FUNCTIONAL DETERMINATION OF PROJECTILE POINT USAGE IN MESOLITHIC GREASBY

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Objective of the study

The objective of this study was to determine whether bow-and-arrow hunting was part of the subsistence repertoire of the Mesolithic inhabitants of Wirral. As little is known about the Mesolithic period of the region, it was hoped that the knowledge gained will facilitate studies on regional landuse and subsistence economy. The approach employed in this study comprises both replicate experimentation as well as quantitative analysis of impact fracture patterns produced by projectile point function.

Introduction

The finds from Greasby are restricted in nature and this complicates the task of site interpretation. Apart from a small quantity of carbonized hazelnut shells (*Corylus avellana*), the majority of finds are lithic material, of both worked and unworked flint/chert (Cowell 1991 and 1992). In common with most prehistoric sites, the Greasby finds may be described as a low resolution, course grained assemblage (see Gamble 1986, 23). The narrow array of residues prohibits a straightforward correlation between specific archaeological events and the available artefactual remains. On the other hand, Greasby does possess relatively good site integrity in that a fair degree of patterning is preserved. This spatial patterning may be related to the archaeological evidence (Cowell 1992) and could be usefully employed to model the site formation processes.

To archaeologists, site interpretation is usually a simple exercise of logic based on the systematic analysis of available evidence. However, given the common bias towards lithic material within an archaeological assemblage, as in the case of Greasby, the evidence available for reconstructing site activities is already biased towards those which employed stone tools. Again, further bias may arise if the interpretation of stone tool function is based on traditional typology.

Typology is by nature a subjective technique as the discipline works on the principle of attribute classification. The number of attributes of an artefact that could potentially be selected as criteria for constructing a classification scheme can be enormous. The choices will depend on the kind of information that a scheme is expected to provide. Many traditional schemes, however, concentrated solely on descriptive attributes such as size, plan-shape and location of retouch; characteristics which may bear little relationship to the function and performance of particular tool types (Cotterell and Kamminga 1990). As a result, mismatching of particular tool categories with specific function may occur. For the Mesolithic, the consequent functional stereotyping of microliths as projectile armatures has led to a fixed conception where ' ... Mesolithic = Microlithic = Bow-and-Arrow hunting ... ' (Clarke 1978, 9). However, there are ample ethnographic - and some rare archaeological - examples of microliths hafted in composite tools, testifying to their usage as plant-gathering, harvesting and processing implements (Fig. 1). This inherent ambiguity of microlith function can be attributed to their deceptively simple design. In view of this, microliths should perhaps be regarded as neutral tool components with their ultimate function dependant on the hafting configuration.

Apart from the risk of imposing preconceived function on stone tools, traditional typologists often fail to acknowledge the significance of unretouched lithic material as tool components contributing to the site economy. Many usewear studies have demonstrated that *debitage* or 'non-tools' have in fact been utilised, perhaps expediently (Keeley 1980; Symens 1986; Dumont 1988). In addition, unretouched flakes have been known to serve as arrowheads. The Final Palaeolithic graveyard at Jebel Sahaba, Sudan, has yielded over 90 pieces of unretouched flakes and chips which were used indisputably as projectile armatures (Wendorf 1968). The San of Southern Africa are known to employ stone arrowheads which either possess no retouch at all or are very minimally modified (Clark 1977, quoted in Odell and Cowan 1986, 197).

Given that a broad range of lithic forms can apparently be utilised as projectile points, it is important that a more functional approach be adopted in the study of lithic artefacts. Usewear analysis can provide a more objective means of assessing tool function than traditional typology, since it is based directly on wear traces retained by the tool after utilisation. Such an approach will help to narrow down the alternatives for the type of specific activities which may have occurred on a site, thus providing a firm foundation for the interpretation of wider issues such as site economy and regional landuse.

For the Greasby site, bow-and-arrow hunting activities are implied by typological analogy with lithic assemblages from other Mesolithic sites (Cowell 1991). However, no direct or indirect evidence related to hunting, for example bow and arrow equipment or animal remains, has been found. It was hoped that through usewear analysis, the practice of bow-and-arrow hunting subsistence strategy on the Mesolithic site of Greasby could be confirmed.

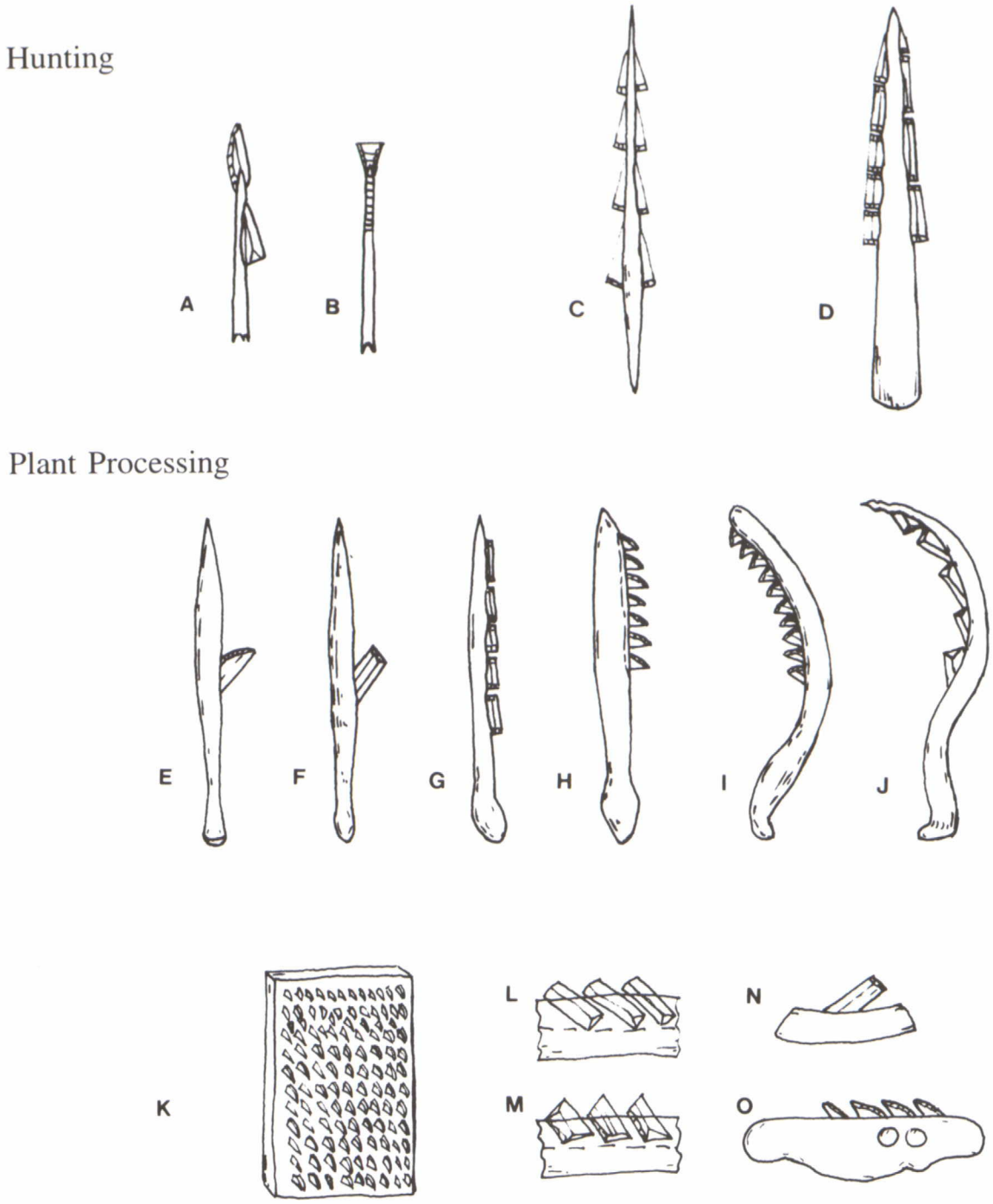

Figure 1: Hafted composite artefacts set with microliths and micro-blades, K is based on ethnographic models. Løshult-type barbed arrowhead (A), Eising-type narrow trapeze arrowhead (B), Tróród-type projectile point (C), Tarvastu-type thrusting spear (D), Qadan-type slicer knife (E) Lucerne-type slicer knife (F), Baikal-type harvesting knife (G), Columnata-type harvesting knife (H), Murcielagos-type harvesting sickle (I), Karanovo-type harvesting sickle (J), Point-set grater (K), Saw edge achieved with oblique blades (L), Saw edge achieved with broad trapezes (M), Obermeilen-type slicer knife (N), Bienne-type saw knife (O). (Adapted from Clarke 1978).

Framework of experiments

Given that microliths used as arrow armatures, and those used as vegetable processing implements, represent the extreme ends of Mesolithic subsistence activities, it was proposed to differentiate microliths that functioned as arrowheads from other classes of microliths through quantitative experiments. To this end, three different types of experiment were performed on microliths replicated in chert obtained in North Wales. These experiments were:

1) shooting at an animal target using bow and arrow,
2) cutting grass and vegetation using a composite knife, and
3) 'non-functional activities' involving treading on and impact damage unrelated to arrowhead function.

The latter experiment was designed to act as a control in order to sample the pattern of non-functional wear.

The fractures resulting from the above experiments were quantified by using a low-power microscope method (up to 40x magnification) and the types of usewear characteristics of arrowhead and non-arrowhead functions defined. The results were then applied to the analysis of Greasby lithic artefacts.

Experimental and laboratory methods

Since an objective of this study was to apply experimentally derived results to an existing lithic collection, it was appropriate that replicate items should be produced with raw material as similar as possible in physical properties to those used for the original Greasby artefacts. A previous study on the Greasby collection by Longworth (1990) has indicated that chert and flint from nearby North Wales are the main categories of raw material utilised. Four specific quarries: Gronant, Trelogan, Bryn Mawr and Pen yr Henblas, all within ten miles distance from Greasby were also cited as probable sources (for a detailed discussion, please see Longworth forthcoming). Various types of chert are available from these locations, including banded samples in grey, off-white, and brown, as well as black ones. However, no flint was found. The Gronant black chert, though, was of a superior quality, being less weathered and comparatively homogeneous in texture. Since black chert was also preferentially utilised in the first occupational phase of Greasby (i.e. Greasby I), it was decided to produce items primarily from this material.

Knapping Exercise

All the knapping in this study was performed by the author. A hard hammer percussion technique was employed to detach flake blanks from cores. Blanks of suitable shape were then selected and pressure retouched by using an antler tine. Due to limited experience, as well as a deliberate decision not to be constrained by specific typological 'style', the finished products were of irregular size and shape.

During the course of knapping it was of interest to note that different parts of the same rock can vary greatly in fracture characteristics. This effect is caused by the variation in the mineralogical composition of the rock. During sedimentation and lithification, fluctuation in the physical and chemical condition of the immediate depositional environment can lead to variations in the fabric and structure of the resultant rock (Sorrell and Sandström 1982).

The inconsistent fracture behaviour of the North Wales chert may have contributed to the unusually high volume of small size *debitage* from Greasby. Similar abundant small-sized chips devoid of technical features were found to be frequently produced in addition to the flake blank during knapping experiments. This phenomenon conforms with Smith's description of some of the Greasby II lithic material ' ... between 5000-8000 pieces (many of them exceptionally small).' (Smith 1991, 12).

The predominance of small-sized *debitage* may, on the other hand, simply be a function of the small size 2mm mesh used in the wet sieving operation. In addition, a high *debitage* to tool ratio is by no means unusual in early prehistoric sites. What is remarkable, perhaps, is that individual elements of the *debitage* are often featureless 'chips' which do not demonstrate clear technical attributes of knapping, such as striking platforms or conchoidal fractures. However, given that these 'chips' are not derived from local raw materials (Longworth forthcoming), it may safely be assumed that human agents were responsible for their deposition. Instead, the crucial question here would be the physical constraints this unpredictable fracture behaviour may exert on the types of wear obtained on the utilised items; a point which will be returned to in the Discussion.

Experiments on Shooting with Bow and Arrow

The shooting experiment was undertaken using a Jaques recurve bow with 11 single-armature arrows, and four composite ones of the Lilla-Løshult style (Fig. 2A and 2B). These were manufactured following the methods adopted by Barton and Bergman (1982) and Fischer *et al.* (1984). Only replicate points weighing about 1 to 2g and possessing a relatively straight profile were selected. In terms of performance, these two attributes of weight and profile shape are limiting factors which constrain the directional stability and penetration ability of an arrow. To ensure maximum efficiency, the weight of the points should be distributed symmetrically around the longitudinal axis of the shaft and the tip of the point should be in exact continuation of the shaft (Fischers *et al.* 1984).

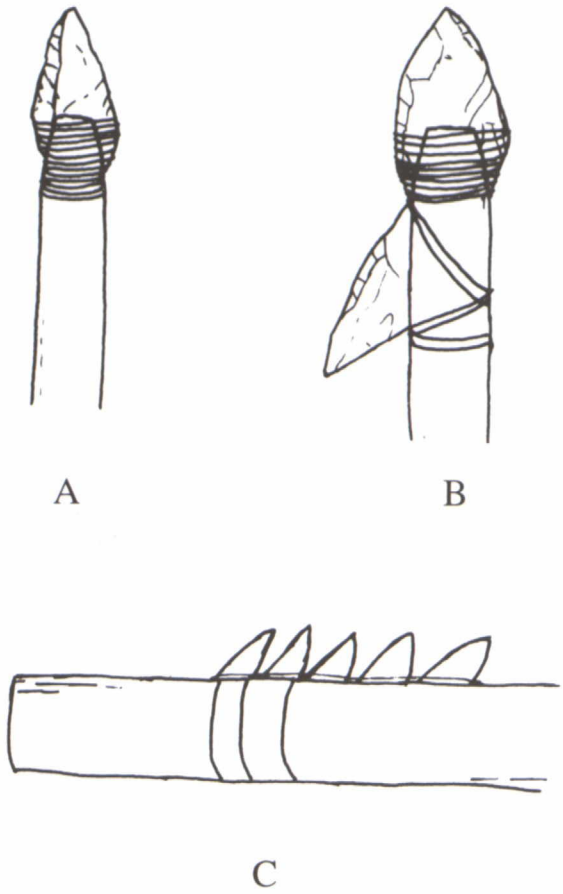

Figure 2: Single arrow (A), composite arrow (B), composite knife (C). Scales: (A) and (B) 1:1; (C) 0.5:1.

The mean size of the points selected was 20.33mm (length) x 10.84mm (breadth) x 3.22mm (width) and is not dissimilar to the mean value of 19.23mm (length) x 8.23mm (breadth) x 2.12mm (width) as calculated for the Greasby microliths by Smith (1991, 49).

The replicate points were set into slots cut into one end of the shafts, some of which were commercially produced arrowshafts with fletchings and some plain pine dowels. The side barb for composite arrows was fixed into a groove excavated on one side of the shaft. A proprietary brand of resin-based wood glue (Evo-stik) was used to fix the points and barbs on the shafts. To prevent the shafts from splitting on impact, and to further secure the points, bindings of cotton and linen thread were applied.

In order to achieve a degree of realism, a horse hindlimb was used as a target. This was obtained from autopsy material through Dr J.R. Baker of the Leahurst Veterinary Field Station. The bow utilised was a 5'6" (167 cm) modern practice bow with a 45 lbs (20 kg) pull and 28" (71 cm) draw. In order to minimize misses and to compensate for the lower strength of the modern bow, a shooting range of five metres was selected. Ethnographic studies on hunting behaviour have suggested that to ensure success, hunters prefer to invest hunting skill in getting close to the prey, i.e. stalking, rather than to invest heavily in equipment improvement (Pope 1918; Cundy 1989). A shooting distance of five metres or less is also indicated by much of the ethnographic records.

As a control, a photograph of individual mounted arrowheads was taken before each shot. Notes were also made on the performance of each arrow as well as the nature of impact. Arrows which sustained no apparent fracture were reused immediately since the purpose of this study was to associate fracture types with activities, not to analyse the amount of time needed to induce fracture. For successful shots, the depth of penetration was measured by marking the shafts while they were still embedded. Broken arrowheads that were deeply embedded in the horse flesh were left in place for subsequent retrieval by dissection. The points of entry were clearly marked with a tag. Arrows that were retired from the trial were immediately wrapped up in individual plastic sample bags and bundled up with bubble wrap.

Experiment on Plant Harvesting

This experiment was conducted with the intention of identifying those types of fracture which are distinctively different from fractures characteristic of utilised arrowheads. A composite knife similar in style to the Columnata example (Fig. 1H) was produced with points surplus to the shooting experiments. Five microliths were fixed obliquely, using the same resin-based wood glue, into a groove excavated in the side of a sawn-off wooden wicket 28.20 cm in length (Fig. 2C). As the points would be exposed to a comparatively prolonged pressure resulting from a longer duration of use, the finished product was left in this case for a week to let the glue harden thoroughly.

During the experiment, the composite knife was used to cut wild grass and the woody shrub, 'broom'. A bunch of vegetation was grasped firmly in the left hand while the knife was used to slice and hack at the straightened stems at angles of approximately 50-60°. The experiment continued until all the points either fractured or became dislodged.

Experiment on Non-functional Activities

The purpose of this experiment was to sample the fracture patterns related to activities to which microliths could be exposed but which have no association with arrowhead function.

Five points were subjected to repeated treading and impact from a chert core weighing 0.62 kg until they all fractured.

Cleaning Procedures and Method of Analysis

In the laboratory, all the arrowheads were dismantled, cleaned and inspected under a microscope. The amount of cleaning required varied from item to item but the complete schedule involved the use of acetone, Lipsol phosphate-free detergent liquid and an ultrasonic tank.

For the main analytical work, a Wild-M3Z Plan sterescopic dissection microscope with a Flatfield lens and a magnification range of 6.5 to 40x was employed. Incident light was provided by a separate Volpi-Intralux 6000 illumination unit equipped with a pair of flexible optical-fibre light guides. During the analysis, 'blu-tack' putty was used to fix the specimen at an optimal viewing position. Macrowear analogous to those discussed in similar experimental studies (e.g. Fischer *et al.* 1984 and Bergman and Barton 1982) were recorded and photo-micrographs were taken of samples with representative types of use fracture.

The decision to adopt a low-power microscope approach in this study was influenced by several factors. Limitation in available equipment aside, several previous studies have all successfully identified macro fracture patterns pertaining to projectile point function using a low-power approach. In one study that embraced both macro- and microwear (50x to 400x magnifications) methods, the authors have concluded that each method can be used independently with equal validity (Fischer *et al.* 1984). Moreover, the macrowear method has the advantage of being less affected by variations in the texture, colour and surface disintegration of the flint. The latter, indeed was the deciding factor in adopting the low-power method, as the chert utilised in the experiments and those from the Greasby collection was found to be fossiliferous (albeit that the fossils are microscopic in dimension), as well as being relatively coarse-grained. Such factors are detrimental to the integrity of microwear traces. Consequently, a macroscopic approach was used which quantifies primarily the morphology and location of fractures on each implement that may be attributable to function.

The classification of impact fractures

Archaeologists are very familiar with the terms 'hinge', 'step' and 'feathered' fracture, which describe the typical ways a flake terminates when it is detached from the core (Purdy 1975). When applied to usewear studies, the difference between wear scars and scars formed from flake removal during stone tool manufacture is essentially one of scale (Cotterell and Kamminga 1990). In a brittle material such as chert, the nature of a fracture termination is largely dependent on the angle of the initiation force and the direction of crack propagation within the stone itself. Hence, the morphology of fracture terminations, when considered in combination with their location on a stone tool, can be used in a qualitative way to model the manner of use to which a tool has been subjected. Apart from fracture terminations, the morphology of fracture initiations is also a useful indicator of loading conditions, i.e. the magnitude and direction of the applied force (Tsirk 1979; Cotterell and Kamminga 1979).

In recognition of the above characteristics of fracture initiation and termination, a protocol for use-fracture classification was drawn up by usewear analysts at the 1976 Vancouver Use-Wear Conference (The Ho Ho Committee 1979). The scheme comprises two fundamentally different types of fracture *initiations*: **cone/point** and **bending initiations** (Fig. 3); as well as four major types of fracture *terminations*: **feather, snap, step and hinge terminations** (Fig. 4).

In identifying macro fractures, particular distinction is made between the following two groups: **cone/point fractures** and **bending fractures**. The two types of fracture are induced by essentially different impact on the arrowhead, or, in other words, are initiated by different types of force.

In cone or point initiated fractures (Fig. 3A), crack initiations necessarily occur adjacent to or very near to a region with high compressive stresses, such as those occurring between a hammerstone and a core (Tsirk 1979). In general, the initiation force is applied to a

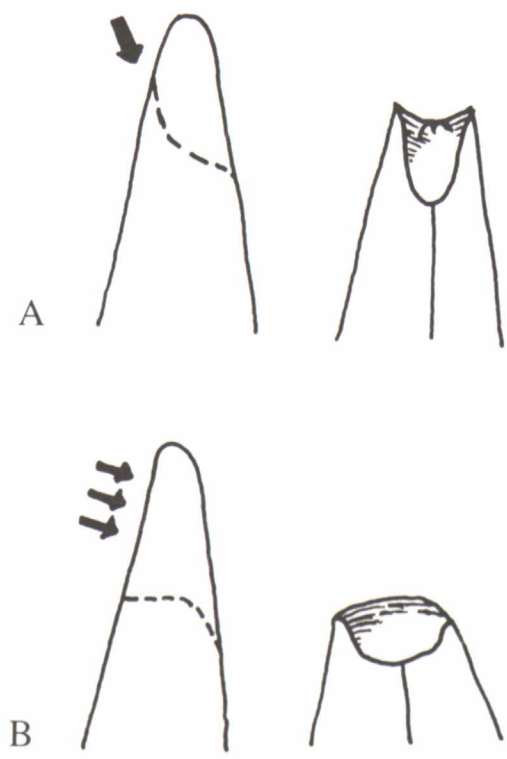

Figure 3: Types of fracture initiation illustrated in longitudinal profile and dorsal view, with arrows denoting the direction of the applied force. Cone fracture (A) and bending fracture (B). (Modified from Fischer et al. 1984).

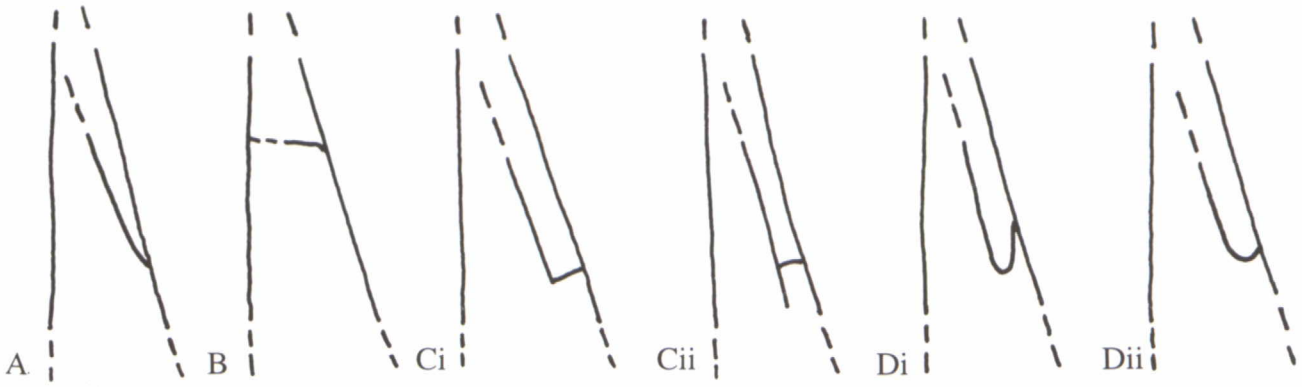

Figure 4: Varieties of fracture termination, as seen in longitudinal profiles. Feather termination (A), Snap termination (B), Step termination, type A (Ci), Step termination, type B (Cii), Hinge termination, type A (Di), Hinge termination, type B (Dii). (Modified from Cotterell and Kamminga 1991).

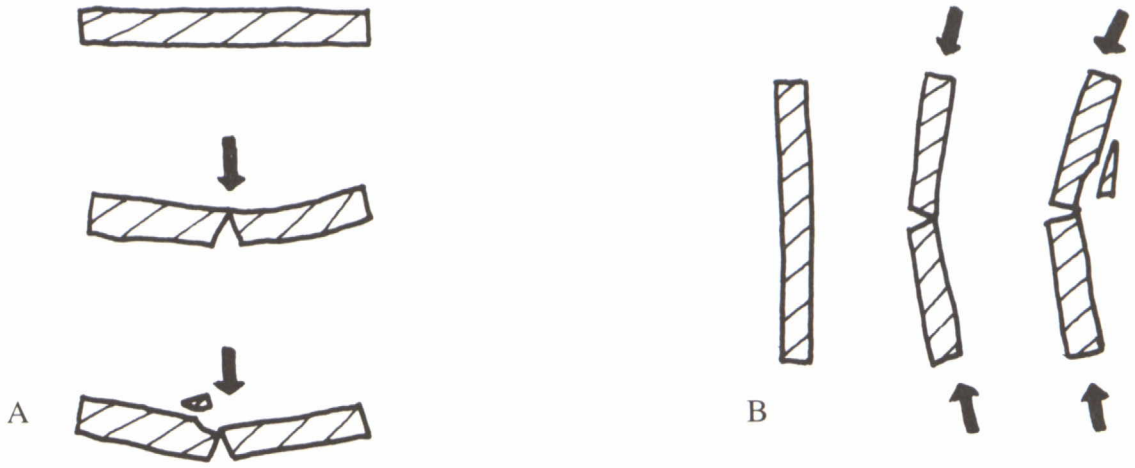

Figure 5: Theoretical model on the formation of spin-off fracture. With pressure applied on one broad side, note small size of the spinned off flake (A). With pressure applied on both ends, a comparatively longer spin-off flake is produced (B). (Modified from Fischer et al. 1984).

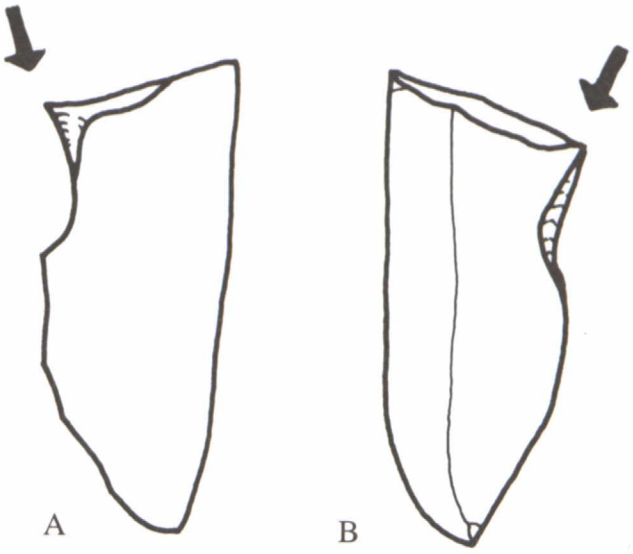

Figure 6: Burin-like fracture. Ventral view (A) and Dorsal view (B). (Modified from Barton and Bergman 1982).

relatively small area, and creates a cone-like fracture. This type of fracture typically results in flake scar that is scalar in appearance; the flake so removed usually has a bulb (Lawrence 1979). In addition, cone/point initiated fractures possess concave profiles in the area of initiation (The Ho Ho Committee 1979).

In bending initiated fractures (Fig. 3B), the fracture is initiated under tensile bending stresses (Cotterell and Kamminga 1979). The load is often applied over a relatively broad contact area with the fracture initiating some distance away from the applied force. The path of fracture generated is usually perpendicular to the edge (Lawrence 1979). When fracture initiations are primarily due to bending, no cones or cone-like features will be created. As a result, the initiation profiles are normally convex or straight in the area of initiation.

In addition to the nomenclatures defined by the Ho Ho Committee, a supplementary category of macro fractures: **spin-off fractures** (Fig. 5) and **burin-like fractures** (Fig. 6) are included in the classification scheme utilised here. The latter are deemed diagnostic of projectile point function. They were used in previous experimental studies by Fischer *et al.* (1984) and Barton and Bergman (1982) and Bergman and Newcomer (1983).

In summary, the classification scheme employed in this study consists of four major fracture varieties: cone fractures, bending fractures, spin-off fractures and burin-like fractures. Three of these were in turn broken down into specific types. An overview of the scheme is as follows:

1. **Cone fractures:**
   i) small cone fractures of <5 mm size; and
   ii) large cone-initiated transverse fractures.

2. **Bending fractures** with:
   i) feather termination;
   ii) snap termination;
   iii) step termination; and
   iv) hinge termination.

3. **Spin-off fractures**:
   i) uni-facially on one broad side only; and
   ii) bi-facially on both broad sides.

4. **Burin-like fractures** on lateral margin/s.

The location of fractures which are not of the transverse variety are recorded with reference to the tip, base and lateral margins of the microlith.

Results of experimental studies

The results of the shooting experiment and the types of fracture sustained by each replicate point in all three experiments are presented in Tables 1 and 2 respectively. In the analysis, all the fragments that are large enough for handling were examined for macro fractures. The only point recovered from dissection was too shattered to be of any use.

Given that the occurrence of function-related wear is connected to performance, the results appear to associate arrowhead activity with step terminating bending fractures. As can be seen in Table 2, all step terminating fractures occurred on arrowheads that had penetrated the target. In contrast, small cone and cone-initiated transverse fractures appear to be much commoner in the non-arrowhead activity classes. In order to test these hypothesized relationships, a series of statistical tests were performed. Since the sample size was small and the variables are at the ordinal level, a robust non-parametric test (the Mann-Whitney U test) was employed. When the cases were grouped by activity, the results were as follows:

'Step terminating bending fractures' were significantly commoner in the arrowhead activity group (corrected $Z=-2.5715$, 2-tailed $P<0.0101$). Secondly, 'cone fractures <5 mm' and 'cone-initiated transverse fractures' were significantly commoner in the two non-arrowhead activity groups (corrected $Z = -4.9577$ and -4.0315, and 2-tailed $P<0.0000$ and 0.0001 respectively).

A multivariate discriminant function analysis was then conducted to test whether it is possible to distinguish arrowhead versus non-arrowhead activities on the basis of multiple fracture varieties, and to see which types of

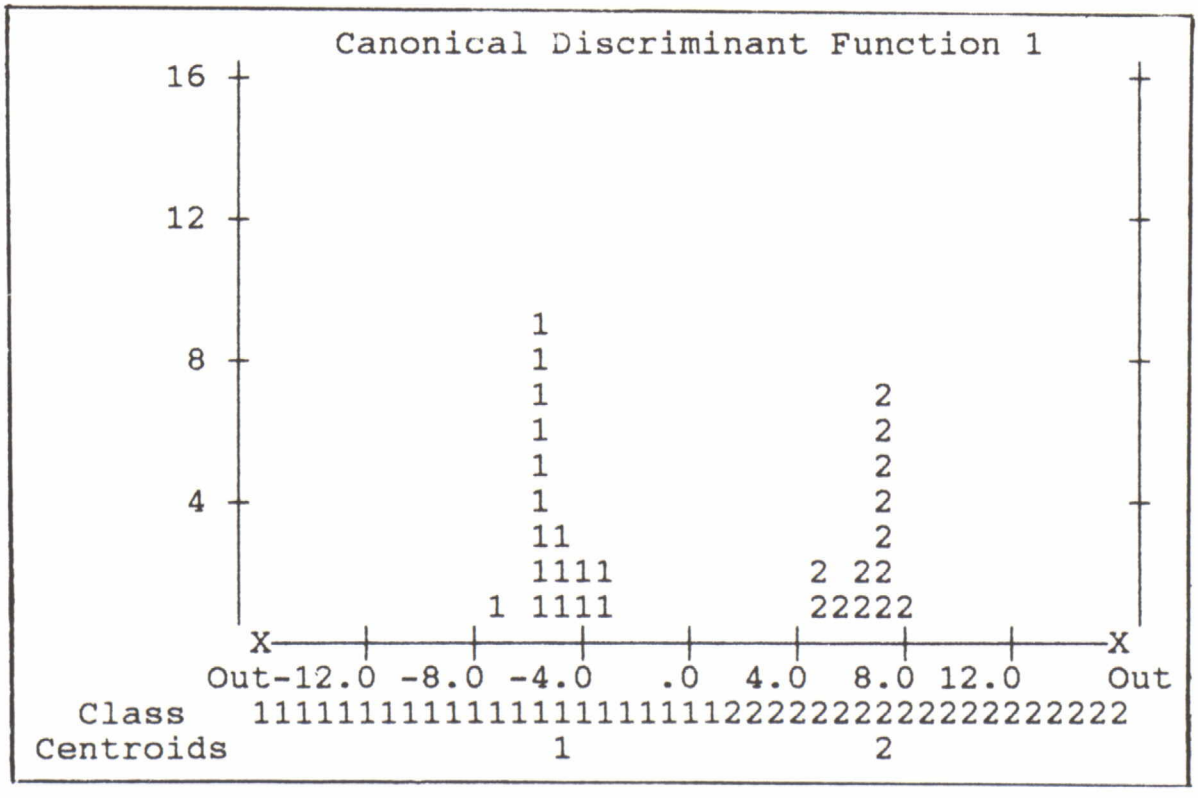

Figure 7: All-groups stacked histogram for arrowhead and non-arrowhead activities as classified by the discriminant analysis. 1=Group 1, arrowhead activity 2=Group 2, non-arrowhead activities.

fracture were the most effective discriminators. The test utilised all the fracture varieties except bi-facial spin-off fracture as *prima-facie* discriminating variables. The latter fracture was excluded since no occurrence was recorded. As in the U tests, side barbs were also excluded from the analysis, since they differ in both hafting style and function from arrowheads. In many respects, a side barb (or more appropriately, secondary armature) functions similarly to a slicing blade. In a composite arrow, the point punctures the prey while the secondary armature aids penetration by increasing the cutting margin of the point (Rozoy 1985). In view of their different functions, the usewear exhibited on a secondary armature would be expected to vary from that on a point, and inclusion of this category was judged unhelpful.

In the analysis, the classification function produced a 100% success in predicting membership of the two groups (Fig. 7). Furthermore, the best predictors, as ordered by size of correlation with the discriminant function, are small cone (0.35755), cone-initiated transverse (0.19124) and step terminating (-0.08052) fractures.

The discriminant analysis again confirms that there is an inherent relationship between specific fracture varieties and functions. These preliminary analyses are necessarily based on a small sample size, with variables showing a tendency to positive skewness. Nevertheless, although a larger sample size would be desirable, the statistical tests performed are fairly robust and the results probably reliable.

Discussion

Interpretation of Experimental Results

The preliminary results presented here have demonstrated a relationship between arrowhead function and both **positive** occurrence of step terminating fractures and **negative** occurrences of small cone and cone-initiated transverse fractures. In contrast, an inverse relationship is established for the other two activities. In similar studies based on larger samples (e.g. Fischer *et al.* 1984, N=153; Odell and Cowan 1986, N=127), step terminating bending fractures have also been identified as the commonest type of impact

No.	No. of Trials	No. of Hits	Depth of Penetration	No. of Rebounds	No. of Misses	Remarks
1	2	1	3.70 cm	-	1	1st trial: penetrated silty soil. 2nd trial: broken tip embedded in target.
2	2	2	10.15 cmm 13.13 cm	-	-	-
3	1	1	4.90 cm	-	-	-
4	7	-	-	3	2	5th trial: penetrated 5.08 cm into silty soil.
5	1	1	6.30 cm	-	-	broken tip embedded in target.
6	4	2	3.75 cm 4.28 cm	2	-	-
7	1	1	16.70 cm	-	-	-
8	1	1	1.55 cm	-	-	broken tip shallowly embedded in target.
9	3	-	-	2	-	3rd trial: hit tree and arrowhead unhafted but subsequently retrieved about 1.20 m away.
10	4	-	-	4	-	3rd & 4th trials: skated on ground ice. 4th trial: hit tree on rebound.
11	1	-	-	-	-	shot at 10 m. distance into tree trunk, broken tip lost.
12*	5	1	3.20 cm	4	-	-
13*	7	-	-	7	-	hit tree 5 times on rebound and skated on ice 2 times.
14*	10	-	-	10	-	hit tree 6 times on rebound and skated on ice 1 time. 10th trial: tip unhafted.
15*	1	1	1.80 cm	-	-	broken tip shallowly embedded in target.

Note: * denotes composite arrow.

Table 1: Results of shooting experiments.

Item	Cone fractures		Bending fractures				Spin-off Fractures		Burin-like	Remarks
	<5mm	Trans-verse	Feather	Snap	Step	Hinge	Uni-facial	Bi-facial		
A1b	-	-	-	-	2	-	-	-	1(b)	-
A2w	1(b)	-	-	-	-	-	-	-	-	-
A3w	-	-	-	1(t)	-	-	-	-	-	-
A4w	-	-	-	-	-	-	-	-	-	No visible damage
A5b	2(b)	-	-	-	3	-	1	-	-	Uni-facial spin-off terminated in step.
A6w	-	-	-	1(t)	-	-	-	-	-	-
A7w	-	-	-	-	3	-	-	-	-	Step terminations in a ladder-like arrangement
A8t	-	-	-	1	1(pa)	-	-	-	-	Snap fracture has a partial Step termination.
A8b	-	-	-	1	1(pa)	-	-	-	1(b)	Snap fracture has a partial Step termination & secondary Burin-like fracture.
A9w	-	-	-	-	-	-	-	-	-	No visible damage.
A10w	-	-	-	-	-	-	-	-	-	No visible damage.
A11b	-	-	-	1	-	-	3	-	-	-
A12P	-	-	-	-	-	-	-	-	-	No visible damage.
A12B	-	-	-	-	-	-	-	-	-	No visible damage.
A13P	-	-	-	-	-	-	-	-	-	Tip very slightly blunted.
A13B	-	-	-	-	-	-	-	-	-	No visible damage.
A14P	-	-	-	-	-	-	-	-	-	Tip slightly blunted.
A14B	-	-	-	-	-	-	-	-	-	No visible damage.
A15Pt	-	-	-	1	1(pa)	-	-	-	-	Snap fracture with partial Step termination.
A15Pb	-	-	-	1	2(1pa)	-	-	-	-	Transverse Snap fracture with part Step termination. 1 Step fracture on lateral edge towards base.
A15B	-	-	-	-	-	-	-	-	-	No visible damage.
Total	3	0	0	7	13	0	4	0	2	-

Table 2A: Results of microscope analysis—shooting experiments. Key: t-tip, b=base, w=whole, P=point, B=barb. (b)=located near base, (t)=located near tip, (L)=located on lateral margin, (pa)=partial.

Item	Cone fractures		Bending fractures				Spin-off Fractures		Burin-like	Remarks
	<5mm	Trans-verse	Feather	Snap	Step	Hinge	Uni-facial	Bi-facial		
K1w	5	-	-	-	-	-	-	-	1(b)	Tip is slightly crushed. Hinge fracture initiated from base.
K2t	3	1	1(L)	-	-	-	-	-	-	-
K2b	3	1	-	-	-	-	-	-	-	-
K3t	6	1	-	-	-	1(L)	-	-	1(b)	1 small Cone fracture on transverse fracture surface.
K3b	3	1	-	-	-	-	-	-	-	-
K4t	4	-	1(L)	1	-	-	-	-	-	Scratches oriented obliquely to working edge.
K4b	5	-	1(L)	1	-	-	-	-	-	2 small Cone fractures on transverse fracture surface.
K5w	3	1	-	1(t)	-	-	-	-	-	-
Total	32	5	3	3	0	1	0	0	2	-

Table 2B: Results of microscope analysis—knife experiment. Key: t-tip, b=base, w=whole, K=composite knife blades, (b)=located near base, (t)=located near tip, (L)=located on lateral margin, (pa)=partial.

Item	Cone fractures		Bending fractures				Spin-off Fractures		Burin-like	Remarks
	<5mm	Trans-verse	Feather	Snap	Step	Hinge	Uni-facial	Bi-facial		
C1	3	1	-	-	-	-	-	-	-	-
C2	4	-	-	1	-	-	-	-	-	Broken into 4 main segments. 1 major diagonal fracture. 3 of the pieces are too small to handle.
C3	3	1	-	-	-	-	-	-	-	Shallow flute-like scars on lateral edge.
C4	3	1(pa)	-	-	-	-	-	-	-	-
C5	2	1	-	-	-	-	-	-	-	-
Total	15	4	0	1	0	0	0	0	0	-

Table 2C: Results of microscope analysis—'non-functional' activities experiment. Key: t-tip, b=base, w=whole, C=points utilised in Experiment 3, (b)=located near base, (t)=located near tip, (L)=located on lateral margin, (pa)=partial.

fracture associated with projectile point function. Why, however, would projectile point function result in a higher frequency of step terminating bending fractures in combination with a *decrease* in small cone and cone-initiated transverse fractures?

A basic assumption of usewear analysis is, as has been observed, that different patterns of tool use will produce different wear patterns. Therefore, if the nature of arrowhead and non-arrowhead function is considered, an attempt can be made to isolate variables that may have contributed to the results observed.

First of all, in function as arrowheads, points are subjected to a high rate of loading (high magnitude/ short duration of force) on impact with the target. Compared with other tools, an arrowhead is only in active contact with the target for a split second before the kinetic energy of the arrow is dissipated by the frictional drag created by the contact. On the other hand, the blade of a knife is subjected to a more prolonged pressure, of varying but lower magnitude, caused by repeated contact with the worked material even in one single episode of use. In the case of the 'non-functional' activities, the points were, of course, subjected to continuous battering for over four minutes in the experiment.

As indicated in Tables 2B and C, the two non-arrowhead activities tend to produce a higher number of small flake removals (i.e. small cone fractures <5 mm). On points utilised as blades (K1-K5), these small fractures tend to cluster along the use edge. This occurrence may be related to the preferential utilisation of the functional edge. However, for points subjected to the 'non-functional activities' experiment (C1-C5), the distribution is more random. This, in contrast, may reflect the non-selective nature of the impacting force. Small flake removals associated with arrowhead function (e.g. A2w and A5b), are located on the base and may be connected with damage caused by compression against the sides of the haft.

Turning to the variation in fracture initiations, the experimental results indicate that arrowhead function produces more bending initiated fracture, with step termination (e.g. A1b, Fig. 8); while the non-arrowhead activities result in more cone-initiated transverse fractures.

According to Fischer and colleagues, step terminating bending fracture is caused by pressure from both ends of the flint objects (i.e. pressure parallel to the long axis) and is the '*most simple* projectile diagnosticating fractures ...' (Fischer *et al.* 1984, 22, my italics). Their conclusion is supplemented by the observation made by Odell and Cowan (1986, 204) that head-on impact forces in projectile point function tend to be directed along the longitudinal axis and are frequently strong enough to produce relatively large step-terminated fractures.

With regard to variations in fracture initiation, the controlling factors are the magnitude and direction of the impacting force (see 'The Classification of Impact Fractures' above). In arrowhead function, the direction of the applied pressure is usually parallel to the broad sides of the point. In addition, when an arrowhead penetrates the target, the severed tissue closes around the point and ensures a broad area of contact. As a result, the initiating force is applied over a relatively broad contact area, so that bending initiations are more likely to occur.

In the other two non-arrowhead activities, on the other hand, the fracture initiating forces are directed more or less perpendicular to the long axis of the points. For the knife blades, the primary loading pressure is applied

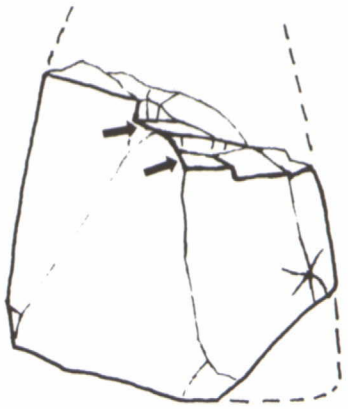

Figure 8a: Fracture with step terminations on arrowhead A1b. Scale: 6.4:1

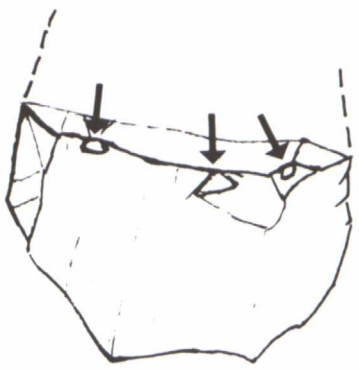

Figure 8b: Unifacial spin-off fractures on arrowhead A11b. Scale: 4:1.

obliquely into the lateral margin (i.e. the use edge), although secondary stress centres may arise due to compression against the haft. In the non-functional activity samples, the impact force was also chiefly directed perpendicular to the broad sides of the points, as they laid flat on the ground. Bending fractures resulting from similar types of random processes will, therefore, have been initiated by pressure from this general direction (Fischer *et al.* 1984). Under such conditions, cone-initiated transverse fractures could theoretically occur if the impact force is localised. Inflexible materials, for example the chert core utilised in the Control Experiment to batter the points, tend to allow only a small contact area and will concentrate the force onto that specific location, thereby enhancing the occurrence of cone-like fractures (Lawrence 1979).

However, this hypothesis is more equivocal when applied to the points hafted as a composite knife. A possible alternative explanation is that the force generated by chopping and hacking at vegetation compressed the points against the haft, resulting in localised areas of high stress. The locations of the fracture initiation on the two points with transverse cone fractures (K2 and K3) appear to converge with the junction between the points and the wooden haft.

The remaining fracture varieties do not appear to have much value in predicting arrowhead function. For example, step terminating bending fracture occurs at comparable frequencies in both arrowhead and non-arrowhead activities and is assigned the second lowest rank in the Structural Matrix of the discriminant analysis.

However, it is interesting to note that in contrast to the findings of similar experimental studies, neither burin-like nor spin-off fractures were found to be significant distinguishing variables. The few burin-like fractures obtained in this study appear to be restricted to the proximal part of the point (see Table 2) and may be attributed to damage caused by compression against the haft. Similarly, spin-off fractures, described in Fischer's study as 'the *most easily recognizable* projectile point diagnosticating fractures' (Fischer *et al.* 1984, 23, my italics) were found to be merely equivocal indicators here. Only two arrowheads sustained uni-facial spin-off fractures (e.g. A11b, Fig. 8B) and these limited in dimension in comparison with those recorded by Fischer *et al.* (1984). Since their projectile points were manufactured from flint, while those utilised in this study were manufactured from chert, petrographical variation may well be responsible for the difference. As remarked previously (see 'Knapping Exercise' above), the chert from North Wales varies greatly in fracture properties and, at one end of the scale, is inclined to shatter into minute pieces. This factor, therefore, may well have restricted the growth of spin-off fractures. More significant, however, is the fact that the characteristics of impact fracture diagnostic of projectile point function differ between lithic materials. Therefore, diagnostic usewear features are only valid discriminators when applied to archaeological samples of comparable lithology.

For this study, the most obvious limitation is the small number of cases in the experiments. Secondly, due to the poor performance of the composite arrows, the data is insufficient to illuminate any possible variation in fracture pattern between the point and barb component; hence, the results should be treated as valid for arrowhead function only. Thirdly, fluctuation in the performance of individual arrows, as well as the unpredictable fracture behaviour of the chert from North Wales, introduced a certain degree of unquantified variability into the experiments. Given that the results are not in complete concordance with previous studies conducted with other lithic material, it may be that the results are valid only for chert from North Wales, or very similar lithic material.

An experimental situation is necessarily artificial, with some variables excluded from analysis. In real-life hunting, the injured life prey would probably crash through undergrowth, making violent internal muscular movements, and catching the protruding arrowshaft on surrounding obstacles. In such a situation, bending stresses might be relatively higher than in the simplified experimental environment (Odell and Cowan 1986).

Nevertheless, given the above limitations, the results reported here do provide means of interpreting lithic artefacts made from lower quality materials which are not suitable for microwear analysis.

Comparative analysis of the Greasby lithic assemblage

As the aim of the study is to isolate artefacts that functioned as arrowheads by means independent of typological consideration, all the excavated lithic artefacts in primary context were scrutinised. About 167 items comprising both retouched and unretouched as well as fragmentary pieces, with a shape that appeared suitable for hafting, were chosen for more detailed examination under a hand lens. Many of these items are in a relatively pristine condition with very minor micro-chipping that does not exhibit a consistent pattern in morphology and which may represent either excavation, post-excavation or 'drawer' damage. From these only 31 pieces were selected for microscope analysis, chosen on the basis of damage pattern, shape and state of preservation.

Subsequently, these pieces were examined under the microscope at full power, in order to quantify the fracture pattern and to evaluate the extent of chemical weathering. At this stage, items which did not exhibit impact fractures and those with chemically altered surface topography were rejected. In the end, only five pieces passed the above criteria, were put through the cleaning procedure, and examined in depth.

In analysing these artefacts, bending fracture with step terminations was used as a positive indicator of arrowhead function, while both cone-initiated transverse fractures and small cone fractures <5 mm were treated as negative indicators.

Results

Each of these five items is described individually below together with detail on the material type and provisional typological designations as determined by Smith (1991). All the margins are described with respect to the dorsal aspect of the artefact. Metric data are presented in Table 3.

Accession code	Length (mm.)	Breadth (mm.)	Thickness (mm.)
01.1221.40	11.90	6.10	2.20
01.779.8	12.70	4.90	4.00
01.5134.519	20.00	6.70	2.71
01.7022.700.1	17.05	10.20	3.10
01.1559.61	22.70	9.51	4.85
Mean	16.87	7.48	3.37

Table 3: Metric measurements of the Greasby artefacts.

01.1221.40, Blade Segment of Coarse Brown Chert (Fig. 9.1)
This item appears to be a distal segment of a truncated point/blade. The left lateral margin is backed by abrupt retouch. The proximal end of the piece is truncated by a snap fracture. The tip has a small step terminating bending initiated fracture. The unretouched sharp edge is quite fresh with very minimal microchipping (<1 mm) except for one burin-like fracture (1 mm in length) on the right lateral margin, originating from the snap fracture.

01.779.8, Obliquely Blunted Point of Marbly Dark Bluey/Grey Flint (Fig. 9.2)
This piece appears to be a distal segment of a fractured point and is almost trihedral in shape. The left lateral margin is backed by semi-invasive retouch giving an edge angle of about 29° (as measured by a goniometer). The right lateral margin seems to be truncated straight down its length. The proximal end of the piece has a snap bending fracture. The tip is fractured with a burin-like break running down one margin and terminating in a ladder like arrangements with three steps of unequal height. About 14 small cone fractures (<3 mm) were found, mainly associated with the right lateral margin.

01.7022.700.1, Microlith of Brown/Grey Fine Chert (Fig. 9.3)
This piece is a complete item, with possible retouch on the proximal end. The bulbar scar has been deliberately thinned, though the proximal end is too weathered for detailed quantification. Both the lateral margins are unretouched and converge to form a point. The tip is fractured and terminates in a step on the bulbar aspect. There is also a shallow flute-like fracture (2.8 mm in length) with step termination running down the left lateral margin below what may have been retouch. The lateral margins are relatively sharp with over 20 microchippings (<2 mm across) randomly distributed.

01.5134.519, Microlith of Grey/Brown Fine Chert (Fig. 9.4)
This item is a complete piece with retouch on the left lateral margin and the proximal end. The backed left lateral margin curves and converges with the unretouched sharp right lateral margin to form a point. There are no impact fractures but the right lateral edge exhibits a relatively high amount of edge damage with over 10 small cone fractures, including one about 2 mm in size.

01.1559.61, unclassified (Fig. 9.5)
This item is complete and appears to be an obliquely blunted point of marbly lavender chert. The left lateral margin is retouched towards the tip and the right lateral margin appears to be retouched towards the distal end. The proximal end is truncated with a feather termination on the dorsal ridge, although the termination may be another independent fracture which occurred subsequently. The tip is fractured, with a two-tiered step termination. None of the lateral margins appear to be preferentially damaged and only two small cone fractures as distinct from retouch are noted.

Summary Interpretation

Only four of the five items exhibited step terminating bending fractures. None of these pieces have any cone-initiated transverse fractures and the small cone fractures recorded are, in most cases, microscopic in size and probably caused by processes other than use. Given the scale difference between the step terminating bending fractures and the microchipping on the same piece, it is probably that they do not originate from the same damage event. Hence these four items appear to satisfy the criteria for a functionally damaged arrowhead. In comparison with the other finds, however, the damage on 01.779.8 appears to be more severe. In view of a large split down its right lateral margin, which could have obliterated other damage and completely distorted its shape, it is advisable not to classify it as an arrowhead. In the case of the remaining item (01.5134.519), the preferential concentration of edge damage on the right lateral margin, in contrast to the relatively fresh state of the other margin and both ends, may suggest a function as a backed blade; given its relatively narrow breadth, it would not have been effective as a side barb. An arrow side barb serves to increase the cutting perimeter of an arrow and, in some cases, as an anchoring device to hold the arrow in the target. Hence, to be effective, a barb needs to have a relatively larger breadth to length ratio (Cundy 1989).

Thus three items (01.1221.40, 01.7022.700.1 and 01.1559.61) from the Greasby Collection do appear to satisfy the criteria for arrowhead function derived from the experimental results, and it can be concluded that the existence of bow-and-arrow hunting in Greasby is confirmed.

Conclusion

Hunting is a specialised activity which generally occurs away from the camp or settlement site. This subsistence practice is likely to be under-represented in a lithic assemblage, since past events must first of all be 'archaeologically visible' from artefactual evidence. For an arrowhead to be 'visible' in an archaeological collection, the utilised points must 'make their way' back to a recognisable site (Bergman and Newcomer 1983). For example, a utilised point was found from Amose Bog, Denmark, lodged within the game brought back to the campsite (Barton and Bergman 1982). Or, alternatively, utilised points may be carried back to the camp because shafts are salvageable. It may only take a skilled knapper minutes to produce an arrowhead, but - it must be stressed - the manufacture of shafts is a much more labour intensive and time-consuming process that involved coppicing, air-drying, bark-striping, straightening, turning and nocking (Pope 1918). Hence, one can reasonably expect prehistoric

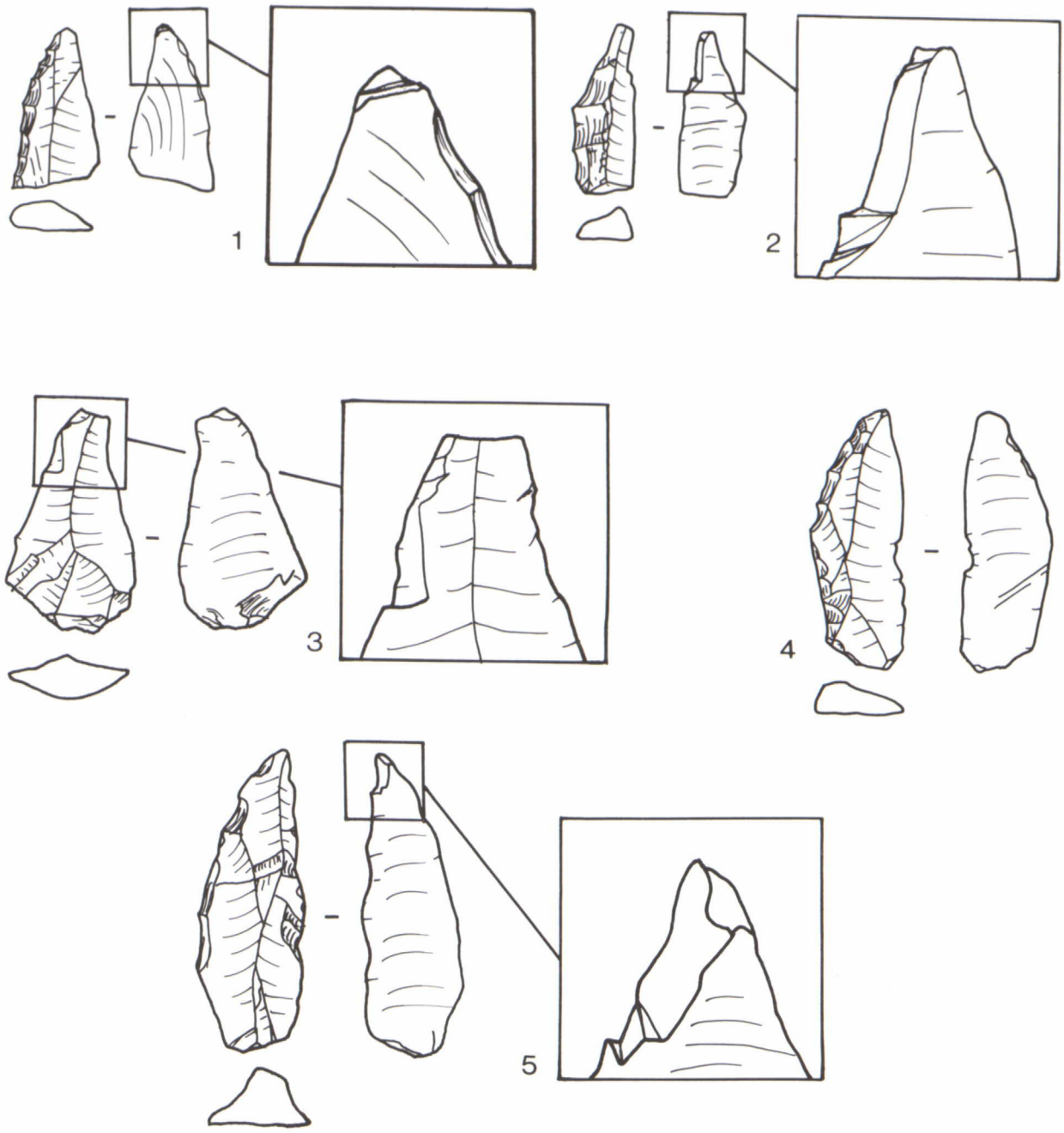

Figure 9: Five microliths from the Greasby collection. Scales: (1-5) 2:1; insets 4:1. Accession codes: (1) 01.1221.40, (2) 01.779.8, (3) 01.7022.700.1, (4) 01.5134.519, (5) 01.1559.61.

hunters to have recycled salvageable shafts by simply replacing the broken armatures. Evidence from Pincevent in the form of a projectile shaft still hafted with damaged armatures may indicate such practices indeed existed as far back in time as the Upper Palaeolithic (Leroi-Gourhan 1983).

As the occurrence of utilised arrowheads on an archaeological site is dependent on the above factors, it is reasonable to expect that only a limited amount of arrowheads with impact fractures would be represented within a site. This figure may also be further distorted by the fact that not all utilised projectile points exhibit diagnostic fracture patterns. Previous experimental studies have reported that 40% of arrows shot into large animals display diagnostic macrowear traces (Fischer *et al.* 1984 and Fischer 1985). Given that hunting is likely be under-represented in an lithic assemblage, it seems logical to conclude that it was probably a common activity of the Mesolithic inhabitants of Wirral.

In spite of the small sample size utilised in this study, the positive results achieved have demonstrated that an experimental and functional approach to lithic analysis is a powerful tool that can yield rewarding information on site activities. Moreover, practical experimentation can provide useful information on the performance of specific tool types, and this, in turn, may illuminate the tool manufacture behaviour of early man (Cotterell and Kamminga 1990).

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