FLAKE MODIFICATIONS DURING FLUVIAL TRANSPORTATION: THREE CAUTIONARY TALES

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INTRODUCTION

This short paper summarises some of the results from an initial, four year programme of experimental archaeology, undertaken by the authors in mid-Wales between 2000 and 2004. The transportation and transformation of replica Lower Palaeolithic stone tools were observed in the Afon Ystwyth gravel-bed river, generating data regarding transportation distances, spatial dispersal patterns, and artefact modification. The experiments are primarily relevant to the interpretation of stone tool assemblages from fluvial sedimentary settings (principally Pleistocene sand and gravel deposits), but may also have wider implications for any archaeological situation in which stone artefacts have been subject to the processes of water flow.

The initial experiments generated a wide range of data, from which three observations are presented and discussed here, with regard to: the relationships between flake sizes and transported distances; the development of edge micro-flaking upon flakes during transportation episodes; and the modification of flake morphology as a result of breakages during transportation episodes.

FIELD EXPERIMENTS

Details of the Llanafan (Grogwynian Reach) experimental site (national grid reference SN 709719; Figure 1) have been published fully elsewhere (Hosfield & Chambers 2002, 2004, in press)[15]. A short summary only is therefore provided here. The Afon Ystwyth is a relatively small system (169.6 km^2 catchment and valley gradient of *c*. 4m km^{-1}), and generated mean annual river discharges of $9.4m^3s^{-1}$ in 2000, $6.1m^3s^{-1}$ in 2001 and $6.8m^3s^{-1}$ in 2002 (measured at the Pont Llolwyn gauging station, SN 591774). Maximum daily mean discharges were $82.6m^3s^{-1}$ in 2000, $73.9m^3s^{-1}$ in 2001 and $75.6m^3s^{-1}$ in 2002 (NERC 2003; data for 2003 are not currently available).

The floodplain sediments are dominated by sandy gravels, with median grain sizes of *c*. 16–32mm (classified as coarse pebbles after Friedman & Sanders 1978). Finer sedimentary units exist as bar tail deposits, as discontinuous sand bodies on bar tops, and on the floodplain surface. The gravels are predominantly derived from local Palaeozoic shales and gritstones, with a high proportion of disc- and blade-shaped clasts (Harding *et al*. 1987: 116). The interactions between the exotic replica flint artefacts and the local shale and gritstone gravels clearly limit the direct applicability of the experiments to archaeological data from other geological settings. However, the experimental site was nonetheless considered acceptable for this initial phase of experimental research in light of: the absence of indigenous Palaeolithic

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[15] In a previous volume of *Lithics* (Hosfield *et al*. 2000), the Llanafan (Grogwynian Reach) site was erroneously referred to as Llanfarian (Grogwynian Reach). Our apologies for any confusion caused by this error.

material in the Afon Ystwyth valley, thus reducing the dangers of contaminating the regional archaeological record; and the contrasts between the river bed-load and the replica artefacts, which aided in the recovery of the latter.

Replica flake artefacts were emplaced between September 2000 and July 2003, with monitoring of the experimental site in January and December 2001, January, March, April, June, August, October, and December 2002, and March and July 2003. Fieldwork was not possible between January 2001 and December 2001 as an outbreak of Foot and Mouth prevented access to the site.

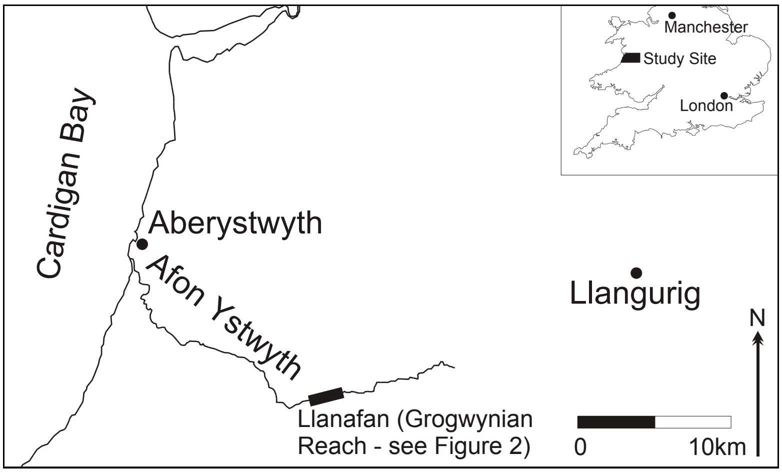

Figure 1: The Afon Ystwyth and Llanafan (Grogwynian Reach) study site, mid-Wales.

Thirteen scatters (Table 1) were emplaced at the Llanafan site, with four knapped *in situ* and nine pre-knapped and subsequently emplaced to replicate the spatial density of an *in situ* knapped scatter. The scatters were emplaced at two main sites: site A was a semi-stable floodplain and point bar complex at the downstream end of the study site (Figure 2); while site B consisted of a point/midstream bar complex at the upstream end of the study site (Figure 3). A series of attributes was recorded for each of the flake scatters: weight (only for pre-knapped scatters); a-axis dimension; b-axis dimension; c-axis dimension (only for pre-knapped scatters); orientation angle; dip angle; and 3-dimensional position (on a site survey grid).

The scatters were recorded over multiple monitoring events, prior to either their burial and/or removal from the study site by the river processes or the removal of the remaining flakes from the study site for laboratory recording. Consequently the number of recovered flakes for each scatter declined over time, although flake breakages did create small numbers of 'new' flakes. Recovery rates therefore varied over time, as well as by scatter (Hosfield & Chambers in press: Table 2), but in general percentage recovery values ranged widely (Table 1).

RESULTS

The transported and transformed scatters revealed a number of patterns with respect to the relationship between flake size and fluvial transportation distances, edge micro-flaking during transportation episodes, and the modification of flake morphology through breakages.

Scatter	*Method*	*Site*	*Emplacement date*	*Original number of flakes*	*Fluvially modified?*	*% flakes recovered*
1	Knapped *in situ*	A	September 2000	21	YES	43%
2	Knapped *in situ*	A	September 2000	38	NO	NA
3	Pre-knapped	A	November 2001	47	YES	98%
4	Knapped *in situ*	A	November 2001	133	NO	NA
5	Pre-knapped	A	January 2002	25	YES	0%
6	Knapped *in situ*	A	April 2002	47	YES	57%
7	Pre-knapped	A	June 2002	36	YES	0%
8	Pre-knapped	A	June 2002	36	YES	67%
9	Pre-knapped	B	June 2002	36	NO	NA
10	Pre-knapped	A	August 2002	36	YES	72%
11	Pre-knapped	B	August 2002	36	YES	36%
12	Pre-knapped	B	August 2002	36	YES	28%
13	Pre-knapped	A	October 2002	36	YES	0%

Table 1: Flake scatter emplacement, Llanafan (Grogwynian Reach), Afon Ystwyth

Figure 2: Semi-stable floodplain and point bar complex (site A), Llanafan (Grogwynian Reach), Afon Ystwyth, January 2002. View is from the north and flow is to the west.

FLAKE SIZE AND TRANSPORTATION DISTANCES

The recovered flakes demonstrated a wide range of transportation distances, from less than 1m up to *c*. 80m (measured as a straight-line distance between two survey points — summarised in Table 2). A central focus of the experiments was to assess whether small flakes would be consistently transported further than large flakes (or indeed vice-versa), and the implications of any patterns for assessing the potential disturbance of recovered archaeological scatters. Scatters Nos. 8, 10, 11 and 12 provided four suitable data-sets for examining the fluvial transportation of flake artefacts. In all cases there were no clear relationships, either positive or negative, between flake size (using weight as an index of size) and transported distance (Figure 4). There were also no clear relationships between flake size (using a-axis x b-axis dimensions as an index of size) and transported distance (Figure 5). The use of this second size index reflected Wilcock's (1997) argument that clast dimensions rather than weight are a more significant factor with respect to fluvial transportation distances.

Figure 3: Point/midstream bar complex (site B), Llanafan (Grogwynian Reach), Afon Ystwyth, March 2003. View is from the north and flow is to the west.

Scatter	***Transportation distances (m)***	
	Minimum	***Maximum***
1	0.46	16.33
3	0.15	2.88
6	0.05	34.53
7	0.09	1.57
8	0.48	21.52
10	1.32	29.34
11	0.07	82.34
12	0.14	84.95

Table 2: Minimum and maximum flake transportation distances by scatter, Llanafan (Grogwynian Reach), Afon Ystwyth

Overall, the experiments suggested that patterns within the spatial distributions and/or size classes of flake materials recovered from fluvial gravel sediments (e.g. the predominance of smaller or larger artefacts or the spatial localisation of the smaller/larger artefacts) should be treated very cautiously, if at all, as a potential indicator of the relative proximity, or not, of the artefact source/s.

The absence of any clear relationships between flake size and transported distance reflects the stochastic nature of bed-load transportation of all clasts (e.g. Hassan & Church 2001; Malmaeus & Hassan 2002; Hunziker & Jaeggi 2002). One particular factor emphasised in these experiments was the localised trapping of flakes of all sizes by local clast configurations on the channel beds and gravel bar surfaces (Figure 6). This was also indicated by the analyses of flake fabric distributions after transportation episodes, with the flakes' long axes failing to show a preference for either normal or parallel (to flow vector) orientations.

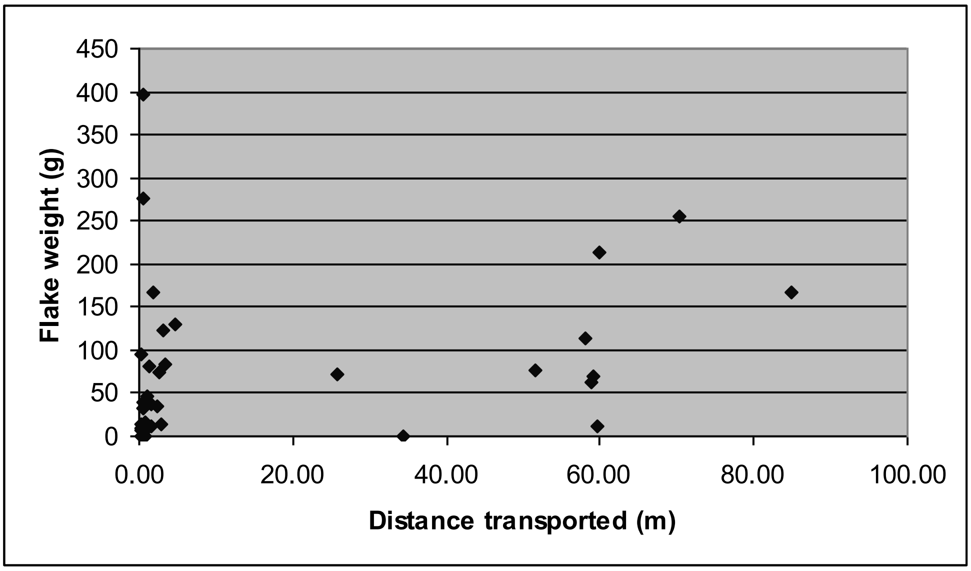

Figure 4: Scatter No. 12 flake transportation distances (August 2002–March 2003) vs flake weight (n=36 and R^2=0.0699)

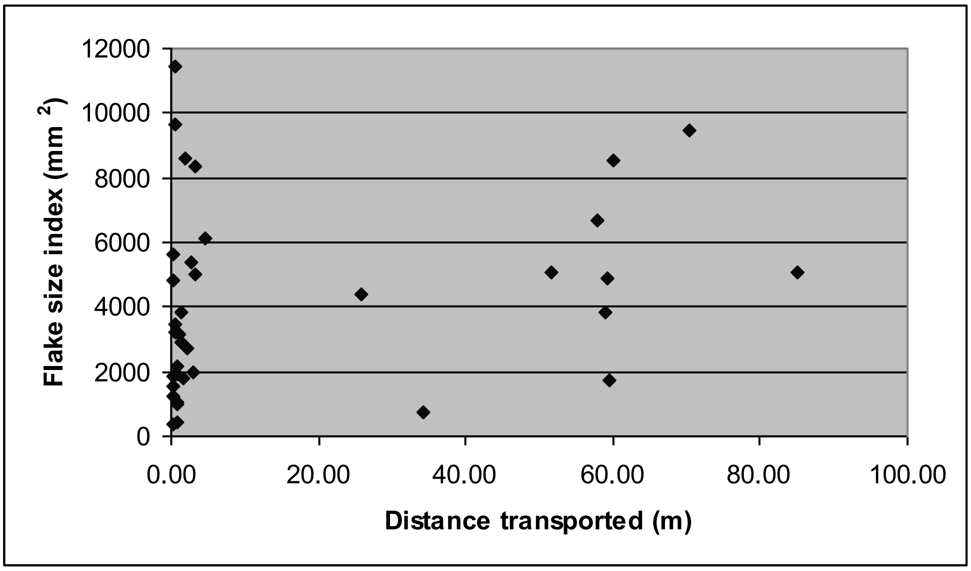

Figure 5: Scatter No. 12 flake transportation distances (August 2002–March 2003) vs flake size index (n=36 and R^2=0.0640)

DEVELOPMENT OF MICRO-FLAKING

There was evidence of edge damage in the form of micro-flaking on a large proportion of the recovered flakes (Table 3; Figure 7b). For scatters Nos. 8, 10, 11 and 12, at least 67% of the recovered flakes showed evidence of edge damage through micro-flaking. Chambers (2004) has related the development of micro-flaking to saltation transport, and the physical condition of the recovered flakes suggests that they were probably transported and modified in this manner. The majority of the micro-flaking scars displayed on the transported flakes are small (less than 5mm in all dimensions) and it is therefore highly unlikely that these micro-flakes would be recovered archaeologically. However, in any circumstances where such flakes were recovered from secondary context fluvial sediments, their presence should not be taken as an automatic indicator for *in situ* knapping activity.

Figure 6: Flake scatter No. 11 after dispersal, Llanafan (Grogwynian Reach), Afon Ystwyth. Note the 'trapping' of small flakes (indicated) between larger clasts and the numbering of the pre-knapped (and colour-coded) scatter flakes.

Scatter	***No. of flakes recovered***	***Broken flakes***		***Edge micro-flaking***	
		No.	***%***	***No.***	***%***
8	21	3	14%	14	67%
10	26	1	4%	18	69%
11	13	1	8%	11	85%
12	10	2	20%	9	90%

Table 3: Edge micro-flaking and breakage data for four experimental flake scatters, Llanafan (Grogwynian Reach), Afon Ystwyth

In some instances (Figure 7d) the products of edge flaking through transportation damage are larger (over 15mm in at least one dimension), highlighting not only the potential for fluvial transport to modify the flakes, but also for the products of these modifications to be mistakenly regarded as the results of hominid knapping activity. The experiments also indicated that sustained episodes of micro-flaking produce scar patterns on flake edges that, if continued, could ultimately be mistaken for intentional retouch (Figure 7c). Transportation damage can also more substantially modify individual flakes, in one instance replicating the morphology of a notch/flaked flake notch (Ashton *et al*. 1991), as shown in Figure 7a.

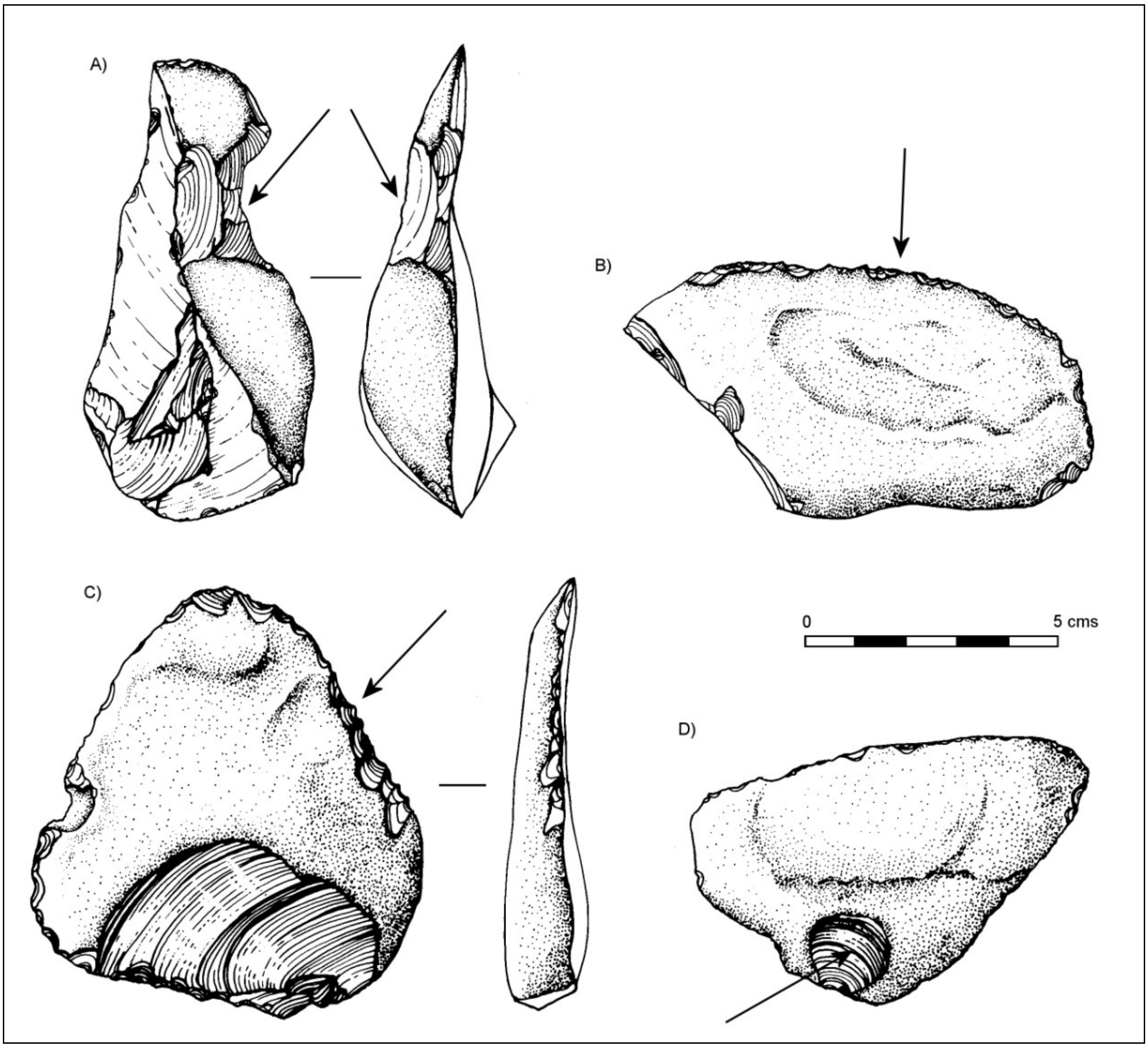

Figure 7: Recovered flakes from Llanafan (Grogwynian Reach), Afon Ystwyth. 7A. Scatter No. 10, flake No. 26. Note the 'notch' to the distal right edge (indicated). The flake was transported 21.23m (straight line distance). 7B. Scatter No. 12, flake No. 22. Note the micro-flaking along the distal edge (indicated). The flake was transported 51.62m (straight line distance). 7C. Scatter No. 12, flake No. 30. Note the developing micro-flaking scar patterns, which if continued could ultimately be suggestive of intentional retouch (indicated). The flake was transported 57.99m (straight line distance). 7D. Scatter No. 11, flake No. 20. Note the micro-flake scar (approximate flake scar dimensions 18 mm x 12 mm) (indicated). The flake was transported 30.14m (straight line distance).

FLAKE MODIFICATIONS THROUGH BREAKAGES

In contrast to the modification and micro-flaking data, evidence for flake breakages on the recovered samples was relatively scarce (Table 3). For scatters Nos. 8, 10, 11 and 12 breakages were only recovered on 20% or less of the flakes. It is also apparent from scatter Nos. 11 and 12 that flakes could survive transportation over a minimum of 80m with little or no evidence of substantial damage. Those breakages that were recorded tended to be minor, although it is emphasised that more substantial breakages would probably occur over longer transportation phases (and that these comments obviously only refer to the recovered flake component).

Nonetheless these observations, combined with the micro-flaking data, would suggest that an absence of broken flakes should not automatically be taken as evidence that a flake assemblage in a fluvial gravel context is *in situ*.

CONCLUSIONS AND NEW DIRECTIONS

In conclusion, the flake transportation experiments on the Afon Ystwyth generated a number of important results with respect to spatial patterns in the dispersal of the artefacts, relationships between size and transportation distances, and the damage and modification of the flakes during fluvial transportation episodes. Despite the low-tech nature of the work (in the absence of radio/electronic tracer technologies), recovery of the replica flake artefact tracers was generally good, and in its first phase the project has produced a wide range of valuable experimental data.

Nonetheless, it is clear that considerable further work is required, particularly with respect to the vertical dispersal of fluvially transported flakes within gravel deposits (e.g. fluvial bar structures), the abrasion of flake artefacts, and the need for longer-running experiments permitting observations of flake dispersal and modification over (ideally) decadal timescales. Nonetheless, the initial Afon Ystwyth experiments have demonstrated the value of experimental geoarchaeological work and its importance for the interpretation and re-interpretation of Palaeolithic assemblages recovered from fluvial secondary contexts.

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