7 CERAMIC STANDARDIZATION AND THE DOMESTIC ECONOMY OF THE ANCIENT MAYA: BELIZE RED TRIPOD PLATES AT CARACOL, BELIZE

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Understanding the degree of self-sufficiency in ancient households is essential to understanding the domestic economy of the Maya Late Classic Period (550-900 C.E.). Traditional models of Maya households view each family unit as largely self-sufficient. In contrast, many current models view Maya households as producers and consumers within integrated market and trade systems. Analyzing the degree of standardization among some artifact forms can provide a proxy measurement of production methodology and self-sufficiency. Irregularities in an artifact class indicate independent production, whereas standardization of an artifact indicates workshop production. If households produced their own ceramics, then vessel form should be variable between household groups. If workshops produced ceramics for widespread distribution, then vessel form should be standardized among household groups. Belize Red, a Late Classic ceramic type, is found at archaeological sites throughout central and western Belize, as well as in the southeast Peten of Guatemala. This study analyzes a sample of 39 Belize Red tripod plates from the site of Caracol, Belize that have been recovered from 29 different household groups to view the degree of standardization in their production. These data are then used to provide an insight into the domestic economy, commerce, and industry of the ancient Maya.

Introduction

Ceramic types are widely used as a short-hand to place pottery into typological bins and compare variation over time and space. The distribution of pottery vessels directly relates to their dimensions, production, and uses. While Belize Red ceramics were traded widely, alternative models suggest that they could have been produced at an individual scale for household use or created in a unified style by full time specialists. These two alternatives are explored by looking at the standardization among vessels. While a high degree of standardization often implies full time specialization over household production, standardization can also be related to markets and trade, which can create a standard mental template for how these vessels should appear, regardless of their production contexts. This pilot study looks at the standardization in Belize Red tripod plates from the site of Caracol, Belize in order to gain insight into the domestic economy of the site.

The main debates in ceramics research revolve around the differences between emic and etic ideas of analysis. On the one hand, Spaulding (1953) argued that statistical analyses could identify types that were significant to ancient potters. On the other, Ford (1954) held that types were nothing more than analytic constructs of the investigator and that the mind of the potter was unknowable. The type-variety-mode analysis by James Gifford (1960, 1976) utilizes phenomenology to study the surface features of pots to categorize vessels in the manner of their users (Gifford 1960:346; 1974:89). Gifford utilized neither petrography nor chemical analyses, despite Anna Shepard having previously demonstrating their importance for ceramic analysis (Shepard 1954). Even so, type-variety-mode has formed the foundation for modern ceramic typologies and analyses in the Maya area (to the chagrin of Adams 2008 and Rice 2013).

While the Belize Red tripod plate vessels used in this analysis have already been the subject of preliminary research centered on standardization (Chase et al. 2005), the current analysis increases the sample size and utilizes additional statistical techniques. New vessels recovered between the 2005 and 2012 Caracol Archaeological Project field seasons augment the original sample. Ron Bishop also undertook neutron activation analysis for chemical composition of paste from some Caracol vessels; these data have not been previously analyzed or published, but are incorporated into this analysis. Thus, this paper investigates the degree of standardization found within Belize Red tripod plates for the site of Caracol, Belize based on statistical and chemical data.

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History of the Belize Red Ceramic Type

The Belize Red Ceramic Type was defined by James Gifford (1976: 255-257) in the two decades following the 1953-56 excavation of Barton Ramie, Belize (Willey et al. 1965). Unfortunately, Gifford passed away in 1973 before he could finish his analysis. Various archaeologists worked together to finish the type-variety-mode analysis in his signature style. The results, plus Gifford's Ph.D. dissertation, were published as a single volume under his name in 1976, and this analysis created the foundation for all formal ceramic identification and typology in the Classic Maya area to this day.

Gifford (1960:346; 1976:5-20) was the first ceramicist to look at individual agency in pottery in the Maya area. While modern techniques of ceramic analysis employ petrography and chemical analysis, the ancient potters would have viewed their vessels based on the physical properties they could perceive rather than on microscopic properties (e.g., Dittert and Plog 1980; Trimble 2007). Instead of relying on these geological and chemical techniques, Gifford used visual identifications and measurements that could be made and perceived with the naked eye, including surface features, sizes, shapes, and macroscopic views of paste.

The specific identifying attributes for Belize Red: Belize Variety were "red-slipped dishes (predominantly) and bowls of medium wall thickness and thinner-walled jars with diagnostic ash paste. The type is easily recognized by the very gritty feel of weathered surfaces and the light buff, fine-textured paste. Surfaces are nearly always characteristically weathered, but on the few preserved sherds the red slip has a slight luster although not glossy" (Gifford 1976:255). The broader type was based on the red paste, which had evidence of either limestone or volcanic tempering (Gifford 1976:255-257). Like the Caracol sample, many of the recovered whole Belize Red vessels from Barton Ramie came from burials.

Over thirty percent of all the Late Classic ceramics from Barton Ramie fell into the Belize Red type and, as a result, Gifford asserted that Barton Ramie manufactured this type locally (Gifford 1976:255). Subsequent excavation at other sites has shown that Belize Red is not only a very common type in the Belize Valley, but that it also has been found as far away as Honduras (Sheptak 1987). The Maya traded Belize Red over a wide spatial area and utilized it for over 200 years (Chase 1994; Chase and Chase 2012).

Figure 1. Examples of Belize Red tripod plates recovered from excavations at Caracol, Belize.

Caracol

The analysis presented here is based on a sample of Belize Red tripod plates (Figure 1) from the site of Caracol, Belize. Caracol was founded by 600 B.C. and abandoned shortly after A.D. 900; in A.D. 650 it had a population of over 100,000 people (Chase and Chase 1994:5). This site exists along an east-west trade route that goes through the Maya Mountains (Chase and Chase 2012). Because Belize Red was known to be traded, the vessels at Caracol could have been produced elsewhere and traded into the site.

Caracol also has an interesting pattern of artifact distribution. The Late Classic elites at Caracol employed a management method that has been termed as "symbolic egalitarianism," meaning that an average individual and an elite member of society both had access to the same set of goods, but the elite individual might have had more of them (Chase and Chase 2009). It has also been suggested that marketplaces existed at Caracol where items such as pottery were distributed to the populace (Chase and Chase 2014). Thus, the point of this paper is to see whether Belize Red was distributed through these markets or through a different production system.

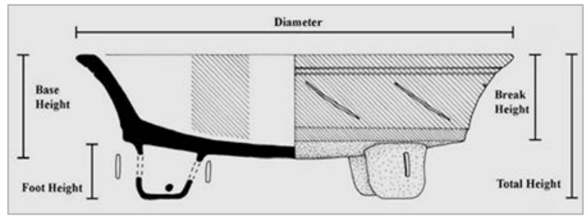

Figure 2. Diagram from showing the measurements used and how they were taken off of the tripod plates (Chase et al. 2005: Figure 2). All measurements were taken off of drawings of vessels.

Methodology: Data

The Belize Red vessels used in this pilot study were recovered from 29 different residential groups at the site of Caracol, Belize, and the chemical data was sampled and processed almost 20 years ago by Ron Bishop. The ceramic vessel measurements were obtained from 1:4 scale scanned drawings of whole vessels found at the site, although the initial analysis (Chase et al. 2005) used 1:1 scale drawings. Measurements for all whole Belize Red tripod plate vessels found *in situ* in interments and on building floors were taken, with the caveat that whole vessels include those that were lacking their feet. The different measurements undertaken are illustrated in Figure 2.

Three sets of data are utilized for this analysis. The first set of data consists of 39 Belize Red vessels of various forms and is utilized only for the chemical analysis. This dataset includes 11 tripod plates and has 34 other Belize Red vessels included to show how close the chemical signature of this subtype is in comparison to the entire assemblage of Belize Red at the site. The second set contains 39 Belize Red tripod plate vessels and includes 'whole' vessels with and without feet that double the size of the initial dataset (Chase et al. 2005:7). This dataset was used for general analysis such as scree plots and includes the sample of Belize Red tripod plates, which lacked feet but still had their chemical signature analyzed. The final data set contains 26 Belize Red tripod plate vessels. This dataset contains only whole vessels with feet. This third set was characterized by k-means clustering, the data for the box-n-whisker plot, and the data for calculations for the coefficient of variation. Together, these statistical datasets allow for an adequate pilot study to investigate variation in Belize Red tripod plates at Caracol.

Methodology: Statistics

All statistics were analyzed with the R programming language[i] (R Development Core Team 2013) using the RStudio IDE (interactive development environment)[ii] (RStudio Inc. 2013)[iii]. The language and software are both open source and easily available on Windows, Apple, and Linux based systems. The following statistics, graphs, and calculations were employed during this analysis: principal components analysis, stem and leaf plots, scree plots, Pearson's R, box and whisker plots, coefficients of variation, and k-means clustering.

The most complicated statistical method employed, and the only multivariate statistical method used in this analysis, was principal components analysis (PCA). A detailed summary of this analysis can be found in Shennan (1997:269-300). The goal of PCA is to reduce the complexity of the dataset by reducing the number of variables to the subset of variables that contribute the most to the differences in the dataset[iv].

Stem and leaf plots (Shennan 1997:27-29) are useful for doing exploratory data analysis. This type of plot is very easy to create by hand[v]. The resulting plot shows a distribution of the data which helps visualize the modes in the dataset.

A scree plot, or scattergram, of each variable against every other variable (Shennan 1997:127-150), was used in data exploration. This analysis can show strongly correlated variables to the naked eye, but it also goes hand in hand with Pearson's R, a calculation of the correlation of any two variables. Pearson's R ranges in value from 0 to 1. A high Person's R (near 1) shows a strong correlation. This means that an equation can be written to calculate one variable based on the other with a high degree of effectiveness. If there was a standard ratio or equation in the form of $y = ax + b$ for Belize Red tripod plates, than the result would be a very strong Pearson's R.

Box and whisker plots (Shennan 1997:45-46) are very useful for visually showing the mean and variation within a dataset[vi]. This type of graph works well with the calculation of coefficients of variation (CVs), the standard deviation divided by the mean. It represents the amount of variation in a dataset as a unitless number (Shennan 1997:44). The calculated values range from 0 to 1 with values closer to zero representing low variation within a dataset. In terms of analyzing ceramic data for standardization, values near zero show a strong degree of standardization. A high CV would imply that this ceramic type is not highly standardized, or it could imply that there are multiple sub-types included within this ceramic type.

In order to tease out the last possibility, we can use a cluster analysis such as K-means (Shennan 1997:250-253). K-means calculates the clusters for a given number, hence the *k* in the name. For example a 3 cluster k-means would divide the dataset into three groups in order to minimize the difference between the center of each cluster and the values assigned to that cluster[vii]. In order to determine which clustering should be used, multiple clusters are run and the sum of the cluster errors, the differences between the cluster centers and their associated values, are graphed against the number of cluster centers. Ideally this should produce a 'kink' or bend in the graph beyond which additional cluster centers do not greatly reduce the error.

Chemical Data Analysis of Belize Red

The chemical data from the Belize Red vessels was analyzed with PCA and shows a clear distinction between Belize Red tripod plates and other Belize Red vessels (Figure 3). The first four components and their values are located in Table 1. The first component explains 99.27 percent of the variance, and together the first four components explain 99.99 percent of

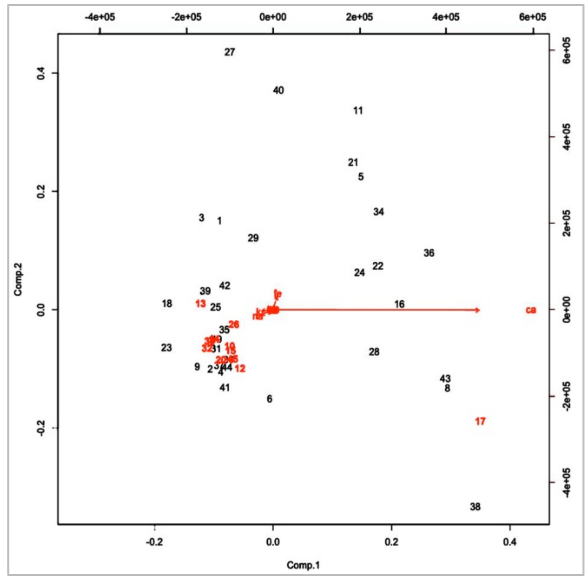

Figure 3. The principal components analysis (PCA) of the Belize Red ceramic data. The first component is calcium and accounts for 99.27 percent of the variance. The red numbers are the tripod plate vessels. Number 17 is the only Belize Red tripod plate from an earlier time period. Table 1 shows the variance explained by and the mineral loadings of the PCA.

the variance (Table 1). The first component's values are based on the calcium levels present in the analysis of the different pastes. That means that the presence or absence of calcium creates the largest source of variation in this data. This seems to fit very well with Gifford's (1976:255-257) description of the type, especially related to the limestone or volcanic tempers used in the Belize red paste; however, without petrographic analysis of the temper, it is impossible to know this for certain.

When looking at the plot (Figure 3), all of the Belize Red tripod plates have their numbers indicated in red. These vessels cluster very closely together except for vessel number 17. This vessel is the only stratigraphically earlier tripod plate included in this chemical analysis. While Gifford (1976:255-257) mentioned the shift in ratios of limestone temper to volcanic temper over time at Barton Ramie, it is impossible to determine if the same change over time occurs at Caracol from the evidence presented by a single vessel.

In terms of the source of the volcanic temper found in Belize Red, Caracol is not located near any volcanoes, but there is evidence of the ancient Maya collecting and hoarding ash

Table 1. This table show the variance explained by each component and its loadings in calcium, iron, sodium, and potassium. No other chemicals had loadings for the first four principal components. These first four principal components explain 99.99 percent of the variance in the chemical data.

Principal Components	Variance Explained	Ca (Calcium)	Fe (Iron)	Na (Sodium)	K (Potassium)
Component 1	99.27 %	0.997	0.000	0.000	0.000
Component 2	0.48 %	0.000	0.915	-0.389	0.000
Component 3	0.20 %	0.000	-0.201	-0.225	-0.951
Component 4	0.04 %	0.000	0.349	0.891	-0.286

Table 2. This is the table of correlations of variables for the entire set of Belize Red tripod plate vessels from Caracol shown in the scree plot in Figure 5.

Pearson's R	Diameter	Break Ht	Base Ht	Foot Ht	Total Ht
Diameter	1.000	0.313	0.021	0.303	0.451
Break Height	0.313	1.000	0.282	-0.170	0.059
Base Height	0.021	0.282	1.000	0.151	-0.035
Foot Height	0.303	-0.170	0.151	1.000	0.425
Total Height	0.451	0.059	-0.035	0.425	1.000

Table 3. This is the table of values for the box and whisker plot in Figure 6.

Box Plot Info	Diameter	Break Ht	Base Ht	Foot Ht	Total Ht
Min.	18.00	4.000	4.800	1.600	7.600
1st Qu.	27.05	4.800	6.100	3.200	8.625
Median	28.10	4.900	7.000	3.750	9.250
Mean	28.26	5.023	6.769	3.900	9.485
3rd Qu.	30.00	5.250	7.500	4.375	10.000
Max.	36.00	7.200	8.400	7.200	14.400
CV	0.131	0.114	0.135	0.337	0.146

fall from volcanic eruptions (Tankersley et al. 2011). More recent eruptions can shed some anecdotal evidence on ash fall. In 1982, El Chichon erupted and covered the Classic Maya site of Palenque with over a foot of ash. El Chichon is located over 100 kilometers away from Palenque. This suggests that volcanic ash can and does fall great distances from the active volcanos. The terraced fields at Caracol are also almost two-thirds smectite (Coultas et al. 1993:200), a soil that is not formed from the underlying limestone bedrock but rather from a decomposed form of volcanic ash (Coultas et al. 1994:27). This means that while there is evidence of ash use in the ceramic paste (Figure 4) and there is evidence of the ancient Maya hoarding ash (Tankersley et al. 2011), it cannot be conclusively confirmed from this study if the ceramic producers of Belize Red were intentionally adding ash to their vessels or simply using the local clay sources which were ash rich.

Analysis of (Scree Plot, Box and Whisker Plot, CVs) all Tripod Plates

One hypothesis for long-distance trade of tripod plate vessels is that they were stacked for transport (Sabloff and Rathje 1975). If this were the case, then we would expect to see modes in the data at separate sizes. In order to quickly

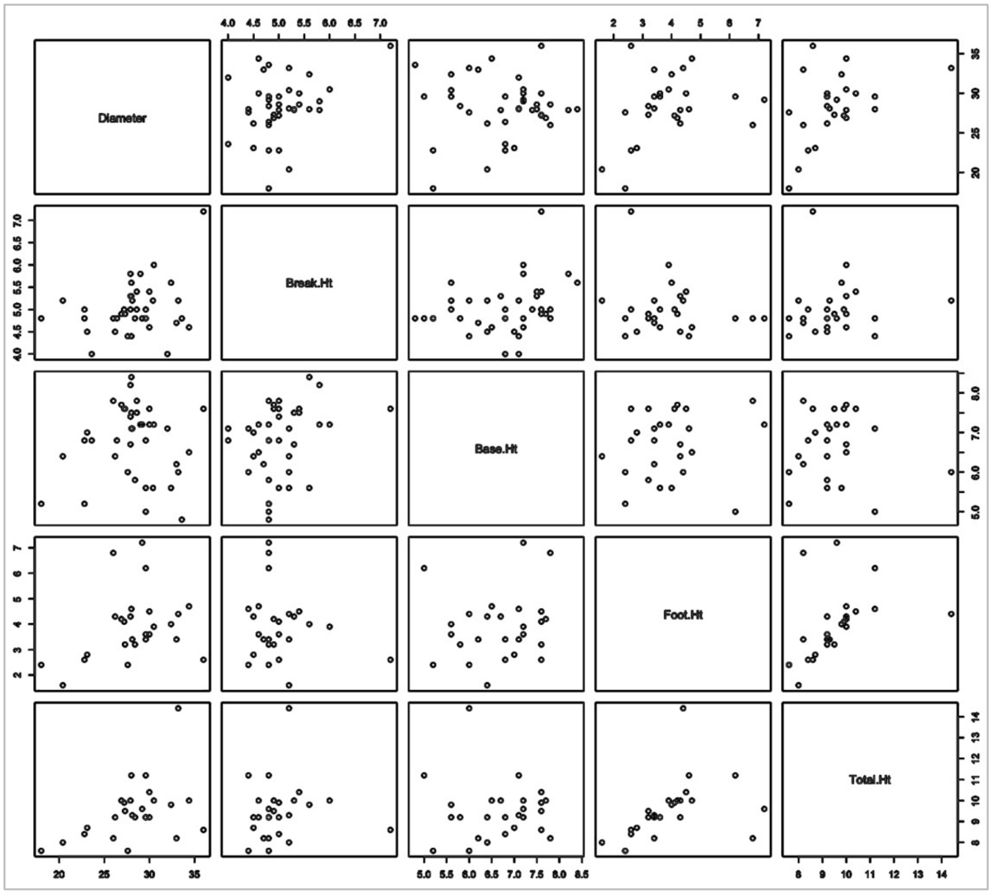

Figure 4. Scree plot of every possible combination of variables from the Belize Red tripod plate measurements. Table 2 shows the correlations values for each pair of variables.

18	0
19	
20	4
21	
22	8
23	1
24	
25	
26	0 2 9
27	2 3 6 9
28	0 1 4
29	2 6 6 6
30	0 0 5
31	
32	4
33	0 2
34	4
35	
36	0

Figure 5. This stem and leaf plot shows the distribution of rim sizes. The data has been color-coded to match the 3 k-means clustering. Blue is the first cluster, red is the second cluster, and green is the third cluster. The reason for choosing the 3 k-means clustering is explained in Figure 7.

examine this, a stem and leaf plot of rim diameters was created (Figure 5). Rim diameters were used because they should be the best-correlated value with vessel function, and visually a smaller vessel rim is easier to see than a smaller vessel foot. The plot shows that the data have a clear median and mean around 28 cm, but the values above 31 cm and below 25 cm could either be separate ranges or the tail ends of the distribution curve of this vessel type. Based on the stem and leaf plot alone multiple modes in the dataset are not supported. Combining this information with data from Barton Ramie, however, makes it clear that different size clusters existed at different sites. While the Caracol vessels cluster around 28 cm, the ones at Barton Ramie cluster between 31 to 33 cm and 24 to 25 cm (Gifford 1976:256).

If the tripod plates were made with a specific ratio as a mental template then we can

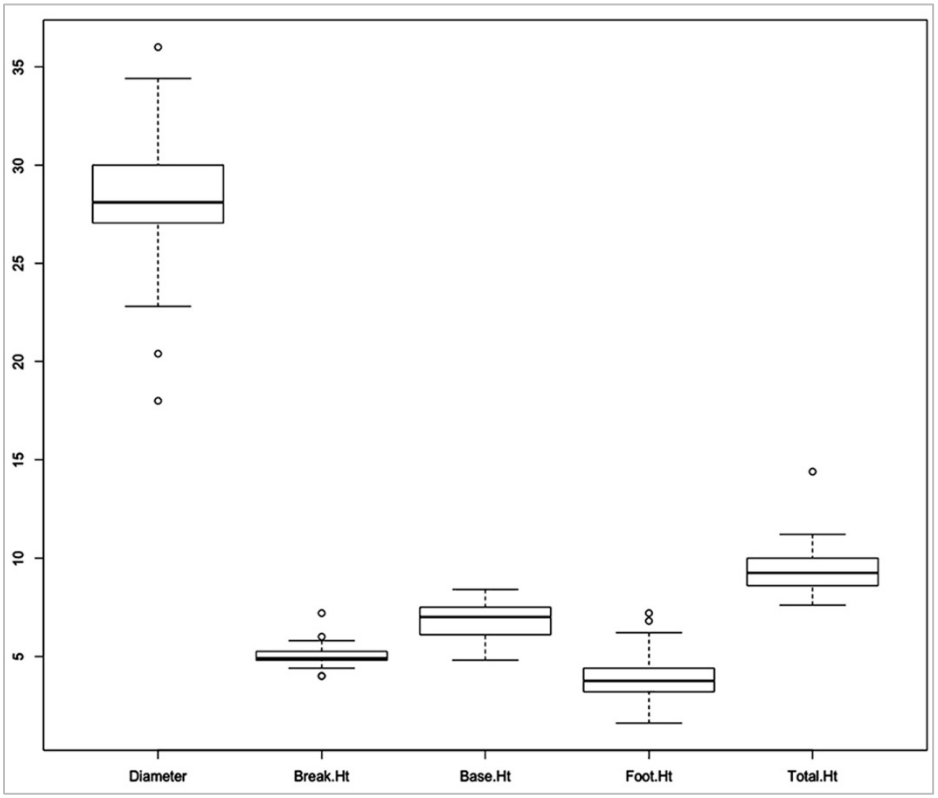

Figure 6. This is a box and whisker plot of the variables of Belize Red tripod plate vessels measurements. Table 3 shows the values for this graph.

expect the measured values to show a strong correlation in the scree plots of the variables against each other. The resulting scree plot does not seem to show these strong correlations (Figure 5). In fact, the two best correlations in the scree plot are between total height and rim diameter and total height and foot height, and those correlations are 0.45 and 0.42 (Table 2). This makes sense because total height incorporates foot height. The low Pearson's R values show correlation of sizes, but some values show no correlation. Looking at the correlations between variables and their scattergrams shows that, while there is a basic ratio between sizes, that ratio is not incredibly strong. This supports the suggestion that there are multiple manufacturing locations or multiple subtypes grouped together. Even so, the type as a whole still seems to be relatively standardized.

The previous two analyses suggest that there is a general mental template for these Belize Red tripod plate vessels; however, there is variation, which reduces the correlation of vessels. In order to investigate the degree of variation in the data, a box and whisker plot was made and the CVs were calculated. The box and whisker plot (Figure 6) shows very tight sets of measurements for most of the variables. The actual CVs show that most of the correlations are between 0.1 and 0.15 (Table 3) suggesting a high degree of standardization in the data. The only exception is the CV for foot height at 0.34, but foot heights tend to be much smaller values than the other measurements, and the calculations for CV exponentiate near zero. Multiple production locations, multiple producers, or inclusion of separate sub-types could explain this limited degree variation. One feature the box and whisker plot (Figure 6) makes very clear is that there is a very limited span of Break Heights (see Figure 2 for visual depiction of break height measurements) with only three vessels falling outside of that limit. In general this analysis seems to reaffirm the initial conclusions of standardization for the Belize Red type (Chase et al. 2005).

These three analyses suggest that Gifford's T-V-M analysis did in fact lead to the establishment of a ceramic type and form that conformed with an ancient mental template, but there seems to be some factor that makes them appear less standardized than they actually are. This could be the result of vessels being produced by multiple independent potters with a relatively standard mental template for the ceramic type, multiple pottery producer production centers with similar mental templates, or the possibility that there are multiple subtypes of vessels included in the tripod plate category. Testing the multiple independent potters hypothesis would require excavation of many more housemounds near separate marketplaces to try and get at the intra-site market system and to identify separate pottery making household exchange systems. The theory for multiple pottery manufacturers would require analysis of this vessel type from across the Belize valley to see if the sites all show the pattern seen here or if each pattern is different, suggesting regional trade. Finally, the last question can be tested through the use of k-means clustering and re-analysis of the clusters it identifies. However, the k-means cluster analysis does not clarify why these clusters would exist. Even so, strong clustering could still be the result of either independent potters with similar mental templates or trade from individual pottery production centers in the Belize Valley (and possibly the result of both).

Cluster Analysis

Cluster analysis attempts to get at any underlying subtypes that could be separated out and analyzed on their own as separate ideals of Belize Red tripod plates or the products of separate production centers. Based on the stem and leaf plot, a three clustering should separate the ceramics into the portion below a rim size of 25 centimeters, the portion above 31 centimeters, and the portion in-between. However a four, five, or even six clustering might be much better than a three. In order to determine which clustering should be used, a graph of clustering error divided by the original error was made (Figure 7); it shows that there is only marginal improvement after the three clustering. This means that for this analysis, we

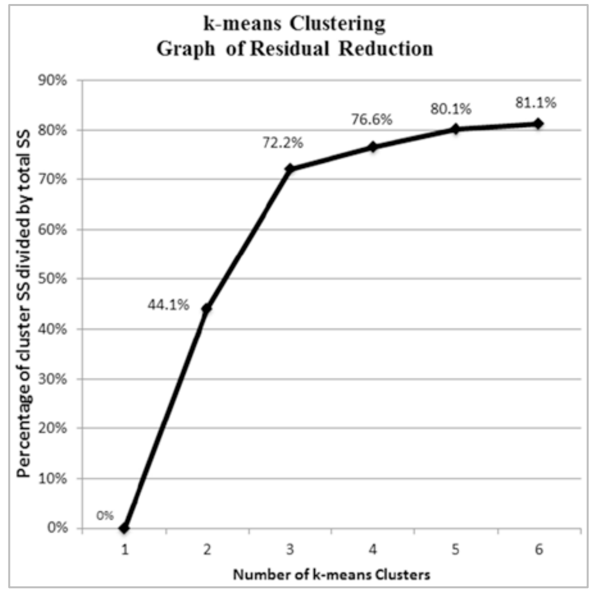

Figure 7. The k-means cluster analysis graph. This shows the percent reduction of distance from the cluster center divided by the one-cluster distance values. The 'kink' in the graph occurs at the three-cluster value.

assume that there are three sub-varieties or styles of Belize Red tripod plates separated from each other by 24 and 31 cm rim sizes. The resulting analysis clearly shows much lower CV values, which implies a very high degree of standardization within each of these sub-varieties. One limitation is that the sample size for this pilot study was only twenty-six footed vessels and the clustering divided that into even smaller sample sizes. In fact the first and third clusters have four and five vessels respectively. This means that their analysis would change drastically with any additional vessel; thus, this analysis focuses on the second cluster which has the largest sample size of seventeen. However, the present analysis will need to be repeated when additional excavation unearths more whole vessels or vessels from other sites are analyzed in conjunction with Caracol's dataset. Based solely on the data under analysis from Caracol, the distinction between three types based on rim size and a single distribution with two large tails cannot be determined; however, the initial analysis by Gifford lends weight to the idea of size variance because the larger and smaller modes were noted in the Barton Ramie assemblage.

Analysis of the second cluster k-means seems to show a lower degree of correlation

Table 4. This is the table of correlations of variables of the second group from the three-cluster analysis of the Belize Red tripod plate vessels.

Pearson's R	Diameter	Break Ht	Base Ht	Foot Ht	Total Ht
Diameter	1.000	0.423	-0.257	-0.058	0.329
Break Height	0.423	1.000	0.242	-0.261	0.251
Base Height	-0.257	0.242	1.000	0.123	-0.010
Foot Height	-0.058	-0.261	0.123	1.000	0.288
Total Height	0.329	0.251	-0.010	0.288	1.000

Table 5. This is the table of values for the box and whisker plot in Figure 8.

Box Plot Info	Diameter	Break Ht	Base Ht	Foot Ht	Total Ht
Min.	26.00	4.400	5.000	2.400	7.600
1st Qu.	27.30	4.800	6.400	3.400	9.200
Median	28.10	4.800	7.100	4.100	9.500
Mean	28.36	4.918	6.847	4.288	9.582
3rd Qu.	29.60	5.000	7.600	4.500	10.000
Max.	30.50	6.000	7.800	7.200	11.000
CV	0.049	0.081	0.120	0.304	0.095

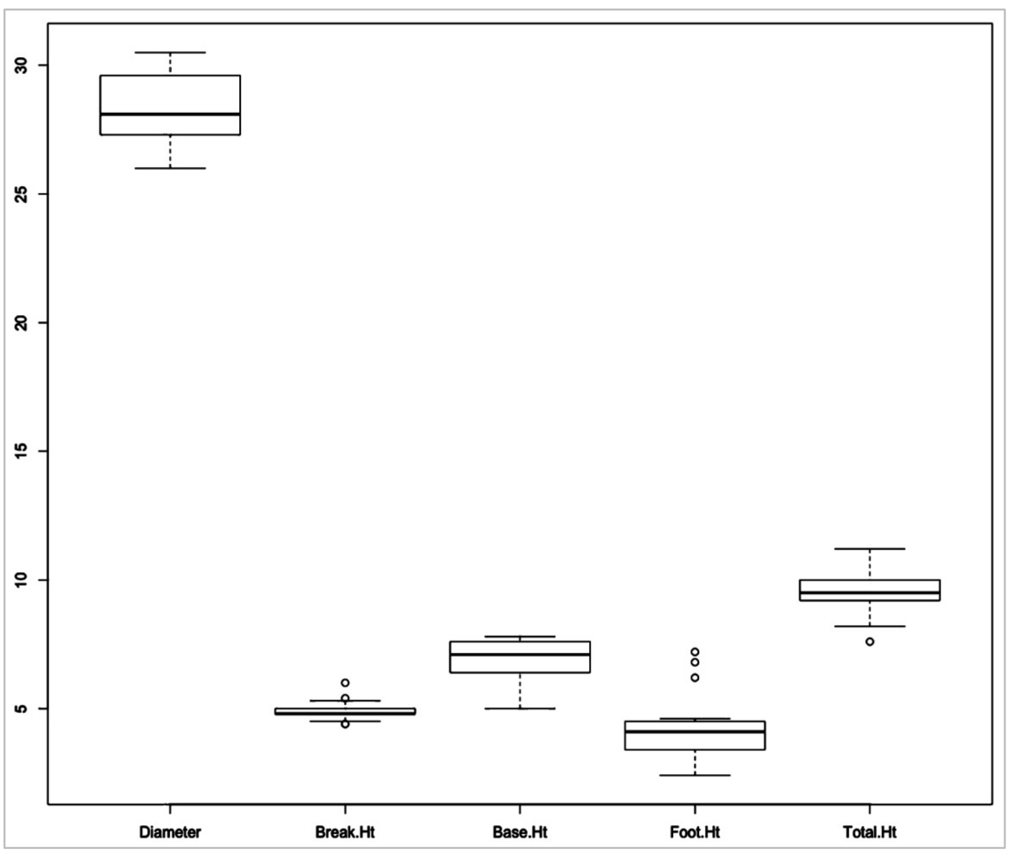

Figure 8. This is a box and whisker plot of the variables of the second group from the three-cluster analysis of the Belize Red tripod plate vessels. Table 5 shows the values for this graph.

between most of the variables (Table 4). The only exception is the increase in the correlation between Diameter and Base Height and Break Height from the complete scree plot data (Table 2). The resultant scree plot also lacks a clearly visible correlation. At first glance this might seem to imply that the group clustering by k-means reduced the relatedness of the vessels in the second group of the cluster; however, after looking at the box and whisker plot (Figure 8), it becomes clear that the vessels in this group are actually much more similar to each other than to the entire set of tripod plates. This can be seen when looking at the data in Table 5. Several CVs in this table are below 0.05 and this value shows a high degree of standardization that generally indicates specialization (Arnold 1991; Arnold and Nieves 1992). The CV of foot height is about the same as before, which may relate to the manner in which the CV is calculated that makes it less reliable for smaller numbers near zero or it could be related to other factors of their production. The CVs in this clustering indicate that the feature of rim diameter may actually have been a ceramic division employed by the ancient Maya for Belize Red tripod plate vessels.

The vessels in the second cluster show a much greater reduction in variation. If this subsample is accepted as a separate style of Belize Red tripod plate, then it becomes clear that, with its small CV, it is a highly standardized type – and this strongly suggests specialization. However, additional vessel data is needed from Caracol and from other sites in order to double check that this cluster makes sense in the greater trade network of Belize Red vessels. If no sites have a higher distribution of vessels in the larger rimmed or smaller rimmed clusters, then these would not actually represent three separate groups, but would instead show the bell-like curve of this ceramic type. The diameter comparisons between the Caracol and Barton Ramie Belize Red samples discussed above, however, suggests that this is not the case.

Conclusion

This pilot study analyzed the degree of standardization of Belize Red tripod plates at the site of Caracol, Belize. Even though these plates were widely distributed among 29 different residential groups at the site, the statistical evidence suggests that this ceramic type was highly standardized, indicating a relatively unified mental template for the appearance of these pottery vessels. The statistical methods demonstrate several lines of evidence supporting standardization of production of Belize Red tripod plates at a level above the individual household. While standardization is evident, a single production area is not evident; rather, this may indicate a standardized mental framework from multiple specialists or workshops. The major limitation of this pilot study is sample size. Neither theory can be proven without additional dimensional and spatial data. Additional analysis on a larger sample will be necessary to solidify the trends seen in the Caracol dataset and tease apart the production and distribution systems of the ancient Maya. There are two possibilities that need further analysis: Belize Red tripod plates could fall into a single category or they could be subdivided into three size classes. While the foot height seems least well correlated with rim size, there may be a separate dimension of ceramic production and use which could only be identified with additional data. The preliminary results presented here are promising and have helped to construct hypotheses for testing in future work. Such future work could focus at either the site level or at the aggregate level of sites in the Belize Valley in order to identify the degree of full time specialization and the spatial distribution of production sites. These data would augment our abilities to discuss specialized ceramic production and the market economies of the ancient Maya. Even though statistical and chemical means were not employed in Gifford's original definition of Belize Red, this analysis of Belize Red tripod plates at Caracol, Belize supports Gifford's initial assertion that T-V-M ceramic types are in fact not artificial constructs by can represent real types created by the prehistoric Maya.

[i] http://cran.r-project.org/

[ii] http://www.rstudio.com/ide/

[iii] Information for running these analyses was obtained from *R in a Nutshell* (Adler 2012), and information on the statistics was obtained from *Quantitative Archaeology* (Shennan 1997).

iv This method is very often used in archaeological analysis of chemical data (Bishop and Blackman 2002; Halperin et al. 2009; Skowronek et al. 2009). It reduces the full set of variables into component axes which are independent of each other. Each component is then given the amount of variance it explains in the original data and the weights from the initial variables.

v One the left side, or the "stem" side, the data intervals are written in order. One the right side, or the "leaf" side, each individual number is placed into its interval and one, and only one, digit is written (the digit that comes right after the leaf digits).

vi The box is drawn around fifty percent of all of the measurements with the mean represented as the line in the middle. The whiskers extend out an additional quartile from the box. Values further out are represented by circles and statistical outliers are represented by X's.

vii K-means works by randomly placing the k-points in the data as centers. The algorithm iteratively moves the k-points to the centroid of the points allocated to them and then redistributes the points to the nearest of the k-points. This process is repeated until the k-points no longer move.

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