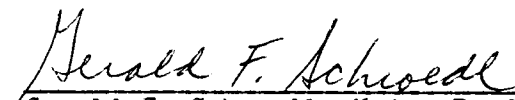
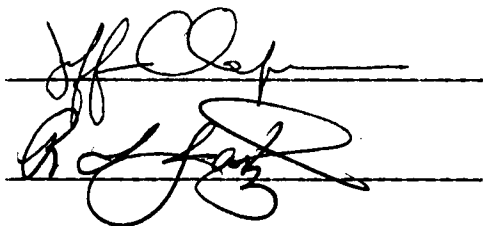


To the Graduate Council:

I am submitting herewith a thesis written by William W. Baden entitled "Mathematical Modelling of Ceramic Assemblages." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.


Gerald F. Schroedl, Major Professor

We have read this thesis
and recommend its acceptance:



Accepted for the Council:


Vice Chancellor
Graduate Studies and Research

MATHEMATICAL MODELLING OF
CERAMIC ASSEMBLAGES

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

William W. Baden

March 1932

3057927

To my mother and father
For being excellent models

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ABSTRACT

A majority of the archaeological research conducted on ceramic assemblages is directed towards delineation of assemblage associations or "relatedness" through the use of seriation and cluster algorithms. Research proposed here redefines this problem in terms of mathematical modelling procedures. The assemblage creation process is seen as stochastic and suitable for reduction to a programmable sherd production model.

Four normative groups are defined, a priori, in terms of the mean expected relative frequency of 33 whole vessel types. Thirty assemblages, each composed of 100 vessels, are developed as random variations about each of the four mean group vectors. The resulting whole vessel assemblages are then transformed into sherd assemblages according to the parameters of a random breakage model.

The whole vessel assemblages are subjected to seriation and cluster solutions to delineate the inherent assemblage associative interrelationships. The same techniques are then applied to the sherd assemblages which are defined in terms of nine traditional motif types, 26 motif/vessel-portion types, and 26 motif/vessel-portion types weighted by relative sherd size. The latter designation scheme provided the best correlation with the whole vessel solutions.

The results of this project suggest that mathematical modelling is a useful tool in artifact analysis in that it: (1) helps to organize theoretical beliefs and empirical observations, (2) improves understanding of archaeological systems, (3) suggests the need for

detail in describing archaeological remains, (4) facilitates the manipulation of systems, and (5) is less expensive than comparable analyses of real systems.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
Statement of Purpose	1
Statement of the Problem	2
II. THE ASSEMBLAGE MODEL	9
System Definition	9
Model Formulation	.17
Data Preparation	.20
Model Translation.	.30
III. ANALYSIS OF THE WHOLE VESSEL ASSEMBLAGES	.39
IV. ANALYSIS OF THE SHERD ASSEMBLAGES.	.55
Traditional Analysis	.53
An Alternative Analysis.	.69
V. DISCUSSION	.95
LIST OF REFERENCES	100
APPENDIXES	105
APPENDIX A . PROGRAM LISTING.	106
APPENDIX B. TABULATION OF WHOLE VESSEL TYPES.	117
APPENDIX C. TABULATION OF NINE SHERD MOTIF TYPES.	149
VITA	154

LIST OF TABLES

TABLE	PAGE
1. Probability distribution of sherds by size and vessel portions	.15
2. Constants for each of the type vessel's profile equations	.22
3. Mean vessel size parameters	.28
4. Cumulative probabilities of sherd types broken down by size for shell tempered jars	.29
5. Cumulative probabilities of sherd types broken down by size for shell tempered bowls.	.29
6. Cumulative probabilities of sherd types broken down by size for quartz tempered jars.	.29
7. Length and width statistics for shell tempered sherds	.31
8. Results of Chi-square and Kolmogorov-Smirnov (K-S) tests on n normal deviates using each assemblage group's seed values and IMSL's GGNML algorithm.	.33
9. Input parameters.	.34
10. Output statistics	.35
11. Total number of shell tempered sherds coded by size for each group.	.36
12. Total number of quartz tempered sherds coded by size for each group.	.36
13. Vessel size statistics by group and vessel type	.38
14. Sequences of whole vessel assemblages derived from a seriation of the relative frequencies of 33 types defined in terms of assemblage totals (A), group totals (B), and total number of vessels (C)	.42
15. Possible occurrences of motifs on sherd vessel portions	.56
16. Seriation sequences of whole vessel assemblages (A) and sherd assemblages defined by nine types (B)	.60
17. Seriation sequences of whole vessel assemblages (A), sherd assemblages defined by nine types (B), and sherd assemblages defined by 26 types (C)	.76

LIST OF FIGURES

FIGURE	PAGE
1. Large jar profile	.23
2. Small jar profile	.24
3. Hemispherical bowl profile.	.25
4. Cazuela bowl profile.	.26
5. Complete linkage clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types	.47
6. Single linkage clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types	.48
7. Average linkage (within) clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types. . .	.49
8. Average linkage (between) clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types. . .	.50
9. Ward's method clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types	.51
10. Plot of units defined by the first two factor scores representing Type 2 relative frequencies of 33 vessel types	.53
11. Complete linkage clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds.	.63
12. Single linkage clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds.	.64
13. Average linkage (within) clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds	.65
14. Average linkage (between) clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds	.66
15. Ward's method clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds.	.67
16. Plot of units defined by the first two factor scores representing Type 1 relative frequencies of nine types of sherds	.68

FIGURE	PAGE
17. Complete linkage clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds.	.70
18. Single linkage clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds.	.71
19. Average linkage (within) clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds .	.72
20. Average linkage (between) clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds .	.73
21. Ward's method clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds.	.74
22. Plot of units defined by the first two factor scores representing Type 2 relative frequencies of nine types of sherds	.75
23. Complete linkage clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types.	.79
24. Single linkage clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types.	.80
25. Average linkage (within) clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types	.81
26. Average linkage (between) clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types	.82
27. Ward's method clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types.	.83
28. Plot of units defined by the first two factor scores representing Type 1 relative frequencies of 26 motif/portion types	.84
29. Complete linkage clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types.	.86
30. Single linkage clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types.	.87
31. Average linkage (within) clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types	.88

FIGURE

PAGE

32. Average linkage (between) clustering of units defined
in terms of Type 2 relative frequencies of 26
motif/portion types 89
33. Ward's method clustering of units defined in terms
of Type 2 relative frequencies of 26 motif/portion types. . . .90
34. Plot of units defined by the first two factor scores
representing Type 2 relative frequencies of 26
motif/portion types 91
35. Ward's method clustering of units defined in terms
of Type 1 relative frequencies of 26 weighted
motif/portion types 92
36. Ward's method clustering of units defined in terms
of Type 2 relative frequencies of 26 weighted
motif/portion types 93

CHAPTER I

INTRODUCTION

Statement of Purpose

The purpose of this thesis is: (1) to develop a modelling sequence for defining formal ceramic variability, and (2) to incorporate the model in a comparative examination of statistical techniques currently used by archaeologists to order ceramic assemblages. This research suggests that the translation of archaeological problems into mathematical terms and statistical relationships can aid the development of appropriate quantitative solutions to archaeological problems. The thesis is not meant to be a critique of any particular application. Rather, it is an examination of current statistical trends in ceramic analyses with particular emphasis placed on their mathematical implications.

To accomplish these goals anthropologically useful representations of ceramics are defined in mathematical terms. The resulting mathematical model is then formalized into a computer program which produces sherds coded according to their group affiliation, temper, motif, and size. Although certain whole vessels and numerous sherds from Overhill Cherokee contexts were examined in order to realistically define vessel forms, styles, and breakability patterns, the actual output is not a simulation of any specific cultural manifestation. The approach is meant to provide a procedural model for future research. The conclusions are intended to provide guidelines for the application of commonly used statistical techniques such as principal component and cluster analyses.

Statement of the Problem

Ceramic analysis, within the archaeological research paradigm, can be defined as the actions taken by ceramic specialists to derive information useful in characterizing culture histories, culture lifeways, and culture processes. The phenomena, or entities, of study are ceramic vessels and sherds preserved in archaeological deposits. These entities are defined by observable, non-randomly assigned characteristics distributed within mineralogical, technological, and stylistic/formal attribute dimensions. Collectively the phenomena constitute a finite set of attribute combinations. The incorporation of ceramic evidence into the process of addressing anthropological research goals involves mapping (elemental one to one correspondence) specific sets of question-oriented observations (that is, data in the strictest sense) into corresponding sets of comprehensible patterns or expectations using valid mathematical techniques.

A review of recent theoretical literature dealing with ceramic studies suggests that archaeologists are most interested in defining the distribution of formal styles across time and space (Dunnell 1970, Gelfand 1971a and 1971b, Cowgill 1972, David 1972, Whallon 1972, McNutt 1973, Read 1974, Borillo 1974, LeBlanc 1975, Johnson and Johnson 1975, Drennan 1976, Erikson and DeAtley 1976, Meighan 1977, Dickens and Chapman 1978, and Ester 1981). The majority of these studies involve the application of various seriation or clustering techniques to delineate chronological orderings and affinity relationships between

cultural manifestations. Combined, these procedures form an associative class of analyses incorporating mathematical techniques which produce ordered sequences based on specified criteria. The anthropological relevance of such studies lies at the interface linking the data, the technique, and the statistical results.

In terms of general trends, associative techniques are incorporated into the archaeological paradigm through two kinds of presentations. The first provides a methodological perspective on the subject wherein techniques are developed in a cookbook or "how-to-do-it" fashion. Such a presentation generally includes a "test" to demonstrate the efficacy of the method which utilizes simplistic imaginary data or a sample of excavated assemblages having suspected associative relationships. If the interpretations drawn from the statistics agree with the a priori ordering of the assemblages then the technique is deemed useful. Generally sufficient discussions on the assumptions and limitations of the technique in question are ignored. The primary goal is the documentation of a successfully applied statistical technique, where success is measured by the apparent acceptability of the statistical conclusions. Such an approach often characterizes descriptive reports or articles where an argument requires quantitative substantiation.

The second kind of presentation develops a theoretical perspective on associative analyses. The assumptions and limitations of specific techniques are discussed within the context of current archaeological theory, but, actual data manipulations are seldom incorporated in the presentation. This approach is generally used to criticize applications of the first approach.

Both types of presentations tend to concentrate on the structure of the analytical technique rather than on the conceptualization of archaeological data in terms appropriate to solving the ordering problem. Statistical analysis of archaeological data involves mapping elements of a set of observations defining culturally produced entities (such as relative frequencies of sherd types) into a set of patterned responses (such as a chronological sequence). In the case of associative analyses the observations are assemblage characteristics and the responses are ordered sequences. A data collection's statistical distribution parameters (e.g. probability density functions and variable types) help determine the set of analytical techniques appropriate for addressing specific questions. The profession has, in recent years, tended to place far too much emphasis on describing techniques more accurately presented in mathematical texts without attempting to first define, using its anthropological perspective, archaeological data in more universal ways.

The development of mathematical models is one way to define the data. Two types of models can be constructed. First, probabilistic models of artifact construction, use, discard, and recovery can be developed based on the observation of random variables believed to be related to each of these transitions. The random variables, when specified as probabilities of occurrence, provide parameters useful in replicating or simulating each artifact's formal alteration from one state to the next. Such models produce archaeological assemblages similar to their real-world counterparts. This procedure is useful in (1) assisting in conceptualizing material assemblages, (2) replicating

specific cultural manifestations in order to test processual hypotheses, or (3) creating data sets of known origins and affinities to test the conclusions of analytical techniques (Zubrow 1971, Zimmerman 1977, Aldenderfer 1977, Schiffer 1975, and Vierra and Taylor 1977).

Statistical models of associative relationships between archaeological remains constitute the second type of mathematical model. These models are incorporated in the statistical techniques archaeologists use to measure the variability within and between artifacts and assemblages. Although archaeologists may not think of a particular cluster algorithm as a model of variability, it is just that. Every statistical technique consists of a set of assumptions about the variables to be examined and a set of computational procedures used to measure the degree of fit between the assumed structure and the actual composition of the data. The response of the technique to the data provides insights into the characteristics of the data. Such models provide standard measures of variability by mapping observations into patterned responses.

Fred S. Roberts (1976:7-8), in his discussion of mathematical modelling, notes that if diverse fields of inquiry translated their individual problems into mathematical terms many seemingly dissimilar situations would find themselves having a common set of solutions. To help achieve this translation, Roberts describes a set of guidelines for mathematical modelling:

1. Gather real-world data (i.e. question oriented observations),
2. Through induction formulate assumptions into mathematical terms producing a mathematical model,

3. Using the model and deduction, produce mathematical predictions,
4. Translate these predictions into expectations that can be tested against real-world situations.

Archaeologists, in applying statistical models, tend to emphasize Steps 1,3, and 4, foregoing the inductive development of Step 2. This can result in the misapplication of a statistical procedure and subsequent misinterpretation of the data. Rigorous research should incorporate all four steps.

To apply associative techniques to an archaeological problem following these steps, one must first transform the real-world situation into a mathematical or, more specifically, a statistical model. In this research the model translates the structure of the data into associative terms related to the question of measuring the similarity between assemblages. One of the goals of this research is to test the application of such techniques. To do this with ceramic assemblages requires that there exists some a priori knowledge of the actual associative nature of the collections. Finding such a real-world data set presents two problems.

First, absolute associative information about real assemblages is at best tenuously defined in the archaeological record. Relative sequencing can be derived from absolute dating techniques or through stratigraphic superposition, but the accuracy of such an approach is dependent upon the error effects associated with the method. Although such assemblages can be mathematically defined, knowledge of their true associative structure may not be dependable enough for a test of associative methods.

Second, differential physical transformations and sampling biases could greatly distort the perceived archaeological associative pattern from the actual, parent cultural pattern. Failure to control for these factors prior to model development could result in generating a sequence of biases rather than cultural groups. For these reasons a test of statistical procedures would not appear to involve archaeologically derived samples.

Using imaginary collections in which associations between test assemblages are artificially specified could provide an alternative. Clear associations could be defined by this method. However, such collections would not necessarily represent real-world variability. A certain degree of complexity is desirable. Real situations are inherently complicated involving the interaction of many attributes and variables. Equally complex imaginary data tend to be difficult to create. Thus, artificially defined data would not necessarily provide a fair basis for judging the results of any procedure.

An alternative to setting up the test data in either of these two ways is to first model the assemblage production process, produce a collection of mathematically derived sherd assemblages of known affinities and composition, and then test the interpretive abilities of various statistical techniques applied to these modelled assemblages (for an example of such an approach see Grahm et al. 1975). By carefully modelling the assemblage production process according to the four stages defined by Roberts, useable assemblages can be generated for statistical tests. This research develops a model of ceramic variability and creates data suitable for comparing the conclusions

drawn from Brainerd-Robinson seriation (Brainerd 1951 and Robinson 1951), principal component analysis, and cluster analysis.

CHAPTER II

THE ASSEMBLAGE MODEL

System Definition

Archaeological cultures can be conceptually viewed as black box phenomena. The inner workings of their behavioral systems are now extinct and unavailable for direct observation. The only evidence of their past existence is found in the material residues produced by composite behaviors of the societies. One goal of archaeology is to provide an orderly and plausible explanation of the internal behavioral processes by observing the characteristics of the material output. This requires that two assumptions are made about archaeological data.

First, if the output of a cultural black box is patterned (i.e. observations are recurring) then the system that produced the material is, in a similar manner, patterned. Since culture can be defined as the sum total of all patterned behaviors in a human society, its material residues are also expected to be patterned. But it is important to recognize that this assumption stipulates that the patterned output must be related to the system's structure and not merely the result of random factors. Ideally, this makes it possible to accept interpretations derived from quantitative analyses as unbiased and strictly related to the cultural system.

Second, it is assumed that observed attributes are stochastic variables. This allows one to estimate system parameters from sample distributions obtained from individual artifact collections or assemblages. These two assumptions must be accepted if we are to derive

system information from output phenomena. If neither assumption is true then no meaningful knowledge will ever be derived from the archaeological record.

Before quantitatively modelling ceramic assemblages, some mathematical principles useful in redefining system residues into probabilistic terms must be developed. Cultural residues collectively take the form of artifact assemblages analytically defined by several material, stylistic and functional attributes. The attributes are non-randomly associated in a manner that produces recurring artifacts, which are analytically termed types and serve as benchmarks of material, stylistic and functional variability. Types can be strictly defined by stylistic attributes as is the case with a complicated stamped vessel or by functional characteristics like an endscraper. In the case of projectile points, both stylistic and functional properties can define types. The specific attributes used to define types vary according to the problem addressed. A valid type is one which adequately accounts for the attribute variability pertinent to a given problem orientation. In this study types are defined by their material and stylistic attributes.

Ceramic types represent non-random, dependent associations of elemental properties, such as temper, vessel form, and surface treatment, produced according to the constraints of their parent cultural system. As such they can be used to characterize cultural units, or more correctly, by-products of cultural units. Because the exact mechanisms of a particular system's ceramic production process are unknown, it is necessary to rely on a probabilistic representation of

its endproducts to define the parent complex. The distribution functions, relative frequency profiles, are assumed to shift in response to changes in the production process and mark cultural separations or evolutionary transitions. Modelling requires that ceramic variables be defined in such a way that they are sensitive to these changes so that statistical analyses can translate variability into meaningful, explanatory terms. The following example demonstrates how types can be defined for modelling purposes.

Suppose an archaeologist is asked to characterize a given shell tempered, check stamped jar. He or she would begin by noting that it displays distinctive characteristics within mineralogical, stylistic, and functional attribute dimensions (Functional aspects of vessels are difficult to discern and since they are not of direct concern to this study they will be ignored). The mineralogical portion of the attribute space is defined along a single, nominal temper dimension specifying all possible tempering agents. This random variable, X_1 , takes on the value "shell tempered" for this vessel. The stylistic portion of the space is defined by five independent dimensions which specify the physical appearance of the vessel. The first, X_2 , is vessel form (i.e. jar). The second, X_3 , is vessel size as measured by the outer surface area of the vessel. The third (X_4), fourth (X_5), and fifth (X_6) dimensions are nominal categorizations of the outer surface treatment of each of the three vessel portions (rim, neck, and body respectively). In this case X_4 , X_5 , and X_6 are each "check stamped". This vessel typology is based on the recognition of six random variables $\{X_1, X_2, \dots, X_6\}$. Artifact types are defined by the intersection of values associated with each of their attribute dimensions in an attribute space.

Assemblages are usually characterized by the relative frequencies of their constituent artifact types. If, from our example, a shell tempered, check stamped jar was a meaningful type, its occurrence (n) divided by the total population size (N) would represent its relative frequency within the assemblage. If the parent assemblage of vessels is representative of a cultural manifestation, then, n/N is a maximum likelihood estimate (m.l.e.) of the probability of finding shell tempered, check stamped jars within the population. Given a random sample of N^* vessels from an assemblage of similar origin we would, therefore, expect nN^*/N vessels to be jars of this type. Assemblages can therefore be defined by their coordinates in a probability space, where each dimension measures the relative occurrence (or popularity) of a specific vessel type.

These concepts can be expanded and applied to a total assemblage by defining more than one vessel type. Let type 1 (T_1) consist of plain rim (pr), plain neck (pn), and plain body (pb) vessels. This can be designated $T_1:\{pr,pn,pb\}$. Adding the attributes check stamped rim (cr), check stamped neck (cn), check stamped body (cb), and incised rim (ir), an assemblage of four types characterized by $T_1:\{pr,pn,pb\}$, $T_2:\{pr,pn,cb\}$, $T_3:\{cr,cn,cb\}$, and $T_4:\{ir,pn,pb\}$ can be defined. Let the "observed" frequency of each type be $n_1 = 30$, $n_2 = 10$, $n_3 = 20$, and $n_4 = 40$, respectively. The probabilities that each type will occur in this assemblage, collectively called the joint probability density function (p.d.f.), can be estimated to be: $P(T_1)=0.3$, $P(T_2)=0.1$, $P(T_3)=0.2$, and $P(T_4)=0.4$, where $P(T_1)=P(pr,pn,pb)$ etc.. Similarly the probabilities of attributes appearing, or the discrete marginal p.d.f.'s of each attribute, are:

$$P(pr)=0.4 \quad P(pn)=0.8 \quad P(pb)=0.7$$

$$P(cr)=0.2 \quad P(cn)=0.2 \quad P(cb)=0.3$$

$$P(ir)=0.4.$$

With these estimates and two given events or occurrences, A_1 and A_2 , conditional p.d.f.'s can be calculated according to:

$$P(A_2|A_1)=P(A_1 \cap A_2)/P(A_1)$$

If A_1 is the occurrence of a plain neck, A_2 is the occurrence of a plain rim, and $A_1 \cap A_2$ is the co-occurrence of a plain rim and plain neck, then observe that $P(A_1 \cap A_2)=0.4$ and $P(A_1)=0.8$. Therefore, the conditional probability of $A_2=pr$, given $A_1=pn$, [i.e. $P(pr|pn)$] is 0.5. Expressed another way one half of all types displaying plain necks have plain rims. Other examples include:

$$P(ir|pb)=0.4/0.7=0.57$$

$$P(pr|pn,pb)=0.3/0.7=0.43.$$

Thus, types are defined within attribute spaces and joint, marginal, and conditional probabilities can be estimated from population parameters used to define assemblages in probabilistic space. To model a population of vessels, the character of each type must be specified in such a manner. Such specifications define the population parameters representing the expected norms for a set of related assemblages. In this study the vessel types are defined by temper, form, size, and surface treatment over the rim, neck, and body portions of a vessel. The probabilities of these attributes occurring are subjectively defined by the author in a way that produces "popularity" trends across assemblages.

One final element of the system must be discussed before the actual model can be constructed. Archaeologically recovered ceramics seldom

consist strictly of whole vessels. Although types are herein defined in terms of whole vessel characteristics the actual output of the model is, like its black box counterpart, sherd counts segregated by attributes of size, motif of surface treatment, and represented vessel portions. To generate this output the model must anticipate the distribution of sherds by size and vessel portion combinations and code them according to the parent vessel's surface treatment(s).

Upon breaking, a vessel of a given size will produce a finite number of sherds of various sizes. The sherds can be characterized by the vessel portions from which they originated. Designating the portions present by R for rim, N for neck, and B for body, creates seven sherd types. Sherds can be further characterized by four arbitrary size classes based on the maximum length, L, of a sherd's long axis. These classes are mnemonically labeled Size 1, 2, 4, and 3 and are defined as:

Size 1 : $L \leq 2$ cm

Size 2 : $2 < L \leq 4$ cm

Size 4 : $4 < L \leq 8$ cm

Size 3 : $8 \text{ cm} < L$.

Tabulation of a large collection of sherds of a given temper by these attributes can produce a model of breakability for a whole assemblage. Conceptually the model takes the relative frequency of each sherd type, subclassified by size, as an estimate of the probability of its occurrence in the assemblage. An example of such a model is given in Table 1. Note that the probability of there being a Size 4 R-N sherd in an assemblage displaying this breakage distribution is 0.09. In other words nine out of every 100 sherds will be expected to be of this

Table 1. Probability distribution of sherds by size and vessel portions
(adapted from Baden 1981) (R=rim, N=neck, and B=body)

Sherd type	Size 1	Size 2	Size 4	Size 8	Total
R-N-B	0.0	0.0	0.0	0.0	0.0
R-N	0.0	0.01	0.09	0.0	0.1
R	0.03	0.04	0.03	0.0	0.1
N-B	0.01	0.01	0.01	0.0	0.03
N	0.0	0.01	0.01	0.0	0.02
B	0.42	0.22	0.12	0.0	0.76
R - B	0.0	0.0	0.0	0.0	0.0
Total	0.46	0.29	0.26	0.0	*1.01

*The total is greater than 1.0 due to rounding error.

type. Although this model is based on a particular assemblage's composition, by extending the meaning of the values it can represent an average measure of how a single whole vessel will randomly break. (Although structurally weak areas exist at various points across the vessel's surface, the actual breaking process can be assumed to produce a random collection of sherds.) In this example 34.6% of all Size 4 sherds from a vessel will be R-N types. The proportion of each size grouping (0.46, 0.29, 0.26, and 0.0 in Table 1) and the average surface area of a sherd from each size class can be used to estimate the total number of sherds produced by a vessel of specific size. If the average sherd sizes are A_1 , A_2 , A_4 , and A_3 ; the relative frequency of each size is P_1 , P_2 , P_4 , and P_3 ; and the vessel's surface area is S_v then for $i = 1, 2, 4, \text{ and } 3$:

$$\text{the number of Size } i \text{ sherds} = \frac{P_i S_v}{\sum_i A_i P_i}$$

In this way the number of sherds produced by a vessel can be estimated.

In formalizing the above concepts, a set of model parameters is specified to represent a specific, imaginary cultural complex or norm. The complex represents an extinct cultural system which can not be completely observed (like a black box phenomenon) and therefore must be interpreted on the basis of limited bits of data. At some point the efforts required to obtain more knowledge about such systems exceeds the value of the new information. Therefore, each complex must be defined in terms of the acquired knowledge developed from interpretations of the system's output, the sum of which is less than the total information required to fully characterize the complex (the Uncertainty Principle).

Because of this uncertainty, specific manifestations of a complex's constituent assemblages will be expected to vary from the defined norms. This inherent variability is a reflection of unaccountable factors that affect the character of individual assemblages within a complex (e.g. biased sampling, internal variability, or differential refuse disposal). In addition to the expected frequency of types, for example, there must be appropriate variance estimates to account for this variability. Thus, as an example, the occurrence of type A vessels can be defined as $20\% \pm 5\%$. In producing a collection of assemblages the expected frequencies will be randomly altered, following an assumed normal distribution of variation (following the ~~the~~ Central Limit Theorem), to reflect this variability.

As developed here, ceramic production systems are seen as black box phenomena which produce ceramic sherds as output. The conceptualization of ceramic complexes in terms of probabilistic principles provides a heuristic tool for modelling such systems. The model to be developed consists of four normative groups (designated Groups 1, 2, 3, and 4), each displaying distinctively defined attribute combinations with unique probabilities of occurrence. Every group consists of 30 assemblages taken to represent a sample of the range of variability possible about the group mean. Each assemblage is composed of 100 vessels constituting a sample of the unit's internal variability. The next section presents the actual formation of the model.

Model Formulation

Formulation of a model of ceramic variability involves first recognizing discrete steps in the sherd production process. This

section discusses the abstraction of a single ceramic system in terms of such a process. The actual numeric values of the model's parameters will be specified in the next section.

The product of the model is an assemblage of analyzable sherds with each assemblage a constituent element of a larger parent cultural complex or system. The norms of the parent system are specified, following the Uncertainty Principle, in terms of ranges of possibilities which yield black box like output.

The norms are defined by expected relative frequencies of vessel types categorized on the basis of form, surface finish, temper, and occasionally size. The possible forms which vessels can assume are large jars, small jars, hemispherical bowls, and cazuela bowls. The jar forms display distinct rim, neck, and body portions, whereas bowls consist only of rim and body sections.

Each vessel type can assume variable, though restricted, sizes where size is defined in terms of outer surface area. Temper is restricted to either shell or quartz. At the same time each vessel has the potential for displaying one or more motifs from a set of possible surface treatments. These treatments include plain smoothing (Pl), cord marking (Cm), check stamping (Ch), complicated stamping (Cmps), and incising (In).

The potential for any single vessel to display a specific sequence of attributes is determined by its group's joint, marginal, and conditional probabilities for such a composite of characteristics. Using a uniform random generator $[0,1]$ numbers are drawn and compared with each random variable's cumulative probability curve to determine

the characteristics of each vessel. The attribute determination process begins with the assignment of temper. Then the form, size, and surface treatment(s) are randomly identified. The end product is a fully characterized vessel.

To create sherds the vessel must be "broken" into pieces. The expected number of sherds of each size can be determined using the average expected surface area of each sherd size category (outlined above). Given a total sherd count by size and a pattern of breakability, specific counts of sherds from each portion of the vessel can be calculated. The sherds' surface treatments are derived from the vessel's distribution of treatments across its surface. A R-N sherd from a vessel displaying a plain rim and a check stamped neck would be coded according to each portion present. This produces a somewhat complex notation scheme for surface treatments. Traditionally this sherd might be coded as having a check stamped motif. In this scheme there are seven types of sherds and four different size classes which could display such a motif. This means 28 distinct kinds of "check stamped" sherds are possible. This notation records a greater amount of information about the nature of each sherd assemblage without losing the potential for incorporating the traditional scheme for classifying sherds.

Because not all sherds can be expected to be recovered archaeologically, part of the model includes a sherd reduction factor. As a result, only a specified fraction of a vessel's total sherd count is coded for later analysis. The reduction occurs relatively evenly across all sherd types regardless of the specific attribute sequence of the vessel type.

Another real situation included in the model is the inability of real-world analysts to determine the vessel portions represented on small sherds. Since the parameters of breakability are empirically derived from just such a situation, the expected number of Size 1 (maximum length ≤ 2 cm) body sherds must include some rim and neck portions. To correct for this problem all Size 1 body sherds from each vessel are divided into groups according to the relative proportion of rim to neck to body surface area. Equal proportions of sherds are coded according to the respective surface treatments found on each vessel portion. Thus, if a vessel produces 100 Size 1 body sherds and the R:N:B ratio is 1:1.4:3.4 the sherds would be assigned surface treatments according to a 17:25:58 distribution.

The model simulates the assemblage production process of a ceramic complex by creating sherd assemblages. It is based on the probabilistic nature of the parent system and is dependent upon estimates of specific probabilities. These values are obtained in two ways. First, mean frequencies of vessel types are arbitrarily defined for each group in a manner that simulates stylistic shifts from one set of assemblages to the next. This provides structured patterns similar to the changes in popularity of types observed in the archaeological record. Second, probabilities related to group breakage patterns, vessel form distributions, and vessel sizes are estimated from actual sherd and vessel collections.

Data Preparation

The first parameters to be defined are the mean size variables of the four vessel types: large jars, small jars, hemispherical bowls, and

cazuela bowls. One representative example of each desired form was selected from the collection of reassembled vessels stored at the Frank H. McClung Museum, University of Tennessee at Knoxville. Because of technical difficulties it was impossible to use an actual large jar to represent that type, instead, a smaller jar of similar form was used with its actual size increased by a factor of six. In all other cases the mean sizes of the vessel types correspond with that of the measured vessels.

The actual computation of the vessels' sizes and quantification of their forms was done as follows. First, the profile of each vessel was drawn to scale on rectangular Cartesian graph paper with the vessel's central axis aligned along the x-axis. The x coordinates represented height above the base in millimeters and the y coordinates measured the distance (mm) from the central axis to the outer surface of the vessel. Using the curve interpolation algorithm available in the CALCOMP software (CALCOMP 1971) a profile-defining equation was derived for each vessel. The equations take the form:

$$z = x - c \quad \text{for } 0 \leq x \leq \text{maximum height in mm}$$

$$y = f(z) = k_6z^6 + k_5z^5 + k_4z^4 + k_3z^3 + k_2z^2 + k_1z + k_0.$$

The values of the constants are provided in Table 2.

Rotating these equations about the x-axis generates surfaces similar to the vessels' outer surfaces (see Figures 1-4). Basic incremental estimation techniques can be used to measure the area of each of these surfaces. Inflection points can be defined at the local maximums and minimums of the profile curves [where the first derivative, $f'(z)$, equals zero]. These coordinates represent the separation of the body from the neck, the neck from the rim, and in the case of cazuela

Table 2. Constants for each of the type vessel's profile equations

Vessel type	c	k ₆	k ₅	k ₄	k ₃	k ₂	k ₁	k ₀
Large jar*	36.1	-5.4273(10 ⁻⁹)	3.7217(10 ⁻⁷)	5.2234(10 ⁻⁶)	-3.1838(10 ⁻⁴)	-0.0185	0.5363	53.436
Small jar	42.6	-2.4397(10 ⁻⁹)	2.6405(10 ⁻⁷)	1.5183(10 ⁻⁶)	-4.7673(10 ⁻⁴)	-0.0163	0.9761	81.414
Hemispherical bowl	36.4	-2.4500(10 ⁻⁹)	2.8735(10 ⁻⁷)	-7.0337(10 ⁻⁴)	-1.1927(10 ⁻⁴)	-0.0043	1.1132	75.152
Cazuela bowl	23.4	-1.6773(10 ⁻⁸)	1.3727(10 ⁻⁶)	-3.1641(10 ⁻⁵)	-1.0360(10 ⁻⁴)	-0.0072	1.1533	53.646

* This vessel was rescaled by a factor of six.

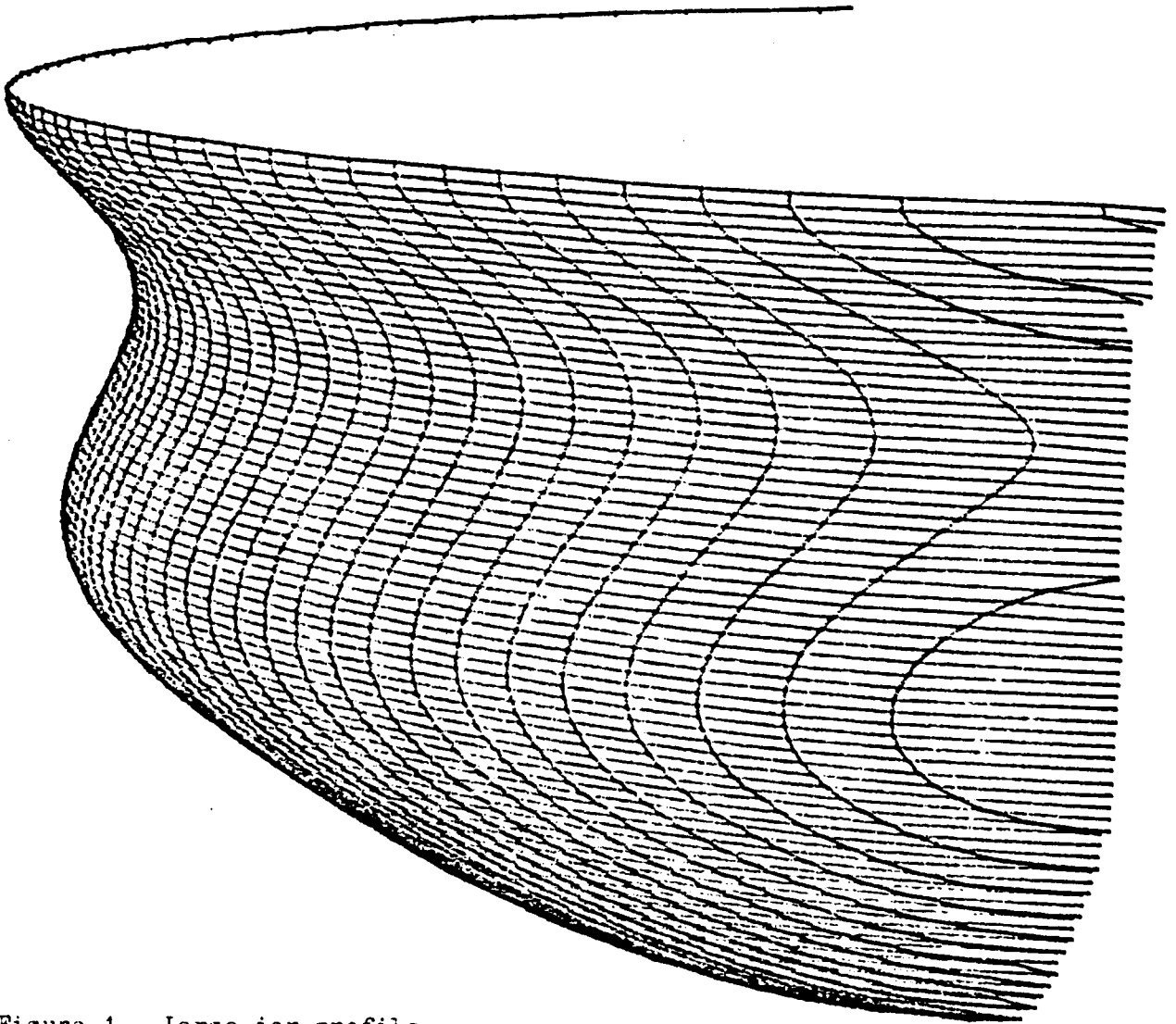


Figure 1. Large jar profile

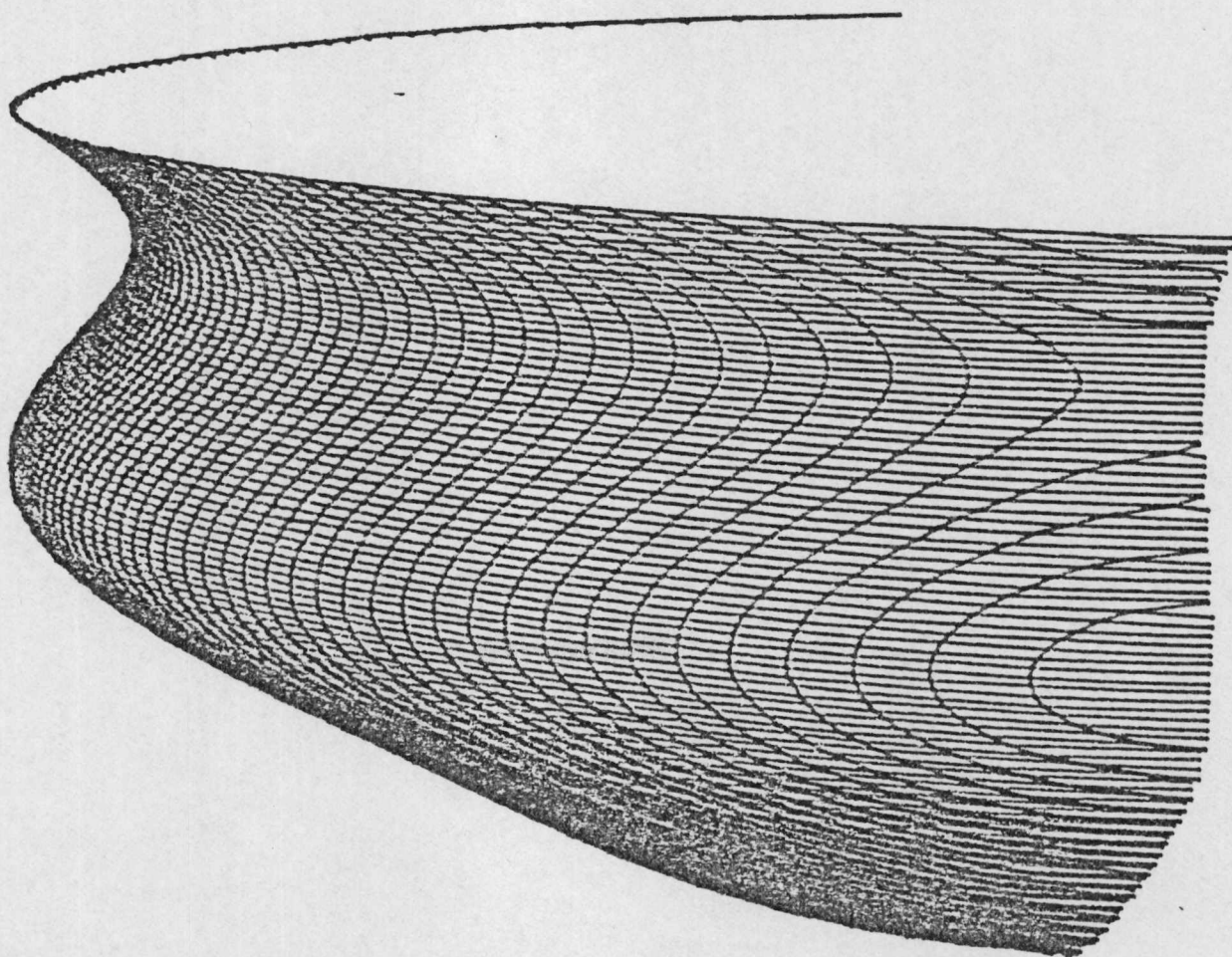


Figure 2. Small jar profile

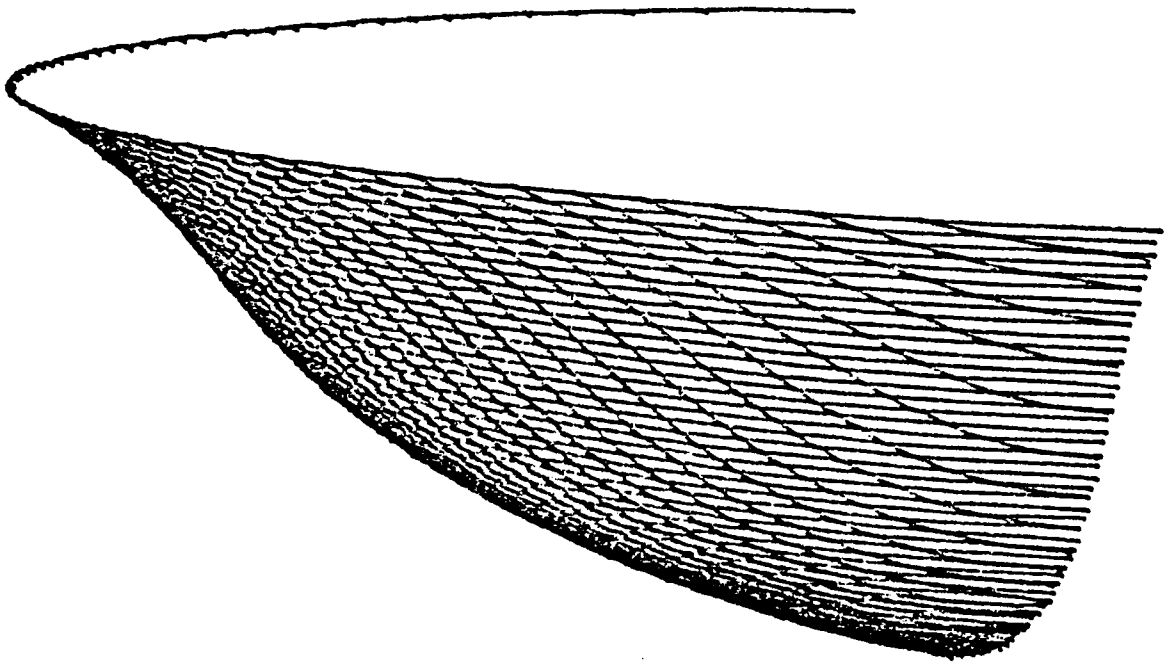


Figure 3. Hemispherical bowl profile

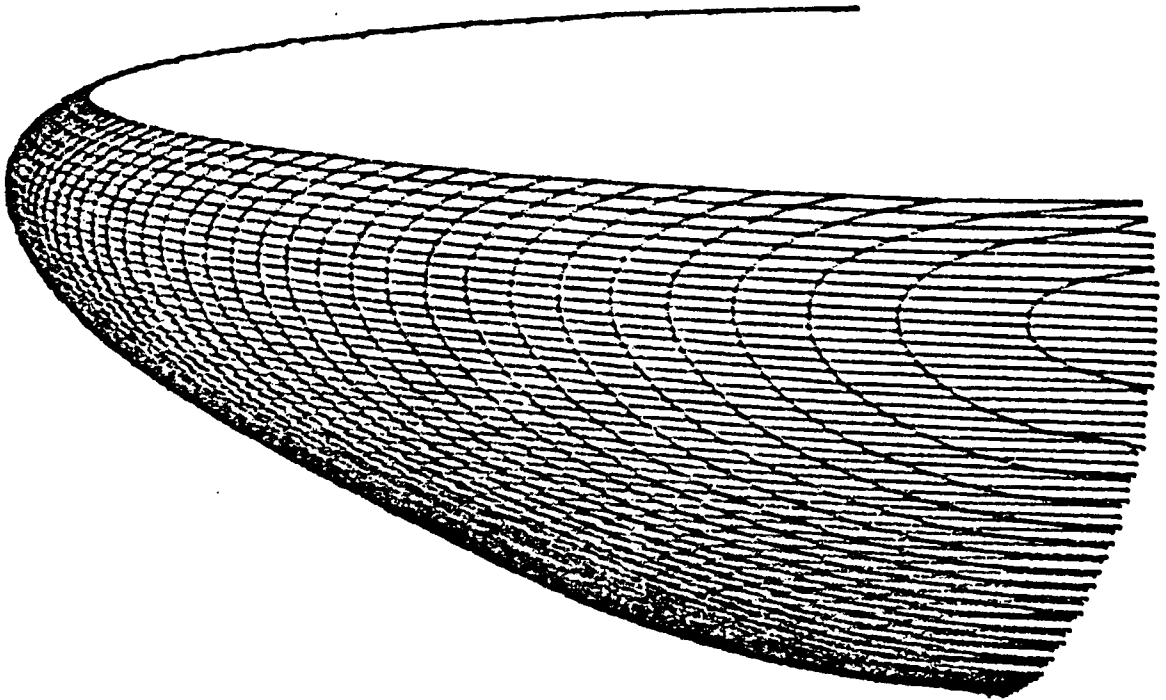


Figure 4. Cazuela bowl profile

bowls, the rim from the body. Surface areas of these segments can be calculated to provide the relative proportion each section contributes to the total surface area. The results of this analysis are provided in Table 3. These measures serve as the model's vessel size parameters. Radius variance estimates for the model are arbitrarily constructed (see Table 3).

The second set of model parameters to be specified is the breakage patterns of vessels for each temper group. Data derived from excavation of the eighteenth century Overhill Cherokee village of Tomotley (40MR5) (Baden 1981) are used to estimate the probabilities of sherds breaking into various sizes with specific vessel portions present. The relative frequency of sherd types summed over each of the four size categories from Tomotley's shell tempered and grit (mostly quartz) tempered material provides these probabilities. The cumulative distributions of these values are shown in Table 4 for shell tempered jars, Table 5 for shell tempered bowls, and Table 6 for quartz tempered jars. As will be made clear later, the model excludes quartz tempered bowls.

The ceramic size data from Tomotley can be used to estimate the relative occurrence of each size grouping for each temper. For shell tempered sherds the relative frequencies of Size 1, 2, 4, and 3 are 0.22, 0.53, 0.21, and 0.04. For quartz tempered sherds the values are 0.36, 0.43, 0.18, and 0.03, respectively.

The final model parameters are the mean surface areas of each of the four sherd sizes. Knowing the mean surface area of sherds from each size grouping makes it possible to estimate the total number of sherds produced by each vessel.

Table 3. Mean vessel size parameters

Vessel type	Surface area (sq. cm)	Radius/s.d. (cm)	Percent Rim	Percent Neck	Percent Body
Large jar	8200.0	29.4/1.45	24.6	23.0	52.4
Small jar	656.7	9.2/2.7	17.1	25.3	57.6
Hemispherical bowl	716.3	11.9/2.4	8.6	0.0	91.4
Cazuela bowl	328.5	6.9/0.7	16.5	0.0	33.5

Table 4. Cumulative probabilities of sherd types broken down by size for shell tempered jars (R=rims, N=neck, and B=body)

Sherd type	Size 1	Size 2	Size 4	Size 3
R-N-B	0.0	0.0011	0.0053	0.0400
R-N	0.0043	0.0381	0.1074	0.2140
R	0.1069	0.1113	0.2047	0.2940
N-B	0.1034	0.1220	0.2385	0.3630
N	0.1102	0.1329	0.2732	0.4340
B	1.0	1.0	1.0	1.0

Table 5. Cumulative probabilities of sherd types broken down by size for shell tempered bowls (R=rims, N=neck, and B=body)

Sherd type	Size 1	Size 2	Size 4	Size 3
R	0.1034	0.0782	0.1163	0.1108
B	1.0	0.9994	0.9397	0.8947
R - B	1.0	1.0	1.0	1.0

Table 6. Cumulative probabilities of sherd types broken down by size for quartz tempered jars (R=rims, N=neck, and B=body)

Sherd type	Size 1	Size 2	Size 4	Size 3
R-N-B	0.0	0.0	0.0154	0.0
R-N	0.0	0.0974	0.2308	0.2500
R	0.0231	0.1429	0.2615	0.2500
N-B	0.0308	0.1553	0.2923	0.2500
N	0.0385	0.1633	0.3335	0.2500
B	1.0	1.0	1.0	1.0

An examination of 367 shell tempered sherds (Baden 1981) produced estimates, segregated by size, of the mean and variance of their lengths and widths. These values are reproduced in Table 7. The correlation of length and width was measured to be 0.831. The surface area of a sherd can be represented by the product of its length (L) and width (W). The expected mean area, $E(LW)$, within each size group can be estimated utilizing the concept of the correlation coefficient. Where μ_L and μ_W are the means of L and W; σ_L and σ_W are the standard deviations of L and W; and ρ is the correlation coefficient, then:

$$E(LW) = \mu_L \mu_W - \rho \frac{\sigma_W}{\sigma_L} \mu_L^2 + \rho \frac{\sigma_W}{\sigma_L} (\sigma_L^2 + \mu_L^2)$$

Thus, estimates of the mean areas of Size 1, 2, 4, and 8 sherds are 2.936, 6.0272, 26.0349, and 60.6350 cm², respectively.

Model Translation

With the parameters defined the next phase of model development is the translation of the assemblage production process into programmable terms. The discrete steps of the program are as follows:

1. Define the model's parameters in terms of specific group expectations,
2. Determine the percentage of the shell and quartz tempered vessels to be represented in each assemblage,
3. Determine the number of vessels of each stylistic type and temper,
4. Define the motif of each vessel,
5. Break each vessel into sherds,
6. Code the sherds into an analyzable format.

The breakage process includes four discrete steps:

Table 7. Length and width statistics for shell tempered sherds
(all measurements are in centimeters)

Size	Variable	n	Mean	s.d.
1	length	101	1.85	0.21
	width	101	1.56	0.27
2	length	186	2.84	0.51
	width	186	2.04	0.52
4	length	43	5.87	1.12
	width	43	4.21	1.34
3	length	32	9.84	1.60
	width	32	5.92	1.69

1. Define the sampling fraction for each vessel,
2. Define the size of each vessel,
3. For each vessel determine the number of sherds of each size that will be coded,
4. Determine the number of sherd types by size for each vessel.

The programming language selected was FORTRAN-10 compiled on the University of Tennessee's DEC-10 system. The program listing is provided in Appendix A. The program requires two random digit generators, one to produce uniform random numbers $[0,1]$ and another to generate random normal variates with a mean of zero and variance of one. The GGUBS and GGNML algorithms available in the International Mathematical and Statistical Libraries, edition 3 (IMSL 1980) were used to provide appropriate sequences of random digits. A Monte Carlo experiment was run to test the normality of 1000 random deviates generated by GGNML. Chi-square and Kolmogorov-Smirnov tests were applied to each sequence generated by the four seed values used in the modelling program with the results shown in Table 8. They suggest that each group's seed value produces acceptable normal deviates.

The group parameters which serve as input data for the model are listed in Table 9. Note that only certain motif/temper combinations were allowed to occur resulting in 33 types of vessels. Similar statistics for the model's output are listed in Table 10. The sample size for each group was 30 assemblages. Combining assemblages, Groups 1 through 4 are composed of 2999, 3001, 2995, and 3002 vessels, respectively. Because of occasional rounding errors not all assemblages produced exactly 100 vessels as desired. Tables 11 and 12 tabulate the quantity of sherds by temper and size for each group. Vessel size

Table 3. Results of Chi-square and Kolmogorov-Smirnov (K-S) tests on n normal deviates using each assemblage group's seed values and IMSL's GGNML algorithm

Group	n	χ^2	$\underline{p}$	K-S max. D	$\underline{p}$
1	100	10.66	0.3846	0.0528	0.1628
	500	3.33	0.5964	0.0269	0.9700
	1000	11.87	0.2940	0.0216	0.7866
2	100	21.44	0.0182	0.1031	0.1932
	500	11.85	0.2951	0.0201	0.9999
	1000	9.10	0.5230	0.0207	0.8499
3	100	6.04	0.8119	0.0637	0.3883
	500	13.00	0.2239	0.0536	0.1131
	1000	7.51	0.6764	0.0163	0.9999
4	100	9.56	0.4799	0.1163	0.1337
	500	7.01	0.7243	0.0165	0.9999
	1000	7.97	0.6314	0.0139	0.9999

Table 9. Input parameters

Parameter	Group 1	Group 2	Group 3	Group 4
Sample fraction	0.2 ± 0.1	0.2 ± 0.2	0.2 ± 0.3	0.2 ± 0.4
Shell tempered %	20 ± 10	40 ± 10	60 ± 10	80 ± 10
Large jar %	4 ± 10	6 ± 10	8 ± 10	10 ± 10
P(Pl,Pl,Pl)	0.1	0.35	0.35	0.35
P(Pl,Pl,Cm)	0.2	0.15	0.0	0.0
P(Pl,Pl,Ch)	0.0	0.0	0.15	0.0
P(Pl,Cm,Cm)	0.2	0.15	0.0	0.0
P(Pl,Ch,Ch)	0.1	0.15	0.15	0.0
P(Pl,Cmps,Cmps)	0.0	0.0	0.15	0.1
P(Cm,Cm,Cm)	0.4	0.2	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.2	0.1
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.45
Small jar %	45	45	40	35
P(Pl,Pl,Pl)	0.1	0.3	0.3	0.3
P(Pl,Pl,Cm)	0.1	0.1	0.0	0.0
P(Pl,Pl,Ch)	0.0	0.0	0.1	0.0
P(Pl,Cm,Cm)	0.2	0.1	0.0	0.0
P(Pl,Cn,Cn)	0.0	0.0	0.1	0.0
P(Pl,Cmps,Cmps)	0.0	0.0	0.0	0.2
P(Cm,Cm,Cm)	0.6	0.5	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.5	0.1
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.4
Hemispherical bowl %	51	49	42	40
P(Pl,Pl)	0.5	1.0	1.0	0.9
P(Cm,Cm)	0.5	0.0	0.0	0.0
P(Cmps,Cmps)	0.0	0.0	0.0	0.1
Cazuela bowl %	0	0	10	15
P(Pl,Pl)	0.0	0.0	0.9	0.1
P(In,Pl)	0.0	0.0	0.1	0.9
Quartz tempered %	30 ± 10	60 ± 10	40 ± 10	20 ± 10
Large jar %	60 ± 10	60 ± 10	50 ± 10	40 ± 10
P(Pl,Pl,Pl)	0.0	0.25	0.25	0.0
P(Pl,Ch,Ch)	0.25	0.25	0.25	0.0
P(Cm,Cm,Cm)	0.75	0.5	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.5	0.4
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.6
Small jar %	40	40	50	60
P(Pl,Pl,Pl)	0.0	0.1	0.1	0.0
P(Pl,Ch,Ch)	0.0	0.1	0.4	0.0
P(Cm,Cm,Cm)	1.0	0.8	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.5	0.5
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.5

Pl=plain, Cm=cord marked, Ch=check stamped, Cmps=complicated stamped, and In=incised

Table 10. Output statistics

Parameter	Group 1	Group 2	Group 3	Group 4
Sample fraction	0.20±0.10	0.22±0.17	0.25±0.24	0.28±0.29
Shell tempered %	20.9 ±10.6	39.5 ±11.4	61.6 ± 9.6	79.0 ±10.1
Large jar %	6.7 ± 7.3	7.3 ± 8.2	9.8 ± 7.6	9.9 ± 9.8
P(Pl,Pl,Pl)	0.0633	0.4353	0.3333	0.3739
P(Pl,Pl,Cm)	0.2128	0.0324	0.0	0.0
P(Pl,Pl,Ch)	0.0	0.0	0.1833	0.0
P(Pl,Cm,Cm)	0.2766	0.1176	0.0	0.0
P(Pl,Ch,Ch)	0.1064	0.1176	0.1833	0.0
P(Pl,Cmps,Cmps)	0.0	0.0	0.1222	0.1043
P(Cm,Cm,Cm)	0.3404	0.2471	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.1778	0.0478
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.4739
Small jar %	40.4 ± 11.5	44.1 ± 3.8	39.3 ± 3.3	35.1 ± 3.7
P(Pl,Pl,Pl)	0.1148	0.2871	0.2961	0.3222
P(Pl,Pl,Cm)	0.0926	0.1034	0.0	0.0
P(Pl,Pl,Ch)	0.0	0.0	0.1102	0.0
P(Pl,Cm,Cm)	0.1889	0.1103	0.0	0.0
P(Pl,Ch,Ch)	0.0	0.0	0.1006	0.0
P(Pl,Cmps,Cmps)	0.0	0.0	0.0	0.1976
P(Cm,Cm,Cm)	0.6037	0.4943	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.4931	0.0946
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.3856
Hemispherical bowl %	46.2 ± 13.3	48.1 ± 4.5	41.1 ± 3.4	39.9 ± 4.4
P(Pl,Pl)	0.5405	1.0	1.0	0.8999
P(Cm,Cm)	0.4595	0.0	0.0	0.0
P(Cmps,Cmps)	0.0	0.0	0.0	0.1001
Cazuela bowl %	0.0	0.0	9.8 ± 1.1	15.1 ± 1.8
P(Pl,Pl)	0.0	0.0	0.8901	0.1003
P(In,Pl)	0.0	0.0	0.1099	0.8997
Quartz tempered %	79.1 ±10.6	60.5 ±11.4	38.4 ± 9.6	21.0 ±10.1
Large jar %	59.6 ±10.2	61.0 ± 9.9	48.5 ±10.5	40.2 ±11.7
P(Pl,Pl,Pl)	0.0	0.2518	0.2414	0.0
P(Pl,Ch,Ch)	0.2537	0.2265	0.2436	0.0
P(Cm,Cm,Cm)	0.7463	0.5127	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.5100	0.3740
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.6260
Small jar %	40.4 ±10.2	39.0 ± 9.9	51.5 ±10.5	56.5 ±13.9
P(Pl,Pl,Pl)	0.0	0.0930	0.0970	0.0
P(Pl,Ch,Ch)	0.0	0.0962	0.3846	0.0
P(Cm,Cm,Cm)	1.0	0.8048	0.0	0.0
P(Ch,Ch,Ch)	0.0	0.0	0.5184	0.4196
P(Cmps,Cmps,Cmps)	0.0	0.0	0.0	0.5804

Pl=plain, Cm=cord marked, Ch=check stamped, Cmps=complicated stamped, and In=incised

Table 11. Total number of shell tempered sherds coded by size for each group

Group	Size 1	Size 2	Size 4	Size 8	Total
Group 1	4522	7349	2281	477	15,129
Group 2	10,473	19,925	5007	962	36,367
Group 3	18,181	35,253	9328	1975	64,742
Group 4	28,057	45,338	16,063	3051	92,564
Total	61,233	103,420	32,634	6465	203,802

Table 12. Total number of quartz tempered sherds coded by size for each group

Group	Size 1	Size 2	Size 4	Size 8	Total
Group 1	123,402	121,971	36,760	6752	233,885
Group 2	106,968	108,143	31,476	5994	252,531
Group 3	70,539	67,718	16,765	3652	153,724
Group 4	41,546	38,443	9706	2019	91,714
Total	342,505	336,275	94,707	18,417	731,904

statistics for each vessel type segregated by groups are presented in Table 13. Thus the model of ceramic variability is complete, and for each respective group 304,014; 283,948; 223,466; and 184,278 sherds were coded. The characteristics of each assemblage, defined in terms of their vessel composition, can be found in Appendix B.

Table 13. Vessel size statistics by group and vessel type

	Mean radius (cm)	s.d.	n
Group 1			
Large jar	29.39	1.45	1453
Small jar	9.21	2.63	1232
Hemispherical bowl	12.06	2.43	309
Cazuela bowl	-	-	0
Group 2			
Large jar	29.45	1.47	1193
Small jar	9.26	2.74	1233
Hemispherical bowl	11.33	2.29	575
Cazuela bowl	-	-	0
Group 3			
Large jar	29.50	1.42	731
Small jar	9.03	2.71	1324
Hemispherical bowl	12.01	2.36	753
Cazuela bowl	7.05	0.71	182
Group 4			
Large jar	29.54	1.45	492
Small jar	9.27	2.63	1202
Hemispherical bowl	11.89	2.49	949
Cazuela bowl	6.96	0.72	359

CHAPTER III

ANALYSIS OF THE WHOLE VESSEL ASSEMBLAGES

The generated output is examined statistically beginning with an analysis of the whole vessel assemblages. As representative examples of overall group variability, the whole vessel assemblages provide the key to developing a priori notions about the internal structure of the combined collection beyond the known group affiliations. Although the ultimate goal of this study involves recognizing and verifying patterning in the sherd assemblages, defining this inherent patterning in terms of whole vessel variables is necessary and vital to the clarification of the a priori structure.

The whole vessel assemblages are characterized by the relative frequencies of the 33 vessel types (refer to Tables 9 and 10, pages 34-35). Therefore, the assemblages' probability space is composed of 33 dimensions. The position of each assemblage in this space geometrically translates "cultural similarities" into linear distances. Those assemblages most alike will be located in the same region of the multidimensional space. If these points could be visualized the associative relationships would be easily identified. Unfortunately this is not possible with 33 dimensions. It is therefore necessary to analyze the dispersion of these points in abstract, mathematical terms.

Several possible techniques could be applied, each providing its own contribution to the learning process. The primary techniques used by archaeologists to analyze such data include seriation to define a monotonic temporal sequence, cluster analysis to develop associative

perspectives, and principal component analysis to reduce the dimensionality of the space and simplify the variability. The seriation algorithm adopted for this study follows from the work of Brainerd (1951) and Robinson (1951) and the computational suggestions of Gelfand (1969, 1971a, 1971b). The cluster procedures are derived from Anderberg (1973), Ward (1963), and Johnson (1967) and consist of the hierarchical algorithms: single linkage, complete linkage, average linkage (within and between groups), and Ward's method. The principal component technique with varimax rotation is provided by the SPSS software (Nie et al. 1975).

In calculating the relative frequencies of any set of artifact types, the population total can be selected in three ways. It can be the total number of artifacts within the assemblage (Type 1 profiles), the total number of artifacts summed over the group (Type 2 profiles), or the total number summed over all assemblages (Type 3 profiles). The relevance of each is dependent upon the problem orientation and the sampling strategy used to gather the data. All the methods assume the data was gathered in an unbiased fashion and that all assemblages are comparable. Type 1 profiles provide an internal measure of each type's popularity within assemblages, but it is subject to distortion whenever an assemblage total is small. Type 2 profiles indicate which assemblages are popularity loci within their group. They alleviate the problem of small assemblage totals but do not accurately measure the popularity of the artifacts within each assemblage. Similarly, Type 3 profiles reflect the popularity loci spanning all groups, but the values can be biased if the assemblage samples are incomparable. Each

computational scheme provides different information about the distribution of artifacts across a set of collection proveniences. Again, problem orientation should decide which is most appropriate. In examining the whole vessel assemblages, sample size problems are unimportant since all assemblages contain a relatively constant number of vessels representing a random sample from a larger population. Because the assemblages were created in terms of group means in order to compare the abilities of statistical analyses to reproduce these group affiliations, using relative frequencies defined in terms of group totals is the most appropriate computational scheme. But, to demonstrate the relationship between variable definition and analytical response, the seriation of the vessels from the 120 assemblages is applied to profiles computed in all three ways. The resulting sequences are listed in Table 14.

Of the 120 possible positions in each sequence only 23 were unaltered by the differences in profile structure. This emphasizes the interrelationship between data characterizations and analytical interpretations. Although there is positional variability between the orderings there is also agreement that internal group homogeneity binds assemblages together. Furthermore, the relative association sequence of the groups is 1, 2, 3, and 4 as designed by the input parameters. Cross-checking the order of the assemblages listed in the middle sequence of Table 14 with the whole vessel compositions listed in Appendix B provides information about the characteristics of the groups that determines the degree of similarity between pairs of assemblages. units similar or dissimilar.

Table 14. Sequences of whole vessel assemblages derived from a seriation of the relative frequencies of 33 types defined in terms of assemblage totals (A), group totals (B), and total number of vessels (C)

A		B		C	
Group	Assemblage	Group	Assemblage	Group	Assemblage
1	25	1	25	1	25
1	1	1	1	1	1
1	29	1	29	1	29
1	7	1	7	1	7
1	9	1	9	1	9
1	28	1	28	1	28
1	27	1	23	1	5
1	23	1	4	1	12
1	12	1	5	1	13
1	4	1	12	1	23
1	13	1	13	1	4
1	19	1	27	1	19
1	5	1	16	1	16
1	14	1	14	1	14
1	16	1	19	1	27
1	17	1	17	1	17
1	22	1	11	1	8
1	8	1	8	1	11
1	11	1	6	1	22
1	6	1	22	1	6
1	3	1	3	1	3
1	2	1	2	1	24
1	24	1	24	1	2
1	26	1	26	1	26
1	20	1	20	1	20
1	21	1	21	1	15
1	15	1	15	1	21
1	30	1	10	1	10
1	10	1	30	1	30
1	18	1	18	1	18
2	1	2	1	2	1
2	14	2	14	2	14
2	23	2	23	2	23
2	29	2	12	2	12
2	12	2	29	2	29
2	5	2	11	2	25
2	25	2	25	2	11
2	11	2	6	2	5
2	6	2	5	2	6
2	3	2	3	2	3
2	27	2	2	2	27

Table 14. (Continued)

A		B		C	
Group	Assemblage	Group	Assemblage	Group	Assemblage
2	2	2	27	2	2
2	26	2	26	2	26
2	20	2	20	2	20
2	21	2	21	2	21
2	9	2	22	2	9
2	22	2	9	2	22
2	10	2	10	2	10
2	8	2	8	2	8
2	30	2	30	2	30
2	18	2	23	2	23
2	23	2	18	2	4
2	24	2	4	2	18
2	4	2	24	2	24
2	17	2	17	2	13
2	7	2	13	2	17
2	13	2	7	2	7
2	16	2	19	2	19
2	19	2	16	2	16
2	15	2	15	2	15
3	9	3	30	3	30
3	30	3	9	3	9
3	11	3	11	3	11
3	3	3	21	3	22
3	21	3	3	3	3
3	14	3	22	3	21
3	22	3	14	3	14
3	25	3	24	3	25
3	24	3	23	3	24
3	23	3	25	3	23
3	7	3	13	3	13
3	13	3	7	3	18
3	13	3	20	3	7
3	20	3	18	3	20
3	26	3	27	3	6
3	6	3	6	3	26
3	2	3	2	3	2
3	27	3	26	3	27
3	15	3	15	3	15
3	1	3	1	3	4
3	4	3	8	3	1
3	8	3	19	3	8
3	19	3	4	3	19
3	17	3	17	3	23
3	23	3	28	3	17

Table 14. (Continued)

A		B		C	
Group	Assemblage	Group	Assemblage	Group	Assemblage
3	16	3	5	3	5
3	5	3	29	3	16
3	29	3	10	3	29
3	10	3	12	3	10
3	12	3	16	3	12
4	8	4	8	4	8
4	1	4	1	4	1
4	30	4	7	4	26
4	23	4	14	4	18
4	18	4	18	4	14
4	12	4	26	4	4
4	2	4	4	4	7
4	7	4	2	4	13
4	11	4	15	4	10
4	5	4	19	4	15
4	4	4	10	4	30
4	17	4	30	4	20
4	10	4	13	4	23
4	3	4	22	4	2
4	6	4	6	4	19
4	13	4	25	4	22
4	14	4	16	4	16
4	24	4	20	4	29
4	26	4	21	4	25
4	15	4	3	4	6
4	20	4	23	4	12
4	19	4	29	4	11
4	22	4	9	4	3
4	25	4	12	4	9
4	23	4	11	4	27
4	16	4	27	4	21
4	21	4	28	4	23
4	27	4	17	4	17
4	29	4	5	4	5
4	9	4	24	4	24

From Group 1 through Group 2, there seems to be a general increase in the proportion of shell tempering, which agrees with the input structure. The transition between Group 2 and Group 3 is not as smooth, suggesting a discontinuity. Group 3 appears to be slightly more homogeneous with relatively little significant variation distinguishing assemblages. The same can be said for Group 4. One way to measure this internal homogeneity is to calculate the similarity coefficient between the endpoints of the group-totaled sequence following a procedure similar to the one used in the seriation (Robinson 1951). The seriation sums, over all 33 types, the absolute value of the differences between relative frequencies for all pairs of assemblages. This is referred to as a city-block distance or Minkowski metric of one and has a maximum possible value of two. The similarity is inversely related to the value of this coefficient, that is, smaller values suggest similarity. For Group 1 comparison of the first and last assemblages produced a value of 0.020. The similarity between the first and last assemblages of Groups 2, 3, and 4 are 0.027, 0.020, and 0.010, respectively. This suggests that in a very tightly packed space, Group 2 is the most heterogeneous and Group 4 is the most homogeneous. To further delineate inter and intra-group variability, cluster analysis is to be applied.

Prior to performing any cluster program a distance metric must be chosen to represent the pairwise similarity between all units. The seriation used a city-block distance but for clustering the Euclidean distance is used. This measure represents the geometric distance between two points in the 33-space. The dendrograms resulting from the application of single linkage, complete linkage, average (within)

linkage, average (between) linkage, and Ward's method to Type 2 profiles are presented in Figures 5, 6, 7, 8, and 9, respectively.

Unlike seriation the ordered sequence of the cluster solution is not important. The form it takes is merely one of drawing convenience, since each figure can be drawn in over 6×10^{35} ways without changing the associative order. The important information lies in the way assemblages cluster into subgroups in conjunction with the merging criteria of the methods.

Each method combines units in a sequence starting with the smallest criteria value and proceeding to the largest. Single linkage merges units or clusters of units according to the minimum distance between them. Complete linkage uses the maximum distance as a criteria for combining two clusters. The average linkage methods take the average distances within two clusters (within) or the average distance between all members of the combined cluster (between) as merging criteria. Ward's method minimizes the increase in the error sum of squares, or variance, with each merger.

Users of cluster analyses often apply only one technique to their data, or if more than one procedure is used, only the "best" result is presented. Unfortunately, this does not make total use of the algorithms. The way in which Ward's method groups units creates clusters with minimum variance. Its application defines a dispersion which meets this criteria. Single linkage produces clusters directly related to the spatial proximity of the elements and tends to define chain-like structures. Contrasting the cluster solutions can provide significant insights into the structure of the data.

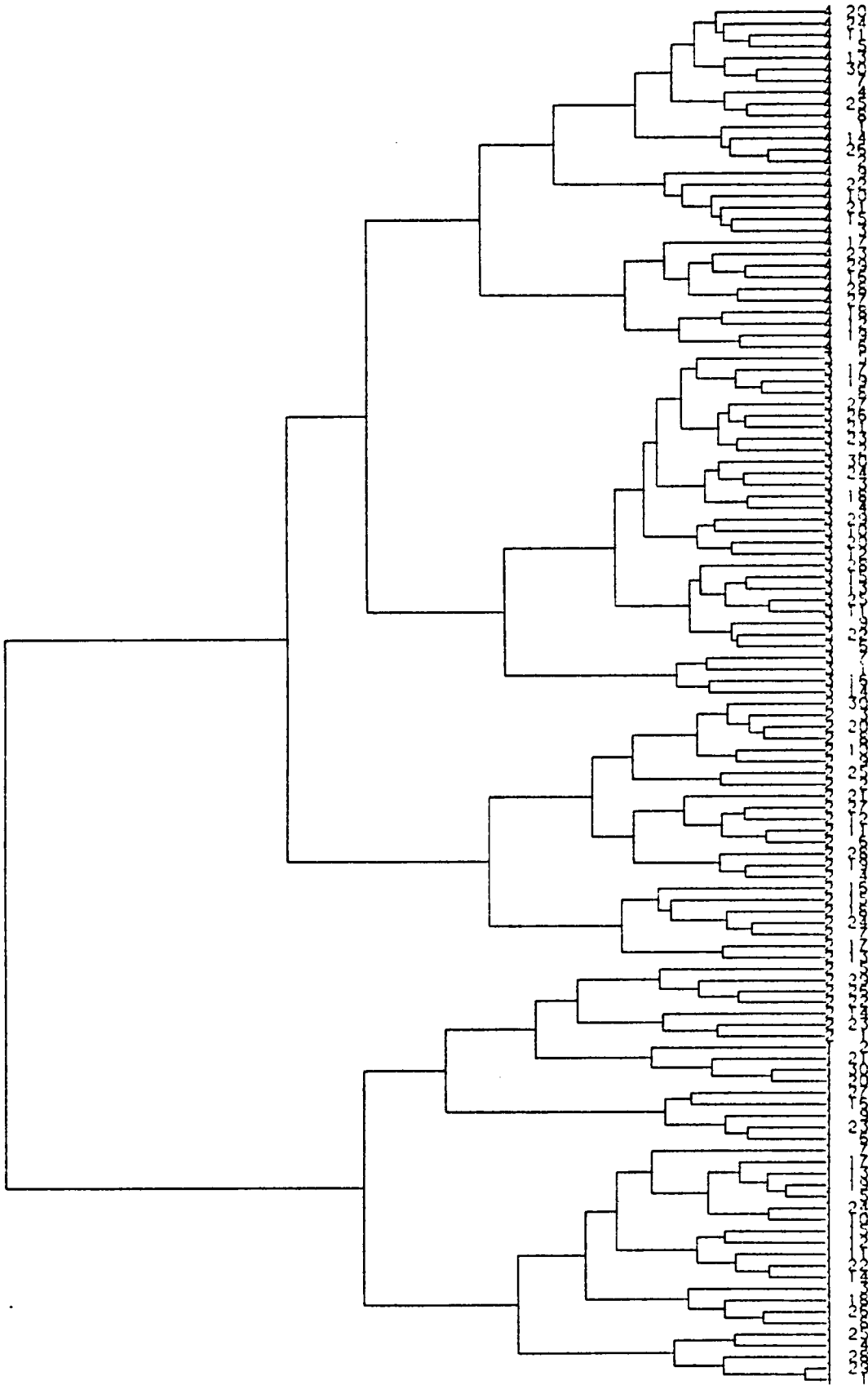


Figure 5. Complete linkage clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types



Figure 6. Single linkage clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types

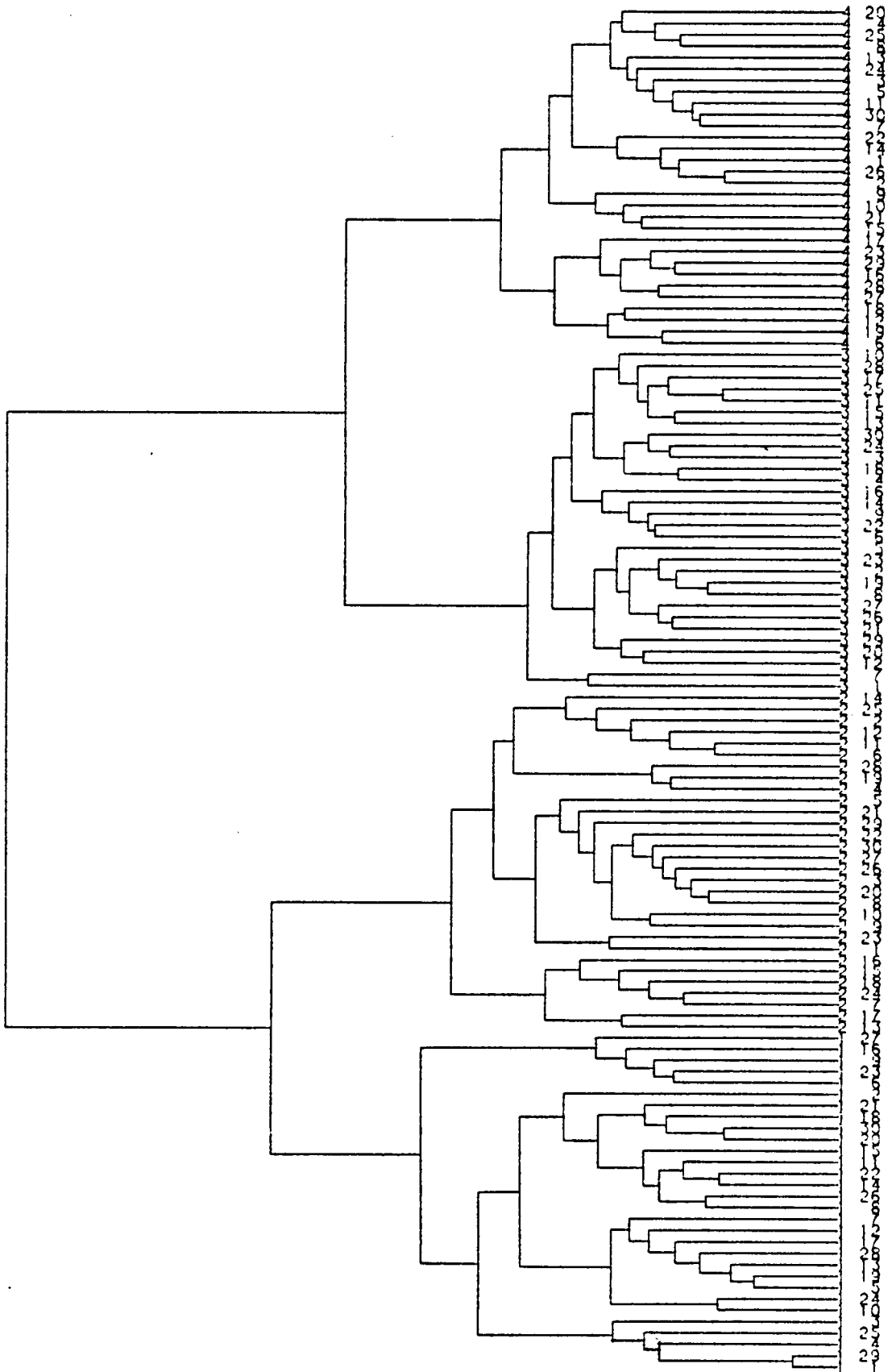


Figure 7. Average linkage (within) clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types

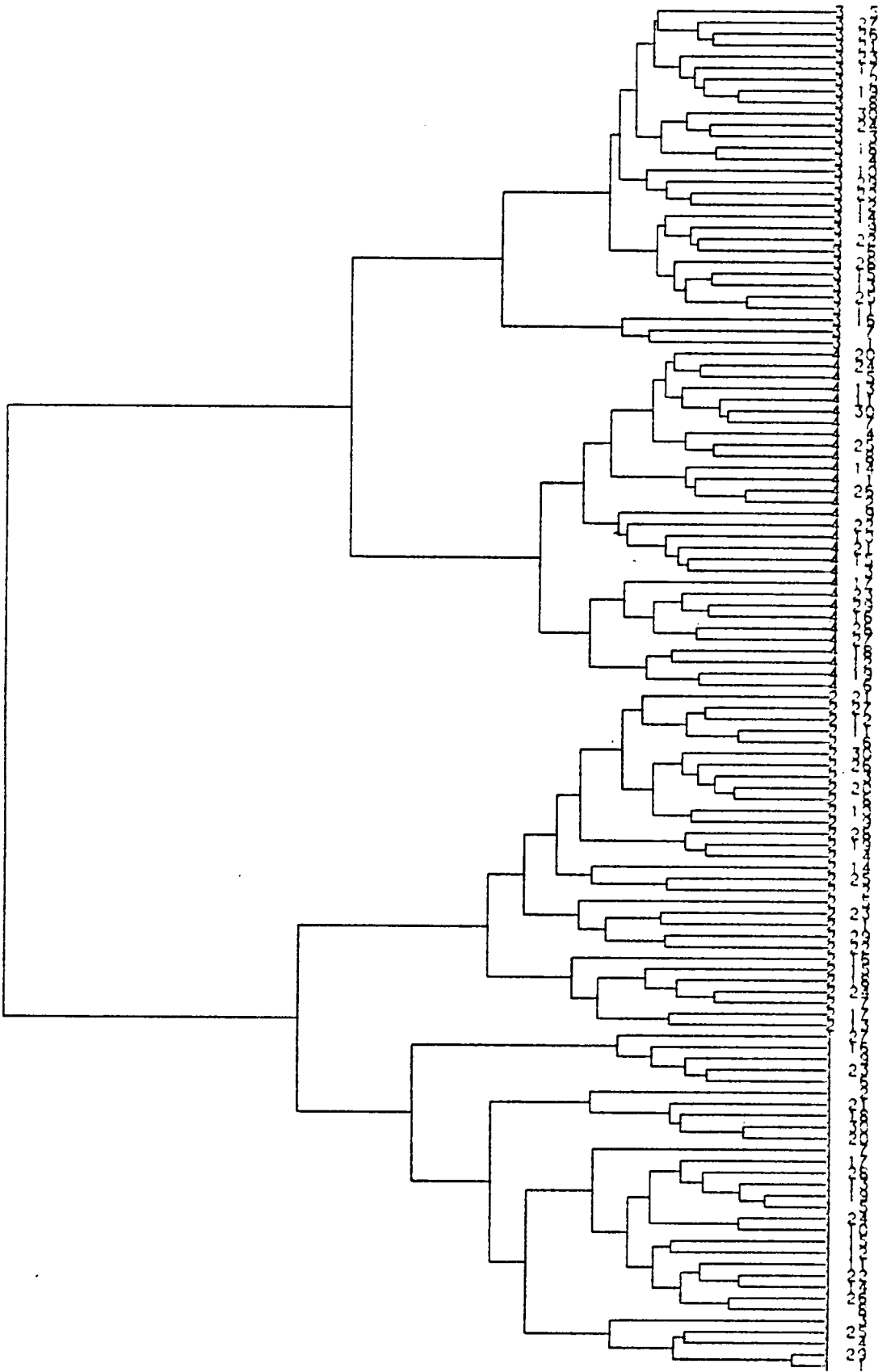


Figure 3. Average linkage (between) clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types

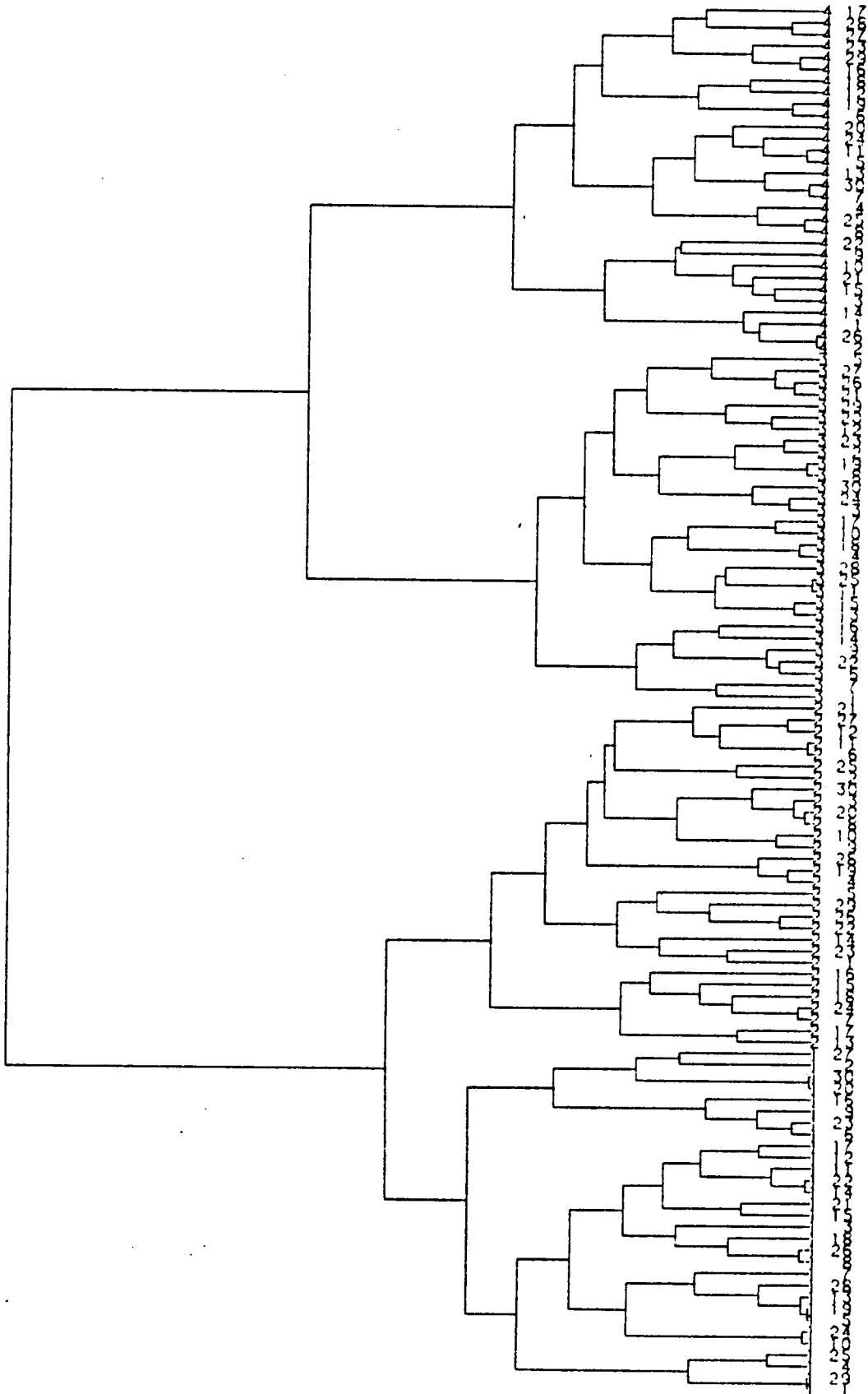


Figure 9. Ward's method clustering of units defined in terms of Type 2 relative frequencies of 33 vessel types

Comparison of Figures 5 through 9 shows that only the complete linkage method failed to accurately portray the four group separation. During the complete linkage procedure six assemblages from Group 2 (1, 5, 14, 23, 26, and 29) were combined with units from Group 1 to form a cluster. This might suggest that these six units closely resemble certain Group 1 assemblages. However, since none of the other four procedures verify this configuration it probably represents a localized anomaly within the probability space where the maximum distance criteria fails to discern the a priori group distinctions. The remaining cluster patterns are essentially identical indicating that, based on proximity criteria, average distances within and between groups, and minimized variance constraints, the group dispersion is significantly unique and discernible. The patterns also suggest that since assemblages forming Groups 3 and 4 coalesced first, these groups exist within a more confined portion of the space characterized by a limited degree of variability. This agrees with the conclusions drawn from the seriation.

To graphically portray the group relationships principal component analysis with varimax rotation was applied to the Type 2 assemblage profiles. Factor scores computed on the first two factors are plotted in Figure 10. The two factors explain 49.0% of the total assemblage variance yet adequately portray the spatial configuration of the four groups. As predicted in the previous analyses and specified by the input parameters, Groups 1 and 2 are similar yet distinct while Groups 3 and 4 are dissimilar and widely separated.

The results of these analyses help to quantitatively define the variability between the parent, whole vessel assemblages from which

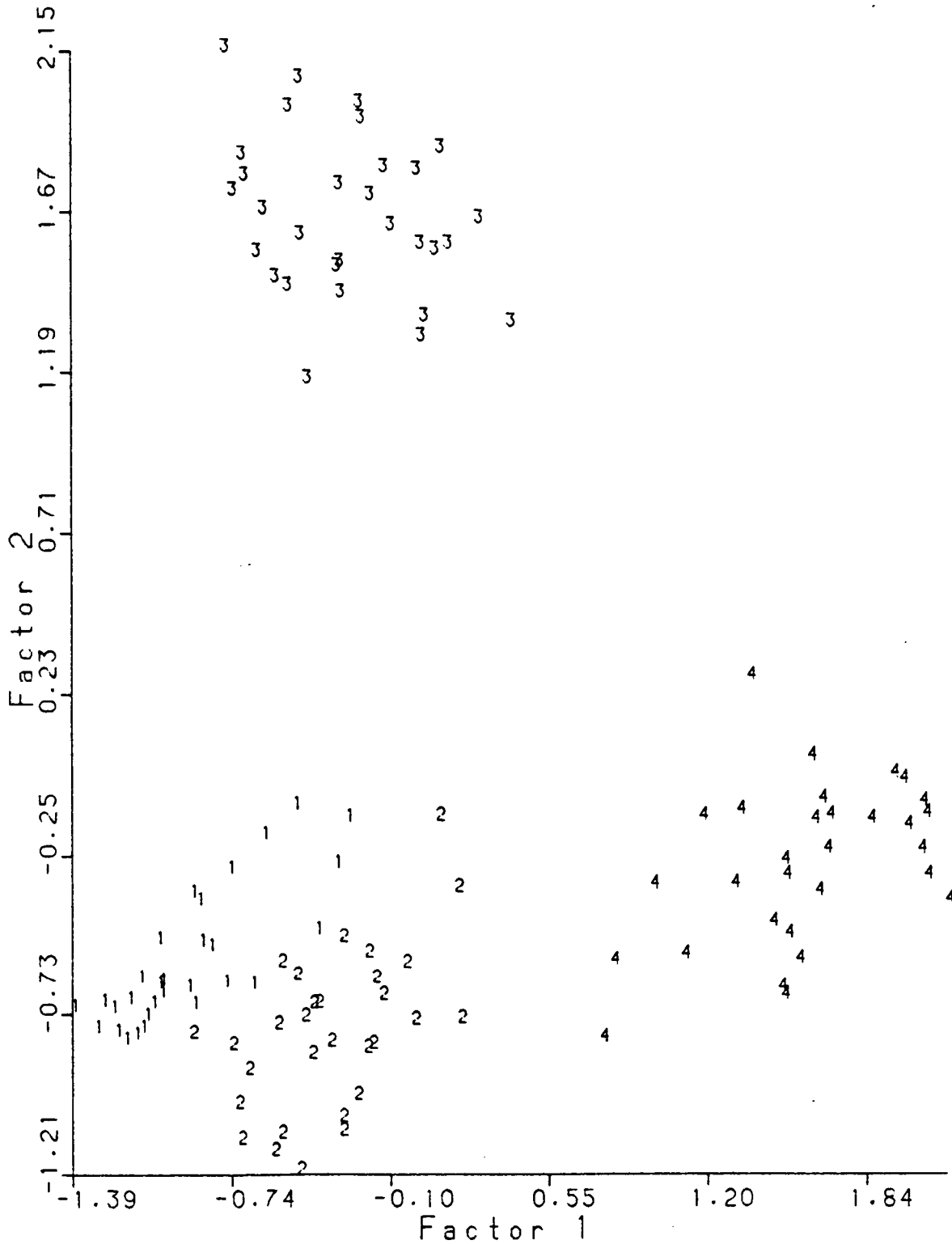


Figure 10. Plot of units defined by the first two factor scores representing Type 2 relative frequencies of 33 vessel types

sherd assemblages were produced. The viability of the group designations has been reinforced and the ability of the statistical procedures to recognize the four group patterning has been substantiated.

CHAPTER IV

ANALYSIS OF THE SHERD ASSEMBLAGES

The sherd assemblages can be defined in three ways. First, they can be categorized by the relative frequency of sherds displaying specific temper and motif combinations. This produces nine temper/motif types, or since it is implicitly understood that different tempers imply different types regardless of motif, simply nine motif types. They are: shell tempered plain, cord marked, check stamped, complicated stamped, and incised; and quartz tempered plain, cord marked, check stamped, and complicated stamped. This classification scheme can be referred to as the traditional way of categorizing sherds. Again, if the provenience units are comparable, relative frequencies can be calculated in terms of sherd totals summed within assemblages, over assemblages, or over groups.

The second way to characterize the 120 assemblages is to measure the relative frequency of types defined in terms of the whole vessel characteristics of the units. Since vessel types are herein distinguished by the location of motifs as well as the type of motif, vessel form, and temper, it follows that a sherd classification system that incorporates motif location information would better represent the parent vessel assemblage. Rather than define types by a single motif on a sherd, a system can be developed that associates a type with the motif found on the vessel portions preserved on a sherd. The possible occurrence of each motif on a recognized vessel portion, as observed on the modeled sherds, is presented in Table 15. The frequency of these 26

Table 15. Possible occurrences of motifs on sherd vessel portions
(X indicates occurrence)

Temper	Portion	Plain	Cord Marked	Check Stamped	Complicated Stamped	Incised
Shell	Rim	X	X	X	X	X
Shell	Neck	X	X	X	X	
Shell	Body	X	X	X	X	X
Quartz	Rim	X	X	X	X	
Quartz	Neck	X	X	X	X	
Quartz	Body	X	X	X	X	

motif/portion types is determined by the frequency of rim, neck, and body portions and the motifs displayed on them. The type's relative frequencies are defined in terms of the sherd count for the population, producing Type 1, 2, or 3 profiles. This generates estimates of the probabilities that a type will occur on a sherd within the population. If, for example, an assemblage contained 500 sherds, 100 of which displayed plain rims, then the probability that the type "plain rim" occurs would be 0.2.

The third way to define sherd assemblages is to utilize the 26 types but weight their frequencies according to the size of the sherds on which they are defined (R. P. S. Davis, Jr. personal communication 1982). Recall that the mean surface areas of sherds of Size 1, 2, 4, and 8 are 2.936, 6.027, 26.035, and 60.635 cm², respectively. The relative size of each compared to the largest produces weights of 0.0484, 0.0994, 0.4294, and 1.0, respectively. Whereas in traditional classification a single sherd represents one unit of analysis, a sherd now represents a fractional portion of one unit depending on its size. For example, a Size 1 sherd contributes 0.0484 to the total sherd count. In this way the interpretive value of each sherd is weighted and represented in the frequency counts. Larger sherds naturally provide more accurate information than smaller sherds. This system weights them accordingly. The resulting frequency profiles are less distorted than those produced by the other two methods. To what degree this distortion affects the interpretive abilities of seriation, cluster, and principal components analyses is discussed in the following sections.

Traditional Analysis

Occurrence frequencies of the nine motif types is provided in Appendix C. In the case of sherd assemblages, Type 3 relative frequencies are not appropriate for analysis because unlike the whole vessel assemblages, sherd sample sizes are not equal. The differences between groups in sherd "output" suggests the presence of some underlying factor(s) that affect the structure of the data. In a real situation this would most often be due to excavation differences. But in this case the derivation of the samples is comparable by design. Therefore, sherd production differences must be related to the system that produced them. Given that in this model large vessels tend to produce more sherds, it follows that the group which has the highest potential for producing larger vessels will also produce the most sherds. For example, Group 1, containing 48.8% large vessels, will clearly have the most sherds and Group 4 with only 16 sherds.0% large vessels will have the fewest sherds. The groups, as abstractions of "culture blocks", display unique vessel distributions related to internal preferences. Statistical analysis of the sherds in terms of the total sherd count over all 120 assemblages should recognize these differences. The statistical discovery of differential sherd production is enlightening but by inspection the sherds counts alone show this. Type 3 profiles are not needed for such an analysis. Also, most real sherd assemblages represent samples of unknown integrity which may not be comparable in terms of Type 3 profiles. Since such profiles are seldom appropriate they are excluded in the sherd analysis.

Because the whole vessel seriation sequence was defined by the assemblages' Type 2 profiles, the seriation of the sherd assemblages is based on similarly calculated measures. The resulting sequence is listed in Table 16 with the order for the whole vessel assemblages. Only one assemblage is found in the same position in both sequences. The overall trend is still from Group 1 to Group 4 but the relative internal homogeneity within groups is less obvious in the sherd derived sequence. Assemblages from Groups 1 and 2 are mixed together as are those from Groups 3 and 4. This suggests that within the constraints of seriation these nine types display far more interassemblage variability than do their whole vessel parents.

The cluster analysis results computed on the assemblages defined by Type 1 profiles are reproduced in Figures 11-15. At the four cluster stage only Ward's method correctly identifies the internal affinities of Groups 3 and 4. However, it is not able to separate all of Group 1 from Group 2. Only the complete linking procedures failed to identify the similarities of all Group 3 assemblages.

Groups 1 and 2 again appear to be very similar. The assemblages from each form two types of subgroups, one that is distinct from the other group's assemblages and one that is similar. Group 4 is generally divided into two subgroups, while Group 3 is consistently isolated as a unique grouping.

The plot of the assemblages defined by the first two principal components (65.5% of the variance) is shown in Figure 16. The dispersion suggests that there are three patterns represented in the data. They consist of (1) Groups 1 and 2, (2) Group 3, and (3) Group 4.

Table 16. Seriation sequences of whole vessel assemblages (A)
and sherd assemblages defined by nine types (B)

A		B	
Group Assemblage		Group Assemblage	
1	25	1	9
1	1	1	25
1	29	1	6
1	7	1	1
1	9	1	16
1	28	1	27
1	23	1	23
1	4	1	29
1	5	1	4
1	12	1	3
1	13	2	26
1	27	2	5
1	16	2	20
1	14	2	1
1	19	1	28
1	17	1	2
1	11	1	14
1	8	1	18
1	6	1	5
1	22	1	30
1	3	1	13
1	2	1	19
1	24	1	20
1	26	1	17
1	20	2	23
1	21	1	8
1	15	1	24
1	10	2	29
1	30	1	22
1	18	2	30
2	1	1	21
2	14	2	27
2	23	2	8
2	12	1	26
2	29	1	7
2	11	2	14
2	25	2	3
2	6	2	13
2	5	2	21
2	3	1	12
2	2	1	15
2	27	2	25
2	26	2	11

Table 16. (Continued)

A		B	
Group Assemblage		Group Assemblage	
2	20	1	10
2	21	2	6
2	22	1	11
2	9	2	22
2	10	2	17
2	8	2	7
2	30	2	12
2	28	2	18
2	18	2	10
2	4	2	9
2	24	2	24
2	17	2	15
2	13	2	19
2	7	2	16
2	19	2	4
2	16	2	2
2	15	2	28
3	30	3	23
3	9	3	29
3	11	3	24
3	21	3	12
3	3	3	25
3	22	3	19
3	14	3	18
3	24	3	2
3	23	3	11
3	25	3	3
3	13	3	17
3	7	3	15
3	20	4	29
3	18	3	26
3	27	3	20
3	6	3	10
3	2	3	22
3	26	4	27
3	15	3	4
3	1	4	15
3	3	3	21
3	19	3	13
3	4	4	16
3	17	3	6
3	28	4	1
3	5	4	2
3	29	4	13

Table 16. (Continued)

A		B	
Group	Assemblage	Group	Assemblage
3	10	3	14
3	12	4	4
3	16	3	27
4	8	3	5
4	1	4	23
4	7	3	7
4	14	4	23
4	13	3	30
4	26	3	1
4	4	4	8
4	2	3	9
4	15	4	17
4	19	4	26
4	10	4	5
4	30	4	24
4	13	4	30
4	22	4	6
4	6	4	19
4	25	4	14
4	16	3	16
4	20	3	23
4	21	4	18
4	3	4	7
4	23	4	3
4	29	4	20
4	9	4	11
4	12	4	25
4	11	3	3
4	27	4	21
4	28	4	12
4	17	4	10
4	5	4	22
4	24	4	9

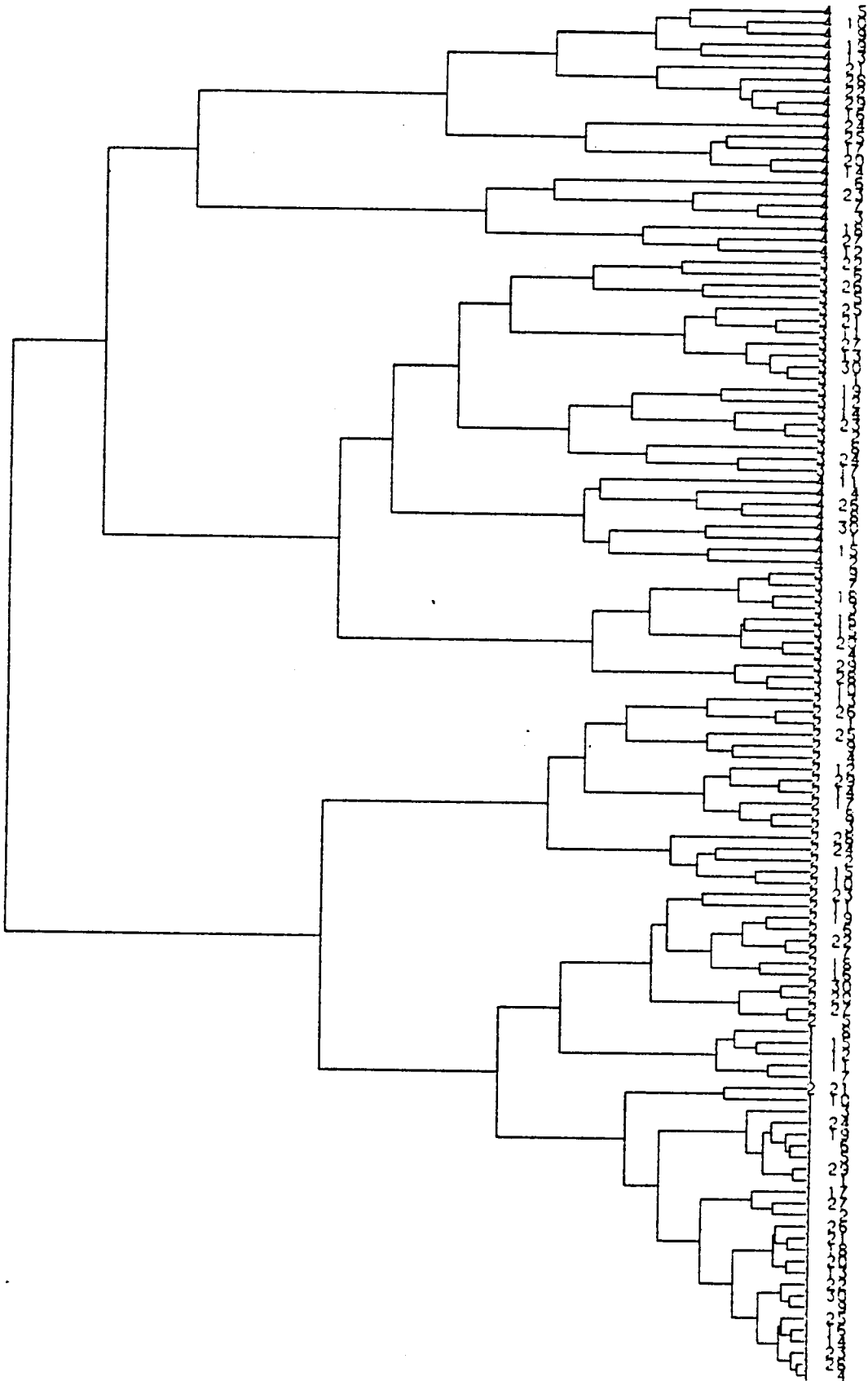


Figure 11. Complete linkage clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds

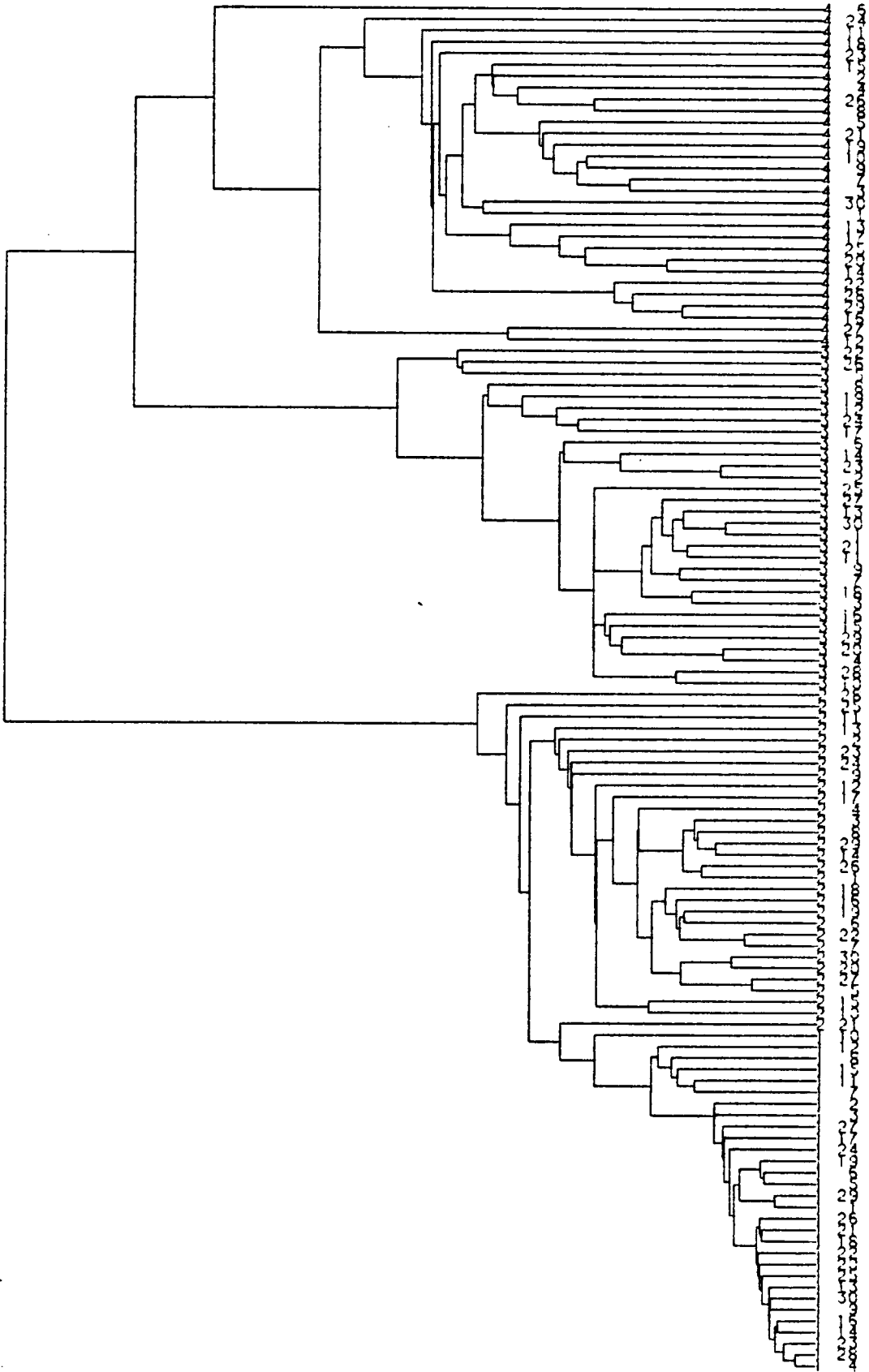


Figure 12. Single linkage clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds

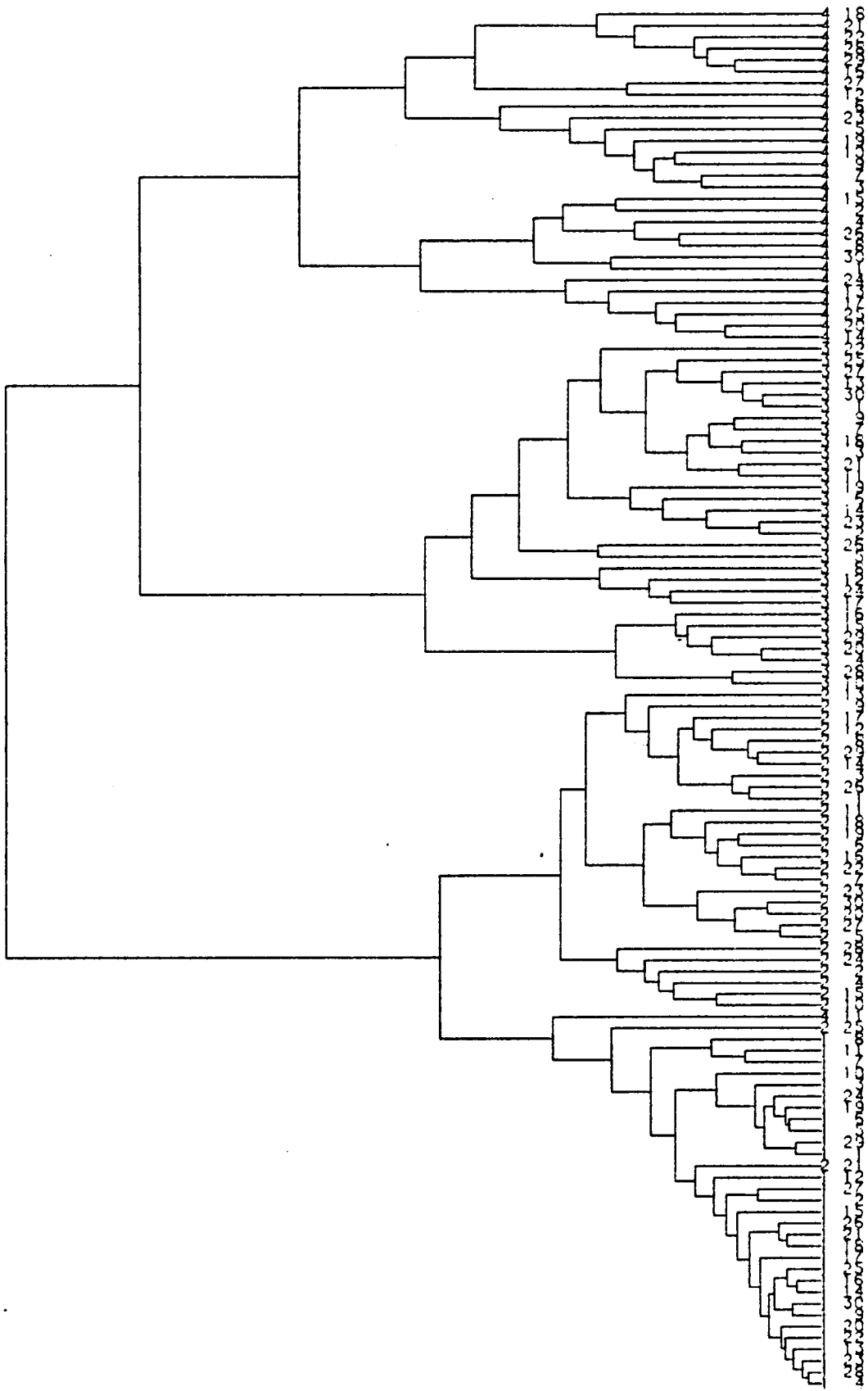


Figure 13. Average linkage (within) clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds

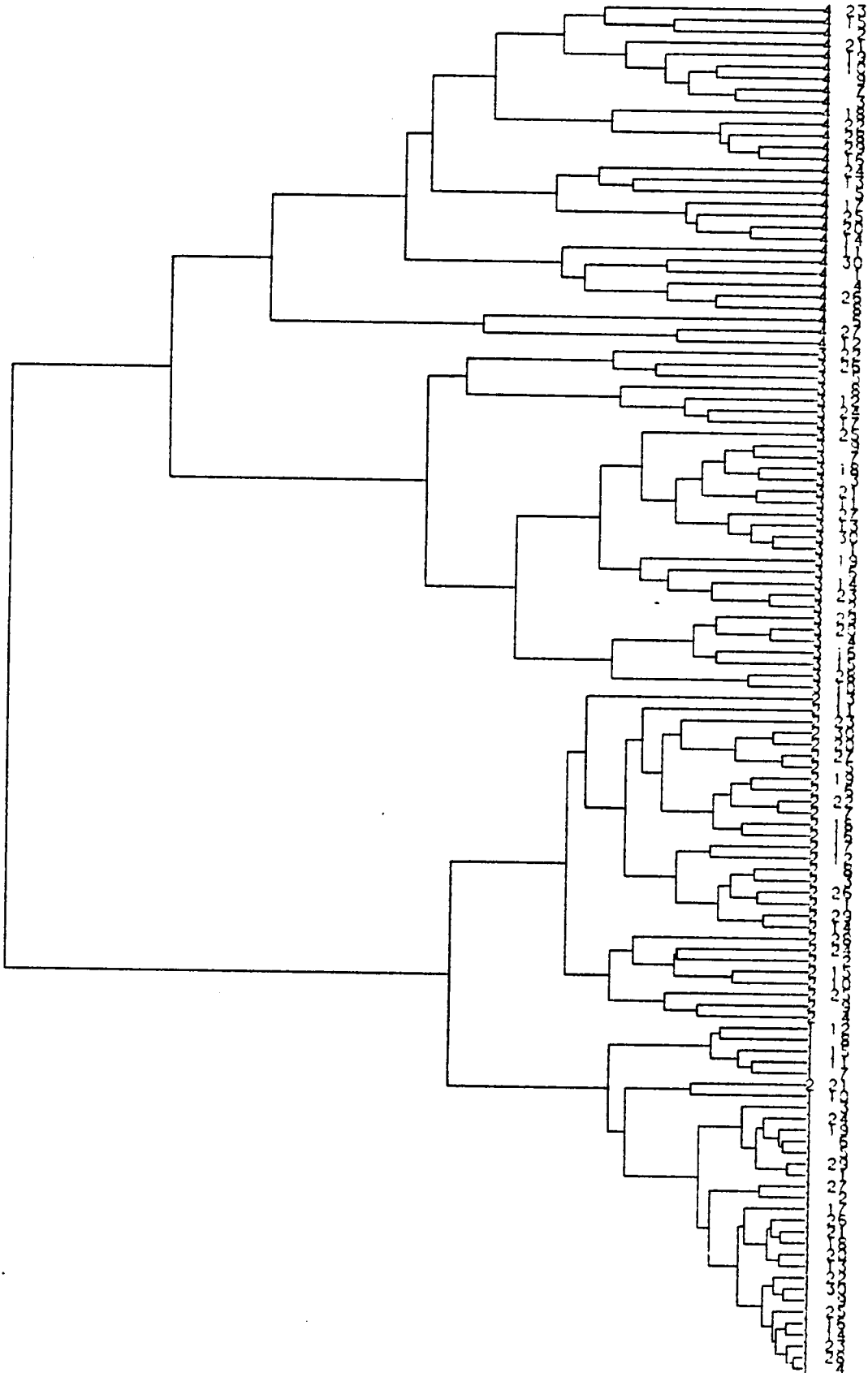


Figure 14. Average linkage (between) clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds

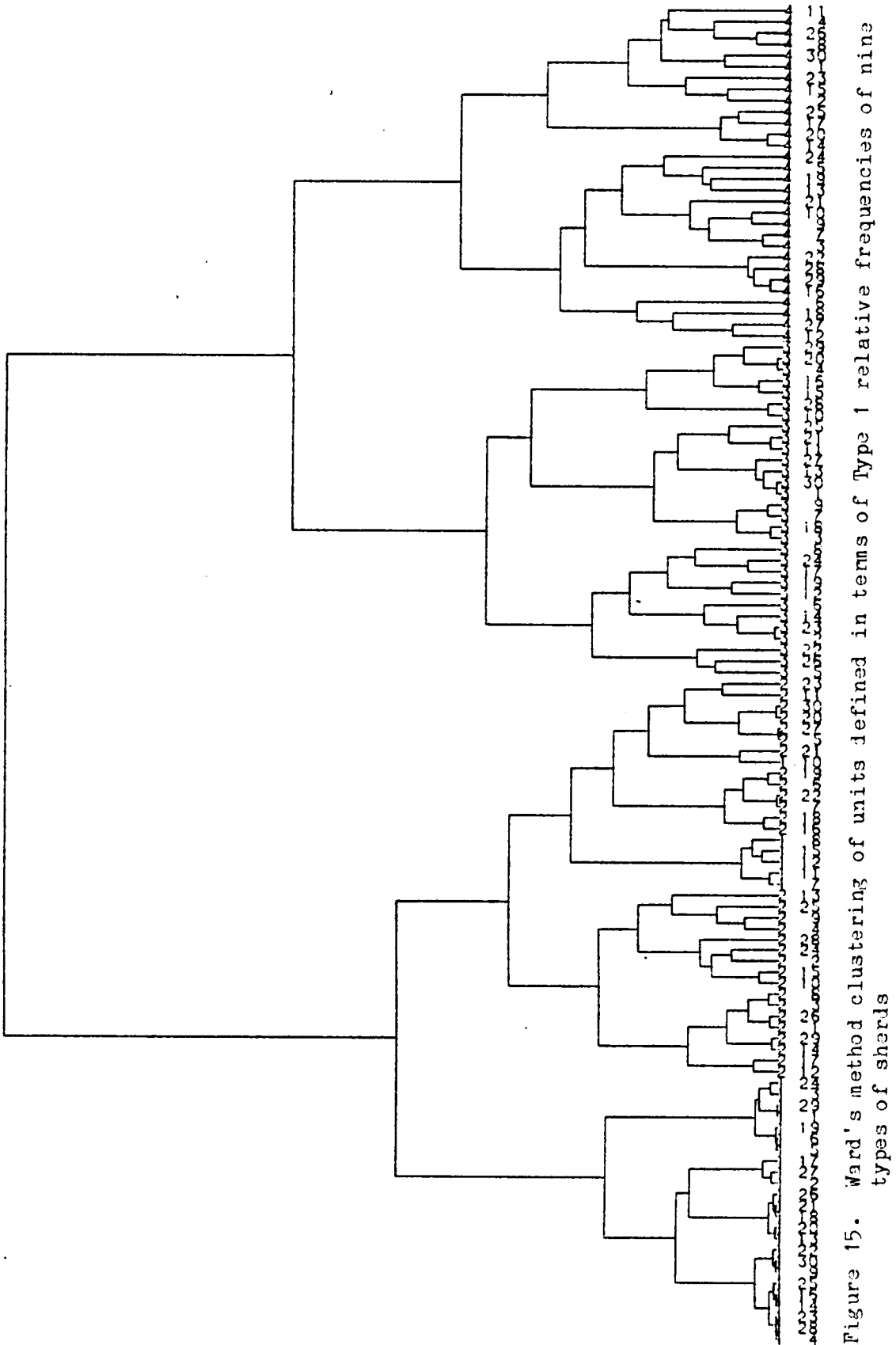
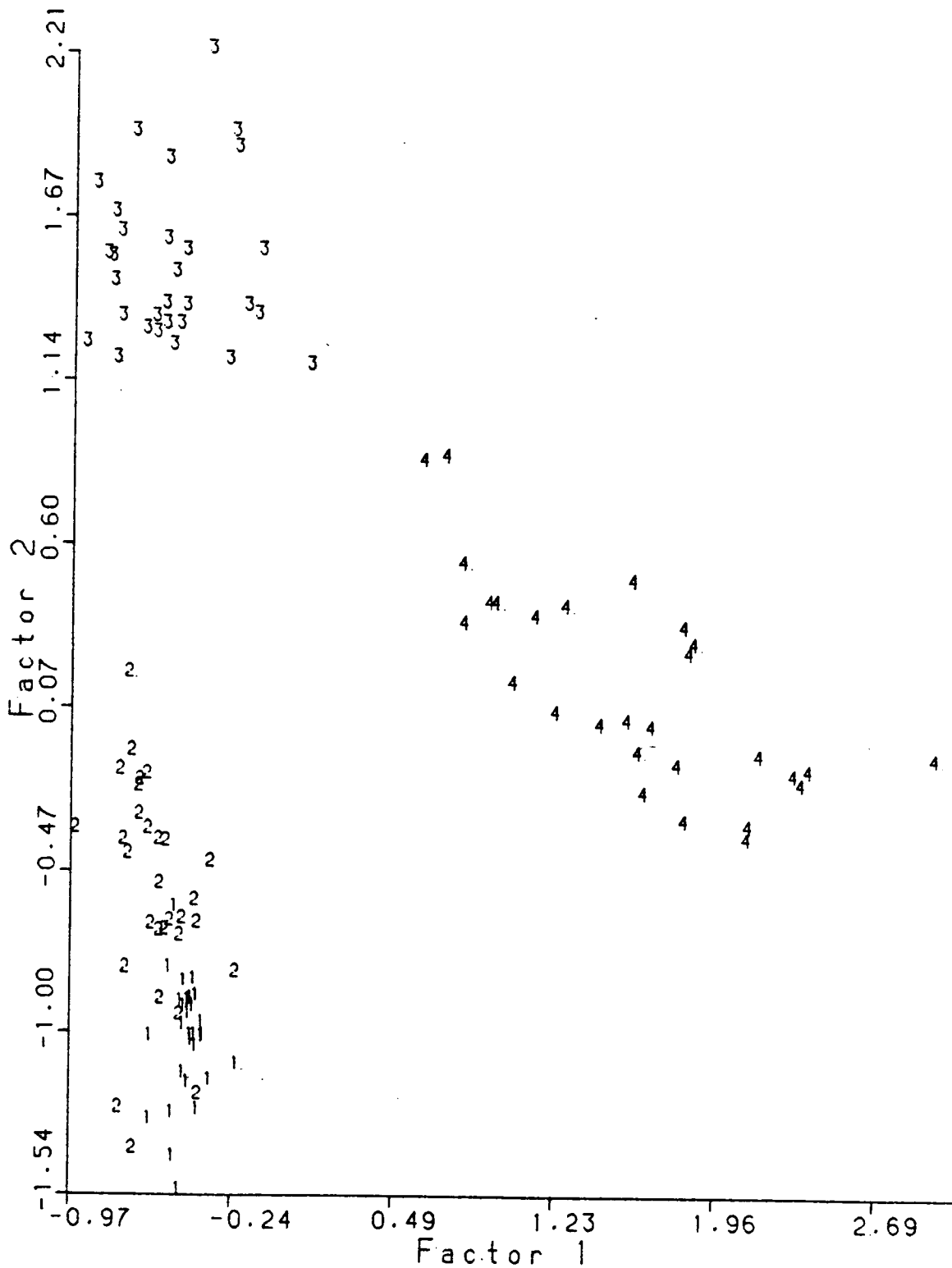


Figure 15. Ward's method clustering of units defined in terms of Type 1 relative frequencies of nine types of sherds



This method does not quite define the groups as clearly as it did when whole vessels were used.

The results of the cluster analyses applied to Type 2 profiles are reproduced in figures 17-21. The principal component plot describing 65.2% of the variance is displayed in Figure 22. Again Ward's method produced the best group definitions emphasizing the distinctiveness of Groups 3 and 4 and the homogeneity of Groups 1 and 2. The other procedures fail to isolate groups as much as they identify unusual assemblages. Type 2 profiles appear to grossly distort the relationships between assemblages in relation to the clustering criteria of these procedures. Their component scores, however, visually provide group separation similar to that in Figure 16.

An Alternative Analysis

Analysis of the nine types provides an indication of the underlying structure of the data but fails to totally match similar characterizations made on the whole vessel assemblages. Use of the unweighted 26 types produces the seriation listed in Table 17 for Type 2 profiles of the data. The order closely resembles that of the nine-type solution. In terms of this procedure the 26 types fail to provide a clearer pattern.

Cluster analyses (Figures 23-27) and principal component representations (39.7% of the variance) of Type 1 profiles (Figure 23) provide no new information about the sherds assemblages. The cluster patterns are very similar to those in Figures 17-21 with Ward's method producing the best four group solution. Any slight improvement in discerning the four groups is overshadowed by the occasional recognition

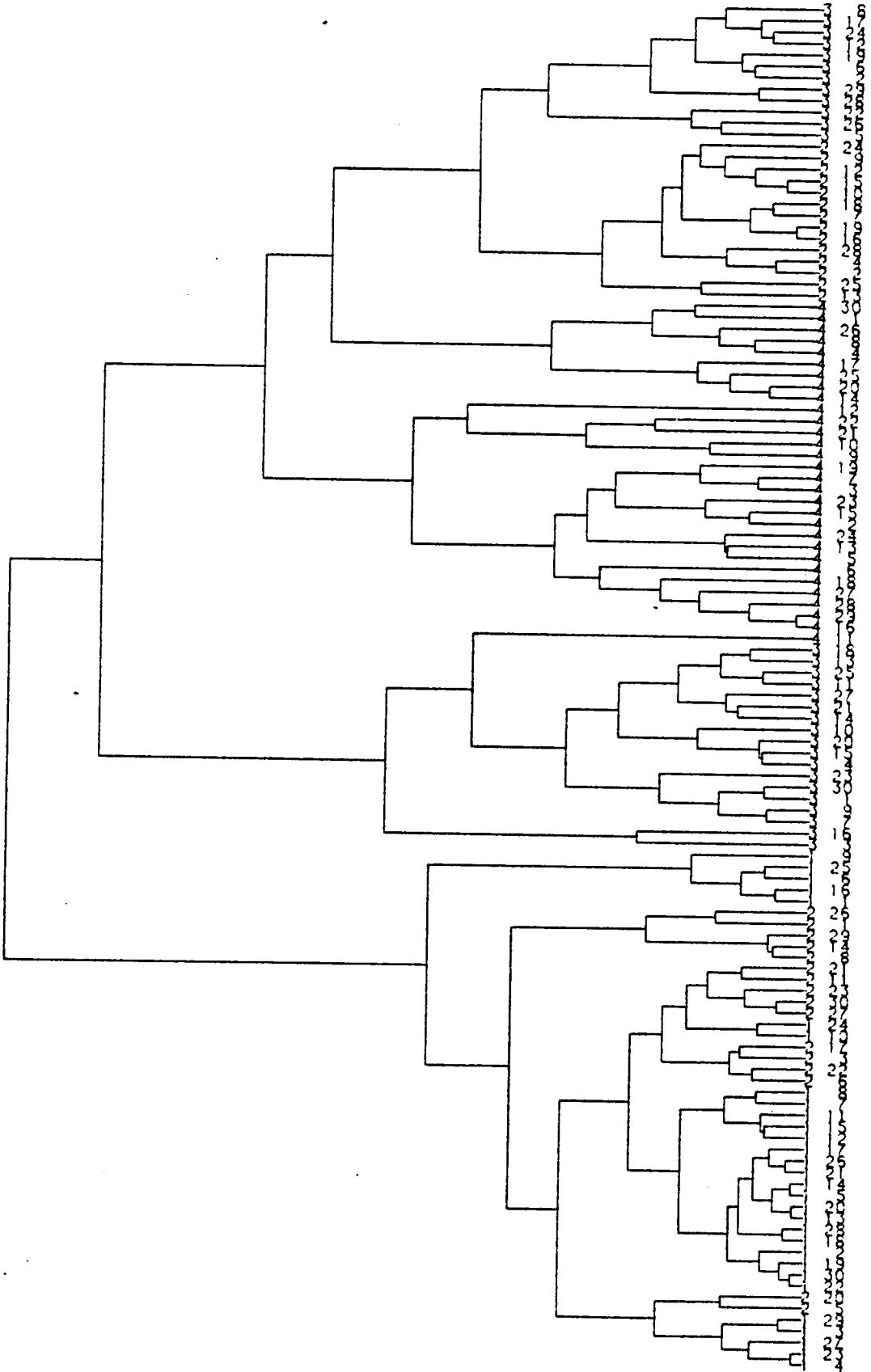


Figure 17. Complete linkage clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds

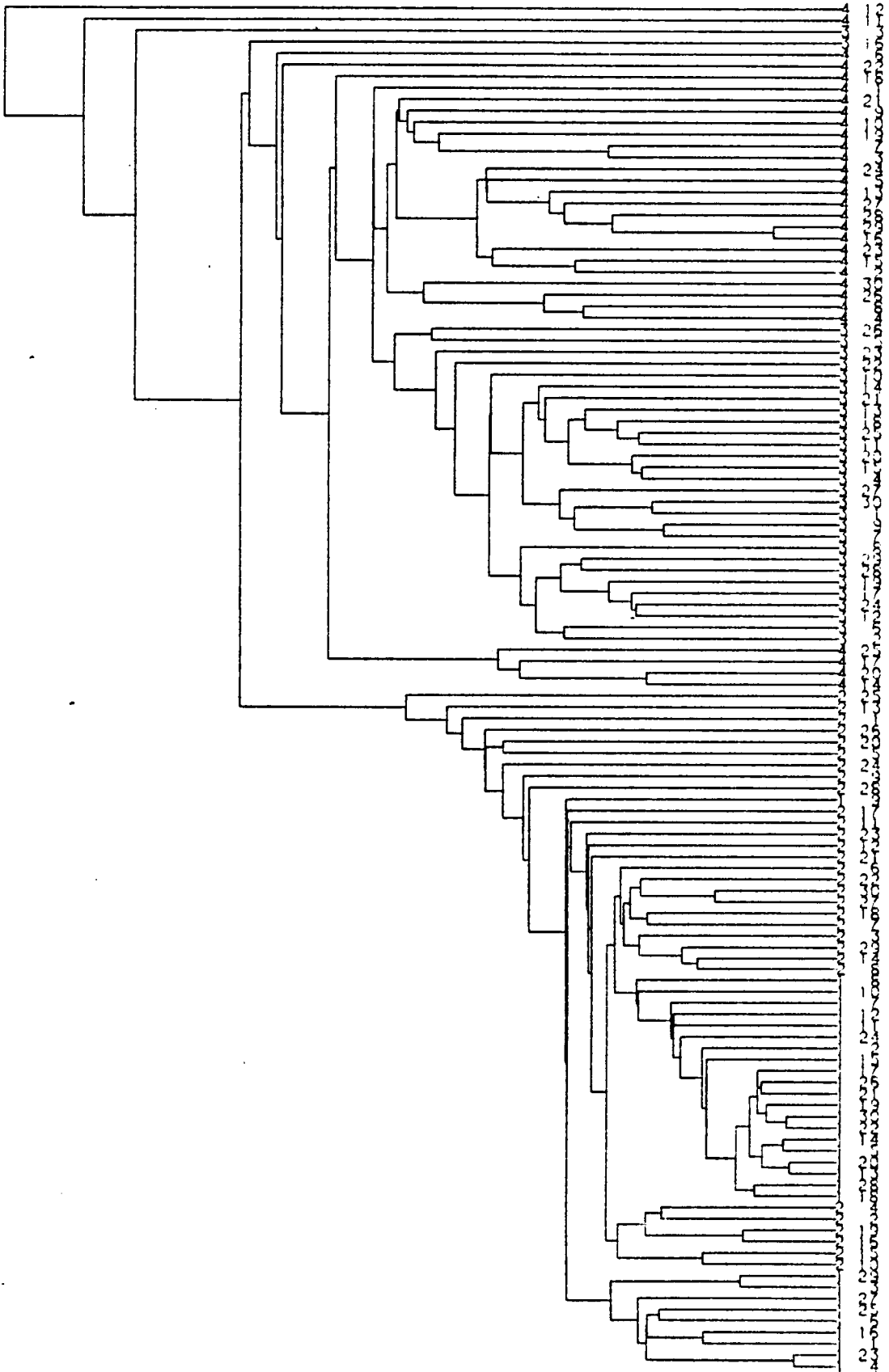


Figure 18. Single linkage clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds

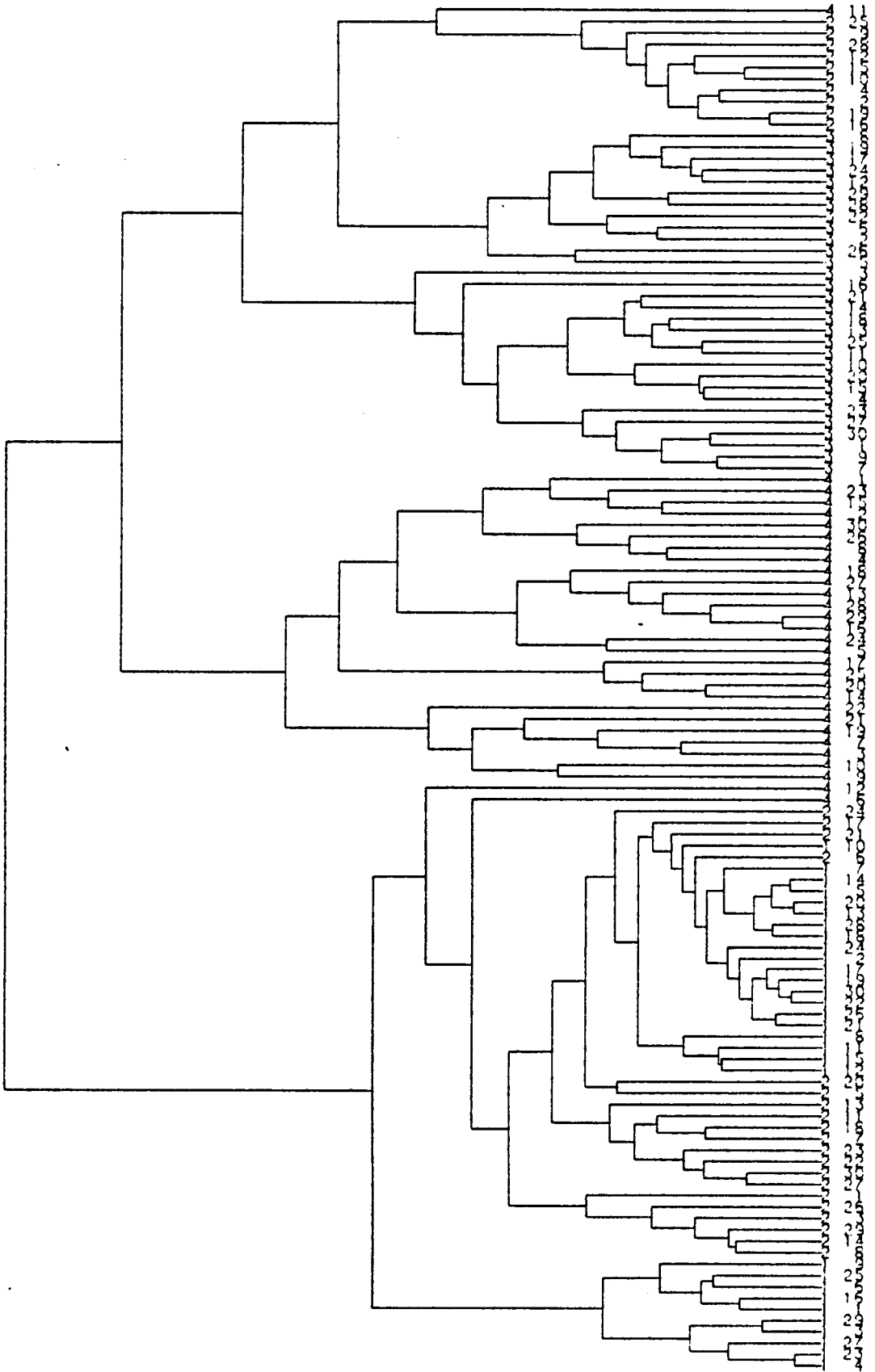


Figure 19. Average linkage (within) clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds

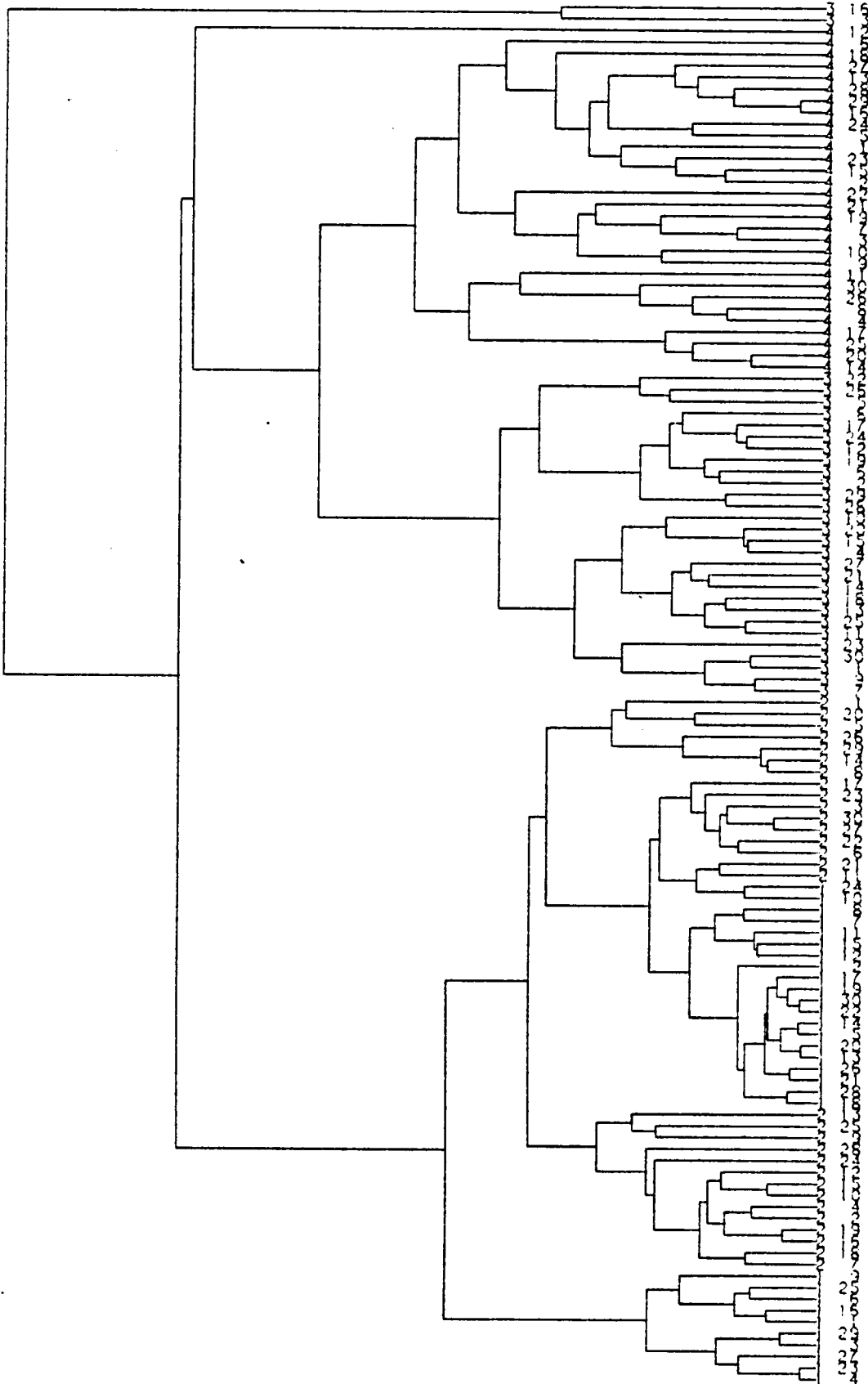


Figure 20. Average linkage (between) clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds

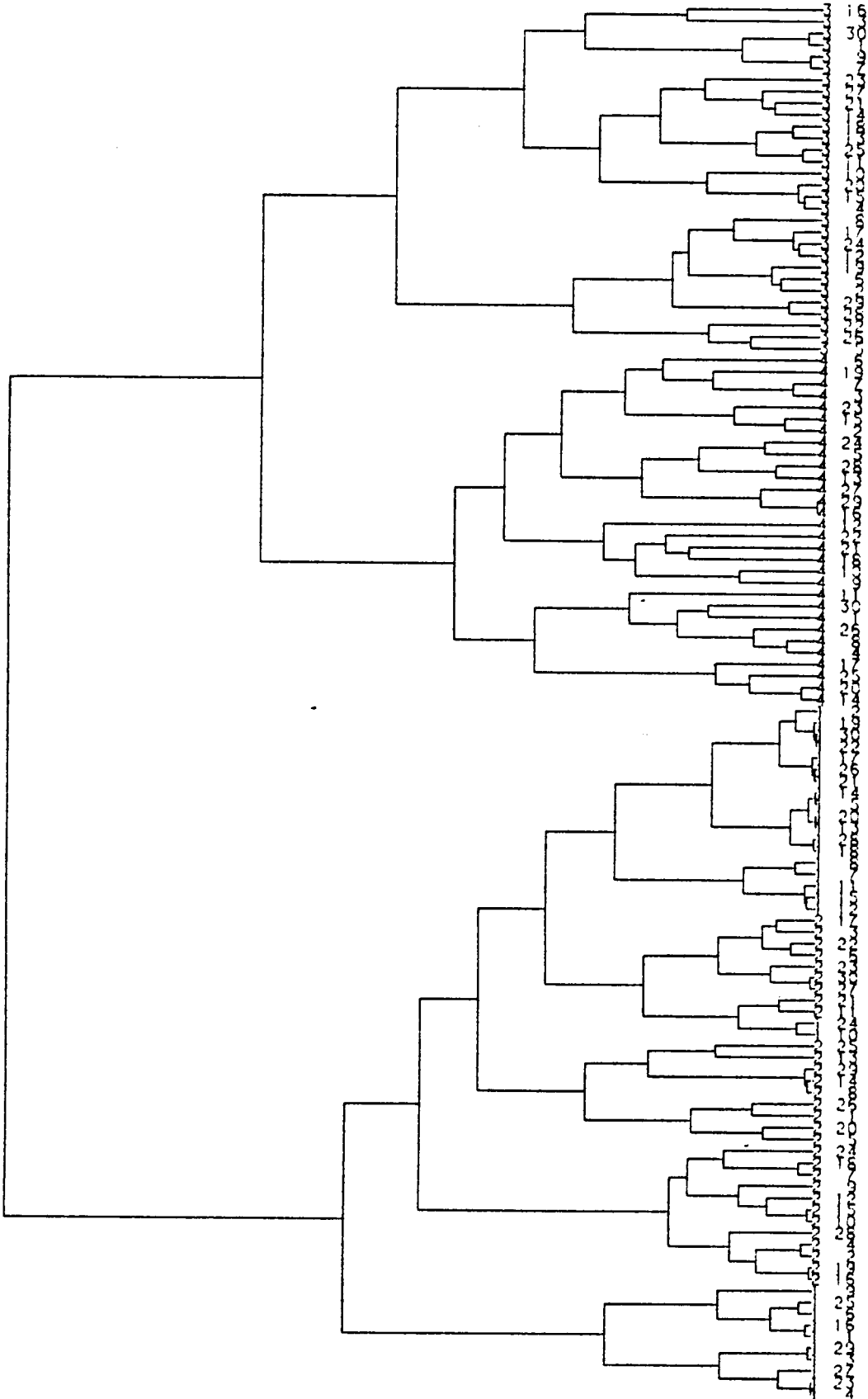


Figure 21. Ward's method clustering of units defined in terms of Type 2 relative frequencies of nine types of sherds

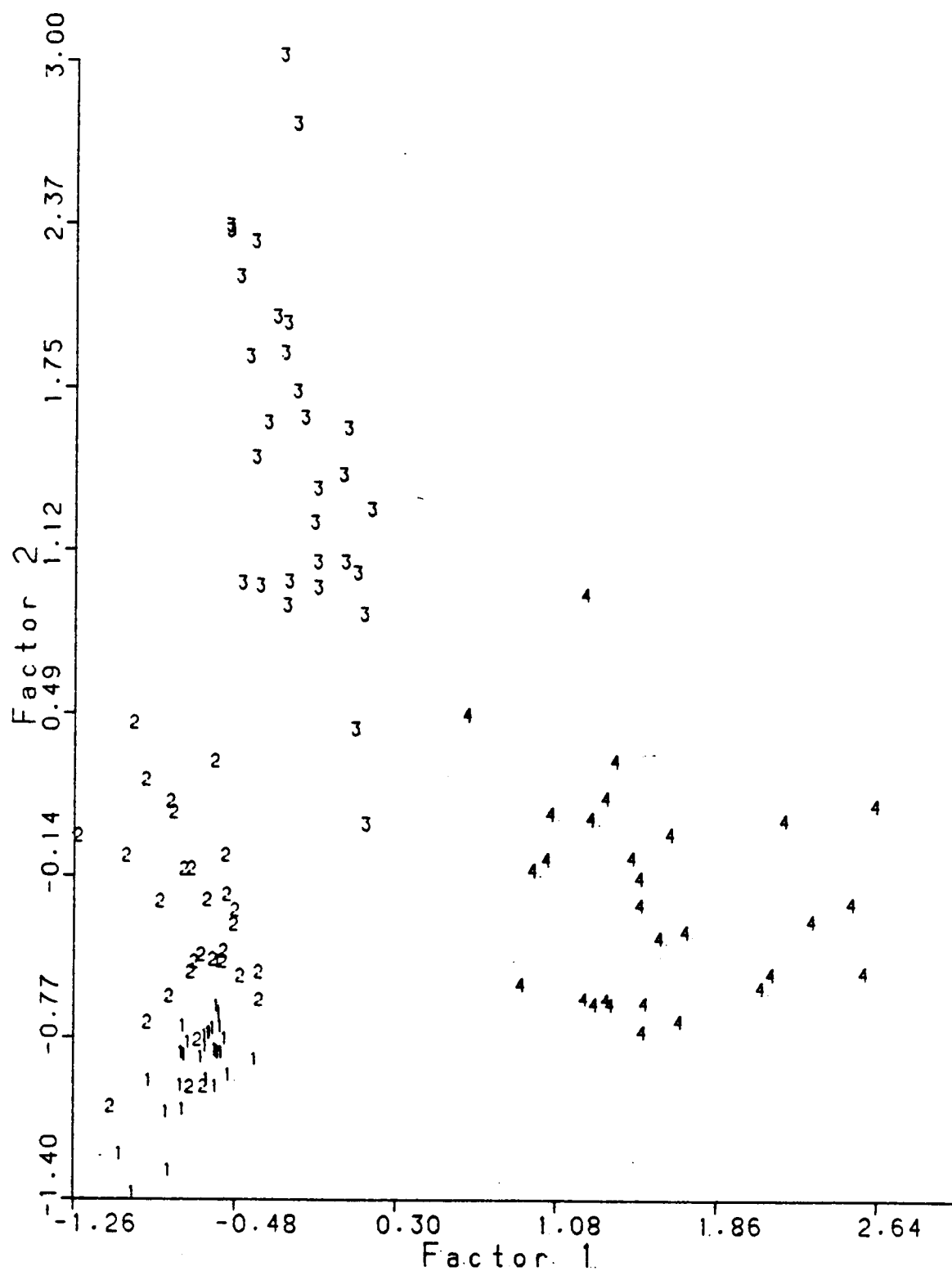


Figure 22. Plot of units defined by the first two factor scores representing Type 2 relative frequencies of nine types of sherds

Table 17. Seriation sequences of whole vessel assemblages (A),
 sherd assemblages defined by nine types (B), and sherd
 assemblages defined by 26 types (C)

A		B		C	
Group	Assemblage	Group	Assemblage	Group	Assemblage
1	25	1	9	1	9
1	1	1	25	1	6
1	29	1	6	1	25
1	7	1	1	1	16
1	9	1	16	1	1
1	23	1	27	1	27
1	23	1	23	1	23
1	4	1	29	1	4
1	5	1	4	1	29
1	12	1	3	1	3
1	13	2	26	2	1
1	27	2	5	2	5
1	16	2	20	2	26
1	14	2	1	1	23
1	19	1	28	2	20
1	17	1	2	1	5
1	11	1	14	1	2
1	8	1	18	1	14
1	6	1	5	1	13
1	22	1	30	2	29
1	3	1	13	1	30
1	2	1	19	1	13
1	24	1	20	1	8
1	26	1	17	2	23
1	20	2	23	1	19
1	21	1	8	1	17
1	15	1	24	1	20
1	10	2	29	2	30
1	30	1	22	1	26
1	18	2	30	1	21
2	1	1	21	1	22
2	14	2	27	1	7
2	23	2	3	1	24
2	12	1	26	2	27
2	29	1	7	2	8
2	11	2	14	2	13
2	25	2	3	2	14
2	6	2	13	2	3
2	5	2	21	1	12
2	3	1	12	2	25
2	2	1	15	1	15
2	27	2	25	1	10

Table 17. (Continued)

A		B		C	
Group	Assemblage	Group	Assemblage	Group	Assemblage
2	26	2	11	2	21
2	20	1	10	2	6
2	21	2	6	2	11
2	22	1	11	2	22
2	9	2	22	1	11
2	10	2	17	2	17
2	8	2	7	2	7
2	30	2	12	2	10
2	23	2	13	2	13
2	18	2	10	2	24
2	4	2	9	2	19
2	24	2	24	2	12
2	17	2	15	2	16
2	13	2	19	2	9
2	7	2	16	2	15
2	19	2	4	2	4
2	16	2	2	2	2
2	15	2	23	2	28
3	30	3	23	3	24
3	9	3	29	3	23
3	11	3	24	3	13
3	21	3	12	3	3
3	3	3	25	3	2
3	22	3	19	3	25
3	14	3	18	3	29
3	24	3	2	3	12
3	23	3	11	3	19
3	25	3	8	3	11
3	13	3	17	3	17
3	7	3	15	3	20
3	20	4	29	3	22
3	18	3	26	3	13
3	27	3	20	3	15
3	6	3	10	3	10
3	2	3	22	3	26
3	26	4	27	4	27
3	15	3	4	4	29
3	1	4	15	3	6
3	3	3	21	3	4
3	19	3	13	4	16
3	4	4	16	4	15
3	17	3	6	3	21
3	23	4	1	4	13
3	5	4	2	4	2

Table 17. (Continued)

A		B		C	
Group	Assemblage	Group	Assemblage	Group	Assemblage
3	29	4	13	4	1
3	10	3	14	4	28
3	12	4	4	3	5
3	16	3	27	4	4
4	8	3	5	3	27
4	1	4	23	3	14
4	7	3	7	4	23
4	14	4	23	4	8
4	18	3	30	4	17
4	26	3	1	3	30
4	4	4	8	3	7
4	2	3	9	4	14
4	15	4	17	3	9
4	19	4	26	4	19
4	10	4	5	4	5
4	30	4	24	4	24
4	13	4	30	4	30
4	22	4	6	4	26
4	6	4	19	3	1
4	25	4	14	3	23
4	16	3	16	4	6
4	20	3	23	3	16
4	21	4	18	4	7
4	3	4	7	4	20
4	23	4	3	4	18
4	29	4	20	4	25
4	9	4	11	4	3
4	12	4	25	4	11
4	11	3	3	4	12
4	27	4	21	4	21
4	28	4	12	4	10
4	17	4	10	3	3
4	5	4	22	4	22
4	24	4	9	4	9

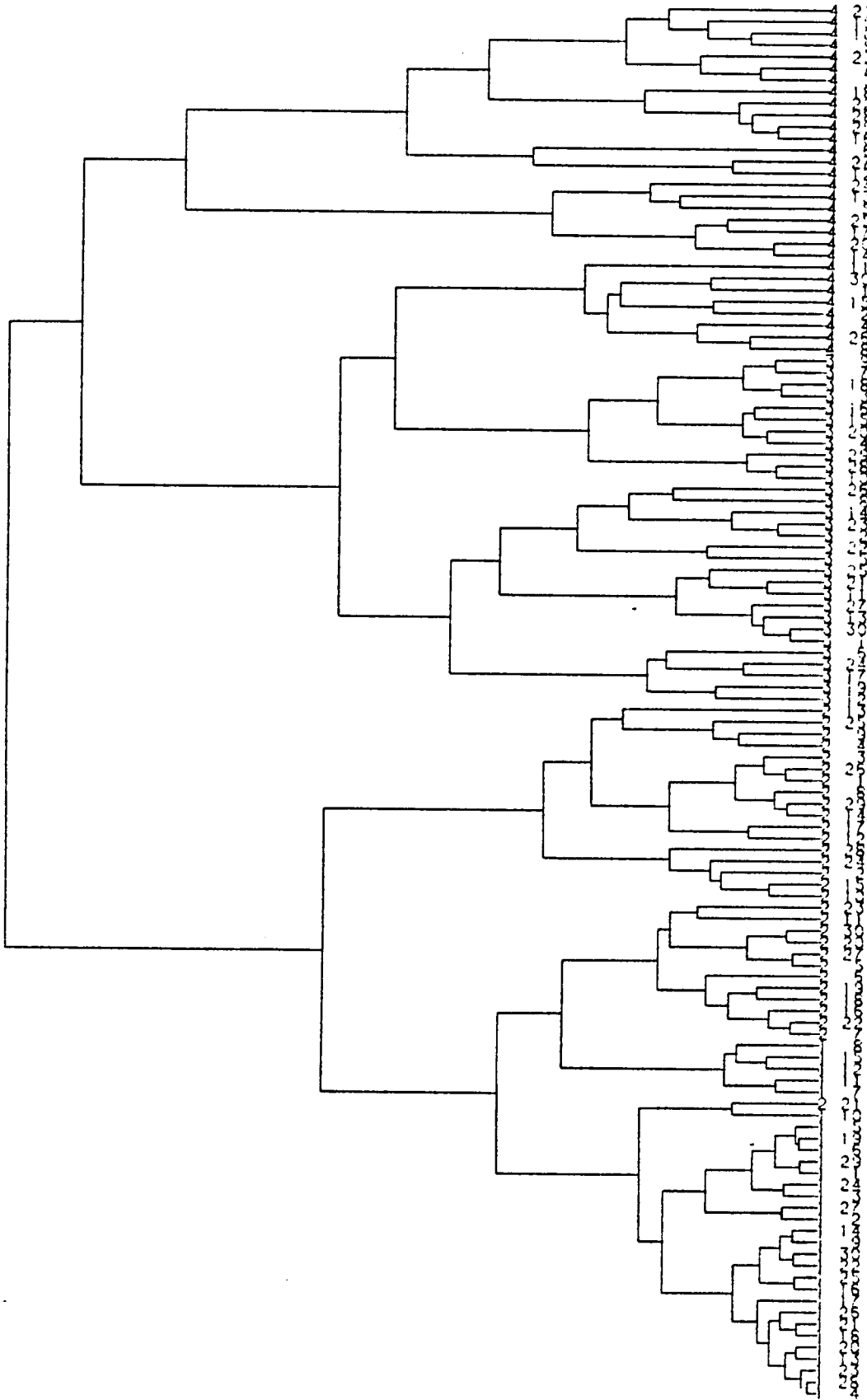


Figure 23. Complete linkage clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types

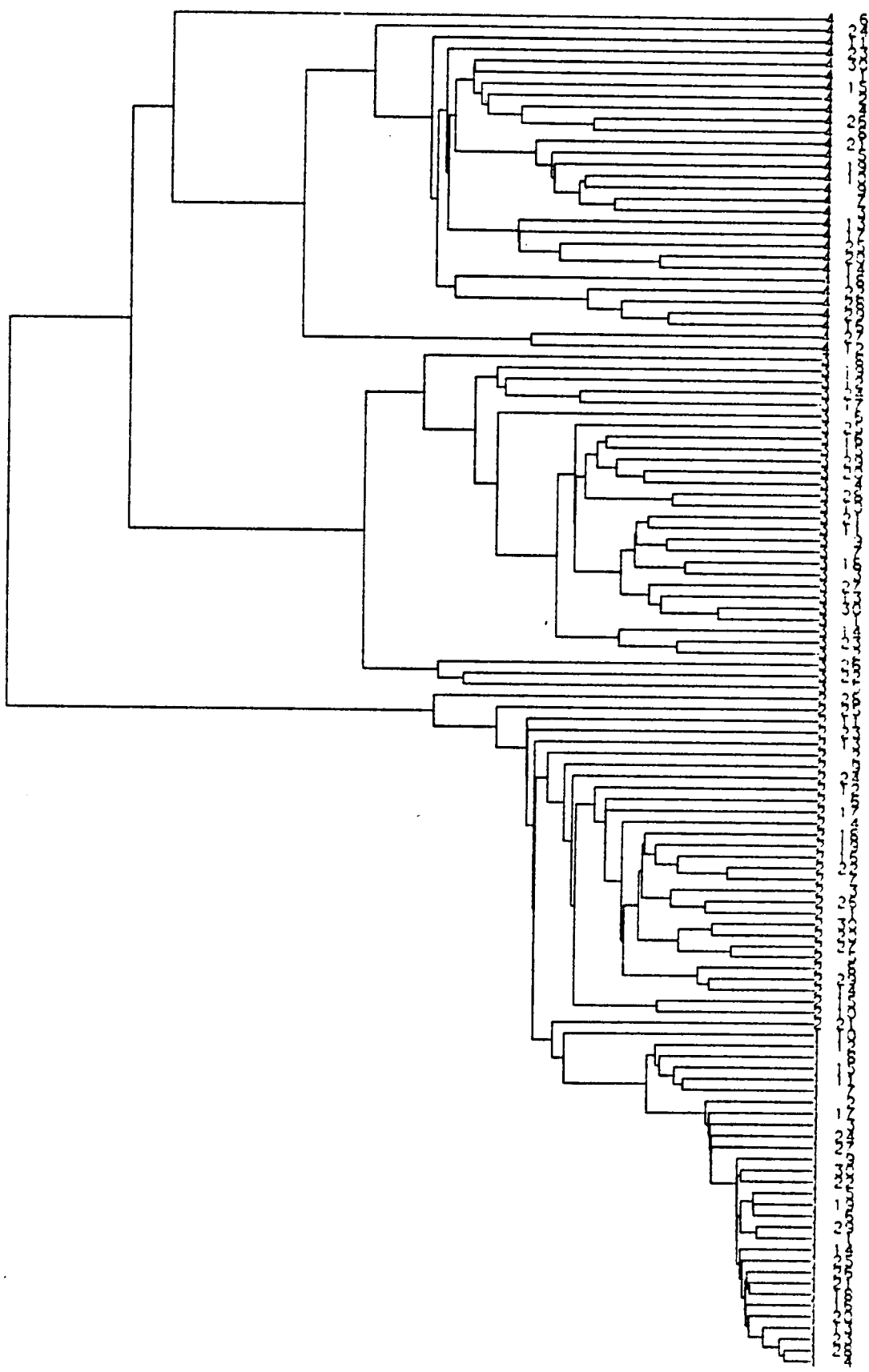


Figure 24. Single linkage clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types

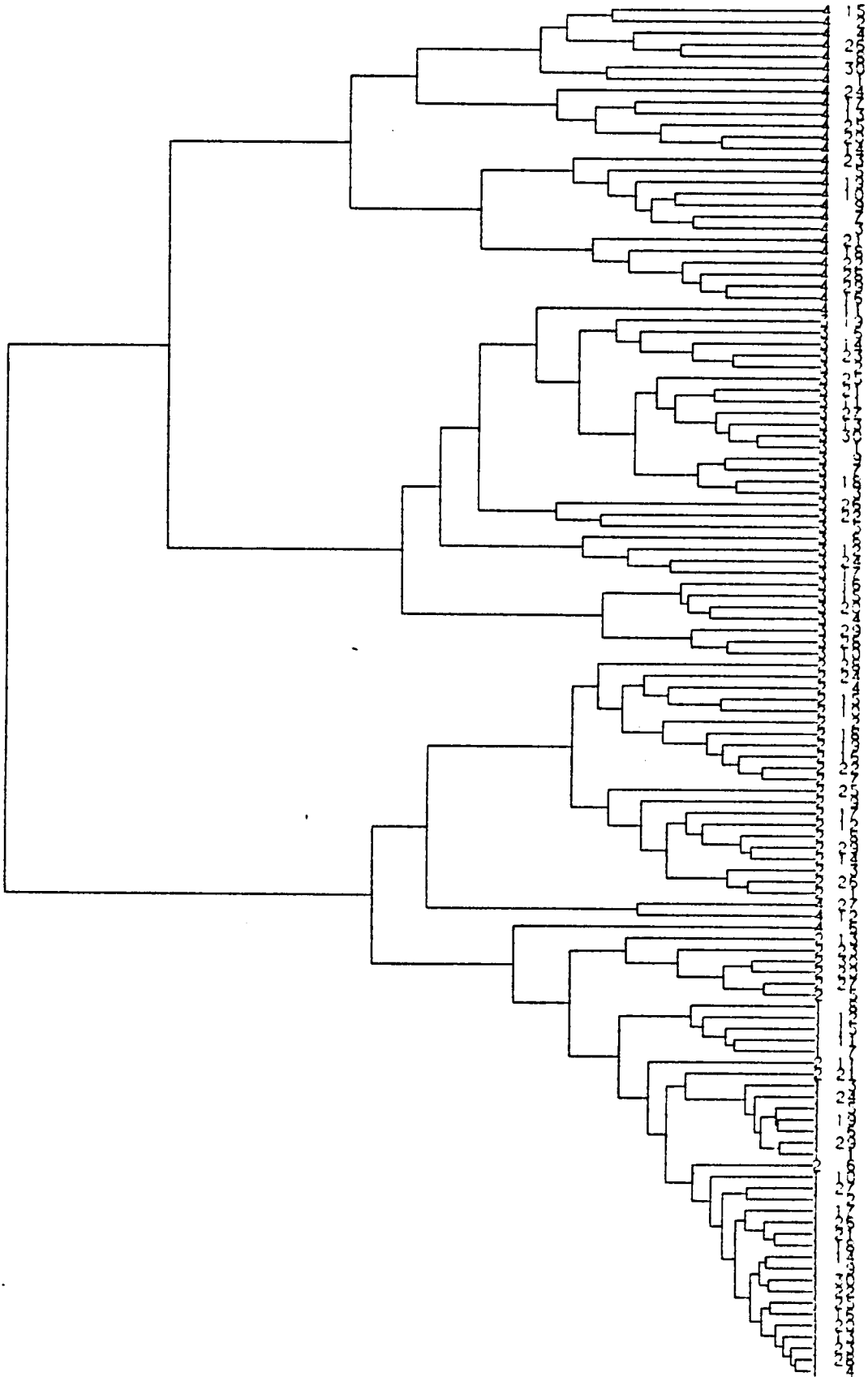


Figure 25. Average linkage (within) clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types

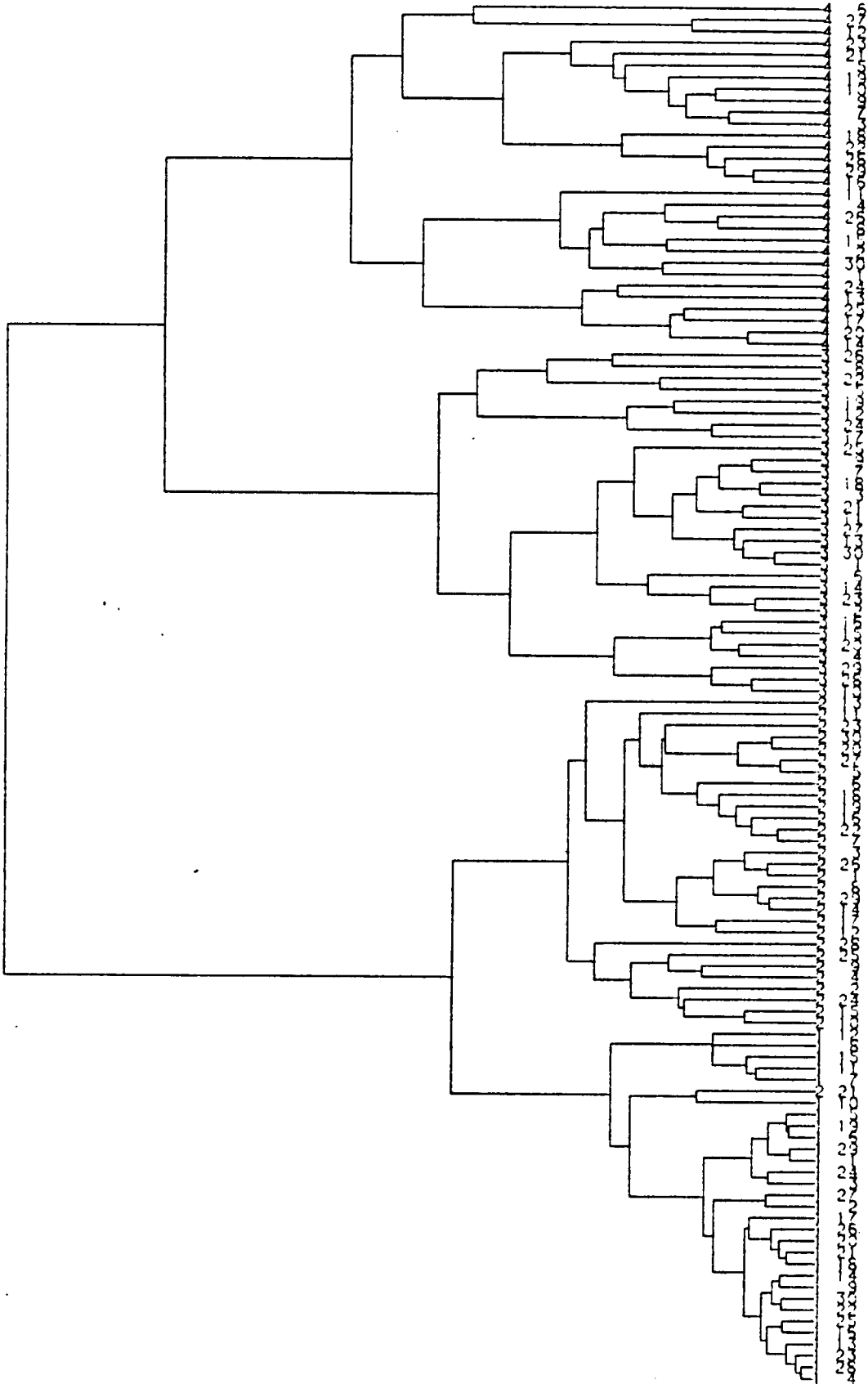


Figure 26. Average linkage (between) clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types

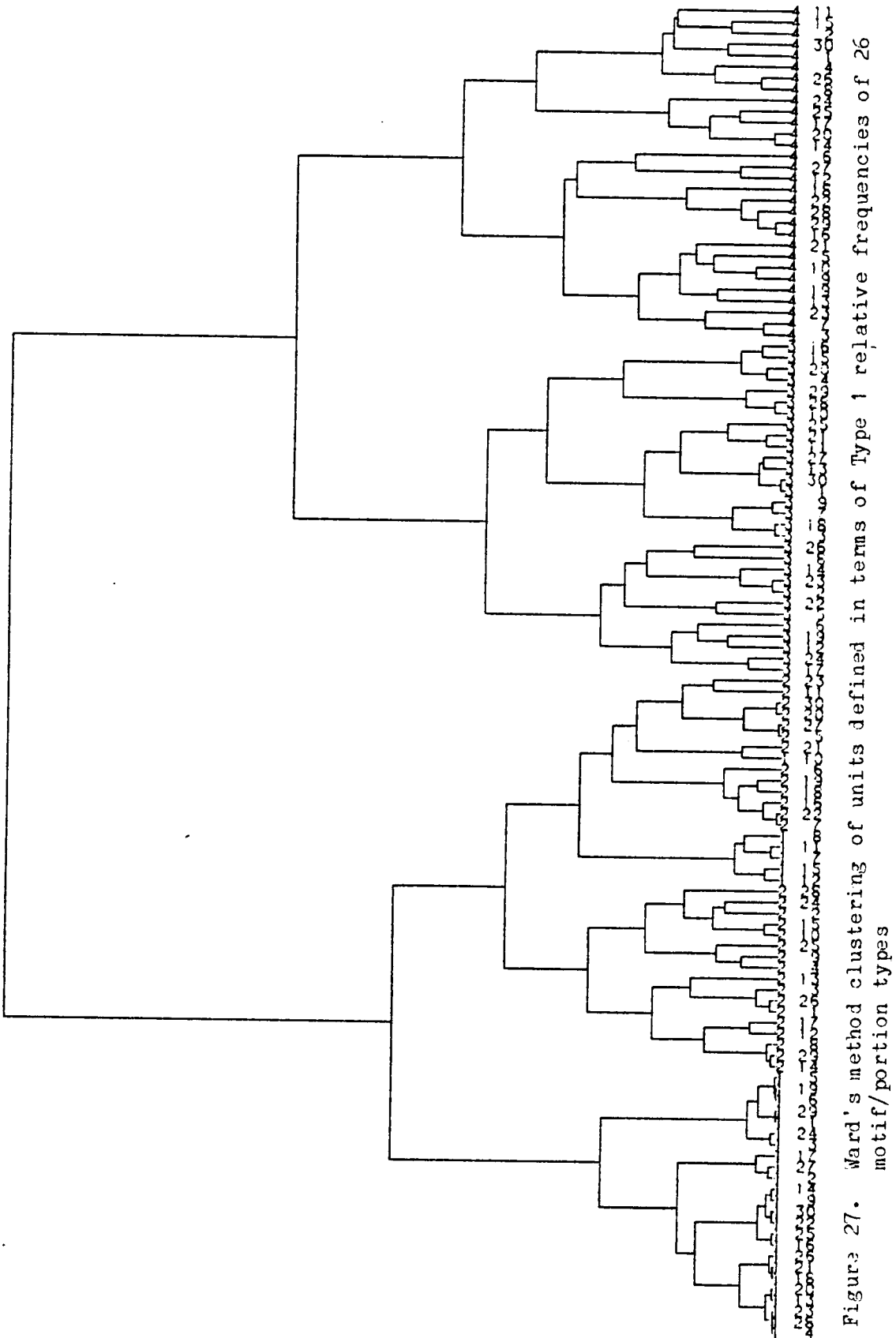


Figure 27. Ward's method clustering of units defined in terms of Type 1 relative frequencies of 26 motif/portion types

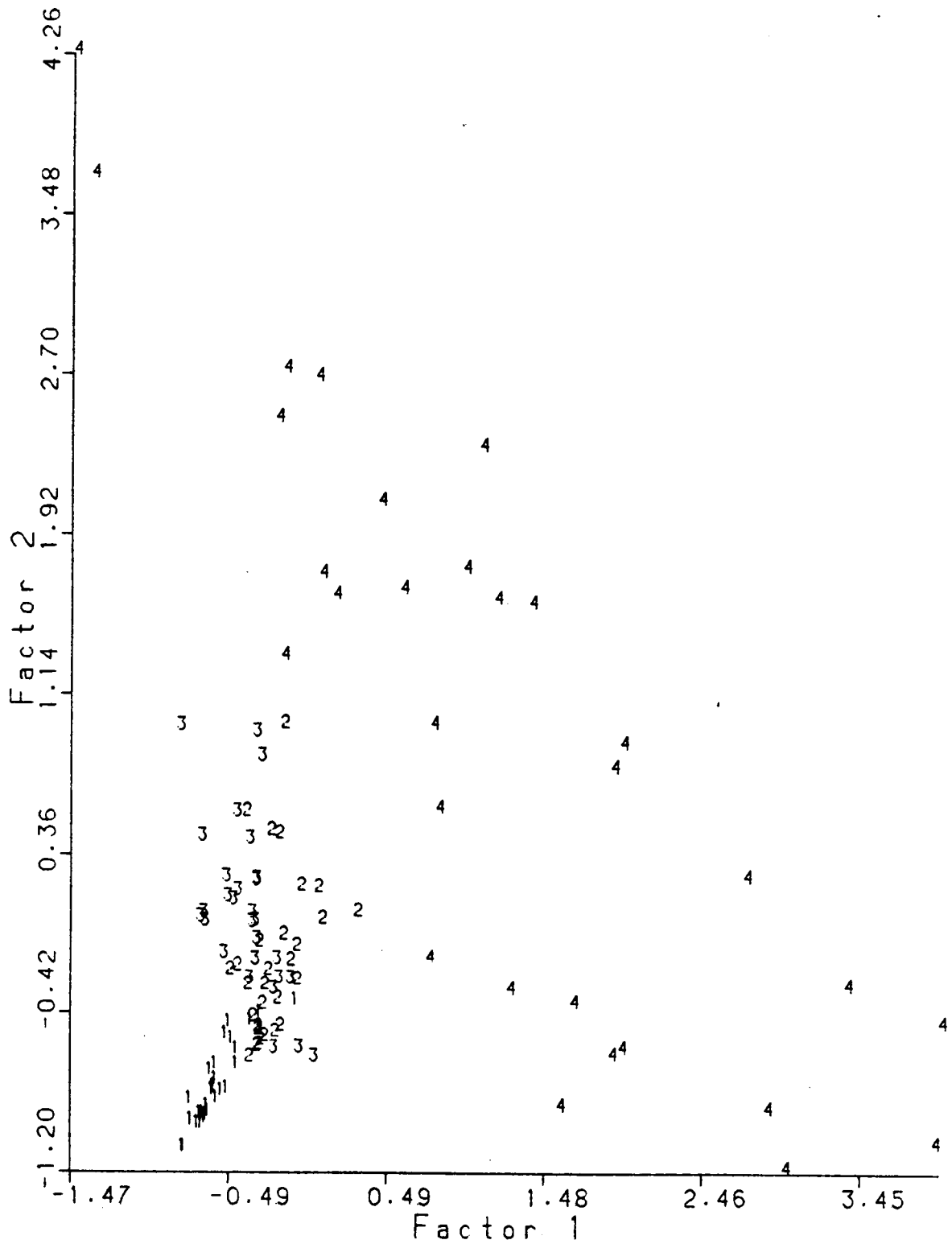


Figure 28. Plot of units defined by the first two factor scores representing Type 1 relative frequencies of 26 motif/portion types

of totally miss-associated assemblages (for example, Group 4, assemblages 12 and 6 in Figure 25). This is probably related to the increase in dimensionality and the subtle changes this causes in the positioning of assemblages. In terms of the clustering criteria, the resulting dispersion permits two assemblages from different groups to be associated together. This is a danger any time assemblages are represented by unstandardized distances within large multidimensional spaces.

Similarly, Type 2 profiles produced cluster patterns (Figures 29-33) much the same as those generated by the nine types. The first two principal components (38.0% of the variance) also failed to provide any new information (Figure 34).

Examination of the unweighted 26 types suggests that, although they theoretically are more representative of the whole vessel composition, they do not provide any more information than the more parsimonious nine types. Incorporation of size weights, as argued above, might help remove some of the distortion that masks the links between sherds and vessels.

It has been shown that the most consistent clustering results have been derived from Ward's method. Therefore, applying this procedure to Type 1 and 2 profiles of the weighted 26 types would seem to be the most appropriate. The results are shown in Figures 35 and 36. Both figures reveal complete success in separating the four groups. A more complete characterization of sherds in terms of size as well as motif appears to provide the greatest amount of information about assemblage associations.

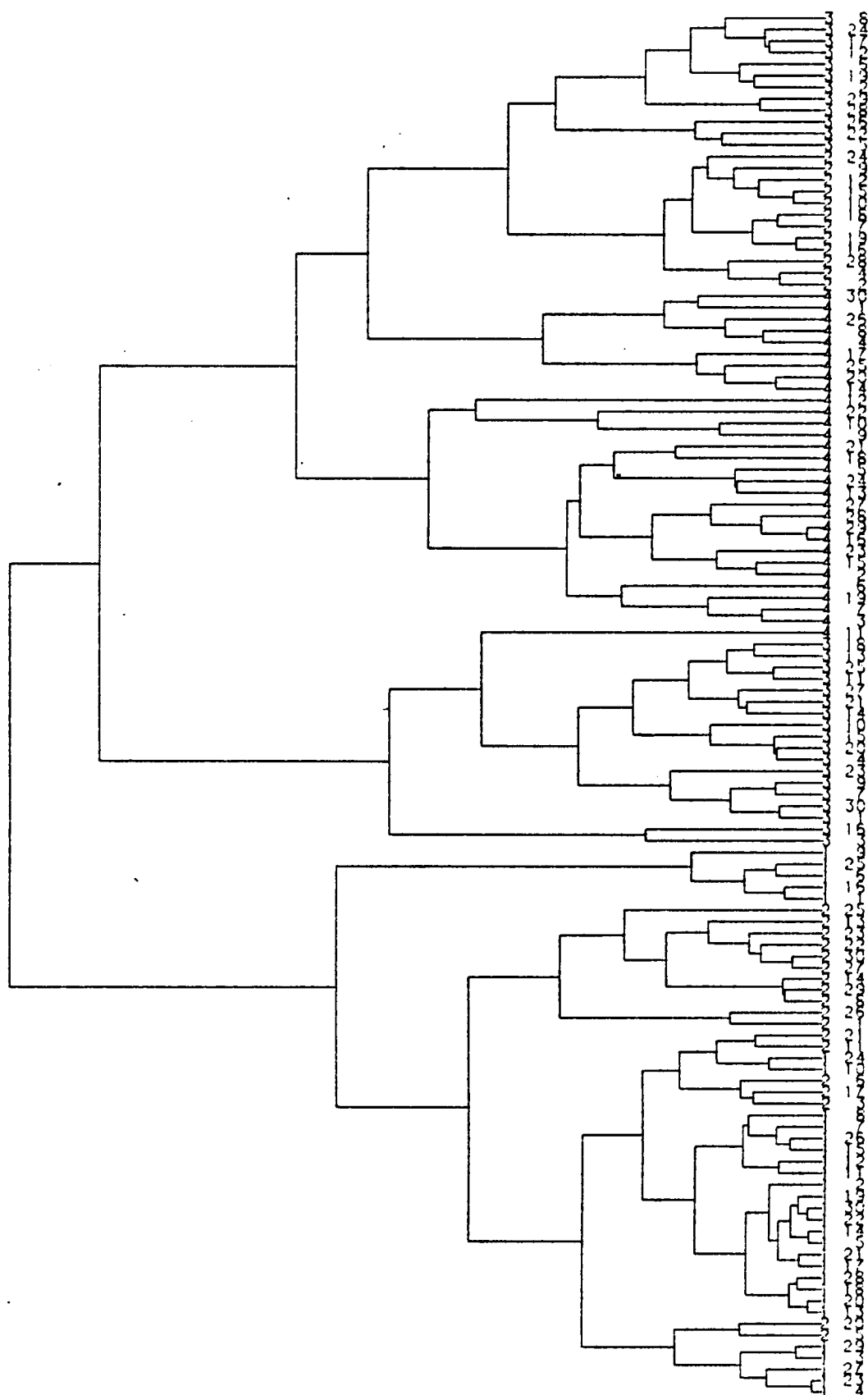


Figure 23. Complete linkage clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types

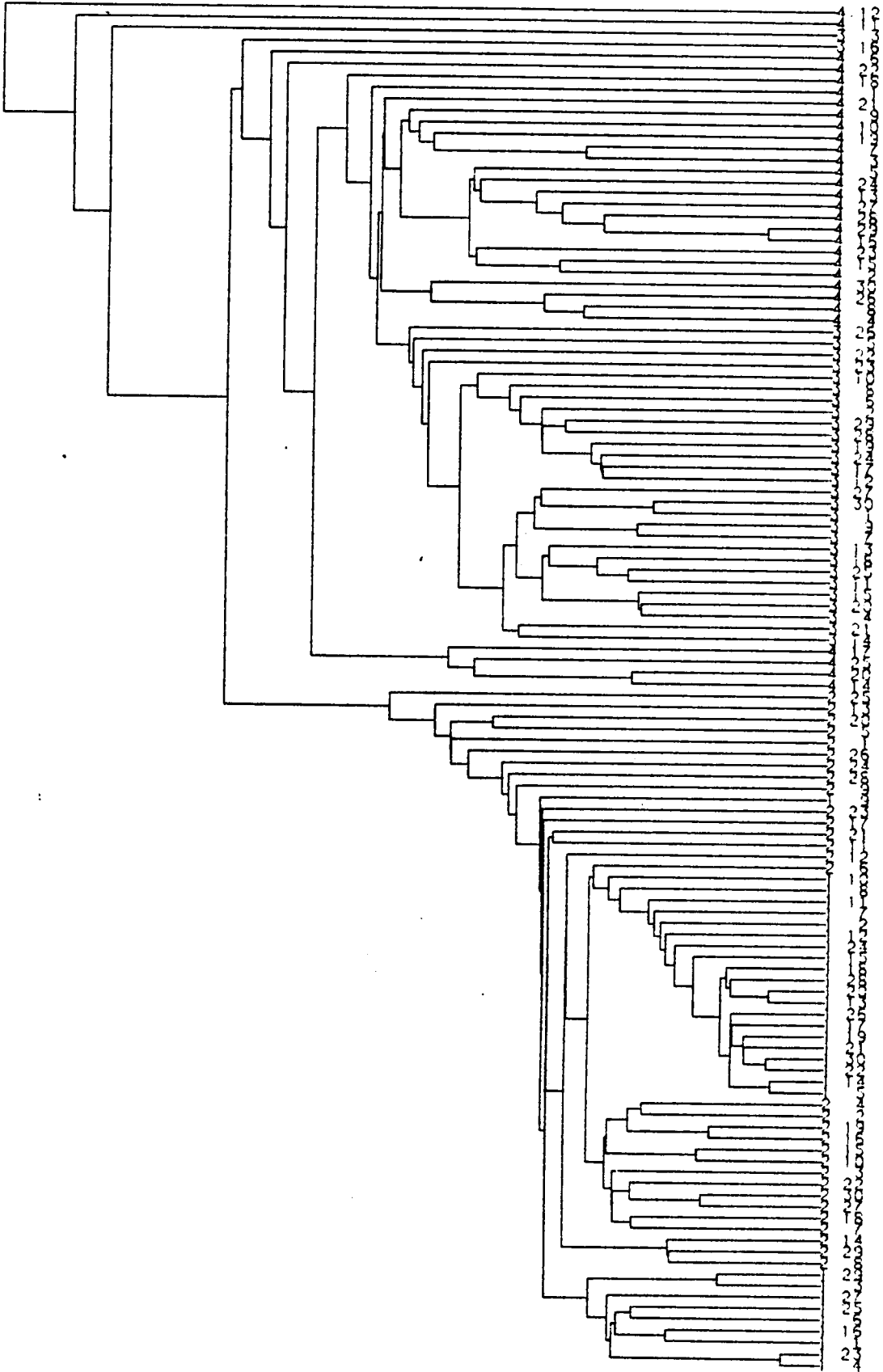


Figure 30. Single linkage clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types

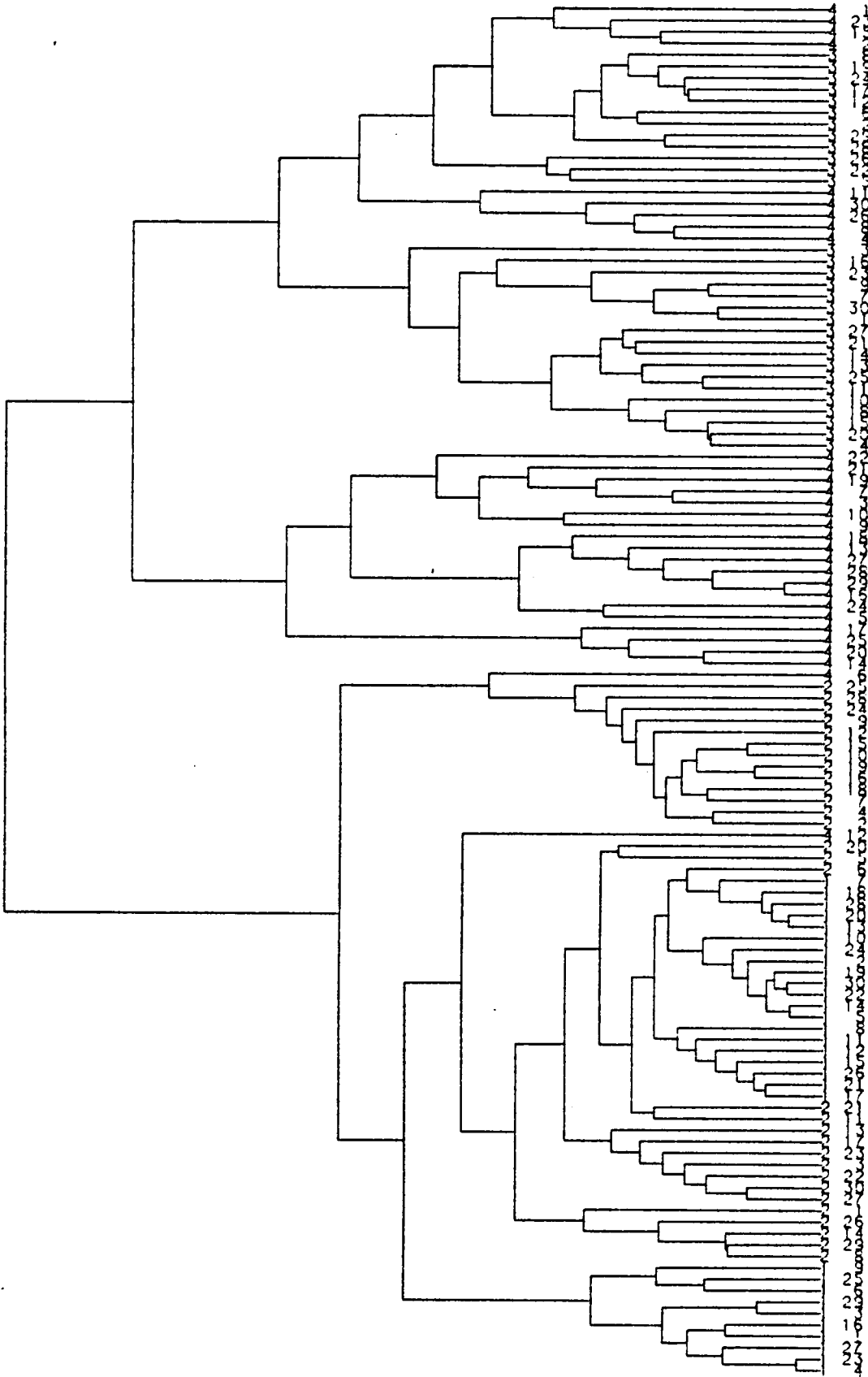


Figure 31. Average linkage (within) clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types

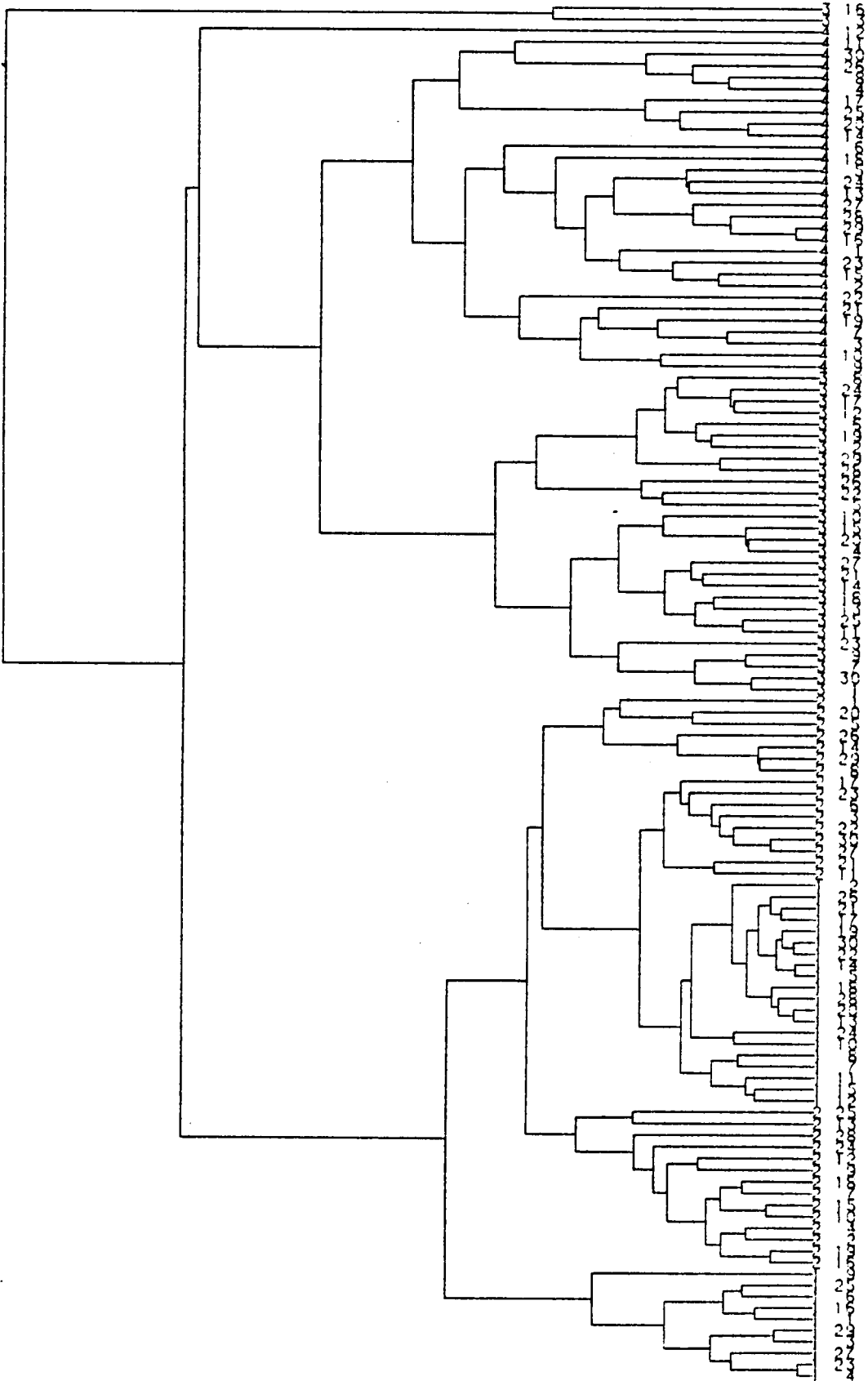


Figure 32. Average linkage (between) clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types

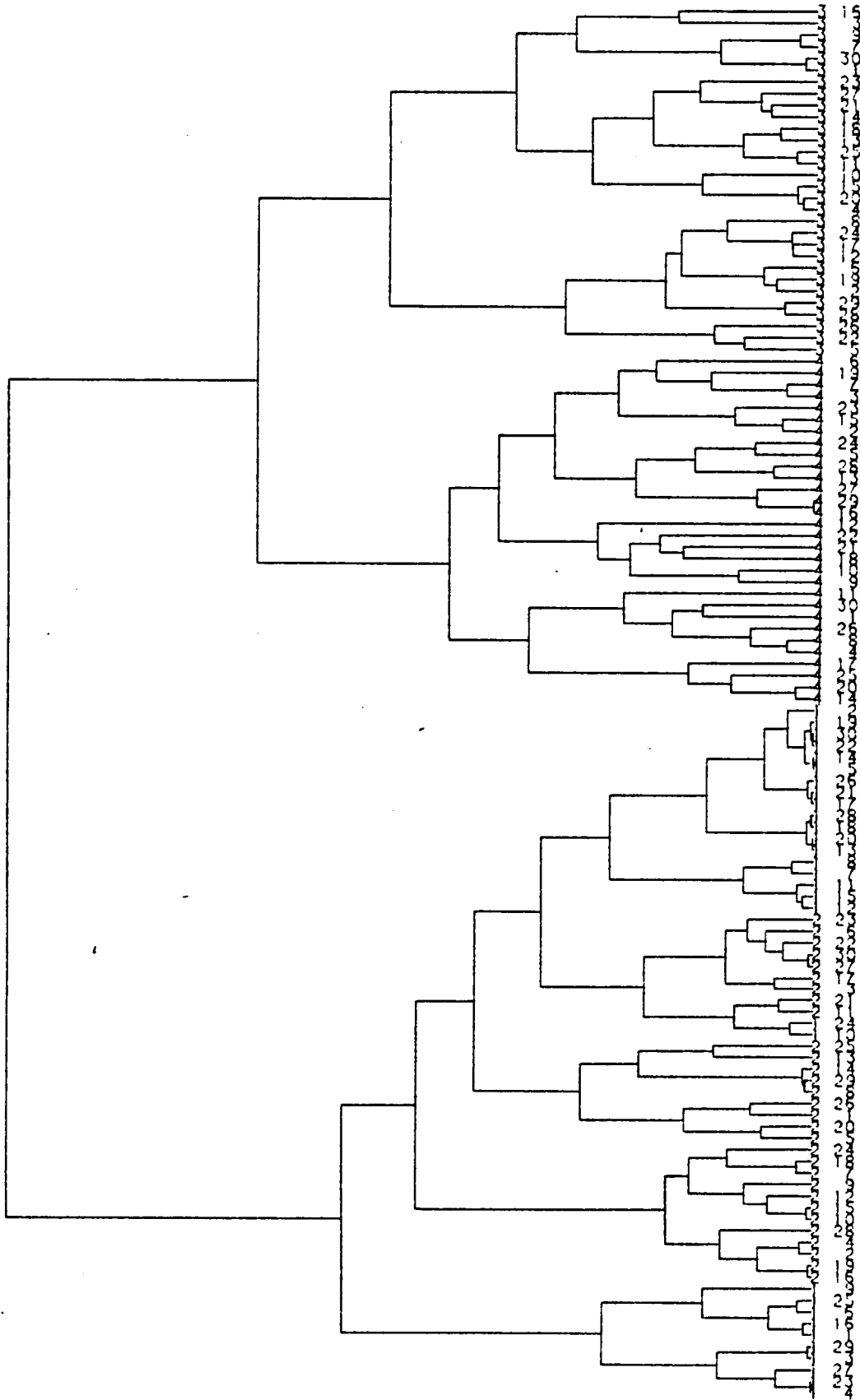


Figure 33. Ward's method clustering of units defined in terms of Type 2 relative frequencies of 26 motif/portion types

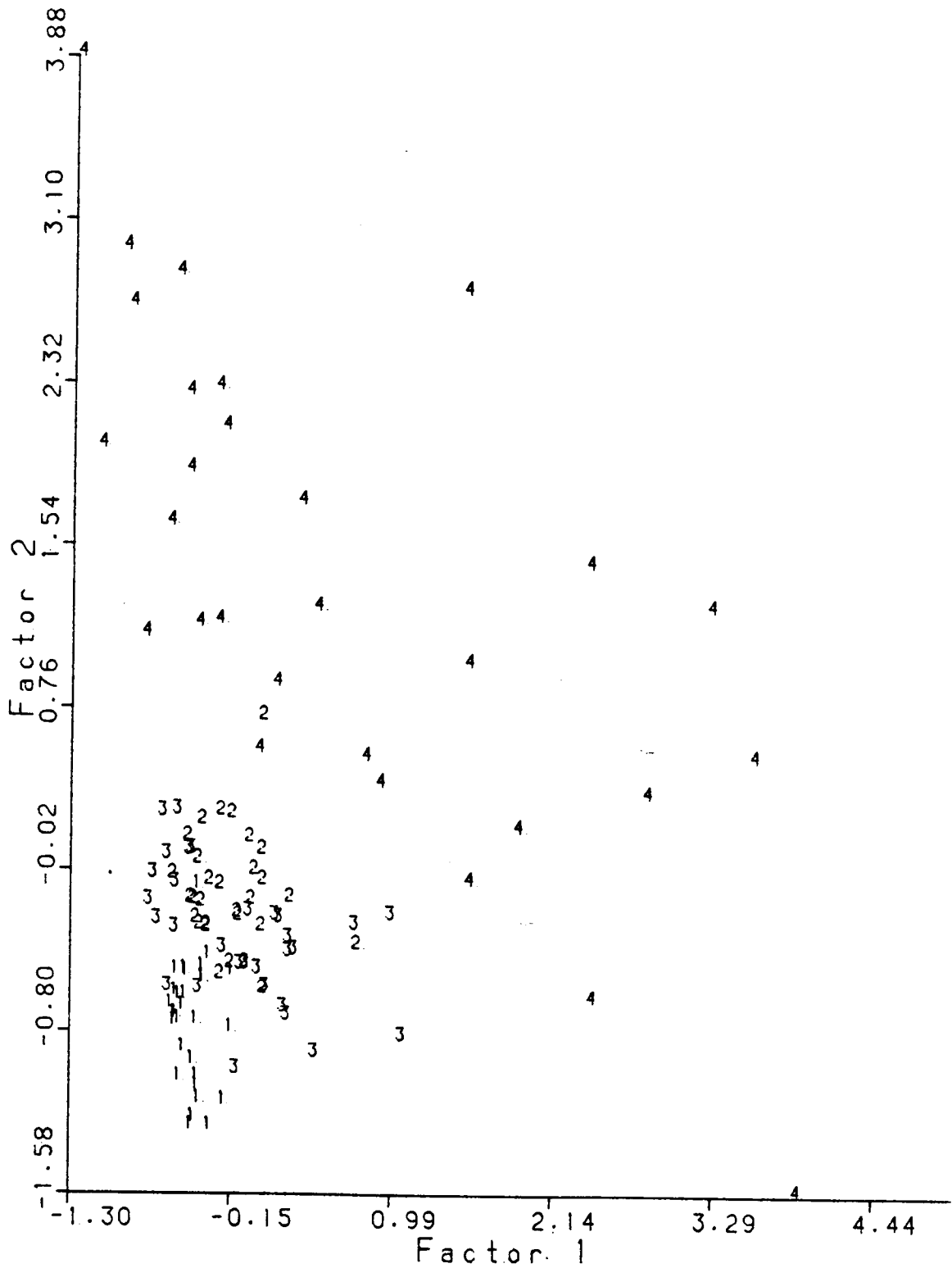


Figure 34. Plot of units defined by the first two factor scores representing Type 2 relative frequencies of 26 motif/portion types

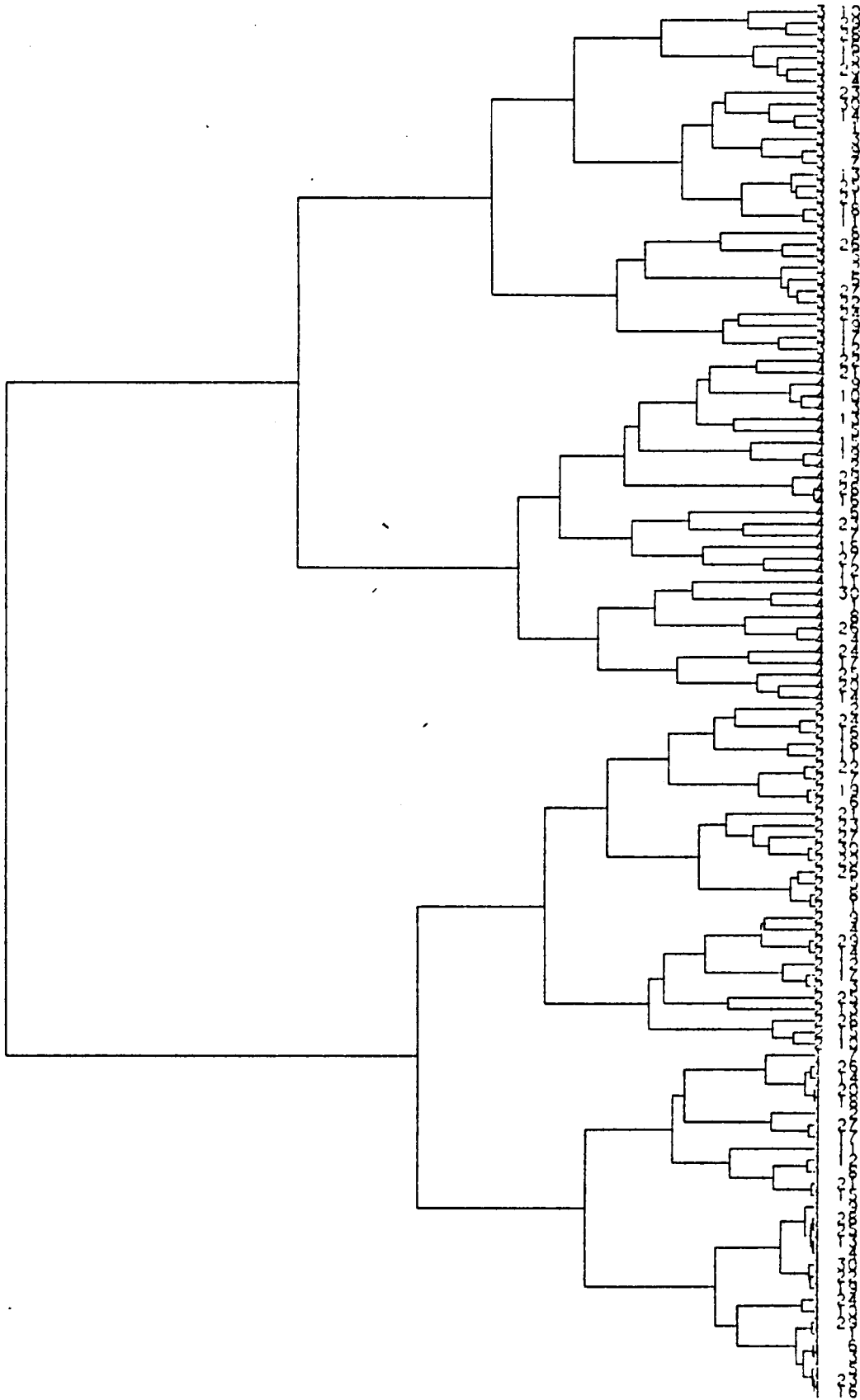


Figure 35. Ward's method clustering of units defined in terms of Type 1 relative frequencies of 26 weighted motif/portion types

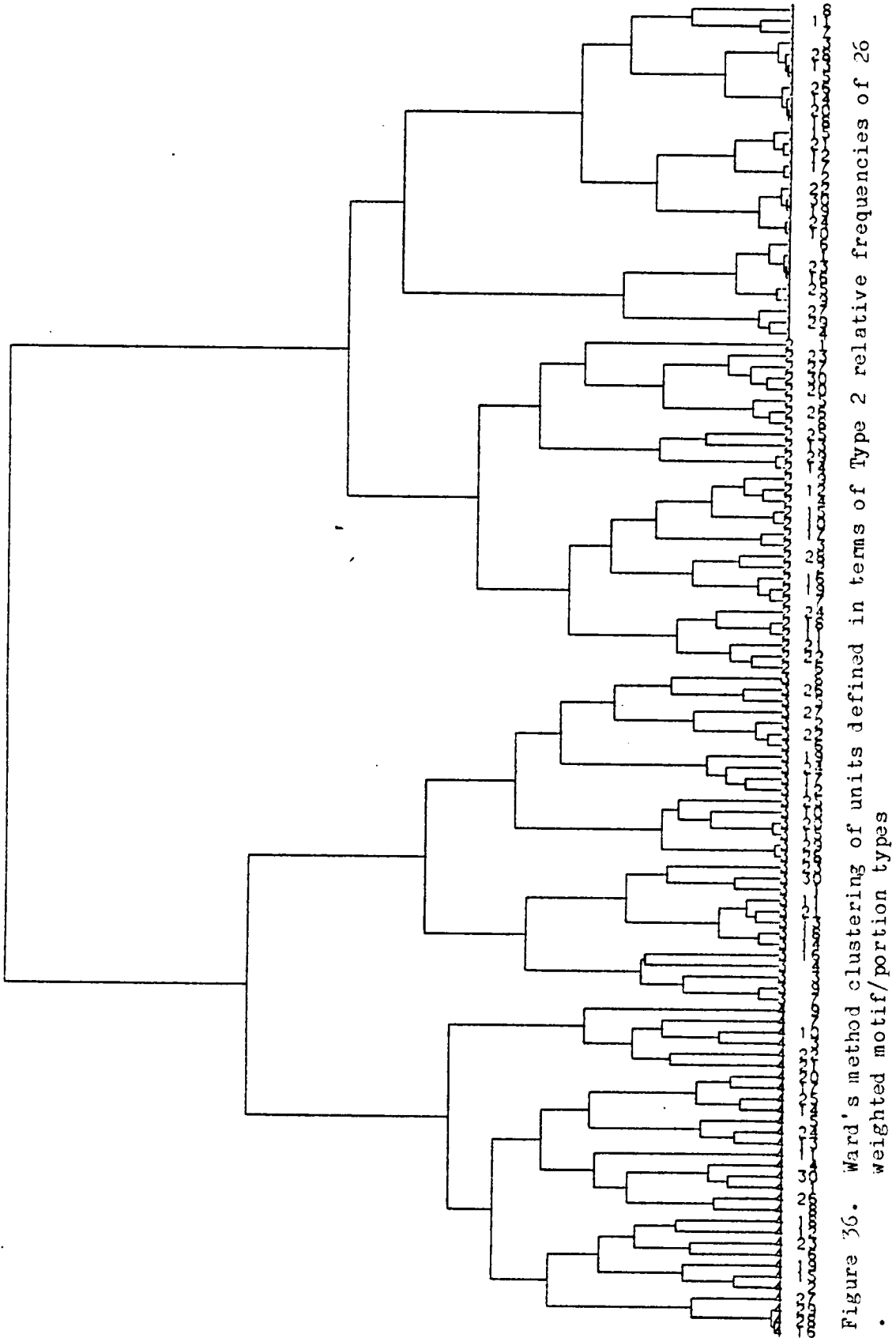


Figure 36. Ward's method clustering of units defined in terms of Type 2 relative frequencies of 26 weighted motif/portion types

Defining the sherd assemblages in terms of the 26 weighted types allows the statistical procedures to produce valid associative interpretations. Their responses to the data are varied but do suggest: (1) the groups represent collections displaying minimum within-group variance, (2) the groups can be divided into a homogeneous set composed of Groups 1 and 2 and a more divergent set composed of Groups 3 and 4, and (3) the acceptance of statistical results should be made with caution and only after many procedures have been tried and compared.

CHAPTER V

DISCUSSION

Science can be defined as the ordering and interpreting of observations collected in a manner procedurally related to specific questions. The ordering implies that there is some underlying structure to the observations. Interpretation involves assigning meaning to the structure. The goal of science is to transform observations into phenomenological models which, as scientific statements, can be tested, improved, and extended in order to derive explanations.

Popper's (1959) view of explanations is that they should prohibit the occurrence of some phenomena. In this way they become testable because they can be falsified by the presence of a prohibited phenomenon. The test(s) only corroborate the validity of the statements; they can not confirm the suitability of any model. All scientific statements must be capable of being tested in this way.

Archaeological science involves the pursuit of characterizing and explaining extinct human behavioral systems in terms of their material residues. The ordering and interpreting of archaeological observations is done within the framework of the discipline's concept of Culture. Culture is the innate structural framework of human existence out of which needs are defined and particular adaptations are developed. On the basis of observations made on living societies, the concept of Culture is refined and, for archaeologists, specified in terms of material correlates of the behavioral system. From this, archaeological observations are ordered into aggregate sets, such as types,

assemblages, sites, phases, and traditions, to facilitate the characterization of the archaeological record. Patterns in the record are then interpreted in behavioral, social, or temporal terms.

Unlike other sciences, the systems being observed are extinct making falsifiable behavioral statements somewhat hard to construct. Therefore, tests to corroborate the validity of such statements must be applied to the structure of archaeological reasoning instead. This can be achieved in two ways. First, archaeologists can refine their interpretive abilities by better defining behavioral systems in terms of their material correlates (see Binford 1978 for an example). Second, as this research demonstrates, abstract models of the archaeological record can be developed and tested in place of the parent systems.

Modelling, in this sense, takes two forms. The first is a material model which performs transformations on actual physical objects. Examples include ceramic and lithic replication studies. The second is a formal model which is a symbolic representation of structural properties of an idealized system. Formal models can be divided into two kinds: open-box models and closed-box models. The open-box variety has all of its inputs specified and provides a predictive model of the output (like an equation). Closed-box models are investigative abstractions designed to serve as aids in the process of understanding a system's output (Mihram 1972:2-3, Rosenblueth and Wiener 1945).

Fishman (1978:2-3) describes five benefits of modelling which can be of value to archaeological research:

1. Models organize theoretical beliefs and empirical observations about a system and deduce the logical implications of this organization,

2. Models lead to improved understanding of systems,
3. Models bring the need for detail and relevance into perspective,
4. Models are easier to manipulate than actual systems,
5. Modelling is less expensive than comparable analysis of real systems.

This research has hopefully provided an example of a framework in which modelling can be incorporated into archaeological research. Both open- and closed-box models were utilized in this study. The assemblage production model (closed-box) produced credible sherd collections useful in testing the applicability of the statistical procedures (open-box models). Conclusions drawn from this study should be related to the original assumptions made about ceramic variability, in particular, that the spatio-temporal character of such assemblages approximates a normal distribution and that the model's variances fall within the limits of real systems. Allowing for these assumptions, the following conclusions can be drawn.

First, mathematical modelling is a useful tool in artifact analysis. The approach presented here suggests a way to conceptualize sherds as portions of whole vessels. Furthermore, it provides ways to define types and their occurrences in probabilistic terms. Thus, modelling helps organize archaeological data in terms of theoretical beliefs.

Based on the cluster solutions, archaeological assemblages can be characterized as minimum variance entities produced by processes which

minimize internal variability (such as Culture). Therefore, statistical procedures which recognize such an inherent structure should provide the most information in archaeological applications. The mixing of Groups 1 and 2 suggests that given a continuum of change from one state to the next the ability of a procedure to accurately recognize the stages of evolution will be dependent on the way in which the units are characterized. Attribute profiles must be defined in terms of the underlying cultural process that produced them. For example, sherds should be defined in terms of whole vessel types since a potter's primary goal is the production of vessels and not sherds. In conjunction with this, the results of any seriation should not be taken to represent an absolute temporal or associative sequence since expected random frequency fluctuations about normative group means can alter the ordering. Seriation can be used to indicate relative positioning or association but to attach absolute meaning to the order presupposes perfectly designed samples and perfectly defined attributes.

Modelling produces an inexpensive way to create large data sets in terms of precise group and attribute associations, a priori. Thus, modelling provides systems that could not otherwise be examined which can be tested and manipulated to a degree that no living system could be studied.

All of these conclusions lead to the realization that more research is needed to provide measures of variability within the archaeological record. This will require developing systematic excavation techniques designed to acquire specific data and not just "representative" samples. It will also require conceptualizing observations in more abstract

terms. When variance-covariance concepts are integrated into a normative paradigm, archaeological cultures will become more fully defined and readily modeled. Failure to measure variability in this sense limits the perspective of the archaeological record to a simplistic model of change. Achievement of the discipline's goals requires more.

LIST OF REFERENCES

LIST OF REFERENCES

- Aldenderfer, M. S.
 1977 Simulation of assemblage formation processes: evaluation of multivariate statistical methods in archaeological research. Ph.D. dissertation, Pennsylvania State University. University Microfilms, Ann arbor.
- Anderberg, M.R.
 1973 Cluster analysis for applications. Academic Press. New york.
- Baden, W. W.
 1931 Tomotley: an eighteenth century Overhill village. MS. on file, McClung Museum, University of Tennessee, Knoxville.
- Binford, L. R.
 1973 Nunamiut ethnoarchaeology. Academic Press. New York.
- Borillo, M.
 1974 A few remarks on Whallon's "A new approach to pottery typology". American Antiquity 39:371-373.
- Brainerd, G. W.
 1951 The place of chronological ordering in archaeological analysis. American Antiquity 16:301-313.
- CALCOMP
 1971 CALCOMP graphics functional software. California Computer Products, Inc. Anaheim.
- Cowgill, G. L.
 1972 Models, methods and techniques for seriation. In: Models in archaeology, edited by D. L. Clarke, pp. 381-424. Methuen and Co. London.
- David, N.
 1972 On the life span of pottery, type frequencies, and archaeological inference. American Antiquity 37:141-142.
- Dickens, R. and J. H. Chapman
 1973 Ceramic patterning and social structure at two late historic upper Creek sites in Alabama. American Antiquity 43:390-393.
- Drennan, R. D.
 1976 A refinement of chronological seriation using nonmetric multidimensional scaling. American Antiquity 41:290-302.
- Ericson, J. E. and S. P. DeAtley
 1976 Reconstructing ceramic assemblages: an experiment to derive the morphology and capacity of parent vessels from sherds. American Antiquity 41:434-483.

- Dunnell, R. C.
1970 Seriation method and its evaluation. American Antiquity 35:305-319.
- Ester, M.
1931 A column-wise approach to seriation. American Antiquity 46:496-512.
- Fishman, G. S.
1973 Principles of discrete event simulation. Wiley. New York.
- Gelfand, A. E.
1969 Seriation of multivariate observations through similarities. Ph.D. dissertation, Stanford University. University Microfilms, Ann Arbor. No. 7010457.
1971a Seriation methods for archaeological materials. American Antiquity 36:263-274.
1971b Rapid seriation methods with archaeological applications. In Mathematics in the archaeological and historical sciences, edited by F. R. Hodson, D. G. Kendall, and P. Tautu, pp. 186-201. University Press. Edinburgh.
- Graham, I., P. Galloway, and I. Scollar
1975 Model studies in seriation techniques. In Computer applications in archaeology 1975, pp. 18-24. The Computer Centre, University of Birmingham, England.
- IMSL
1930 International Mathematics and Statistical Libraries, Inc. Houston.
- Johnson, A. E. and A. S. Johnson
1975 K-means and temporal variability in Kansas City Hopewell ceramics. American Antiquity 40:283-295.
- Johnson, S. C.
1967 Hierarchical clustering schemes. Psychometrika 32:241-254.
- LeBlanc, S. A.
1975 Micro-seriation: a method for fine chronological differentiation. American Antiquity 40:22-38.
- Mihram, G. A.
1972 Simulation: statistical foundations and methodology. Academic Press. New York.
- Meighan, C. W.
1977 Recognition of short time periods through seriation. American Antiquity 42:628-629.

- McNutt, C. H.
1973 On the methodological validity of frequency seriation. American Antiquity 38:45-60.
- Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent
1975 Statistical package for the social sciences. McGraw-Hill, Inc. New York.
- Popper, K. R.
1959 The logic of scientific discovery. Basic Books, Inc. New York.
- Read, D. W.
1974 Some comments on typologies in archaeology and an outline of a methodology. American Antiquity 39:216-242.
- Roberts, F. S.
1976 Discrete mathematical models, with applications to social, biological, and environmental problems. Prentice-Hall. Englewood Cliffs, N. J..
- Robinson, W. S.
1951 A method for chronological ordering archaeological deposits. American Antiquity 16:293-301.
- Rosenblueth, A. and N. Wiener
1945 The role of models in science. Philosophical Science 12:316-321.
- Schiffer, M.
1975 Simulation analysis of tool kits. Plains Anthropologist 20:61-70.
- Vierra, R. K. and R. L. Taylor
1977 Dummy data distributions and quantitative methods: an example applied to overlapping spatial distributions. In For theory building in archaeology, edited by L. R. Binford, pp. 317-324. Academic Press. New York.
- Ward, J. H., Jr.
1963 Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association, 58:236-244.
- Whallon, R., Jr.
1972 A new approach to pottery typology. American Antiquity 37:13-33.
- Zimmerman, L. J.
1977 Prehistoric locational behavior: computer simulation of central plains tradition. PhD. dissertation, University of Kansas. University Microfilms, Ann Arbor.

Zubrow, E. B. W.

1971 A southwestern test of an anthropological model of population dynamics. PhD. dissertation, University of Arizona, Tucson.
University Microfilms, Ann Arbor.

APPENDIXES

APPENDIX A
PROGRAM LISTING

```

C      ++++++
C>>>> This program models ceramic variability for four groups
C>>>> of assemblages. There are two temper types:
C      1 - Shell
C      2 - Quartz
C>>>> and four vessel types:
C      1 - Large jar
C      2 - Small jar
C      3 - Hemispherical bowl
C      4 - Cazuela bowl
C>>>> There are five possible surface treatments:
C      1 - Plain
C      2 - Cord marked
C      3 - Check stamped
C      4 - Complicated stamped
C      5 - Incised

Dimension TEMPER(4,2),VTPC(2,4,4),SAMPLE(4),RADII(4),SIZEJ(2,6,4),
1      SIZEB(6,4),SMOTIF(4,5,0:6,0:6),QMOTIF(4,5,0:6,0:6),
2      SIZE(2,4),T(2),NVES(2,4),SDRAD(4),VS(4),PORT(4,3),
3      LSIZE(4),LABEL(4,6),MT(4,6,3),NV(2),A(4)

Integer ASSEM,VTYPE,G,TT,V,TOTSH

Double Precision DSEED

Common /AREA1/DSEED,ASSEM,G,TOTSH
Common/AREA2/SAMPLE,RADII,SIZEJ,SIZEB,SIZE,T,
1      NVES,SDRAD,VS,LSIZE,LABEL,A
Common /AREA3/SMOTIF
Common /AREA4/QMOTIF
Common /AREA5/MT,PORT

C TEMPER
C>>>> Percentage of shell and quartz tempered vessels per group
C      Group 1 : 20% - 80%
C      Group 2 : 40 - 60
C      Group 3 : 60 - 40
C      Group 4 : 80 - 20
C      Data ((TEMPER(I,J),J=1,2),I=1,4)/.2,1.0,.4,1.0,.6,1.0,.8,1.0/

C VTPC
C>>>> Percentage of vessel types by group and temper
C      Data (((VTPC(K,I,J),J=1,4),I=1,4),K=1,2)/.04,.469,1.0,0.0,.06,
1      .479,1.0,0.0,.08,.435,.803,1.0,.1,.339,.727,1.0,.6,1.0,0.0,
2      0.0,.6,1.0,0.0,0.0,.5,1.0,0.0,0.0,.4,1.0,0.0,0.0/

C SAMPLE
C>>>> Standard deviations for the mean proportion of sherds (.2) kept
C      in each group.
C      Data SAMPLE/.1,.2,.3,.4/

```

C RADII

C>>>> Mean radii (cm) of each vessel type
Data RADII/29.4,9.16,11.94,6.94/

C SDRAD

C>>>> Standard deviations of each vessel type's radius measurement
Data SDRAD/1.45,2.7,2.4,.7/

C PORT

C>>>> Relative proportion of rim to neck to body for each vessel type
Data ((PORT(I,J),J=1,3),I=1,4)/.17,.25,.53,.25,.23,.52,.1,0.0,
1 .9,.165,0.0,.335/

C SIZEJ

C>>>> Jar breakage patterns by temper, portions, and size.
C These values are cumulatively summed over size.
Data (((SIZEJ(K,I,J),I=1,6),J=1,4),K=1,2)/0.0,.0043,.1059,
1 .1084,.1102,1.0,.0011,.0331,.1113,.1220,.1329,1.0,
2 .0058,.1074,.2047,.2335,.2732,1.0,.04,.214,.294,.363,
3 .434,1.0,0.0,0.0,.0231,.0303,.0335,1.0,0.0,.0974,.1429,
4 .1558,.1638,1.0,.0154,.2303,.2615,.2923,.3335,1.0,0.0,
5 .25,.25,.25,.25,1.0/

C SIZEB

C>>>> Bowl breakage pattern by portions and size
Data ((SIZEB(I,J),I=1,3),J=1,4)/.1034,1.0,1.0,.0732,.9994,1.0,
1 .1168,.9397,1.0,.1103,.3947,1.0/

C VS

C>>>> Mean surface area (sq. cm) of each vessel type
Data VS/8200.0,656.71,716.27,328.51/

C SIZE

C>>>> Values used to calculated percentage of each size category
C for each temper group.
C Shell : 22%, 53%, 21%, and 4%
C Quartz : 36%, 43%, 13%, and 3%
Data ((SIZE(I,J),J=1,4),I=1,2)/.22,.6795,.34,1.0,.36,.6719,.3571,
1 1.0/

C LSIZE

C>>>> Labels for size codes
DATA LSIZE/'1','2','4','3'/

C LABEL

C>>>> Labels for vessel portions
Data ((LABEL(I,J),J=1,6),I=1,2)/'111','110','100','011',
1 '010','001','111','110','100','011','010','001'/
Data ((LABEL(I,J),J=1,6),I=3,4)/'100','001','101','3*',
1 '100','001','101','3*' /

```

C A
C>>>> Mean area (sq. cm) of each sherd size grouping
      Data A/2.935,6.0272,26.0349,60.635/

C>>>> Output data is stored in DATA.DAT
      Open(Unit=6,Device='DSKB',File='DATA.DAT',DIALOG)

C>>>> Listing of the run's statistics is found in REPORT.LST
      Open(Unit=7,Device='DSKD',File='REPORT.DAT')

C>>>> Surface treatment probabilities are stored in files by
C      groups.
      Open(Unit=21,Device='DSK',File='GROUP1.DAT')
      Open(Unit=22,Device='DSK',File='GROUP2.DAT')
      Open(Unit=23,Device='DSK',File='GROUP3.DAT')
      Open(Unit=24,Device='DSK',File='GROUP4.DAT')

C      ++++++
C>>>> Define group to be modelled
      Type 1000
1000   Format(' Group to be modeled > '$)
      Read(5,*,ERR=99) G

C      ++++++
C>>>> Define cumulative motif probabilities for shell and quartz
C      vessels
      DSEED= 1234.000 * G
      IDEV= 20+G
1      Read(IDEV,100,END=101) TT,V,I,J,K,X
100     Format(1X,5I2,1X,F6.4)
      If(TT.EQ.1) SMOTIF(V,I,J,K)=X
      If(TT.EQ.2) QMOTIF(V,I,J,K)=X
      Go To 1
101     Continue

C      ++++++
C>>>> Run simulation for 30 assemblages (100 vessels each)
      Do 9999 ASSEM=1,30

C      ++++++
C>>>> No. of shell and quartz vessels
      Call GGNML(DSEED,1,P)
      T(1)=P*0.1 + TEMPER(G,1)
      If(T(1).LT.0.0) T(1)= 0.0
      If(T(1).GT.1.0) T(1)= 1.0
      NV(1)= 100*T(1) + 0.5
      NV(2)= 100 - NV(1)

C      ++++++
C>>>> Set number of vessels of each temper and type
      Do 20 I=1,2
      Call GGNML(DSEED,1,X)
      C= 1.0

```

```

      XX= X*0.1 + VTPC(I,G,1)
      If(XX.LT.0.0) XX=0.0
      If(XX.GT.1.0) XX=1.0
      NVES(I,1)= NV(I)*XX + 0.5
      Do 19 K=2,4
      C= C-XX
      XX=C*VTPC(I,G,K)
      If(XX.LT.0.0) XX=0.0
      NVES(I,K)= NV(I)*XX + 0.5
19      Continue
20      Continue

C      ++++++
C>>>> Break each vessel type/temper
      Do 30 I=1,2
      II=I
      Do 29 J=1,4
      JJ=J
      Call BREAK(II,JJ)
29      Continue
30      Continue

      TYPE 1001, ASSEM
1001     FORMAT(' Assemblage ',I2,' done.'/)
9999     Continue

C      ++++++
C>>>> Write out the total number of sherds on the screen
      Type 1002, TOTSH
1002     FORMAT(' Total sherd count: ',I7//)

99      Continue
      Close(Unit=3)
      Close(Unit=6)
      Close(Unit=21)
      Close(Unit=22)
      Close(Unit=23)
      Close(Unit=24)
      Stop
      End

```

```

C *****
C Defines vessels; breaks them into sherds; and codes the sherds.
C *****
      Subroutine BREAK(TEMP,VTYPE)

      Integer ASSEM,G,TEMP,VTYPE,VESNUM,TOTSH,SHERD(100)

      Dimension SAMPLE(4),RADII(4),SDRAD(4),SIZEJ(2,6,4),SIZEB(6,4),
1          SMOTIF(4,5,0:6,0:6),QMOTIF(4,5,0:6,0:6),SIZE(2,4),T(2),
2          NVES(2,4),PORT(4,3),VSIZE(100),RADIUS(100),VS(4),
3          B(4),NSIZE(4),MT(4,6,3),LSIZE(4),LABEL(4,6),
1          ICOUNT(6,4),PROB(3000),ZZ(4),SAMP(100),A(4)

      Double Precision DSEED

      Common /AREA1/DSEED,ASSEM,G,TOTSH

      Common /AREA2/SAMPLE,RADII,SIZEJ,SIZEB,SIZE,T,
1          NVES,SDRAD,VS,LSIZE,LABEL,A
      Common /AREA3/SMOTIF
      Common /AREA4/QMOTIF
      Common /AREA5/MT,PORT

      If(NVES(TEMP,VTYPE).EQ.0) RETURN

C *****
C>>>> Set coding percentage for each vessel
      Call GGNML(DSEED,NVES(TEMP,VTYPE),SAMP)
      DO 5 I=1,NVES(TEMP,VTYPE)
      SAMP(I)= SAMP(I)*SAMPLE(G) + 0.2
      If(SAMP(I).LT.0.0) SAMP(I)= 0.004
      If(SAMP(I).GT.1.0) SAMP(I)= 1.0
5      CONTINUE

C *****
C>>>> Set size of each vessel
      Call GGNML(DSEED,NVES(TEMP,VTYPE),VSIZE)
      DO 10 I=1,NVES(TEMP,VTYPE)
      RADIUS(I)= VSIZE(I)*SDRAD(VTYPE) + RADII(VTYPE)
      If(RADIUS(I).LT.0.0) RADIUS(I)= 0.0
      VSIZE(I)=((RADIUS(I)/RADII(VTYPE))**2)*VS(VTYPE)
10     Continue

      DO 9999 VESNUM=1,NVES(TEMP,VTYPE)! Coding loop for each vessel

C *****
C>>>> Number of sherds per size category for vessel i.
      Call GGNML(DSEED,3,ZZ)! Define 3 of each sherd size for this
C          vessel.

      C= 1.0
      B(1)= ZZ(1)*0.25 + SIZE(TEMP,1)
      If(B(1).LT.0.0) B(1)=0.0

```

```

      If(B(1).GT.1.0) B(1)=1.0
      ZZ(4)=0.0
      Do 30 I=1,3
      C= C- B(I)
      B(I+1)= (ZZ(I+1)*.25 + SIZE(TEMP,I+1))*C
      IF(B(I+1).LT.0.0) B(I+1)= 0.0
      If(B(I+1).GT.1.0) B(I+1)= 1.0
30    CONTINUE
      DIV= B(1)*A(1) + B(2)*A(2) + B(3)*A(3) + B(4)*A(4)

      DO 31 I=1,4 ! Set the number of sherds coded for this vessel
      NSIZE(I)= (B(I)*VSIZE(VESNUM)/DIV)*SAMP(VESNUM) + 0.5
      If(NSIZE(I).LT.0) NSIZE(I)=0
      TOTSH= TOTSH + NSIZE(I)
31    Continue

C      ++++++
C>>>> Set MOTIF for vessel i.
      If(TEMP.EQ.1) Call SHELL(MT,VTYPE)
      If(TEMP.EQ.2) Call QRTZ(MT,VTYPE)

C      ++++++
C>>>> Set vessel portion combinations per sherd per size
      Do 40 I=1,4
      If(NSIZE(I).EQ.0) Go To 40
      If(NSIZE(I).GT.3000) TYPE 1000, I,NSIZE(I)
1000  FORMAT(' ERROR NSIZE(' ,I1,') > 3000'/' NSIZE= ',I5/)
      Call GGUBS(DSEED,NSIZE(I),PROB)
      Do 39 J=1,NSIZE(I)
      Do 38 K=1,6
      L=7-K
      If(PROB(J).LT.SIZEJ(TEMP,L,I).AND.VTYPE.LE.2) KK=L
      If(PROB(J).LT.SIZEB(L,I).AND.VTYPE.GE.3) KK=L
38    CONTINUE
      ICOUNT(KK,I)= ICOUNT(KK,I) + 1
39    CONTINUE
40    CONTINUE

C      ++++++
C>>>> Write out discription of vessel into REPORT.DAT
      L=1
      If(VTYPE.GE.3) L=3
      Write(7,200) G,ASSEM,TEMP,VTYPE,SAMP(VESNUM),RADIUS(VESNUM),
C      1 VESNUM,(NSIZE(I),I=1,4),(MT(VTYPE,L,I),I=1,3)
200  Format(I1,I3,2I2,F6.4,F6.2,I4,4I4,3I2)

C      ++++++
C>>>> Define the radius for coding if the rimsherd is > size 2
      DO 50 J=1,4
      DO 49 I=1,6
      RAD=0.0
      If(ICOUNT(I,J).EQ.0) Go To 49
      If(J.GE.3.AND.I.LE.3) RAD= RADIUS(VESNUM)

```

If(VTYPE.GE.3.AND.I.EQ.2) RAD=0.0

```

C      ++++++
C>>>> Re-classify motif of size 1 sherds
      IV=VESNUM
      If(J.EQ.1.AND.I.EQ.2.AND.VTYPE.GE.3) CALL RECONT(&49,ICOUNT(I,J),
1      VTYPE,ASSEM,G,IV,LABEL(VTYPE,I),RAD,LSIZE(J),TEMP)
      If(J.EQ.1.AND.I.EQ.6.AND.VTYPE.LE.2) CALL RECONT(&49,ICOUNT(I,J),
1      VTYPE,ASSEM,G,IV,LABEL(VTYPE,I),RAD,LSIZE(J),TEMP)

C      ++++++
C>>>> Code data on each sherd grouping
      Write(6,100) G,ASSEM,IV,VTYPE,TEMP,LABEL(VTYPE,I),MT(VTYPE,I,1),
1      MT(VTYPE,I,2),MT(VTYPE,I,3),RAD,LSIZE(J),ICOUNT(I,J)
100    FORMAT(I1,I2,I3,2I2,1X,A3,3I2,F6.2,1X,A1,I5)

49     ICOUNT(I,J)=0
50     CONTINUE

9999   Continue
      Return
      End

```

```

C *****
C   Sets the motiff code for shell tempered rims, necks, and bodies.
C *****

Subroutine SHELL(MT,VTYPE)
Integer VTYPE,ASSEM,G,TOTSH
Dimension MT(4,6,3),B(3),SMOTIF(4,5,0:6,0:6)

Double Precision DSEED

Common /AREA1/DSEED,ASSEM,G,TOTSH
Common /AREA3/SMOTIF
M1=0
M2=0
M3=0
Call GGUBS(DSEED,3,B)
Do 10 I=1,5
  L=6-I
  If(B(1).LT.SMOTIF(VTYPE,L,6,6)) M1=L
10  Continue
  MT(1,1,1)=M1
  MT(1,2,1)=M1
  MT(1,3,1)=M1
  MT(3,1,1)=M1
  MT(3,3,1)=M1
  If(VTYPE.GE.3) Go To 21
  Do 20 I=1,5
    L= 6-I
    If(B(2).LT.SMOTIF(VTYPE,M1,L,6)) M2=L
20  Continue
    MT(1,1,2)=M2
    MT(1,2,2)=M2
    MT(1,4,2)=M2
    MT(1,5,2)=M2
21  Continue
    Do 30 I=1,5
      L= 5-I
      If(B(3).LT.SMOTIF(VTYPE,M1,M2,L)) M3=L
30  Continue
      MT(1,1,3)=M3
      MT(1,4,3)=M3
      MT(1,6,3)=M3
      MT(3,2,3)=M3
      MT(3,3,3)=M3
      DO 40 I=1,6
        Do 39 J=1,3
          MT(2,I,J)=MT(1,I,J)
          MT(4,I,J)=MT(3,I,J)
39  Continue
40  Continue
      Return
End

```

```

C      ++++++
C      Sets the motif code for quartz tempered rims, necks, and bodies.
C      ++++++

      Subroutine QRTZ(MT, VTYPE)
      Integer VTYPE, ASSEM, G, TOTSH
      Dimension MT(4,6,3), B(3), QMOTIF(4,5,0:6,0:6)

      Double Precision DSEED

      Common /AREA1/DSEED, ASSEM, G, TOTSH
      Common /AREA4/QMOTIF
      M1=0
      M2=0
      M3=0
      Call GGUBS(DSEED, 3, B)
      Do 10 I=1,5
      L=5-I
      If(B(1).LT.QMOTIF(VTYPE, L, 6, 6)) M1=L
10      Continue
      MT(1,1,1)=M1
      MT(1,2,1)=M1
      MT(1,3,1)=M1
      MT(3,1,1)=M1
      MT(3,3,1)=M1
      If(VTYPE.GE.3) Go To 21
      Do 20 I=1,5
      L= 5-I
      If(B(2).LT.QMOTIF(VTYPE, M1, L, 6)) M2=L
20      Continue
      MT(1,1,2)=M2
      MT(1,2,2)=M2
      MT(1,4,2)=M2
      MT(1,5,2)=M2
21      Continue
      Do 30 I=1,5
      L= 5-I
      If(B(3).LT.QMOTIF(VTYPE, M1, M2, L)) M3=L
30      Continue
      MT(1,1,3)=M3
      MT(1,4,3)=M3
      MT(1,6,3)=M3
      MT(3,2,3)=M3
      MT(3,3,3)=M3
      DO 40 I=1,6
      Do 39 J=1,3
      MT(2,I,J)=MT(1,I,J)
      MT(4,I,J)=MT(3,I,J)
39      Continue
40      Continue
      Return
      End

```

```

C      ++++++
C      Redefines motif for size 1 sherds according to the proportion
C      of rim:neck:body surface area
C      ++++++
      SUBROUTINE RECONT(*,N,VTYPER,ASSEM,G,VESNUM,L1,RAD,LS,T)
      DIMENSION PORT(4,3),MT(4,6,3),MCOUNT(3)
      INTEGER VTYPER,VESNUM,ASSEM,G,T
      Common /AREA5/MT,PORT

      NQ=0
C>>>> L : Sets the vessel portion type as a (1,1,1) or a (1,0,1)
      L=1
      If(VTYPER.GE.3) L=3
      Do 10 I=1,2
10      MCOUNT(I)=N*PORT(VTYPER,I) + 0.5
      If(VTYPER.GE.3) MCOUNT(2)= 0
      MCOUNT(3)=N - MCOUNT(1) - MCOUNT(2)

      DO 20 I=1,3
      NQ=NQ+MCOUNT(I)
      If(MCOUNT(I).EQ.0) Go To 20
      Write(6,100) G,ASSEM,VESNUM,VTYPER,T,L1,IDUMY,IDUMY,
1          MT(VTYPER,L,I),RAD,LS,MCOUNT(I)
100     FORMAT(I1,I2,I3,2I2,1X,A3,3I2,F6.2,1X,A1,I5)
      MCOUNT(I)=0
20      CONTINUE
      IF(N.NE.NQ) TYPE 1000, N,NQ
1000    FORMAT(' N: ',I6,' NQ: ',I6)
      RETURN 1
      END

```

APPENDIX B

TABULATION OF WHOLE VESSEL TYPES

Assemblage 1

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2102	.2512	.2442	.2501
Shell tempered vessels	0	19	40	61
Large jars	0	2	10	2
N(P1 ,Pl ,Pl)	0	1	3	0
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	3	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Cn ,Cn)	0	1	3	0
N(P1 ,Cmps ,Cmps)	0	0	1	0
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	0	1
N(Cmps ,Cmps ,Cmps)	0	0	0	1
Small jars	0	8	13	23
N(P1 ,Pl ,Pl)	0	3	4	10
N(P1 ,Pl ,Cm)	0	1	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Cn ,Ch)	0	0	3	0
N(P1 ,Cmps ,Cmps)	0	0	0	1
N(Cm ,Cm ,Cm)	0	4	0	0
N(Ch ,Ch ,Cn)	0	0	4	4
N(Cmps ,Cmps ,Cmps)	0	0	0	8
Hemispherical bowls	0	9	14	26
N(P1 , - ,Pl)	0	9	14	24
N(Cm , - ,Cm)	0	0	0	0
N(Cmps , - ,Cmps)	0	0	0	2
Cazuela bowls	0	0	3	10
N(P1 , - ,Pl)	0	0	1	2
N(In , - ,Pl)	0	0	2	3
Quartz tempered vessels	100	31	59	38
Large jars	53	56	26	17
N(P1 ,Pl ,Pl)	0	11	9	0
N(P1 ,Ch ,Ch)	13	12	4	0
N(Cm ,Cm ,Cm)	45	33	0	0
N(Cn ,Ch ,Ch)	0	0	13	10
N(Cmps ,Cmps ,Cmps)	0	0	0	7
Small jars	42	25	33	21
N(P1 ,Pl ,Pl)	0	4	3	0
N(P1 ,Ch ,Ch)	0	1	12	0
N(Cm ,Cm ,Cm)	42	20	0	0
N(Ch ,Ch ,Ch)	0	0	18	9
N(Cmps ,Cmps ,Cmps)	0	0	0	12

Assemblage 2

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2060	.2197	.2632	.2075
Shell tempered vessels	45	33	67	64
Large jars	5	6	10	8
N(P1 ,Pl ,Pl)	0	3	2	4
N(P1 ,Pl ,Cm)	1	0	0	0
N(P1 ,Pl ,Ch)	0	0	4	0
N(P1 ,Cm ,Cm)	2	0	0	0
N(P1 ,Ch ,Ch)	1	1	2	0
N(P1 ,Cmps ,Cmps)	0	0	2	1
N(Cm ,Cm ,Cm)	1	2	0	0
N(Ch ,Ch ,Ch)	0	0	0	0
N(Cmps ,Cmps ,Cmps)	0	0	0	3
Small jars	19	13	25	22
N(P1 ,Pl ,Pl)	0	4	5	7
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	4	0
N(P1 ,Cm ,Cm)	6	1	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps ,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	13	8	0	0
N(Ch ,Ch ,Ch)	0	0	15	2
N(Cmps ,Cmps ,Cmps)	0	0	0	8
Hemispherical bowls	21	14	26	25
N(P1 , - ,Pl)	9	14	26	23
N(Cm , - ,Cm)	12	0	0	0
N(Cmps , - ,Cmps)	0	0	0	2
Cazuela bowls	0	0	6	9
N(P1 , - ,Pl)	0	0	5	3
N(In , - ,Pl)	0	0	1	6
Quartz tempered vessels	55	67	33	36
Large jars	40	31	16	12
N(P1 ,Pl ,Pl)	0	10	6	0
N(P1 ,Ch ,Ch)	9	9	3	0
N(Cm ,Cm ,Cm)	31	12	0	0
N(Ch ,Ch ,Ch)	0	0	7	5
N(Cmps ,Cmps ,Cmps)	0	0	0	7
Small jars	15	36	17	24
N(P1 ,Pl ,Pl)	0	3	1	0
N(P1 ,Ch ,Ch)	0	3	6	0
N(Cm ,Cm ,Cm)	15	30	0	0
N(Ch ,Ch ,Ch)	0	0	10	10
N(Cmps ,Cmps ,Cmps)	0	0	0	14

Assemblage 3

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1768	.2066	.2380	.2799
Shell tempered vessels	19	34	64	77
Large jars	2	0	9	13
N(P1 ,Pl ,Pl)	1	0	5	7
N(P1 ,Pl ,Cm)	1	0	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Cn ,Cn)	0	0	2	0
N(Cmps,Cmps,Cmps)	0	0	0	6
Small jars	8	16	24	25
N(P1 ,Pl ,Pl)	1	2	8	6
N(P1 ,Pl ,Cm)	1	0	0	0
N(P1 ,Pl ,Ch)	0	0	5	0
N(P1 ,Cm ,Cm)	4	3	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps,Cmps)	0	0	0	7
N(Cm ,Cm ,Cm)	2	11	0	0
N(Ch ,Cn ,Cn)	0	0	10	4
N(Cmps,Cmps,Cmps)	0	0	0	8
Hemispherical bowls	9	18	25	28
N(P1 , - ,Pl)	7	18	25	25
N(Cm , - ,Cm)	2	0	0	0
N(Cmps, - ,Cmps)	0	0	0	3
Cazuela bowls	0	0	6	11
N(P1 , - ,Pl)	0	0	6	0
N(In , - ,Pl)	0	0	0	11
Quartz tempered vessels	80	66	35	24
Large jars	47	43	23	11
N(P1 ,Pl ,Pl)	0	11	3	0
N(P1 ,Ch ,Ch)	7	12	9	0
N(Cm ,Cm ,Cm)	40	20	0	0
N(Ch ,Ch ,Ch)	0	0	11	4
N(Cmps,Cmps,Cmps)	0	0	0	7
Small jars	33	23	12	13
N(P1 ,Pl ,Pl)	0	3	1	0
N(P1 ,Ch ,Ch)	0	2	4	0
N(Cm ,Cm ,Cm)	33	18	0	0
N(Ch ,Ch ,Ch)	0	0	7	5
N(Cmps,Cmps,Cmps)	0	0	0	3

Assemblage 4

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1393	.2230	.2401	.2393
Shell tempered vessels	10	49	66	72
Large jars	1	0	5	0
N(P1 ,Pl ,Pl)	0	0	1	0
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps,Cmps)	0	0	1	0
N(Cm ,Cm ,Cm)	1	0	0	0
N(Ch ,Cn ,Ch)	0	0	0	0
N(Cmps,Cmps,Cmps)	0	0	0	0
Small jars	4	23	26	23
N(P1 ,Pl ,Pl)	1	8	9	10
N(P1 ,Pl ,Cm)	0	3	0	0
N(P1 ,Pl ,Ch)	0	0	6	0
N(P1 ,Cm ,Cm)	0	3	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps,Cmps)	0	0	0	7
N(Cm ,Cm ,Cm)	3	9	0	0
N(Ch ,Cn ,Ch)	0	0	3	1
N(Cmps,Cmps,Cmps)	0	0	0	10
Hemispherical bowls	5	26	28	32
N(P1 , - ,Pl)	4	26	28	27
N(Cm , - ,Cm)	1	0	0	0
N(Cmps, - ,Cmps)	0	0	0	5
Cazuela bowls	0	0	7	12
N(P1 , - ,Pl)	0	0	7	3
N(In , - ,Pl)	0	0	0	9
Quartz tempered vessels	90	51	34	28
Large jars	56	27	17	10
N(P1 ,Pl ,Pl)	0	7	1	0
N(P1 ,Ch ,Ch)	13	7	3	0
N(Cm ,Cm ,Cm)	43	13	0	0
N(Ch ,Ch ,Ch)	0	0	13	6
N(Cmps,Cmps,Cmps)	0	0	0	4
Small jars	34	24	17	13
N(P1 ,Pl ,Pl)	0	1	4	0
N(P1 ,Ch ,Ch)	0	1	4	0
N(Cm ,Cm ,Cm)	34	22	0	0
N(Ch ,Ch ,Ch)	0	0	9	6
N(Cmps,Cmps,Cmps)	0	0	0	12

Assemblage 5

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1993	.2265	.2290	.2561
Shell tempered vessels	13	33	73	78
Large jars	0	1	14	8
N(P1 ,Pl ,Pl)	0	1	7	4
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	3	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Cn)	0	0	0	0
N(P1 ,Cmps,Cmps)	0	0	3	2
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	1	0
N(Cmps,Cmps,Cmps)	0	0	0	2
Small jars	8	15	26	27
N(P1 ,Pl ,Pl)	0	3	9	5
N(P1 ,Pl ,Cm)	1	0	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	2	2	0	0
N(P1 ,Ch ,Cn)	0	0	0	0
N(P1 ,Cmps,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	5	10	0	0
N(Ch ,Ch ,Ch)	0	0	15	1
N(Cmps,Cmps,Cmps)	0	0	0	16
Hemispherical bowls	10	17	27	31
N(P1 , - ,Pl)	5	17	27	29
N(Cm , - ,Cm)	5	0	0	0
N(Cmps, - ,Cmps)	0	0	0	2
Cazuela bowls	0	0	6	12
N(P1 , - ,Pl)	0	0	6	0
N(In , - ,Pl)	0	0	0	12
Quartz tempered vessels	32	67	26	23
Large jars	41	57	17	11
N(P1 ,Pl ,Pl)	0	15	7	0
N(P1 ,Ch ,Cn)	8	12	0	0
N(Cm ,Cm ,Cm)	33	30	0	0
N(Ch ,Ch ,Cn)	0	0	10	3
N(Cmps,Cmps,Cmps)	0	0	0	8
Small jars	41	10	9	12
N(P1 ,Pl ,Pl)	0	0	2	0
N(P1 ,Ch ,Cn)	0	0	4	0
N(Cm ,Cm ,Cm)	41	10	0	0
N(Ch ,Cn ,Ch)	0	0	3	6
N(Cmps,Cmps,Cmps)	0	0	0	6

Assemblage 6

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1996	.2181	.2435	.2337
Shell tempered vessels	13	39	52	89
Large jars	1	7	4	15
N(P1 ,Pl ,Pl)	0	3	1	4
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	1	2	0	0
N(P1 ,Ch ,Ch)	0	1	2	0
N(P1 ,Cmps,Cmps)	0	0	0	2
N(Cm ,Cm ,Cm)	0	1	0	0
N(Ch ,Ch ,Ch)	0	0	0	0
N(Cmps,Cmps,Cmps)	0	0	0	9
Small jars	3	15	21	29
N(P1 ,Pl ,Pl)	2	3	4	8
N(P1 ,Pl ,Cm)	0	2	0	0
N(P1 ,Pl ,Ch)	0	0	3	0
N(P1 ,Cm ,Cm)	0	1	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps,Cmps)	0	0	0	3
N(Cm ,Cm ,Cm)	6	9	0	0
N(Ch ,Cn ,Ch)	0	0	12	3
N(Cmps,Cmps,Cmps)	0	0	0	10
Hemispherical bowls	9	17	22	33
N(P1 , - ,Pl)	6	17	22	29
N(Cm , - ,Cm)	3	0	0	0
N(Cmps, - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	5	12
N(P1 , - ,Pl)	0	0	4	0
N(In , - ,Pl)	0	0	1	12
Quartz tempered vessels	82	61	47	11
Large jars	62	32	13	5
N(P1 ,Pl ,Pl)	0	5	6	0
N(P1 ,Ch ,Ch)	10	3	3	0
N(Cm ,Cm ,Cm)	52	19	0	0
N(Ch ,Ch ,Ch)	0	0	9	2
N(Cmps,Cmps,Cmps)	0	0	0	3
Small jars	20	29	29	6
N(P1 ,Pl ,Pl)	0	1	2	0
N(P1 ,Ch ,Ch)	0	2	10	0
N(Cm ,Cm ,Cm)	20	26	0	0
N(Ch ,Ch ,Ch)	0	0	17	2
N(Cmps,Cmps,Cmps)	0	0	0	4

Assemblage 7

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1856	.2330	.2616	.2373
Shell tempered vessels	9	53	36	74
Large jars	0	0	5	9
N(P1 ,Pl ,Pl)	0	0	1	3
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps,Cmps)	0	0	0	2
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	0	0
N(Cmps,Cmps,Cmps)	0	0	0	4
Small jars	4	25	14	25
N(P1 ,Pl ,Pl)	1	5	6	9
N(P1 ,Pl ,Cm)	2	4	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	1	2	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps,Cmps)	0	0	0	4
N(Cm ,Cm ,Cm)	0	14	0	0
N(Ch ,Ch ,Ch)	0	0	6	1
N(Cmps,Cmps,Cmps)	0	0	0	11
Hemispherical bowls	5	23	14	29
N(P1 , - ,Pl)	1	23	14	28
N(Cm , - ,Cm)	4	0	0	0
N(Cmps, - ,Cmps)	0	0	0	1
Cazuela bowls	0	0	3	11
N(P1 , - ,Pl)	0	0	3	0
N(In , - ,Pl)	0	0	0	11
Quartz tempered vessels	91	47	63	26
Large jars	45	31	35	12
N(P1 ,Pl ,Pl)	0	7	6	0
N(P1 ,Ch ,Ch)	15	7	12	0
N(Cm ,Cm ,Cm)	30	17	0	0
N(Ch ,Ch ,Ch)	0	0	17	6
N(Cmps,Cmps,Cmps)	0	0	0	6
Small jars	46	16	23	14
N(P1 ,Pl ,Pl)	0	1	1	0
N(P1 ,Ch ,Ch)	0	2	10	0
N(Cm ,Cm ,Cm)	46	13	0	0
N(Ch ,Ch ,Ch)	0	0	17	6
N(Cmps,Cmps,Cmps)	0	0	0	3

Assemblage 3

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2130	.2279	.2532	.2373
Shell tempered vessels	20	37	72	71
Large jars	5	0	13	3
N(P1 ,P1 ,P1)	0	0	4	1
N(P1 ,P1 ,Cm)	1	0	0	0
N(P1 ,P1 ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	1	0	0	0
N(P1 ,Ch ,Ch)	1	0	5	0
N(P1 ,Cmps,Cmps)	0	0	1	0
N(Cm ,Cm ,Cm)	2	0	0	0
N(Ch ,Cn ,Cn)	0	0	3	0
N(Cmps,Cmps,Cmps)	0	0	0	2
Small jars	7	18	26	27
N(P1 ,P1 ,P1)	1	7	5	10
N(P1 ,P1 ,Cm)	0	1	0	0
N(P1 ,P1 ,Ch)	0	0	4	0
N(P1 ,Cm ,Cm)	1	1	0	0
N(P1 ,Ch ,Ch)	0	0	3	0
N(P1 ,Cmps,Cmps)	0	0	0	4
N(Cm ,Cm ,Cm)	5	9	0	0
N(Ch ,Ch ,Cn)	0	0	14	4
N(Cmps,Cmps,Cmps)	0	0	0	9
Hemispherical bowls	8	19	27	30
N(P1 , - ,P1)	5	19	27	27
N(Cm , - ,Cm)	3	0	0	0
N(Cmps, - ,Cmps)	0	0	0	3
Cazuela bowls	0	0	6	11
N(P1 , - ,P1)	0	0	6	1
N(In , - ,P1)	0	0	0	10
Quartz tempered vessels	79	63	27	28
Large jars	47	41	11	16
N(P1 ,P1 ,P1)	0	12	3	0
N(P1 ,Ch ,Cn)	14	9	2	0
N(Cm ,Cm ,Cm)	33	20	0	0
N(Cn ,Cn ,Cn)	0	0	6	8
N(Cmps,Cmps,Cmps)	0	0	0	8
Small jars	32	22	16	12
N(P1 ,P1 ,P1)	0	3	3	0
N(P1 ,Ch ,Ch)	0	2	6	0
N(Cm ,Cm ,Cm)	32	17	0	0
N(Ch ,Ch ,Ch)	0	0	7	4
N(Cmps,Cmps,Cmps)	0	0	0	3

Assemblage 9

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2030	.1852	.2580	.2938
Shell tempered vessels	11	33	50	68
Large jars	2	4	4	25
N(P1 ,Pl ,Pl)	0	1	0	8
N(P1 ,Pl ,Cm)	0	1	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	1	0	0	0
N(P1 ,Ch ,Ch)	0	1	0	0
N(P1 ,Cmps ,Cmps)	0	0	1	4
N(Cm ,Cm ,Cm)	1	1	0	0
N(Ch ,Ch ,Ch)	0	0	1	0
N(Cmps ,Cmps ,Cmps)	0	0	0	13
Small jars	4	16	20	17
N(P1 ,Pl ,Pl)	0	1	7	6
N(P1 ,Pl ,Cm)	0	2	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	1	4	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps ,Cmps)	0	0	0	3
N(Cm ,Cm ,Cm)	3	9	0	0
N(Ch ,Ch ,Ch)	0	0	10	1
N(Cmps ,Cmps ,Cmps)	0	0	0	7
Hemispherical bowls	5	18	21	19
N(P1 , - ,Pl)	2	18	21	17
N(Cm , - ,Cm)	3	0	0	0
N(Cmps , - ,Cmps)	0	0	0	2
Cazuela bowls	0	0	5	7
N(P1 , - ,Pl)	0	0	5	1
N(In , - ,Pl)	0	0	0	6
Quartz tempered vessels	39	62	50	31
Large jars	64	36	24	14
N(P1 ,Pl ,Pl)	0	13	7	0
N(P1 ,Ch ,Ch)	15	9	9	0
N(Cm ,Cm ,Cm)	49	14	0	0
N(Ch ,Ch ,Ch)	0	0	8	4
N(Cmps ,Cmps ,Cmps)	0	0	0	10
Small jars	25	26	26	17
N(P1 ,Pl ,Pl)	0	4	1	0
N(P1 ,Ch ,Ch)	0	5	11	0
N(Cm ,Cm ,Cm)	25	17	0	0
N(Ch ,Ch ,Ch)	0	0	14	6
N(Cmps ,Cmps ,Cmps)	0	0	0	11

Assemblage 10

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2037	.2289	.2795	.2763
Shell tempered vessels	27	40	69	73
Large jars	4	5	5	17
N(P1 ,Pl ,Pl)	1	3	2	7
N(P1 ,Pl ,Cm)	1	0	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps,Cmps)	0	0	1	1
N(Cm ,Cm ,Cm)	2	2	0	0
N(Ch ,Ch ,Ch)	0	0	1	0
N(Cmps,Cmps,Cmps)	0	0	0	9
Small jars	11	17	28	22
N(P1 ,Pl ,Pl)	3	3	9	4
N(P1 ,Pl ,Cm)	1	1	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	0	4	0	0
N(P1 ,Ch ,Ch)	0	0	3	0
N(P1 ,Cmps,Cmps)	0	0	0	4
N(Cm ,Cm ,Cm)	7	9	0	0
N(Ch ,Ch ,Ch)	0	0	15	1
N(Cmps,Cmps,Cmps)	0	0	0	13
Hemispherical bowls	12	18	29	25
N(P1 , - ,Pl)	10	18	29	24
N(Cm , - ,Cm)	2	0	0	0
N(Cmps, - ,Cmps)	0	0	0	1
Cazuela bowls	0	0	7	9
N(P1 , - ,Pl)	0	0	7	2
N(In , - ,Pl)	0	0	0	7
Quartz tempered vessels	73	61	31	26
Large jars	33	32	14	11
N(P1 ,Pl ,Pl)	0	7	0	0
N(P1 ,Ch ,Ch)	7	10	1	0
N(Cm ,Cm ,Cm)	26	15	0	0
N(Cn ,Ch ,Ch)	0	0	13	2
N(Cmps,Cmps,Cmps)	0	0	0	9
Small jars	40	29	17	15
N(P1 ,Pl ,Pl)	0	2	2	0
N(P1 ,Ch ,Ch)	0	6	10	0
N(Cm ,Cm ,Cm)	40	21	0	0
N(Ch ,Ch ,Ch)	0	0	5	8
N(Cmps,Cmps,Cmps)	0	0	0	7

Assemblage 11

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1874	.2295	.2488	.2378
Shell tempered vessels	23	40	54	78
Large jars	2	9	0	3
N(P1 ,Pl ,Pl)	0	5	0	2
N(P1 ,Pl ,Cm)	0	1	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	2	0	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps ,Cmps)	0	0	0	1
N(Cm ,Cm ,Cm)	0	3	0	0
N(Ch ,Ch ,Ch)	0	0	0	0
N(Cmps ,Cmps ,Cmps)	0	0	0	5
Small jars	10	15	23	27
N(P1 ,Pl ,Pl)	3	3	9	5
N(P1 ,Pl ,Cm)	0	2	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	5	3	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps ,Cmps)	0	0	0	6
N(Cm ,Cm ,Cm)	2	7	0	0
N(Ch ,Ch ,Ch)	0	0	10	4
N(Cmps ,Cmps ,Cmps)	0	0	0	12
Hemispherical bowls	11	16	25	31
N(P1 , - ,Pl)	5	16	25	28
N(Cm , - ,Cm)	6	0	0	0
N(Cmps , - ,Cmps)	0	0	0	3
Cazuela bowls	0	0	6	12
N(P1 , - ,Pl)	0	0	5	1
N(In , - ,Pl)	0	0	1	11
Quartz tempered vessels	77	59	46	23
Large jars	46	30	23	10
N(P1 ,Pl ,Pl)	0	4	7	0
N(P1 ,Ch ,Ch)	17	7	6	0
N(Cm ,Cm ,Cm)	29	19	0	0
N(Ch ,Ch ,Ch)	0	0	10	4
N(Cmps ,Cmps ,Cmps)	0	0	0	6
Small jars	31	29	23	13
N(P1 ,Pl ,Pl)	0	3	3	0
N(P1 ,Ch ,Ch)	0	1	11	0
N(Cm ,Cm ,Cm)	31	25	0	0
N(Ch ,Ch ,Ch)	0	0	9	6
N(Cmps ,Cmps ,Cmps)	0	0	0	7

Assemblage 12

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2043	.1802	.2775	.2521
Shell tempered vessels	23	30	76	101
Large jars	4	0	5	19
N(P1 ,Pl ,Pl)	0	0	2	7
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	1	0	0	0
N(P1 ,Ch ,Ch)	1	0	0	0
N(P1 ,Cmps,Cmps)	0	0	1	1
N(Cm ,Cm ,Cm)	2	0	0	0
N(Ch ,Ch ,Ch)	0	0	2	1
N(Cmps,Cmps,Cmps)	0	0	0	10
Small jars	9	14	31	32
N(P1 ,Pl ,Pl)	0	3	6	9
N(P1 ,Pl ,Cm)	0	5	0	0
N(P1 ,Pl ,Ch)	0	0	5	0
N(P1 ,Cm ,Cm)	2	1	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps,Cmps)	0	0	0	7
N(Cm ,Cm ,Cm)	7	5	0	0
N(Ch ,Ch ,Ch)	0	0	13	1
N(Cmps,Cmps,Cmps)	0	0	0	15
Hemispherical bowls	10	16	32	36
N(P1 , - ,Pl)	4	16	32	32
N(Cm , - ,Cm)	6	0	0	0
N(Cmps, - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	3	14
N(P1 , - ,Pl)	0	0	7	1
N(In , - ,Pl)	0	0	1	13
Quartz tempered vessels	77	70	25	0
Large jars	38	37	9	0
N(P1 ,Pl ,Pl)	0	8	2	0
N(P1 ,Ch ,Ch)	14	10	2	0
N(Cm ,Cm ,Cm)	24	19	0	0
N(Ch ,Ch ,Ch)	0	0	5	0
N(Cmps,Cmps,Cmps)	0	0	0	0
Small jars	39	33	16	0
N(P1 ,Pl ,Pl)	0	3	0	0
N(P1 ,Ch ,Ch)	0	2	7	0
N(Cm ,Cm ,Cm)	39	23	0	0
N(Ch ,Ch ,Ch)	0	0	9	0
N(Cmps,Cmps,Cmps)	0	0	0	0

Assemblage 13

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2053	.2294	.2951	.2737
Shell tempered vessels	18	46	56	78
Large jars	0	0	1	1
N(P1 ,Pl ,Pl)	0	0	0	0
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	0	0
N(Cmps,Cmps,Cmps)	0	0	0	1
Small jars	8	22	24	30
N(P1 ,Pl ,Pl)	0	7	5	10
N(P1 ,Pl ,Cm)	2	3	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	1	5	0	0
N(P1 ,Ch ,Ch)	0	0	5	0
N(P1 ,Cmps,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	5	7	0	0
N(Ch ,Ch ,Ch)	0	0	12	4
N(Cmps,Cmps,Cmps)	0	0	0	11
Hemispherical bowls	10	24	25	34
N(P1 , - ,Pl)	5	24	25	34
N(Cm , - ,Cm)	5	0	0	0
N(Cmps, - ,Cmps)	0	0	0	0
Cazuela bowls	0	0	6	13
N(P1 , - ,Pl)	0	0	4	0
N(In , - ,Pl)	0	0	2	13
Quartz tempered vessels	82	54	43	22
Large jars	39	40	15	7
N(P1 ,Pl ,Pl)	0	11	5	0
N(P1 ,Ch ,Ch)	10	7	4	0
N(Cm ,Cm ,Cm)	29	22	0	0
N(Ch ,Cn ,Ch)	0	0	6	3
N(Cmps,Cmps,Cmps)	0	0	0	4
Small jars	43	14	23	15
N(P1 ,Pl ,Pl)	0	4	6	0
N(P1 ,Ch ,Ch)	0	2	10	0
N(Cm ,Cm ,Cm)	43	8	0	0
N(Ch ,Ch ,Ch)	0	0	12	6
N(Cmps,Cmps,Cmps)	0	0	0	9

Assemblage 14

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2105	.2417	.2009	.2753
Snell tempered vessels	23	18	56	66
Large jars	0	4	12	5
N(Pl ,Pl ,Pl)	0	2	4	2
N(Pl ,Pl ,Cm)	0	1	0	0
N(Pl ,Pl ,Ch)	0	0	1	0
N(Pl ,Cm ,Cm)	0	0	0	0
N(Pl ,Ch ,Ch)	0	0	4	0
N(Pl ,Cmps,Cmps)	0	0	2	0
N(Cm ,Cm ,Cm)	0	1	0	0
N(Ch ,Ch ,Ch)	0	0	1	1
N(Cmps,Cmps,Cmps)	0	0	0	2
Small jars	11	7	19	24
N(Pl ,Pl ,Pl)	0	4	3	11
N(Pl ,Pl ,Cm)	1	0	0	0
N(Pl ,Pl ,Ch)	0	0	3	0
N(Pl ,Cm ,Cm)	5	1	0	0
N(Pl ,Ch ,Ch)	0	0	2	0
N(Pl ,Cmps,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	5	2	0	0
N(Ch ,Ch ,Ch)	0	0	6	3
N(Cmps,Cmps,Cmps)	0	0	0	5
Hemispherical bowls	12	7	20	27
N(Pl , - ,Pl)	5	7	20	23
N(Cm , - ,Cm)	7	0	0	0
N(Cmps, - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	5	10
N(Pl , - ,Pl)	0	0	4	0
N(In , - ,Pl)	0	0	1	10
Quartz tempered vessels	77	82	44	33
Large jars	44	47	21	9
N(Pl ,Pl ,Pl)	0	12	4	0
N(Pl ,Ch ,Ch)	13	13	7	0
N(Cm ,Cm ,Cm)	31	22	0	0
N(Ch ,Ch ,Ch)	0	0	10	4
N(Cmps,Cmps,Cmps)	0	0	0	5
Small jars	33	35	23	24
N(Pl ,Pl ,Pl)	0	7	2	0
N(Pl ,Ch ,Ch)	0	2	9	0
N(Cm ,Cm ,Cm)	33	26	0	0
N(Ch ,Ch ,Ch)	0	0	12	9
N(Cmps,Cmps,Cmps)	0	0	0	15

Assemblage 15

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1921	.2182	.2660	.2551
Shell tempered vessels	30	58	55	78
Large jars	5	6	0	12
N(P1 ,Pl ,Pl)	1	3	0	6
N(P1 ,Pl ,Cm)	2	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	1	1	0	0
N(P1 ,Ch ,Ch)	0	1	0	0
N(P1 ,Cmps,Cmps)	0	0	0	1
N(Cm ,Cm ,Cm)	1	1	0	0
N(Ch ,Ch ,Ch)	0	0	0	1
N(Cmps,Cmps,Cmps)	0	0	0	4
Small jars	12	25	24	26
N(P1 ,Pl ,Pl)	2	6	7	9
N(P1 ,Pl ,Cm)	2	4	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	4	0
N(P1 ,Cmps,Cmps)	0	0	0	4
N(Cm ,Cm ,Cm)	8	15	0	0
N(Ch ,Ch ,Ch)	0	0	13	2
N(Cmps,Cmps,Cmps)	0	0	0	11
Hemispherical bowls	13	27	25	29
N(P1 , - ,Pl)	9	27	25	22
N(Cm , - ,Cm)	4	0	0	0
N(Cmps, - ,Cmps)	0	0	0	7
Cazuela bowls	0	0	6	11
N(P1 , - ,Pl)	0	0	4	1
N(In , - ,Pl)	0	0	2	10
Quartz tempered vessels	70	42	45	22
Large jars	37	32	16	9
N(P1 ,Pl ,Pl)	0	6	1	0
N(P1 ,Ch ,Ch)	12	13	4	0
N(Cm ,Cm ,Cm)	25	13	0	0
N(Ch ,Ch ,Ch)	0	0	11	2
N(Cmps,Cmps,Cmps)	0	0	0	7
Small jars	33	10	29	13
N(P1 ,Pl ,Pl)	0	1	5	0
N(P1 ,Ch ,Ch)	0	1	11	0
N(Cm ,Cm ,Cm)	33	8	0	0
N(Ch ,Ch ,Ch)	0	0	13	7
N(Cmps,Cmps,Cmps)	0	0	0	6

Assemblage 16

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1929	.2187	.2539	.3127
Shell tempered vessels	19	64	48	38
Large jars	0	0	7	0
N(P1 ,P1 ,P1)	0	0	1	0
N(P1 ,P1 ,Cm)	0	0	0	0
N(P1 ,P1 ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps ,Cmps)	0	0	2	0
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	1	0
N(Cmps ,Cmps ,Cmps)	0	0	0	0
Small jars	9	31	13	34
N(P1 ,P1 ,P1)	1	11	6	9
N(P1 ,P1 ,Cm)	2	0	0	0
N(P1 ,P1 ,Ch)	0	0	4	0
N(P1 ,Cm ,Cm)	0	3	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps ,Cmps)	0	0	0	11
N(Cm ,Cm ,Cm)	6	17	0	0
N(Ch ,Ch ,Ch)	0	0	7	4
N(Cmps ,Cmps ,Cmps)	0	0	0	10
Hemispherical bowls	10	33	19	39
N(P1 , - ,P1)	6	33	19	35
N(Cm , - ,Cm)	4	0	0	0
N(Cmps , - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	4	15
N(P1 , - ,P1)	0	0	4	0
N(In , - ,P1)	0	0	0	15
Quartz tempered vessels	31	36	52	12
Large jars	67	21	18	4
N(P1 ,P1 ,P1)	0	5	2	0
N(P1 ,Ch ,Ch)	15	2	2	0
N(Cm ,Cm ,Cm)	52	14	0	0
N(Ch ,Ch ,Ch)	0	0	14	0
N(Cmps ,Cmps ,Cmps)	0	0	0	4
Small jars	14	15	34	8
N(P1 ,P1 ,P1)	0	1	3	0
N(P1 ,Ch ,Ch)	0	1	15	0
N(Cm ,Cm ,Cm)	14	13	0	0
N(Ch ,Ch ,Ch)	0	0	16	1
N(Cmps ,Cmps ,Cmps)	0	0	0	7

Assemblage 17

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2020	.2032	.2404	.3039
Snell tempered vessels	28	51	68	88
Large jars	5	0	8	0
N(P1 ,Pl ,Pl)	0	0	4	0
N(P1 ,Pl ,Cm)	2	0	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	1	0	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps ,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	2	0	0	0
N(Ch ,Ch ,Ch)	0	0	1	0
N(Cmps ,Cmps ,Cmps)	0	0	0	0
Small jars	11	24	26	34
N(P1 ,Pl ,Pl)	1	2	7	17
N(P1 ,Pl ,Cm)	1	4	0	0
N(P1 ,Pl ,Ch)	0	0	4	0
N(P1 ,Cm ,Cm)	3	5	0	0
N(P1 ,Ch ,Ch)	0	0	4	0
N(P1 ,Cmps ,Cmps)	0	0	0	6
N(Cm ,Cm ,Cm)	6	13	0	0
N(Ch ,Ch ,Ch)	0	0	11	3
N(Cmps ,Cmps ,Cmps)	0	0	0	8
Hemispherical bowls	12	27	27	39
N(P1 , - ,Pl)	5	27	27	35
N(Cm , - ,Cm)	7	0	0	0
N(Cmps , - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	7	15
N(P1 , - ,Pl)	0	0	5	3
N(In , - ,Pl)	0	0	2	12
Quartz tempered vessels	72	49	32	13
Large jars	35	39	13	7
N(P1 ,Pl ,Pl)	0	10	2	0
N(P1 ,Ch ,Ch)	7	9	2	0
N(Cm ,Cm ,Cm)	28	20	0	0
N(Ch ,Ch ,Ch)	0	0	9	1
N(Cmps ,Cmps ,Cmps)	0	0	0	6
Small jars	37	10	19	6
N(P1 ,Pl ,Pl)	0	2	3	0
N(P1 ,Ch ,Ch)	0	3	9	0
N(Cm ,Cm ,Cm)	37	5	0	0
N(Ch ,Ch ,Ch)	0	0	7	2
N(Cmps ,Cmps ,Cmps)	0	0	0	4

Assemblage 18

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2130	.2158	.2495	.2671
Shell tempered vessels	30	58	62	93
Large jars	0	8	0	14
N(P1 ,Pl ,Pl)	0	2	0	5
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	1	0	0
N(P1 ,Ch ,Ch)	0	2	0	0
N(P1 ,Cmps,Cmps)	0	0	0	1
N(Cm ,Cm ,Cm)	0	3	0	0
N(Ch ,Ch ,Ch)	0	0	0	3
N(Cmps,Cmps,Cmps)	0	0	0	5
Small jars	14	24	27	31
N(P1 ,Pl ,Pl)	4	4	10	11
N(P1 ,Pl ,Cm)	1	5	0	0
N(P1 ,Pl ,Ch)	0	0	3	0
N(P1 ,Cm ,Cm)	3	4	0	0
N(P1 ,Ch ,Ch)	0	0	6	0
N(P1 ,Cmps,Cmps)	0	0	0	3
N(Cm ,Cm ,Cm)	6	11	0	0
N(Ch ,Ch ,Ch)	0	0	8	4
N(Cmps,Cmps,Cmps)	0	0	0	13
Hemispherical bowls	16	26	28	35
N(P1 , - ,Pl)	10	26	28	29
N(Cm , - ,Cm)	6	0	0	0
N(Cmps, - ,Cmps)	0	0	0	6
Cazuela bowls	0	0	7	13
N(P1 , - ,Pl)	0	0	7	1
N(In , - ,Pl)	0	0	0	12
Quartz tempered vessels	70	43	39	6
Large jars	43	23	22	2
N(P1 ,Pl ,Pl)	0	4	4	0
N(P1 ,Ch ,Ch)	11	5	5	0
N(Cm ,Cm ,Cm)	32	14	0	0
N(Ch ,Ch ,Ch)	0	0	13	0
N(Cmps,Cmps,Cmps)	0	0	0	2
Small jars	27	20	17	4
N(P1 ,Pl ,Pl)	0	1	2	0
N(P1 ,Ch ,Ch)	0	1	5	0
N(Cm ,Cm ,Cm)	27	18	0	0
N(Ch ,Ch ,Ch)	0	0	10	1
N(Cmps,Cmps,Cmps)	0	0	0	3

Assemblage 19

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1955	.2465	.2404	.2942
Shell tempered vessels	19	43	68	86
Large jars	2	0	15	14
N(P1 ,Pl ,Pl)	0	0	6	6
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	1	0	3	0
N(P1 ,Cmps ,Cmps)	0	0	2	0
N(Cm ,Cm ,Cm)	1	0	0	0
N(Ch ,Ch ,Ch)	0	0	3	0
N(Cmps ,Cmps ,Cmps)	0	0	0	3
Small jars	8	23	23	28
N(P1 ,Pl ,Pl)	0	13	4	10
N(P1 ,Pl ,Cm)	2	1	0	0
N(P1 ,Pl ,Ch)	0	0	4	0
N(P1 ,Cm ,Cm)	2	0	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps ,Cmps)	0	0	0	11
N(Cm ,Cm ,Cm)	4	9	0	0
N(Ch ,Ch ,Ch)	0	0	14	0
N(Cmps ,Cmps ,Cmps)	0	0	0	7
Hemispherical bowls	9	25	24	32
N(P1 , - ,Pl)	5	25	24	31
N(Cm , - ,Cm)	4	0	0	0
N(Cmps , - ,Cmps)	0	0	0	1
Cazuela bowls	0	0	6	12
N(P1 , - ,Pl)	0	0	6	1
N(In , - ,Pl)	0	0	0	11
Quartz tempered vessels	81	51	32	14
Large jars	42	23	13	4
N(P1 ,Pl ,Pl)	0	5	3	0
N(P1 ,Ch ,Ch)	10	7	3	0
N(Cm ,Cm ,Cm)	32	11	0	0
N(Ch ,Ch ,Ch)	0	0	7	2
N(Cmps ,Cmps ,Cmps)	0	0	0	2
Small jars	39	23	19	10
N(P1 ,Pl ,Pl)	0	1	2	0
N(P1 ,Ch ,Ch)	0	4	8	0
N(Cm ,Cm ,Cm)	39	23	0	0
N(Ch ,Ch ,Ch)	0	0	9	4
N(Cmps ,Cmps ,Cmps)	0	0	0	6

Assemblage 20

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1911	.2297	.2500	.2969
Shell tempered vessels	33	34	66	75
Large jars	0	2	0	0
N(P1 ,Pl ,Pl)	0	1	0	0
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	1	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	0	0
N(Cmps,Cmps,Cmps)	0	0	0	0
Small jars	15	15	29	29
N(P1 ,Pl ,Pl)	1	4	7	9
N(P1 ,Pl ,Cm)	2	1	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	0	1	0	0
N(P1 ,Ch ,Ch)	0	0	4	0
N(P1 ,Cmps,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	12	9	0	0
N(Ch ,Ch ,Ch)	0	0	17	3
N(Cmps,Cmps,Cmps)	0	0	0	12
Hemispherical bowls	18	17	30	33
N(P1 , - ,Pl)	10	17	30	30
N(Cm , - ,Cm)	8	0	0	0
N(Cmps, - ,Cmps)	0	0	0	3
Cazuela bowls	0	0	7	13
N(P1 , - ,Pl)	0	0	6	1
N(In , - ,Pl)	0	0	1	12
Quartz tempered vessels	67	66	34	25
Large jars	45	40	14	16
N(P1 ,Pl ,Pl)	0	12	2	0
N(P1 ,Ch ,Ch)	16	7	7	0
N(Cm ,Cm ,Cm)	29	21	0	0
N(Ch ,Ch ,Ch)	0	0	5	4
N(Cmps,Cmps,Cmps)	0	0	0	12
Small jars	22	26	20	9
N(P1 ,Pl ,Pl)	0	2	0	0
N(P1 ,Ch ,Ch)	0	4	11	0
N(Cm ,Cm ,Cm)	22	20	0	0
N(Ch ,Ch ,Ch)	0	0	9	6
N(Cmps,Cmps,Cmps)	0	0	0	3

Assemblage 21

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2020	.2135	.2721	.2622
Shell tempered vessels	37	39	64	79
Large jars	3	2	1	23
N(P1 ,Pl ,Pl)	0	1	1	7
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	1	1	0	0
N(P1 ,Ch ,Ch)	1	0	0	0
N(P1 ,Cmps ,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	1	0	0	0
N(Ch ,Cn ,Ch)	0	0	0	2
N(Cmps ,Cmps ,Cmps)	0	0	0	9
Small jars	16	13	27	22
N(P1 ,Pl ,Pl)	3	9	3	9
N(P1 ,Pl ,Cm)	3	2	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	3	1	0	0
N(P1 ,Ch ,Ch)	0	0	4	0
N(P1 ,Cmps ,Cmps)	0	0	0	4
N(Cm ,Cm ,Cm)	7	6	0	0
N(Ch ,Ch ,Cn)	0	0	14	1
N(Cmps ,Cmps ,Cmps)	0	0	0	8
Hemispherical bowls	18	19	29	25
N(P1 , - ,Pl)	8	19	29	22
N(Cm , - ,Cm)	10	0	0	0
N(Cmps , - ,Cmps)	0	0	0	3
Cazuela bowls	0	0	7	9
N(P1 , - ,Pl)	0	0	7	1
N(In , - ,Pl)	0	0	0	8
Quartz tempered vessels	63	61	36	21
Large jars	36	34	23	7
N(P1 ,Pl ,Pl)	0	4	3	0
N(P1 ,Ch ,Ch)	12	4	6	0
N(Cm ,Cm ,Cm)	24	26	0	0
N(Ch ,Ch ,Ch)	0	0	9	1
N(Cmps ,Cmps ,Cmps)	0	0	0	6
Small jars	27	27	13	14
N(P1 ,Pl ,Pl)	0	1	1	0
N(P1 ,Ch ,Ch)	0	2	5	0
N(Cm ,Cm ,Cm)	27	24	0	0
N(Ch ,Ch ,Ch)	0	0	7	6
N(Cmps ,Cmps ,Cmps)	0	0	0	3

Assemblage 22

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1928	.2037	.2536	.3147
Shell tempered vessels	22	34	59	68
Large jars	0	5	4	15
N(P1 ,Pl ,Pl)	0	1	1	7
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	1	0	0
N(P1 ,Ch ,Ch)	0	1	1	0
N(P1 ,Cmps ,Cmps)	0	0	0	2
N(Cm ,Cm ,Cm)	0	2	0	0
N(Ch ,Ch ,Ch)	0	0	2	0
N(Cmps ,Cmps ,Cmps)	0	0	0	6
Small jars	10	14	24	21
N(P1 ,Pl ,Pl)	2	9	7	9
N(P1 ,Pl ,Cm)	0	3	0	0
N(P1 ,Pl ,Ch)	0	0	3	0
N(P1 ,Cm ,Cm)	2	0	0	0
N(P1 ,Ch ,Ch)	0	0	4	0
N(P1 ,Cmps ,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	6	2	0	0
N(Ch ,Ch ,Ch)	0	0	10	4
N(Cmps ,Cmps ,Cmps)	0	0	0	3
Hemispherical bowls	12	15	25	23
N(P1 , - ,Pl)	5	15	25	23
N(Cm , - ,Cm)	7	0	0	0
N(Cmps , - ,Cmps)	0	0	0	0
Cazuela bowls	0	0	6	9
N(P1 , - ,Pl)	0	0	5	1
N(In , - ,Pl)	0	0	1	3
Quartz tempered vessels	78	66	41	32
Large jars	42	44	16	10
N(P1 ,Pl ,Pl)	0	11	5	0
N(P1 ,Ch ,Ch)	13	10	6	0
N(Cm ,Cm ,Cm)	29	23	0	0
N(Ch ,Ch ,Ch)	0	0	5	1
N(Cmps ,Cmps ,Cmps)	0	0	0	9
Small jars	36	22	25	22
N(P1 ,Pl ,Pl)	0	3	2	0
N(P1 ,Ch ,Ch)	0	3	7	0
N(Cm ,Cm ,Cm)	36	16	0	0
N(Ch ,Ch ,Ch)	0	0	16	13
N(Cmps ,Cmps ,Cmps)	0	0	0	9

Assemblage 23

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2015	.2172	.2368	.3166
Shell tempered vessels	20	26	60	39
Large jars	0	5	7	6
N(P1 ,Pl ,Pl)	0	0	4	1
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	1	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps ,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	0	2	0	0
N(Ch ,Ch ,Ch)	0	0	2	1
N(Cmps ,Cmps ,Cmps)	0	0	0	4
Small jars	9	10	23	32
N(P1 ,Pl ,Pl)	0	2	4	6
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	3	0	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps ,Cmps)	0	0	0	6
N(Cm ,Cm ,Cm)	6	3	0	0
N(Ch ,Ch ,Ch)	0	0	16	4
N(Cmps ,Cmps ,Cmps)	0	0	0	16
Hemispherical bowls	11	11	24	37
N(P1 , - ,Pl)	5	11	24	34
N(Cm , - ,Cm)	6	0	0	0
N(Cmps , - ,Cmps)	0	0	0	3
Cazuela bowls	0	0	6	14
N(P1 , - ,Pl)	0	0	6	2
N(In , - ,Pl)	0	0	0	12
Quartz tempered vessels	80	75	40	11
Large jars	58	45	22	4
N(P1 ,Pl ,Pl)	0	10	6	0
N(P1 ,Ch ,Ch)	11	5	6	0
N(Cm ,Cm ,Cm)	47	30	0	0
N(Ch ,Ch ,Ch)	0	0	10	2
N(Cmps ,Cmps ,Cmps)	0	0	0	2
Small jars	22	30	18	7
N(P1 ,Pl ,Pl)	0	6	0	0
N(P1 ,Ch ,Ch)	0	4	7	0
N(Cm ,Cm ,Cm)	22	20	0	0
N(Ch ,Ch ,Ch)	0	0	11	1
N(Cmps ,Cmps ,Cmps)	0	0	0	6

Assemblage 24

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2059	.2303	.1904	.2945
Snell tempered vessels	27	52	65	77
Large jars	1	6	12	0
N(P1 ,Pl ,Pl)	0	4	4	0
N(P1 ,Pl ,Cm)	1	1	0	0
N(P1 ,Pl ,Ch)	0	0	3	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps,Cmps)	0	0	2	0
N(Cm ,Cm ,Cm)	0	1	0	0
N(Ch ,Ch ,Ch)	0	0	1	0
N(Cmps,Cmps,Cmps)	0	0	0	0
Small jars	12	22	23	30
N(P1 ,Pl ,Pl)	1	4	8	3
N(P1 ,Pl ,Cm)	2	3	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	1	1	0	0
N(P1 ,Ch ,Ch)	0	0	1	0
N(P1 ,Cmps,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	8	14	0	0
N(Ch ,Ch ,Ch)	0	0	12	1
N(Cmps,Cmps,Cmps)	0	0	0	16
Hemispherical bowls	14	24	24	34
N(P1 , - ,Pl)	10	24	24	29
N(Cm , - ,Cm)	4	0	0	0
N(Cmps, - ,Cmps)	0	0	0	5
Cazuela bowls	0	0	6	13
N(P1 , - ,Pl)	0	0	5	0
N(In , - ,Pl)	0	0	1	13
Quartz tempered vessels	74	43	36	24
Large jars	31	31	21	12
N(P1 ,Pl ,Pl)	0	7	5	0
N(P1 ,Ch ,Ch)	5	9	6	0
N(Cm ,Cm ,Cm)	26	15	0	0
N(Ch ,Ch ,Ch)	0	0	10	5
N(Cmps,Cmps,Cmps)	0	0	0	7
Small jars	43	17	15	12
N(P1 ,Pl ,Pl)	0	0	3	0
N(P1 ,Ch ,Ch)	0	3	2	0
N(Cm ,Cm ,Cm)	43	14	0	0
N(Ch ,Ch ,Ch)	0	0	10	3
N(Cmps,Cmps,Cmps)	0	0	0	9

Assemblage 25

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2042	.2397	.2049	.3255
Shell tempered vessels	0	30	60	77
Large jars	0	7	0	0
N(P1 ,Pl ,Pl)	0	4	0	0
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	1	0	0
N(P1 ,Cmps,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	0	2	0	0
N(Ch ,Ch ,Ch)	0	0	0	0
N(Cmps,Cmps,Cmps)	0	0	0	0
Small jars	0	11	26	30
N(P1 ,Pl ,Pl)	0	3	10	14
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	3	0
N(P1 ,Cm ,Cm)	0	3	0	0
N(P1 ,Ch ,Ch)	0	0	3	0
N(P1 ,Cmps,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	0	5	0	0
N(Ch ,Ch ,Ch)	0	0	10	3
N(Cmps,Cmps,Cmps)	0	0	0	8
Hemispherical bowls	0	12	27	34
N(P1 , - ,Pl)	0	12	27	23
N(Cm , - ,Cm)	0	0	0	0
N(Cmps, - ,Cmps)	0	0	0	6
Cazuela bowls	0	0	7	13
N(P1 , - ,Pl)	0	0	7	0
N(In , - ,Pl)	0	0	0	13
Quartz tempered vessels	100	70	40	23
Large jars	65	39	19	12
N(P1 ,Pl ,Pl)	0	17	5	0
N(P1 ,Ch ,Ch)	19	7	5	0
N(Cm ,Cm ,Cm)	46	15	0	0
N(Ch ,Ch ,Ch)	0	0	9	6
N(Cmps,Cmps,Cmps)	0	0	0	6
Small jars	35	31	21	11
N(P1 ,Pl ,Pl)	0	2	3	0
N(P1 ,Ch ,Ch)	0	3	3	0
N(Cm ,Cm ,Cm)	35	26	0	0
N(Ch ,Ch ,Ch)	0	0	10	4
N(Cmps,Cmps,Cmps)	0	0	0	7

Assemblage 26

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1991	.2230	.2540	.3314
Shell tempered vessels	22	36	71	65
Large jars	1	0	11	3
N(P1 ,Pl ,Pl)	0	0	4	3
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps ,Cmps)	0	0	1	0
N(Cm ,Cm ,Cm)	1	0	0	0
N(Ch ,Ch ,Ch)	0	0	3	0
N(Cmps ,Cmps ,Cmps)	0	0	0	0
Small jars	10	17	26	24
N(P1 ,Pl ,Pl)	1	6	8	8
N(P1 ,Pl ,Cm)	0	3	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	3	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps ,Cmps)	0	0	0	4
N(Cm ,Cm ,Cm)	9	5	0	0
N(Ch ,Ch ,Ch)	0	0	16	2
N(Cmps ,Cmps ,Cmps)	0	0	0	10
Hemispherical bowls	11	19	27	28
N(P1 , - ,Pl)	8	19	27	24
N(Cm , - ,Cm)	3	0	0	0
N(Cmps , - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	7	10
N(P1 , - ,Pl)	0	0	7	3
N(In , - ,Pl)	0	0	0	7
Quartz tempered vessels	78	64	29	35
Large jars	46	45	19	13
N(P1 ,Pl ,Pl)	0	12	9	0
N(P1 ,Ch ,Ch)	12	10	3	0
N(Cm ,Cm ,Cm)	34	23	0	0
N(Ch ,Ch ,Ch)	0	0	7	6
N(Cmps ,Cmps ,Cmps)	0	0	0	7
Small jars	32	19	10	22
N(P1 ,Pl ,Pl)	0	1	0	0
N(P1 ,Ch ,Ch)	0	0	5	0
N(Cm ,Cm ,Cm)	32	18	0	0
N(Ch ,Ch ,Ch)	0	0	5	10
N(Cmps ,Cmps ,Cmps)	0	0	0	12

Assemblage 27

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.2074	.2099	.2614	.3111
Shell tempered vessels	29	36	73	93
Large jars	3	1	9	0
N(P1 ,Pl ,Pl)	0	1	2	0
N(P1 ,Pl ,Cm)	1	0	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	1	0	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps,Cmps)	0	0	1	0
N(Cm ,Cm ,Cm)	1	0	0	0
N(Ch ,Ch ,Ch)	0	0	5	0
N(Cmps,Cmps,Cmps)	0	0	0	0
Small jars	12	17	28	36
N(P1 ,Pl ,Pl)	0	5	7	11
N(P1 ,Pl ,Cm)	0	5	0	0
N(P1 ,Pl ,Ch)	0	0	1	0
N(P1 ,Cm ,Cm)	2	0	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps,Cmps)	0	0	0	5
N(Cm ,Cm ,Cm)	10	7	0	0
N(Ch ,Ch ,Ch)	0	0	18	2
N(Cmps,Cmps,Cmps)	0	0	0	18
Hemispherical bowls	14	18	29	41
N(P1 , - ,Pl)	5	18	29	36
N(Cm , - ,Cm)	9	0	0	0
N(Cmps, - ,Cmps)	0	0	0	5
Cazuela bowls	0	0	7	16
N(P1 , - ,Pl)	0	0	6	0
N(In , - ,Pl)	0	0	1	16
Quartz tempered vessels	71	64	28	7
Large jars	55	39	16	3
N(P1 ,Pl ,Pl)	0	9	6	0
N(P1 ,Ch ,Ch)	13	8	5	0
N(Cm ,Cm ,Cm)	42	22	0	0
N(Ch ,Ch ,Ch)	0	0	5	2
N(Cmps,Cmps,Cmps)	0	0	0	1
Small jars	16	25	12	4
N(P1 ,Pl ,Pl)	0	1	0	0
N(P1 ,Ch ,Ch)	0	1	3	0
N(Cm ,Cm ,Cm)	16	23	0	0
N(Ch ,Ch ,Ch)	0	0	9	3
N(Cmps,Cmps,Cmps)	0	0	0	1

Assemblage 23

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1934	.2093	.2169	.3031
Shell tempered vessels	11	47	58	95
Large jars	1	5	1	0
N(P1 ,Pl ,Pl)	0	1	0	0
N(P1 ,Pl ,Cm)	0	1	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	1	2	0	0
N(P1 ,Ch ,Ch)	0	1	0	0
N(P1 ,Cmps,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	1	0
N(Cmps,Cmps,Cmps)	0	0	0	0
Small jars	5	20	25	37
N(P1 ,Pl ,Pl)	0	7	12	13
N(P1 ,Pl ,Cm)	1	1	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	1	2	0	0
N(P1 ,Ch ,Ch)	0	0	3	0
N(P1 ,Cmps,Cmps)	0	0	0	7
N(Cm ,Cm ,Cm)	3	10	0	0
N(Ch ,Ch ,Ch)	0	0	3	3
N(Cmps,Cmps,Cmps)	0	0	0	14
Hemispherical bowls	5	22	26	42
N(P1 , - ,Pl)	3	22	26	33
N(Cm , - ,Cm)	2	0	0	0
N(Cmps, - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	6	16
N(P1 , - ,Pl)	0	0	4	4
N(In , - ,Pl)	0	0	2	12
Quartz tempered vessels	39	53	41	6
Large jars	43	25	14	2
N(P1 ,Pl ,Pl)	0	9	1	0
N(P1 ,Ch ,Ch)	11	6	2	0
N(Cm ,Cm ,Cm)	37	10	0	0
N(Ch ,Ch ,Ch)	0	0	11	0
N(Cmps,Cmps,Cmps)	0	0	0	2
Small jars	41	28	27	4
N(P1 ,Pl ,Pl)	0	3	2	0
N(P1 ,Ch ,Ch)	0	0	11	0
N(Cm ,Cm ,Cm)	41	25	0	0
N(Ch ,Ch ,Ch)	0	0	14	3
N(Cmps,Cmps,Cmps)	0	0	0	1

Assemblage 29

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1772	.2173	.2490	.2753
Shell tempered vessels	2	22	73	92
Large jars	0	0	0	0
N(P1 ,Pl ,Pl)	0	0	0	0
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	0	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps ,Cmps)	0	0	0	0
N(Cm ,Cm ,Cm)	0	0	0	0
N(Cn ,Ch ,Ch)	0	0	0	0
N(Cmps ,Cmps ,Cmps)	0	0	0	0
Small jars	1	11	32	36
N(P1 ,Pl ,Pl)	0	5	12	7
N(P1 ,Pl ,Cm)	0	1	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	1	0	0	0
N(P1 ,Ch ,Ch)	0	0	0	0
N(P1 ,Cmps ,Cmps)	0	0	0	10
N(Cm ,Cm ,Cm)	0	5	0	0
N(Cn ,Ch ,Ch)	0	0	18	5
N(Cmps ,Cmps ,Cmps)	0	0	0	14
Hemispherical bowls	1	11	33	41
N(P1 , - ,Pl)	1	11	33	37
N(Cm , - ,Cm)	0	0	0	0
N(Cmps , - ,Cmps)	0	0	0	4
Cazuela bowls	0	0	3	15
N(P1 , - ,Pl)	0	0	7	3
N(In , - ,Pl)	0	0	1	12
Quartz tempered vessels	98	73	27	8
Large jars	57	54	13	4
N(P1 ,Pl ,Pl)	0	17	2	0
N(P1 ,Ch ,Ch)	12	12	2	0
N(Cm ,Cm ,Cm)	45	25	0	0
N(Ch ,Ch ,Ch)	0	0	9	1
N(Cmps ,Cmps ,Cmps)	0	0	0	3
Small jars	41	24	14	4
N(P1 ,Pl ,Pl)	0	3	1	0
N(P1 ,Ch ,Ch)	0	5	5	0
N(Cm ,Cm ,Cm)	41	16	0	0
N(Ch ,Ch ,Ch)	0	0	3	0
N(Cmps ,Cmps ,Cmps)	0	0	0	4

Assemblage 30

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1906	.2379	.2572	.3101
Shell tempered vessels	33	42	65	80
Large jars	0	0	3	10
N(P1 ,Pl ,Pl)	0	0	1	2
N(P1 ,Pl ,Cm)	0	0	0	0
N(P1 ,Pl ,Ch)	0	0	2	0
N(P1 ,Cm ,Cm)	0	0	0	0
N(P1 ,Ch ,Ch)	0	0	2	0
N(P1 ,Cmps ,Cmps)	0	0	1	1
N(Cm ,Cm ,Cm)	0	0	0	0
N(Ch ,Ch ,Ch)	0	0	2	1
N(Cmps ,Cmps ,Cmps)	0	0	0	6
Small jars	15	20	25	27
N(P1 ,Pl ,Pl)	3	5	4	9
N(P1 ,Pl ,Cm)	1	0	0	0
N(P1 ,Pl ,Ch)	0	0	7	0
N(P1 ,Cm ,Cm)	2	4	0	0
N(P1 ,Ch ,Ch)	0	0	4	0
N(P1 ,Cmps ,Cmps)	0	0	0	3
N(Cm ,Cm ,Cm)	9	11	0	0
N(Ch ,Ch ,Ch)	0	0	10	4
N(Cmps ,Cmps ,Cmps)	0	0	0	11
Hemispherical bowls	18	22	26	31
N(P1 , - ,Pl)	9	22	26	31
N(Cm , - ,Cm)	9	0	0	0
N(Cmps , - ,Cmps)	0	0	0	0
Cazuela bowls	0	0	6	12
N(P1 , - ,Pl)	0	0	6	1
N(In , - ,Pl)	0	0	0	11
Quartz tempered vessels	67	58	34	21
Large jars	44	34	23	3
N(P1 ,Pl ,Pl)	0	3	6	0
N(P1 ,Ch ,Ch)	14	5	3	0
N(Cm ,Cm ,Cm)	30	21	0	0
N(Ch ,Ch ,Ch)	0	0	9	4
N(Cmps ,Cmps ,Cmps)	0	0	0	4
Small jars	23	24	11	13
N(P1 ,Pl ,Pl)	0	3	0	0
N(P1 ,Ch ,Ch)	0	2	4	0
N(Cm ,Cm ,Cm)	23	19	0	0
N(Ch ,Ch ,Ch)	0	0	7	7
N(Cmps ,Cmps ,Cmps)	0	0	0	6

Total

	Group 1	Group 2	Group 3	Group 4
Mean sample fraction	.1935	.2214	.2478	.2337
Shell tempered vessels	626	1186	1846	2373
Large jars	47	35	130	230
N(P1 ,Pl ,Pl)	3	37	60	86
N(P1 ,Pl ,Cm)	10	7	0	0
N(P1 ,Pl ,Ch)	0	0	33	0
N(P1 ,Cm ,Cm)	13	10	0	0
N(P1 ,Ch ,Ch)	5	10	33	0
N(P1 ,Cmps ,Cmps)	0	0	22	24
N(Cm ,Cm ,Cm)	16	21	0	0
N(Ch ,Ch ,Ch)	0	0	32	11
N(Cmps ,Cmps ,Cmps)	0	0	0	109
Small jars	270	526	726	835
N(P1 ,Pl ,Pl)	31	151	215	269
N(P1 ,Pl ,Cm)	25	57	0	0
N(P1 ,Pl ,Ch)	0	0	80	0
N(P1 ,Cm ,Cm)	51	58	0	0
N(P1 ,Ch ,Ch)	0	0	73	0
N(P1 ,Cmps ,Cmps)	0	0	0	165
N(Cm ,Cm ,Cm)	163	260	0	0
N(Ch ,Ch ,Ch)	0	0	353	79
N(Cmps ,Cmps ,Cmps)	0	0	0	322
Hemispherical bowls	309	575	758	949
N(P1 , - ,Pl)	167	575	758	854
N(Cm , - ,Cm)	142	0	0	0
N(Cmps , - ,Cmps)	0	0	0	95
Cazuela bowls	0	0	182	359
N(P1 , - ,Pl)	0	0	162	36
N(In , - ,Pl)	0	0	20	323
Quartz tempered vessels	2373	1815	1149	629
Large jars	1411	1103	551	262
N(P1 ,Pl ,Pl)	0	279	133	0
N(P1 ,Ch ,Ch)	353	251	137	0
N(Cm ,Cm ,Cm)	1053	578	0	0
N(Ch ,Ch ,Ch)	0	0	231	93
N(Cmps ,Cmps ,Cmps)	0	0	0	164
Small jars	962	707	593	367
N(P1 ,Pl ,Pl)	0	70	58	0
N(P1 ,Ch ,Ch)	0	63	230	0
N(Cm ,Cm ,Cm)	962	569	0	0
N(Ch ,Ch ,Ch)	0	0	310	154
N(Cmps ,Cmps ,Cmps)	0	0	0	213

APPENDIX C

TABULATION OF NINE SHERD MOTIF TYPES

Group	Assemblage	Shell				Quartz				Total		
		Pl	Cm	Cn	Cmps	In	*	Pl	Cm		Ch	Cmps
1	1	0	0	0	0	0		186	9765	1974	0	11925
1	2	327	393	44	0	0		155	6633	1201	0	9303
1	3	173	137	0	0	0		135	3333	1136	0	9919
1	4	69	203	0	0	0		323	3794	2569	0	11963
1	5	50	163	0	0	0		125	6361	1524	0	8728
1	6	202	163	0	0	0		291	10689	2131	0	13476
1	7	18	117	0	0	0		392	6138	2967	0	9632
1	8	171	962	20	0	0		341	5928	3301	0	10723
1	9	31	618	0	0	0		304	11741	2860	0	15554
1	10	374	330	0	0	0		99	5282	934	0	7519
1	11	126	380	0	0	0		235	4830	2510	0	8131
1	12	116	939	73	0	0		202	5189	2035	0	8609
1	13	67	238	0	0	0		274	6777	2039	0	9445
1	14	53	218	0	0	0		151	6339	1767	0	9028
1	15	319	453	0	0	0		282	5631	2331	0	9066
1	16	110	163	0	0	0		374	9340	2531	0	13023
1	17	143	662	0	0	0		229	6273	1724	0	9031
1	18	280	302	0	0	0		272	7248	2382	0	10484
1	19	94	187	129	0	0		153	6476	1270	0	8309
1	20	276	205	0	0	0		254	6303	2031	0	3574
1	21	205	417	87	0	0		201	6301	1933	0	9194
1	22	184	287	0	0	0		216	6419	1663	0	8769
1	23	81	243	0	0	0		335	3953	2450	0	12065
1	24	110	275	0	0	0		75	5322	974	0	7256
1	25	0	0	0	0	0		364	10623	2919	0	13906
1	26	103	211	0	0	0		260	6191	2203	0	8973
1	27	133	940	0	0	0		219	3674	1904	0	11370
1	28	40	151	0	0	0		212	7237	2129	0	9769
1	29	0	9	0	0	0		153	8349	1532	0	10043
1	30	136	386	0	0	0		177	6529	1494	0	8722
Total		4504	10267	353	0	0		6939	221323	60573	0	304014

Group	Assemblage	Pl	Cm	Shell Ch	Cmps	In	*	Pl	Quartz Cm	Ch	Cmps	Total
2	1	890	74	342	0	0		4138	8005	2910	0	16359
2	2	1016	459	305	0	0		1635	2589	317	0	6821
2	3	428	127	0	0	0		2301	5349	2224	0	10429
2	4	652	284	0	0	0		2005	2617	1286	0	6844
2	5	407	110	0	0	0		2471	7914	2347	0	13249
2	6	913	302	92	0	0		1026	5526	2116	0	9975
2	7	625	314	0	0	0		1373	4088	1320	0	7720
2	8	438	104	0	0	0		2852	5595	2874	0	11863
2	9	787	123	33	0	0		2931	2796	2307	0	9042
2	10	612	823	0	0	0		1834	3304	1697	0	8270
2	11	1245	773	0	0	0		1261	4782	378	0	8439
2	12	224	109	0	0	0		1625	3106	2405	0	7469
2	13	474	166	0	0	0		3248	4425	755	0	3068
2	14	752	209	0	0	0		3223	5221	2771	0	12176
2	15	953	833	183	0	0		1449	3153	1875	0	8452
2	16	781	393	0	0	0		1091	3027	1122	0	6419
2	17	563	284	0	0	0		1548	4515	2628	0	9538
2	18	1129	375	130	0	0		1037	3953	1415	0	8544
2	19	703	275	0	0	0		712	3017	1201	0	5913
2	20	638	546	0	0	0		2261	7220	1130	0	11795
2	21	1179	133	0	0	0		883	5655	710	0	8565
2	22	954	414	89	0	0		1481	4914	1523	0	9375
2	23	372	1130	0	0	0		2036	5186	1053	0	9777
2	24	2217	677	0	0	0		1960	3759	2111	0	10624
2	25	631	1066	402	0	0		4402	3444	1908	0	11853
2	26	395	289	0	0	0		3678	6729	2136	0	13227
2	27	380	272	0	0	0		1656	5539	1560	0	9407
2	28	905	1167	17	0	0		1006	1653	1019	0	5767
2	29	311	167	0	0	0		3509	5517	3121	0	12625
2	30	445	171	0	0	0		1862	5753	1112	0	9343
Total		22024	12634	1659	0	0		62394	138356	51831	0	283948

Group	Assemblage	Pl	Qm	Shell Ch	Cmps	In	*	Pl	Qm	Ch	Cmps	Total
3	1	1066	0	1071	3	0		2770	0	5667	0	10577
3	2	1446	0	1032	50	0		1424	0	2541	0	6493
3	3	2228	0	1124	0	0		2039	0	3316	0	14257
3	4	985	0	458	41	0		269	0	4917	0	6670
3	5	1749	0	1101	442	0		3643	0	1970	0	8905
3	6	1023	0	1824	0	0		1488	0	2849	0	7184
3	7	741	0	1099	0	0		1936	0	5850	0	9626
3	8	2253	0	1125	5	0		934	0	1947	0	6319
3	9	377	0	859	460	0		1899	0	6059	0	10254
3	10	1709	0	508	5	0		117	0	3608	0	5947
3	11	683	0	179	0	0		1839	0	3682	0	6383
3	12	1221	0	1198	6	2		283	0	2043	0	4753
3	13	744	0	1054	0	0		1543	0	3861	0	7202
3	14	1641	0	753	173	0		2003	0	4047	0	8622
3	15	762	0	265	0	1		828	0	4662	0	6518
3	16	747	0	458	539	0		760	0	7691	0	10195
3	17	1353	0	1899	0	0		292	0	1937	0	5531
3	18	764	0	306	0	0		1090	0	3762	0	5922
3	19	333	0	1183	4	0		570	0	2703	0	5348
3	20	712	0	564	0	2		320	0	4255	0	5853
3	21	833	0	513	0	0		1925	0	4631	0	7902
3	22	838	0	1493	0	0		2565	0	2164	0	7065
3	23	2193	0	1736	0	0		2467	0	4765	0	11211
3	24	1228	0	1314	91	1		549	0	1403	0	4592
3	25	459	0	267	0	0		2172	0	3122	0	6020
3	26	2483	0	711	192	0		2531	0	2067	0	7939
3	27	902	0	1562	1	2		2407	0	4273	0	9147
3	28	860	0	125	0	4		32	0	1911	0	2932
3	29	852	0	339	0	4		122	0	2770	0	4087
3	30	781	0	1294	109	0		2613	0	5165	0	9962
	Total	35126	0	27474	2126	16		43530	0	115194	0	223466

Group	Assemblage	Pl	Cm	Shell Cn	Cmps	In	*	Pl	Quartz Cm	Cn	Cmps	Total
4	1	437	0	797	435	4		0	0	1531	1663	5017
4	2	1063	0	129	1157	9		0	0	1721	909	4933
4	3	2202	0	50	2537	38		0	0	1193	1905	7925
4	4	864	0	48	472	16		0	0	3062	1337	5799
4	5	787	0	9	1510	3		0	0	495	2041	4850
4	6	1370	0	18	2832	5		0	0	18	504	4747
4	7	1691	0	0	2824	15		0	0	1155	1593	7283
4	8	1371	0	54	797	12		0	0	2718	1579	6531
4	9	2362	0	3	3640	2		0	0	1003	3346	10361
4	10	2800	0	114	2610	3		0	0	785	2881	9193
4	11	760	0	76	2465	8		0	0	4031	1569	8959
4	12	4211	0	352	2700	3		0	0	0	0	7271
4	13	955	0	36	608	27		0	0	593	1633	3857
4	14	921	0	148	530	9		0	0	1753	3674	7085
4	15	1343	0	128	623	10		0	0	1263	944	4311
4	16	1142	0	10	526	10		0	0	14	827	2529
4	17	1481	0	19	356	12		0	0	1360	3133	6361
4	18	2672	0	276	1135	8		0	0	0	928	5019
4	19	1633	0	0	1535	13		0	0	1391	1890	6512
4	20	315	0	56	383	26		0	0	1779	4166	7225
4	21	2622	0	930	2023	24		0	0	301	2320	8220
4	22	3952	0	16	1523	9		0	0	757	3007	9264
4	23	1374	0	511	1737	20		0	0	1210	609	5511
4	24	849	0	38	710	15		0	0	218	2591	4421
4	25	1327	0	20	294	8		0	0	2569	3807	8025
4	26	1500	0	33	593	13		0	0	2933	2281	7213
4	27	1156	0	49	391	19		0	0	20	191	2426
4	28	1486	0	13	508	15		0	0	18	1382	3422
4	29	1077	0	91	373	23		0	0	2	783	2349
4	30	1021	0	1039	1260	11		0	0	2628	1590	7599
	Total	47349	0	5173	39642	400		0	0	36626	55088	184278

VITA

William Walter Baden was born in Cleveland, Ohio on December 26, 1952. He grew up in Sherwood, Ohio and attended Fairview High School where he graduated in May 1970. From September 1970 through June 1973 he attended Miami University, Oxford, Ohio where he received an Associate in Arts degree. In September 1975 he entered The University of Toledo, Toledo, Ohio. He received a Bachelor of Arts degree in Anthropology in August 1976. In September 1977 he began study towards a Master's degree at The University of Tennessee, Knoxville. This degree was awarded in March 1982. Between 1970 and 1979, when not enrolled as a student, he worked as a carpenter. From 1977 to 1981 he served as a research assistant to the Tellico Archaeological Project. He is currently a research associate with the Tellico Archaeological Survey Project at The University of Tennessee. The author is a member of the American Anthropological Association, Society for American Archaeology, American Statistical Association, and Society for Computer Simulation.

He is married to the former Marla M. Beal of Lynchburg, Virginia.