# Lithics and Landscape: GIS Approaches to the Analysis of Lithic Artefact Scatters

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**Abstract.** Discussions of the 'prehistoric' landscape have been dominated by the study of monumentality. Although evidence for contemporary occupation in the form of domestic structures is limited, extensive traces of former 'settlement patterns' have been identified in the form of lithic artefact scatters. Despite the biases inherent in the distribution of artefacts within these scatters, lithic assemblages recovered by surface artefact survey represent an unparalleled dataset for the study of the inhabited landscape. Lithic scatters are frequently part of a more extensive, multi-period surface spread, the complexity of which has presented an insurmountable barrier. GIS provides a powerful set of tools with which the complexity of surface artefact scatters can be explored. Potential applications will be discussed with reference to the analysis of a lithic artefact scatter from Eastern Yorkshire.
**Keywords:** continuous surfaces, GIS, lithic artefact scatters, spatial modelling and surface artefact survey

## 1. Introduction

Despite a growing realisation that prehistoric monuments were built within an 'inhabited' landscape, little emphasis has been placed on the routine activities implicit within that landscape. These activities can be identified through the analysis and interpretation of lithic scatters recovered by surface artefact survey. The interpretative potential of lithic artefact scatters has long been recognised; however this potential remains largely unfulfilled (Schofield 1991, 1995).
The increasing popularity of surface artefact survey over recent decades is often attributed to the development of landscape archaeology. Given the widespread adoption of GIS by 'landscape' archaeologists, it is not surprising that there have been a number of publications highlighting the potential applications of GIS to the analysis and interpretation of surface artefact scatters (e.g. Gillings and Sbonias 1999).
Recent discourse on surface artefact survey has been heavily influenced by the notion of off-site archaeology (e.g. Bintliff 1999). The associated body of theory, embracing both behavioural and post-depositional processes, emphasises the spatially continuous nature of human activity. Consequently there has been increased emphasis on the analysis of differential patterning in the distribution of artefacts across the landscape.

## 2. Off-Site Archaeology

Artefact scatters are typically considered to represent the cumulative product of numerous and repeated patterns of discard (Foley 1981). These patterns may be differentiated both spatially and quantitatively with clusters of artefacts representing locales within which debris-producing activity took place. Consideration of the range of debris may therefore indicate the nature of activity that took place at a particular locale. The greatest range of activities will usually take place at settlements, beyond which locales within the home range are often task-specific.
The application of this interpretive framework, however, has been largely uncritical. All too frequently clusters of artefacts, synonymous with 'sites', are differentiated from the general 'noise' of the background scatter. Little attempt has been made to ascertain and interpret the qualitative differences (if any) between clusters and the background scatter. This problem is exacerbated by the apparent assumption that, whilst an artefact scatter might be the product of multiple episodes of activity, these episodes represent a single pattern of discard.
Increasingly, it has been recognised that an artefact scatter will typically represent a palimpsest of traces of past human activity. Whilst locales associated with individual phases of activity can be identified at the level of the landscape, the paucity of chronologically diagnostic artefacts has precluded the differentiation of phases of activity at a more refined scale.

## 3. Artefact Distributions

Analysis of the spatial structure of surface artefact scatters has been dominated by the interpretation of point-provenance distribution plots (Boismier and Reilly 1988). Distributions of individual classes of artefact can be represented by symbol style or colour, whilst artefact frequencies or densities can be visualised using graduated symbols. The resultant distribution plots are often overly simplistic.
More recently, methodologies for modelling data from surface artefact survey have been developed using geostatistical techniques such as kriging (e.g. Lock, Bell and Lloyd 1999). These approaches typically employ interpolated grids to represent spatial variation in artefact density as a continuous surface. Techniques such as thresholding have subsequently

been used to compare the distribution of artefacts from consecutive chronological periods (Lock and Daly 1999).

The adoption of GIS has enabled a move away from the interpretation of static distribution maps, towards dynamic analysis of the attribute data that lies behind the spatial distribution of surface artefact scatters (Spikins 1995). Potential applications will be considered with reference to a lithic artefact scatter from Wharram-le-Street in Eastern Yorkshire.

## 4. Case Study

An extensive scatter of worked flint has been identified at Wharram-le-Street as part of ongoing surface artefact survey by the Wharram Research Project. The survey was carried out in order to determine the nature and extent of prehistoric activity around the source of the Gypsey Race. The Gypsey Race is currently the only surface watercourse on the Yorkshire Wolds.

The survey was carried out using transects 10m apart, with collection units spaced at 20m intervals along each transect. Artefacts were collected from a corridor 1m either side of the centre line of each transect, providing a 20% sample of the material visible on the surface of the site. This strategy is commonly employed by commercial units in field evaluations.

A total of 340 pieces of worked flint were recovered during the course of the survey. On the basis of this sample it is estimated that over 40,000 pieces of worked flint are circulating within the ploughsoil at the site. Preliminary assessment of the assemblage of worked flint indicates that it is derived from a multi-period scatter with a strong Mesolithic component.

## 5. Interpolation

Kriging is an optimal interpolation technique, respecting known values at sample locations (Ebert 2002). Confidence in the interpolated values is indicated by the kriging variance. Continuous surfaces can be interpolated from point data to enable consideration of the spatial variation in artefact frequency or density between known points.

Each collection unit is equivalent to a polygon, 20m long and 2m wide. Artefact frequencies were attached to the centroid of each collection unit to create a regular grid of points. The statistical biases introduced by the use of polygon or grid centroids are considered to be negligible given the resolution of the collection units (Robinson and Zubrow 1999).

Surface artefact survey at Wharram-le-Street is ongoing. Each plot of land is treated as a separate survey area. Collection units were set out on the British National Grid to allow easy integration of results from adjacent plots of land and to ensure that errors introduced by the sampling strategy are consistent across the entire study area.

Transects do not respect field boundaries and incomplete collection units were included in the survey to ensure total coverage of each survey area. Artefact frequencies were therefore converted into densities relative to the surface area of each collection unit prior to interpolation. Residuals in the standardised data were excluded from the analysis below (Fig. 1).

The semivariogram generated during kriging indicates that the distribution of artefacts across the survey area is not uniform, with pronounced variation between 150 m and 300 m (Fig. 2). Similarity between the semivariograms parallel and perpendicular to the survey transects suggests that the variation in artefact density is isotropic, i.e. independent of direction.

The resultant interpolated surface shows pronounced clustering within the distribution of artefacts. A variety of statistical techniques have been used to delineate clusters of artefacts (e.g. Millett 1991). The approach taken here is comparable to that employed as part of the Sangro Valley Project, where standard deviations were used to define the threshold between the background scatter and concentrations of artefacts (Lock and Daly 1999).

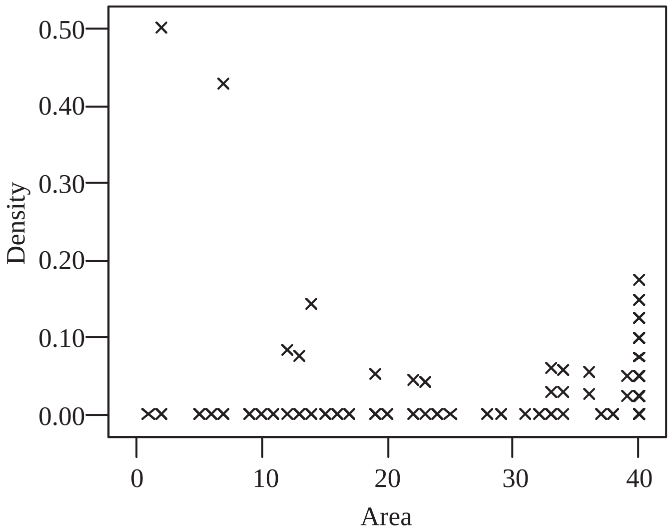


**Fig. 1.** Scatter plot showing residual values of artefact density relative to the surface area of individual collection units.

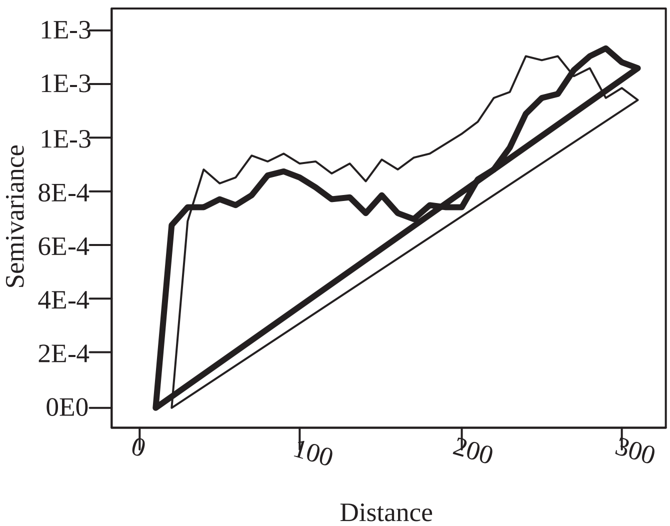


**Fig. 2.** Semivariogram showing the variation in artefact density along transects (normal) and between collection units (bold)

## 6. Spatial Patterning

Each cell within the interpolated grid has a z-value corresponding to the artefact density. The z-values have a log normal distribution (Fig. 3). Whilst collection units that yielded no worked flint were included in the interpolated grid, cells with zero artefacts per metre square were replaced with null values in order to allow the logarithmic transformation of z-values.

At one standard deviation above the mean two clusters of artefacts were identified within the lithic artefact scatter, the first to the west of the source of the Gypsey Race, the second just to the east and extending beyond the limits of the survey area (Fig. 4). Both clusters are nucleated perhaps suggesting middening associated with domestic or industrial activity.

Localised areas of higher artefact density can be identified within each of these clusters. Furthermore, lower density concentrations of artefacts can be identified elsewhere within the study area, most notably a group forming an arc to the west of the first cluster. What do the clusters of artefacts represent?

It is not possible to make a simple distinction between locales associated with flint knapping (debitage producing) and those associated with other activities (modified pieces). Despite marked spatial differentiation, there is little or no differentiation in the ratio of debitage (primary/secondary /tertiary flakes, angular shatter and cores) to modified pieces (arrowheads, scrapers and other retouched pieces) between the artefact clusters and the background scatter (Fig. 5).

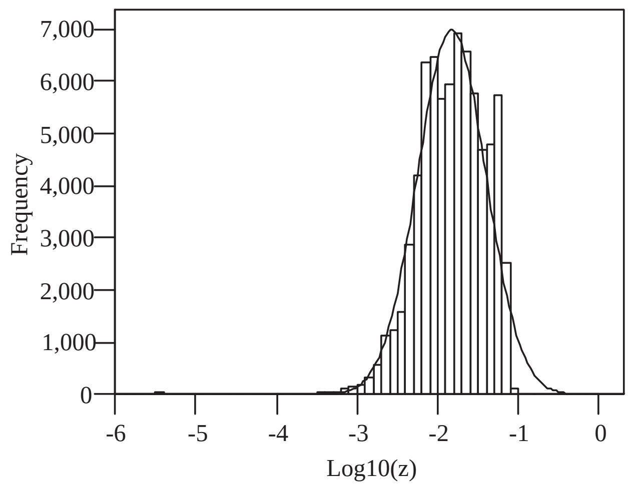


**Fig. 3.** Histogram showing frequency of logged z values with normal curve (mean = -1.8280 standard deviation = 0.4245)

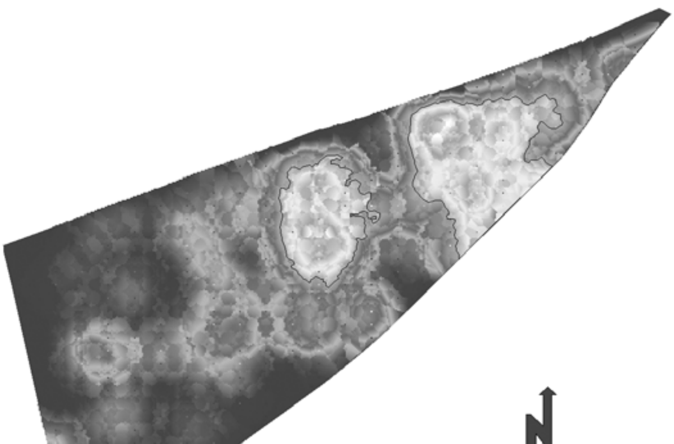


**Fig. 4.** Continuous surface showing variation in artefact density across survey area. The solid lines indicate artefact clusters

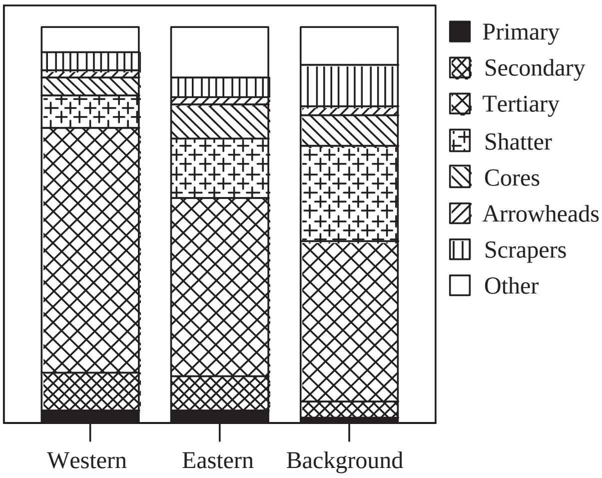


**Fig. 5.** Stacked bar charts showing relative proportions of lithic debitage and modified pieces in relation to artefact clusters

Consideration of the relative proportions of individual classes of lithic debitage also indicates little differentiation between the artefact clusters and the background scatter. The western cluster was associated with a slightly higher proportion of tertiary flakes – possibly indicating later stages in the reduction sequence. In contrast, the background scatter yielded a slightly higher proportion of angular shatter – perhaps indicating less concern for the controlled knapping of flint.

The low overall frequency of primary and secondary flakes is not unsurprising given the distance of the site from the Holderness coast where the majority of the flint would have been procured. These classes of debitage are often associated with the testing of raw materials and the roughing out of blanks or cores- activities that would have typically taken place closer to the coastline rather than on site.

The distribution of arrowheads is relatively uniform across the site. A slightly higher proportion of scrapers was noted in the background scatter than either of the artefact clusters. Scrapers are often regarded as a utilitarian tool, however there are insufficient modified pieces to attempt to identify the locus of domestic activity. This picture is further confused when the temporal depth of material represented within each of the clusters is considered.

## 7. Temporal Depth

Diagnostic artefacts and core working traditions represented within the lithic assemblage suggest at least two phases of activity. Late Mesolithic and Early Neolithic activity is characterised by the manufacture of blades struck from carefully prepared and maintained cores. Later Neolithic and Bronze Age activity is indicated by the proliferation of predetermined forms and the appearance of discoidal and polyhedral cores.

Mesolithic and Early Neolithic activity is strongly represented in both clusters of artefacts (Fig. 6). The proportion of Mesolithic artefacts in both artefact clusters is much greater than that for the backgrounds scatter. A strong Early Neolithic component was also noted within the eastern artefact cluster, however the proportion of Early Neolithic artefacts within the western cluster was much lower.

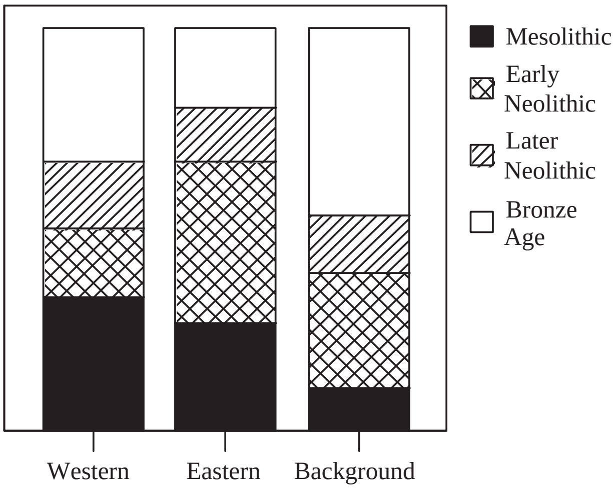


**Fig. 6.** Stacked bar charts showing relative proportions of chronologically diagnostic material in relation to artefact clusters.

Subsequently, during the Later Neolithic there is little or no differentiation between the background scatter and the two clusters of artefacts. The relative proportion of chronologically diagnostic artefacts in the background scatter increases dramatically during the Bronze Age, possibly suggesting more widespread activity.

The problems in identifying different phases of activity from assemblages of surface artefacts have been highlighted with reference to pottery collected during the course of the Ager Tarraconensis project (Millett 1999). Phasing is often highly reductive and the frequency of diagnostic typically falls within range of the background scatter (Gillings and Sbonias 1999).

Only 15% of the pieces of worked flint could be assigned to a particular chronological period. Given the low incidence of diagnostic artefacts, it is not possible to generate a continuous interpolated surface for each chronological period. Instead it is necessary to model the geographic locus of activity using weighted distances.

## 8. Location Profiling

Location profiling is a grid-based spatial modelling technique used to identify geographic centres of activity from a series of known points. The average distance to all points within a given search radius is calculated for each cell within the grid. Points can be weighted to reflect their significance.

The lowest average weighted distances correspond to centres of activity.

Although commonly used to determine optimal store locations, it is ideally suited to modelling the spatial structure of surface artefact scatters. The technique can be used to identify the geographic centres of activity represented by the distribution different classes of artefact using weighted values attached to the centroid of each collection unit.

Location profiles were generated for each chronological period. In each instance, all collection units where worked flint was recovered were assumed to be of equal significance, i.e. were assigned the same weight. Collection units where chronologically diagnostic artefacts were recovered have greater significance and were accorded greater weighting. The resultant grids were used to generate contour plots at 2 m intervals.

The isoline plot of Mesolithic activity (Fig. 7) indicates two loci of activity, both of which correspond to the artefact clusters identified above and are thought to be indicative of middening. Pronounced distortion is noted where a single point lies close to the edge of the survey area.

Densely packed contours around these points indicate a pronounced drop-off possibly an edge effect associated with fewer sample points.

Both loci persist in the isoline plot of Early Neolithic activity (Fig. 8). A third locus of activity can also be identified, further

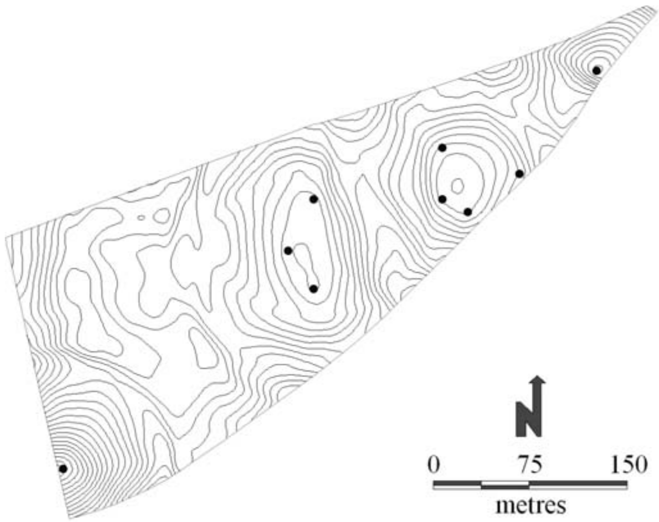


**Fig. 7.** Contour plot showing locus of Mesolithic activity in relation to associated chronologically diagnostic artefacts.

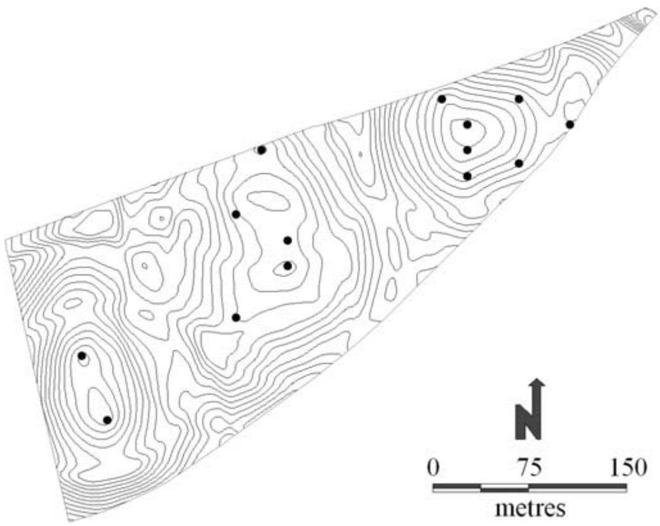


**Fig. 8.** Contour plot showing locus of Early Neolithic activity in relation to associated chronologically diagnostic artefacts.

to the west, in an area of lower overall artefact density equated with the background scatter. Comparison of the two plots suggests a subtle differentiation in the geographic centre of activity in the vicinity of the eastern cluster between the two chronological periods with Mesolithic activity top the south and Early Neolithic activity to the north.

The isoline plot for the Later Neolithic (Fig. 10) reveals a markedly different pattern of activity.

All of the chronologically diagnostic artefacts are derived from collection units that lie on a linear axis aligned from NNE to SSW. This axis coincides with the projected alignment of a cropmark identified to the east of the survey area. The linear distribution of the Later Neolithic artefacts has produced a pronounced ripple effect.

The linear trend persists in the isoline plot of Bronze Age activity with approximately one third of the chronologically diagnostic artefact derived from collection units that lie on the axis. The distribution of Bronze Age artefacts, however, appears to be more dispersed with a series of smaller foci of activity, each of which corresponds to areas of lower artefact density equated with the background scatter.

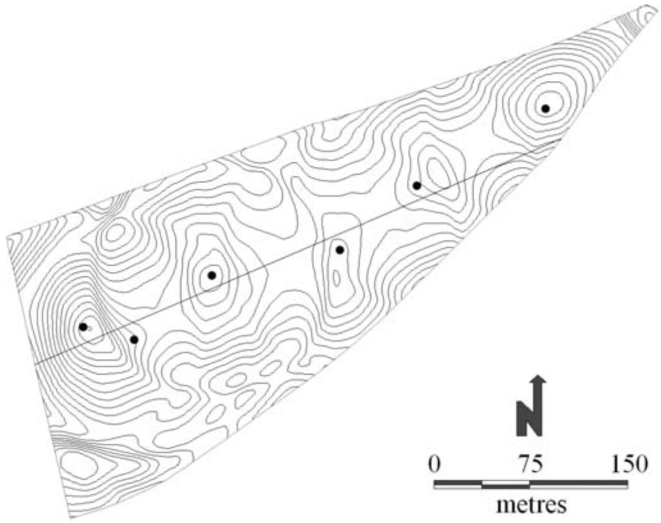


**Fig. 9.** Contour plot showing locus of Later Neolithic activity in relation to associated chronologically diagnostic artefacts.

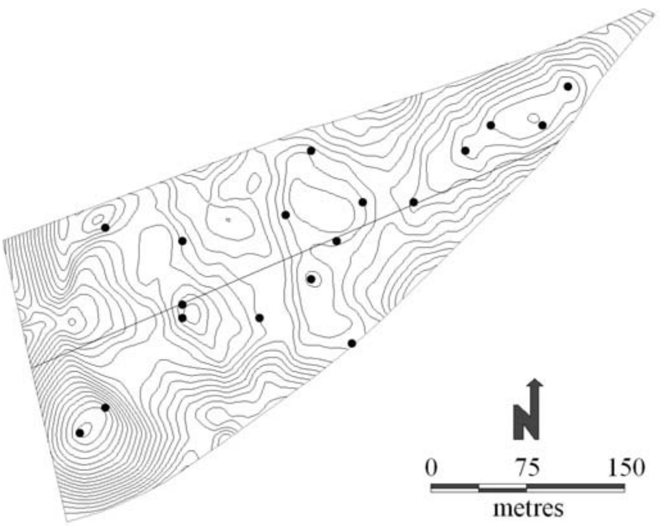


**Fig. 10.** Contour plot showing locus of Bronze Age activity in relation to associated chronologically diagnostic artefacts.

## 9. Conclusion

Although discrete clustering was identified within the lithic artefact scatter from Wharram-le-Street, clusters of artefacts cannot be directly correlated with the patterns of activity suggested by the distribution of chronologically diagnostic artefacts. Spatial modelling of the distribution of artefacts would appear to suggest that the lithic scatter is the product of at least two phases of activity. However, detailed technological analysis is required in order to substantiate the apparent differentiation between the associated patterns of discard.

Comparison of material from surface artefact scatters with lithic assemblages from excavated contexts will allow the introduction of a greater degree of chronological resolution. Recent discussion of surface artefact survey has highlighted the need to develop theoretically informed methodologies, with contextual approaches being advocated in response to perceived inadequacies in off-site analysis. The concept of chaînes opératoires, for example, could be employed in order to enable the reconstruction of taskscapes through consideration of the spatial organisation of different stone working traditions.

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