APPENDIX III

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Welton-le-Wold: artefact abrasion report

Introduction

This report is complimentary to the detailed technological report complied by MacNabb (Appendix II of this report). Three bifaces and a flake were presented for abrasion analysis from the till deposits at the site of Welton-le Wold, Lincolnshire, UK. Analysis will focus on the nature of arêtes abrasion and artefact edge damage, in order to establish the most likely transportation scenarios to which these artefacts have been subjected.

Studies of artefact abrasion

It has long been noted that artefacts recovered from gravels display a range of physical modifications resulting from the high-energy depositional conditions they have been subjected to. Thus the *état physique* of such artefacts can be utilised as an indicator of how far from their original point of discard within the landscape they have been fluvially transported.

With regard to artefact abrasion, studies have focused on the degradation of biface arêtes (flake scar ridges). On freshly knapped bifaces arêtes arise thin and proud from the body of the artefact. As artefacts become incorporated within active fluvial systems they behave as clasts (Harding et al., 1987); rolling, saltating, sliding and colliding with other clasts. These impacts reduce the height and increase the width of the arêtes. Artefacts with sharp edges and little visible abrasion to the arêtes, found in association with knapping debitage and perhaps faunal remains, were considered to remain in close proximity to their original point of use and discard. Those artefacts that displayed 'very rolled' characteristics were considered to have been transported significant distances within the river environment. (Wymer, 1968). No attempts were made to define transportation distances except in these relative terms.

Two main techniques for classifying artefact abrasion exist; those based on visual assessment of the relative degree of abrasion sustained (e.g. Wymer 1968) and those based on techniques pioneered by Shackley (1974 & 1975) that utilise microscopic technology to objectively measure arête widths in micrometers.

Purely visual assessments of artefact abrasion generated a range of, user-specific, descriptive terms such as 'mint', 'worn' and 'rolled'. The inherent subjectivity of such terms was compounded by the absence of a standardised terminology. An attempt at standardisation was proposed by Wymer (1968, plate xi), suggesting five categories to encompass the range of abrasion damage displayed by artefacts recovered from river gravels. These categories were 'mint', 'sharp', 'slightly rolled', 'rolled' and 'very rolled', where by artefacts in the rolled and very rolled categories displayed arêtes widths of up to $^{1}/_{32}$ and $^{1}/_{8}{}^{th}$ of an inch, respectively (*ibid.*).

This standardisation allowed different workers to employ the same terminology to different artefacts and assemblages of artefacts and provided a means of quantifying the most abraded artefacts recorded, however standardisation of a subjective classificatory system does not in itself reduce the potential inter-observer variability.

A quantifiable technique was proposed by Shackley (1974 & 1975), based on the measurement of arêtes under an x75 microscope eyepiece calibrated in micrometers (μm; 1μm = 0.001mm). Shackley (*ibid.*) divided each biface into imaginary thirds of tip, mid and butt sections, documenting the width of 25 arêtes across the entire artefact, collecting broadly equally from each third. These 25 arête values were combined to produce an average observed arête width for the entire artefact. This methodology was applied to both experimental (tumbling mill abraded) and archaeological artefacts, providing a means with which to provide objective measurements and classification of abraded archaeological lithics. To further facilitate quantification of results, Shackley (1975) also proposed a scheme to correlate the commonly used verbal descriptive terms of artefact abrasion with the damage sustained by her experimental bifaces during the tumbling mill experiments (Table 1).

ARETE WIDTH (μM)	VERBAL DESCRIPTION	SHACKLEY'S INDEX VALUE
0-10	Mint	0
10-20	Very Fresh	1
20-50	Fresh	2
50-100	Slight Abrasion	3
100-200	Abraded	4
200-300	Heavily Abraded	5
300+	Very Heavily Abraded	6

Table 1 Abrasion indices and verbal description correlation (Shackley 1975)

The generation of an average abrasion value, or an index value, for each artefact provided a quantifiable means of assessing both individual, and more importantly, assemblages of abraded artefacts. The recording of arête widths at the micrometer scale led to the recognition that artefacts that may not appear abraded to the naked eye, can have sustained transport-related arête damage.

Very few attempts have been made to correlate abrasion development and real-world transportation distances. The most detailed research in this area has been undertaken by Hosfield (1999). Devising an adaptation of Shackley's methodology, where 15 rather than 25 data points are collected across the biface, Hosfield (*ibid.*.) combined quantitative abrasion data provided by microscopic recording with the abrasion damage sustained within fluvial environments generated by the experiments of Harding *et al* (1987) and his own experimental abrasion development data on replica artefacts. Based on the sum of these data, Hosfield (1999) devised seven preliminary rates of wear (*ibid.* 116-117). The expansion of this model to include a larger archaeological sample allowed the refining of artefact wear rate to 0.1475 μm m^{-1}.

While quantitative methods of measuring artefact abrasion have been suggested (Shackley 1974 & 1975; Hosfield 1999), these techniques focus on the generation of an average abrasion value for the entirety of each artefact. However, this averaging masks the detail of the transport-related damage an artefact has sustained. It can be demonstrated (Chambers in prep) that once abrasion begins to develop, it does not do so in a uniform manner across the whole artefact, that different degrees of damage are sustained on both an intra and inter-face basis. This differential abrasion development has implications for the type and duration of transportation artefacts have been subjected to. It was therefore necessary to develop a recording strategy that reflects the varying arête abrasion values that artefacts commonly display.

This methodology was devised during the course of my PhD research (Chambers in prep, Hosfield et al 2000), based on the observed physical characteristics of Palaeolithic bifaces recovered from the gravels of the River Axe (Devon, UK) and the Solent River System (Hants, UK). In a manner reminiscent of Shackley's original methodology (1974 & 1975), each face of the artefact is divided into six equal zones

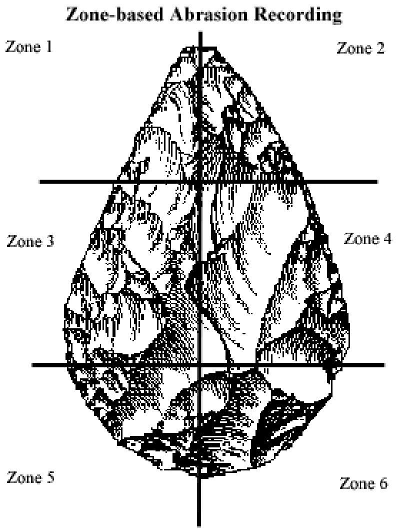

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Figure 1), and two arête widths are recorded (using microscopic techniques) from each zone, in a systematic manner from zone one through to zone six on each face.

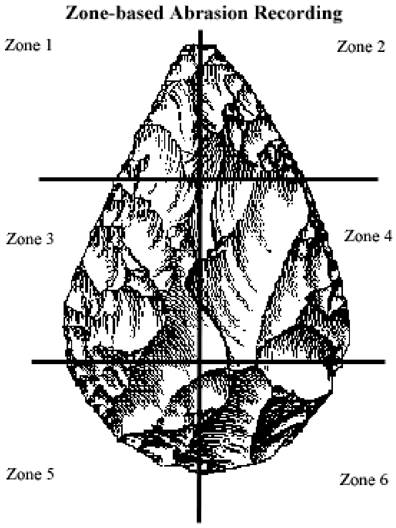

Figure 1: Zone based recording of artefact arête widths

This data can then be plotted graphically (Figure 2), allowing the identification of differential abrasion development within, and between, the faces of the artefact. This characterisation of damage can provide information about both the type and duration of transportation each artefact has been subjected to within fluvial environs. Analysis of the Welton-le-Wold artefacts will be based on data collected following this (Chambers in prep) methodology.

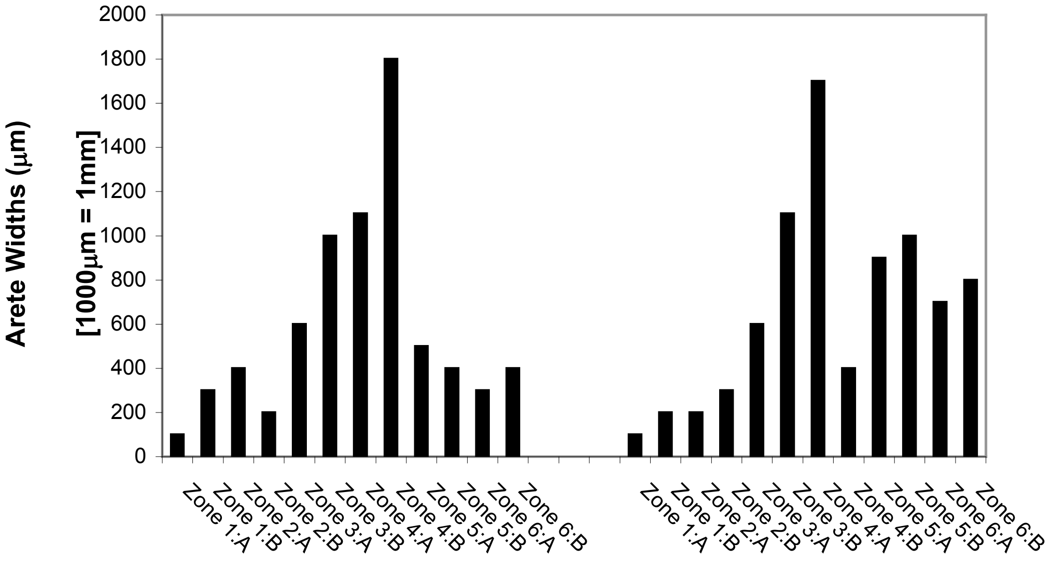

Figure 2: plotting biface abrasion values recorded by zone

Flume experiments were conducted to evaluate the effect of different types of bed-load transportation, (e.g. sliding, rolling and saltation), and the resulting damage sustained by replica bifaces. These experiments showed that different transportation regimes produce different abrasion and edge damage signatures (Chambers in prep). Artefact morphology was also demonstrated to influence movement, as only plano-convex artefacts are likely to slide (on their planar face) for any significant distance. Therefore a consideration of the morphology of individual artefacts and comparisons with the appropriate experimental data set allows the identification of the transportation regime and duration that individual (and populations of) artefacts are most likely to have been subjected. This process is described in Figure 3.

The transportation-related damage of each of the Welton-le-Wold artefacts will be discussed individually, before a consideration of the assemblage as a whole is offered.

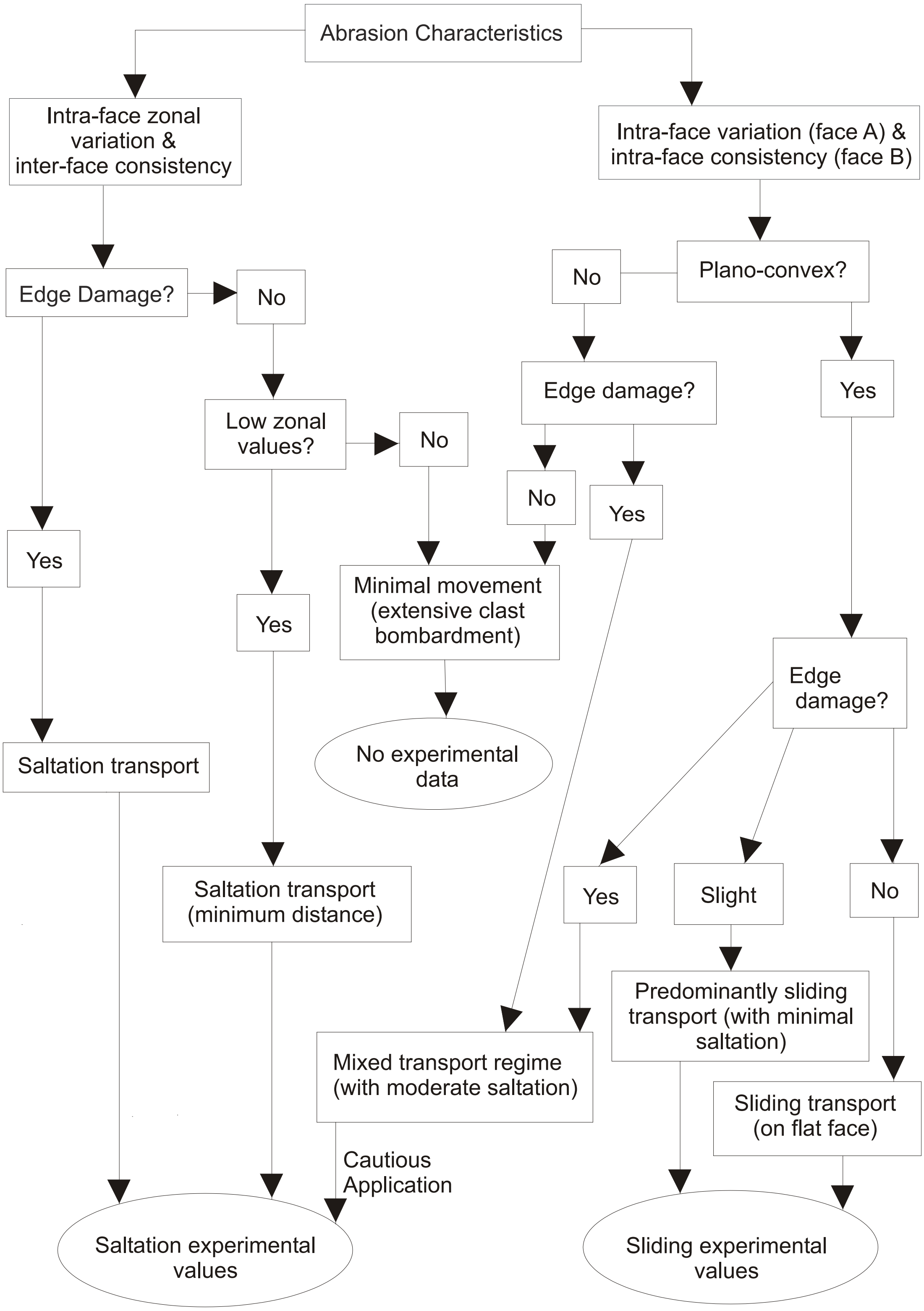

Figure 3: flow chart of the correlation between experimental and archaeological abrasion data sets

Biface 39.76

Biface 39.76 does not display marked plano-convexity. The edges of Biface 39.76 display moderate quantities of micro-flaking around the circumference of the artefact (Figure 4). Consideration of these morphological characteristics suggests that the artefact is most likely to have been transported primarily through saltation and/or rolling motion.

Figure 4 Profile of Biface 39.76; note absence of marked plano-convexity, retained cortex and micro-flaking to edge.

Plotting the arêtes widths of Biface 39.76 broadly indicate transportation via saltation, the arête widths of Face A are highly variable. Comparison with the saltation experimental data set would indicate that Biface 39.76 has been transported a minimum distance of 250m. This correlation is based on morphological grounds (the absence of pronounced plano-convexity and presence of micro-flaking indicates saltation motion). As can be seen in (Figure 5) the arêtes of Face A correspond well to the experimental arêtes widths after 250m of movement.

Arêtes Widths (□m) for Biface 39.76			
FACE A		FACE B	
Zone 1:A	100	Zone 1:A	200
Zone 1: B	100	Zone 1: B	100
Zone 2: A	200	Zone 2: A	100
Zone 2: B	100	Zone 2: B	200
Zone 3: A	300	Zone 3: A	200
Zone 3: B	0	Zone 3: B	200
Zone 4: A	0	Zone 4: A	100
Zone 4: B	200	Zone 4: B	100
Zone 5: A	300	Zone 5: A	0
Zone 5: B	700	Zone 5: B	0
Zone 6: A	200	Zone 6: A	0
Zone 6: B	300	Zone 6: B	200

Table 2 Arêtes abrasion values for Biface 39.76

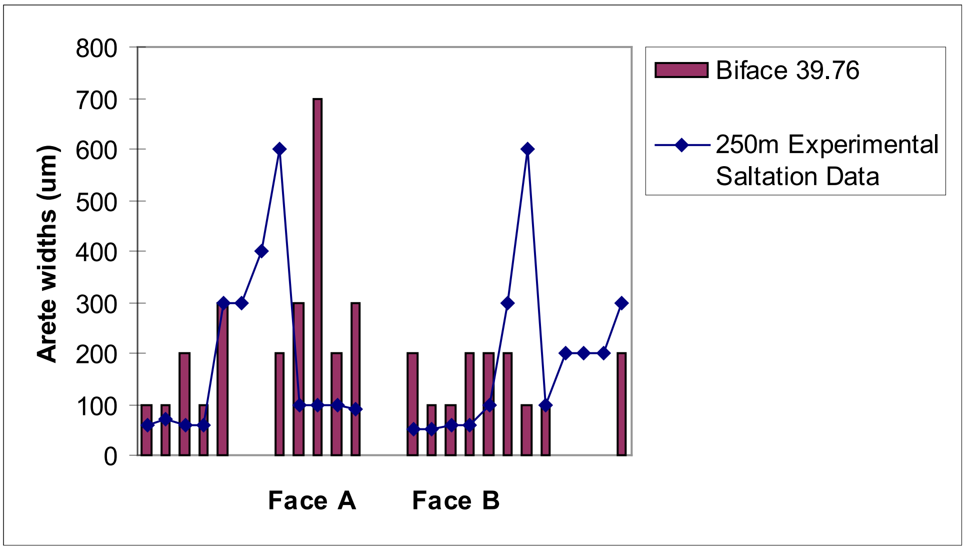

Figure 5 Arêtes correlation of experimental data and Biface 39.76

The different peak locations in the graph correspond to the thickest regions of the artefact, which are prone to greater abrasion damage. Correlation of the Face B data is rather weak. However, whilst highly variable within a single face, saltation abrasion damage usually produces very similar inter-face values. Biface 39.76 is not invasively flaked. Cortex is retained in the thickest portions of the artefact, most extensively on Face B. As these areas most commonly sustain the greatest abrasion damage transportation distance has been based on the correlation of the Face A arête values and the experimental data set. Due to the retention of cortex in diagnostic zones of the artefact, it is possible that Biface 39.75 has been transported substantially further than the modelled data suggest. The distance of 250m transportation via a primarily saltating motion is offered as a **minimum** transportation distance.

Biface 40.76

Biface 40.76 displays plano-convexity (Face A = planar, Face B = convex), and shows only very slight evidence of edge damage in the form of micro-flaking (Figure 6). These morphological characteristics and the relative homogeneity of the arête widths on Face A, the planar face (Table 3), suggest that it is most likely to have been transported by sliding motion.

Figure 6 Profile of Biface 40.76; note plano-convexity and minimal edge damage

Arêtes Widths (□m) for Biface 40.76

FACE A (PLANAR)		FACE B (CONVEX)	
Zone 1:A	200	Zone 1:A	100
Zone 1: B	300	Zone 1: B	200
Zone 2: A	200	Zone 2: A	200
Zone 2: B	200	Zone 2: B	100
Zone 3: A	200	Zone 3: A	200
Zone 3: B	200	Zone 3: B	200
Zone 4: A	100	Zone 4: A	300
Zone 4: B	000	Zone 4: B	200
Zone 5: A	300	Zone 5: A	400
Zone 5: B	400	Zone 5: B	1200
Zone 6: A	300	Zone 6: A	300
Zone 6: B	200	Zone 6: B	200

Table 3 Arêtes abrasion values for Biface 40.76

Comparison with the experimental abrasion development data showed a strong correlation with the sliding data set. Sliding is typified by more uniform abrasion damage to the planar face (Face A for Biface 40.76), combined with highly variable arête values for the convex face (Face B for Biface 40.76). The variable abrasion to the convex face is produced as exposed areas are bombarded by other mobile clasts. The abrasion sustained during sliding motion by plano-convex artefacts has only been modelled up to a distance of 250m (Chambers in prep). Correlation between archaeological and experimental sliding data sets focuses on the damage displayed by the planar face, as this directly related to transportation rather than the more random, effects of clast bombardment.

Exact correlation between the experimental and archaeological datasets cannot always be demonstrated, however the methodology provides a means off assessing the most likely mechanisms and duration of artefact transportation with hydraulic regimes.

The arête values for Biface 40.76 are slightly higher than those demonstrated by the experimental artefacts at the maximum sliding transportation distance (Figure 7). This suggests that Biface 40.76 has been transported slightly greater than 250m. The more variable abrasion damage displayed by the convex face of Biface 40.76 is considered to relate to the bombardment of this face either during its exposure during sliding episodes, or during episodes of immobility and/or partial burial. The substantial 'additional' abrasion sustained to the thickest area of the artefact (Figure 7) and the absence of edge micro-flaking supports this interpretation.

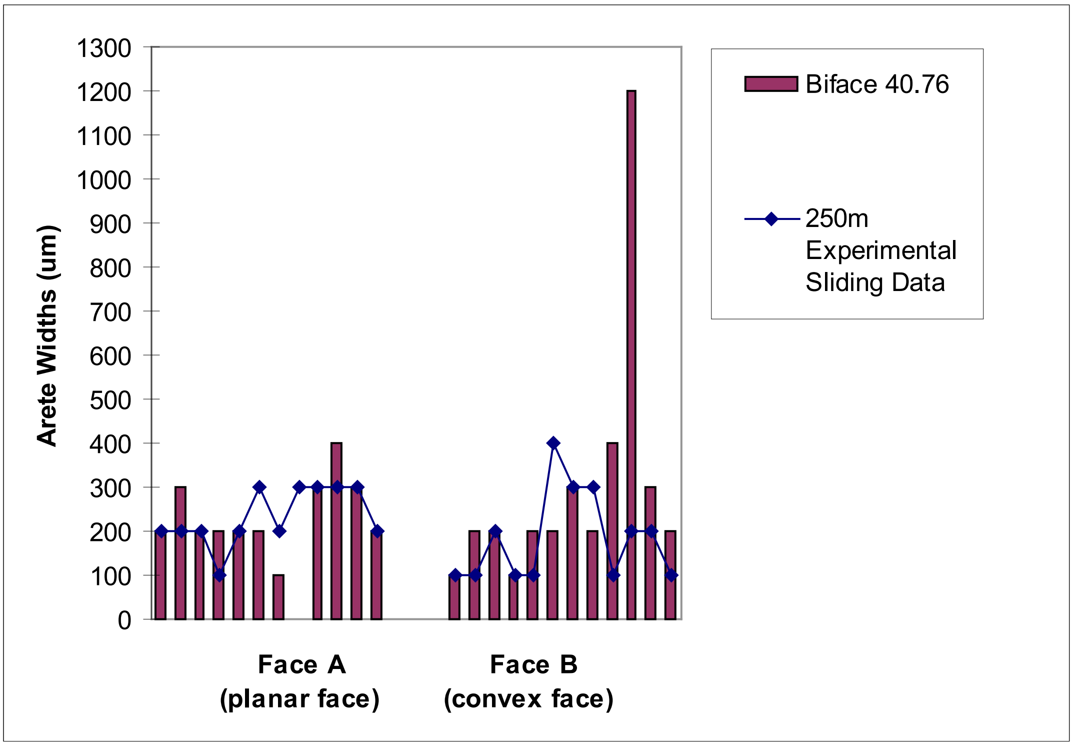

Figure 7 Arête correlation of experimental data and Biface 40.76

Biface 56.70

Biface 56.70 does not display marked plano-convexity. The edges of Biface 56.70 display moderate quantities of micro-flaking around the circumference of the artefact (Figure 8). Consideration of these morphological characteristics suggests that the artefact is most likely to have been transported primarily through saltation and/or rolling motion.

Arêtes Widths (□m) for Biface 56.70			
FACE A		FACE B	
Zone 1:A	100	Zone 1:A	100
Zone 1: B	100	Zone 1: B	200
Zone 2: A	200	Zone 2: A	0
Zone 2: B	100	Zone 2: B	100
Zone 3: A	100	Zone 3: A	300
Zone 3: B	300	Zone 3: B	500
Zone 4: A	300	Zone 4: A	600
Zone 4: B	500	Zone 4: B	200
Zone 5: A	200	Zone 5: A	400
Zone 5: B	700	Zone 5: B	200
Zone 6: A	200	Zone 6: A	200
Zone 6: B	400	Zone 6: B	100

Table 4 Arêtes abrasion values for Biface 56.70

Figure 8; Biface 56.70; note edge micro-flaking and the absence of plano-convexity

Plotting the arêtes widths of Biface 56.70 confirms transportation via saltation; the arête widths of each face vary substantially, but inter-face comparisons show strong similarities (Table 4, Figure 8).

Comparison with the saltation experimental data set would indicate that Biface 56.70 has been transported approximately 250m (Figure 9). Biface 56.70 shows slightly larger arêtes widths than the replica artefacts showed after 250m, but less than those shown after 300m of saltation transport. It is therefore suggested that Biface 56.70 had been transported c.275m.

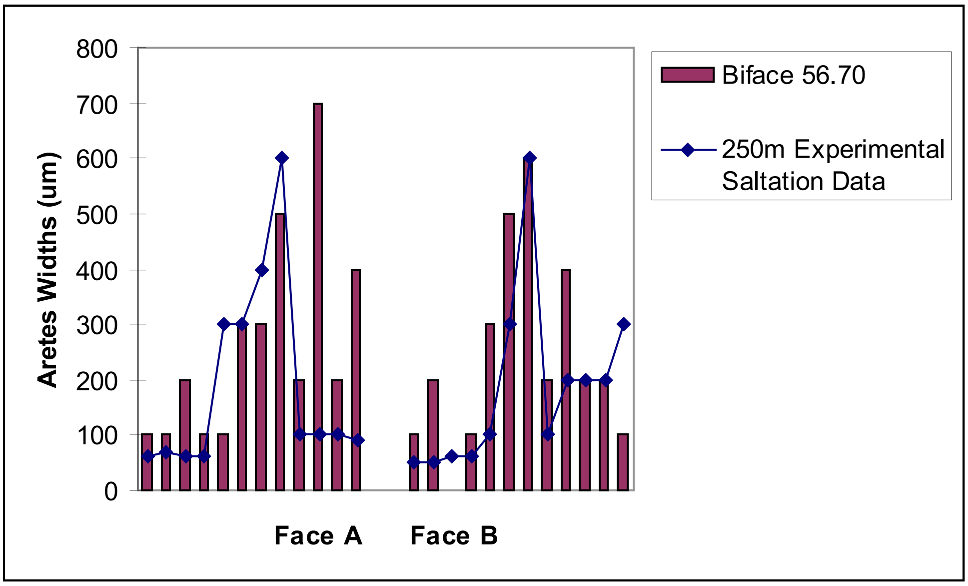

Figure 9 Arêtes correlation of experimental data and Biface 56.70

Artefact 41.76

41.76 is a hard hammer, side struck flake (MacNabb, Appendix II of this report).

The abrasion recording and experimental data sets used in this analysis were generated primarily for application to bifacially flaked artefacts, however there are general trends within the experimental data set that can be applied to flake material recovered from secondary contexts. Flake 41.76 shows an extensive dorsal scar pattern, these arêtes can be recorded in the same manner as biface arêtes. Morphological considerations of the most likely mode of transport can also be undertaken.

Flake 41.76 does not show pronounced plano-convexity, which has been experimentally demonstrated to preclude substantial sliding transportation. Consideration of the damage to the edges of Flake 41.76 indicates that substantial transportation via rolling or saltation also seems highly unlikely (Figure 10).

However, while the edges of Flake 41.76 show little sign of damage, the arêtes of the dorsal face show substantial damage (Figure 11 & Figure 12). Unfortunately, the ventral face provides little opportunity for assessing abrasion via arêtes widths, although measurements of the bulbar scar arêtes generated values in the region of 100-200 µm, much smaller than the dorsal arêtes.

If considered in isolation, the dorsal arête damage would be indicative of transportation for c.400m with additional damage sustained locally. However, the overall pattern of damage of Flake 41.76 (large dorsal arête widths, very little edge damage and little discernable ventral damage) suggests that much of the arête abrasion damage may have occurred *in situ*.

Figure 10 Profile of Flake 41.76; note absence of plano-convexity and edge damage micro-flaking

Figure 11Dorsal face of Flake 41.76 preserving natural and technological flake scars and arêtes

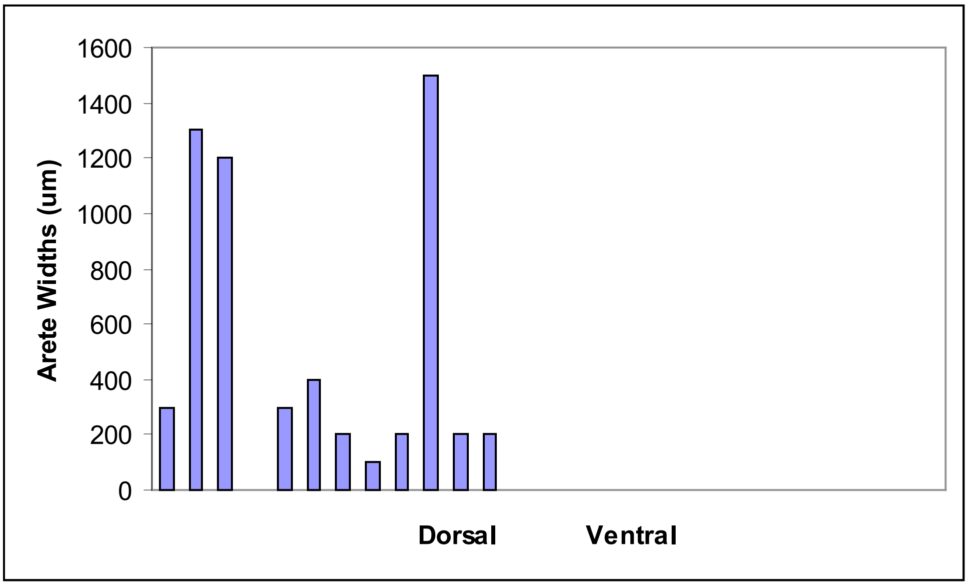

Figure 12 Arêtes width of the dorsal face of Flake 41.76

The absence of an unambiguously planar face (on which sliding would have taken place) indicates that it is unlikely that Flake 41.76 moved any significant distance via sliding motion. Had substantial saltation or rolling movement taken place the edges of the flake would have become damaged through the removal of micro-flakes.

It therefore seems most probable that the dorsal arêtes abrasion damage primarily reflects the bombardment of Flake 41.76 by mobile clasts or sediment.

Summary

The three bifaces from Welton-le-Wold can be demonstrated to be of relatively local origin. Comparison of the *état physique* data from the Welton-le-Wold bifaces and experimentally abraded replica artefacts (Chambers in prep) indicate that they have been transported via bed-load movement mechanisms approximately 250m. Modelling the transportation of Flake 41.76 has proved more problematic due to the absence of ventral arêtes, however its morphology suggests that much of the demonstrated damage relates to bombardment rather than transportation.

It should be emphasised that it is not currently possible to model suspended load transportation, and therefore the transportation distances presented here should be regarded as the **minimum** distances during which the observed damage could have developed.

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