I materials (unmodified rocks) observed at quarry sites, or at sites to which the obtained materials were transported.

The selected core blanks of product group I serve as the input for the second step, core preparation and initial reduction. The quality of the raw material, the reduction techniques available to the craftsman, the size of the core and desired end-product, and the scarcity of abundance of raw material are all criteria in the initial reduction step (Collins 1975; cf. Crabtree 1967a, 1967b, 1970, 1972). For example, a craftsman capable of antler billet flaking would have better control over and obtain maximum use of the mass of a core than would a person using hard-hammer percussion. This would be important if materials were rate or had to be imported long distances. The desired end-products of this step may be the cores, the flakes detached from the cores, or both (Collins 1975: 21).

Another activity of this step may be the preparation of core platforms - the margins of the core against which the percussion tool or impactor is struck. Certain kinds of flakes require special preparation before removal (eg.

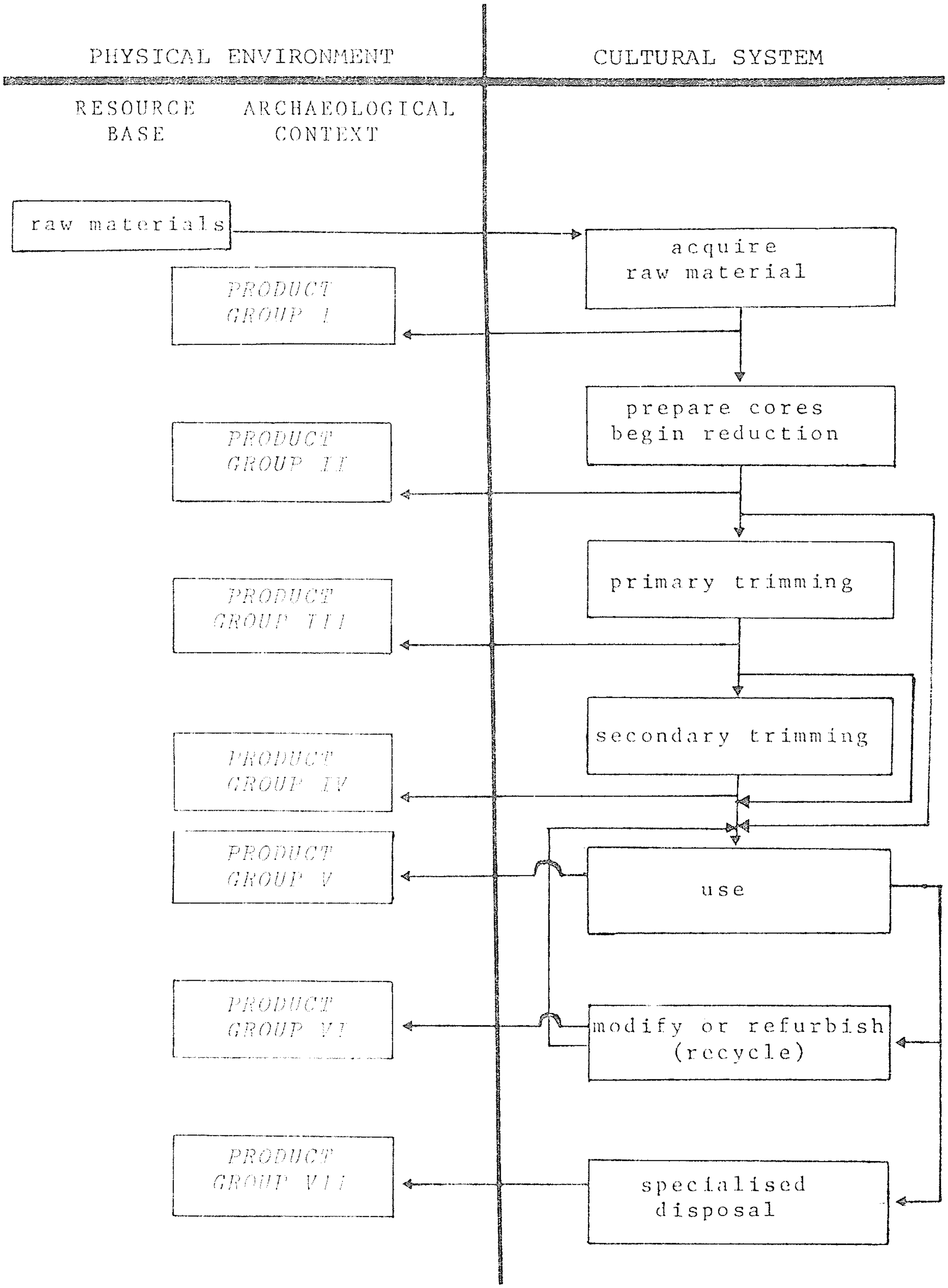


Figure 9. Flow Chart of Collins' (1975) Model of Lithic Technology (After Collins 1975: 25)

Levallois flakes, lamellar blades), or the platform may be weak with inherent flaws which need to be removed. In simple technologies there is often no preparation observable in product group II artifacts. The craftsman may simply select a flat facet adjacent to an edge on a quarry blank or cobble as a suitable place to remove a flake. Flakes utilised without modification may be the only tools of this product group. The cores themselves may or may not be used.

Product group III consists of the materials of product group II that have been further reduced and some perhaps used. Primary trimming is optional simply because it need not occur in a lithic technological system: unmodified flakes or cores are suitable for the accomplishment of many tasks. Objects from product group II are here subjected to criteria of shape, including outline, section (longitudinal and/or cross-section), and edge. Cores and flakes or product group II achieve their final form here, or serve as preforms for the next step of secondary trimming and shaping.

In product group IV are found artifacts whose shapes have been further refined by carefully controlled percussion or pressure flaking. Edges are straightened, bevelled or notched. While bifacially flaked implements are "predominantly" the output of this step, Collins (1975) implies that unifacially flaked implements may also be important products here.

Objects that are discarded because they are no longer useful and by-products such as use-wear flakes, are included in product group V, as well as the step in which they were manufactured. Worn or broken implements may be abandoned at the locus of use, intentionally modified and recycled, or occasionally transported to other sites. Tools and debitage produced in recycling activities form product group VI (burins on bifaces, re-worked projectile points, narrow, resharpened bifaces, burin spalls, resharpening flakes, etc.)

The final product group (VII) is that which results from the specialised disposal of artifacts, such as in burials, caches, potlatches, etc. (Collins 1975: 22).

Collins does not describe in detail how one may evaluate the form of reduced implements and consistently decide whether or not they are preforms or tools of product groups III or IV. That is, the qualities that differentiate the output of these activities are not made entirely clear (cf. Johnson 1978). It seems logical that these qualities should be related to the observable technological criteria of each reduction stage. A solution to this problem is offered in the ensuing chapter on artifact classification.

Although the precise utility of an artifact may not be a necessary element in the study of lithic reduction, the presence or absence of use-wear may be important, especially for the determination of preform morphologies, and certainly for the determination of product group II implements versus debitage.

A deficiency in the model is that although Collins stresses quite the opposite, lithic by-products or debitage seems to play a minor role towards the explication of lithic reduction strategies. He states:

> If isolated, product groups can be described in terms of their technological attributes and inferences can be drawn concerning the specific activities by which the particular manufacturing step was accomplished. <u>The waste, or debitage, is particularly amenable to this technological analysis</u> (Collins 1975: 17; emphasis mine).

We are not shown, however, how to recognise the debitage of each separate product group. Collins also maintains that debitage is a highly reliable source of data when the research is directed towards an understanding of the spatial relationships of activities. That is, debitage is not as subject to "curation" as are tools (Collins 1975: 19; Binford 1973). Another problem is that the quality of the raw material would affect the appearance of the tools and the debitage. Obsidian, fine-grained cherts and flints tend to exhibit the attributes of reduction more clearly than do more crystalline materials such as quartzites.

Collins' (1975) model, then, seems to have heuristic potential, but application of it in its present form would be fraught with difficulties of classification, unless it is recognised that any specific technology will exhibit product groups distinct in character as a result of available raw materials and individual percussion techniques.

Lithic Debitage

Given the archaeological potential of debitage analyses, the approach taken here is that research seeking to understand the variability of assemblages composed almost entirely of lithic remains should carefully and explicitly consider the forms and quantities of lithic debitage, and not simply give passing mention to an abundant class of artifacts.

Lithic debitage can be defined as non-utilised stone materials which result from the manufacture, use, and maintenance of stone tools. The analysis of debitage is not new and there exists no standard treatment of such artifacts, but those researchers which have taken the time to analyse debitage have often produced more information than that which would have been achieved using data from the tools alone.

Frison's studies of bison kill sites in Montana (1970a) and Wyoming (1968) have shown that scrapers and knives were brought intact to the sites, used, resharpened and discarded. Frison's demonstration that prehistoric butchers maximised tool use-lives has typological implications that can be tested through use-wear analyses (1968: 154). One implication is that the form of one tool can change significantly through repeated use and renewal (see also Frison 1970b). Shafer (1970) has shown that unifaces may be produced or renewed through three techniques identifiable from debitage, and Ahler (1971, 1975) has tested for tool resharpening strategies and their spatial contexts.

Other research has focused on the value of debitage analyses in conjunction with complete tool analysis and raw material analysis at quarry sites (Singer and Erickson 1977), and on the spatial patterning of stages of lithic reduction (Lavine-Lishka 1976).

Debitage analyses, however, have rarely considered the debitage classes as equivalent to tool classes in the investigation of relationships among groups of prehistoric sites. In a great many site reports there are examples of analysis based solely on raw material types, but these are useful in certain problems only. For example, Osborne (1965) asserts that at Weatherill Mesa he could place a site within the regional chronology using a sample of only 100 flakes. Young and Sheets' (1975) test of socio-economic ranking among a series of California Late Horizon sites using obsidian weights and sizes negated an hypothesis of differential access of raw materials. Schneider (1972) has studied technological change through time on the northern plains using lithic debitage classes based on raw materials and flake morphology.

Another common use of lithic debitage is the debitage/tool ratio which may contain some misleading assumptions. Wilmsen (1970: 78) concluded that such a ratio of 25:1 at the Levi Paleo-Indian site indicated that all stages of tool manufacture were preserved. Either Wilmsen's conclusion is highly questionable, or his actual evidence is from the tool alone. It can be expected, for example, that workshop sites where items are only brought to the stage of preforms (product group III), and then transported elsewhere for further reduction would evidence even higher debitage/tool ratios. Further, Newcomer (1971) has made it clear that biface manufacture results in more debitage than uniface manufacture.

The problem of equal attention to all types of debitage seems to be a result of archaeologists' apparent inability to construct behaviorally meaningful classes. Those commonly in use are based on amount of cortex (weathered outer surface) observable on flakes, and include such classes as primary and secondary decortication flakes. The definition of these is often ambiguous and based on an inadequate understanding of the practical aspects of stone tool manufacture. The reduction of a stone nodule with a completely weathered surface may result in only one true primary decortication flake - the first one to be removed. The second and subsequent flakes would be "secondary decortication flakes" if the margin of a flake scar is used to guide the removal of the next flake. Also such classes as "detritus", "thinning flakes", or "groundmass" do not cover the entire range of forms of the material in any specific archaeological situation, and may in fact include most of the materials under study (eg. Wiersum and Tisdale 1977: 66).

Thus, while the value of lithic debitage in a technological framework has been widely recognised, no explicit classification of debitage exists whereby the behavior responsible for the production of certain forms may be inferred. In terms of the general model of lithic technology presented here, it seems essential that in order to avoid ambiguity, a debitage classification should consist only of relevant criteria. This requirement has been noted by John Speth, a specialist in lithic fracture dynamics:

> Further research into the technological aspects of flake production should lead to a significant reduction in the total number of attributes needed to quantify technological variability, and to the replacement of dozens of arbitrarily chosen and redundent measurements presently in vogue with considerably smaller numbers of attributes

> carefully selected on the basis of sound theoretical principles (Speth 1972: 57).

It has been shown that there is a need to incorporate both tools and debitage in archaeological analysis. Both are products of human activities, can be archaeologically recognised and both should possess attributes that are regular and susceptible to cultural interpretation.

Technologically relevant attributes of tools and debitage are discussed in relation to Collins' model in the following chapter, providing an artiface classification through which variability in lithic assemblages may be behaviorally explicated.

CHAPTER 6

ARTIFACT CLASSIFICATION

Classes of implements are here combined with classes of debitage to produce inventories of prehistoric lithic material culture that are nearly complete, lacking only those items which were not recovered. Based on Collins' (1975) model presented earlier, 60 artifact classes (Table 2) are presented as "activity indicators" (Ahler and MacMillan 1976: 164). These classes serve to associate the materials with inferred activities, and are used to describe and compare the variability in content of four Archaic lithic assemblages from the Porcupine Mountain region. The classification should have more general applicability although it has been formed within the limitations of the available artifacts.

Four of the seven product groups (II - V) were observed at the four sites. Groups I, VI, and VII were not observed, but it is indeed possible that these are present at the sites and were not recovered within the sampled areas. Given the focus of this study, all implements have been classified in the product groups associated with their manufacture, and group V (use) is not considered in the analysis.

Implements are separated from debitage on the commonly used morphological criteria obtained from unifacial and bifacial reduction. No microscopic analysis was conducted to determine the probable use of tools, and much of the marginal damage observed may have also resulted from the preparation of flake platforms, and from grinding or hafting requirements. Certain implications regarding use of implements are, however, derived in the later stages of the analysis.

The presumed use of implements served as a criterion for classification only in the cases of utilised flakes, where consistent marginal crushing, step or hinge-terminated flake scars, or rounding of margins served to differentiate these from debitage proper as defined in Chapter 5.

Cores are classified as implements because they also obtain their final forms from activities in which material was removed from them through percussion techniques. In many lithic studies, tools are distinguished as being either core or flake tools (eg. Bordaz 1970), but in any reduction activity, the object being reduced is essentially a "core" for flakes. The term core in this study refers strictly to non-utilised exhausted cobbles reduced for the purpose of obtaining flakes. While some of the other implements could be commonly classed as core tools, they are differentiated on the basis of other morphological criteria.

Throughout the study, all implements and debitage are inferred to be predominantly products of hard-hammer percussion, although some evidence of soft-hammer or indirect percussion is discussed in the results of the analyses (Chapter 8).

The problem of identifying product III and IV implements noted in the presentation of Collins' model is overcome here by making the number of tool reduction sequences per face of tools a basic technological criteria. Several attempts at initial classification demonstrated that for the assemblages here under consideration, tools with up to only two reduction sequences per face did not have the symmetry of form, outline, cross-section or edge that characterises those implements with more than two reduction sequences. The number of reduction sequences is determined by counting overlapping and contiguous flake scars back from the implements' edges but not including those short, steep step flake scars that are more likely the results of use or platform preparation (Figure 10). Product group III tools are classified as "rough" implements, and those of product group IV as "fine" implements.

The debitage classes have also been formed using technological attributes. The presence or absence of cortex is thought to measure the role of the inferior qualities of weathered outer surfaces in the reduction strategies of the lithic craftsmen.

Debitage is sorted into two major groups, flakes with remnant striking platforms, and shatter, without striking platforms. The overall morphology of shatter items is

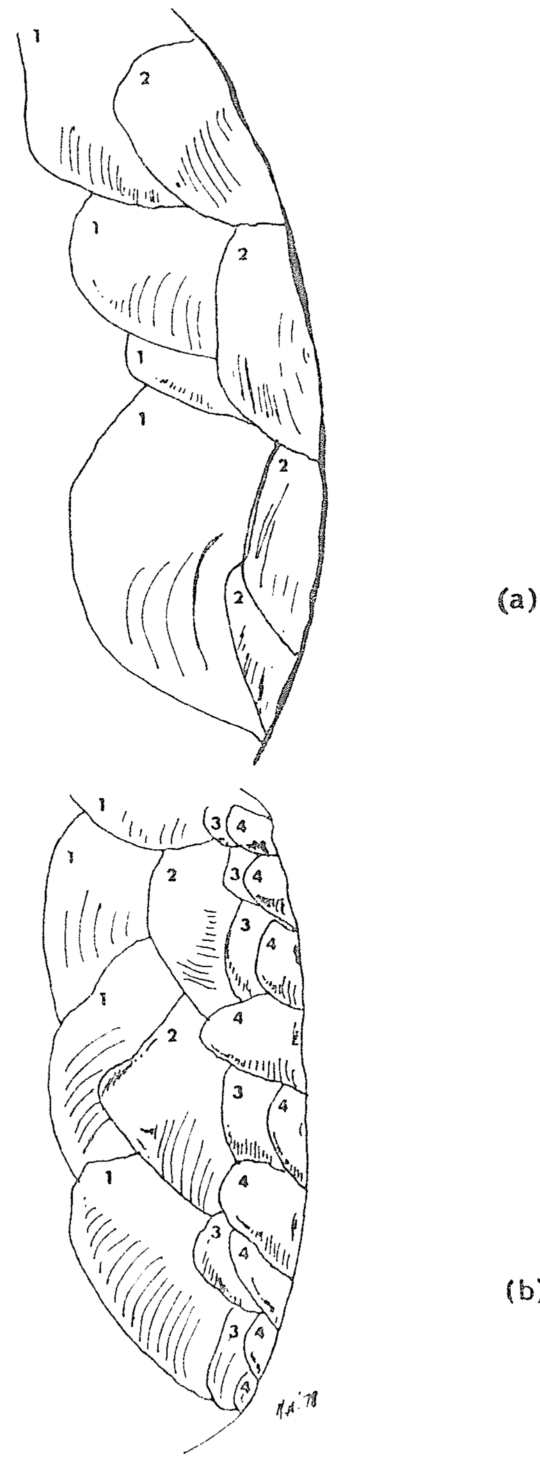


Figure 10. Illustration of Implement Reduction Sequences (a): Typical margin of a rough implement (product group III); (b): Typical margin of a fine implement (product group IV). Numbers refer to order of reduction sequence.

used as the criterion for assigning these to the classes of shatter flakes or shatter blocks. The morphology of flake platforms is the basis for the definition of the remainder of the debitage classes. The striking platforms are important to the understanding of reduction technology because they are the business end of flake removal. It is at the platform that the force of impact or pressure is applied for the removal of the flake, and as will be discussed, certain attributes indicative of specific reduction steps are isolatable (eg. Bonnichsen 1977; Bradford 1977; Speth 1972). The debitage classes presented here are provisional because study of flake morphology is still in its early stages. Most lithic fracture studies focus on platform attributes in attempts to understand the many causes of morphological variability of flakes.

The criteria are based on experimental and archaeological evidence, as well as firsthand experience with flintknapping. They are also related to attributes possessed by the implements of the product group in question. In the course of forming the classification, it was realised that the debitage classes include some items which may in fact be produced at any of the reduction steps here described. The criteria for assigning the separate classes to individual product groups are discussed, but generally a class is incorporated into the product group most reasonably inferred to be associated with its frequent or modal production. Table 2 is the final classification. Figure 11 provides a key to the flake illustrations to follow.

The Classification

Product Group II

The raw material extracted from local or distant sources serves as material input to the activity sets of core preparation and initial reduction.

Product Group II Implements

Cores (Classes 1, 2, 3) Cores are the discarded remnants of cobbles that were struck for the purposes of removing flakes. Three kinds of cores were observed in the four assemblages. Irregular cores are those exhibiting striking platforms occurring randomly on the artifacts' surface. Discoidal cores are bifacially reduced, and have a truncated biconical appearance. Keeled cores are defined as cores with only one striking platform. No cores in the assemblages evidence any kind of platform preparation.

Utilised Flakes and Blocks (Classes 4, 5, 6, 7) All of the utilised debitage items observed in the assemblages are products of initial reduction as defined here (see product group II debitage, below). Modification is present only in the form of readily observable step-flakes

IMPLEMENT AND DEBITAGE CLASSES	ARCHAEOLOGICAL CONTEXT	CULTURAL SYSTEM
Unmodified cobbles - no representation in the four assemblages	Raw material PRODUCT GROUP I	Acquisition of raw material
1. Irregular cores 2. Discoidal cores 3. Keeled cores 4. Utilised intact platform flakes with and without cortex 5. Utilised crushed platform flakes with and without cortex 6. Utilised shatter flakes with and without cortex 7. Utilised shatter blocks with and without cortex	PRODUCT GROUP II Implements	(i) Reduce flake cores and discard (ii) Select, use and discard unmodified flakes
8. Intact platform flakes with cortex 9. Intact platform flakes without cortex 10. Crushed platform flakes with cortex 11. Crushed platform flakes without cortex 12. Shatter flakes with cortex 13. Shatter flakes without cortex 14. Shatter blocks with cortex 15. Shatter blocks without cortex	PRODUCT GROUP II Debitage	(i) Prepare and reduce flake cores (ii) Discard undesirable products

Table 2
IMPLEMENT AND DEBITAGE CLASSES IN RELATION TO COLLIN'S (1975) MODEL OF LITHIC TECHNOLOGY

IMPLEMENTMENT AND DEBITAGE CLASSES	ARCHAEOLOGICAL CONTEXT	CULTURAL SYSTEM
16. Rough unifaces 17. Rough uniface fragments 18. Rough bifaces 19. Rough biface fragments 20. Spokeshaves 21. Gravers	PRODUCT GROUP III Primary Trimming Implements	(i) Modify flake or cobble cores with up to two reduction sequences (ii) Select implement, use and/or discard
22. Prepared platform flakes with cortex 23. Prepared platform flakes without cortex 24. Concave platform flakes with cortex 25. Concave platform flakes without cortex 26. Crushed/prepared platform flakes with cortex 27. Crushed/prepared platform flakes without cortex 28. Crushed/concave platform flakes with cortex 29. Crushed/concave platform flakes without cortex 30. Prepared/concave platform flakes with cortex 31. Prepared/concave platform flakes without cortex 32. Crushed/prepared/concave platform flakes with cortex 33. Crushed/prepared/concave platform flakes without cortex	PRODUCT GROUP III Primary Trimming Debitage	(i) Prepare flake platforms (ii) Maximize core's thickness (iii) Discard undesirable products

Table 2 con't
IMPLEMENT AND DEBITAGE CLASSES IN RELATION TO COLLIN'S (1975) MODEL OF LITHIC TECHNOLOGY

	IMPLEMENT AND DEBITAGE CLASSES	ARCHAEOLOGICAL CONTEXT	CULTURAL SYSTEM
34.	Fine unifaces	PRODUCT GROUP IV Secondary Trimming Implements	(i) modify flake or cobble cores & preforms with more than two reduction sequences. (ii) Achieve symmetry in form (iii) Select implements, use and/or discard
35.	Fine uniface margins		
36.	Fine uniface bases*		
37.	Fine uniface tips		
38.	Fine bifaces		
39.	Fine biface margins		
40.	Fine biface bases		
41.	Fine biface tips		
42.	McKean projectile points		
43.	Oxbow projectile points		
44.	Duncan projectile points		
45.	Uniface reduction flakes	PRODUCT GROUP IV Secondary Trimming Debitage	(i) Remove flakes from very acute angle edges (ii) Discard undesirable products
46.	Biface reduction flakes		
47.	Lipped flakes with cortex		
48.	Lipped flakes without cortex		
49.	Crushed/lipped flakes with cortex		
50.	Crushed/lipped flakes without cortex		
51.	Prepared/lipped flakes with cortex		
52.	Prepared/lipped flakes without cortex		
53.	Concave/lipped flakes with cortex		
54.	Concave/lipped flakes without cortex		
55.	Crushed/prepared/lipped flakes with cortex		
56.	Crushed/prepared/lipped flakes without cortex		
57.	Prepared/concave/lipped flakes with cortex*		
58.	Prepared/concave/lipped flakes without cortex		
59.	Crushed/prepared/concave/lipped flakes with cortex*		
60.	Crushed/prepared/concave/lipped flakes without cortex*		

Table 2 con't
IMPLEMENT AND DEBITAGE CLASSES IN RELATION TO COLLIN'S (1975) MODEL OF LITHIC TECHNOLOGY

*Indicates those classes not represented in the four assemblages, but formed here as logical consequences of classification

IMPLEMENT AND DEBITAGE CLASSES	ARCHAEOLOGICAL CONTEXT	CULTURAL SYSTEM
Observed (Classes 4,5,6,7) but not relevant to study	PRODUCT GROUP V	Use
Not observed	PRODUCT GROUP VI	Recycle - modify or refurbish
Not observed	PRODUCT GROUP VII	Specialised disposal

Table 2 con't
IMPLEMENT AND DEBITAGE CLASSES IN RELATION TO COLLIN'S (1975) MODEL OF LITHIC TECHNOLOGY

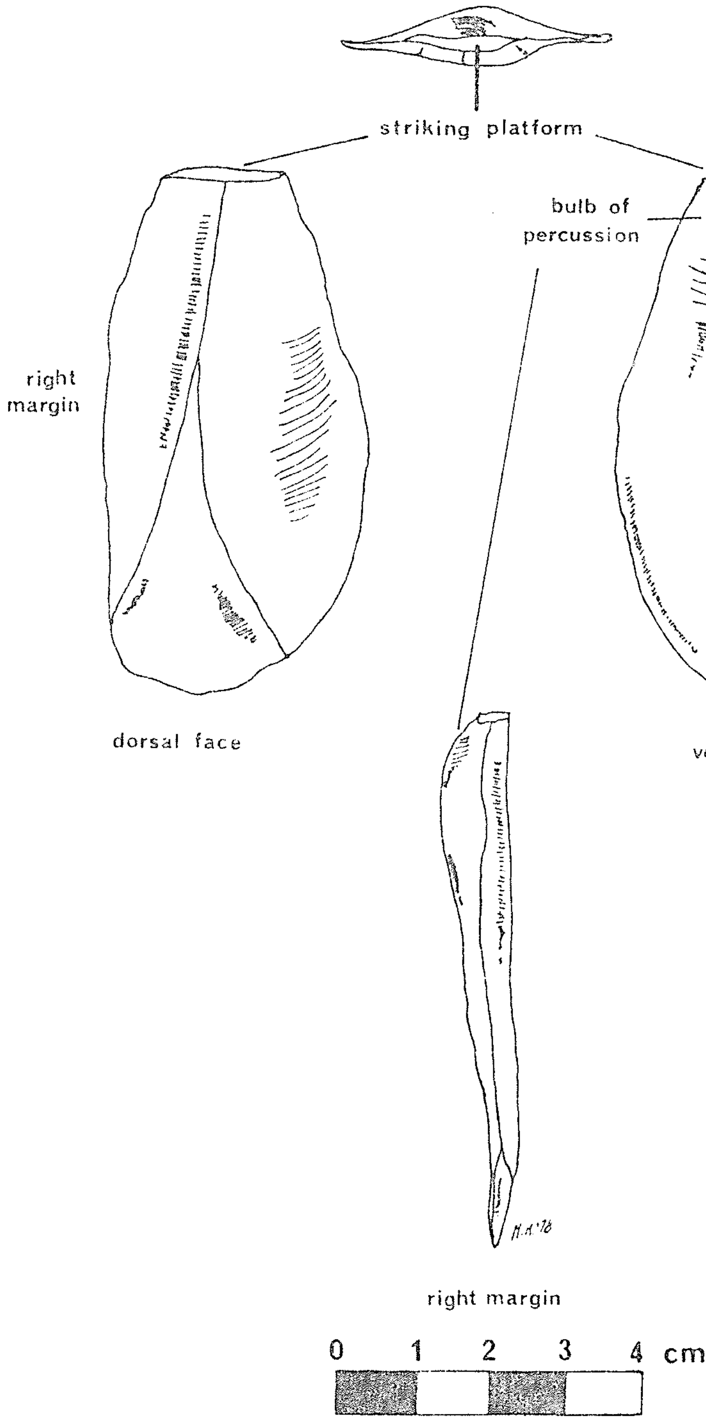


Figure 11. Key to accompanying flake diagrams

and dulled edges resulting from the forces of use. No cortex is present on any of the utilised edges, and if present, is restricted to areas of the dorsal face. Consequently, cortex was not used as a criterion in the formation of these classes.

Product Group II Debitage

Intact Platform Flakes (Classes 8-9; Figure 12) Intact Platform Flakes form a residual class (see also Wiersum and Tisdale 1977: 163). These have unmodified striking platforms, but still exhibit the common flake attributes of bulb of percussion, eraillure scars, and in some cases, Hertzian ring cracks. They are placed in product group II since the cores evidenced no platform preparation.

Crushed Platform Flakes (Classes 10 and 11; Figure 13) Crushed striking platforms are commonly observed on flakes produced in technologies where hard-hammer percussion is a reduction technique. The striking platform can be totally obliterated, leaving only the bulb of percussion to orient the direction of impact, or as is more often the case, there exists a platform remnant. In this classification, a crushed platform flake must bear evidence of crushing on both ventral and dorsal faces. A flake with crushing near the platform on the dorsal face only is classified as a prepared platform flake (see product group III, below).

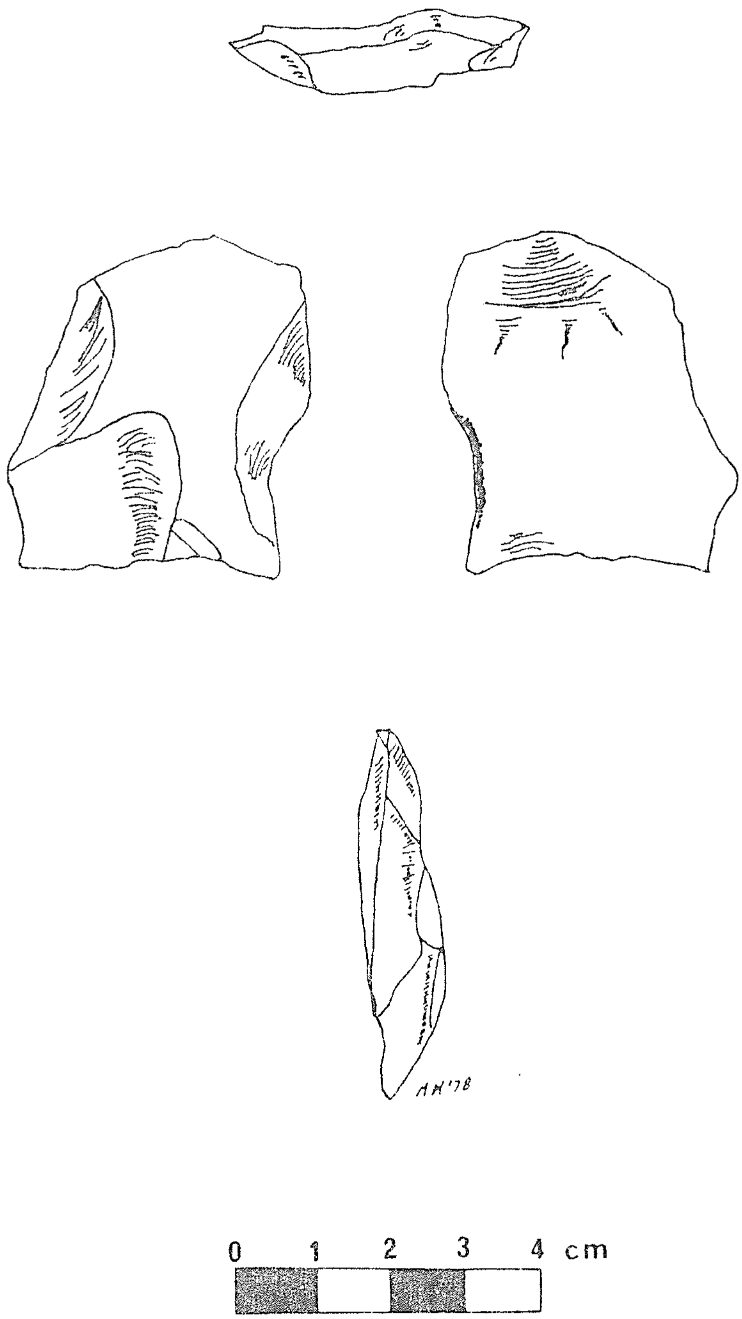


Figure 12. Intact Platform Flake

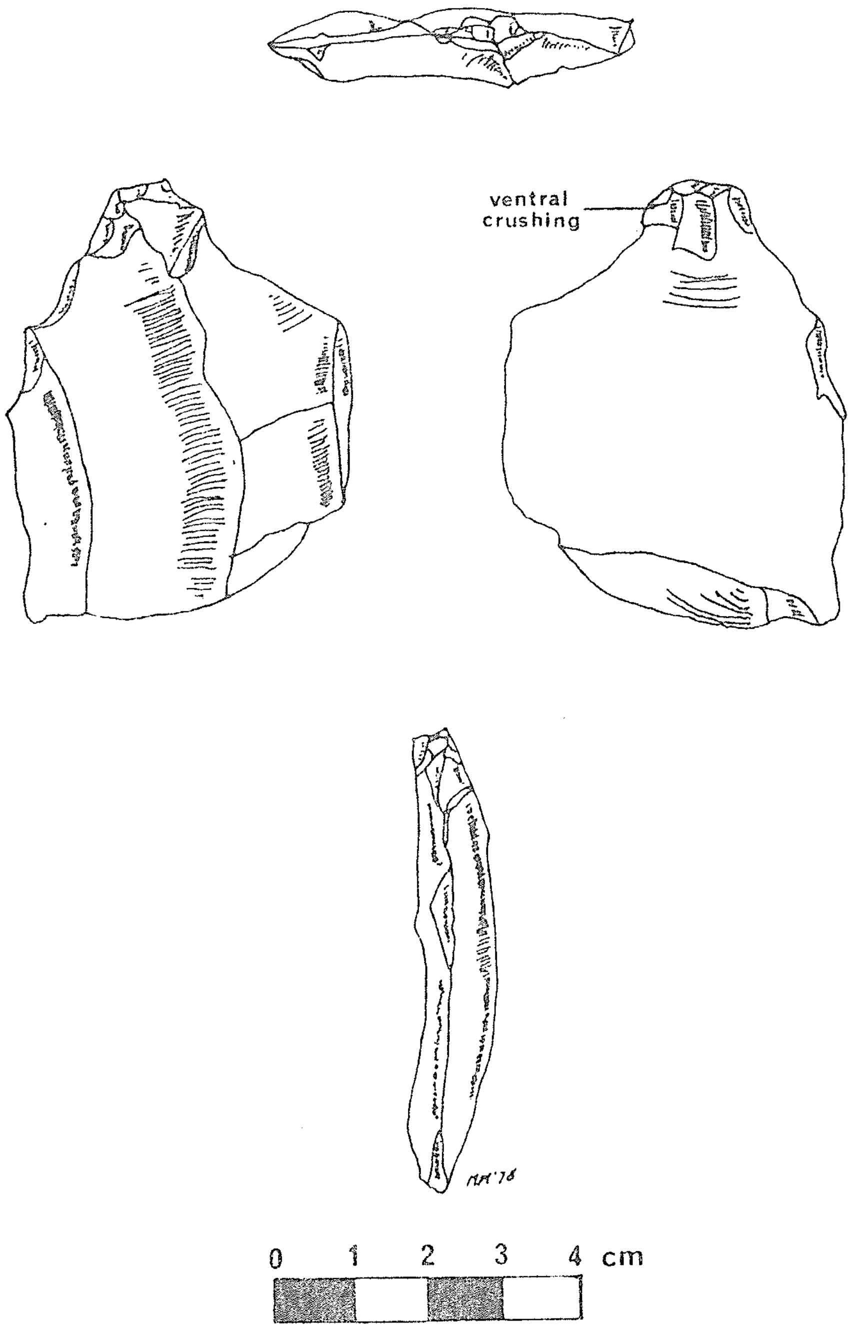


Figure 13. Crushed Platform Flake

Shatter Flakes and Shatter Blocks (Classes 12-15, also Classes 6-7) These classes incorporate those materials that do not possess striking platforms. Shatter flakes are "flake-like", thin trapezoids in cross-section, while blocks are highly irregular and angular. Several kinds of activities may produce these forms. In hard-hammer percussion, misdirected blows often produce shatter when the flake collapses under excess stress. Shatter may also be produced by the trampling of materials at the locus of production.

In this analysis, all flakes with platform remnants were separated from the shatter form examination and classification. However, given the large number of shatter items obtained at the four sites (a total of more than 30,000 items), a 25% sample of the shatter was obtained with the aid of geological sample splitter. The full sample of platformed flakes was not split in this manner, and all were classified.

Product Group III

The flakes or reduced cores of product group II serve as material input here. The unifaces and bifaces resulting from the activity sets of primary trimming are made of both these cores and flakes.

Product Group III Implements

Rough Unifaces (Class 16) These are unifacially flaked artifacts exhibiting up to two reduction sequences.

Edges of these implements are not uniform, with as much as 45 degress of variation in edge angle of a single implement.

Rough Uniface Fragments (Class 17) These are fragments of rough unifaces not complete enough to enable approximation of the original implement, nor to warrant designation as to which section of the tool they originally comprised. None of the rough uniface fragments in the samples matched.

Rough Bifaces and Rough Biface Fragments (Classes 18 and 19) The same criteria apply here as with rough unifaces, except that rough bifaces exhibit bifacial flaking not exceeding two reduction sequences per face.

Spokeshaves (Class 20) The name of this class is not intended to carry any functional implications. These are the commonly recognised form of tool that consists of flake with a concavity retouched along one margin.

Gravers (Class 21) Again, there are no functional implications of this class. The sole item observed has a short tapered point flaked along two margins to produce what may have been an implement used to engrave wood or bone materials.

Product Group III Debitage

Prepared Platform Flakes (Classes 22-23; Figure 14) These are flakes with short step or hinge terminated flake

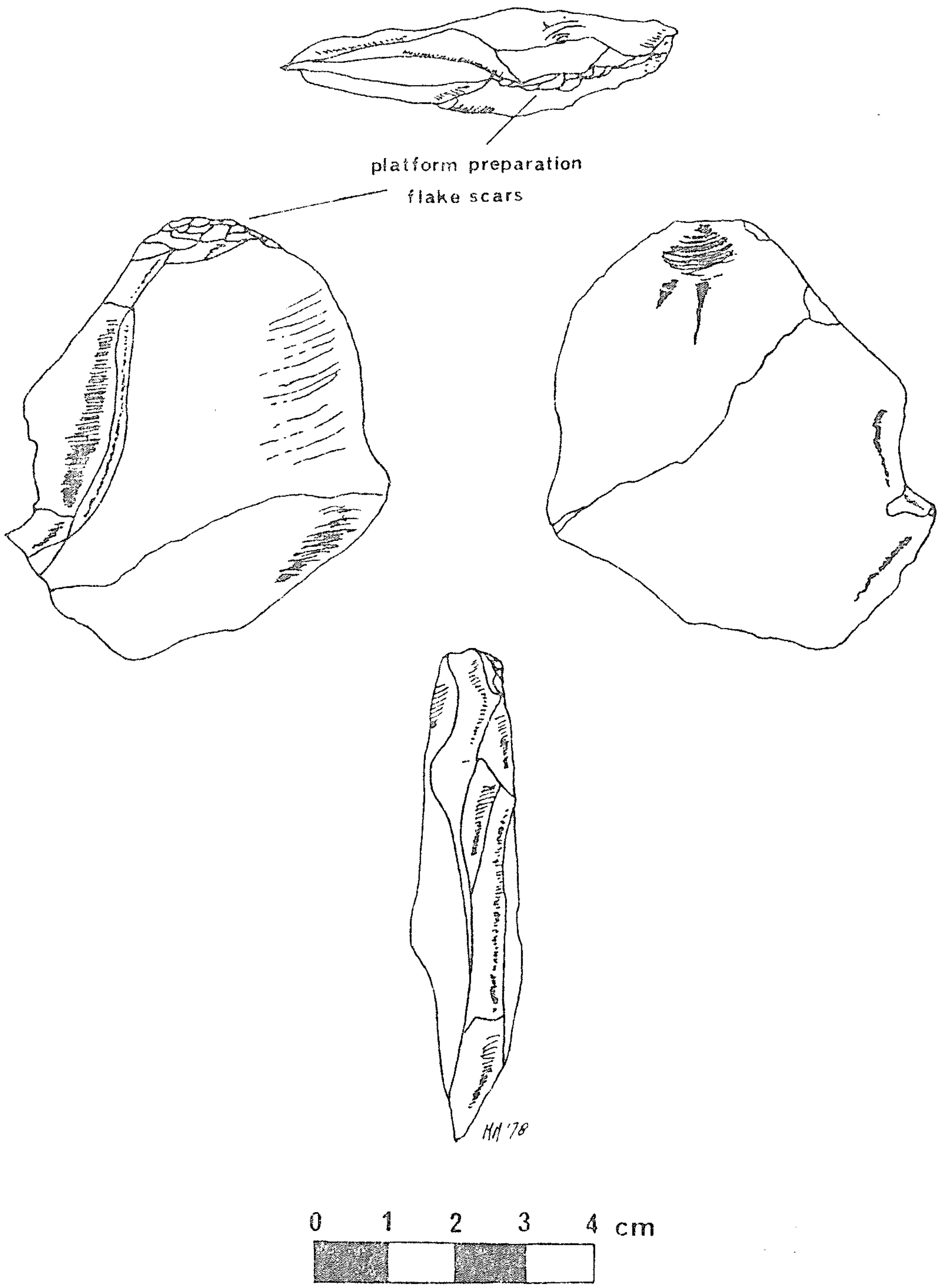


Figure 14. Prepared Platform Flake

scars on their dorsal faces near their striking platforms. These flakes are produced through abrasion of the platform area which removed material overhanging the dorsal face or weak areas in the platform. Greater control of the shape of the flake is achieved in this manner than if the craftsman merely attempted flake removal from a platform with these flaws. Some of the abrasion observed on the edges of the rough implements was likely a result of platform preparation.

Concave Platform Flakes (Classes 24-25; Figure 15)

Flakes with bulbs of percussion directly opposite negative bulbs of percussion on their dorsal faces are classified as concave platform flakes. These are produced in the course of implement reduction in cases where the craftsman intends to maximise the thickness or width of the core being reduced, as in preform manufacture. These flakes are thin at the point where most flakes are thickest (ie. at the bulb of percussion).

Jelinek *et al* (1971) also examined flakes with this morphology and found that a hammer with a broad striking end may at times remove two flakes, the interior one being concave. Examination of the published photographs, however, shows that the concavity seems to result from the removal of shatter flakes through crushing of the platform area. The flakes discussed by Jelinek *et al*

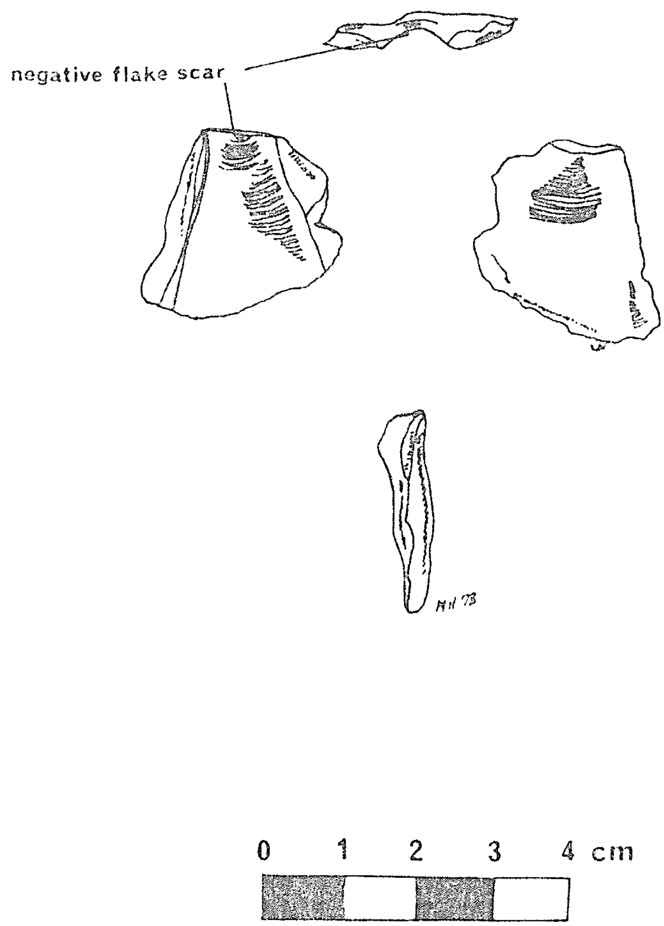


Figure 15. Concave Platform Flake

(1971) can be distinguished from the concave platform flakes defined here, since the ones classified here exhibit only one flake scar on their dorsal faces opposite the positive bulb of percussion. Further, while they assert that these flakes are largely produced through random or accidental factors, the class is here presented as one that can be deliberately and consistently produced.

Debitage Classes 26 to 33

The remaining debitage classes in product group III as well as classes 49 to 60 in product group IV are formed by the intersection of attributes, forming what Dunnell (1971: 70-76) has termed a paradigmatic classification. This serves to classify those items which possess two or more of the critical attributes defined here. It seems logical, for example, that in a hard-hammer technology, one should expect some concave platform flakes to exhibit crushing.

Product Group IV

Reduced cores or flakes (preforms) can be further worked to produce items which are symmetrical and have straight and sharp edges. The distinction between cores and flakes is usually lost here when reduction sequences number more than two per face. This may result in the obliteration of certain flake characteristics such as platforms and bulbs of percussion.

Product Group IV Implements

Fine Unifaces (Class 34) This class is defined as unifacially flaked implements exhibiting more than two reduction sequences on one or more margins.

Fine Uniface Margins (Class 35) These are items not complete enough to enable reconstruction of the outline of the original implement, but identifiable as edges.

Fine Uniface Bases (Class 36) This class consists of items which were once the basal portion of fine unifacial implements, defined as the narrow and sharply truncated end of the implement. No items in the four assemblages conformed to these requirements.

Fine Uniface Tips (Class 37) Fragments of the portion of fine unifaces where the margins converge to an acute angled tip at the end opposite the base are included in this class.

Fine Bifaces, Fine Biface Margins, Fine Biface Bases, and Fine Biface Tips (Classes 38-41) The same criteria apply to these classes as to fine unifaces, except that fine bifaces must be bifacially flaked with more than two reduction sequences per face.

McKean, Oxbow, and Duncan Projectile Points (Classes 42-44) As discussed previously, the artifact classes follow the types as defined by Mulloy (1954), Wheeler

(1952, 1954), and Nero and McCorquodale (1958) and adhered to by Haug (1976), Syms (1969, 1970) and Wettlaufer and Mayer-Oakes (1960). Briefly, McKean are lanceolate in outline with concave bases. Oxbow are squat, broad, "eared", or corner-notched points with concave bases, and Duncan points have a contracting stem with concave bases.

Product Group IV Debitage

Uniface and Biface Reduction Flakes (classes 45-46; Figures 16-17) These are distinctive flake forms resulting from the reduction of unifacial or bifacial implements. Although other flake forms may also be produced at this step, they are lipped on their ventral faces, and possess truncated flake scars on that lip when a biface is produced. A uniface reduction flake exhibits no truncated flake scars on the lip (see Figure 16a). A unifacially retouched flake with retouch on the lip indicates biface reduction and is therefore classed as a biface reduction flake (see Figure 16b). These kinds of flakes may also be produced in implement recycling, although determination of use-wear is not a part of this analysis. None of the unifacial or bifacial reduction flakes here were derived from the implements recovered at the sites. Good illustrations of biface reduction flakes are provided in MacDonald's (1969) report on the Paleo-Indian site, Debert, in Nova Scotia (MacDonald 1969: 196-197, Plate XIX).

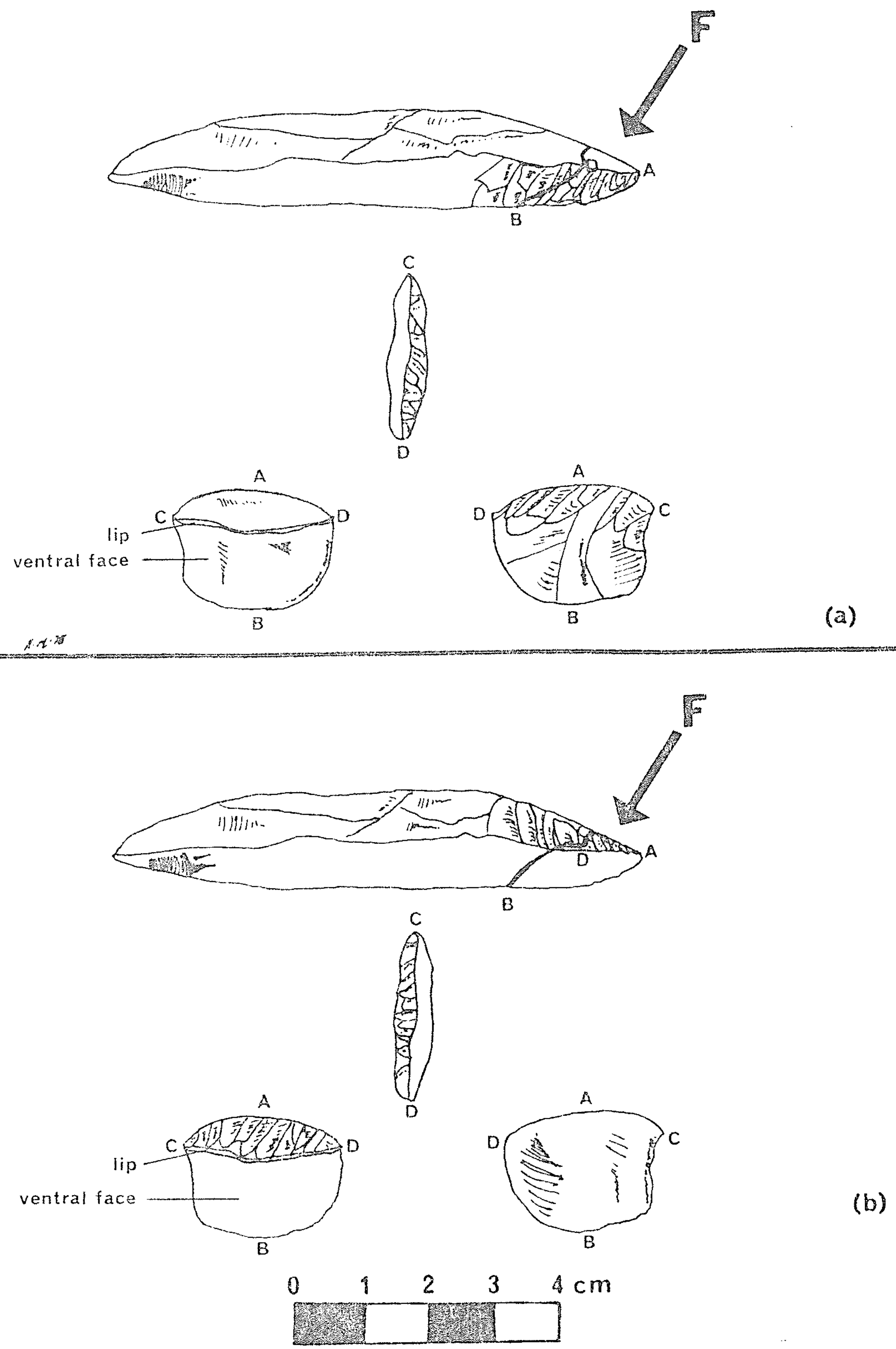


Figure 16. Implement Reduction Flakes Exhibiting Unifacial Retouch. (a) Flake resulting from the production of a uniface; (b) Flake resulting from the production of a biface. Letters in diagram serve as points of reference. "F" indicates direction of impact.

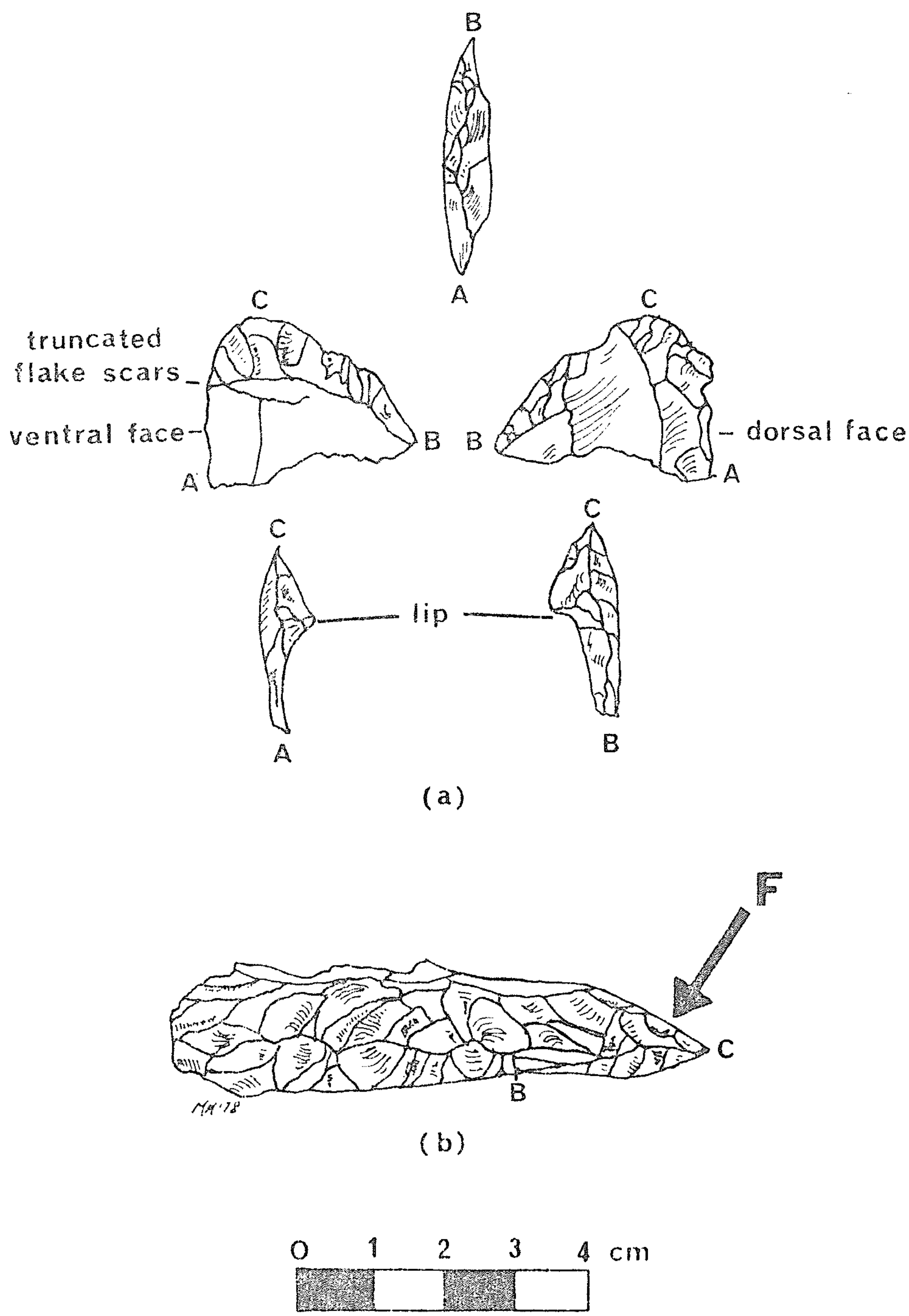


Figure 17. Bifacially Retouched Implement Reduction Flake. (a) Flake morphology; (b) Flake on bifacial core with direction of impact indicated. Letters in diagram serve as points of reference.

<u>Lipped Flakes</u> (Classes 47-48; Figure 18) This class is comprised of flakes without retouch scars, and exhibiting overhang on their ventral surfaces. These are produced when the craftsman strikes a very acute angled edge, such as during the secondary trimming of implements. This inference is supported by some of my own "uncontrolled" experimentation and by the experimental work of Bonnichsen (1977) who found that lipped flakes are produced when the platform-core face angle approaches 45 degrees. Certain lithic technologists have identified the use of soft-hammer percussion flaking by the presence of lipped flakes, but this seems doubtful. In Bonnichsen's words, "... experimental evidence...suggests lips on primary flakes cannot be used to distinguish between the use of hard and soft impactors has been common practice" (1977: 165).

The completed classification (Table 2) includes product groups and their behavioral inferences discussed above.

The immediate issue is that the utility of the classification must be demonstrated. That is, the variability of the four assemblages should be measurable through the use of the classification.

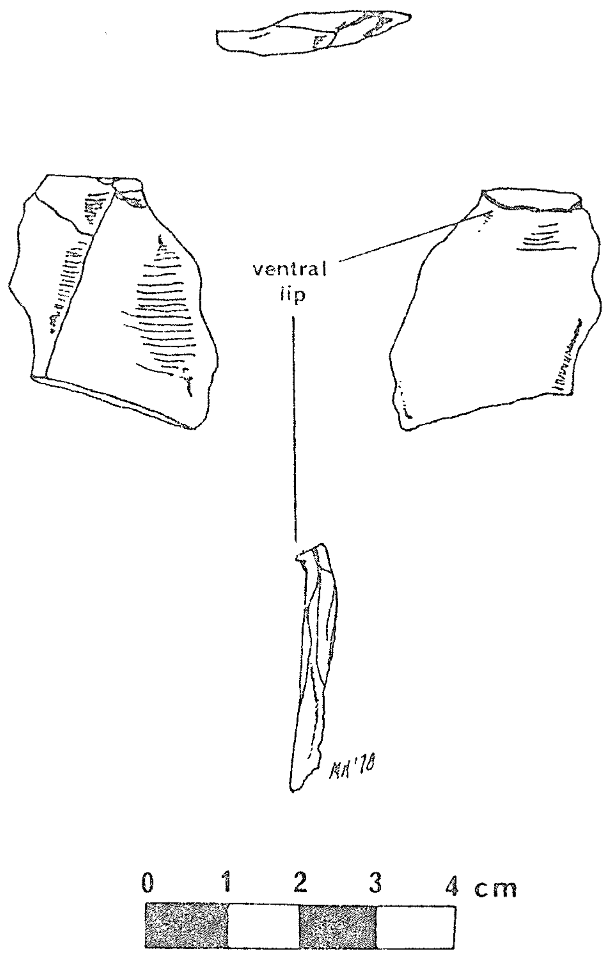


Figure 18. Lipped Platform Flake

CHAPTER 7

APPLICATION OF MODEL

A total of 12,627 artifacts were analysed in this study. Only four classes (36,57,59,60), noted in Table 2, were not found in any of the assemblages.

Based on the artifact counts obtained with the classification (Table 3), the frequencies of implements and debitage sorted into the three product groups are shown in Table 4. For ease of discussion, the term "product group" will be used interchangeably with "group".

Overall, AG15 is the largest assemblage, containing more implements and debitage than any of the others. UN55 is the smallest assemblage, but still contains more implements than PH1. AG19 is seen to contain a high number of implements in relation to its debitage content. PH1 contains more debitage in group IV than the other assemblages, while the debitage of AG15 is the highest frequency of all in groups II and III. AG19 contains more implements in groups II and IV than do the other sites, with AG15 containing the most implements in group III.

All of the assemblages contain their greatest amounts of debitage in group II, and it can be seen by referring to Table 3 that this is a result of high shatter frequencies.

Comparing the contents of the sites through density calculations produces the data in Table 5.

Group	No.	ARTIFACT CLASS	PH1	AG15	AG19	UN55
Product Group II	1.	Irregular Cores	2	6	3	4
	2.	Discoidal Cores	0	0	1	2
	3.	Keeled Cores	1	4	1	3
	4.	Utilised Intact Plat.	0	5	7	3
	5.	Utilised Crushed Plat.	0	4	7	2
	6.	Utilised Shatter Flakes	0	5	6	1
	7.	Utilised Shatter Blocks	0	2	4	1
	8.	Intact Plat. with Cort.	52	116	33	16
	9.	Intact Plat. w/o Cort.	230	136	98	53
	10.	Crushed Plat. with Cort.	155	182	76	57
	11.	Crushed Plat. w/o Cort.	803	323	335	119
	12.	Shatter Flakes with Cort.	204	320	55	40
	13.	Shatter Flakes w/o Cort.	1547	2458	354	592
	14.	Shatter Blocks with Cort.	173	238	60	61
	15.	Shatter Blocks w/o Cort.	366	367	155	111
Product Group III	16.	Rough Unifaces	1	13	5	4
	17.	Rough Uniface Fratments	1	8	5	1
	18.	Rough Bifaces	2	7	2	2
	19.	Rough Biface Fratments	4	7	6	2
	20.	Spokeshaves	0	2	1	1
	21.	Gravers	0	0	0	1
	22.	Prepared Plat. with Cort.	32	63	32	10
	23.	Prepared Plat. w/o Cort.	139	192	89	22
	24.	Concave Plat. with Cort.	9	9	2	3
	25.	Concave Plat. w/o Cort.	63	83	27	11
	26.	Cru/Pre Plat. with Cort.	40	45	29	13
	27.	Cru/Pre Plat. w/o Cort.	242	161	134	27
	28.	Cru/Con Plat. with Cort.	6	29	4	3
	29.	Cru/Con Plat. w/o Cort.	91	92	39	16
	30.	Pre/Con Plat. with Cort.	1	3	0	0
	31.	Pre/Con Plat. w/o Cort.	3	14	2	0
	32.	Cru/Pre/Con Plat. with Cort.	0	2	0	0
	33.	Cru/Pre/Con Plat w/o Cort.	0	12	2	0
Product Group IV	34.	Fine Unifaces	0	3	12	2
	35.	Fine Uniface Margins	0	4	1	3
	37.	Fine Uniface Tips	0	1	2	2
	38.	Fine Bifaces	2	6	3	2
	39.	Fine Biface Margins	3	4	2	2
	40.	Fine Biface Bases	0	6	9	3
	41.	Fine Biface Tips	0	5	1	3
	42.	McKean Projectile Points	1	3	1	1
	43.	Oxbow Projectile Points	0	0	2	1
	44.	Duncan Projectile Points	0	0	1	0
	45.	Uniface Reduction Flakes	7	11	14	2
	46.	Biface Reduction Flakes	18	20	11	3
	47.	Lipped Plat. with Cort.	15	17	7	3
	48.	Lipped Plat. w/o Cort.	83	40	28	11
	49.	Cru/Lip Plat. with Cort.	13	9	6	5
	50.	Cru/Lip Plat. w/o Cort.	100	28	34	19
	51.	Pre/Lip Plat. with Cort.	6	9	1	0
	52.	Pre/Lip Plat. w/o Cort.	41	65	15	14
	53.	Con/Lip Plat. with Cort.	0	2	0	0
	54.	Con/Lip Plat. w/o Cort.	10	12	0	2
	55.	Cru/Pre/Lip Plat. with Cort.	3	0	2	0
	56.	Cru/Pre/Lip Plat. w/o Cort.	11	3	5	0
	58.	Pre/Con/Lip Plat. w/o Cort.	0	1	0	0

Table 3
Implement and Debitage Class Frequencies

		SITES			
		PH1	AG15	AG19	UN55
GROUP II	Implements	3	26	29	16
	Debitage	3530	4140	1166	1049
	Total	3533	4166	1195	1065
GROUP III	Implements	8	37	19	11
	Debitage	626	705	360	105
	Total	634	742	379	116
GROUP IV	Implements	6	32	34	19
	Debitage	307	217	123	59
	Total	313	249	157	78
TOTAL SAMPLE		4480	5157	1731	1259
TOTAL IMPLEMENTS		17	95	82	46
TOTAL DEBITAGE		4463	5062	1649	1213

Table 4.
Frequency of Artifacts By Product Groups

		SITES			
		PH1	AG15	AG19	UN55
AREA (m^2)		9.5	34.0	14.0	72.4
All Artifacts/m^2		484.3	151.7	123.6	17.5
Implements/m^2		1.8	2.8	5.9	0.6
Debitage/m^2		482.5	148.9	117.8	16.9
GROUP II	Implements	0.3	0.8	0.1	0.2
	Debitage	371.6	121.8	83.3	14.6
	Total	371.9	122.5	85.4	14.8
GROUP III	Implements	0.8	1.1	1.4	0.2
	Debitage	65.9	20.7	25.7	1.5
	Total	66.7	21.8	27.1	1.6
GROUP IV	Implements	0.6	0.9	2.4	0.3
	Debitage	32.9	6.4	8.8	0.8
	Total	33.3	7.3	11.2	1.1

Table 5.
Artifact Densities By Product Groups

PH1 is by far the site with the highest debitage density, AG19 has the highest implement density, and UN55 the lowest densities of both kinds of artifacts. AG15 has a greater debitage density, but a lower implement density than AG19.

The greatest densities among the four assemblages are observed in group II, but interesting patterns are shown with respect to implements. Both PH1 and AG15 have their highest implement densities in group III, while AG19 and UN55 have their highest implement densities in group IV. Also, among the four assemblages, there is a corresponding decline in debitage densities as one proceeds from group II to group IV.

Comparisons at this point cannot readily be made from raw counts because the sample sizes are so uneven, and thus the data has been converted to percentages (Table 6). In order to further explore relationships among the sites in terms of reduction stages, percentages have also been calculated for the classes based on the total number of implements only, and on the totals of debitage (Table 7). Sorting this data by product groups results in the following information (Table 8):

1) There is a decrease in the relative amounts of debitage in the assemblages from product group II to product group IV.

		ARTIFACT CLASS	PH1	AG15	AG19	UN55
Product Group II	1.	Irregular Cores	.04	.12	.17	.32
	2.	Discoidal Cores			.06	.16
	3.	Keeled Cores	.02	.08	.06	.24
	4.	Utilised Intact Plat.		.10	.40	.24
	5.	Utilised Crushed Plat.		.08	.40	.16
	6.	Utilised Shatter Flakes		.10	.35	.08
	7.	Utilised Shatter Blocks		.04	.23	.08
	8.	Intact Plat. with Cort.	1.16	2.25	1.91	1.27
	9.	Intact Plat. w/o Cort.	5.13	2.64	5.66	4.21
	10.	Crushed Plat. with Cort.	3.46	3.53	4.39	4.53
	11.	Crushed Plat. w/o Cort.	17.92	6.26	19.35	9.45
	12.	Shatter Flakes with Cort.	4.55	6.21	3.18	3.18
	13.	Shatter Flakes w/o Cort.	34.53	47.66	20.45	47.02
	14.	Shatter Blocks with Cort.	3.86	4.62	3.47	4.85
	15.	Shatter Blocks w/o Cort.	8.17	7.12	8.95	8.82
Product Group III	16.	Rough Unifaces	.02	.25	.29	.32
	17.	Rough Uniface Fragments	.02	.16	.29	.08
	18.	Rough Bifaces	.04	.14	.12	.16
	19.	Rough Biface Fragments	.09	.14	.34	.16
	20.	Spokeshaves		.04	.06	.08
	21.	Gravers				.08
	22.	Prepared Plat. with Cort.	.71	1.22	1.85	.79
	23.	Prepared Plat. w/o Cort.	3.10	3.72	5.14	1.75
	24.	Concave Plat. with Cort.	.20	.17	.12	.24
	25.	Concave Plat. w/o Cort.	1.41	1.61	1.56	.87
	26.	Cru/Pre Plat. with Cort.	.89	.87	1.68	1.03
	27.	Cru/Pre Plat. w/o Cort.	5.40	3.12	7.74	2.14
	28.	Cru/Con Plat with Cort.	.13	.56	.23	.24
	29.	Cru/Con Plat. w/o Cort.	2.03	1.78	2.25	1.27
	30.	Pre/Con Plat. with Cort.	.02	.06		
	31.	Pre/Con Plat. w/o Cort.	.07	.27	.12	
	32.	Cru/Pre/Con Plat. with Cort.		.04		
	33.	Cru/Pre/Con Plat. w/o Cort.		.23	.12	
Product Group IV	34.	Fine Unifaces		.06	.69	.16
	35.	Fine Uniface Margins		.08	.06	.24
	37.	Fine Uniface Tips		.02	.12	.16
	38.	Fine Bifaces	.04	.12	.17	.16
	39.	Fine Biface Margins	.07	.08	.12	.16
	40.	Fine Biface Bases		.12	.52	.24
	41.	Fine Biface Tips		.10	.06	.24
	42.	McKean Projectile Points	.02	.06	.06	.08
	43.	Oxbow Projectile Points			.12	.08
	44.	Duncan Projectile Points			.06	
	45.	Uniface Reduction Flakes	.16	.21	.81	.16
	46.	Biface Reduction Flakes	.40	.39	.64	.29
	47.	Lipped Plat. with Cort.	.33	.33	.40	.24
	48.	Lipped Plat. w/o Cort.	1.85	.78	1.62	.87
	49.	Cru/Lip Plat. with Cort.	.29	.17	.35	.40
	50.	Cru/Lip Plat. w/o Cort.	2.23	.54	1.96	1.51
	51.	Pre/Lip Plat. with Cort.	.13	.17	.06	
	52.	Pre/Lip Plat. w/o Cort.	.92	1.26	.87	1.11
	53.	Con/Lip Plat. with Cort.		.04		
	54.	Con/Lip Plat. w/o Cort.	.22	.23		.16
	55.	Cru/Pre/Lip Plat. with Cort.	.07		.06	
	56.	Cru/Pre/Lip Plat. w/o Cort.	.25	.06	.29	
	58.	Pre/Con/Lip Plat. w/o Cort.		.02		

Table 6
Artiface Class Frequencies as Percent of All Artifacts

		ARTIFACT CLASS	PH1	AG15	AG19	UN55
	1.	Irregular Cores	11.76	6.32	3.66	8.70
	2.	Discoidal Cores			1.22	4.35
Product Group II	3.	Keeled Cores	5.88	4.21	1.22	6.52
	4.	Utilised Intact Plat.		5.26	8.54	6.52
	5.	Utilised Crushed Plat.		4.21	8.54	4.35
	6.	Utilised Shatter Flakes		5.26	7.32	2.17
	7.	Utilised Shatter Blocks		2.11	4.88	2.17
	8.	Intact Plat. with Cort.	1.17	2.29	2.00	1.32
	9.	Intact Plat. w/o Cort.	5.15	2.69	5.94	4.37
	10.	Crushed Plat. with Cort.	3.47	3.60	4.61	4.70
	11.	Crushed Plat. w/o Cort.	18.00	6.38	20.32	9.81
	12.	Shatter Flakes with Cort.	4.57	6.32	3.34	3.30
	13.	Shatter Flakes w/o Cort.	34.66	48.56	21.47	48.80
	14.	Shatter Blocks with Cort.	3.88	4.70	3.64	5.03
	15.	Shatter Blocks w/o Cort.	8.20	7.25	9.40	9.15
	16.	Rough Unifaces	5.88	13.68	6.10	8.70
	17.	Rough Uniface Fragments	5.88	8.42	6.10	2.17
	18.	Rough Bifaces	11.76	7.37	2.44	4.35
	19.	Rough Biface Fragments	23.53	7.37	7.32	4.35
Product Group III	20.	Spokeshaves		2.11	1.22	2.17
	21.	Gravers				2.17
	22.	Prepared Plat. with Cort.	.72	1.24	1.94	.82
	23.	Prepared Plat. w/o Cort.	3.11	3.79	5.40	1.81
	24.	Concave Plat. with Cort.	.20	.18	.12	.25
	25.	Concave Plat. w/o Cort.	1.41	1.64	1.64	.91
	26.	Cru/Pre Plat. with Cort.	.90	.89	1.76	1.07
	27.	Cru/Pre Plat. w/o Cort.	5.42	3.18	8.12	2.23
	28.	Cru/Con Plat. with Cort.	.13	.57	.24	.25
	29.	Cru/Con Plat. w/o Cort.	2.04	1.82	2.37	1.32
	30.	Pre/Con Plat with Cort.	.02	.06		
	31.	Pre/Con Plat. w/o Cort.	.07	.28	.12	
	32.	Cru/Pre/Con Plat. with Cort.		.04		
	33.	Cru/Pre/Con Plat w/o Cort.		.24	.12	
	34.	Fine Unifaces		3.16	14.63	4.35
	35.	Fine Uniface Margins		4.21	1.22	6.52
	37.	Fine Uniface Tips		1.05	2.44	4.35
	38.	Fine Bifaces	11.76	6.32	3.66	4.35
	39.	Fine Biface Margins	17.65	4.21	2.44	4.35
	40.	Fine Biface Bases		6.32	10.98	6.52
	41.	Fine Biface Tips		5.26	1.22	6.52
Product Group IV	42.	McKean Projectile Points	5.88	3.16	1.22	2.17
	43.	Oxbow Projectile Points			2.44	2.17
	44.	Duncan Projectile Points			1.22	
	45.	Uniface Reduction Flakes	.16	.22	.85	.16
	46.	Biface Reduction Flakes	.40	.40	.67	.25
	47.	Lipped Plat. with Cort.	.34	.34	.42	.25
	48.	Lipped Plat. w/o Cort.	1.86	.79	1.70	.91
	49.	Cru/Lip Plat. with Cort.	.29	.18	.36	.41
	50.	Cru/Lip Plat. w/o Cort.	2.24	.55	2.06	1.57
	51.	Pre/Lip Plat. with Cort.	.13	.18	.06	
	52.	Pre/Lip Plat w/o Cort.	.92	1.28	.91	1.15
	53.	Con/Lip Plat with Cort.		.04		
	54.	Con/Lip Plat w/o Cort.	.22	.24		.16
	55.	Cru/Pre/Lip Plat with Cort.	.07		.12	
	56.	Cru/Pre/Lip Plat w/o Cort.	.25	.06	.30	
	58.	Pre/Con/Lip Plat w/o Cort.		.02		

Table 7
Implement Class Frequencies as Percent of Implements Only
Debitage Class Frequencies as Percent of Debitage Only

		PRODUCT GROUP	PH1	AG15	AG19	UN55
a)	AS % of TOTAL N	II III IV	78.8 14.1 7.0	80.8 14.4 4.8	69.0 21.9 9.0	84.6 9.2 6.2
b)	IMP. AS % N	II III IV	.1 .2 .1	.5 .7 .6	1.7 1.1 2.0	1.3 .9 1.5
c)	DEB. AS % N	II III IV	78.8 14.0 6.9	80.3 13.7 4.2	67.4 20.8 7.1	83.3 8.3 4.7
d)	IMP. AS % N_1	II III IV	17.6 47.0 35.3	27.4 38.9 33.7	35.4 23.2 41.5	34.8 23.9 41.3
e)	DEB. AS % N_2	II III IV	79.1 14.0 6.9	81.8 13.9 4.3	70.8 21.8 7.4	86.5 8.7 4.9

Table 8

Relative Frequencies of Implements
and Debitage by Product Groups

Total N = All Artifacts
N_1 = Implements Only
N_2 = Debitage Only

2) The high proportion of debitage dominates the artifact frequencies.

3) Both PH1 and AG15 have their highest implement percentages in group III, while AG19 and UN55 have their highest implement percentages in group IV (Table 8d).

4) AG19 contains more debitage in group III than the other assemblages (Table 8c, e).

It is interesting to note that the intersite comparisons apparent here correspond to those noted for the density calculations. It is also apparent that the inclusion of shatter flake and blocks inflates the composition of group II, such that it seems that the process of initial reduction results in more wastage than any other activity.

Only general comparisons are possible at this stage of the analysis. Implements at PH1 and AG15 were disposed of most frequently after primary trimming, while at AG19 and UN55, relatively more implements were disposed of secondary trimming. Although artifacts of all three product groups are represented at the four sites, it is reasonable to propose that the activities at PH1 and AG15 are related to a careful selection of preforms. That is, implements of PH1 and AG15 were disposed of frequently after primary trimming perhaps because the implements were not suitable for further reduction. The presence of group IV implements in PH1 and AG15 may be accounted for by regarding them as rejects of the selection of fine implements for transport to other sites.

AG19 contains the lowest frequency of product group II materials (as a percentage of all artifacts), but also the highest frequencies for groups III and IV. The later stages of artifact manufacture are stressed here more than in any of the other assemblages. Finally, UN55, the smallest assemblage, seems most different from the others. It contains the highest relative frequency of materials (as percentage of all artifacts; Table 8a) in product group II, and the least for product groups III and IV.

When examined by product groups, the raw counts of total items separate PH1 and AG15 from AG19 and UN55. PH1 and AG15 seem to reflect activities resulting predominantly in the deposition of groups II and III artifacts. The sheer amounts of debitage at these two sites, along with their relative few implements, indicate a great deal of initial reduction and primary trimming. It is also possible that stringent criteria were being imposed on the group III preforms before these would enter the secondary trimming stage. At both sites, the numbers of reduction flakes indicate that biface trimming was more frequent than uniface trimming. Indeed, it is possible that unifaces of group III were being trimmed to bifaces, although none of the biface reduction flakes are of the type illustrated in Figure 16b.

The high relative frequency of group IV implements in the AG19 and UN55 assemblages indicates that tools tended to be fully reduced before being discarded. This seems to imply the use of finished tools. While product groups II and III are well represented in the two assemblages, AG19 contains more uniface than biface reduction flakes, and UN55 has a low occurrence of both. AG19 also has a rather large number of fine unifaces, which may result from different tasks or expedient production. UN55 evidences very little secondary trimming. On the other hand, PH1, AG15 and AG19 evidence a great deal of secondary trimming as well as initial reduction.

It is argued here that the locations of PH1 and AG15 in the lower reaches of the escarpment very close to Lake Agassiz strandlines is no coincidence. The two assemblages represent workshops from which the final products of lithic reduction were exported. While it cannot be shown that the implements were brought to AG19 or UN55, it seems likely that sites of this kind were the destination of the product group IV implements manufactured at PH1 and AG15.

In general, the data are difficult to interpret in behavioral terms because of the large number of artifact classes, and also because the variability exhibited in terms of the product groups is not consistent enough to warrant final conclusions based on these figures. The variability of reduction stages among the assemblages indicates a possible close similarity between PH1 and AG15, and also between AG19 and UN55. It is essential that more objective means of searching for similarities and differences be applied to the assemblages, to provide more detailed accounts of factors that produced the observed variabilities. Such means are available in the techniques of cluster and multidimensional scaling analyses.

CHAPTER 8

CLUSTER AND NON-METRIC MULTIDIMENSIONAL SCALING ANALYSES

Cluster Analyses

Hierarchical clustering has its origin in the biological sciences and is a technique aimed at providing "natural units" (Sneath and Sokal 1973). The utility of such a technique here is that the inferred similarities between PH1 and AG15 and between AG19 and UN55 can be measured. The technique not only groups those entities that are most similar but also shows the degree of similarity among entities.

The cases to be compared, in this instance the sites, are termed "OTU's" or operational taxonomic units. The classes of this study can be referred to as characters (Sneath and Sokal 1973). Cluster analysis as used here will regard all of the characters as being equally important to the final formation of assemblage clusters. That is, no classes will be considered to be of higher value than any others towards the measurement of overall similarities or differences among the sites.

The first step in such an undertaking is to compute the similarity between either OTU's or characters. If similarity between OTU's is the goal, the analysis is termed "Q-mode", and if the investigator is interested in the similarity among characters, the analysis is termed

"R-mode". Q-mode was used here because it suits the purposes expressed above, and also because the small number of OTU's prohibits the use of R-mode analysis.

Several kinds of clustering techniques exist, each differing in the criteria they use to admit new members to clusters. Although the program used here is capable of computing eight different kinds of cluster analyses, only one, the unweighted pair-group method, is regarded as suitable for reasons discussed below.

A technique such as single-link (Nearest Neighbor) clustering will admit a new member to an existing cluster on the basis of its similarity to the member most similar to it within that cluster. Complete linkage (Furthest Neighbor) clustering will admit a new member on the basis of its similarity to the most distant member within the cluster (Johnson 1972: 334-335). Such techniques often result in extremes which are undesirable because of the strain they place on attempts to use the underlying classification (Sneath and Sokal 1973: 228). Furthest Neighbor analysis will tend to exaggerate the differences among the OTU's, while Nearest Neighbor would tend to obscure them.

A way to solve this problem is to use as admission criteria the average similarity between the new member and the cluster's averaged similarity measures. The term pair-group refers to the iterative technique used in the search for new members. The computer searches the similarity matrix for average pairs that are most similar. "Unweighted" means that the overall average of the new cluster does not change in relation to a member still to be joined. A "weighted" technique biases the average measure in favour of the last member to join the cluster. Given the small number of OTU's in the present analysis, the unweighted technique will result in less distortion of the data (cf. Sneath and Sokal 1973: 230-234). The nearest neighbour and furthest neighbour techniques were calculated in the study as a matter of course, and did not yield results substantially different from those of the unweighted pair-group technique.

The initial similarity matrix was computed using a rank-order correlation coefficient, Spearman's r_s. Spearman's r_s does not require assumptions concerning the normality of the distribution of scores, a situation appropriate for this analysis. In the calculation of r_s, the five classes of the classification which were represented in only single assemblages (21,32,44,53,58; see Table 3) were combined into a single class of "other" (Table 9). This was done to reduce the effects of tied ranks (Speth and Johnson 1976). The r_s formula that corrects for tied ranks was then calculated for 52 characters in the cluster analysis of all artifacts, and is given as (Siegel 1956):

$$r_s = \frac{\sum x^2 + \sum y^2 - \sum d^2}{2\sqrt{\sum x^2 \sum y^2}}$$

where: $\sum x^2 = \frac{N^2 - N}{12} - \sum T_x$ and $\sum y^2 = \frac{N^2 - N}{12} - \sum T_y$;

where: $T_{x(y)} = \frac{t^3 - t^2}{12}$;

where: t = the number of observations tied at a given rank;

and x, y = the cases between which the similarity is being computed;

and d = the difference between ranks at a character;

and N = the number of characters.

For further comparisons, the coefficient was also calculated for the data on implement frequencies only (21 classes, and using the data for debitage only (30 classes) each time omitting those classes found in only one assemblage. Thus for each data set, six Spearman's r_s correlations were calculated, one for each possible pair of assemblages (Table 10). The resulting values have been here subtracted from +1.00 to obtain a dissimilarity matrix, which serves as the input to clustering program (Table 11).

ARTIFACT CLASS	PH1	AG15	AG19	UN55
1	21	20	19.5	33.5
2	7	2	6.5	19
3	17	12.5	6.5	28.5
4	7	16.5	30	28.5
5	7	12.5	30	19
6	7	16.5	27	10
7	7	5.5	21.5	10
8	39	43	41	41.5
9	48	44	48	47
10	45	46	46	48
11	51	50	51	51
12	47	49	44	46
13	52	52	52	52
14	46	48	45	49
15	50	51	50	50
16	17	31	24	33.5
17	17	24	24	10
18	21	22.5	14.5	19
19	26	22.5	27	19
20	7	5.5	6.5	10
22	36	39	40	36
23	44	47	47	44
24	30	26	14.5	28.5
25	40	41	37	37.5
26	37	38	39	39
27	49	45	49	45
28	27.5	36	21.5	28.5
29	42	42	43	41.5
30	17	8.5	1.5	3.5
31	24	14	14.5	3.5
33	7	29.5	14.5	3.5
34	7	8.5	34	19
35	7	12.5	6.5	28.5
37	7	4	14.5	19
38	21	20	19.5	19
39	24	12.5	14.5	19
40	7	20	32	19
41	7	16.5	6.5	28.5
42	17	8.5	6.5	10
43	7	2	14.5	10
45	29	28	35	19
46	35	34	33	28.5
47	34	33	30	28.5
48	41	37	38	37.5
49	33	26	27	35
50	43	35	42	43
51	27.5	26	6.5	3.5
52	38	40	36	40
54	31	29.5	1.5	19
55	24	2	14.5	3.5
56	32	8.5	24	3.5

Table 9

Ranked Data For Computation of Spearman's r_s

The cluster analysis, HCLUS, was written by J. J. Wood of Northern Arizona University (Wood 1973). The program was obtained from G. Monks, and is the same version implemented by R. G. Matson of the University of British Columbia. HCLUS was used to compute seven of the eight available techniques, but only the results of Method 4, the group average or unweighted pair-group method, are presented here. The other six techniques include: single linkage or nearest neighbor; complete linkage or furthest neighbor, simple average, Gower's median method, centroid or weighted pair-group, and Ward's method or error sum of squares (Wood 1973). Examples of applications of these techniques are numerous, and several kinds of cluster analysis are discussed in an archaeological context by Hodson (1970).

Cluster Analyses Results

All Artifacts

The dendrogram (Figure 19 a) clearly demonstrates two separate clusters. PH1 and AG15 merge sooner than do AG19 and UN55, meaning that there is less dissimilarity between PH1 and AG15 than there is between AG19 and UN55. Finally, both clusters merge at a relatively high level of dissimilarity. The PH1 - AG15 cluster is hereafter referred to as cluster A, the AG19 - UN55 cluster as cluster B.

		PH1	AG15	AG19	UN55
	PH1	1.0			
ALL ARTIFACTS	AG15	0.86	1.0		
	AG19	0.75	0.82	1.0	
	UN55	0.74	0.84	0.84	1.0

		PH1	AG15	AG19	UN55
	PH1	1.0			
IMPLEMENTS	AG15	0.57	1.0		
	AG19	-0.05	0.40	1.0	
	UN55	0.18	0.37	-0.02	1.0

		PH1	AG15	AG19	UN55
	PH1	1.0			
DEBITAGE	AG15	0.90	1.0		
	AG19	0.95	0.91	1.0	
	UN55	0.96	0.93	0.95	1.0

Table 10.

Similarity Matrices Based on Spearman's r_s

		PH1	AG15	AG19	UN55
	PH1	0.0			
ALL	AG15	0.14	0.0		
ARTIFACTS	AG19	0.25	0.18	0.0	
	UN55	0.26	0.16	0.16	0.0

		PH1	AG15	AG19	UN55
	PH1	0.0			
	AG15	0.43	0.0		
IMPLEMENTS	AG19	1.05	0.60	0.0	
	UN55	0.82	0.63	1.02	0.0

		PH1	AG15	AG19	UN55
	PH1	0.0			
	AG15	0.10	0.0		
DEBITAGE	AG19	0.05	0.09	0.0	
	UN55	0.04	0.07	0.05	0.0

Table 11.

Dissimilarity Matrices Based on Spearman's r_s

Implements

This analysis does not produce the separate units observed in the total sample run, and some slightly different relationships are apparent. First PH1 and AG15 merge at a relatively low level of dissimilarity, then this unit links to UN55 at a higher level of dissimilarity, and finally AG19 merges at the end of the analysis. It is possible to interpret PH1 and AG15 as a cluster (cluster C), and AG19 (D) and UN55 (E) as separate entities (Figure 19b).

Debitage

Strikingly different results are obtained (Figure 19c) showing PH1 very similar to UN55. Later AG19 joins that cluster at a much higher dissimilarity, and finally AG15 merges. Two separate clusters are apparent; PH1, UN55 and AG19 (cluster F), and AG15(G) as a separate entity.

The results of the analysis of all artifacts agree closely with the product group interpretations made earlier. PH1 and AG15 are clearly different from AG19 and UN55 in terms of debitage content and implement frequencies of groups III and IV. In the implements only run, PH1 and AG15 retain their similarity, but AG19 and UN55 seem to form separate units. This agrees with the earlier suggestion that UN55 is very different from the other assemblages in terms of overall content. Reference to Tables 4 and 5 above shows that the implement densities and implement relative frequencies are closely matched with the derivation of clusters C, D, and E.

The debitage results are difficult to understand because PH1 and UN55 are very dissimilar with regard to the raw data. The relationships observed may be a result of the rank-order correlation coefficient, which could mask differences that otherwise might distinguish the assemblages.

In general, it may be stated that the analysis performed with the total artifact sample provides the most clear-cut arrangement of the assemblages. The cluster analyses have served their purpose by demonstrating the existence of two groups, which may indicate that two basic kinds of sites are being examined. The cluster analyses are most clearly understood in terms of the general variabilities noticed in the initial application of Collins' (1975) model, and a greater degree of resolution needs to be attained to allow further evaluation of the utility of the artifact classes.

Non-Metric Multidimensional Scaling Analyses

Multidimensional scaling has been used to test archaeological interpretation based on cluster analyses (eg. Hodson 1970; Matson and True 1974; True and Matson 1970; Matson 1974; Monks 1976; Peacock 1976). Non-metric scaling basically involves placing the values of a dissi-

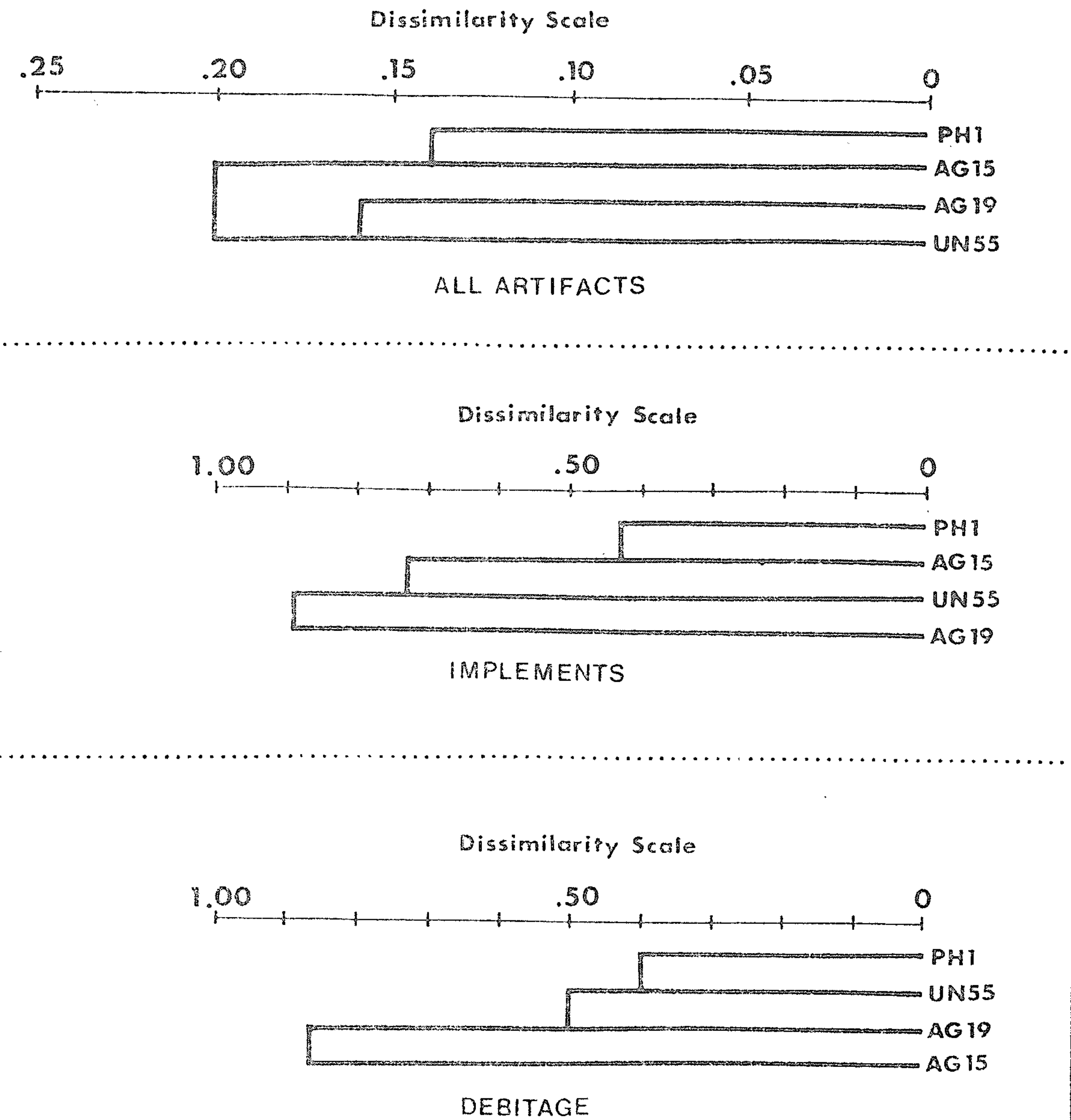


Figure 19. Group Average Cluster Analysis Dendrograms

milarity matrix as points in multidimensional space until the rank-order of the interpoint distances closely matches the order of the matrix values. As stated by Kruskal (1964a: 1):

> The problem of multidimensional scaling... is to find n points whose interpoint distances match in some sense the experimental distance of n objects.

The scaling procedure used here is Kruskal's MDSCAL (Kruskal 1964a, 1964b). The advantage of Kruskal's technique over other non-metric scaling procedures (eg. Shephard 1962) is that it calculates a measure of the "goodness of fit" of the arrangement. This measure is called stress, and acceptable results are obtained when stress is low, generally, less than 10% (Kruskal 1964a: 3, 1964b: 119). It should be noted here that a metric scaling procedure was not used because of the nature of the similarity coefficient used, which is rank-order or "non-metric".

As discussed by Johnson (1972: 367-368), a useful analogy may be drawn between MDSCAL and factor analysis. The vectors or dimensions provided by MDSCAL are similar to the factors of factor analysis, and stress is similar to the amount of explained variance.

For a specified number of dimensions, the program attempts to achieve the lowest stress value in a certain number of attempts or interations. The number of iterations specified here was a maximum of 100, and the maximum number of dimensions to be considered was six. The program fits the points first to the lowest stress possible in one dimension, then likewise in two and so on, until the addition of more dimensions does not alter the configuration of points, or until stress is zero.

Multidimensional scaling has been used to support or cast doubt upon established cultural sequences, and has yielded results relevant to interpreting poorly recorded or reported data (eg. Matson 1974). While the usual way of interpreting multidimensional scaling results is to use the interpoint distances of the scaled items, it has been argued that the interpretation of the overall vectors is the valid way to interpret non-metric results (cf. Johnson 1972: 367). Vectors described in this way have been able to produce patterns representing time (Peacock 1976, Monks 1976), changes in subsistence patterns through time (Matson and True 1974: 63), or as artifact class representation (eg. "core-toolness": Matson and True 1974: 63).

The dissimilarity matrices used in the HCLUS analyses were also used as input to the MDSCAL program. A two-dimensional cut-off was later decided upon in all three cases when further dimensions failed to reduce stress by more than one percent. Kruskal (1971) also states that when stress is plotted against the number of dimensions, the point at which an "elbow" appears in the graph indicates the most reliable number of dimensions to be con-

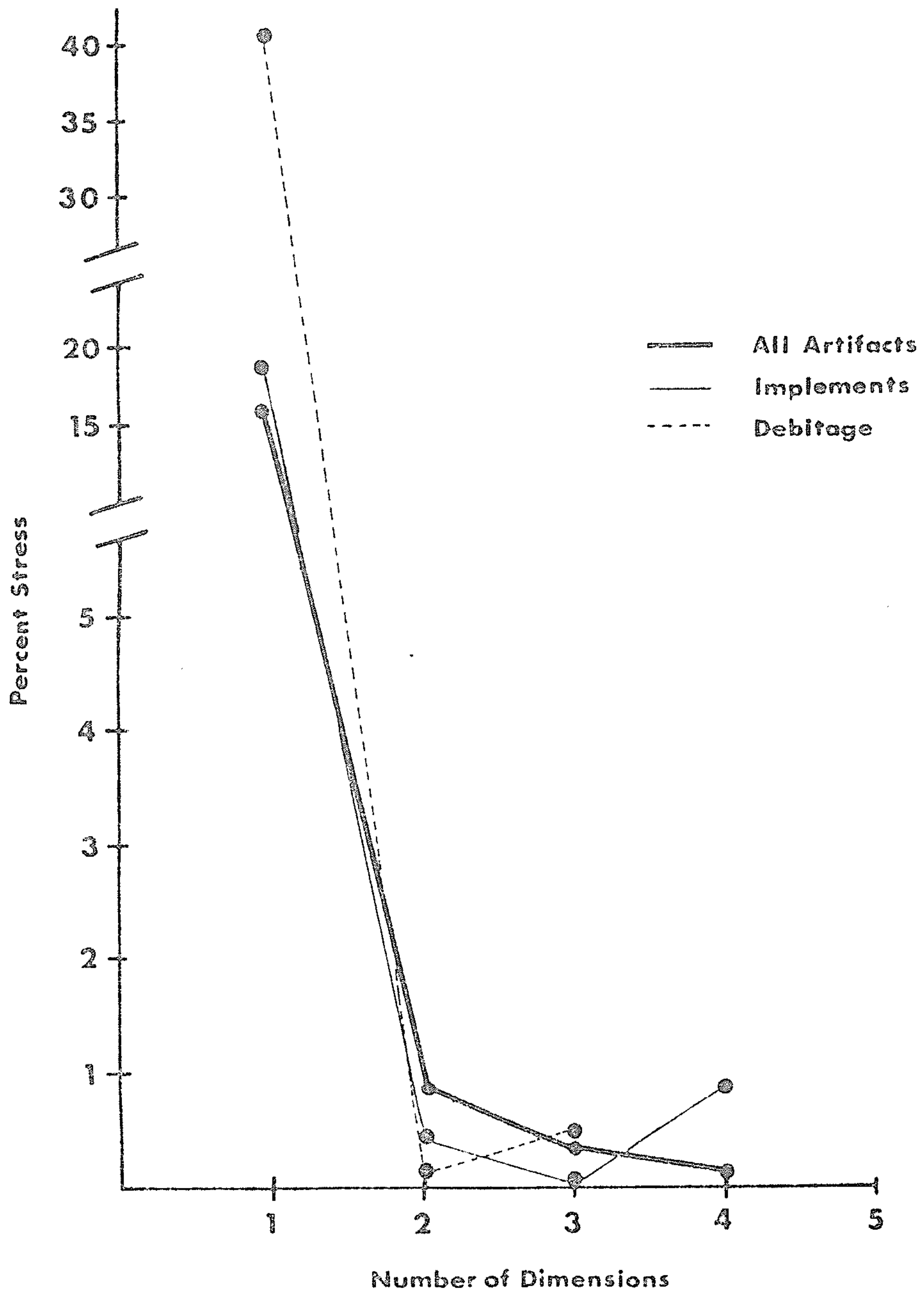


Figure 20. Stress Curves of Non-Metric
Multidimensional Scaling Analyses

sidered. This elbow is clearly visible at the two-dimensional point in Figure 20. In the implements solution, stress actually increased when the matrix was arranged in four dimensions; the same occurred for the debitage solution at three dimensions. This is highly unusual, since according to Kruskal (1964a, b; 1971) stress always decreases as the number of dimensions increases. Perhaps the small number of cases affects the arrangement when stress is very low.

Multidimensional Scaling Results

The arrangements of points were compared with the raw data, relative frequencies of all artifacts, implements, and debitage, as well as with debitage/implement ratios, densities, and product group occurrences. The data were matched satisfactorily with the vectors when the rank-order of the points along the vectors agreed perfectly with the rank-order of the variable being considered (r_s = +1.00 or -1.00) The high correlations are possible because of the small number of QTU's involved here. The correlation would likely decrease if given a larger number of sites. For example, Matson and True (1974: 63-66) achieved significant rank-order correlation values in the range of .73-.89, with a sample of 20 sites subjected to MDSCAL analysis. In the following discussion vector I is always the horizontal axis and vector II is always the vertical axis.

All Artifacts

Comparison of the following variables with the order of points along vector I (Figure 21) produced r_s values of +1.0 or -1.0 (Table 5):

	Variables	PH1	AG15	UN55	AG19
		Order of Sites Along Vector I			
1.	Implements as %N	0.4	1.8	3.6	4.7
2.	Implement fragments as %N	0.2	0.7	1.3	1.5
3.	Implements as %N in PG II	17.6	27.4	34.8	35.3
4.	Implements as %N in PG III	47.0	38.9	23.9	23.2
5.	Implements as %N in PG IV	0.1	0.6	1.5	2.0
6.	Debitage/Implement Ratio	262.5:1	53.3:1	26.4:1	20.1:1
7.	Shatter/Implement Ratio	134.7:1	35.6:1	17.5:1	7.6:1
8.	Debitage as %N	99.6	98.2	96.3	95.3
9.	Rough Bifaces and Rough Biface Fragments as %N	0.1	0.3	0.3	0.5
10.	Fine Unifaces and Fine Uniface Fragments as %N	0.0	0.2	0.6	0.9
11.	Fine Bifaces and Fine Biface Fragments as %N	0.1	0.4	0.8	0.9
12.	Projectile Points as %N	0.0	0.1	0.2	0.2

Table 12. Variables Relevant to Vector I, MDSCAL All Artifacts Solution

N = All Artifacts
N_1 = Implements
P.G. = Product Group

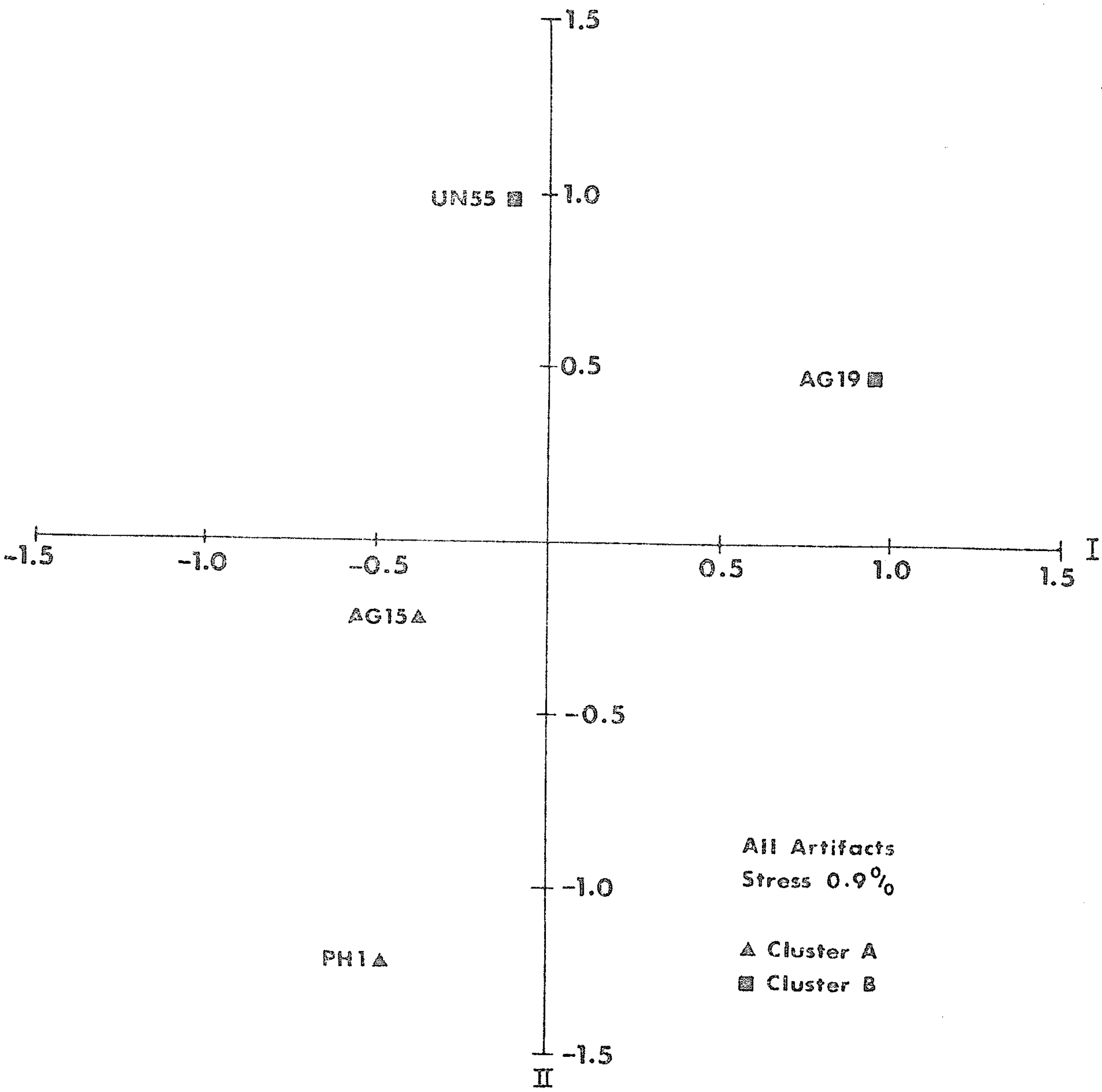


Figure 21. Vectors I and II, MDSCAL All Artifacts Solution

Vector I is best interpreted as arranging the assemblages with respect to the relative frequencies or implements contained within each. PH1 at one extreme contains relatively the fewest, and AG19, the most. The debitage/ implement ratio is 15.5 times greater for PH1 than for AG19. It is also interesting to note that PH1 contains 24% more implements in product group III than does AG19, but 17% less in group II. With less certainty, this dimension may also be interpreted as amount of primary trimming.

Vector II seems to reflect density of debitage at the four sites, although the other variables in Table 13 also have a perfect Spearman's r_s with rank-order of the sites along the vector. The interpoint distances match most closely with the density of shatter flakes and blocks. Interpoint distance refers to the length of a straight line connecting the site coordinates produced by the MDSCAL program. The actual value is along an arbitrary scale. This dimension also reveals a relationship among the assemblages through the ratio of platformed flakes: implements, which decreases sharply along vector II from PH1 to UN55.

Implements

Vector I (Figure 22) reflects the relative amounts of unretouched but utilised items in the assemblages in that the variables in Table 14 correlate perfectly with

	VARIABLES	Order of Sites Along Vector II PH1	AG15	AG19	UN55
1.	Shatter Flakes and Blocks/m^2	247.6	99.5	44.6	11.2
2.	Debitage/m^2	482.5	148.9	117.8	16.9
3.	Estimated*Debitage/m^2	1225.2	447.4	251.5	50.4
4.	Platformed Flakes/ Implements Ratio	126.4	17.4	12.2	8.8
5.	Rough Bifaces and Rough Biface Fragments as $\%N_1$	35.3	14.7	9.6	8.7
6.	Cores as %N	0.1	0.2	0.3	0.7
7.	Spokeshaves and Gravers as %N	0.0	0.0	0.1	0.2

Table 13. Variables Relevant to Vector II, MDSCAL All Artifacts Solution

* Estimate is obtained by multiplying Shatter frequencies by 4, and summing these with the platformed flake frequencies.

the order of the assemblages along the vector. The values of the interpoint distances are best matched with the utilised debitage variables, but the relative amounts of rough unifaces and rough uniface fragments also increase from PH1 to AG19. While some utilisation of debitage is evident in the AG15 assemblage, there is much more at AG19. With respect to the factor, the difference between PH1 and UN55 is almost as great as that between AG15 and AG19, but the difference between AG15 and UN55 is minimal. Both AG15 and UN55 have similar percentages of rough

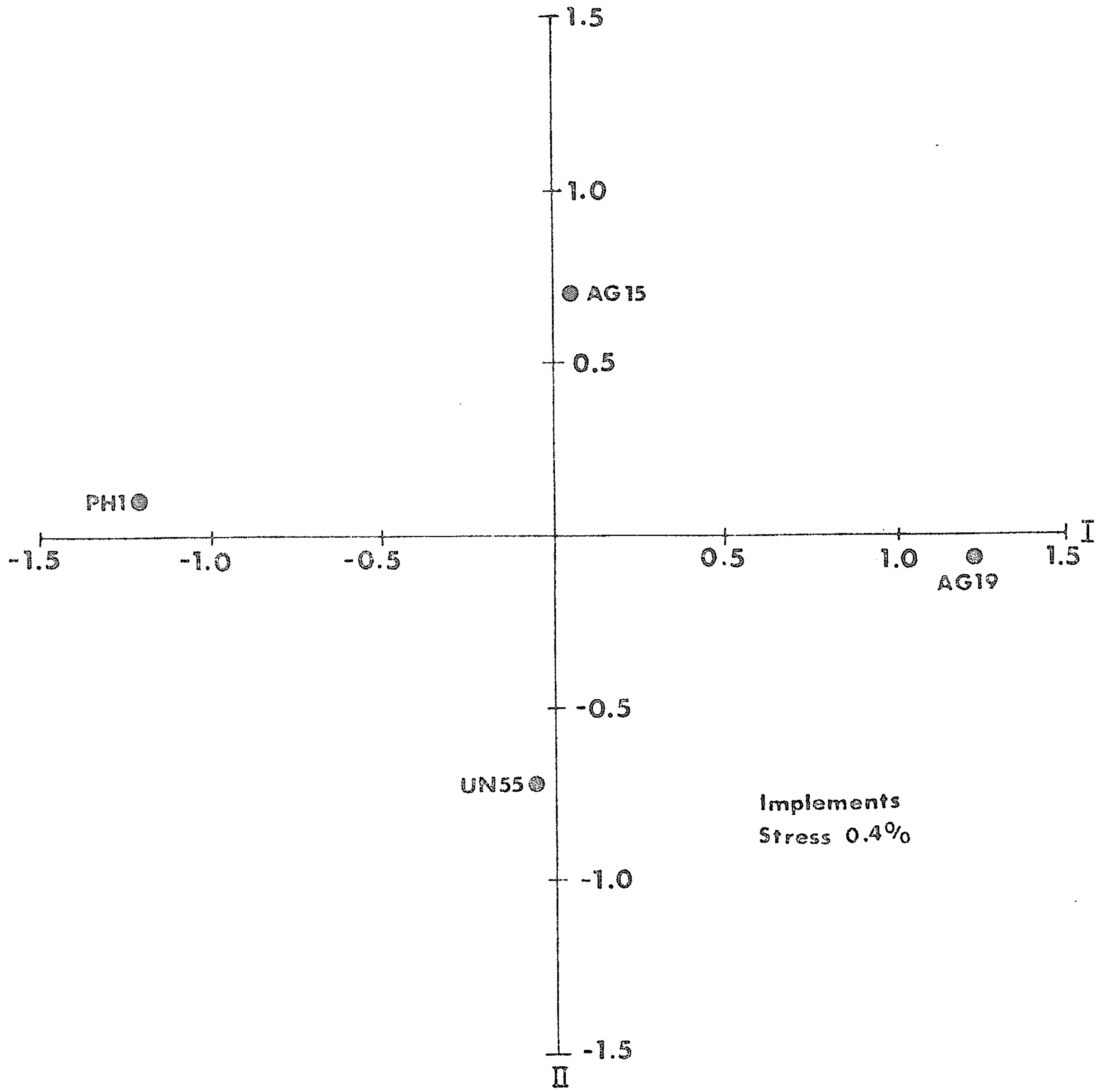


Figure 22. Vectors I and II, MDSCAL Implements Solution

uniface fragments in contrast to PH1 and AG19, and this ranking parallels that of utilised debitage. This vector clearly separates PH1 and AG19 from the other two sites, which appear to be very similar.

		Order of Sites Along Vector I			
	Variables	PH1	UN55	AG15	AG19
1.	Utilised Platform Flakes and Shatter Flakes and Blocks as $\%N_1$	0.00	15.21	16.84	29.98
2.	Utilised Shatter Flakes and Blocks as %N	0.00	4.34	7.37	12.20
3.	Rough Unifaces and Rough Uniface Fragments as %N	0.04	0.40	0.41	0.58

Table 14. Variables Relevant to Vector I, MDSCAL Implements Solution

The rank order of the arrangement of the assemblages along Vector II agrees perfectly with the rank-order of the values of only one variable (Table 15). This vector

		Order of Sites Along Vector II			
	Variable	UN55	AG19	PH1	AG15
1.	Fine Bifaces/m^2	0.03	0.21	0.22	0.65

Table 15. Variable Relevant to Vector II, MDSCAL Implements Solution

is thus interpreted as representing the density of product group IV bifaces at the sites, with UN55 at the low end of the scale, and AG15 at the high end. The interpoint distances also agree well with this variable.

Debitage

Vector I (Figure 23) of this scaling analysis demands a more complex interpretation than the previous analyses. The nine variables in Table 16 have a rank-order correlation of +1.0 or -1.0 with the order of the assemblages along Vector I. The vector seems to scale the sites in relation to the amount of precision maintained in the reduction process. The relative frequencies of flakes with platforms increases from AG15 to AG19, while the relative frequencies of shatter decrease in the same direction. Also, the relative amount of product group IV debitage increases from AG15 to AG19. The interpretation of relative degrees of precision at the sites is arrived at by considering that initial reduction and primary trimming using a hard-hammer technique generally produce a large amount of shatter items as results of excess input. The indications of increasing amounts of secondary trimming debitage in the same direction along the vector may be taken as showing that the final shaping of artifacts is done much more carefully than the production of preforms. Perhaps different kinds of reduction techniques (ie. soft-

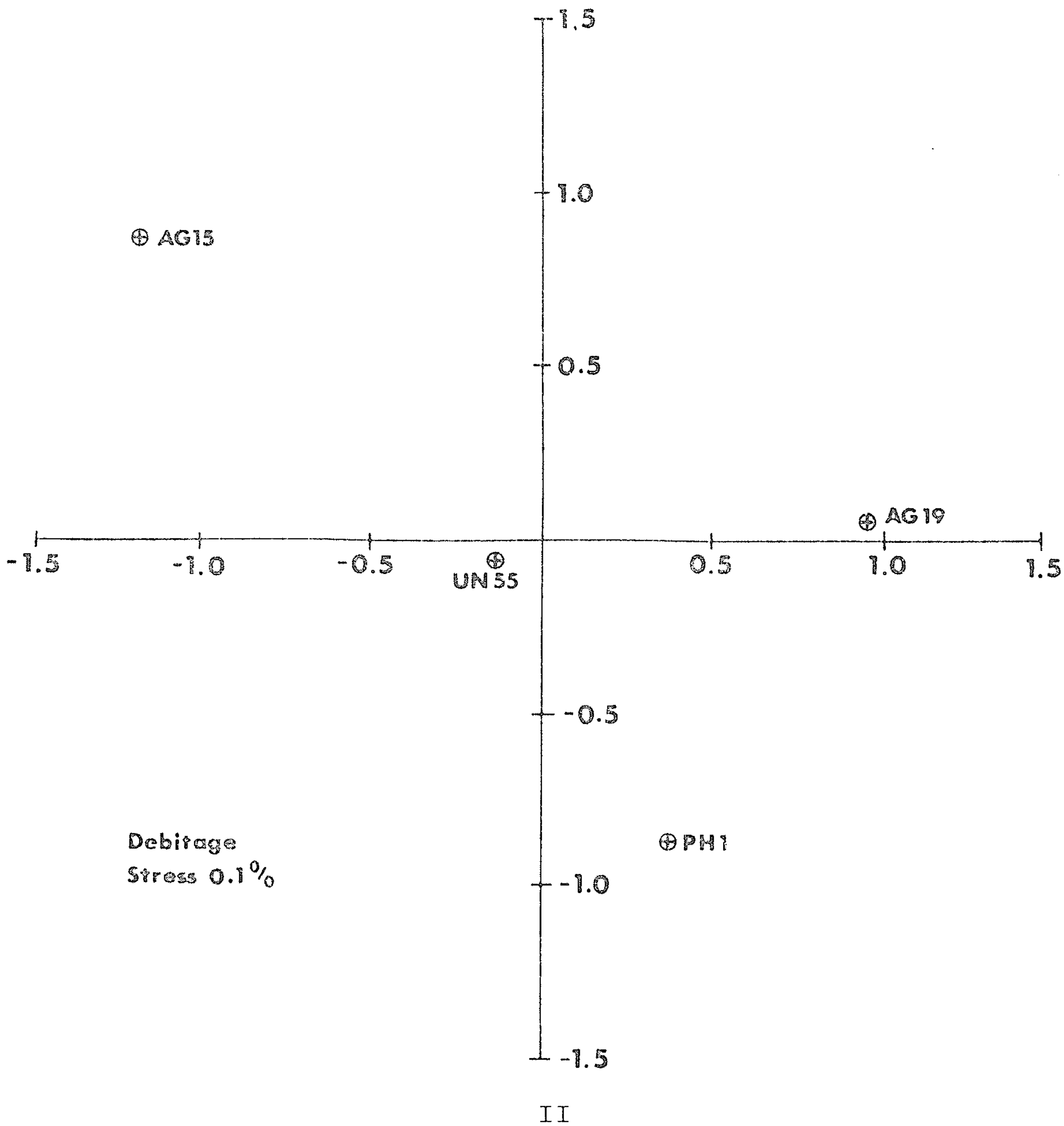


Figure 23. Vectors I and II, MDSCAL Debitage Solution

hammer or indirect percussion) are the cause of this, but this specific factor cannot be reliably inferred here.

	Order of Sites Along Vector I			
Variables	AG15	UN55	PH1	AG19
1. Shatter Flakes and Blocks: Platformed Flakes Ratio	2.0:1	2.0:1	1.1:1	0.6:1
2. Shatter Flakes as $\%N_2$	54.9	52.1	39.2	24.8
3. All Crushed Flakes as $\%N_2$	17.5	21.4	32.8	40.4
4. All Platform Flakes as $\%N_2$	32.0	32.1	47.9	57.8
5. Intact Platform Flakes as $\%N_2$	5.0	5.7	6.7	7.9
6. Crushed Only Platform Flakes as $\%N_2$	10.0	14.5	21.5	24.9
7. Prepared/Lipped Platform Flakes as $\%N_2$	1.5	1.2	1.1	1.0
8. Product Group IV Debitage as $\%N_2$	4.3	4.9	6.9	7.5
9. Product Group IV Debitage as %N	4.2	4.7	6.9	7.1

Table 16. Variables Relevant to Vector I, MDSCAL Debitage Solution

Vector II of this scaling analysis of relatively straightforward, relating to the amount of debitage that was observed to possess cortex (Table 17). The amount of all debitage with cortex increases from PH1 to AG15, as does the same variable with respect to platform flakes only

	Variables	PH1	UN55	AG19	AG15
1.	Percent of Debitage with Cortex	15.89	17.39	18.62	20.62
2.	Intact Platform Flakes with Cortex as $\%N_2$	1.17	1.32	2.00	2.29

Table 17. Variables Relevant to Vector II, MDSCAL Debitage Solution

The MDSCAL analyses facilitate inferences of behavioral factors for inter-assemblage variability, and demonstrate the value of the detailed classification based on Collins' (1975) model of lithic technology. It is important to recognize that although reduction precision is measured without direct reference to the model, it is possible to infer that greater precision is practised on product group IV materials. They also offer support for the use of lithic debitage in archaeological interpretation. Without the debitage classes, the implements would have yielded little information. Further, the solutions also show site relationships that could not have been objectively demonstrated using the frequencies of artifacts arranged by product groups alone.

Summary of Comparisons

Specifying the lithic technological behaviors at the four Archaic sites would seem to be best accomplished through the comparison of the HCLUS results with those of the MDSCAL program. Table 18 combines the HCLUS and MDSCAL results with respect to the three data sets used in the analyses. The general state of the individual MDSCAL vectors is described along a scale of low - medium - high in the cells formed by the intersection of the vectors with the cluster units A to G.

The analyses of the total artifact data produced the clearest interpretations. The MDSCAL results offer a basis for the two-cluster grouping of the assemblages. Cluster A (PH1 - AG15), with assemblages exhibiting low relative frequencies of implements, also contains those assemblages with the greatest density of debitage. The situation is reversed in Cluster B, where AG19 and UN55 contain high relative implement frequencies and low debitage densities.

The analysis of implements only is more difficult to interpret. The arrangements of the sites along the MDSCAL

DATA SET	MDSCAL VECTOR VARIABLE INTERPRETATION	ORDER OF SITES ALONG VECTOR	VARIABLE STATE IN RELEVANT CLUSTER		
ALL ARTIFACTS	I Relative Frequency of Implements	1-2-4-3	A (1+2) LOW	B (3+4) HIGH	
	II Density of Debitage	1-2-3-4	HIGH	LOW	
IMPLEMENTS	I Utilisation of Debitage	1-4-2-3	C (1+2) LOW-MEDIUM	D (3) HIGH	E (2) MEDIUM
	II Density of Fine Bifaces	4-3-1-2	MEDIUM-HIGH	MEDIUM	LOW
DEBITAGE	I Precision in Reduction Technique	2-4-1-3	F (1+3,4) MEDIUM-HIGH	G (2) LOW	
	II Relative Amount of Debitage with Cortex	1-4-3-2	LOW-MEDIUM	HIGH	

Table 18. Combined Results of HCLUS and MDSCAL Analyses
1 = PH1; 2 = AG15; 3 = AG19; 4 = UN55

NOTE: Sites are arranged from Negative to Positive Scale Values vectors do not correspond well to the derived clusters. Generally, PH1 and AG15 (cluster C) exhibit low to medium debitage utilisation, cluster D (AG19) exhibits the highest frequency of debitage utilisation, and cluster E (UN55) contains an amount similar to AG15 of cluster C. The density of fine bifaces is medium to high in cluster C, medium in cluster D, and low in cluster E.

The three assemblages in cluster F demonstrate medium to high precision in reduction, while cluster G (AG15) exhibits low precision. The relative amount of cortexed debitage, however, is high in cluster G, and low to medium in cluster F. Simply put, it seems as if precision in reduction increases as the amount of cortexed debitage decreases.

Thus it has been shown that there are two inverse relationships among the four assemblages that account best for the observed variabilities in content. One of these inverse relationships is between implement frequency and debitage density, the other between reduction precision and cortexed debitage frequency.

It can be inferred that the first is a result of implement reduction, and transport of the selected tools to other sites for use. Specifically, at PH1 and AG15, the high frequency of product group III implements along with the presence of group IV debitage shows that the group IV implements have been exported. At AG19 and UN55, high relative frequencies of product group IV implements and low overall debitage frequencies and densities imply disposal of fine implements after use, with less tool manufacture having occurred at these sites.

The medium-high density of fine bifaces at PH1 and AG15 (cluster C) indicates that considerable numbers of product group IV implements were being manufactured, and that very stringent criteria was being imposed on the final selection decision.

The utilisation of debitage is low to medium at PH1 and AG15, while it is medium to high at AG19 and UN55 (clusters D and E). More activity related to the use of implements is inferred for AG19 than any other assemblage here studied, and less implement usage than at the others is inferred for PH1. Also, precision in reduction is highest at AG19, medium at PH1 and UN55, and low at AG15. The high amounts of cortexed debitage at AG15 and the low amount at PH1 may indicate that hard-hammer percussion is most practical, albeit imprecise, for the removal of cortex in the initial reduction stage.

It now is clear that PH1 and AG15 may be classified as workshop sites, and it has been also shown that the content of each of these reflects slightly differing activities. The variability exhibited in these two assemblages is best accounted for in terms of those variables related to high amounts of tool manufacture. At AG15, some use of tools is implied, and also the removal of cortex from cores was a more important activity than at PH1, where more precision in reduction was apparently achieved.

The similarity between AG19 and UN55 is not as great. The AG19 assemblage seems to be the result of much more tool use than is the UN55 material. The assemblage at UN55 may also reflect activities which left implements in states suitable for transport elsewhere, as evidenced by the low density of fine bifaces.

CHAPTER 9

SUMMARY

This thesis has presented a methodology for examining and comparing Archaic lithic assemblages in Manitoba through processual rather than culture-historical paradigms. Lithic assemblages from four Archaic sites in the Porcupine Mountain region were first described with reference to a modified version of the model of lithic technology put forth by Collins (1975). The modifications mainly involved the explicit formation of 60 classes of lithic debitage and implements by which lithic reduction activities could be inferred. The new classification also sets out explicit criteria for the placement of various tools within Collins' model.

PH1 and AG15 were seen to be noticeably different from AG19 and UN55 with respect to implement and debitage frequencies when the artifact frequencies were sorted in respective product groups of the lithic reduction process. At this stage in the analysis it was suggested that PH1 and AG15 were sites that functioned as workshops, and where high frequencies of group II and group III artifacts were deposited. The variability in content of the AG19 and UN55 assemblages was not so clearly understood here, but these possessed substantially higher frequencies of group IV implements.

Rather than leave the behavioral inferences at a very preliminary level, the assemblages were analysed using Q-mode clustering and non-metric multidimensional scaling procedures, to provide further details about factors underlying interassemblage variability.

The interpretations of the statistical procedures seem most clear-cut when they are based on the entire classification rather than on the implements or debitage alone. The cluster analysis of the total sample supported the initial evidence for two kinds of sites by forming two clusters of PH1 - AG15 and AG19 - UN55. The MDSCAL analyses indicated that the activities within the site clusters were considerably more complex than was apparent from the HCLUS analyses. Through comparison of all sets of results it was proposed that PH1 and AG15 functioned mainly as sites where the manufacture of lithic implements was the main activity, although each is different in the degree of precision over reduction achieved by the lithic craftsmen. PH1 craftsmen seemed to take greater care to avoid breakage of flakes upon removal (ie. low shatter: platform debitage ratio) and were probably more successful in the production of fine implements than were craftsmen at AG15. Precision in reduction is greatest at AG19, and very low at UN55. Perhaps this precision reflects the presence of soft-hammer percussion flaking, but it is interesting to note that precision increases with the amount of product group IV debitage. This indicates that, generally, greater care is taken in the secondary trimming of implements than in the production of preforms.

At PH1, completed tools of high quality would be transported to other sites for use, while at AG15, considerably greater numbers of preforms were left behind, being inadequate for further reduction. AG19 and UN55 are distinctly divergent from the workshop sites, exhibiting more fine implements that were presumably deposited after use. Some debitage use is evident at AG15, and none at all at PH1. It seems that AG19 had a wider range of activities than the other sites. A large number of fine unifaces and uniface reduction flakes at AG19 implies relatively expedient tool manufacture since unifaces are more easily produced than bifaces. At UN55, very little secondary trimming is apparent. Perhaps this site was occupied for a limited time then the implements then curated to other sites in intermediate stages of their use-life.

The geographical context of PH1 and AG15 also supports their classification as workshop sites. The occurrence of Swan River Chert cobbles in the stream gravels at the base of Porcupine Mountain seems to have served as a strong determinant of lithic workshop locations during the Archaic. The relative scarcity of raw materials in the upper reaches of the Porcupine Mountain region may account for the high uniface content of AG19 (uniface manufacture requires less material than biface manufacture), and at UN55 tools may have been curated because of the uncertainty of finding suitable raw materials elsewhere.

The primary environmental source of variability isolated here is the availability of lithic raw materials. The final resolution of the proposed technological activities requires that the geological character of Swan River chert be more precisely examined. Manitoba archaeologists need to focus on the spatial aspects of cobble size, concentration, quality, degree of weathering, angularity, colour, and exposure, all of which are important considerations in raw material procurement. To enable cultural inferences of wider scope than those achieved here, there is a need to detail tool use-wear evidence, transport and trade of Swan River Chert, the quality of materials used at habitation and kill sites, the nearest source of materials, as well as the relative quantities of other materials such as Knife River Flint, Cathead Chert, or Canadian Shield siliceous rocks. Changes through time in selection and use of various materials is a viable topic of study, as is tool/debitage deposition rates in relation to type and length of site occupation. Size analysis of debitage may enable statements to be presented concerning degrees of lithic conservation. The classification and results of this thesis may be seen as means to approaching these problems.

Social factors that the present study could not control for are also in need of isolation. Group preferences for raw materials, the teaching of flintknapping skills, individual styles and stylistic variation among specific tasks within groups are all such variables leading to interassemblage variability that are beginning to be considered by other lithic studies (eg. Gunn 1975; Hartman 1975; Knudson 1973). The collections of the Glacial Lake Agassiz Surveys could supply the data for a large scale experiment towards these ends. A fact related to this discussion is that the conclusions and suggestion presented in this thesis have been produced with the use of powerful techniques on a sample of only four Archaic sites, when there exist conceivably thousands more in the Porcupine Mountain region.

This thesis remains without ethnographic analogy for the proposed technological patterning because unfortunately, there are no presently known accounts of historic lithic technology in the region. It would be possible to structure a discussion around the subsistence-settlement models presented by Ray (1974) and Syms (1977), but these use a very different data base than the present study and the results would tend to be poorly integrated.

In conclusion, the Archaic lithic technology of the Porcupinc Mountain region is much better understood in light of this thesis. It is proposed that the composition of Archaic lithic assemblages in the region will vary directly in relation to their geographical proximity to the shoreline features of Lake Agassiz. Those nearest the features will tend to be workshop sites, exhibiting artifacts resulting from quarrying and initial reduction of implements, with little tool use. Those furthest from the features will tend to exhibit assemblages where the artifacts have been disposed of as the result of inutility through wear, and secondarily trimmed implements will form a relatively larger part of the assemblages. Lithic quarrying and implement manufacture in the region's lowland areas formed a consistently important set of activities in the ecological adaptations of Archaic peoples.

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