40 Quantitative methods for spatial analysis at rockshelters: the case of Klithi

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40.1 INTRODUCTION

Time and space provide the most common interpretative frameworks for considering variation in archaeological data. Spatial studies embody special problems involving both pattern identification and pattern interpretation. It may be argued that location in space can be observed and measured objectively. However, the difficulties arise in the stage of interpretation, as it is not expected that spatial patterns in a site are *a priori* related to human behaviour. The effects of depositional and postdepositional factors in the formation of the archaeological record have to be identified and only then can some of the messages encoded in the patterning be understood as a result of cultural and physical factors.

In the archaeological literature of the late eighties — early nineties one finds that spatial archaeology is more mature than before, regarding its models, and self sufficient, regarding its analytical techniques. Recent studies of mobile peoples' use of space (Gamble & Boismier 1991, Kroll & Price 1991) emphasise an asymmetrical refinement of pattern recognition methods versus realistic interpretations of past behaviour and attempt to develop a methodology for analysing living areas by providing cross–cultural comparisons of intra–site behaviour. The issue to resolve is defined explicitly as to how behaviour is coded in static item distributions. In order to respond to this challenge research has shifted towards:

- actualistic (i.e. ethnoarchaeological and experimental) studies, which undertake new projects aimed at the exploration of behavioural and other processes, which might result in the formation of a specific pattern of material distribution on an occupation surface (Gamble 1991);
- a reconsideration of the perspective from which archaeological case studies approach the organisation of space, of the units of observation and of the structure of the archaeological record (Gamble 1991);
- development of spatial analytical methods in concordance with the relevant archaeological data structure and patterns of variability (Carr 1984; Whallon 1984).

This paper addresses pattern recognition methods for spatial analysis and it is a part of a wider study of the organisation of space within constrained locations such as rockshelters. Its main objectives are:

1) to present one way of approaching spatial questions in the context of high density distributions without structured features, by employing a variety of quantitative techniques in the first stage of "coarse–grained" analysis;
2) to evaluate the impact of analytical techniques, developed for archaeological needs and, broadly, tested on ethnographic observations of known behavioural origin, in identifying spatial patterning in archaeological palimpsets.

The study focuses on lithic material recovered from Klithi, a rockshelter in NW Greece with Upper Palaeolithic occupation between16,000–10,000 BP.

40.2 THE ARCHAEOLOGICAL CONTEXT AND THE SPATIAL QUESTIONS

Klithi is a spacious rockshelter, on the right bank of the Voidomatis river. Excavations, carried out over five seasons (1983–1986, 1988), have yielded a lithic industry dominated by backed bladelets

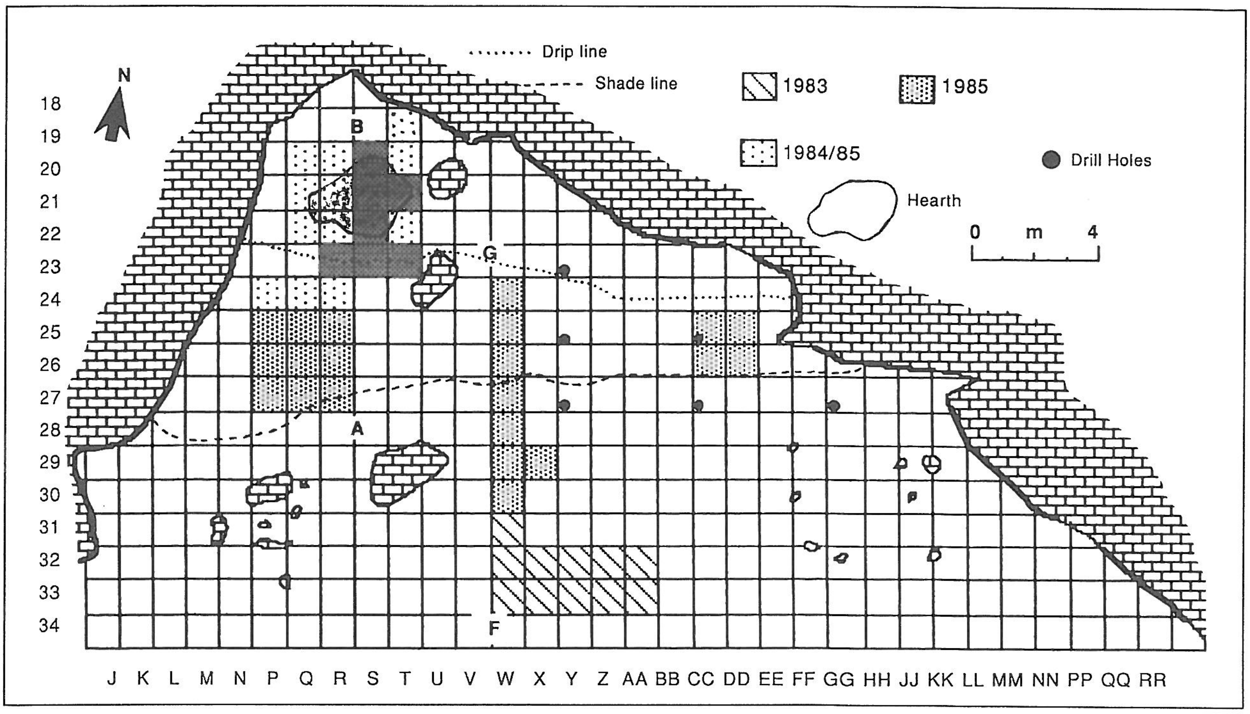

Figure 40.1: Excavations at Klithi.

and associated fauna, which argue for a seasonally specialised function of the site in exploiting caprines. Decorative objects (such as ochre, perforated sea shells and deer canines) and organic implements (such as bone needles, awls) contribute minimally to the site inventory. The fieldwork strategy was developed around three variables : intra–site variation, inter–site variation, local and regional palaeoenvironmental context (Bailey *et al.* 1984, 1986). The total excavated area is 51 m^2 and the layout of the excavation forms a transect from the back wall of the shelter to the front limit of the shelter floor (Figure 40.1). The deposits are generally very dense and the unique feature of the site was a hearth, represented by lenses extremely poor in finds' content, and located in the well–protected area near the back wall of the shelter .

Rockshelter sites like Klithi are generally characterised by low spatial resolution. Their micro topography may act as a sediment trap and stratigraphic layers do not necessarily represent distinct occupation surfaces. Consequently, most studies are confined to an examination of the variation within archaeological assemblages along a temporal axis, while they neglect or avoid consideration of the spatial variation. Although spatial questions were part of the agenda, until the present pilot study the discussion was based mainly on the overall impression of the excavators.

The aims of spatial analysis at Klithi at this stage were exploratory. The first aim was the identification of the overall, redundant, patterning across space, which would subsequently enable decisions to be made for future detailed spatial analysis by incorporating faunal and small finds data. In other words, this pilot study was aimed at establishing, whether it would be worthwhile undertaking "fine–grained" spatial analysis in this type of site. The second aim was the definition of the appropriate units for spatial analysis .

Three points are of general interest:

1) the unique feature of the entire excavated site is the hearth in the back trench;
2) there is little variation in the density of lithic and faunal specimens over the whole site; and
3) the front area at the shelter mouth, seems to yield longer bones usually burnt and more non–meat bearing bones than the back area around the hearth.

Therefore, according to the excavators (Bailey *et al.* 1986:20), spatial variation is expected on two scales:

1) around the major hearth;
2) between the hearth area and deposits elsewhere in the site.

40.3 THE METHODOLOGY ADOPTED

The development of spatial analytical methods has always been closely integrated with the models under investigation. For a detailed overview of the analytical techniques see Carr (1984) and Blankholm (1991). The majority of recent methodological approaches no longer restrict their aim to definition of activity areas, but view spatial distributions of objects as complex entities, consisting of various quantitative and qualitative attributes. The attempt is made to analyse the distributions in terms of the inherent attributes, created during the formation of the archaeological record (Carr 1987, Hietala 1984). Due to variation in the ways lithic specimens are incorporated into the archaeological record, the emphasis in the analysis was given equally to the tools themselves and to the by–products of tool manufacture.

As this study considered the lithic assemblage from the first three years of excavation, it was not expected to provide a full picture of the spatial patterning in the site. The variables entered in the analysis were tool and debitage types, cores, raw material categories, breakage and cortex patterns. During this stage of analysis, a minimum number of assumptions were made regarding the range of activities and the variables, which contribute in the overall site structure. Two broad categories of activities, related to stone implements, were expected: manufacture and use of tools. Breakage was assumed to occur, partly during postdepositional incidents for all the specimens; in debitage and cores partly during tool manufacture; and in tools partly during their utilisation. Cortex on debitage indicates early stages in preparation of blanks for tool manufacture.

A multi–stage approach was adopted throughout the study. Starting from visual inspection of distributions, it proceeded with more sophisticated heuristic techniques. A fundamental criterion for selecting the analytical methods, was to avoid any prior assumptions regarding the structure of the archaeological record, thus allowing the analysis to reveal the patterning in spatial distributions regardless of our preconceptions for the site. In due course, Simple Descriptive Statistics, Correspondence Analysis, Multiple Response Permutation Procedures and Unconstrained Cluster Analysis were applied.

The selection of analytic methods is determined by the current questions and the data at hand. In the past, the degree of precision with which the location of artefacts had been measured used to delimit the subsequent analysis. However, most of the currently available techniques operate both with cell frequency and point location data. Cell frequency data was used for this study. Although it may be argued, that with cell frequency techniques an amount of detail and accuracy is lost, they have the potential to reveal areal trends and they have often been preferred for reasons of fieldwork economy.

The main problems are: first, the very large number of excavated specimens; second, the lack of clearly defined occupation surfaces within the stratigraphic units; and third, the patchy excavated sample of the site. Therefore, the use of robust computerised data handling and analysis methods is essential. The second problem has been resolved, but not unravelled, by analysing the data in two fashions. Initially by ignoring the depth information and aggregating all the layers, thus examining the data simply in two dimensions, and then by testing the distributions in each one of the seven main layers separately[1], in order to establish the relationship between the overall patterning (i.e. at a site level) and contextual patterning (i.e. at a stratum level) . The sample of the excavated site, although patchy, is considered to represent adequately the three main areas of the rockshelter (i.e. the sheltered part, the part outside the drip and shade lines and the unprotected part in the front). It should be noted that despite the considerable size of Klithi ($700m^2$) the sheltered area is notably small.

The data was handled in several tables using the SIR Data Base Management System, which was thought to be the best available at that time on the Southampton IBM 3090 for two reasons:

1) it provided substantial SQL facilities, for querying the data base;
2) it had a satisfactory interface with a high level programming language, thus enabling me to link the data base with an interactive graphics program.

40.4 MULTIPLE RESPONSE PERMUTATION PROCEDURES

Multiple Response Permutation Procedures were introduced by Berry *et al.* (1980,1984) and aim to trace spatial patterning in distributions of items over a site by performing rigorous permutation tests. The tests detect any locational differences in distribution of item classes. Three of the MRPP

1 A study currently in progress.

features make them a valuable tool for spatial analysis at Klithi:

- they do not require any distributional assumptions;
- they operate either with cell frequency data or point location data, in one, two or three dimensions;
- they are able to deal with non–contiguous site structure.

The tests evaluate seven variables (test statistic, distance adjuster, observed delta, expected delta, variance of delta, skewness of delta, probability), which provide the means for describing the distributions. The primary unit of analysis is the average distance between artefacts within classes. The average distance in each class is calculated on the basis of pairwise association of all items in the class. Henceforth, small average distance indicates tendency towards clustering in the particular class and separation between different artefact classes. If this is so, the observed sampling distribution (delta) will be smaller than the other delta values. If the probability value is also small, then locational difference in distribution of items is evident. Locational difference can stem either from concentration or from separation of items. In such a case the differentiation of the varying distributions will be made through the average distance values. In the case of separation, the average distance values should be similar in magnitude and smaller than the expected delta value. In the case of concentration, the average distance values differ in magnitude and one or more of the values is greater than the expected delta. The possibility of concentration and separation within artefact classes can be tested only by visual inspection of the plot of data distribution (Berry *et al.* 1984; Rodgers 1988).

The version of the program, which was used (MRPPX) runs on the SUN workstations at Southampton University and has a user friendly interface. In case of large assemblages, such as the Klithi lithic industry, a random sampling procedure is recommended (Berry *et al.* 1984) , so that computation time will be kept to a reasonable level. A sampling strategy was adopted in the present application, with random sampling without replacement.

The basic hypothesis was that if manufacture and use of tools had taken place in different areas of the site and assuming that tools were discarded at the location of their use, then debitage should be differentially distributed from tools within the intra–site space. Earlier attempts to enter in the analysis several artefact classes at a time, failed to detect any significant patterning. As the presence of non–significant variables could have introduced a background 'noise' and thus blurred the result, I decided to examine pairs of variables: the two main types of tools (i.e. backed bladelets and endscrapers) and the blanks on which they are formed (i.e. bladelets and flakes) were selected and comparisons of bladelets with backed bladelets, of flakes with endscrapers. In addition the impact of breakage information for the tools was examined by analysing whole and broken backed bladelets and endscrapers. Ten trials were carried out for each of four pairs of artefact classes, for 0.5 m and 1 m minimum provenance units.

The first four tests were carried out for specimens with a one meter square provenance unit.

Test 1 (Table 40.1) compared endscrapers with flakes. The probability value was calculated as .092. Considering as statistically significant results only those less than .05, the first attempt did not detect any significant patterning in the data.

Test 2 (Table 40.2) compared backed bladelets with bladelets. The probability value was calculated as 3.317E–05, a statistically significant result. The average distance values are different from one another and in the backed bladelets equals 2.156, which is greater than the expected delta of 1.687. Therefore the test revealed evidence of concentration.

Test 3 (Table 40.3) compared whole backed bladelets with broken ones. The probability value was calculated as 3.5937E–05, a statistically significant result. The average distance values are similar (3.449 and 2.962) and smaller than the expected delta (3.67). Therefore the analysis revealed evidence for separation.

Test 4 (Table 40.4) compared whole and broken endscrapers. The probability value was calculated as .147, thus failing to detect any patterning in the data. This may be interpreted as a safe indication of the discard of broken and whole endscrapers at the same areas.

The last four tests were carried out for the same classes of artefacts having 0.5 m square provenance unit and yielded similar results to the first four tests.

Test 5 (Table 40.5) compared endscrapers with flakes. The calculated probability value (.222) is statistically non–significant. Therefore no patterning was revealed in their relative distributions.

Test 6 (Table 40.6) compared backed bladelets with bladelets. The probability value was calculated as .013, a statistically significant result. The

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of 2.831
Group number 2 of size 100 has an average distance of 1.062
The test statistic = -2.803
The distance adjuster = .1000E+01
The observed delta = 1.996
The expected delta = 2.143
The variance of delta = 9.2883E-04
The skewness of delta = -2.568
The probability of a T this extreme or more extreme = .092

Table 40.1: Results for test 1

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of .723
Group number 2 of size 100 has an average distance of .2.156
The test statistic = -10.421
The distance adjuster = .1000E+01
The observed delta = 1.551
The expected delta = 1.678
The variance of delta = 1.7121E-04
The skewness of delta = 1.971
The probability of a T this extreme or more extreme = 3.317E-05

Table 40.2: Results of test 2

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of 3.449
Group number 2 of size 100 has an average distance of 2.962
The test statistic = -14.073
The distance adjuster = .1000E+01
The observed delta = 3.212
The expected delta = 3.67
The variance of delta = 1.093E-03
The skewness of delta = -2.533
The probability of a T this extreme or more extreme = 3.5937E-05

Table 40.3 Results of test 3

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of 6.18
Group number 2 of size 100 has an average distance of 5.072
The test statistic = -2.056
The distance adjuster = .1000E+01
The observed delta = 5.626
The expected delta = 5.712
The variance of delta = 1.8477E-03
The skewness of delta = -2.114
The probability of a T this extreme or more extreme = .147

Table 40.4: Results of test 4

average distance values differ and that of backed bladelets (2.698) is greater than the expected delta (2.146). Therefore concentration of the particular class of tools and their blanks is the conclusion.

Test 7 (Table 40.7) compared whole with broken backed bladelets and yielded a statistically significant probability value (2.6662E–5). The average distance values (3.555 and 2.725) are similar and one of them is smaller than the expected delta (3.519). Therefore there is evidence for separation in broken and entire backed bladelets.

Test 8 (Table 40.8) compared whole endscrapers with broken ones. The probability value was calculated as .243 and thus it did not reveal any patterning in the distribution.

Conclusively, the analysis has not detected any patterning in the distributions of flakes and endscrapers and in the distributions of broken and whole endscrapers, while it has revealed evidence for concentration of bladelets and backed bladelets and evidence for separation of entire and broken backed bladelets. Furthermore MRPP evidenced no significant differences in the results from different size provenance units. Therefore one meter squares hold sufficient information and may reasonably be used as the spatial units in subsequent analyses.

40.5 UNCONSTRAINED CLUSTER ANALYSIS

40.5.1 Introduction

Unconstrained Cluster Analysis (UCA) was introduced by Whallon (1984) and it is not a new multivariate method *sensu stricto* but a combination of heuristic techniques, that operate under minimum constraints. UCA is the result of research directed towards the development of analytical techniques operating in accordance with the formation processes and the structure of the archaeological record. It advocates that the description of spatial structure should not be conditioned by the methods of analysis employed and it involves:

1) drawing of smoothed spatial distributions for visual inspection;

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of 1.936
Group number 2 of size 100 has an average distance of .872
The test statistic = -2.018
The distance adjuster = .1000E+01
The observed delta = 1.405
The expected delta = 1.598
The variance of delta = 1.2145E-04
The skewness of delta = -2.099
The probability of a T this extreme or more extreme = .222

Table 40.5: Results of test 5

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of 1.396
Group number 2 of size 100 has an average distance of 2.698
The test statistic = -6.409
The distance adjuster = .1000E+01
The observed delta = 2.046
The expected delta = 2.146
The variance of delta = 3.49E-04
The skewness of delta = -1.874
The probability of a T this extreme or more extreme = .013

Table 40.6: Results of test 6

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of 3.555
Group number 2 of size 100 has an average distance of 2.725
The test statistic = -13.926
The distance adjuster = .1000E+01
The observed delta = 3.065
The expected delta = 3.519
The variance of delta = 1.0695E-03
The skewness of delta = -2.475
The probability of a T this extreme or more extreme = 2.6662E-05

Table 40.7: Results of test 7

Input consists of: 200 data points
In 2 dimensions
There were 2 groups
Sizes 100 100

Group number 1 of size 100 has an average distance of 6.213
Group number 2 of size 100 has an average distance of 5.107
The test statistic = -2.076
The distance adjuster = .1000+01c
The observed delta = 5.651
The expected delta = 5.747
The variance of delta = 2.0308E-03
The skewness of delta = -2.1526
The probability of a T this extreme or more extreme = .243

Table 40.8: Results of test 8

2) density calculation of each class of artefacts for each data point;
3) conversion of the absolute densities into relative ones for each data point;
4) application of cluster analysis to the multivariate local density matrix created during step 3;
5) plotting of the clustered data points on the site plan and inspection for spatial integrity;
6) and finally description of the clustered groups in terms of size, shape, density composition, and internal patterns of co–variation with a view to later interpretation of the processes which created the pattern (Whallon 1984).

An alternative way of implementing the same technique (with parallel application of correspondence analysis and hierarchical cluster analysis during the fourth step) has been proposed by Djindjian (1988). Basic units in the analysis were the 52 meter squares. The variables which were entered in the analysis were core, flake, blade, bladelet, endscraper, backed bladelet, other tools, and raw materials.

40.5.2 Visual inspection

At the first steps UCA involves representation of the distribution of each class over the area being analysed. Whallon suggests smooth density contour maps for this purpose. A first attempt to draw density contours (using UNIRAS) was not satisfactory, due to the non–contiguous nature of the excavated area. Instead, plots of densities were produced by an interactive graphics program, which was developed especially for Klithi. It is a host application program, written in FORTRAN (Galanidou 1989: appendix I), and it is linked to the SIR data base, from which it gets the frequency and provenance information for artefact classes. Then it displays absolute densities of variables on the two–dimensional site plan. The program runs on the IBM 3090 and produces output on an IBM 5080 graphics screen or colour hardcopy on the IBM 5087 laser printer[2].

2 Colour hardcopy output unfortunately cannot be reproduced in this publication.

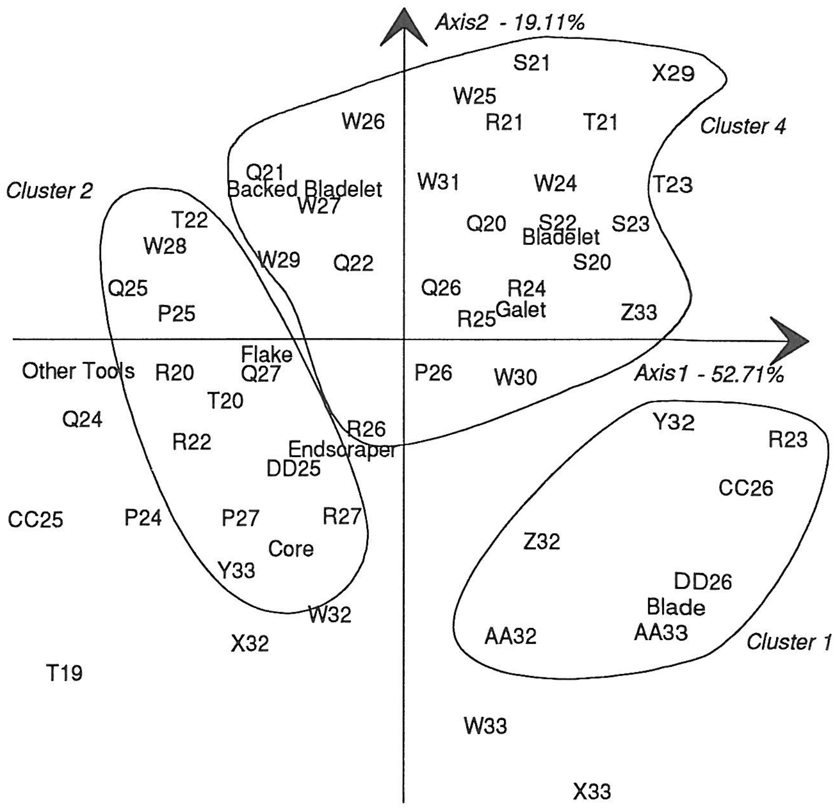

Figure 40.2: Correspondence analysis plot, Klithi lithic assemblage classes and provenance units. Clusters separated through cluster analysis (see 40.5.4) are indicated on the plot.

The visual inspection of the distributions has shown that there exist three distinct groups of concentrations. The first one has very high densities of tools and debitage and it is located in the well–protected part of the shelter around the hearth; the second group has medium densities of tools and debitage and similar densities of cores and raw nodules, and extends from just outside the drip line to just outside the shade line; and the third group has generally low densities of items in all classes and is located in the shelter front, near the talus.

40.5.3 Correspondence analysis

The percentages of the eight artefact classes were evaluated for each provenance unit (1 m square) (Table 40.9) and Correspondence Analysis was applied. The first two axes account for the 71.82% of the total variation being exhibited on the plot (Figure 40.2). The horizontal axis (52.71%) contrasts bladelets, galets, and blades with other tools, flakes and cores. The vertical axis (19.11%) contrasts backed bladelets, bladelets and galets with the rest. When examining the relationship between variables and squares (Figure 40.2), one may see three main clusters of squares related I. to blades, II. to backed bladelets, bladelets and galet and III. to flakes, endscrapers and cores. The first axis indicates a concentration of distinct artefact classes (all types of tools, flakes and cores), which are related both to tool manufacture and utilisation. The second axis seems to differentiate squares according to the criterion of size of the artefacts they yielded.

40.5.4 Cluster analysis

Cluster analysis was then performed on the same data, by the hierarchical average method available in CLUSTAN. The results are plotted on the site plan (Figure 40.3). Four main clusters with high levels of similarity were defined. CA and cluster analysis yielded similar although not identical results. With the exception of T23, which is grouped with cluster 4 on the CA plot, squares from clusters 1, 2 and 4 form distinct groups on the same plot. Cluster 3 does not form a distinct group on the CA plot. Squares W33, X33 are rather loosely clustered with cluster 1 and the rest are close to cluster 2. It becomes apparent that the pattern of variation in this set of data is quite

Square	Core	Flake	Blade	Bladelet	Endscraper	Backed blt.	Other	Galet
AA32	3,24	41,70	23,48	22,27	2,02	4,86	2,02	0,40
AA33	4,65	32,35	27,51	24,38	2,09	5,31	1,90	1,80
CC25	7,41	70,37	0,00	11,11	0,00	11,11	0,00	0,00
CC26	4,87	17,48	29,80	40,97	2,01	4,01	0,57	0,29
DD25	4,84	62,68	3,70	12,54	2,28	9,69	3,13	1,14
DD26	5,49	28,52	26,01	29,47	2,27	5,97	1,31	0,95
P24	11,03	43,75	1,84	8,09	2,57	14,34	18,38	0,00
P25	3,73	45,75	4,62	28,61	1,79	10,43	4,02	1,04
P26	3,04	34,39	14,62	31,04	2,29	7,37	5,95	1,30
P27	5,17	49,90	5,89	14,58	3,60	9,22	9,55	2,03
Q20	3,57	34,59	5,41	37,87	2,43	10,27	5,21	0,65
Q21	2,75	41,40	2,20	24,48	2,89	19,39	6,46	0,41
Q22	3,81	40,51	4,56	31,15	2,15	10,60	2,40	4,81
Q24	5,91	50,71	0,41	9,78	0,61	16,50	16,09	0,00
Q25	2,69	52,17	0,60	23,77	1,35	10,76	8,52	0,15
Q26	2,58	41,85	6,13	28,27	1,11	9,23	8,41	2,44
Q27	4,20	50,71	4,33	15,07	2,72	9,77	12,23	0,97
R20	5,52	49,02	2,69	15,61	3,41	15,47	6,32	1,96
R21	3,51	28,70	6,52	38,60	2,63	16,29	3,63	0,13
R22	5,04	58,94	2,52	12,17	2,94	12,68	3,95	1,76
R23	1,44	21,48	26,72	36,28	1,44	11,20	1,23	0,21
R24	3,51	25,51	13,86	37,34	0,18	9,61	9,06	0,92
R25	2,39	38,40	9,73	27,47	2,22	10,75	6,14	2,90
R26	3,64	42,82	10,59	18,91	1,94	12,53	7,86	1,71
R27	5,44	53,80	4,92	17,66	2,09	8,20	5,66	2,24
S20	2,70	26,09	13,66	38,53	1,71	14,00	1,90	1,41
S21	1,37	25,28	3,64	42,14	0,57	20,16	2,73	4,10
S22	2,89	28,24	13,14	32,90	1,77	16,78	3,82	0,47
S23	2,01	20,71	16,42	38,41	0,55	15,97	1,28	4,65
T19	9,03	73,24	0,00	2,34	3,01	4,35	4,68	3,34
T20	4,35	47,95	9,13	22,18	1,88	12,37	1,71	0,43
T21	3,35	34,88	11,81	30,37	1,34	14,55	2,19	1,52
T22	2,36	52,85	0,59	25,15	0,20	14,73	3,34	0,79
T23	2,85	17,91	15,06	50,24	1,43	11,09	1,43	0,00
W24	1,89	29,17	12,77	32,22	1,45	13,64	4,64	4,21
W25	2,17	29,55	5,01	38,90	0,83	17,03	4,34	2,17
W26	1,89	35,53	1,10	28,30	1,43	22,80	8,33	0,63
W27	3,27	40,77	2,18	29,17	3,08	13,29	6,05	2,18
W28	2,96	45,67	4,08	25,69	2,39	14,57	4,01	0,63
W29	3,94	40,71	3,35	25,54	2,59	16,31	6,86	0,70
W30	5,83	29,90	14,57	29,96	2,20	8,92	7,43	1,19
W31	9,62	29,21	3,26	37,29	1,72	11,86	3,95	3,09
W32	13,99	30,04	10,70	26,34	2,06	4,94	9,88	2,06
W33	7,04	23,12	32,66	20,10	4,02	4,52	7,54	1,01
X29	1,94	33,81	9,27	36,38	1,87	12,49	3,22	1,12
X32	18,59	38,19	6,53	22,61	2,51	3,52	2,51	5,53
X33	11,66	23,03	36,73	15,45	2,92	4,08	4,96	1,17
Y32	5,21	19,79	22,40	34,90	1,56	13,02	1,56	1,56
Y33	8,02	50,47	1,42	16,98	2,83	7,55	12,74	0,00
Z32	3,21	31,38	26,47	25,71	2,27	7,56	1,51	1,89
Z33	5,02	26,16	16,31	37,46	1,97	8,78	1,25	3,05

Table 40.9: Percentages of eight artifact classes in each provenance unit (1m square).

complex, and that any interpretation should be validated against the artefact content of each square.

Cluster 1 is located in peripheral parts of the site in the south and east trenches as well as in R23 and T23. It is characterised by squares yielding high proportions of blades.

Cluster 2 is found mainly in the part of the site within the shade line and in the periphery of the hearth. It is characterised by squares yielding exceptionally high proportions of flakes and of all types of tools.

Cluster 3 is located in the periphery of the site in the south trench, the east trench and near the north and west wall. The composition of the squares in this cluster is determined by high proportions of cores, flakes and galets and very low proportions of bladelets and backed bladelets.

Cluster 4 is the most numerous and it is located inside the shade and drip lines and along the north – south axis (*x* co–ordinate W). The composition of the squares represents the average composition of the site and is characterised by high proportions of bladelets and backed bladelets (which is the most abundant tool in the site).

40.5.5. Discussion

By juxtaposing the clusters and the relative densities of artefact classes in each square, one may see a localised pattern of high proportions of cores and debitage for clusters 1 and 3. The problem in interpreting it resides in the fact that such a specialisation may be attributed to several factors. There are at least three possibilities: that these were tool manufacturing or rubbish disposal areas; that they are locations where, due to exposure to heavy weathering, only larger pieces have survived; that they were areas of "toss" rather than "drop" so that any larger pieces were deposited in the first place. Two points should attract one's attention. First, the absolute densities from all the squares outside the rock overhang are significantly lower than the ones inside the drip line. Second all artefact classes are represented. If these were areas where manufacture of tools took place, primary stages in reduction sequences represented by cortex on debitage would be expected. By inspecting the percentages of cortex on debitage in the squares from the south trench, no significant pattern was identified and therefore this hypothesis was rejected. The front trench is noteworthy in that it yields larger pieces of flint

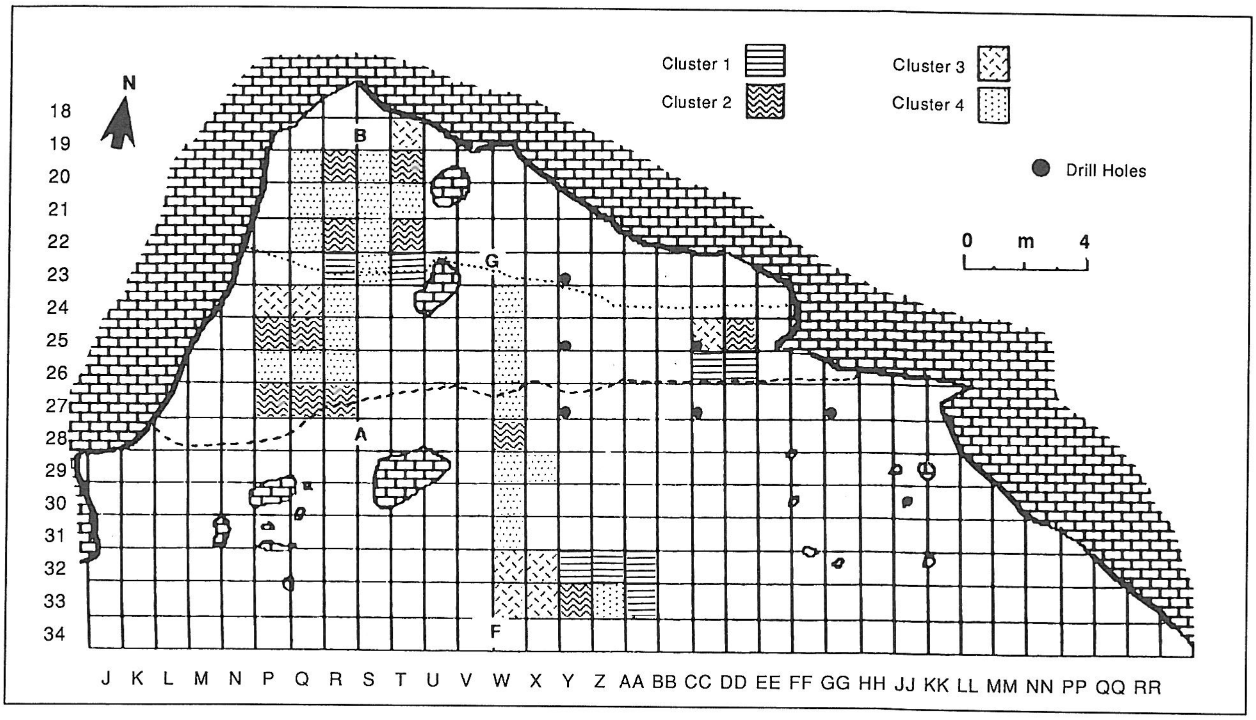

Figure 40.3: Four main clusters.

(i.e cores, flakes, blades). A similar observation, for the bone specimens, has already been made by the excavators (Bailey *et al.* 1986). It is possible that size as a sorting factor, and breakage are key variables to understanding the patterning in this part of the site and there is a need for further research in this direction.

Cluster 2 seems to be significant as it may reflect refuse areas created by clean–up around the hearth and elsewhere. Unfortunately, with the data at hand, this conclusion is only tentative. It is possible that size and breakage patterns could throw further light on the interpretation of these areas as well.

Cluster 4 seems to represent areas with evidence for an overlap of tool manufacture and tool use activities as these are documented by the presence of bladelets and backed bladelets (a pattern also revealed by MRPP). However one of the weak points of UCA is that it is unable to define overlapping distributions.

40.6 CONCLUSION

Application of quantitative techniques for analysing spatial variation at Klithi has revealed patterning in the data distributions in addition to that observed during the excavations. The distributions of tools and of debitage do not indicate any areal trend. Manufacture and use areas seem to overlap in the part of the shelter which provides the most sheltered conditions. The hearth area does not seem to be the location of a specialised activity but rather the locus around which many activities in the camp site were performed. However, this can only be a tentative conclusion until the pattern of distribution for each stratigraphic unit has been recognised and analysed. In the south trench, a concentration of proportions of large specimens is noted. The overall very low quantity of artefacts yielded make obvious a different pattern of utilisation or preservation of this area from the rest of the shelter. But unless detailed analysis of the fauna and the whole artefact assemblages is pursued, interpretations of possible functions of this part of the site remain tentative.

There is a lot of scope for undertaking fine grained analysis, by working with 1 meter squares, and establishing relationships between spatio–temporal units (i.e. strata) and patterns of spatial distributions. UCA has provided very satisfactory results and has highlighted possible directions for further research. To the question «does an appropriate method for analysing the organisation of space in rockshelters exist?» the answer is no, there are no recipes. The strength of complementary use of multiple alternative techniques in the early stages of pattern recognition has a great potential, which, I hope has been illustrated through this pilot work at Klithi.

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