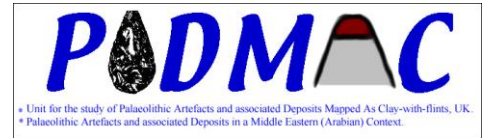




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## PADMAC Unit Working Paper

### **The use of Photogrammetry in investigations of Palaeolithic sites: surface scatters and excavations.**

Method: Photogrammetry is used to create a 3 dimensional, rectified model from overlapping two-dimensional photographs. In the context of our investigations, it is used to recreate a model of a site and associated artefacts in order to determine their orientations. These orientations (of a-axis and angle of dip) can then be used to determine potential geomorphological processes that might have influenced the distribution of the artefacts. Photogrammetry also provides an accurate photographic record of a site in three dimensions.

The PADMAC Unit uses photogrammetry in two main applications:

1. During excavation of potential Palaeolithic sub-surface sites and evidence, to record the surface of each 5cm spit during excavations and to model the locations and orientations of clasts and artefacts.
2. To record the entire distribution and orientations of surface scatters (particularly in arid environments such as the UAE where surface artefacts are visible in the landscape and not obscured by vegetation).

We investigated and trialled three of the main software programs that provide photogrammetry analysis: i-witness, PI-3000 and PhotoModeler.

The most suitable for our purposes is i-witness, which was originally designed to record road traffic accidents and is well-suited to analysis of large areas, with many photographs where the investigation requires detailed analysis of particular points or features rather than an overall rectification of photographs to recreate a composite image. Other programmes are more suitable for recreating a 3d image but become very unwieldy if more than 10 photographs are used.

Numbered markers are placed at ~1 metre intervals over the site or surface. The markers are in the form of a 1mm white circle within a 5cm black circle. This allows the photogrammetry software to automatically locate the centre of each circle for matching between photographs. For example, 30 photographs were taken of the site of ESF06A in the UAE (Scott-Jackson 2008) using a Canon E400d SLR camera which had previously been calibrated for i-witness. The photographs were taken at approximate 1 metre intervals with each 1 metre square being photographed from four different angles (~N, S, W, E).

The photographs are input to i-witness and pairs of photographs are compared to match markers that appear in each of the overlapping photograph. Because the photographs overlap and are taken from different angles, the software uses the matched markers to calculate the angles and 3d positions of all the markers and the camera positions involved. All the artefacts visible in the detailed photographs are also marked with a point at each end of the a-axis (the longest axis). Once the artefacts (and their lengths) have been marked and matched in each photograph, the software can include them in its calculation thus providing an accurate 3d position of each and artefact and its a-axis. From this, the artefacts can be mapped as lines of differing lengths (see below) with accurate angles of a-axis and dip. The positions can be exported to a 3d modelling program (in this case turbo-cad) for further analysis and investigation.

In Turbo-cad the artefacts, represented by their a-axis, can be viewed from various angles and directions. In addition, the angle (relative to North) and dip of the a-axis (relative to horizontal) can be derived.

The angle of a-axis and angles of dip can then be exported to a programme, Oriana, which calculates circular statistics (allowing for the fact that the angles of 0 and 360 are identical).

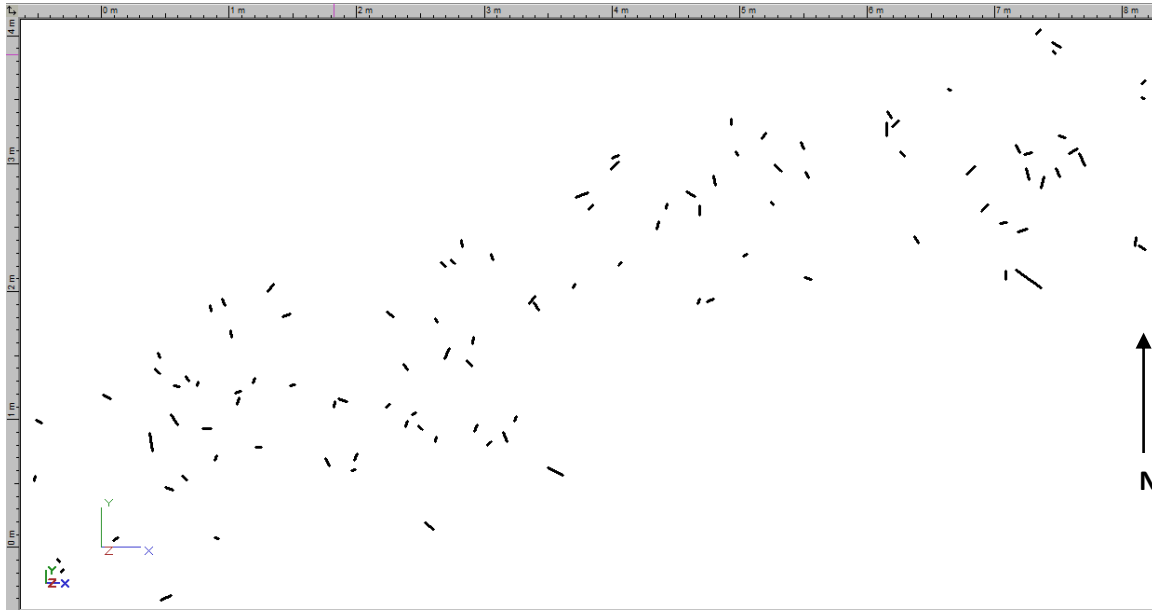
## RESULTS

Excavated spit at Dickett's Field near Alton, Hants - DFY08 (for site details refer to Scott-Jackson 2001)

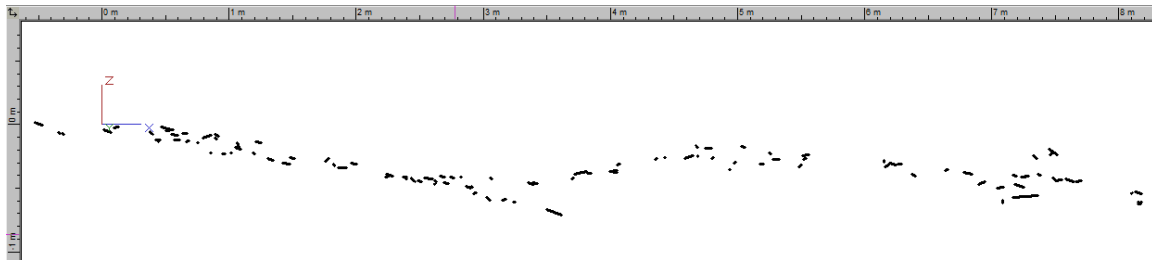


**Example of Surface Scatter from Sharjah, UAE.**

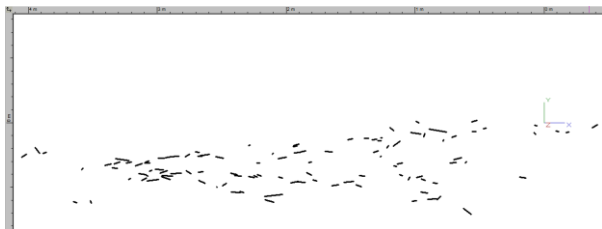
ESF06A Plan View (see Scott-Jackson 2009)



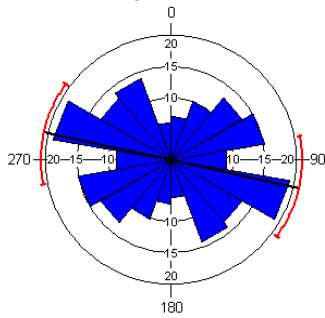
ESF06A – Profile from South (length of site)



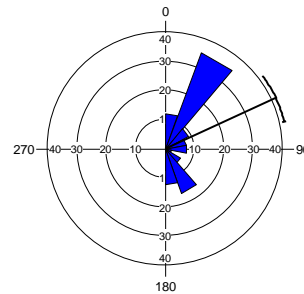
ESF06A Profile from East (width of site)



a-axis (from East)



Dip



BASIC STATISTICS

Variable	Dip	a-axis (from East)
Data Type	Angles	Axial
Number of Observations	106	106
Data Grouped?	No	No
Group Width (& Number of Groups)		
Mean Vector ( $\mu$ )	65.065°	102.666°
Length of Mean Vector (r)	0.582	0.164
Concentration	1.439	0.333
Circular Variance	0.418	0.418
Circular Standard Deviation	59.587°	54.447°
Rayleigh Test (Z)	35.94	2.861
Rayleigh Test (p)	< 1E-12	0.057
Rao's Spacing Test (U)	285.283	138.063
Rao's Spacing Test (p)	< 0.01	0.50 > p > 0.10

**Reference:**

Scott-Jackson, J.E. Winton, V. (2001). Recent investigations at Dickett's Field, Yarnham's Farm, Holybourne, Hants. In : S. Milliken. J. Cook. Editors. *A Very Remote Period Indeed: Papers on the Palaeolithic presented to Derek Roe*. Oxbow Books, Oxford, 2001: 214-22.

Scott-Jackson, J.E., Scott-Jackson, W.B. Rose, J.I. (2009) Palaeolithic Stone Tool Assemblages from Sharjah and Ras al Khaimah in the United Arab Emirates. In: Petraglia, M, Rose, J. editors. [\*The Evolution of Human Populations in Arabia\*](#). Springer, Netherlands. 125-138.

## Appendix Notes on Statistics

### Basic Statistics

The mean vector will have two properties; its direction (the mean angle,  $\mu$ ) and its length (letter  $r$ ). The length will range from 0 to 1; a larger  $r$  value indicates that the observations are clustered more closely around the mean than a lower one. The mean vector is an expression of preferred orientation (similar to the mean of a linear data series) whilst the vector magnitude is a sensitive measure of dispersion around the mean. A high value for vector magnitude means that the orientations varied greatly.

The concentration ( $k$ ) is a parameter specific to the [von Mises](#) distribution and measures the departure of the distribution from a perfect circle (or a uniform distribution). It is related to the length of the mean vector. The value reported by Oriana is the maximum likelihood estimate of the population concentration.

Circular variance and circular standard deviation are equivalent to their linear counterparts, but are calculated in a much different way. Variance is calculated from the length of the mean vector through the simple formula  $V = 1 - r$ ; standard deviation is then calculated by  $S = (-2 \ln(r))^{1/2}$ . The result  $S$ , which is in radians, may then be converted to degrees by multiplying by  $180/\pi$ .

The standard error of the mean is also calculated based on the length of the mean vector ( $r$ ) and the concentration. The 95% and 99% confidence intervals are then derived from the standard error as would be done for the normal distribution (i.e. multiplying by 1.9604 or 2.5762). When the standard error is calculated a check is made of the concentration for the sample as well as the sample size. The standard error can be unreliable if the combination of these is low.

The circular median direction can be difficult to calculate, due to the problem of choosing an appropriate axis on the circular scale, which wraps around. In Oriana the median is calculated by minimizing the function:

### Significance tests

The Rayleigh test is a simple method of testing whether a set of data possesses a distribution of orientation which is significantly different from normal. A probability less than the chosen significance

level of 0.05 indicates that the data are not distributed uniformly and that they show evidence of a preferred direction. (Graham 1988:45, Lindholm 1987:47).

### Chi-squared test

Oriana can perform Pairwise Chi-squared tests between any two selected samples and determines whether the two samples differ significantly from each other in some way. The p value printed for each test is the probability associated with the null hypothesis that the two samples are drawn from the same population. If this probability is less than the chosen significance level of 0.05) then the null hypothesis can be rejected in favour of the hypothesis that the two samples are from different populations that differ in some way. The difference may be in the distribution, mean direction, or other parameter; further investigation is then needed to determine the nature of difference between the two samples.