The structure of ceramic exchange at Tikal, Guatemala

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1 Introduction

The reconstruction of patterns of exchange among ancient communities is an important aspect of archaeological research. However, most studies have concentrated on long-distance exchange of rare or exotic items used primarily by restricted social classes. In part this has been due to a long-standing emphasis on establishing outward cultural ties, rather than concentrating on the internal socio-political and economic organization of ancient societies. This paucity of research is also due to the generally greater difficulty in identifying sources of the utilitarian items predominantly exchanged in these localized systems. Exotic items or finer tradewares often have unique methods of production, distinctive composition, or stylistic attributes which make them more readily identifiable. Thus recent advances in defining trade in utilitarian items have come primarily through application of refined techniques such as microscopic analysis of thin sections (Kidder and Shepard 1936; Rands 1967), spectrographic analysis, and neutron activation analysis (Perlman and Asaro 1971).

Despite these advances in the analysis of technological attributes of artefacts, there are still many cases when such techniques are unable to identify localized centres of production. There may be either too little or too much variability in the constituent materials or trace elements analysed. While one can sometimes turn to distinctive stylistic features for identification, these too are often lacking, especially in areas where there are a large number of centres producing stylistically similar items. In such cases the correlation of a series of micro-stylistic or technological features may lead to the sources of utilitarian items. Such an approach has been aided by the recent extensive use of multivariate statistical analysis aided by large high-speed computers.

This study concerns the production and distribution of two major classes of utilitarian pottery at the site of Tikal, Guatemala. The technique of non-metric multi-dimensional scaling is used to reveal the structure of these economic systems. The patterns uncovered in the analysis serve as tests of two recently proposed models of lowland Maya social and economic organization.

2 Lowland Maya ceramic production and exchange

It is generally assumed that most Classic period Lowland Maya pottery was produced by full- or part-time specialists. The homogeneity of ceramic traditions in the area, in spite of the great volume of pottery produced, tends to support this conclusion. Little archaeological evidence has been encountered which would resolve our questions concerning (1) the number of production centres within any archaeological zone, (2) the location and distribution of such centres in relationship to areas of dense settlement and (3) the degree of specialization within each production centre. Several possible ceramic production areas have been discovered at Tikal, Guatemala. One structure group at the eastern margins of dense settlement had a very high frequency of ceramics, including mould fragments (Becker 1973: 399). An unusual secondary deposit with an extremely high frequency of serving plates, vases and drum fragments of a distinctive paste type was encountered adjacent to a causeway in the northern Tikal earthworks (Puleston and Callender 1967). This deposit may have come from a nearby production centre which produced only serving wares and exotic items (Fry 1969).

While pottery production is unclear, the means of distribution are even more ambiguous. Adams (1971) has recently shown that certain specially decorated vessels may have been produced specifically for elite mortuary rituals. However, the great bulk of utilitarian ceramics could have been circulated through systems of local and regional markets, through clientage relationships, or some combination of the two. Previous studies have concentrated on models of exchange involving some form of market economy (Rands 1967; Fry 1969). Such a system of production and exchange can be inferred from contact period sources (Tozzer 1941; Roys 1943), and is still present in modern Yucatan (Thompson 1956).

Robert Rands has developed a research programme to investigate the economic and social organization of Maya communities through the analysis of utilitarian ceramic production and exchange (Rands 1967). Using ceramics from Palenque, Chiapas and the surrounding region, Rands has tested two different models of community-ceremonial centre relationships. His outward-looking model sees Maya communities as having social, economic and religious ties with a number of ceremonial centres, some quite distant. In contrast, his inward-looking model sees major ceremonial centres as a focal point of social, economic and ritual relationships for a number of surrounding communities. In both models, relationships would be intensified on certain market and festival days, when large numbers of people from these communities would come to ceremonial centres to take part in religious ceremonies, and exchange local items in the major market.

Rands' test of these models assumes that most utilitarian pottery was produced in a number of different centres, and channelled primarily through markets associated with religious festivals at major ceremonial centres.

> The principal marketplace, located at the ceremonial centre and attended most consistently by people having socio-political and ceremonial allegiance to that centre, would apparently funnel the pottery primarily to the various satellite communities within the sustaining arae. People from outside the district, who attended the market less frequently, would take home significantly smaller quantities of the pottery (Rands 1967: 147–8).

Given these assumptions, it follows from the outward-looking model that ceramic assemblages from neighbouring settlements near a major ceremonial centre would be highly variable. Each settlement would have an assemblage reflecting its unique set of ceremonial and economic ties. With the inward-looking model, one would expect ceramic assemblages from communities within the sustaining area of a major ceremonial centre to be quite similar, closely resembling assemblages from the centre itself. Such assemblages would be markedly different from those of communities outside the sustaining area. Rands' test of these models involved thin section analysis of samples of pottery from ten sites in the Palenque region. Distinctive paste characteristics differentiated assemblages within 10 km. of Palenque from those of more distant sites, which also differed among themselves. The data thus tended to support the inward-looking model.

3 Ceramic production and exchange at Tikal, Guatemala

In the present study we are concerned with further testing and refining models of ceramic exchange and settlement integration using data from the important lowland Maya site of Tikal, Guatemala. The basic problems with which we are concerned are:

(*a*) Does the inward-looking model apply to settlements in the densely populated Central Peten at the height of the Late Classic peak of complexity and population size?
(*b*) Does an observed decrease in mound density between 5–6 km. from the centre of Tikal in the Late Classic, mark a boundary of (1) political hegemony and (2) intense economic interaction?
(*c*) Do patterns of exchange vary between shape classes of pottery which differ in fragility and portability? If so, what significant information can be derived from these differences?
(*d*) Are patterns of similarity and dissimilarity between ceramic assemblages the same for technological and stylistic variables? If there are differences, what new hypothesis could explain them?

4 The ceramic collections from Tikal

The ceramic collections used in the analysis were derived from several excavation programmes in both peripheral and central zones of the site of Tikal, Guatemala (Coe 1965). The peripheral area collections were made under the auspices of the Tikal Sustaining Area Project (Haviland 1970). Most of the ceramics were excavated in a test-pitting programme covering two of the four strips of settlement mapped by the Project. These strip maps represent areas 500 m. wide by 10 km. long extending in the cardinal directions from the edge of the 16 km.^{2} central Tikal site map (fig. 31). The northern and southern strips were divided into geographical sampling universes. Within each universe one-third of the mound groups were test-pitted using a random sampling procedure. One metre and one-and-a-half metre square test pits were located in the areas

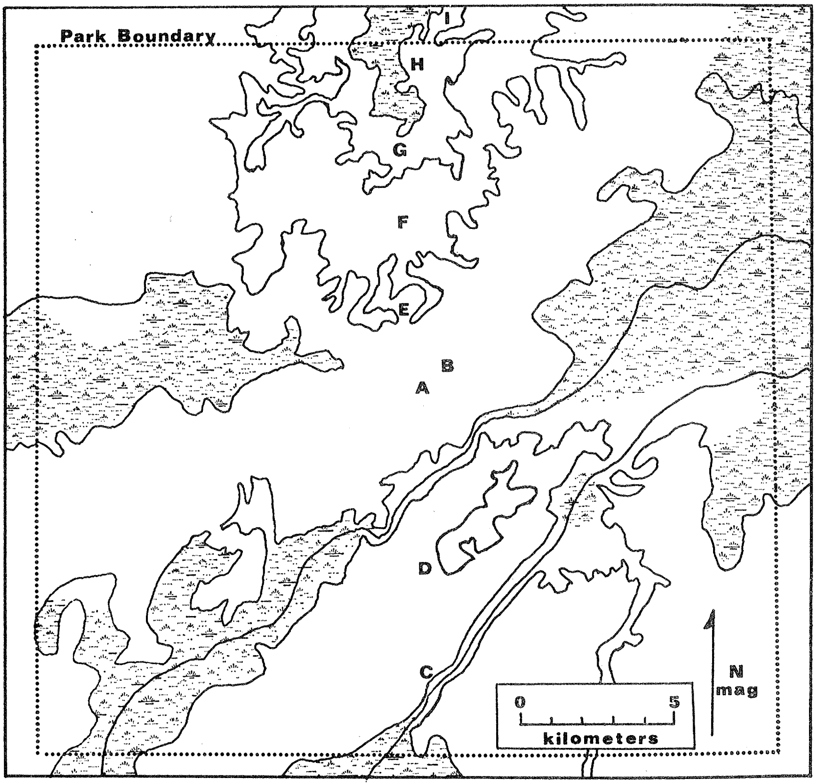

Figure 31 Map of Tikal area showing geographical areas sampled. A: Central Tikal; B: North Tikal; C: Navajuelal; D: Mid South Survey Strip; E: Near North Survey Strip; F: Mid North Survey Strip; G: Far North Survey Strip; H: Jimbal Area; I: Jimbal

deemed to be most productive of occupation debris. A total of ninety-seven mound groups were tested within these universes. Excavations at the small nucleated site of Navajuelal, 9½ km. south of Tikal's Great Plaza, produced additional ceramics used in the analysis (Green 1970; 1972). A small amount of material from minor excavation and surface collection at the site of Jimbal completed our peripheral area sample. Jimbal is a moderate sized site with several stelae and larger temple construction some 14 km. north of the Great Plaza (Coe 1965: 51).

Collections from central Tikal used in this study come entirely from the north-east quadrant of the mapped 16 km.² area. One large assemblage derives from excavations in the East Plaza area, including areas close to a unique structure tentatively identified as a market place (Coe 1965: 52). The remainder of the north-east quadrant collections were produced by excavations of the Tikal Small Structure Programme (Haviland 1963; 1965). This programme intensively explored a wide range of structure types in an area running north-east from the East Plaza to near the edges of the Tikal 16 km.² site map. Structures were not chosen by a random sampling technique. However, excavation at these mound groups was more extensive than in the peripheral areas, with the exception of Navajuelal. The collections do not represent a total sample, as only selected rim sherds were available for analysis.

Only rim or diagnostic body sherds representing single vessels were selected for analysis. In this way we sought to eliminate the biasing of our sample in favour of larger or more fragile vessels. A total of 2,493 sherds were coded for 28 technological, stylistic, and functional variables. It is assumed that ceramics recovered from a sampling universe were principally used within that geographical area. While this seems highly probable for material from undisturbed occupation debris, there may be some question of its accuracy for ceramics from construction fills and other secondary contexts. For the purposes of this programme, it is assumed that most fill deposits were not transported more than a few kilometres from their original context. This reduces the amount of extraneous variance caused by such secondary deposition. Excavation in structural fills in the peripheral zones at Tikal indicates a scarcity of cultural debris when compared to central Tikal. Thus the problem of redeposition is more serious for central rather than peripheral Tikal.

5 The multi-dimensional scaling analysis

In order to test the proposed models of site organization we had to choose a method of data analysis which could assess and graphically represent patterns of similarity among assemblages using a large number of variables. The technique of multi-dimensional scaling attracted us, since its main functions are

> . . . getting hold of whatever pattern or structure may otherwise lie hidden in a matrix of empirical data and . . . of representing that structure in a form that is much more accessible to the human eye – namely as a geometric model or picture. The objects under study . . . are represented by points in the spatial model in such a way that the significant features of the data about these objects are revealed in the geometrical relations among the points (Shepard 1972: 1).

Multi-dimensional scaling techniques have been used previously by archaeologists, primarily for extracting chronological information from grave lots or from Palaeolithic assemblages (Doran and Hodson 1966; Kendall 1971; see also Kruskal 1971 for an extended discussion on multi-dimensional scaling analysis and its applications in archaeology). Multi-dimensional scaling starts from a matrix of proximities or distances between the units of concern (in our case, pottery assemblages). We describe first what these assemblages represent, and then how they have been quantified for treatment by multi-dimensional scaling.

Since the total numbers of rim sherds from the excavation units were quite variable, with few units producing over 100 rim sherds, we decided to pool data from individual excavations in each sampling universe. Thus the analyses were run on pooled data from nine geographical areas (table 3, see also fig. 31). The pooled data were in turn partitioned in order to control for temporal, functional and social variability. In this report we will be concerned only with ceramics of the Imix complex, A.D. 650–830 (Culbert 1963). Again, previous studies have indicated that frequencies of shape classes are

TABLE 3

Listing of geographical areas, with the number of basin and wide-mouth jar rim sherds used in the multi-dimensional scaling analyses

Geographical area	Code	Location	Basins	Wide-mouth jars
Central Tikal	A	Within 500 m. Main Plaza, Tikal	96	78
North Tikal	B	NE. quadrant Tikal map	104	126
Navajuelal	C	10½ km. South survey strip	111	54
Mid-south survey strip	D	3–6 km. South survey strip	15	25
Near north survey strip	E	2–4½ km. North survey strip	31	37
Mid-north survey strip	F	4½–6 km. North survey strip	36	38
Far north survey strip	G	6–9½ km. North survey strip	57	64
Jimbal area	H	11–12 km. North survey strip	25	35
Jimbal	I	2 km. NE. of North survey strip	6	—

affected by differing activities (Culbert 1973; Lischka 1968). Such frequencies are also affected by differences in social rank as inferred from variation in size and complexity of structure groups. To exclude such variation which might obscure significant patterning, we decided to concentrate on variation within single major shape categories. Given the differences in portability of utilitarian vessels, separate analyses should also allow us to discriminate between different manufacturing centres, and estimate the size of their distribution network. In this study we are concerned with the two most frequent utilitarian pottery categories, slipped basins and unslipped wide-mouth jars. Slipped basins are thought to have served as both cooking and storage vessels, while unslipped jars were probably used for storage of both solids and liquids (Thompson 1958).

The variables chosen to describe the pottery involved technological and stylistic attributes with both nominal and ordinal variables being represented in each category.

The final coding format consisted of eighteen variables (a–r) each divided into a suitable number of states or values:

(1) Technological variables
- a. Completeness of firing
- b. Differential firing
- c. Fire clouding
- d. Paste texture
- e. Temper frequency
- f. Type of inclusions
- g. Frequency of inclusions – manganese
- h. Frequency of inclusions – mica

(2) Stylistic variables
- i. Wall orientation
- j. Wall curvature
- k. Wall thickness
- l. Lip shape
- m. Lip orientation
- n. Lip thickness
- o. Basin decoration
- p. Basin decoration dimensions – depth
- q. Basin decoration dimensions – width
- r. Neck height – jars

Variables having low frequencies or inappropriate for a particular shape category were excluded from analyses.

The next step in the analysis involves the calculation of a measure of distance between the assemblages from each pair of geographical areas. A measure of distance *D* between two assemblages *x* and *y* was calculated:

$$D=\sqrt{\sum_{i=1}^{n}\left[\frac{(P_{xi}-P_{yi})^2}{(P_{xi}+P_{yi})}\right]}$$

where P_{xi} represents the relative frequency of the *i*th variable value for assemblage *x*, P_{yi} represents the relative frequency of the *i*th variable value for assemblage *y*, with *n* being the total number of variable values. Examples of frequency profiles involving technological variables for two assemblages are represented graphically in figs 32 and 33. The items on the horizontal axis represent the values defined for a restricted set of technological variables, while the scale on the vertical axis represents the relative frequency of that particular value of the variable for the assemblage in question. The distance measure *D* may be represented graphically as derived from the two previous figures (fig. 34). The distance formula was used to generate distance measures between all nine assemblages, and these were in turn put into matrix form for input into the multi-dimensional scaling program.

For our analysis we chose the recently developed KYST multi-dimensional scaling program (Kruskal, Young and Seery 1973). This powerful program includes many

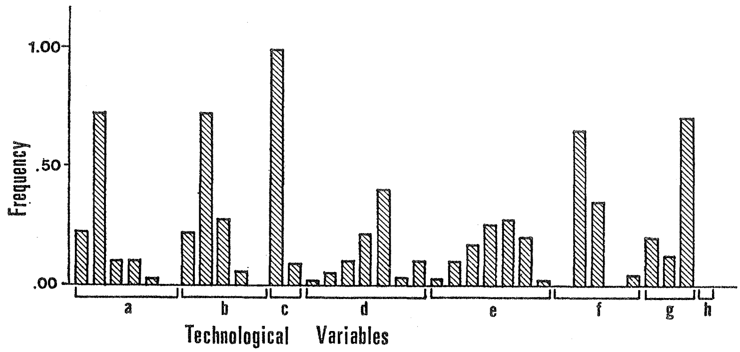

Figure 32 Portion of the frequency profile for technological variables of Imix complex wide-mouth jars from Central Tikal

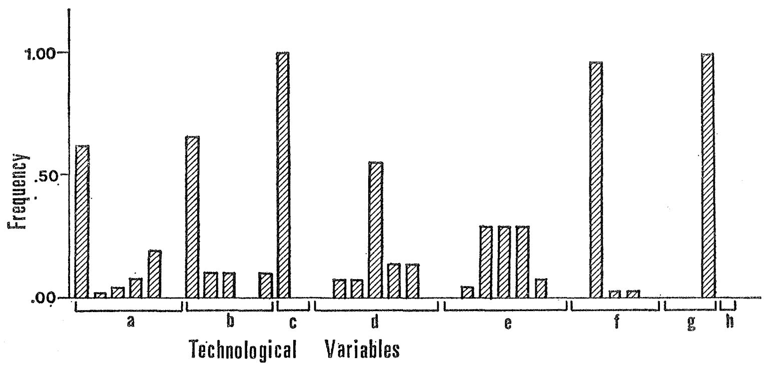

Figure 33 Portion of frequency profile for technological variables of Imix complex wide-mouth jars from Mid North Survey Strip

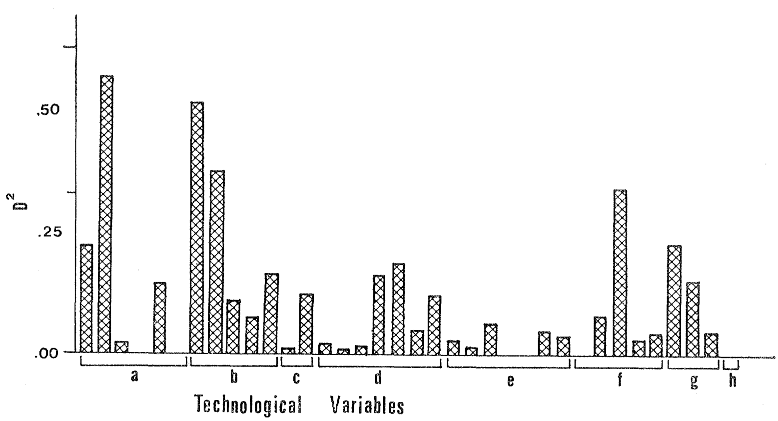

Figure 34 Portion of dissimilarity profile comparing technological variables of Imix complex wide-mouth jars from Central Tikal and the Mid North Survey Strip

options; e.g. a flexible method of generating the initial configuration. Since our hypotheses involved the correlation between assemblage dissimilarities and actual geographic distances, we decided to use a starting configuration based on actual geographic distances. The centroids of each geographical area were computed, and distances between all pairs of centroids calculated (fig. 31). The distances were then placed in matrix form and input into the program as the initial configuration (fig. 35) from which the first iteration

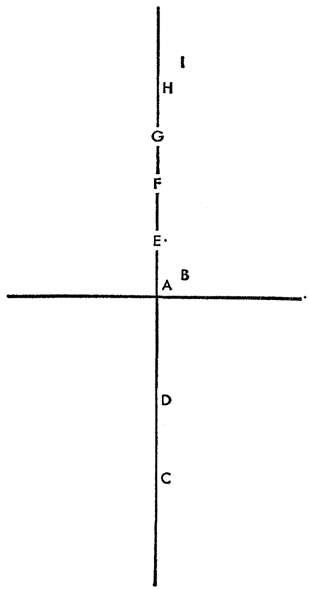

Figure 35 Multi-dimensional scaling solution representing map of centroids of each geographical area sampled. Stress 0·001. A: Central Tikal; B: North Tikal; C: Navajuelal; D: Mid South Survey Strip; E: Near North Survey Strip; F: Mid North Survey Strip; G: Far North Survey Strip; H: Jimbal area; I: Jimbal

derives. In this manner we could obtain the goodness of fit between assemblage dissimilarities and actual geographic distances by noting the stress before the first iteration. The location of Central Tikal (Point A) was fixed in all solutions. This can result in somewhat higher stress for the final configurations, but allows direct visual comparisons of configurations. Separate solutions were generated for technological and stylistic variables in order to reveal more thoroughly the differences between separate production centres. All of the solutions presented are in two dimensions.

6 Evaluation of the multi-dimensional scaling solutions

Having presented the stages of analysis we now examine the multi-dimensional scaling solutions to see which of the proposed models of social and economic interaction they support. If the outward-looking model is more appropriate we should expect either a quite random dispersion of assemblages, or one in which non-adjacent assemblages should show greater similarity than would be expected. There would be no clustering of assemblages indicating a distinctive area that we might label 'greater Tikal'. If the inward-looking model is correct, we would expect to see a high degree of similarity among assemblages clustering around central Tikal, and distinctive assemblages for more remote settlement areas. One alternative, given the correctness of the inward-looking model, would be the localized clustering of neighbouring assemblages indicating market regionalism within the sustaining area, with only the most remote settlements being very distinctive. We first present results of the analysis of Imix complex basins, discussing the differences between solutions using technological and stylistic variables within each phase. Finally we present the solutions for technological and stylistic variables of wide-mouth jars.

Basins are generally medium to medium-large vessels, usually well fired and of moderate thickness. Thus they are fairly portable and could have been quite widely exchanged. Since our two most distant assemblages are only 24 km. apart, it is quite possible that individual production centres could have circulated basins throughout our total sampled area. Thus a test of the proposed models considers patterning of relationships among assemblages, rather than concentrating on inter-assemblage distances. There seems to have been little correlation between assemblage dissimilarities and actual geographical distances. This is implied by high stress scores before the first iteration when using the centroids of the geographical areas as the starting configuration. This stress was 0·404 for the analysis using technological variables. Stress was even higher in the analyses using stylistic variables, at 0·444 when scaling all assemblages, and 0·415 when scaling all but the Jimbal assemblage.

Turning to the two-dimensional configuration based on technological attributes of Imix complex basins (fig. 36) we do see a regularity of pattern, though without a marked clustering of points. There are basically two groups of assemblages, a north survey strip cluster on the right and a looser central Tikal and south survey strip group. The latter grouping consists of a fairly tight central Tikal cluster (Points A and B) then a more distant mid-south survey strip and a distinct Navajuelal. Stress was a quite acceptable 0·046. The patterning displayed would tend to support the inward-looking model, as geographically proximate assemblages tend to be adjacent in the solution as well. The lack of tight clustering can be explained as due to widespread interchange of basins among the geographical areas sampled. However, it must also be considered that pottery was similar through the use of similar raw materials. To help determine which of these alternatives is more likely we must turn to the final configuration for the same class of pottery based on stylistic variables (fig. 37).

Extreme clustering is immediately apparent in considering stylistic variability for the same shape class. There are only two clusters, Jimbal (Point I) and all other assemblages (Points A to G are all packed in the area around Point E). Stress was a quite remarkable 0·002. This marked distinctiveness of the Jimbal assemblage may well indicate that Jimbal was outside the major economic sphere around Tikal at its Late Classic height.

Whenever one set of data is very different from all other sets in a multi-dimensional scaling analysis, there is a tendency for compaction of those other sets in the solutions, making interpretation of variation among the sets more difficult. Thus, in order to

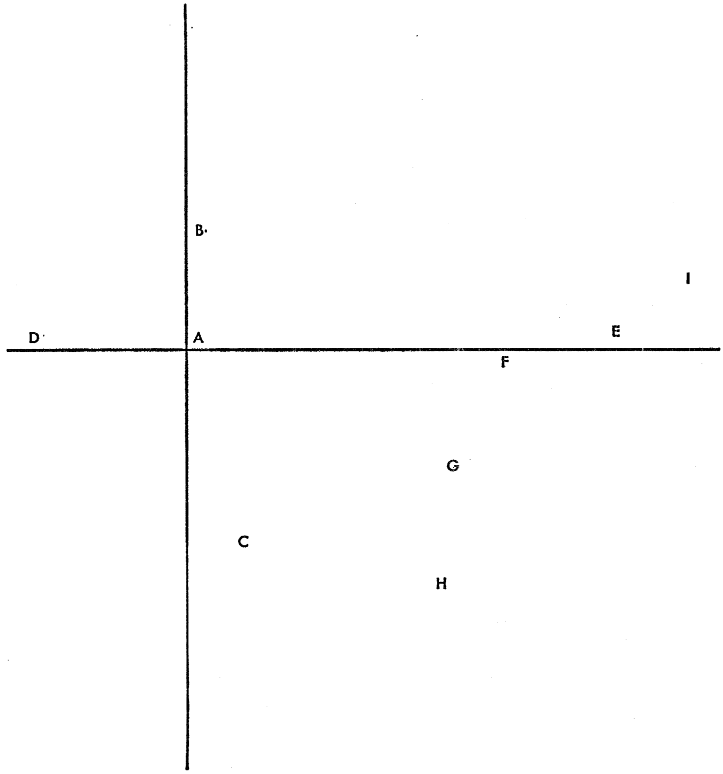

Figure 36 Two-dimensional configuration of Tikal assemblages based on technological attributes of Imix complex basins. Stress 0·046. For key, see fig. 35

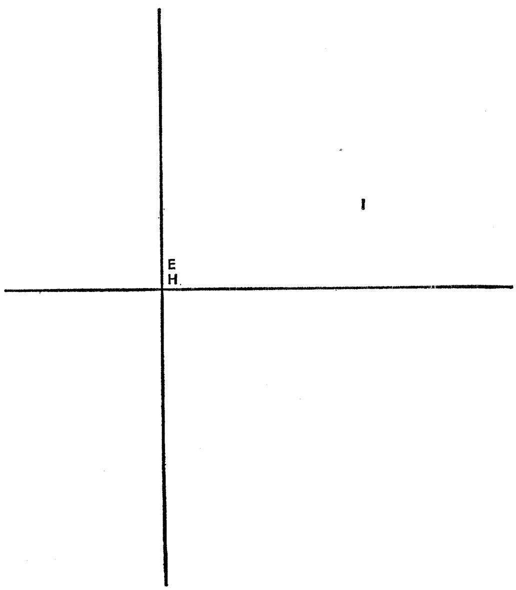

Figure 37 Two-dimensional configuration of Tikal assemblages based on stylistic attributes of Imix complex basins, Jimbal assemblage included. Points A–D, F, G are located in same area as Point E. Stress 0·002

examine more thoroughly stylistic variability among assemblages closer to Tikal, another multi-dimensional scaling solution was sought eliminating the Jimbal assemblage (fig. 38). Patterning here is not as clear cut as in the previous solution, with stress

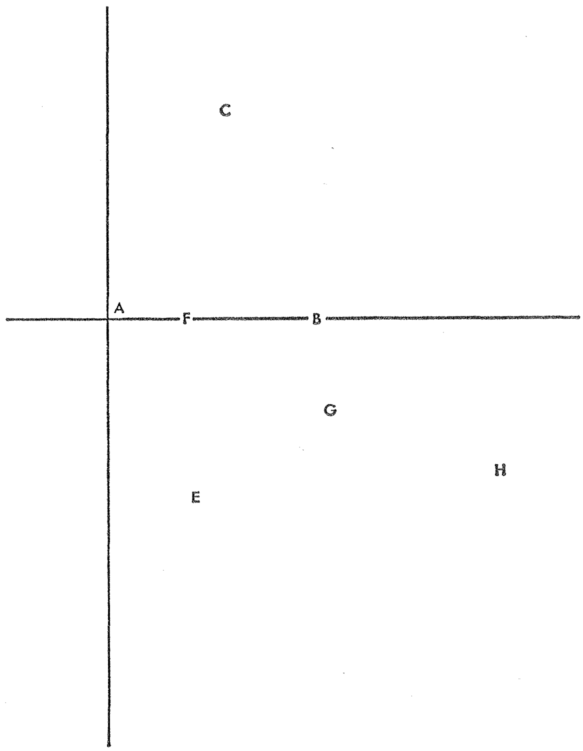

Figure 38 Two-dimensional configuration of Tikal assemblages based on stylistic attributes of Imix complete basins, Jimbal assemblage excluded. Stress 0·115

noticeably higher at 0·115. There is a tendency for the central Tikal and nearer north survey strip assemblages to cluster, with south survey strip and far north survey strip assemblages somewhat more distant and distinct. Most interesting are the strong similarities between central Tikal, and the mid-north survey strip, and north Tikal and the far north survey strip. The north survey strip area has previously been noted as a possible residential district for a rural elite (Fry 1969), since there are many large structure groupings in these areas, some of which include 'palace' type buildings. As a possible upper-class residential zone, this area might have had stronger economic ties with central Tikal.

The multi-dimensional scaling solutions for wide-mouth jars provide some striking contrasts when compared with the configurations for basins. Unslipped wide-mouth jars are larger, heavier and more poorly fired than slipped basins. Consequently, this class of utilitarian vessel was less likely to be exchanged widely. Thus in analysing the multi-dimensional configurations for this vessel class, we should expect to find greater distances among assemblage clusters. Since only a few wide-mouth jars were encountered in the assemblages from Jimbal, the data from that assemblage were not included in the analysis. The lack of correlation between geographical distances and assemblage dissimilarities noted in our analyses of basins was also characteristic of the wide-mouth jar category. Stress before the first iteration was 0·430 for technological variables, and 0·437 for stylistic variables. When considering technological attributes (fig. 39), the assemblages form four clusters: central Tikal, mid-south survey strip,

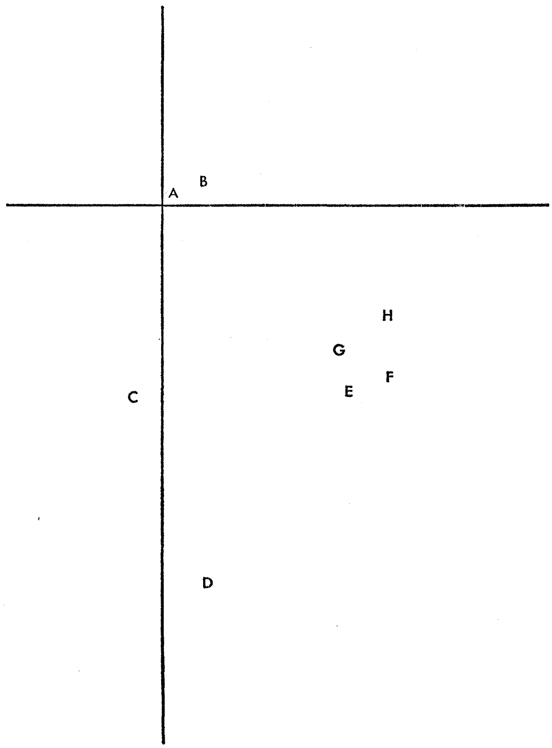

Figure 39 Two-dimensional configuration of Tikal assemblages based on technological attributes of Imix complex wide-mouth jars. Jimbal assemblage excluded. Stress 0·078

Navajuelal, and north survey strip. This pattern might indicate the presence of four distinctive technological traditions within the greater Tikal area, perhaps reflecting specialized production centres. The distances among the clusters would then indicate the same number of more isolated community sub-segments or sub-communities. However, we again must be cautious in our interpretation of similarities based only on technological attributes.

A somewhat different pattern emerges when we examine the final configuration for assemblages based on stylistic attributes (fig. 40). Again there are four distinct clusters. However, the membership in these clusters has shifted. The largest grouping includes central Tikal and mid-south survey strip assemblages, plus the far north brecha. The nearer north survey strip assemblages cluster at some distances, with Navajuelal and the Jimbal area assemblages in relative isolation. Stress was quite high at 0·173. The shifting of assemblage clusterings when contrasting technological and stylistic attributes, taken in consideration with the transport problems with these large vessels, indicates

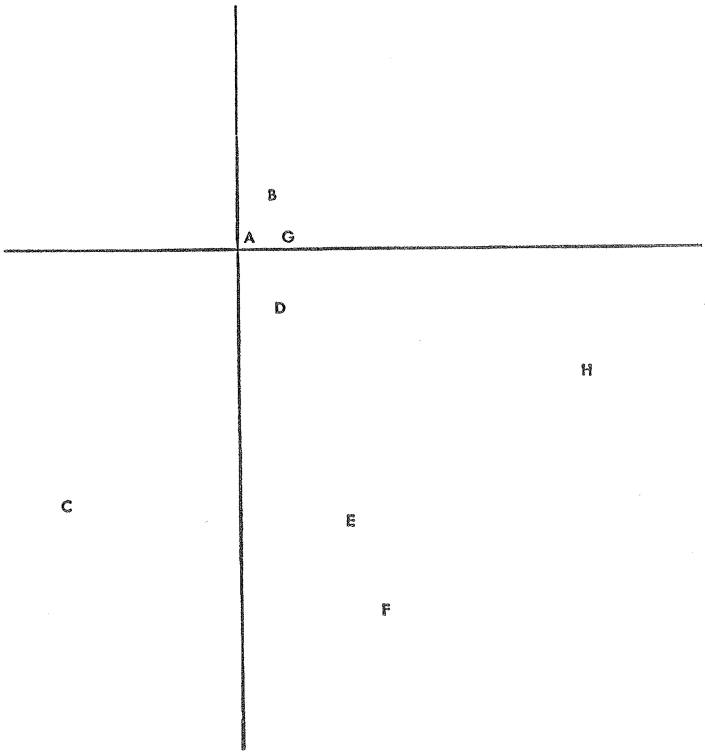

Figure 40 Two-dimensional configuration of Tikal assemblages based on stylistic attributes of Imix complex wide-mouth jars. Jimbal assemblage excluded. Stress 0·173

that distribution spheres of such ceramics were quite small, and production thus highly localized. Stylistic similarity would thus indicate a higher degree of social interaction between pottery producers, and/or shared norms among the consumers. Thus the analysis of wide-mouth jars of the Imix complex indicates four regions of more intense interaction: one concentrating in central Tikal, and as far south as the mid-south survey strip, Navajuelal, nearer north survey strip, and the Jimbal area. The major anomaly we must explain is the inclusion of the far north survey strip in the central Tikal cluster. Wide-mouth jars may have been produced locally by individuals in a clientage relationship with the local elite residents, who moved with the elite from central to peripheral dwellings, and thus may have learned pottery norms in central Tikal. Another alternative model would see elite preferences shaping local stylistic norms, these preferences being learned in central Tikal. With the present data there is no way of deciding among these or other alternative hypotheses.

Conclusions

The multi-dimensional scaling analyses of selected shape classes have tended to confirm the inward-looking model of community organization. However, separate analyses of major shape categories indicate that further refinements of the model are in order. It has become obvious that differing classes of pottery were involved in distinct systems of production and exchange. Therefore, the lumping of major shape categories for analysis may obscure much important interclass variation. The analyses also confirmed the usefulness of analysing separately stylistic and technological variables. The partitioning of the data in this way maximizes our recovery of significant variation, providing new ways of reconstructing economic systems.

Our data indicate a greater Tikal economic sphere with a north–south spread of at least 22 km. for the Late Classic. This area includes many palace-type constructions and small nucleated sites, but no major independent sites. This area is greater than approximately 123 $km.^2$ (Haviland 1970: 190) of dense settlement around the site centre of Tikal. The larger area may thus comprise the sustaining area for Tikal. Within this sustaining area, there seems to be a number of smaller units of more intense economic interaction. These may represent suburbs, sub-communities, or some other type of more coherent community organization. However, social class patterns relating to the internal organization of greater Tikal or some larger socio-political unit can cross-cut these community patterns.

The above reconstruction of community economy is based on the analysis of production and distribution of utilitarian pottery. Such pottery was produced at specialized centres and distributed through markets, and possibly also through special clientage relationships. Other categories of artefacts as well as the analysis of architectural features can also provide data with which to test the proposed models. The technique of multidimensional scaling, which provides a powerful but visually comprehensible way of examining the patterning of variability among assemblages, can be used with these classes of data as well. Analyses of this type supplement and add important dimensions to studies of trade and marketing based on technological analysis. Used together these techniques can help us reconstruct in greater detail the economic and social activities of ancient communities.

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Abstract

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The structure of ceramic exchange at Tikal, Guatemala

Two models of Lowland Maya socio-economic organization are tested using ceramic data from Tikal, Guatemala. Patterns of similarity between assemblages derived from the models are compared with actual patterns of resemblance revealed through a multi-dimensional scaling analysis of selected shape classes. The data tend to support the 'inward-looking' model of site organization, while also indicating possible boundaries of the Late Classic sustaining area around Tikal. Separate analyses of technological and stylistic attributes provide interesting differences in patterns of similarity emphasizing the value of studying different aspects of the same material.