2. Invisible Individuals, Visible Groups: On the evidence for individuals and groups at the Lower Palaeolithic site of Caddington, Bedfordshire, UK

Frederick W.F. Foulds

Abstract

An emphasis on socially orientated approaches to studying the Palaeolithic has become commonplace. As a result, a “bottom up” approach to interpreting the material record has developed, which emphasises the individual as the appropriate analytical unit. However, this often reduces discussion to “theoretical storytelling”, and there is currently no suitable methodology in place to enable the hypotheses brought about by such discourse to be adequately tested. This paper presents research designed to investigate whether the individual is truly a viable unit of analysis within the Lower Palaeolithic. Using an innovative form of analysis centred around the study of flake scar patterning on Acheulean handaxes, the possibilities of tracing individual knappers through Lower Palaeolithic tools from the site of Caddington, Bedfordshire, are explored. The results indicate that a suite of factors collaborate to continually redefine lithic reduction, resulting in any idiosyncrasies present being subsumed within a flexible approach to stone tool manufacture. However, the possibilities of variable group traditions are detected. The implications of this bring into question our ability to produce meaningful dialogues regarding the study of individuals and emphasises that we still do not fully understand how the group influenced Palaeolithic society.

Introduction

The past two decades have seen a flourish in the use of social theory to better understand the Palaeolithic (e.g. Dobres 2000; Gamble 2007; Gamble & Gittins 2004; papers in Gamble & Porr 2005; Gravina 2004). Such works aim to shift our analytical perspective, promote the individual[1] as the base unit of analysis and advocate an understanding of the material record in terms of the social relationships that it forges and maintains. This agenda leaves behind the traditional approach of the group, replacing our top-down analysis with one that attempts to form an understanding from the bottom up (Gamble 2007; Gamble & Gittins 2004). Our goal now is to understand how hominins constructed their identities, sustained their relationships, and established themselves within their societies. To do so, it has been suggested that we must fathom the actions of hominins as a means to understand the way they formulated their relationships. It is possible that the traces of such actions can be detected within the material record, which embodies the manner in which hominin agents engaged with the world around them (Ingold 1993).

This approach to understanding the Palaeolithic is not without criticism. The study of the individual in its current state can be considered nothing more than a new rhetorical device that is unfortunately unable to move beyond 'theoretical storytelling' (Hopkinson & White 2005; Pettitt & White 2012; White 2008). The resolution of the record and issues of time depth are also used to argue that studying individual hominins is potentially impossible (Clark 1992). Some have attempted to bypass such difficulties by relying upon the *concept* and *idea* of the individual (such as Mithen 1993), arguing that we do not need to trace specific individuals *per se*, but should instead focus on recognising actions and agency that can be attributed to individuals (Dobres 2000; c.f. Redman 1977). However, others have warned that this will only lead to the construction of axiomatic supra-individuals, the agency of which can only truly be validated, and thus the socially orientated theories on which they rest confirmed, through the analysis of the *observed* individual (Pettitt & White 2012, 161). As a result, we should consider the possibilities of attempting to trace *actual* individuals within the material record to evaluate and substantiate our theories.

The British Lower Palaeolithic and the Individual

The question that now arises is how one actually traces an individual within the Acheulean record. While several studies address the Palaeolithic individual (Dobres

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[1] Here it should be noted that references to the individual made within the text refer not to the Western concept of a bounded self. Instead this is a reference to an individual agent within a wider society founded on the social relationships that they both create and maintain, irrespective of how they conceived of themselves.

2000; papers in Gamble & Porr 2005; Gravina 2004; Grimm 2000; Pigeot 1990; Schlanger 1990, 1994), few relate to the Lower Palaeolithic and even less discuss methods for tracing individual actors (though see Foulds 2010). Therefore, what can Lower Palaeolithic material culture reveal about hominin individuals and their sociality, given its arguably 'monotonous' technological diversity spread over an extensive geographical and temporal range (Isaac 1972, 1976)?

The British record presents one possible avenue of inquiry. Several British Lower Palaeolithic sites contain tools that display idiosyncrasies outside of usual variation or appear to be the work of individual hominins (Ashton & White 2003; Bradley & Sampson 1978; Pope *et al.* 2006; Porr 2005; White & Plunkett 2004). Caddington, Bedfordshire, is one such site. Situated at the northeastern end of the Chiltern Hills, ~4km west of Luton, it is part of a series of Acheulean sites discovered by Worthington G. Smith in the late nineteenth century (Sampson 1978b; Smith 1889, 1894, 1916). The site itself is composed of tools and debitagé recovered from seven brickearth pits (Figure 2.1), which produced both *in situ* material, as well as 'ocherous' artefacts from what Smith (1894) termed 'contorted drift', representing derived material of currently unknown origin (Bradley & Sampson 1978, 139). Bradley and Sampson (1978) have suggested that four of the handaxes from the Cottages Site (Pit C) are the work of a single individual (Figure 2.2). This, coupled with the *in situ* nature of much of the material and Smith's meticulous record keeping (Campbell & Sampson 1978; White 1997), marks Caddington with the potential for tracing individuals within the Lower Palaeolithic record. This would, if successful, not only allow us to test our theoretical assertions, but further explore the variability present within the Acheulean as a whole.

To trace an individual…

The notion that actual individuals can be traced through their lithic signatures has previously been mooted several times. Gunn (1975, 1977) proposed a methodology for tracing idiosyncrasies by quantifying variation within flake scar patterns on bifacial tools. His methodology employed laser diffraction, also known as optical Fourier analysis, which has seen applications in biology (Oxnard 1973), geology (Davis & Preston 1971; Preston *et al.* 1969) and geography (McCullagh & Davis 1972). Gunn asserted that differences in the intensity of Fourier transform spectra produced by this technique could be attributed to variation in the pattern of flake scars created during tool manufacture (Figure 2.3). His method appeared to demonstrate similarities between the patterns seen within the flake scars on tools and clustered then according to their knappers. As a result, he suggested that there is enough variability in flake scar patterning to separate out some knappers, while other variables, such as skill and experience, influenced the tightness of the clusters produced.

Gunn's experiments are important, not least because they provide a quantitative method that claims to distinguish an individual's products. However, they are not without issue (see Bodu *et al.* 1990; Cross 1983). Furthermore, Gunn analysed a series of replica bifacial tools based on a common template using the same raw material and technique. In imposing these constraints much of the variability that complicates real archaeological assemblages was removed and variability was reduced to that of the individual's involved. This created a bias in the results that overemphasised its suitability for ascertaining individual knappers. Overall, therefore, Gunn's methodology has not been adequately tested, nor systematically applied to archaeological assemblages. Despite these issues, it is currently the only objective method that claims to be able to trace individuals through stone tools, and is thus explored further below.

Methodology

Gunn's methodology favoured physical over digital equipment due to issues surrounding the digitisation of light waves (Oxnard 1973, 176; see Figure 2.4). Advances in computing means this is no longer a complex process. The methodology presented in this paper revised Gunn's method by using a computer program designed to return the two-dimensional discrete Fourier transform of a digital image containing a scar pattern trace, computed using a fast Fourier transform algorithm. To implement the analysis, both sides of a handaxe were photographed and digitally traced. Each of the traces was then converted to a 500 by 500 pixel image to remove variability in size. The computer program was then used to convert each of the trace images into Fourier transform spectra and calculate intensity values across a 180º arc divided into five-degree segments. This produced data across a total of thirty-six variables, which are comparable to those produced in Gunn's analysis. Only half of the spectrum was analysed in each case, due to the fact that the spectra display rotational symmetry. The extracted data were then interrogated using principal component analysis to extract components accounting for the majority of the variance. These components were then plotted as scatter diagrams to explore the data further.

Materials

Exploring individuals in the archaeological record is, of course, fraught with difficulties, not least because we cannot make *a priori* assumptions about the identity of the individuals we are trying to trace. Therefore, to 'test' the methodology described above, a control group was created, comprising twenty-six replica handaxes created by several skilled knappers (Table 2.1). Minimal constraints were placed on this assemblage to explore whether other forms of variability, such as raw material, shape and size, have a greater signature than knapping idiosyncrasies. Knappers freely selected the tool forms they created, an approach that allowed for testing of whether a knapper's idiosyncratic technique transcends the shape of the finished product. Furthermore, this enabled the extent to which forcing knappers to conform to a set example, as Gunn did, might introduce a bias into the results.

Following the replica handaxes, the assemblages from the site of Caddington were analysed. A total of sixty-six handaxes were studied from five of the brickearth pits. Although it is not possible to ascribe every handaxe to its pit of origin (Roe 1981), an effort was made to provenance each artefact using Smith's (n.d.) 'List of Palaeolithic Implements'. Five of the artefacts studied were listed as 'no fixed provenance', indicating which cannot be traced back to a specific pit. Two of these still retained Smith's find numbers and are attributed to the initial finds from behind Dunstable Grammar School (Smith 1889; 1894, 93; n.d.). According to Smith (1894, 94), gravels were sent to Dunstable from both Pit B and C at Caddington. However, it is impossible to accurately attribute the handaxes to these pits. Therefore, no attempt was made to associate them to a specific find spot and they, along with the other unprovenanced artefacts, were not included in the analysis presented here. In addition, as the majority of sites from the Chiltern Hills are formed in solution hollows in the underlying chalk, it is possible that the pits Smith studied are in fact separate instances of Palaeolithic activity of different ages. The remaining handaxes were thus divided according to the brickearth pits from which they were recovered (Table 2.2).

No attempt has been made to differentiate between the contorted drift and Palaeolithic floor assemblages, although this has been done elsewhere (Foulds 2012).

Analysis and results

For both the experimental and archaeological sample, scar patterns from both surfaces of each handaxe were traced and processed using Fourier transform analysis. In both cases the surface data was analysed separately, as well as combined so patterning across the whole tool could be explored. Analysis was conducted in SPSS (release 17.0.0) using a combination of principal component (PCA) and hierarchical cluster analysis, the results of which were used to determine whether handaxes grouped according to the individual who created them, or other factors.

The replica assemblage

The PCA results produced five components with eigenvalues greater than 1.0 from both the surface and combined data, which explained 81.44% and 89.04% of the variance respectively (Table 2.3 to 2.6). However, the analysis of the combined data produced negative eigenvalues, probably owing to the limited number of cases (n=26) compared to the variables under study (n=36). Therefore, the results from the combined data can only be interpreted tentatively, although they show good correlation with those from the surface data.

The results were plotted as scatter diagrams, using typological data based on Roe's (1968) method to differentiate shape (Figure 2.5 and 2.6). These display a clear division of the handaxes based on outline morphology, especially where component one and two are concerned, suggesting that these simply highlight the *overall shape* of the handaxes. It is also notable that ovates remain tightly clustered compared to points, suggesting greater variation within the scar patterns on pointed tools. Additionally, while clustering of opposing surfaces from the same tool is not prevalent, this is more common amongst ovates, indicating a higher degree of similarity in scar patterning across both faces. However, the majority of handaxes show little clustering of associated surfaces. This demonstrates differences in the progression of the thinning strategy applied to each face. It is also noted that points often display dominance of a particular line orientation within their scar pattern. It is possible that this is caused by differences in the knapping strategy applied (Figure

2.7). Ovate tools are often produced using a circumferential reduction strategy, resulting in a greater variation in flake scar orientation. Extensive thinning also increases the number of flake scars present. As a result a greater combination of line orientations is seen within the scar patterns. Pointed tools, on the other hand, display high levels of thinning to the tip, while the butt shows limited flaking. This results in lower variability of line orientation due to the limited number of removals. This may lead to one orientation dominating. If this is correct, then the desired form of a handaxe will, to a certain extent, dictate the scar pattern present on finished tools and explain why these results strongly correlate with shape.

Cluster analysis of the PCA results from the combined data was used to test whether handaxes grouped according to the knappers who produced them. When compared to the typological information, it is clear that the suggested groupings are primarily based on shape and are highly reliant on components one and two (Figure 2.8). It is unlikely that cluster analysis is able to attribute tools to their creators, although tools made by Knapper 1 and Knapper 2 do cluster to a certain extent, especially with regard to component four and five (see Figure 2.9). While this does not immediately differentiate these handaxes from the rest of the assemblage, it suggests conformity to a specific shape and pattern of reduction that is not readily apparent amongst the other knappers. However, these individuals contributed the majority of the handaxes in the assemblage. Therefore, it is possible that a bias in the construction of the assemblage prevents patterning being seen amongst the other knappers due to the fact that they contributed fewer tools.

Overall, the analysis of the replica assemblage indicates that variation within and between scar patterns is complex and that the majority of the variance relates to differences in shape. The results also demonstrate the inability of the technique to trace significant idiosyncratic patterning within flake scars. The reasons for this are suggested to be the heavy influence of shape in governing and restricting flake scar morphology and, by extension, the reduction techniques used. While it is understood that each individual will contribute to the total variation according to the choices they make, it appears that these choices are not so much reflections of the individual's abilities, *per se*. Rather they are flexible responses to producing a desired end product. However, the fact that Knapper 1's tools show a high degree of similarity suggests that preference for a specific shape and, by extension, a learned reduction strategy may delineate the final form of some tools.

The Caddington assemblage

Despite the failure to attribute replica handaxes to their knappers, it is important to highlight both similarities and differences between the replica and archaeological material through the analysis of the Caddington assemblage. However, as the hierarchical cluster analysis was unable to group tools according to their knappers, this technique was not applied.

The PCA extracted just two components with eigenvalues greater than 1.0 from the surface data (Table 2.7 and 2.8), and only a single component from the combined data (Table 2.9 and 2.10). These results explain 91.85% and 92.64% of the variance in each sample respectively. To enable further analysis of the combined data, a second component with an eigenvalue approaching one was extracted, which compares well with the results from the surface data. The results indicate a much lower level of complexity compared to the replica assemblage. The reason for this may be due to the limited restraints placed on the replica assemblage, resulting in greater sources of variation being present, such as raw material choices, knapping strategy selection, and the potential that some may have deliberately changed their approach to provide a range of tool morphologies. In contrast, the hominins at Caddington relied on locally available flint and, as will be discussed further, possibly conformed to socially mediated knapping strategies.

The results were used to produce scatter diagrams, using typological and contextual data to differentiate the handaxes (Figures 2.10 and 2.11). The results from the surface analysis show that clustering of associated surfaces is not prevalent, which is comparable to the replica assemblage. However, there are some instances where this does occur and it is worth noting that two of these are suggested to be the product of the same hand by Bradley and Sampson (1978). While this is possible, there is not enough evidence to support this supposition and the similarities between these handaxes are not as distinct as other notable handaxe pairs in Britain, such as those from Foxhall Road (White & Plunkett 2004).

The scatter diagrams also display limited separation of the tools according to their shape, although there is some separation according to different pits. Most interesting is the separation of Pit A, C and G handaxes from those attributed to Pits E and F. However, the overlap seen suggests that differences based on find location are not the only explanation for this pattern. Further analysis suggests some degree of separation is dictated by differences in raw material selection, primarily in terms of nodule size. The assemblage displays a range of nodule types, including smaller tabular blanks and rounded pebbles, large tabular nodules, and sub-spheroids. These will almost certainly have affected the choice of reduction strategy (Ashton & McNabb 1994; White 1998a), with smaller nodule size limiting the flaking intensity applied. However, other factors could potentially include differences in skill and contrasts between tools from the Palaeolithic floor and contorted drift.

Discussion

The results presented above clearly demonstrate that Gunn's methodology is unable to correctly differentiate Acheulean handaxes according to their knappers in assemblages where variability extends beyond idiosyncrasies introduced by the individual's hand. Instead, a range of factors force knappers to adopt flexible strategies to lithic reduction. In terms of the replica assemblage, handaxe shape appears to be the primary factor that conditions scar patterning. At Caddington nodule size and variation between the brickearth pits provides a more prominent explanation. The lack of clustering seen between associated handaxe surfaces in both assemblages also demonstrates that both sides of the same tool are often dissimilar. This emphasises the presence of fluidity in the approach to manufacture, thinning and shaping of tools. As a result, knappers modify their strategies in response to a variety of factors to obtain a satisfactory end result, which has clearly resulted in divergent scar patterns. However, some clustering of tools related to specific individuals was noted, such as those produced by Knapper 1. These tend to be similar in size, form and flaking, suggesting that handaxes produced by a single individual that are morphologically similar can be grouped together. This may support Bradley and Sampson's (1978) notion that some of the handaxes from Caddington are related to a single individual, given that these cluster closely in the scatter diagrams, though this cannot be unequivocally proven. This hints that the analysis of individuals within the Palaeolithic may be possible, though only in isolated and limited circumstances.

The fact that the handaxes from Caddington appear to cluster according to the brickearth pit that they were recovered from that is the most intriguing of all the results. Significant differences in raw material size and type do not seem to be the cause of this, nor does variation in knapping skill. As a result, it is possible that there is a subtle distinction in the way that handaxe manufacture was conducted at Pit E and F, compared to Pits A, C and G. This potentially suggests the presence of different shared, socially mediated templates for the manufacture of handaxes (cf. Pettitt & White 2012; White in press). It also highlights that the brickearth pits may not be contemporaneous, as Smith (1894) originally suggested. Sampson (1978b) has already expounded on this, noting that the horizons containing artefacts formed in isolated solution hollows within the chalk. Therefore, a chronological element may be present which could account for the clustering seen. This is certainly important to consider, given the difficulties in providing an accurate date to the Caddington material (Campbell & Hubbard 1978; Catt *et al.* 1978; McNabb 2007; White 1997). Interpretation is further complicated due to the mixture of *in situ* artefacts from the Palaeolithic floor with derived material within the contorted drift. As a result, the separation according to brickearth pits could be argued to result from temporal or cultural factors, or both. However, this does not deny that hominins at Pit E and F appear to have worked flint in subtly different ways. As a result, it can be emphatically stated that the artefacts from Caddington can no longer be treated as a *whole* and must be considered as *separate* assemblages.

The suggestion that differences in socially mediated knapping strategies can be detected stands in contrast to the seemingly continuous variation seen at the inter-site level within the Acheulean. It is suggested that, given limited differences in the flint available between the Caddington brickearth pits, the differences in scar patterning seen, and by extension the method of reduction used, may have been detected due to the fact that hominins were utilising relatively similar raw material sources. Therefore, while group templates may be present, time averaging and the properties of the flint selected for reduction tend to conceal them. In other words, this appears to be Isaac's (1972) random drift model writ large.

This has immediate resonance for the study of the hominin individual. It appears that any method of reduction that has been socially defined is only detectable at sites that have been extensively used by different groups of hominins with access to similar raw material sources. At the inter-site level, flexible mental templates were constantly being redefined by differences in locally available raw material. This forced hominins to adapt any predefined knapping strategy in order to achieve their goals. Thus, we would expect to see regular drift within reduction modes due to the suggested mobility of hominins as they traversed between nodal points within their localised landscapes of habitat (Gamble 1999), as well as the general passage of time. Such an interpretation has strong implications for how we view local variability and the wider patterning in the Acheulean.

In terms of the British record, White (1998a, b) has noticed characteristics within handaxe manufacture that cannot be explained by extra-somatic factors and may be linked to cultural variation. Some of these may be due to the Palaeolithic settlement of Britain, which is represented by colonisation and extirpation events that correspond to the presence/absence of the land bridge that links to the rest of Europe (Ashton & Lewis 2002; Pettitt & White 2012; White & Schreve 2000). Given that Britain is therefore a population sink, characteristics linked to potential cultural variation may have been introduced by colonising groups, as well as spread through inter-group networks and localised operational areas (Pettitt & White 2012; White & Pettitt 2011). A primary example is found in the twisted ovate phenomenon (White 1998b), attributed to MIS 11/10, which displays temporal clustering of artefacts, despite limited evidence of spatial clustering (White & Schreve 2000). It is possible that this technique was common amongst early colonisers and insularity helped sustain this technique, though earlier assemblages from Swanscombe and Hoxne where twisted forms are rare argues against this. It is also possible that the twisted form was an underused variant, which then proliferated with the isolation of Britain from the continental mainland.

White also sees further patterning that may be due to the nature in which Britain was colonised (Pettitt & White 2012; White pers. comm.). Using Roe's (1968) handaxes groups, which initially display no evidence of patterning based on broad differences between pointed and ovate forms, finer scale variation within the sub-groups can be linked to chronological patterns based on date ranges from sites with recent age correlations from biostratigraphic, lithostratigraphic and absolute dating. If White is correct and this patterning is real, then this may be a step towards explaining why strong traditions appear within intra-regional studies of the British record (e.g. Mithen 1994), as opposed to elsewhere. However, the apparent conservatism within the Acheulean suggests that this industry involved strong rules, with variation amounting to constant changes to an overarching formula governed by social guidelines. Individuals may have been able to express themselves through tool manufacture, inserting the variability that is present within the archaeological record, but did not have the capacity to invoke lasting change to the parameters that governed the techniques used (Hopkinson & White 2005).

The evidence from the analysis presented here would seem to support this view, with the added caveat that such variation may stem from changes in group structure. This would also be a potential explanation for the presence of local variations, such as the twisted ovate (White 1998b; White & Schreve 2000). On a wider scale, the phylogenetic drift seen within the global patterning of the Acheulean (Lycett 2009) may also be linked to concepts of group movements and the social transmission of learned behaviour. However, utilisation of localised resources, proved by raw material studies, suggests hominins had to overcome raw material constraints relative to the locally available resources in order to meet a set of required needs. In addition, it is possible that the limited range of options available to hominins, combined with the requirement to meet specific needs, would have limited the range of forms that could be selected from, thus restricting the development of individual or group styles. As Nowell and White (2010) have postulated, the locality of social life and low group membership within the Lower Palaeolithic would have limited the wide ranging transmission of innovations, thus leading to isolated and short lived instances of highly variable behaviour being transmitted, probably learnt through a many-to-one process (Lycett & Gowlett 2008), which subsequently vanished as groups became extinct.

Overall, therefore, we do not see different socially mediated modes of reduction, but rather detect contrasts in the materials that were utilised at localised nodal points within short ranging landscapes of habit. Subsumed within this are individuals themselves, whose actions appear to be guided by society, but must mitigate the limitations of raw material in the manufacture of a useable end product. Therefore, the variability of the Acheulean is considered to be the result of individual action, which is mediated by society and adapted to the nature of the lithic material chosen for reduction. In many ways, we can draw parallels between these concepts and the social behaviour seen in our societies today. However, as McNabb (2007) notes, we cannot conceive of Lower Palaeolithic hominins being the same as us. While it is tempting to try and compare modern social behaviour to that of *Homo heidelburgensis,* it is important not to fall readily into this trap. As yet, it appears that the interplay between the factors that were instrumental in determining hominin behaviour are not fully understood. If our goal is to produce a meaningful analysis that is orientated from the bottom up, then further work is needed to tease these elements apart in the hope that they can be better understood.

Conclusions

This paper has attempted to trace individuals via the analysis of flake scar patterning, using a methodology based on Gunn's (1975) experiments. The results of this analysis have shown that the handaxes under study do no cluster according to the individual who created then, contra to what Gunn originally claimed. This emphasises a bias in Gunn's original sample of bifaces, which was controlled in such a way as to maximise the individual's contribution to the variance. Instead, it is the size of the raw material and shape of the finished tool that appear to influence any patterning in flake scars. However, clustering of handaxes from the Acheulean site of Caddington displays separation of the archaeological material based on the brickearth pits it was recovered from. This suggests that some of the variance can potentially be explained by differences in the approach to reduction used by hominins at these pits, though the lack of strong chronological constraints and the issues of separating the material from the Palaeolithic floor and contorted drift prevent the author from determining whether changes to the scar patterning result from contemporary or temporally displaced groups. Given the chronological patterning suggested by White (in press), it is more likely that the latter of these is correct. This then emphasises the fact that artefacts from Caddington are *not* a single assemblage and should not be treated as such. Instead, they present a series of potentially chronologically displaced exploitation events around solution holes formed within the local chalk bedrock, during which hominins manufactured tools guided by their desires and the limitations of the raw materials, as well as some form of socially mediated or learnt tradition.

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Figure 2.1. A map of the Caddington brickearth pits that Smith recovered Palaeolithic material. The seventh pit (G) is not shown, but Smith (1894) suggests it was southwest of Dunstable.

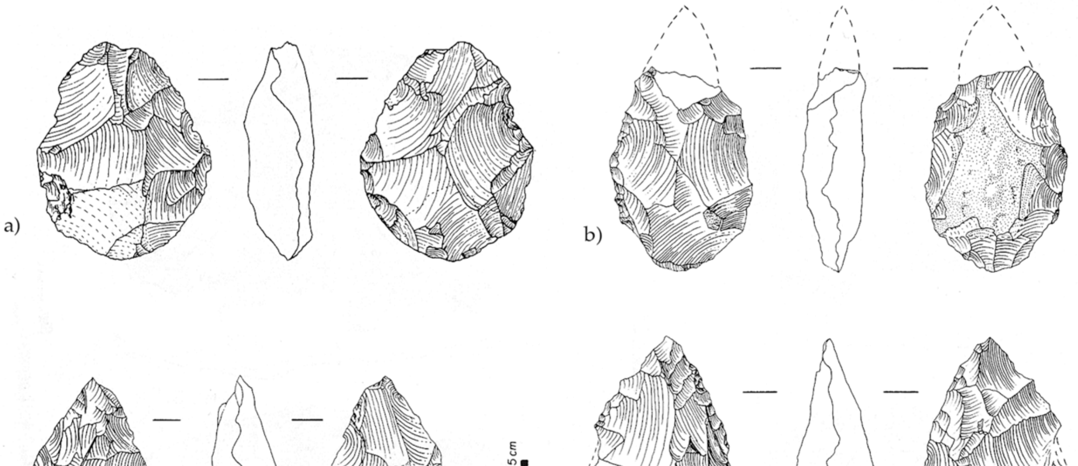


Figure 2.2. Handaxes from Caddington that have been suggested to be the product on the same knapper: a) #1416; b) #1468; c) #1419; d) #1417. Artefact numbers given are after W.G. Smith. Image modified after Sampson (1978a, Figure 7.3) (I am grateful to both C. Garth Sampson and Bruce Bradley for their permission to reproduce this figure).

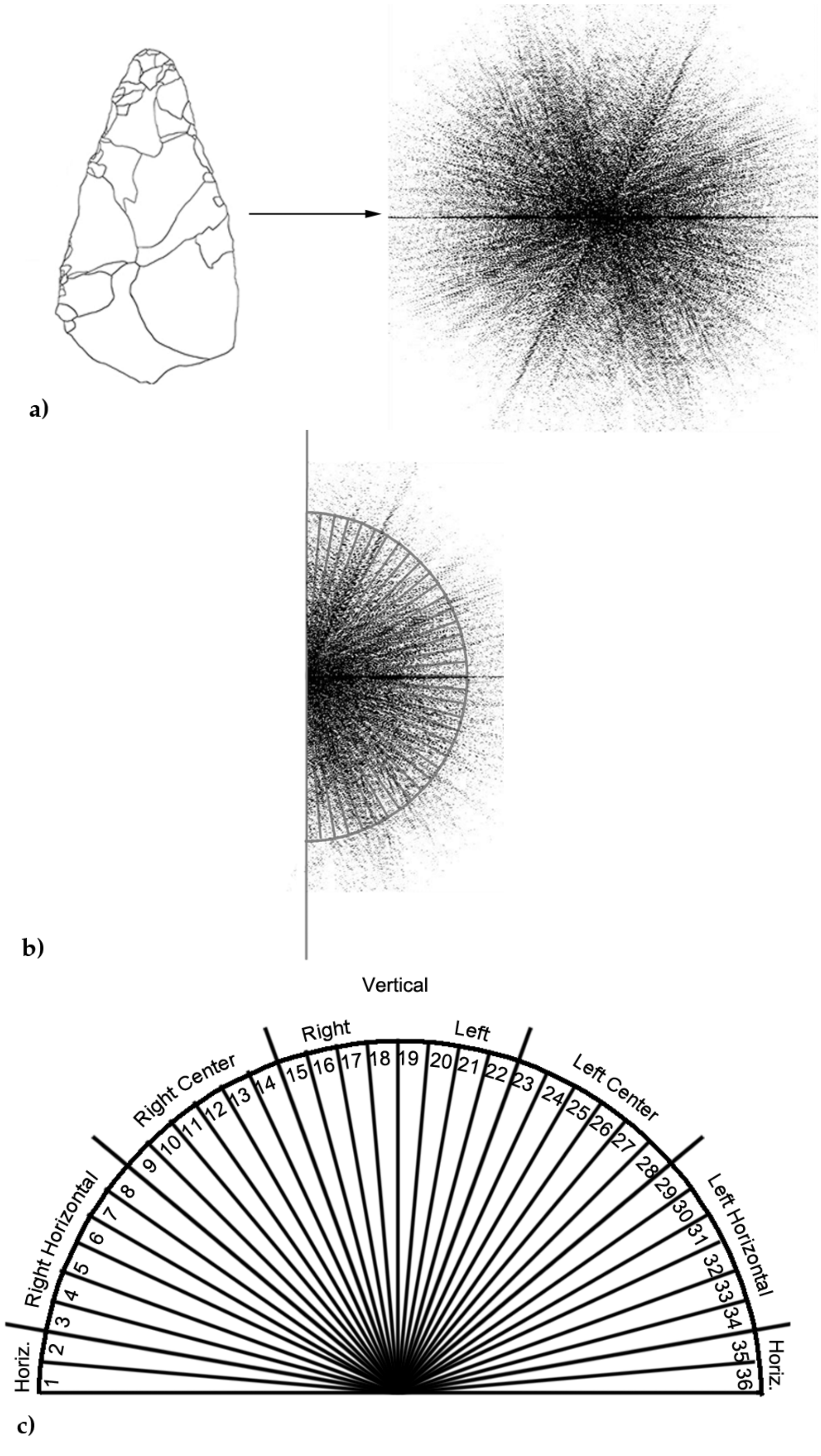


Figure 2.3. Example of the recording system used during the Fourier transform analysis: a) the scar pattern (left) is converted to a Fourier transform spectrum; b) intensity values are calculated for each 5º segment between 0º and 180º, producing thirty-six variables. The full spectrum is not analysed, given its rotational symmetry; c) the thirty-six variables correlate to the orientation of lines in the scar pattern.

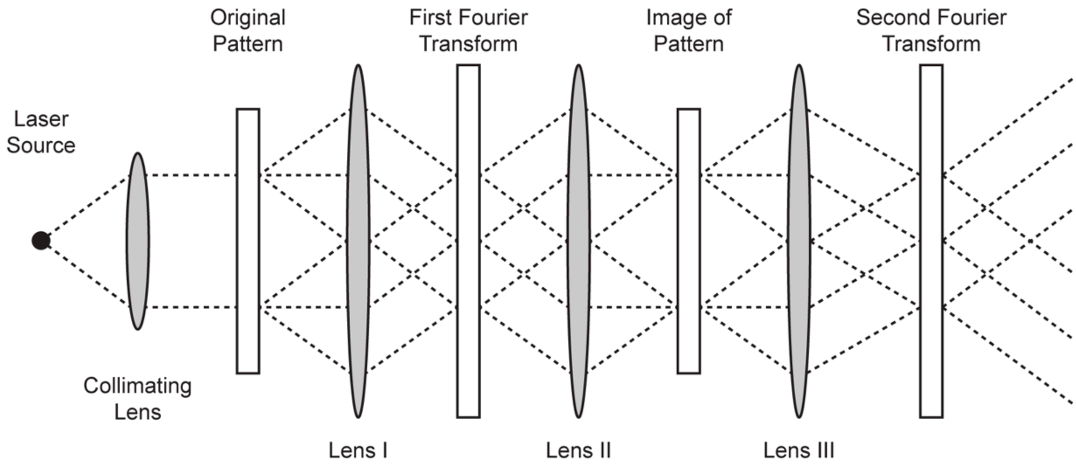


Figure 2.4. Example of the equipment setup used by Gunn (redrawn after Oxnard 1973, Figure 114). Laser light passes through the original pattern (in this case a photonegative of a scar pattern trace), followed by a series of lens and Fourier transforms, before the simplified waveform is analysed.

Handaxe No.	Knapper	B/L	B1/B2	L1/L	Roe's Shape
1	1	0.773	0.727	0.409	Ovate
2	1	0.740	0.857	0.457	Ovate
3	2	0.500	0.569	0.236	Point
4	3	0.524	0.979	0.507	Ovate
5	2	0.688	0.806	0.421	Ovate
6	2	0.574	0.483	0.195	Point
7	4	0.473	0.954	0.433	Ovate
8	1	0.793	0.805	0.359	Ovate
9	5	0.707	0.702	0.309	Point
10	1	0.600	0.966	0.354	Ovate
11	2	0.506	0.655	0.317	Point
12	2	0.677	0.925	0.440	Ovate
13	6	0.749	0.952	0.385	Ovate
14	4	0.722	0.799	0.385	Ovate
15	1	0.689	0.978	0.432	Ovate
16	4	0.625	0.567	0.308	Point
17	5	0.529	0.751	0.311	Point
18	2	0.648	0.927	0.380	Ovate
19	5	0.623	0.618	0.340	Point
20	1	0.833	0.952	0.415	Ovate
21	4	0.698	0.839	0.436	Ovate
22	4	0.721	0.785	0.467	Ovate
23	1	0.621	0.564	0.269	Point
24	2	0.686	0.790	0.305	Point
25	4	0.635	0.830	0.431	Ovate
26	1	0.561	0.556	0.279	Point

Table 2.1. List of replica assemblage handaxes, including measurements and typological data based on Roe (1968).

Handaxe No.	Pit	B/L	B1/B2	L1/L	Roe Shape
1398	A	0.548	0.686	0.281	Point
1400	F	0.755	0.880	0.379	Ovate
1416	C	0.823	0.906	0.469	Ovate
1417	C	0.494	0.726	0.426	Ovate
1418	C	0.613	0.991	0.412	Ovate
1419	C	0.561	0.924	0.361	Ovate
1421	A	0.711	0.806	0.568	Ovate
1428	C	0.617	0.702	0.469	Ovate
1431	C	0.734	0.799	0.396	Ovate
1439	C	0.703	0.917	0.443	Ovate
1440	A	0.563	0.518	0.160	Point
1441	A	0.654	0.842	0.483	Ovate
1454	C	0.679	0.990	0.620	Ovate
1468	C	0.686	1.275	0.422	Ovate
1478	A	0.868	0.744	0.420	Ovate
1496	C	0.542	0.718	0.356	Ovate
1514	C	0.671	0.716	0.396	Ovate
1515	C	0.687	0.626	0.331	Point
1531	A	0.512	0.643	0.269	Point
1532	A	0.686	0.568	0.428	Ovate
1537	A	0.689	0.675	0.365	Ovate
1545	A	0.472	1.332	0.574	Ovate
1555	A	0.651	0.589	0.248	Point
1562	C	0.652	0.679	0.375	Ovate
1563	A	0.699	0.842	0.453	Ovate
1571	C	0.518	1.161	0.543	Ovate
1583	A	0.815	1.031	0.472	Ovate
1598	A	0.701	0.794	0.442	Ovate
1599	A	0.702	1.104	0.605	Ovate
1602	E	0.720	0.744	0.452	Ovate
1614	E	0.641	0.525	0.273	Point
1615	F	0.640	0.900	0.431	Ovate
1616	E	0.518	0.857	0.305	Point
1619	E	0.758	0.921	0.439	Ovate
1637	E	0.559	0.493	0.265	Point
1639	E	0.797	0.608	0.375	Ovate
1643	C	0.758	0.726	0.383	Ovate
1647	C	0.619	0.865	0.274	Point
1648	C	0.736	0.775	0.529	Ovate
1655	C	0.770	0.726	0.378	Ovate
1659	C	0.741	0.906	0.473	Ovate
1661	F	0.656	1.008	0.458	Ovate
1688	C	0.730	0.393	0.263	Point
1697	C	0.571	0.664	0.354	Ovate
1705	C	0.704	0.878	0.443	Ovate
1706	C	0.648	0.864	0.438	Ovate
1709	F	0.717	0.631	0.407	Ovate
1713	F	0.594	1.051	0.373	Ovate
1715	G	0.624	0.653	0.380	Ovate
1718	G	0.691	0.795	0.382	Ovate
1719	G	0.599	0.884	0.462	Ovate
1722	F	0.784	0.938	0.584	Ovate
1723	C	0.667	0.774	0.360	Ovate
1724	C	0.639	0.652	0.284	Point
1725	C	0.624	0.559	0.239	Point
1726	F	0.850	0.899	0.507	Ovate

1727	C	0.554	0.785	0.368	Ovate
1729	C	0.852	0.647	0.301	Point
1731	C	0.560	1.102	0.547	Ovate
1732	C	0.711	0.554	0.198	Point
1740	E	0.753	0.508	0.312	Point
1766	A	0.621	0.826	0.275	Point

Table 2.2. List of handaxes from the Caddington assemblages, including the pits from which they were recovered from, as well as typological information based on Roe (1968).

Total Variance Explained						
Component	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***		
	Total	***% of Variance***	***Cumulative %***	***Total***	***% of Variance***	***Cumulative %***
1	17.113	47.536	47.536	17.113	47.536	47.536
2	4.797	13.324	60.86	4.797	13.324	60.86
3	4.256	11.823	72.682	4.256	11.823	72.682
4	2.012	5.589	78.272	2.012	5.589	78.272
5	1.141	3.169	81.441	1.141	3.169	81.441
6	0.937	2.602	84.043			
7	0.692	1.923	85.966			
8	0.553	1.535	87.501			
9	0.545	1.513	89.014			
10	0.504	1.401	90.415			
11	0.409	1.135	91.551			
12	0.379	1.053	92.603			
13	0.344	0.955	93.559			
14	0.3	0.832	94.391			
15	0.24	0.666	95.056			
16	0.231	0.643	95.699			
17	0.203	0.565	96.264			
18	0.176	0.49	96.754			
19	0.172	0.478	97.232			
20	0.147	0.409	97.641			
21	0.136	0.377	98.018			
22	0.117	0.324	98.342			
23	0.098	0.273	98.615			
24	0.091	0.253	98.868			
25	0.083	0.23	99.098			
26	0.059	0.165	99.263			
27	0.051	0.141	99.404			
28	0.043	0.119	99.523			
29	0.037	0.103	99.626			
30	0.031	0.087	99.713			
31	0.029	0.08	99.793			
32	0.025	0.069	99.861			
33	0.018	0.05	99.911			
34	0.016	0.043	99.954			
35	0.013	0.035	99.989			
36	0.004	0.011	100			

Table 2.3. The results of the principal component analysis applied to the replica assemblage surface data.

	Component Matrix					
		Component				
		1	*2*	*3*	*4*	*5*
Horz.	V1	0.489	0.656	-0.305	-0.058	0.214
	V2	0.586	0.448	-0.57	-0.021	0.024
Right Horizontal	V3	0.617	0.39	-0.575	0.021	-0.115
	V4	0.655	0.295	-0.604	0.03	-0.181
	V5	0.657	0.196	-0.544	0.035	-0.281
	V6	0.729	-0.162	-0.3	0.266	-0.163
	V7	0.7	-0.317	-0.33	0.211	0.079
	V8	0.722	-0.376	-0.233	0.313	-0.037
Right Centre	V9	0.669	-0.413	-0.203	0.448	0.05
	V10	0.692	-0.418	-0.151	0.362	0.116
	V11	0.648	-0.4	-0.073	0.416	0.361
	V12	0.776	-0.265	0.099	0.155	0.308
	V13	0.734	-0.215	0.227	0.149	0.139
	V14	0.764	-0.071	0.152	0.237	-0.208
Vertical	V15	0.678	0.102	0.436	0.173	-0.185
	V16	0.668	0.253	0.437	0.105	-0.266
	V17	0.686	0.378	0.233	0.306	0.118
	V18	0.448	0.602	0.541	0.054	0.025
	V19	0.37	0.651	0.32	0.044	0.416
	V20	0.466	0.611	0.371	-0.085	0.304
	V21	0.66	0.415	0.354	0.127	-0.008
	V22	0.709	0.368	0.395	0.186	-0.133
Left Centre	V23	0.687	0.238	0.438	0.021	-0.304
	V24	0.811	-0.075	0.315	-0.129	-0.024
	V25	0.773	-0.207	0.359	-0.117	-0.233
	V26	0.833	-0.279	0.177	-0.121	-0.101
	V27	0.728	-0.295	0.306	-0.276	-0.11
	V28	0.679	-0.369	0.215	-0.496	0.117
Left Horizontal	V29	0.74	-0.402	0.166	-0.39	0.015
	V30	0.769	-0.346	0.004	-0.336	0.066
	V31	0.806	-0.318	-0.033	-0.293	0.134
	V32	0.764	-0.274	-0.098	-0.193	0.104
	V33	0.76	-0.031	-0.319	-0.258	0.006
	V34	0.781	0.131	-0.3	-0.308	0.078
Horz.	V35	0.651	0.386	-0.45	-0.166	-0.046
	V36	0.641	0.526	-0.409	-0.206	0.06

Table 2.4. The component matrix from the analysis of the replica assemblage surface data, displaying loadings for each extracted components.

Total Variance Explained

Component	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***		
	Total	***% of Variance***	***Cumulative %***	***Total***	***% of Variance***	***Cumulative %***
1	20.724	57.565	57.565	20.724	57.565	57.565
2	5.698	15.828	73.393	5.698	15.828	73.393
3	2.622	7.283	80.676	2.622	7.283	80.676
4	1.954	5.429	86.105	1.954	5.429	86.105
5	1.055	2.931	89.036	1.055	2.931	89.036
6	0.838	2.327	91.363			
7	0.547	1.519	92.882			
8	0.505	1.403	94.284			
9	0.397	1.103	95.388			
10	0.266	0.739	96.126			
11	0.236	0.656	96.783			
12	0.206	0.573	97.356			
13	0.173	0.481	97.836			
14	0.159	0.441	98.277			
15	0.125	0.348	98.625			
16	0.088	0.245	98.87			
17	0.088	0.244	99.114			
18	0.086	0.238	99.352			
19	0.076	0.21	99.562			
20	0.049	0.136	99.698			
21	0.038	0.104	99.802			
22	0.028	0.077	99.879			
23	0.027	0.075	99.955			
24	0.011	0.03	99.985			
25	0.005	0.015	100			
26	0	0	100			
27	0	0	100			
28	0	0	100			
29	0	0	100			
30	0	0	100			
31	0	0	100			
32	0	0	100			
33	0	0	100			
34	0	0	100			
35	0	0	100			
36	0	0	100			

Table 2.5. The results of the principal component analysis applied to the replica assemblage combined data.

		Component Matrix				
		Component				
		1	***2***	***3***	***4***	***5***
Horz.	V1	0.624	0.655	-0.141	0.091	0.223
	V2	0.675	0.459	-0.459	0.042	0.057
Right Horizontal	V3	0.676	0.469	-0.484	-0.041	0.001
	V4	0.782	0.411	-0.395	-0.059	-0.053
	V5	0.823	0.263	-0.224	0.096	-0.357
	V6	0.774	-0.132	-0.045	0.319	-0.379
	V7	0.766	-0.281	-0.235	0.398	-0.194
	V8	0.759	-0.419	-0.061	0.336	-0.235
Right Centre	V9	0.643	-0.533	-0.06	0.426	0.103
	V10	0.674	-0.531	-0.09	0.347	0.152
	V11	0.631	-0.524	-0.129	0.442	0.219
	V12	0.78	-0.419	0.106	0.126	0.309
	V13	0.755	-0.318	0.118	0.118	0.344
	V14	0.811	-0.096	0.21	0.123	0.044
Vertical	V15	0.775	0.033	0.455	0.102	-0.203
	V16	0.757	0.189	0.38	-0.024	-0.249
	V17	0.792	0.367	0.168	0.286	-0.006
	V18	0.541	0.621	0.456	-0.014	-0.114
	V19	0.517	0.66	0.217	0.194	0.288
	V20	0.592	0.64	0.238	0.108	0.135
	V21	0.764	0.401	0.321	0.105	0.086
	V22	0.819	0.344	0.349	-0.029	0.057
Left Centre	V23	0.776	0.194	0.464	-0.122	-0.073
	V24	0.91	-0.152	0.155	-0.15	0.093
	V25	0.8	-0.31	0.252	-0.315	-0.083
	V26	0.861	-0.322	0.06	-0.199	0.017
	V27	0.762	-0.363	0.246	-0.368	0.023
	V28	0.736	-0.415	-0.074	-0.463	0.105
Left Horizontal	V29	0.763	-0.429	0.006	-0.394	0.1
	V30	0.835	-0.353	-0.074	-0.212	-0.096
	V31	0.884	-0.302	-0.171	-0.196	-0.008
	V32	0.905	-0.205	-0.214	-0.117	-0.07
	V33	0.86	-0.03	-0.218	-0.141	-0.187
	V34	0.858	0.162	-0.286	-0.107	0.082
Horz.	V35	0.71	0.397	-0.435	-0.2	0.097
	V36	0.712	0.574	-0.321	-0.115	0.043

Table 2.6. The component matrix from the analysis of the replica assemblage combined data, displaying loadings for each extracted components.

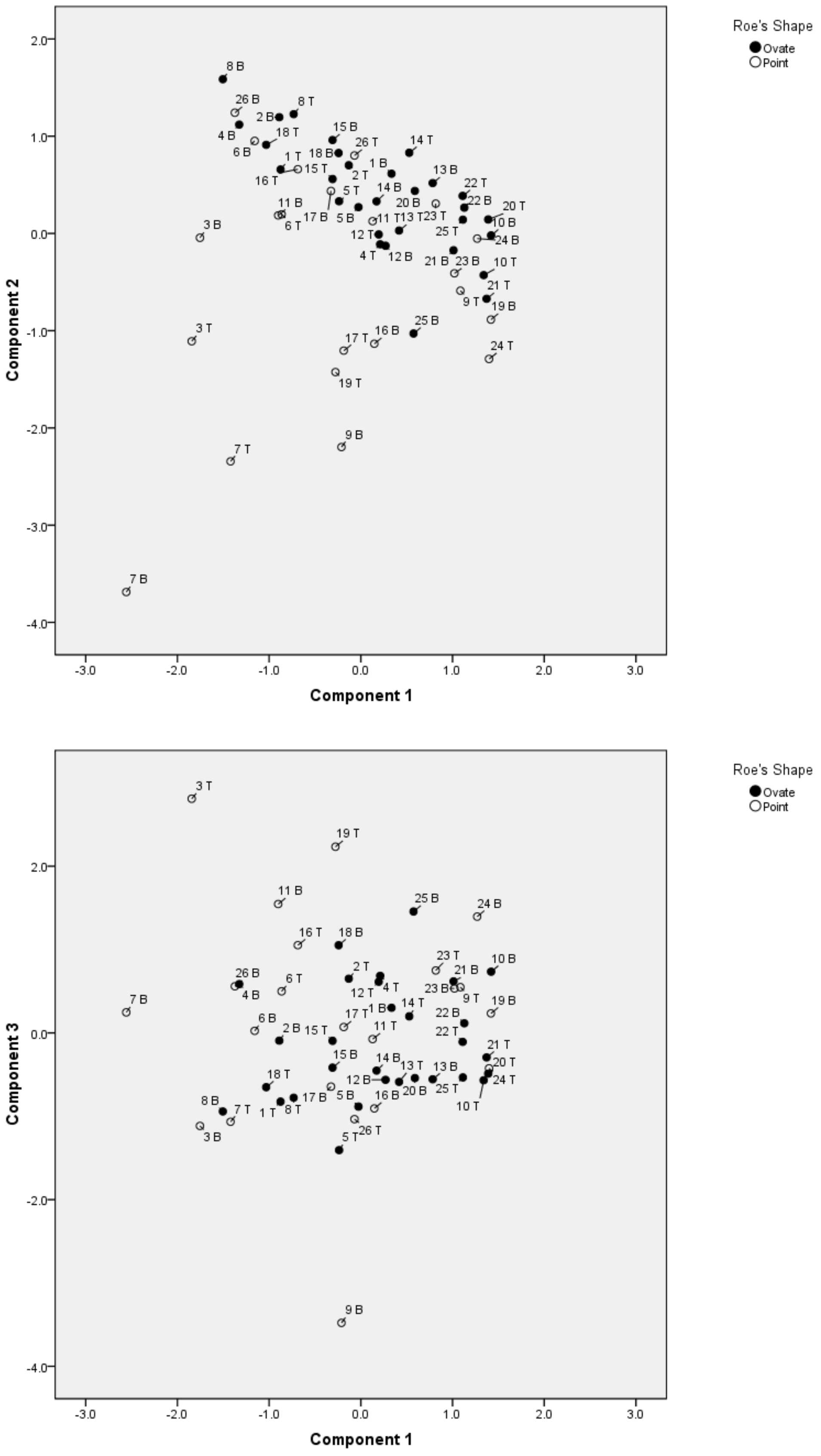


Figure 2.5a. Plots from the analysis of the replica assemblage surface data (T= Top, B=Bottom): top) component one versus two; bottom) component one versus three. The handaxes are differentiated by shape, based on Roe's (1968) typology.

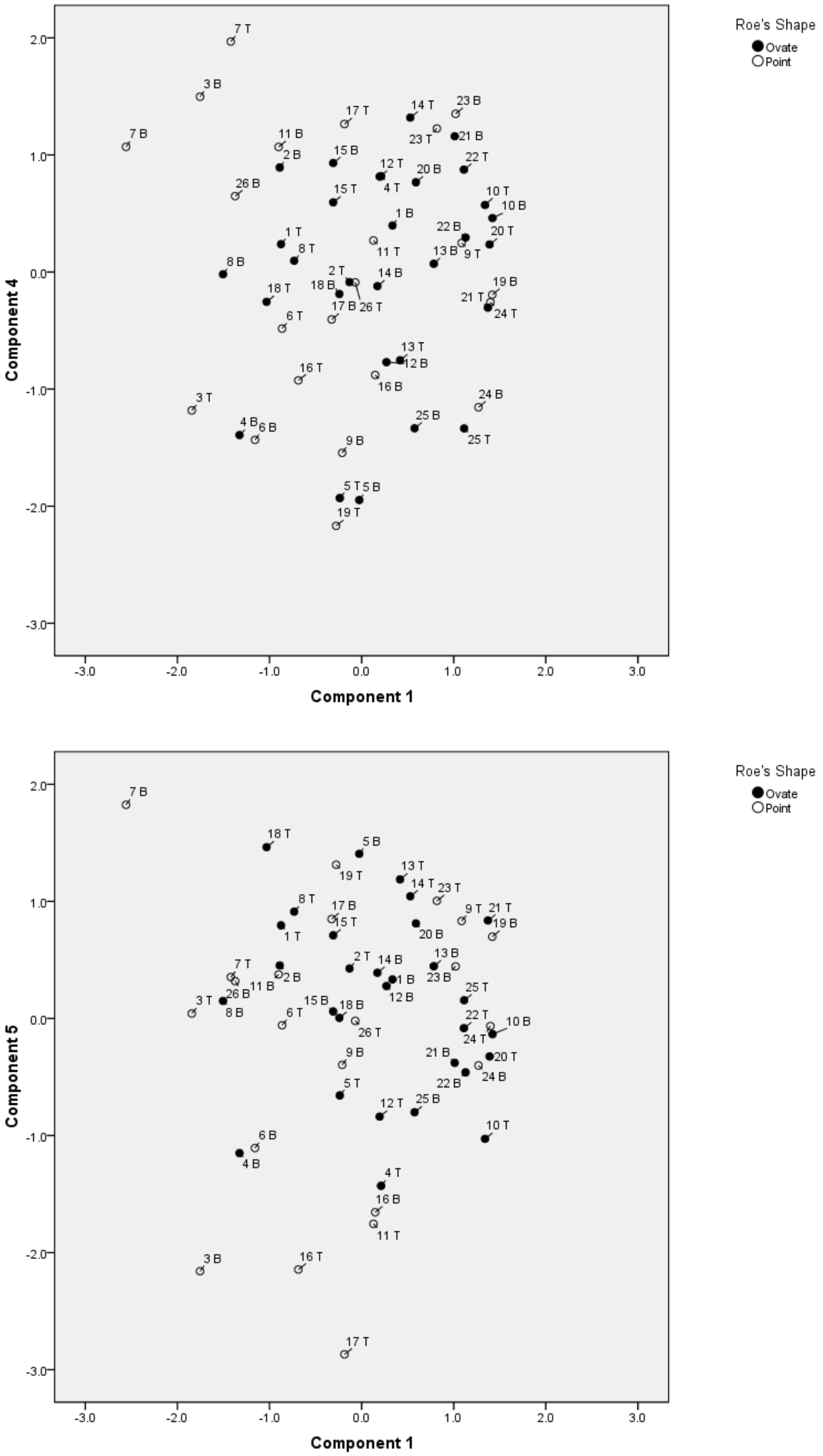


Figure 2.5b. Plots from the analysis of the replica assemblage surface data: top) component one versus four; bottom) component one versus five. The handaxes are differentiated as per Figure 2.5a.

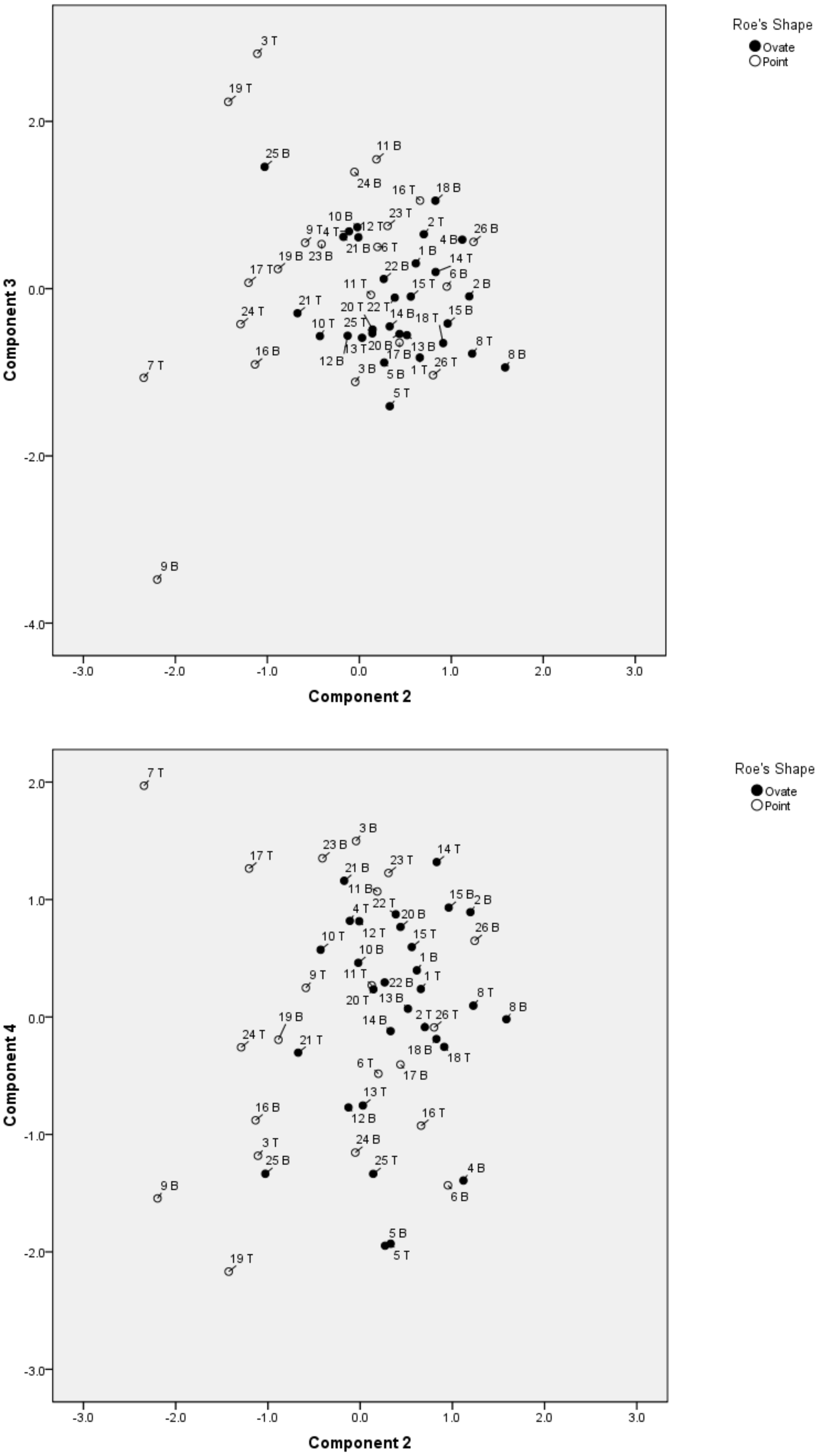


Figure 2.5c. Plots from the analysis of the replica assemblage surface data: top) component two versus three; bottom) component two versus four. The handaxes are differentiated as per Figure 2.5a.

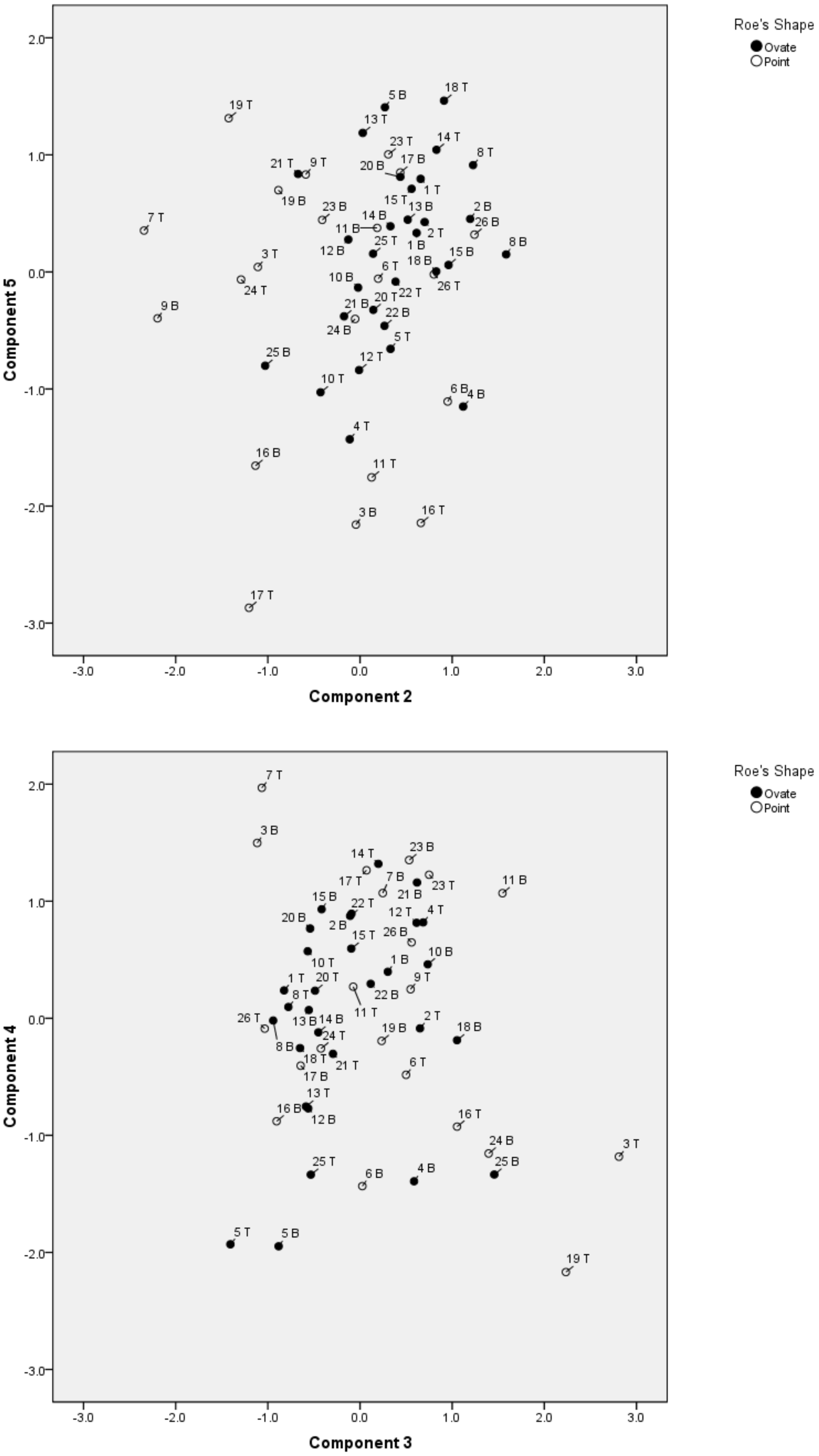


Figure 2.5d. Plots from the analysis of the replica assemblage surface data: top) component two versus five; bottom) component three versus four. The handaxes are differentiated as per Figure 2.5a.

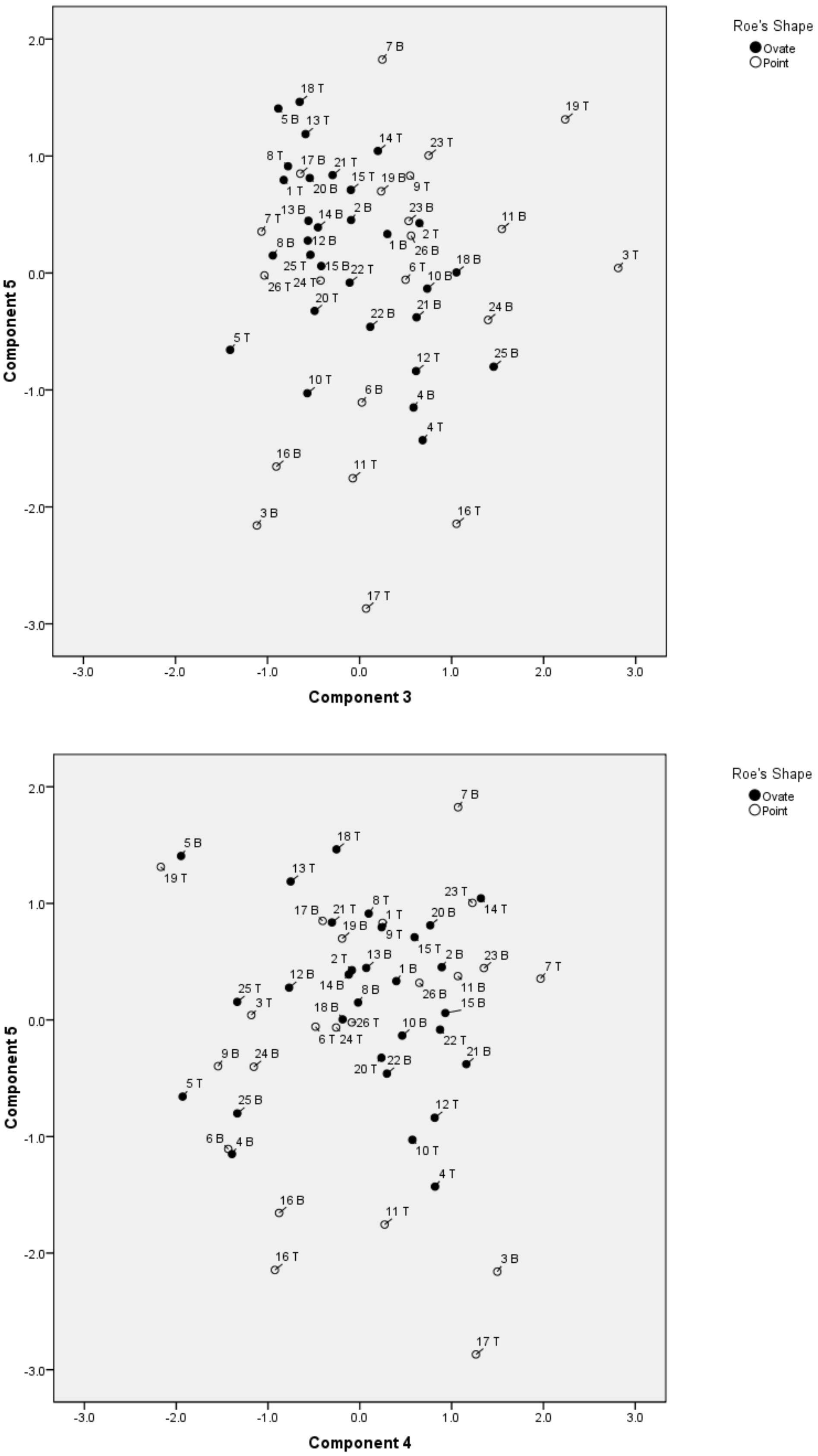


Figure 2.5e. Plots from the analysis of the replica assemblage surface data: top) component three versus five; bottom) component four versus five. The handaxes are differentiated as per Figure 2.5a.

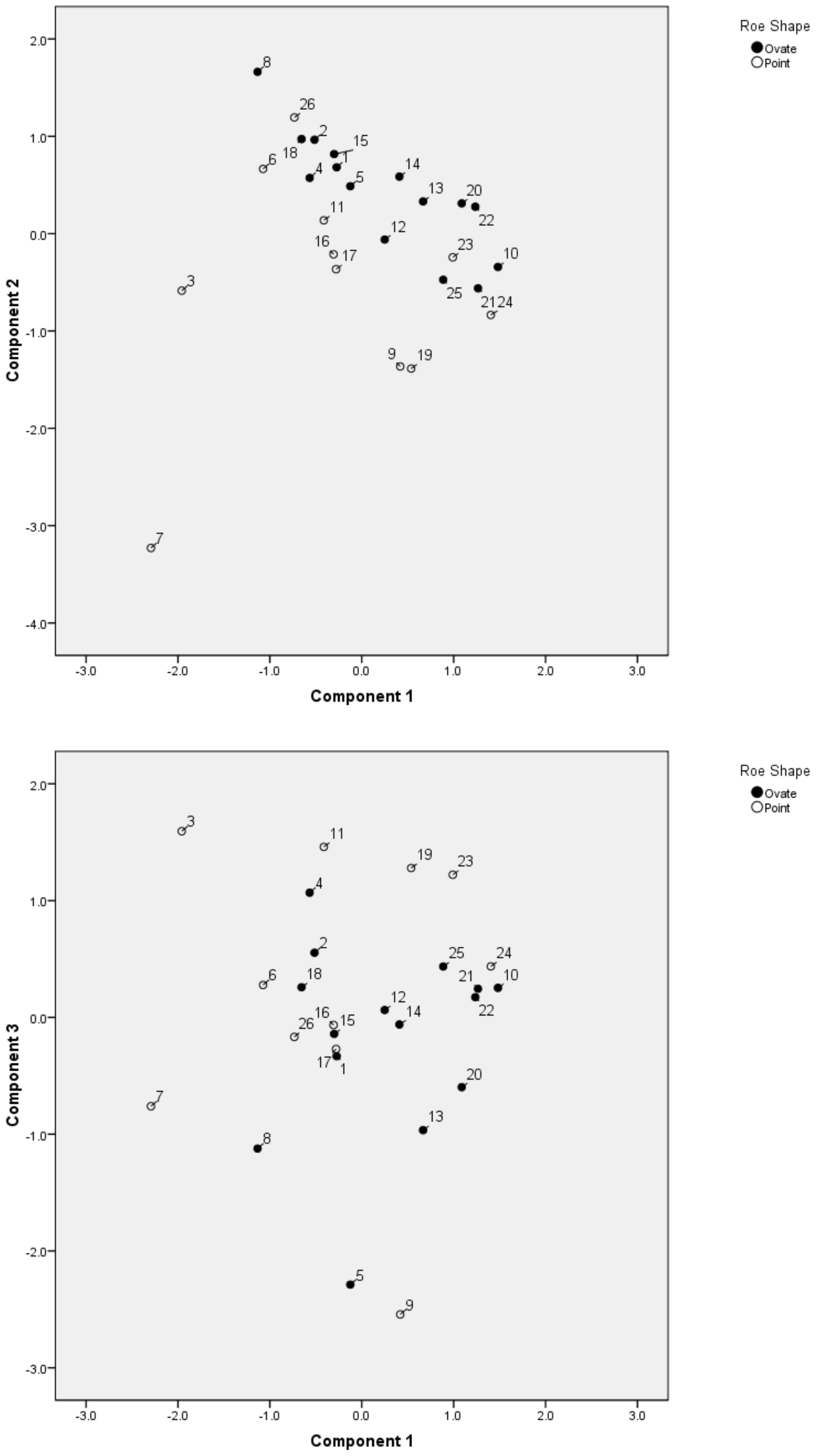


Figure 2.6a. Plots from the analysis of the replica assemblage combined data: top) component one versus two; bottom) component one versus three. The handaxes are differentiated by shape, based on Roe's (1968) typology.

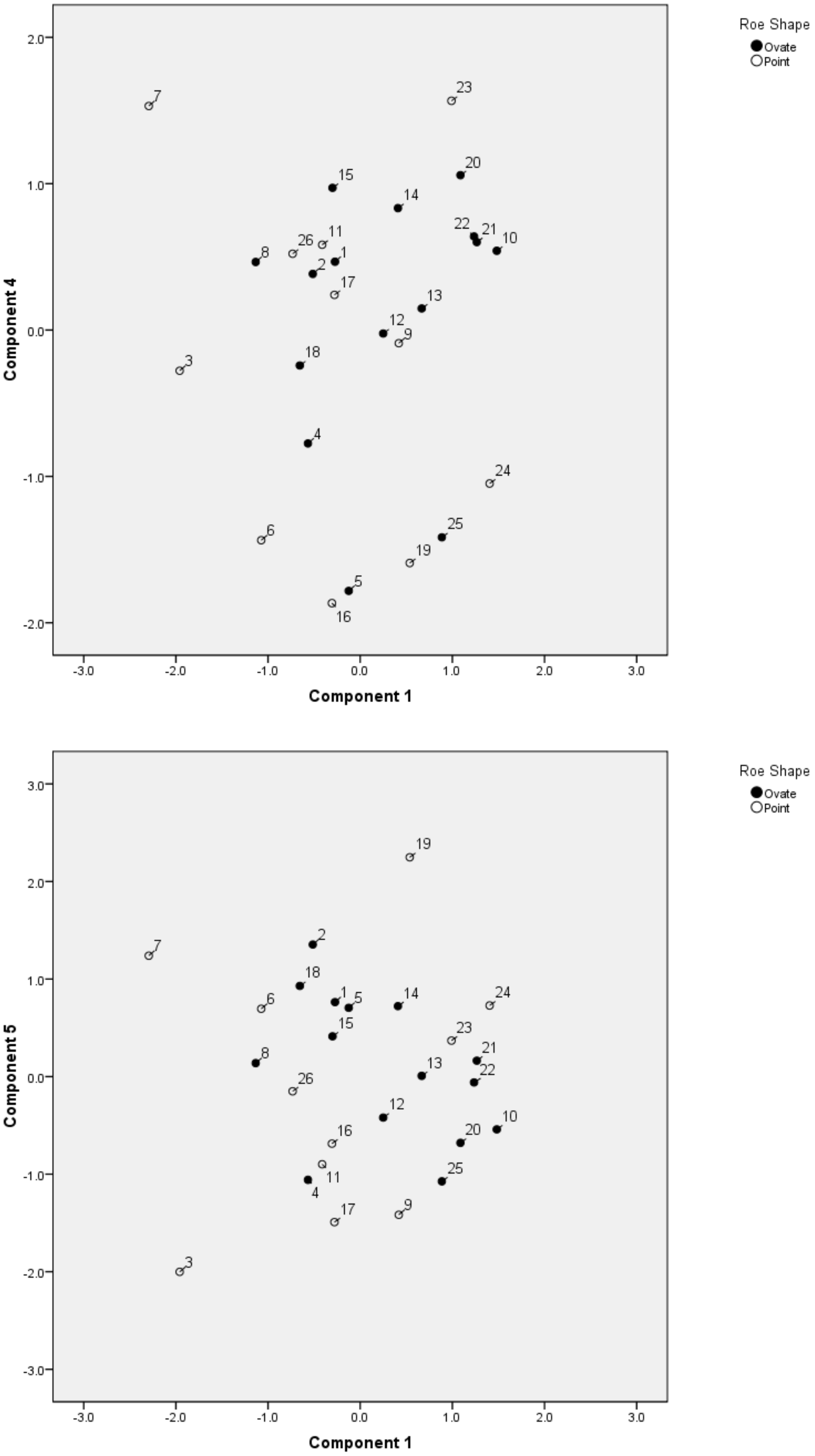


Figure 2.6b. Plots from the analysis of the replica assemblage combined data: top) component one versus four; bottom) component one versus five. The handaxes are differentiated as per Figure 2.6a.

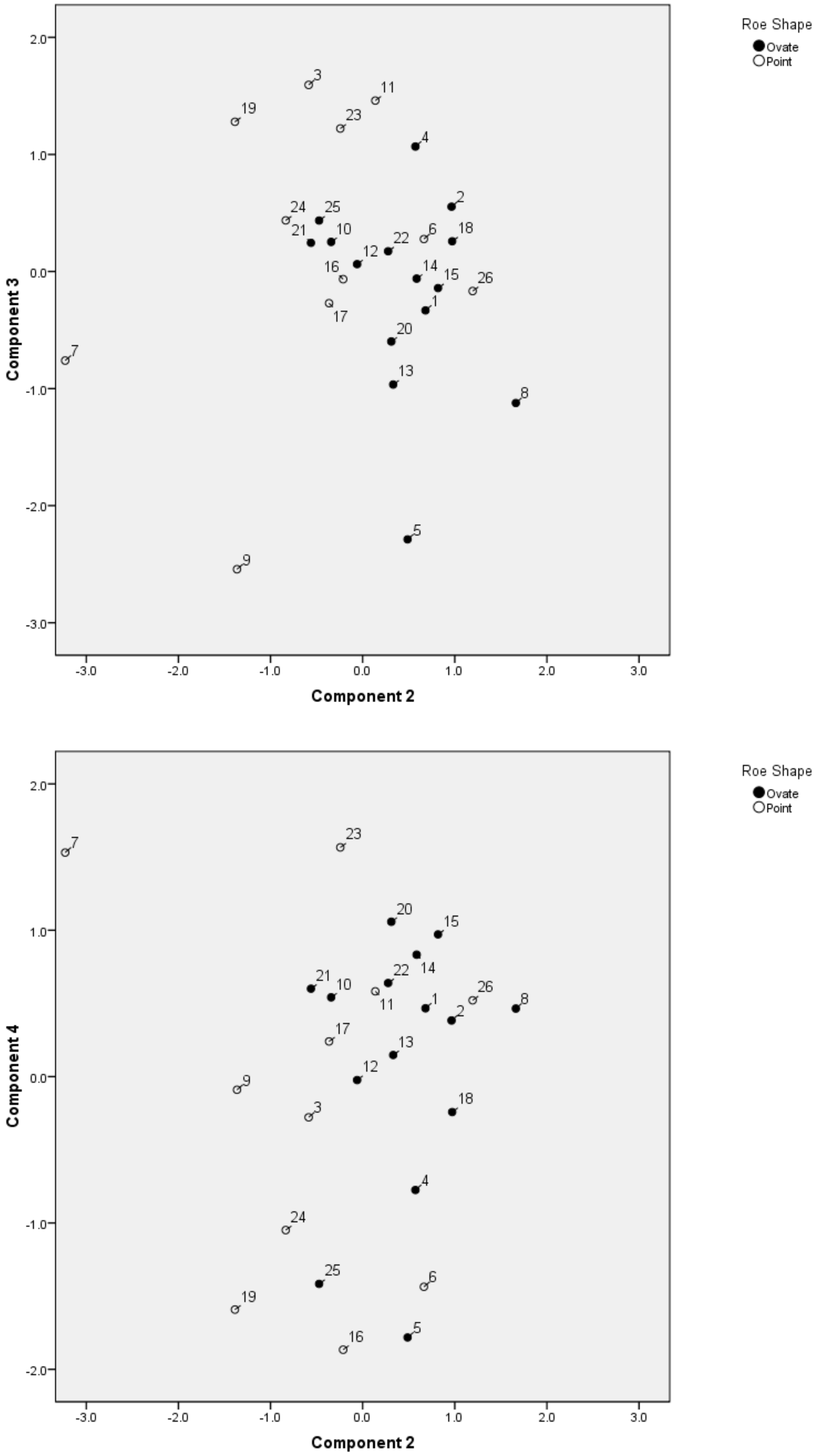


Figure 2.6c. Plots from the analysis of the replica assemblage combined data: top) component two versus three; bottom) component two versus four. The handaxes are differentiated as per Figure 2.6a.

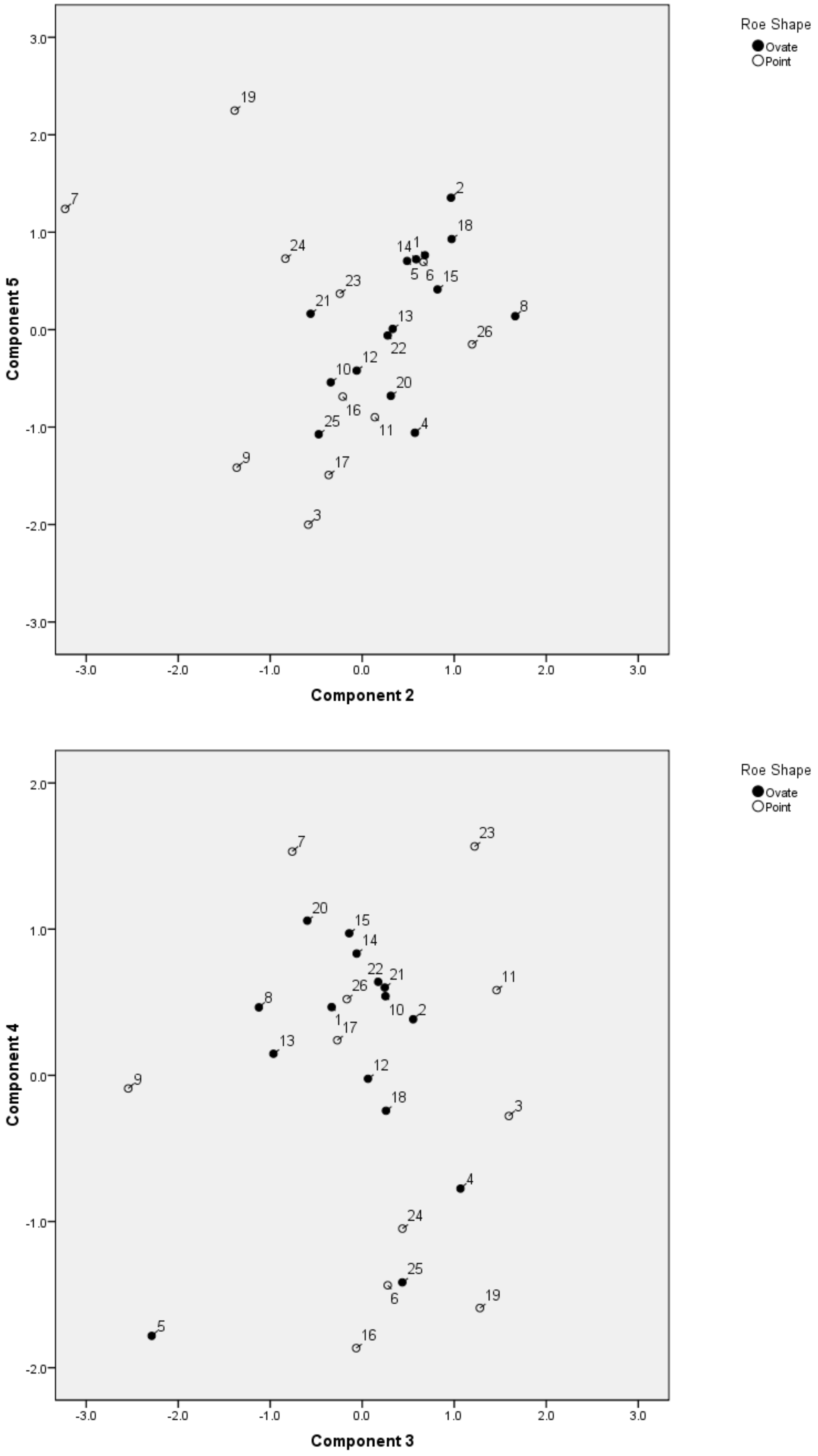


Figure 2.6d. Plots from the analysis of the replica assemblage combined data: top) component two versus five; bottom) component three versus four. The handaxes are differentiated as per Figure 2.6a.

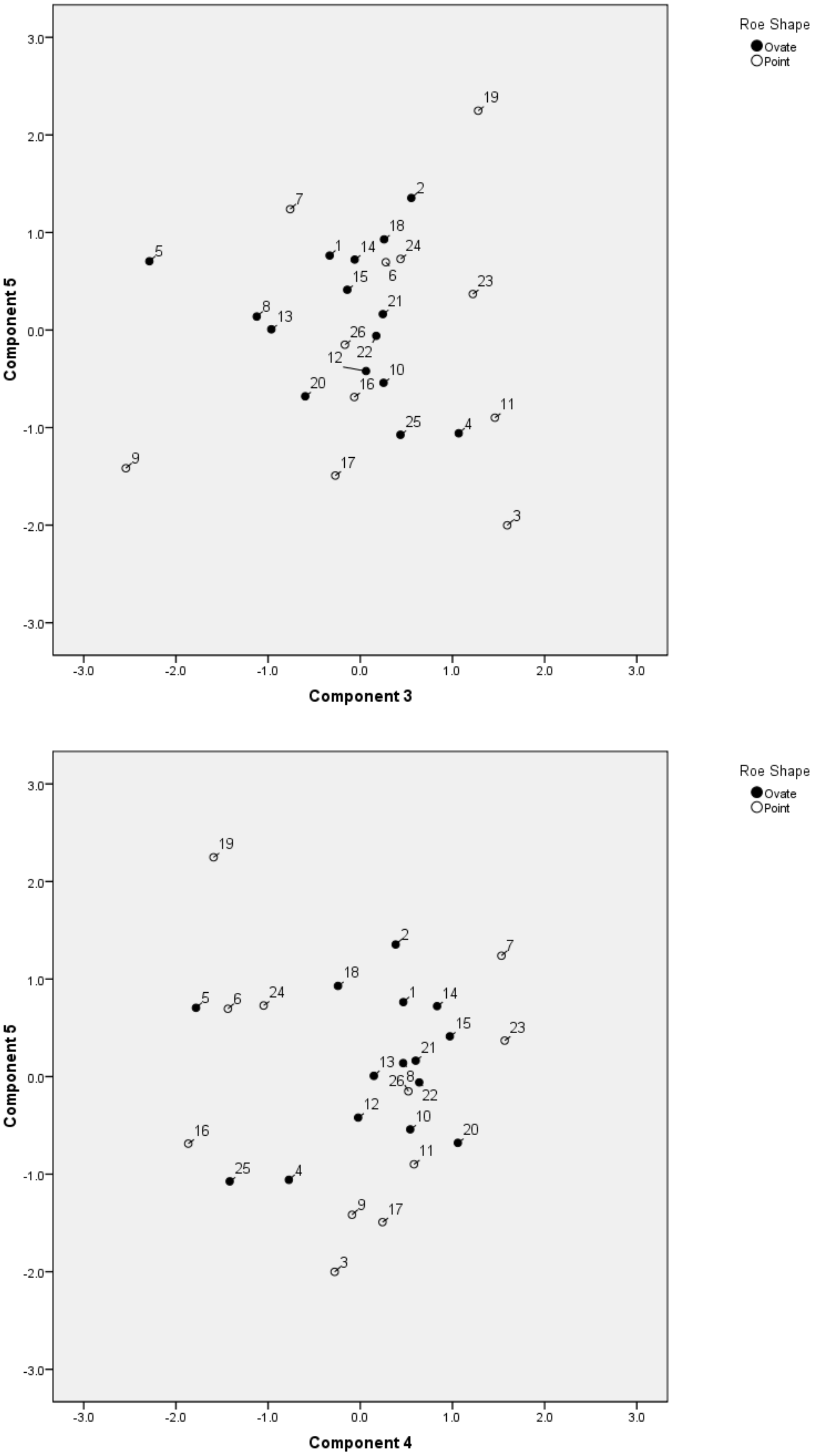


Figure 2.6e. Plots from the analysis of the replica assemblage combined data: top) component three versus five; bottom) component four versus five. The handaxes are differentiated as per Figure 2.6a.

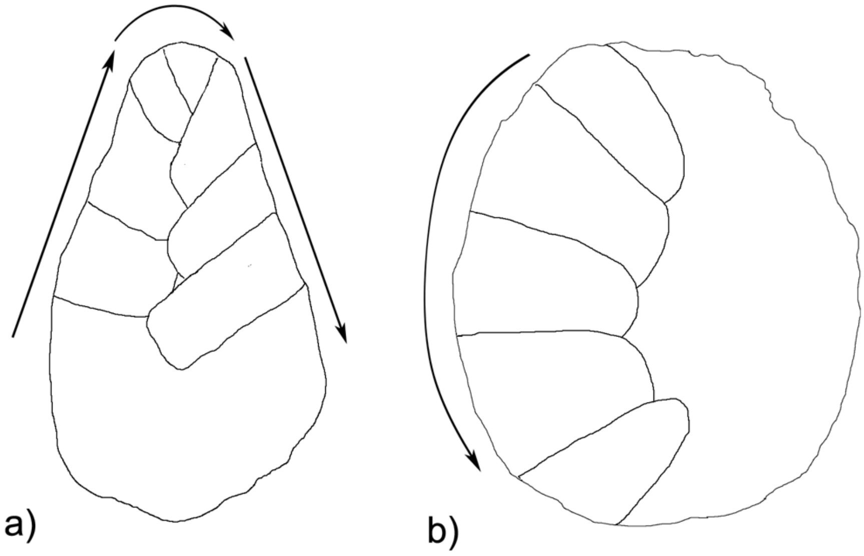


Figure 2.7. A simplified example of the differences between pointed and ovate thinning strategies: a) points are worked along the edge, with removals truncating previous scars, resulting in increased vertically and horizontally orientated lines in the scar pattern; b) ovates display circumferential working, leading to a greater diversity in line orientation.

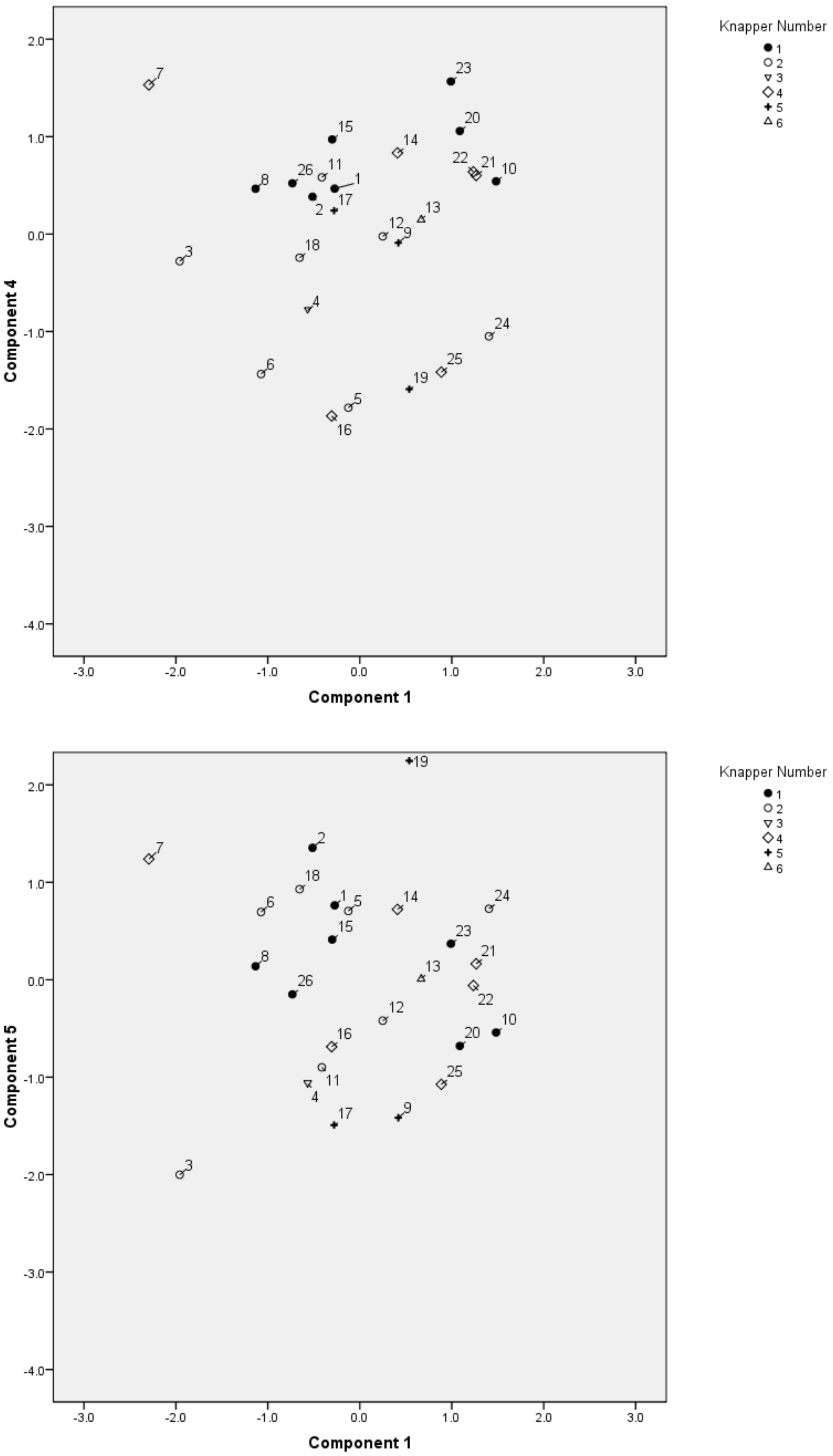
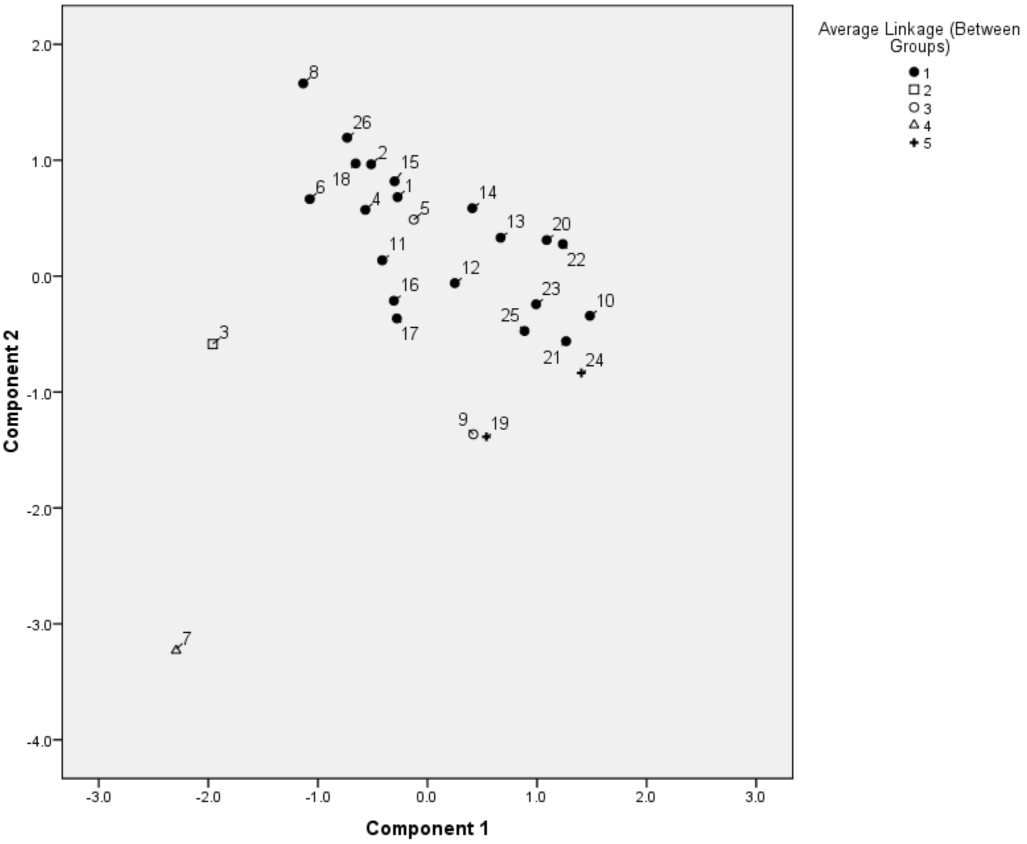


Figure 2.8a. Plots of component one and two from the analysis of the combined data, with handaxes grouped according to the cluster analysis: top) three clusters; bottom) four clusters.



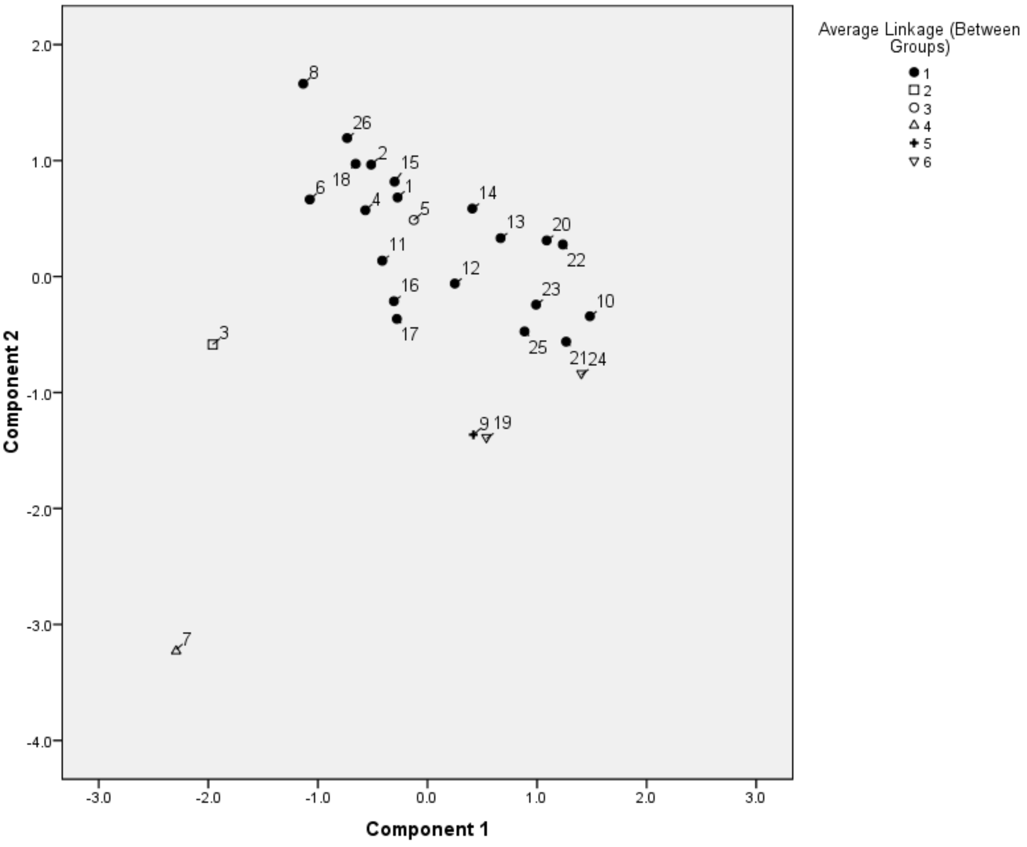


Figure 2.8b. Plots of component one and two from the analysis of the combined data, with handaxes grouped according to the cluster analysis: top) five clusters; bottom) six clusters.

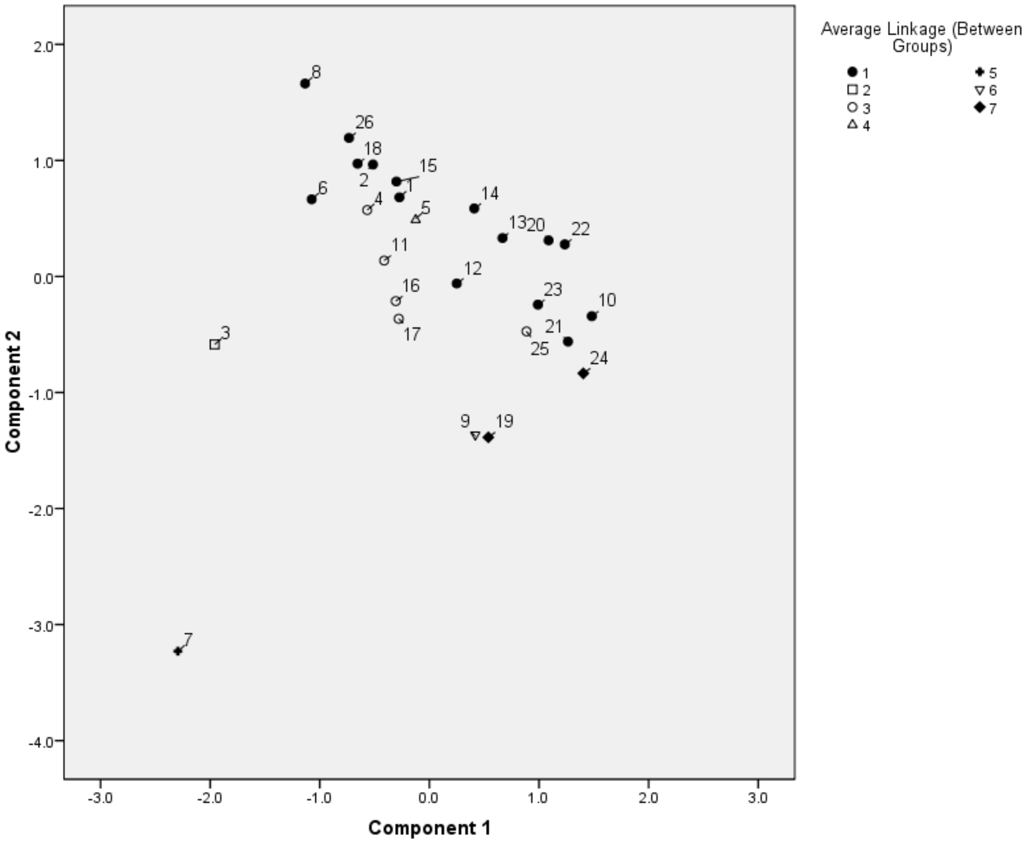


Figure 2.8c. Plot of component one and two from the analysis of the combined data, with handaxes differentiated into seven groups, based on the cluster analysis.

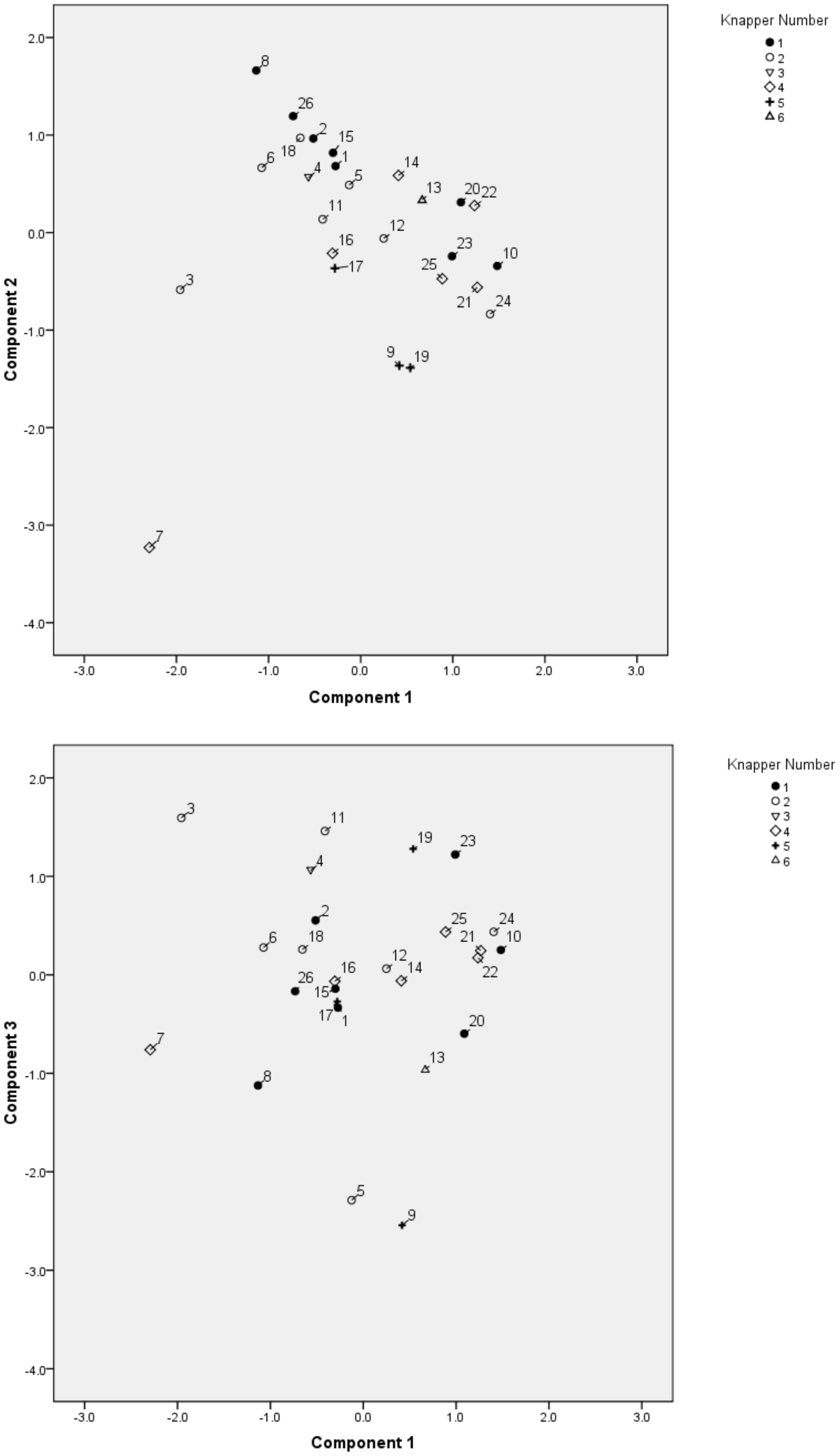


Figure 2.9a. Plots from the analysis of the replica assemblage combined data: top) component one versus two; bottom) component one versus three. The handaxes are differentiated according to the knappers who made them.

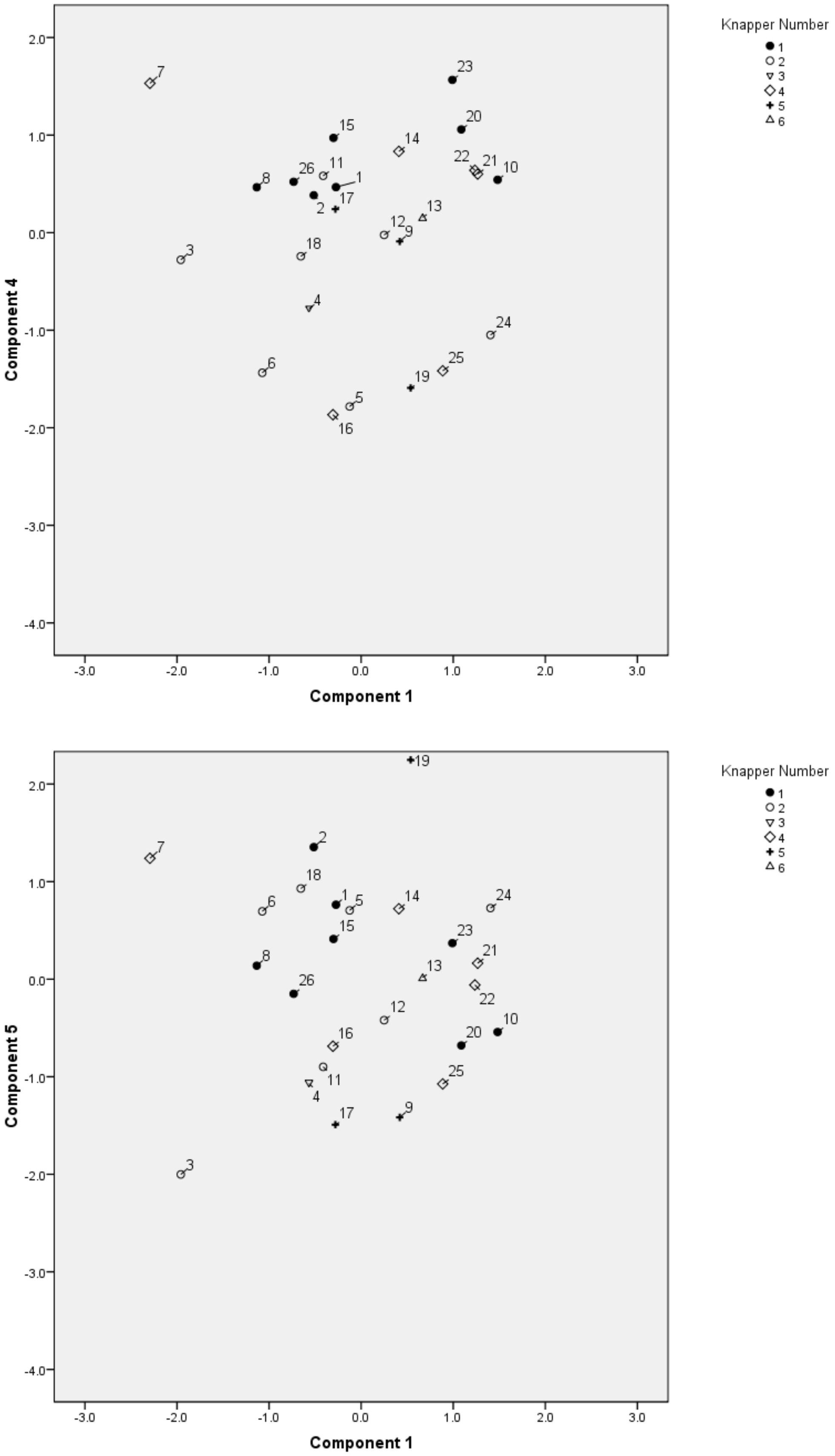


Figure 2.9b. Plots from the analysis of the replica assemblage combined data: top) component one versus four; bottom) component one versus five. The handaxes are differentiated as per Figure 2.9a.

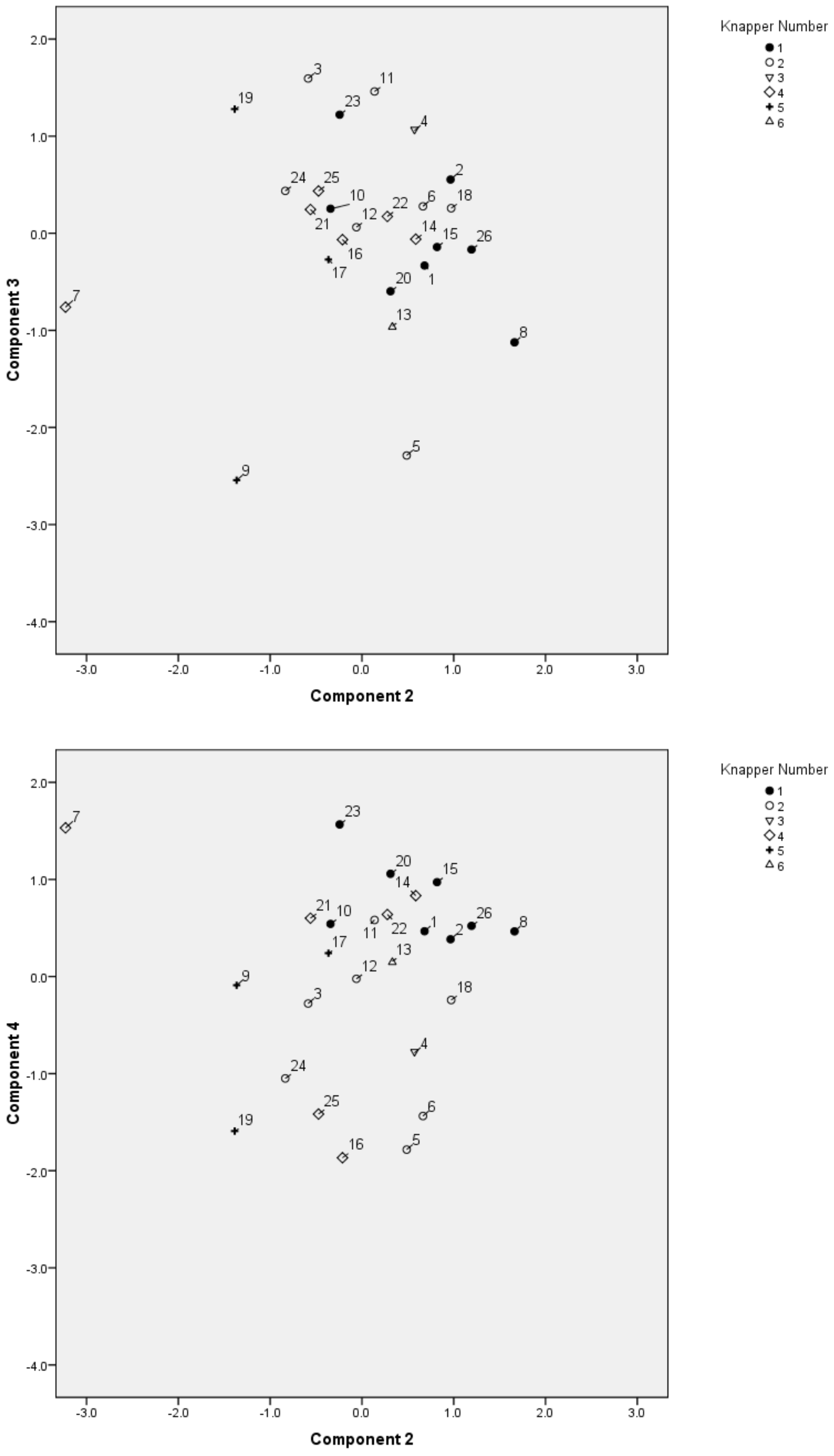


Figure 2.9c. Plots from the analysis of the replica assemblage combined data: top) component two versus three; bottom) component two versus four. The handaxes are differentiated as per Figure 2.9a.

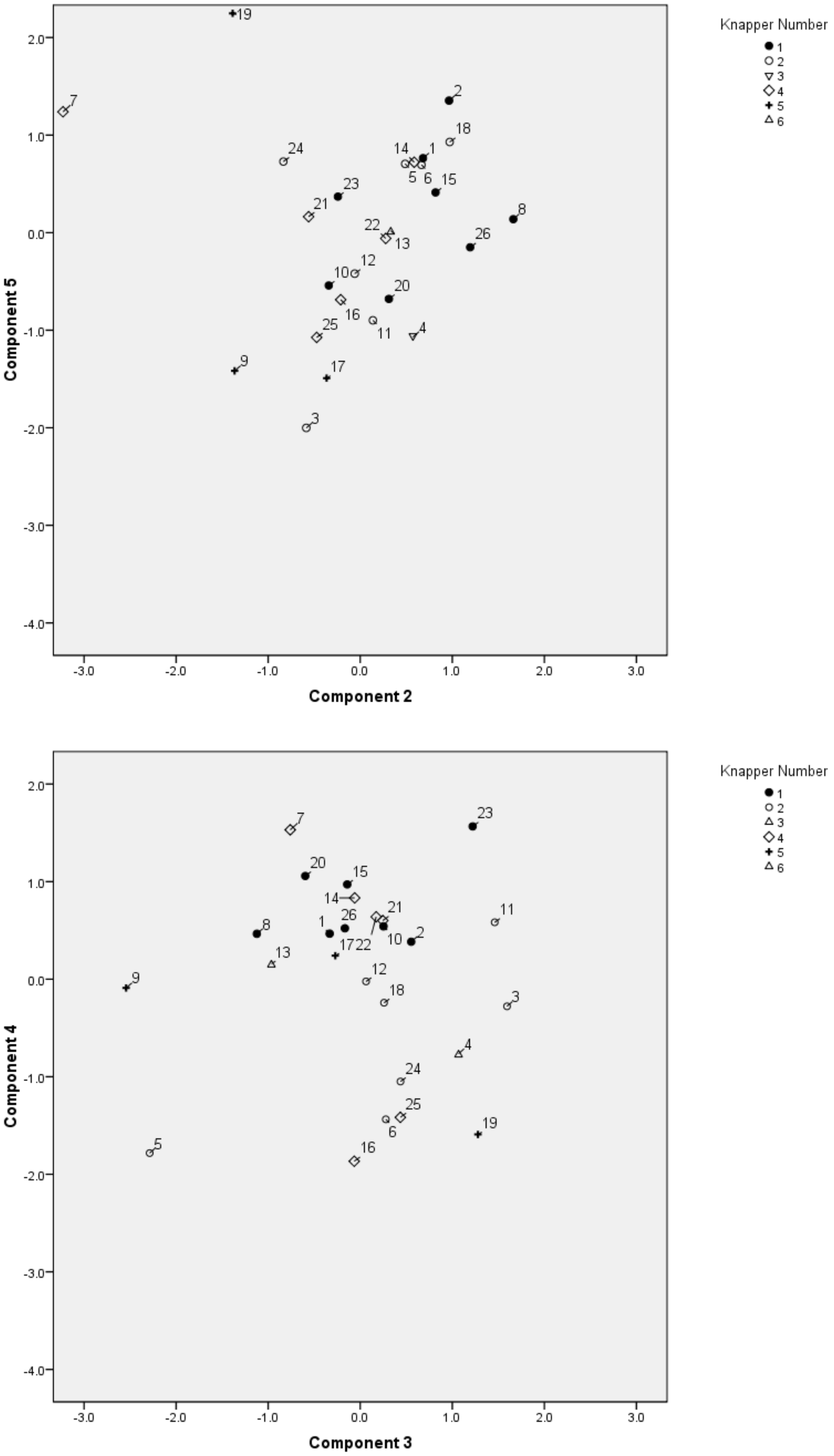


Figure 2.9d. Plots from the analysis of the replica assemblage combined data: top) component two versus five; bottom) component three versus four. The handaxes are differentiated as per Figure 2.9a.

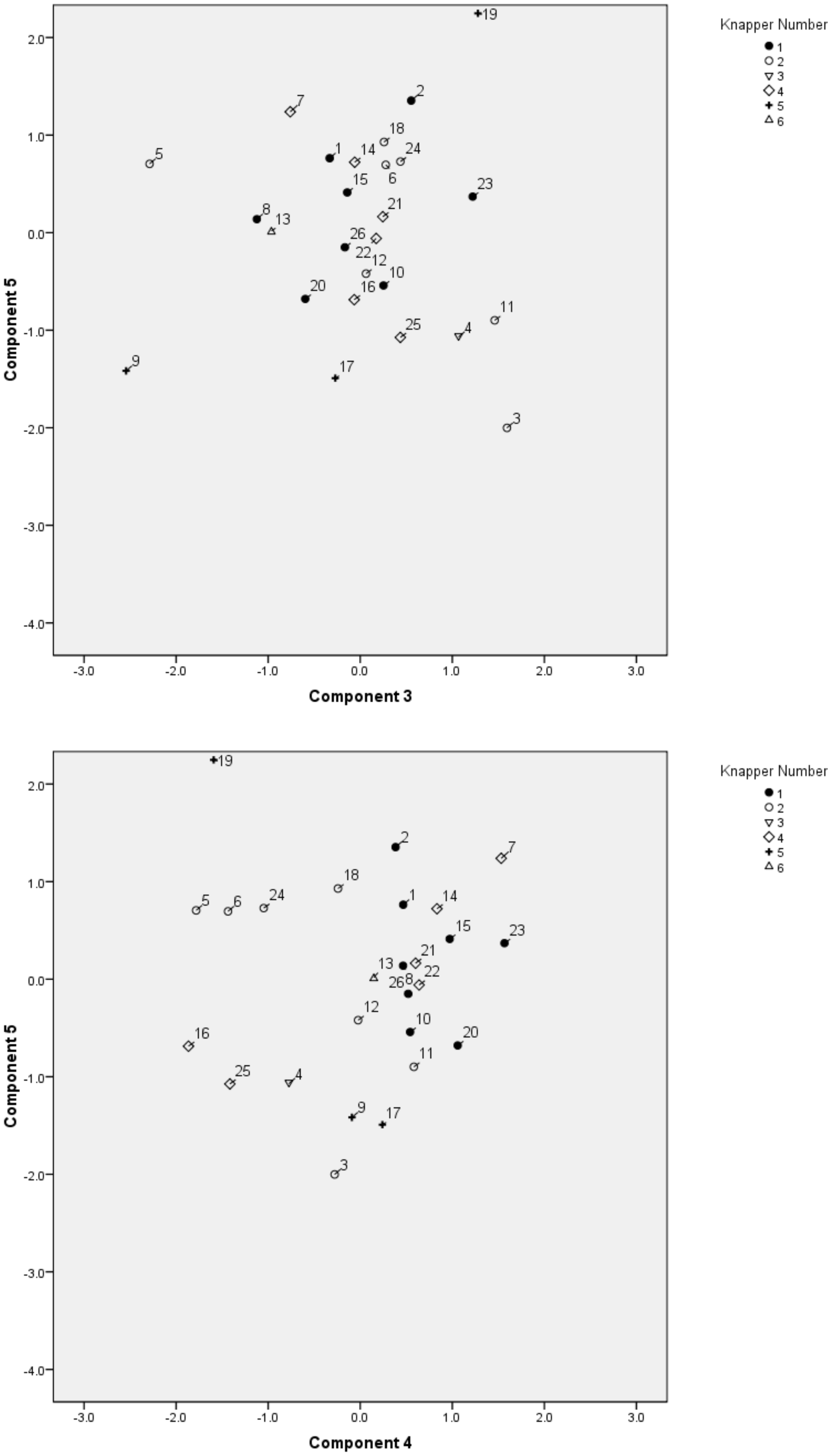


Figure 2.9e. Plots from the analysis of the replica assemblage combined data: top) component three versus five; bottom) component four versus five. The handaxes are differentiated as per Figure 2.9a.

Total Variance Explained

Component	*Initial Eigenvalues*			*Extraction Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	32.017	88.937	88.937	32.017	88.937	88.937
2	1.036	2.878	91.815	1.036	2.878	91.815
3	0.678	1.884	93.698			
4	0.355	0.986	94.685			
5	0.181	0.502	95.187			
6	0.161	0.448	95.634			
7	0.141	0.393	96.027			
8	0.129	0.359	96.385			
9	0.109	0.303	96.689			
10	0.099	0.275	96.963			
11	0.092	0.255	97.218			
12	0.087	0.241	97.459			
13	0.075	0.207	97.666			
14	0.074	0.204	97.871			
15	0.071	0.196	98.067			
16	0.065	0.180	98.247			
17	0.062	0.171	98.419			
18	0.059	0.165	98.584			
19	0.054	0.151	98.734			
20	0.047	0.132	98.866			
21	0.045	0.126	98.992			
22	0.040	0.111	99.103			
23	0.038	0.105	99.208			
24	0.034	0.096	99.304			
25	0.032	0.090	99.394			
26	0.031	0.087	99.481			
27	0.027	0.074	99.555			
28	0.026	0.071	99.626			
29	0.025	0.069	99.695			
30	0.024	0.065	99.761			
31	0.018	0.050	99.811			
32	0.017	0.047	99.858			
33	0.015	0.043	99.901			
34	0.014	0.038	99.939			
35	0.013	0.035	99.974			
36	0.010	0.026	100.000			

Table 2.7. Results of the principal component analysis applied to the Caddington assemblage surface data.

	Component Matrix		
		Component	
		1	***2***
Horz.	V1	0.872	0.357
	V2	0.894	0.360
Right Horizontal	V3	0.919	0.276
	V4	0.936	0.223
	V5	0.934	0.163
	V6	0.940	0.087
	V7	0.957	-0.043
	V8	0.951	-0.074
Right Centre	V9	0.955	-0.076
	V10	0.948	-0.127
	V11	0.953	-0.163
	V12	0.955	-0.179
	V13	0.949	-0.171
	V14	0.963	-0.157
Vertical	V15	0.961	-0.101
	V16	0.955	-0.032
	V17	0.944	0.064
	V18	0.931	0.117
	V19	0.898	0.204
	V20	0.917	0.213
	V21	0.946	0.111
	V22	0.965	0.072
Left Centre	V23	0.961	-0.032
	V24	0.962	-0.115
	V25	0.953	-0.193
	V26	0.955	-0.198
	V27	0.959	-0.184
	V28	0.957	-0.196
Left Horizontal	V29	0.949	-0.208
	V30	0.942	-0.155
	V31	0.949	-0.162
	V32	0.947	-0.074
	V33	0.947	0.033
	V34	0.952	0.088
Horz.	V35	0.933	0.164
	V36	0.931	0.212

Table 2.8. The component matrix from the analysis of the Caddington assemblage surface data, displaying loadings for both extracted components.

Total Variance Explained						
Component	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***		
	Total	***% of Variance***	***Cumulative %***	***Total***	***% of Variance***	***Cumulative %***
1	33.348	92.635	92.635	33.348	92.635	92.635
2	0.952	2.644	95.279	0.952	2.644	95.279
3	0.474	1.316	96.594			
4	0.192	0.535	97.129			
5	0.131	0.365	97.494			
6	0.116	0.321	97.815			
7	0.088	0.246	98.060			
8	0.079	0.219	98.279			
9	0.064	0.177	98.457			
10	0.062	0.171	98.628			
11	0.053	0.148	98.776			
12	0.049	0.136	98.912			
13	0.045	0.124	99.036			
14	0.042	0.117	99.154			
15	0.036	0.101	99.254			
16	0.034	0.095	99.349			
17	0.030	0.084	99.432			
18	0.027	0.074	99.507			
19	0.024	0.067	99.574			
20	0.022	0.061	99.635			
21	0.020	0.055	99.690			
22	0.019	0.052	99.742			
23	0.014	0.039	99.781			
24	0.012	0.034	99.816			
25	0.012	0.034	99.849			
26	0.010	0.028	99.877			
27	0.008	0.022	99.899			
28	0.007	0.020	99.919			
29	0.006	0.017	99.936			
30	0.006	0.015	99.952			
31	0.005	0.013	99.964			
32	0.004	0.011	99.975			
33	0.004	0.010	99.985			
34	0.002	0.007	99.991			
35	0.002	0.005	99.996			
36	0.001	0.004	100.000			

Table 2.9. Results of the principal component analysis applied to the Caddington assemblage combined data.

	Component Matrix		
		Component	
		1	***2***
Horz.	V1	0.904	0.340
	V2	0.925	0.319
Right Horizontal	V3	0.943	0.234
	V4	0.958	0.213
	V5	0.957	0.147
	V6	0.967	0.077
	V7	0.974	-0.042
	V8	0.969	-0.090
Right Centre	V9	0.973	-0.061
	V10	0.969	-0.121
	V11	0.968	-0.151
	V12	0.966	-0.182
	V13	0.964	-0.168
	V14	0.974	-0.159
Vertical	V15	0.972	-0.103
	V16	0.974	-0.040
	V17	0.963	0.082
	V18	0.952	0.144
	V19	0.929	0.219
	V20	0.940	0.226
	V21	0.963	0.143
	V22	0.977	0.082
Left Centre	V23	0.980	-0.018
	V24	0.979	-0.101
	V25	0.971	-0.173
	V26	0.966	-0.197
	V27	0.974	-0.178
	V28	0.969	-0.177
Left Horizontal	V29	0.965	-0.201
	V30	0.966	-0.158
	V31	0.967	-0.160
	V32	0.961	-0.094
	V33	0.969	0.019
	V34	0.972	0.071
Horz.	V35	0.964	0.130
	V36	0.958	0.196

Table 2.10. The component matrix from the analysis of the Caddington assemblage combined data, displaying loadings for both extracted components.

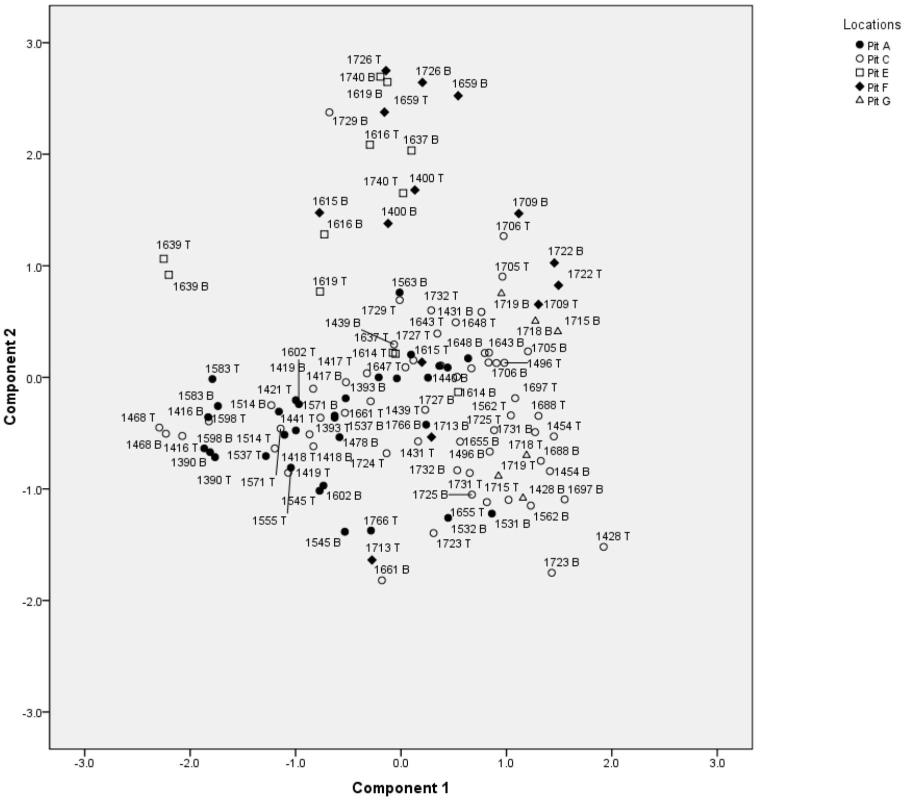


Figure 2.10. Plot of component one and two from the analysis of the Caddington assemblage surface data. The handaxes are differentiated according to which pit they originated from.

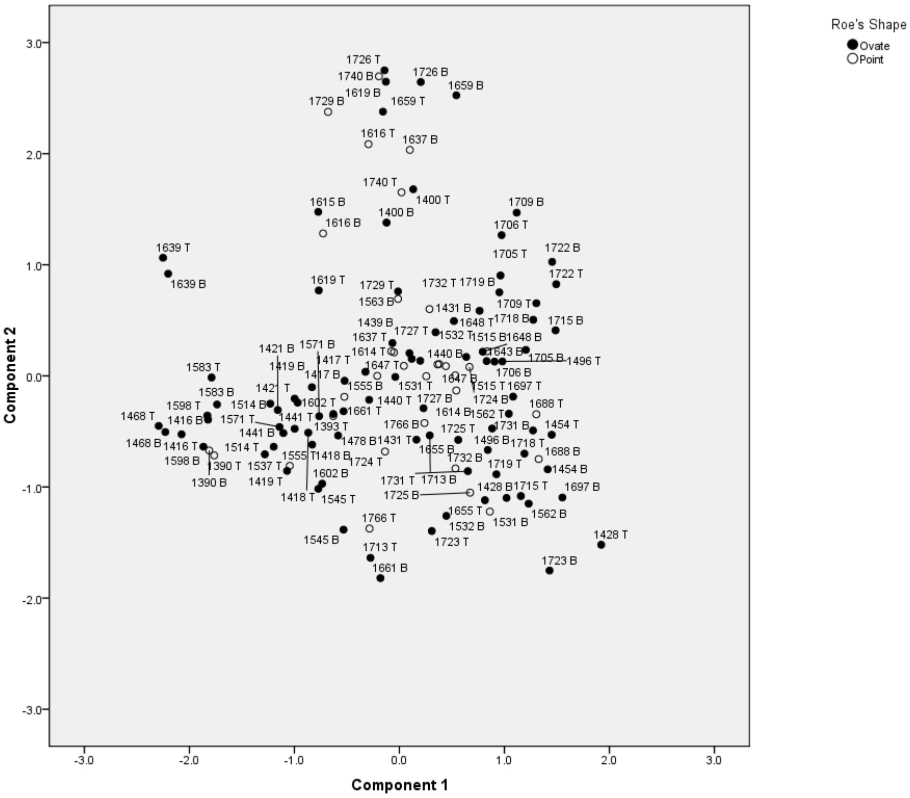


Figure 2.11. Plot of component one and two from the analysis of the Caddington assemblage surface data. The handaxes are differentiated by shape, based on Roe's (1968) typology.

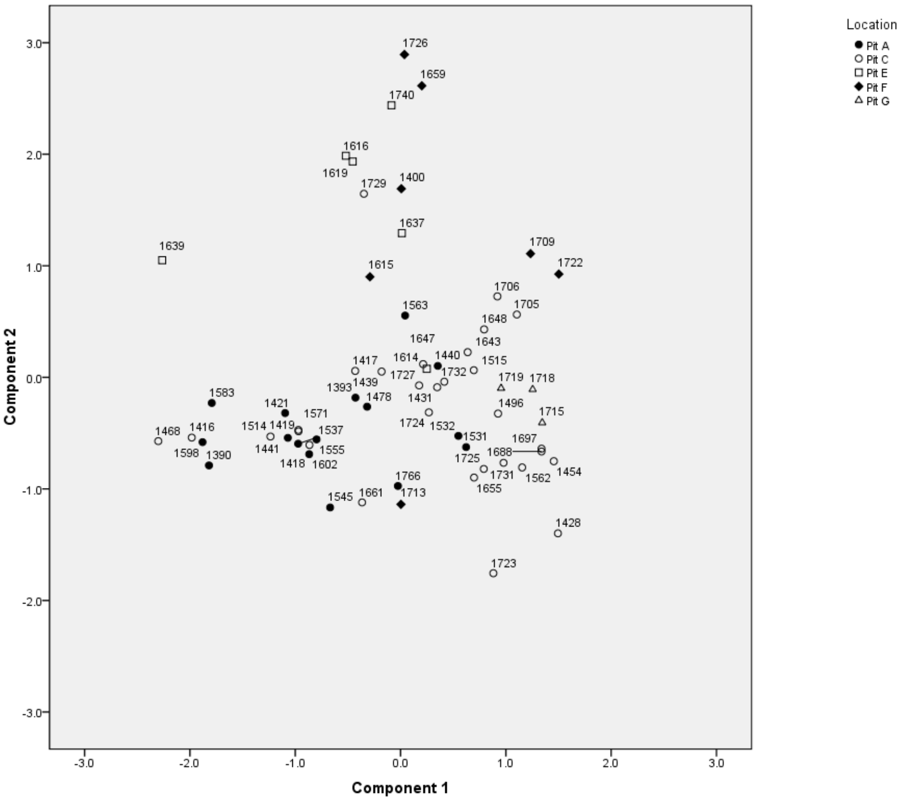


Figure 2.12. Plot of component one and two from the analysis of the Caddington assemblage combined data. The handaxes are differentiated according to which pit they originated from.

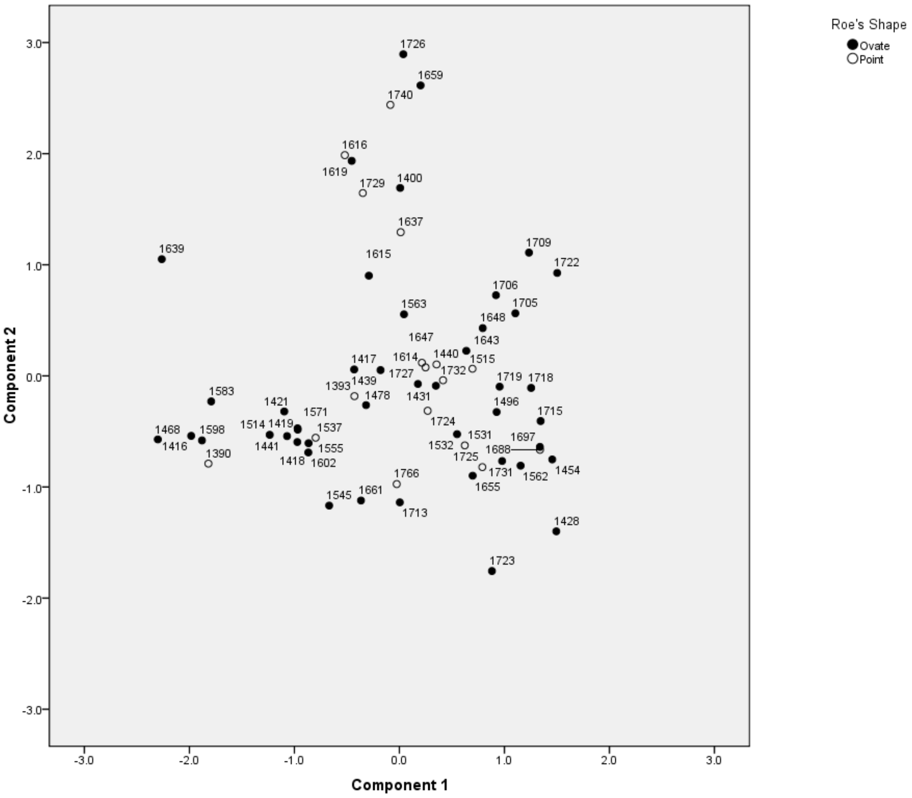


Figure 2.13. Plot of component one and two from the analysis of the Caddington assemblage combined data, with handaxes differentiated by shape, based on Roe's (1968) typology.