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CUMULATIVE SERIATION AND CERAMIC FORMULA DATING: A PRELIMINARY STUDY

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Cumulative Seriation and
Ceramic Formula Dating:
A Preliminary Study

by Roger T. Grange, Jr.

Abstract

Seriation diagrams may be used both as a means of establishing chronology and for studying the dynamic changes in relative popularity of artifact types through time. For chronological purposes individual units (sites or parts of sites) are selected for their short duration or are assumed to have a short temporal life. The graphic patterns of increasing and decreasing popularity produced by such standard seriation diagrams do not depict correctly the artifact popularity trends in sequence where sites with long occupational spans are used as seriated units. This problem is illustrated with standard seriation diagrams of historic sites and ceramic types.

Cumulative seriation is a graphic method which permits long site occupation spans, overlapping site occupations and known ceramic type periods of manufacture to be taken into account simultaneously in the construction of seriation graphs for historic sites of known occupation date. Cumulative seriation is not designed to reveal chronology since that is already known. It is instead intended to produce more accurate diagrams of relative popularity of ceramic types than is possible by standard seriation technique. Cumulative seriation diagrams for several historic ceramic types are discussed and dates of peak popularity are estimated. The results are tested by the

application of such modal dates in South's mean ceramic dating formula.

Submitted for publication 1973, by Roger T. Grange, Jr., University of South Florida, Tampa.

Abrégé

Les diagrammes de mise en série peuvent servir à élaborer la chronologie ou à étudier les changements dynamiques survenus dans la popularité relative des divers types d'artefacts au fil des ans. Pour les besoins de la chronologie, des unités individuelles (sites ou sections de sites) ont été déterminées en raison de leur caractère passager réel ou présumé. Les représentations graphiques de popularité croissante et décroissante résultant de ces diagrammes de mise en série n'illustrent pas fidèlement les tendances de la popularité des artefacts dans les sites qui ont une longue durée d'occupation et qui servent d'unités de base pour la mise en série. L'évidence de cette constatation apparaît dans les diagrammes-standard de mise en série des sites historiques et des divers types de poterie.

Ce programme a été entrepris dans le cadre de l'étude comparative des céramiques récupérées lors des fouilles faites au parc historique national de Fort Lennox au Québec, dans le but d'établir une chronologie de la céramique permettant la datation et la mise en série des éléments mis au jour.

On a utilisé entre autres méthodes d'analyse, la formule de datation de South. Divers commentaires concernant la méthode de South signalaient que la formule de datation pourrait fournir de meilleurs résultats si l'on y substituait les dates de popularité dominante des types de céramique aux dates centrales de leur période de fabrication. C'est ainsi que l'on a tenté de déterminer les dates dominantes des types. La mise en série standard s'est

avérée inefficace car elle ne fait pas apparaître le chevauchement des périodes d'occupation de site.

La mise en série cumulative est une nouvelle technique conçue pour remédier à ce problème. La mise en série cumulative est une méthode graphique dans laquelle la hauteur des bâtonnets représente la chronologie de site tandis que leur largeur reflète la fréquence du pourcentage de chaque type. Les longues périodes d'occupation se superposent sur le graphique et l'effet cumulatif de densité ainsi obtenu révèle la période de popularité dominante du type de céramique. La mise en série cumulative a permis de définir les périodes de popularité substantielle relativement importante et de popularité dominante et d'évaluer les dates dominantes de 29 types de céramique provenant de l'échantillon de 16 sites utilisé par South lors de ses travaux. On a calculé les dates des sites au moyen de la formule de datation de la céramique, à partir des facteurs de date dominante, pour vérifier l'efficacité de la méthode de mise en série cumulative.

La comparaison des résultats de datation a montré que les dates de la formule de la céramique obtenues grâce aux dates dominantes sont aussi réelles que celles obtenues avec la méthode d'ajustement originale de South; toute différence dans les résultats des deux méthodes est probablement fortuite. Nous nous sommes basés sur cette observation pour soutenir la thèse selon laquelle la mise en série cumulative constitue une bonne méthode d'étude de la popularité des types de céramique. En effet, l'utilisation de dates dominantes fausses aurait dû déformer considérablement les résultats obtenus par la formule de datation des tessons de céramique provenant des sites étudiés.

Nous ne prétendons pas à perfection de nos calculs des périodes et des dates de popularité dominante des types de céramique. On peut s'en servir provisiorement, en tenant compte des limites de cette étude. Mais il importe surtout d'utiliser la méthode d'analyse décrite ici pour améliorer encore les courbes de popularité des céramiques étudiées et procéder à l'évaluation de la popularité dominante d'autres types de céramique. La formule de datation, utilisant les dates de plus de 29 types et des données provenant de sites plus nombreux, pourrait peut-être fournir de meilleurs résultats.

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Part of the research leading to the cumulative seriation approach used in this paper was done in an attempt to apply the ceramic formula dating method to Pawnee archaeology. The Pawnee pottery dating project was made possible by release time provided by the Department of Anthropology at the University of South Florida.

Permission to republish the Pawnee pottery seriation diagram (Fig. 4) was granted by the Nebraska State Historical Society. This figure was originally published as Figure 6 in "Pawnee and Lower Loup Pottery" by Roger T. Grange, Jr., Nebraska State Historical Society Publications in Anthropology, Number 3 (1968), Nebraska State Historical Society, Lincoln, Nebraska. Portions of this figure have also been utilized in Figures 5 and 10 in this paper.

I am indebted to Dorothy Griffiths and Gérard Gusset of the National Historical Parks and Sites Branch, Parks Canada, for their comments and suggestions, some of which have been incorporated in the revision of this paper. I am also grateful to Curtis Weinker, Department of Anthropology, University of South Florida, for his advice on statistical matters. Any misuse of their suggestions is my responsibility.

Introduction

Cumulative seriation is a graphic method of analysis for the study of popularity trends in ceramics which I developed in the course of a comparative study of materials recovered from Fort Lennox National Historic Park, Quebec. South's ceramic dating formula (S. South 1972a) was introduced at the time the study of the Ile-aux-Noix specimens was under way and I desired to make use of the formula method in my analysis. During this same period I was also attempting to apply South's formula to protohistoric and historic Pawnee pottery (Grange 1972: 191; 1974). Simultaneous.work on these two problems led to the development of what I have termed "cumulative seriation" as a technique for determining ceramic popularity date factors for use in formula dating.

Several commentators on South's original paper indicated their belief that some date factor other than the median manufacture date might improve the results of site dating with the formula. Cumulative seriation was devised in an attempt to meet the need expressed in those comments on South's paper.

South's ceramic dating formula utilizes both sherd counts and median manufacture dates of pottery types to calculate mean dates of site occupation (S. South 1972a: 72, 75, 83). Walker has suggested that the term "mid-range date" is a more accurate expression of the point midway between beginning and end of manufacture (Walker 1972: 131). Conceptually, South's formula is based partly on ceramic seriation theory and the idea that ceramic types and other artifacts have a typical life history of increasing popularity followed by decline in a unimodal battleship-shaped curve (S. South 1972a: 73). Walker has criticised this assumption and asserted that asymmetrical, multi-modal and amodal curves are more likely (Walker 1972: 128, 135). Fitting (1972: 161) and Liggett (1972: 189-90) agree concerning the unimodal curve problem, while Jelks has suggested that histograms might be used to illustrate the shape of the curve (Jelks 1972: 176).

Walker has also suggested that the mid-range date is not necessarily the point of maximum popularity and that mean dates or modal dates might be more useful in South's formula (Walker 1972: 131). Walker supplies several hypothetical curves to illustrate this point (Walker 1972: Figs. 1-4). Cleland asked, "Could it be that the frequency of various ceramic types in tightly dated historic sites is a more accurate reflection of the popularity of these types than mean historic dates of manufacture?" (Cleland 1972: 186). Similarly, Jelks has noted that the only acceptable method of establishing the archaeological date for a type is one based on "direct observance of that type's occurrence in the archaeological record itself" (Jelks 1972: 178). Concerning the use of mean or modal dates rather than type mid-range dates, Walker has said, "One feels the use of alternative dates obtained as indicated above by this writer might produce equal refinements if, of course, there were a practical method of estimating these dates" (Walker 1972: 132).

Thus it appears that there is a general recognition that type mid-range dates may not be the most accurate ones for formula dating purposes and that real dates of type popularity determined from the archaeological record would be more useful, if there was a method for determining such dates. Cumulative seriation offers just such a practical method.

In developing the method I made use of the sherd count data presented in South's (1972a) and other papers in the Historical Archaeology Forum, 1971. These are some of the most readily available data, frequency analysis having been neglected in historical archaeology (S. South 1972a: 72) despite South's demonstration of its utility in 1960 (S. South 1972a: 71).

Ideally the sites used would be controlled for regional location, function, size, length of occupation, extent excavated and other such factors as well as being selected to provide an equal sample for each segment of the time period being studied. It is not possible to obtain a sufficiently large number of sites for use with this graphic method if control factors are all applied. I have assumed that it is appropriate to include them all in the analysis since what is sought are modal type dates for use in formula dating in general rather than for use in formula dating restricted to a single region or functional class of sites. I have also assumed that the published sherd counts adequately represent the sites used in the study. Not all historic site reports include adequate ceramic data by type, sherd count and provenience, and the modal popularity estimates presented here have not been revised on the basis of additional data since 1973 when the analysis was first completed. A larger and better controlled sample might improve the results, and the potential bias due to the sample used should be recognized.

Although it would be possible to use revised manufacturing date spans and median or mid-range date factors for the types included in this study on the basis of new evidence (Griffiths and Gusset: pers. com.), this has not been done. The type date periods listed by South (1972a) have been employed. I have chosen this course because the revision of type manufacturing dates is beyond the scope of this paper. Furthermore, such changes might obscure the comparison of my results with those obtained originally by South. It would be difficult to determine whether any difference in formula dating results was due to the use of modal popularity estimates or the result of altering the type dates. When someone assembles a list of types and their dates more complete than that supplied by South, further study of type modal dates would be in order.

I have also employed the same ceramic categories used by South (1972a) in his formula dating paper. It has been suggested to me (Griffiths: pers. com.) that these include ware types, ware sub-types and shape types, and that more detailed graphing based on less inclusive categories might result in different and more useful popularity curves. Such detailed data are not readily available and would be part of an analysis beyond the intended scope of this paper, but this bias must also be kept in mind. If the cumulative seriation method outlined here works, then more detailed studies would be profitable in the future. For the present I have utilized the data presented by South as a means of illustrating the technique of cumulative seriation.

Potential users of the modal type date estimates presented later in this paper should be aware of the limitations and assumptions outlined above. Commentators on South's formula dating paper suggested that more accurate results might be obtained if the date factors used reflected the greatest popularity of the ceramic types rather than the manufacturing periods alone. This paper is primarily a presentation of a method of analysis designed to make such estimates and it would be better to view it as a progress report rather than as the presentation of immutable conclusions. A much more extensive analysis using a broader sample from additional sites and controlling more of the variables will be necessary before final estimates of modal popularity dates can be determined for ceramic types by this or any other method.

The modal date estimates presented below can be used instead of some of South's median dates, but users should bear in mind the intended purposes of this paper when using the date factors developed by the cumulative seriation method.

Cumulative Seriation

Let us now turn to the problem of explaining and illustrating the method of cumulative seriation and its application to English ceramics from selected historic sites in the New World.

Standard seriation diagrams may be used both as a means of establishing chronology and for studying the dynamic changes in relative popularity of artifact types through time (Ford 1972: 49, 50).

Standard seriation bar graphs are based on the percentages of various ceramic types found in a site or excavation unit. The sherd counts used in this analysis (see Table 1) are taken from South (1972a; 1972b), Stone (1972), Grange (1971) and from my notes on Fort Lennox. These data were used in developing a standard site seriation.

Since the dates of these sites are known, my first effort at producing a seriation diagram was simply to arrange the sites in the order of their known median occupation dates. This produced a pattern of increasing and decreasing frequency curves in several ceramic types. Since some 60 types are involved, such graphs are lengthy. For illustrative purposes I have selected three types; South's type numbers (S. South 1972a: Fig. 1) are employed. The first of these is type number 49, 18th-century decorated delftware. Type 43, white salt-glazed stoneware plates, and type 22, creamware, are also used in the detailed illustrations. These types were selected for this purpose because they illustrate the method and the results well.

The upper half of Figure 1 illustrates a standard seriation diagram with the sites arranged in the sequence based on their known historic median occupation dates. This site sequence produces reasonably typical seriation curves although the curves are not all identical, unimodal or battleship-shaped. The lower part of the graph shows the same sites rearranged arbitrarily using an ideal curve for creamware suggested by the median date graph as the basis for the sequence. It, too, produces acceptable seriation results in the other two types. Although the ordering does minor violence to the historically known site sequence, it would be acceptable if the site dates were unknown.

The same sites and types, this time arranged in the order determined by the mean ceramic formula dates calculated by South (1972a), are illustrated in Figure 2. It is obvious that this order is also an acceptable one although the creamware curve looks a little more like a barge than a battleship.

Thus, it can be established that historic sites and historic ceramic types produce standard seriation curves of popularity not unlike those seen in the seriation of prehistoric ceramics or of colonial tombstones (Dethlefsen and Deetz 1966). However, we might ask if these curves do, in fact, provide a firm basis for the seriation of historic sites of unknown date by inserting them into this sequence. The answer to this is no, because we are unable to determine which of the several "acceptable" sequences and seriation curves is the correct one. Any of the three sequences used as examples above might be arbitrarily selected as correct. We might also ask whether or not these curves allow us to determine a type's peak of popularity and therefore to select mean or modal dates to use in place of mid-range manufacture dates for formula dating purposes. Again, unless we can be sure the sequence of sites is correct, we cannot be sure the curves are "correct." Furthermore, such standard seriation curves reflect relative time only and dates cannot be calculated from them.

These problems are rooted in a difficulty inherent in standard seriation which necessarily requires or assumes a relatively short time span for the duration of each unit being placed in the seriation (Ford 1972: 41). The actual occupation span may make such an assumption unwarranted. I have discussed this problem in an analysis of Pawnee pottery (Grange 1968: 106), as has Dunnell (1970: 312) in a more general way.

Figure 3 illustrates this problem by graphically comparing the duration of occupation of the several sites involved in this analysis. They overlap one another in time to such a degree that any standard bar-graph representation of these sites as having been occupied in sequence can only be inaccurate. Similarly, a standard seriation of long occupation units illustrating ceramic frequencies as if the sites were occupied in sequence can only provide an improper illusion of the popularity trends in pottery types. A standard seriation diagram which treats these sites as if they were short-term units occupied in sequence cannot provide a true picture of ceramic trends. For this reason more accurate type dates cannot be calculated from such graphs. Cumulative seriation provides a way around this difficulty of standard seriation.

A standard seriation of protohistoric (Lower Loup) and historic Pawnee pottery (Grange 1968: Fig. 6) is shown in Figure 4. This seriation was based on a combination of stratified excavation units and dated historic sites which established the popularity trends of pottery. Non-stratified units were then inserted in standard seriation manner. This seriation is an excavation unit seriation; that is, each bar represents an individual garbage-filled storage pit, house floor or other short term occupational feature. The only exception to this is that site totals are also included and were placed in the sequence as if they were short- rather than long-term phenomena. In subsequent figures only the left side of this graph will be repeated. Note that the excavation unit seriation is composed of features of short temporal duration and thus reduces or eliminates the overlapping occupation problem noted earlier. Variations in the temporal length of the excavation units result in some irregularities in the graph as Dunnell demonstrates (Dunnell 1970: Fig. 3).

A portion of the excavation unit seriation is shown on the left side of Figure 5 while the sequence of site units based on the position of the site total bar graphs in the excavation unit sequence is on the right side of the figure. The vertical bars in between are representations of the relative length of occupation time spans of selected sites. These are derived from the positions of the earliest and latest features from a site in the excavation unit sequence. This analysis, done several years ago (Grange 1968), was used to illustrate the defect of the standard seriation graph discussed earlier and to develop a method for determining the relative lengths of occupation of the various Lower Loup (protohistoric Pawnee) sites. Time spans for the historic Pawnee sites could, of course, be determined on historical evidence. In the context of the present paper, this figure illustrates the relationship between site unit seriation, excavation unit seriation and site occupation spans. Note that the excavation unit seriation provides a different curve of popularity for the Nance flared plain pottery type than would a graph based solely on site unit data.

The significant point in the present analysis is that in the case of the Pawnee sites we were trying to determine the length of site occupations. In contrast, this is precisely what we already know about the historic sites in our sample. We have also shown that standard site unit seriation cannot properly illustrate ceramic trends in these historic sites. What we need to do is to utilize our knowledge of site occupation spans to achieve an equivalent of an excavation unit seriation for the historic sites. One obvious procedure would be to get data from a large number of short-term features from historic sites and do a conventional excavation unit seriation. Unfortunately, such data are not readily at hand; it is even difficult to find sherd counts from entire sites from published sources. In any event, many historic site features were used for much longer periods of time in contrast to the short useful life of a Plains village storage pit. An alternative approach, making use of the known historic site occupation spans, is cumulative seriation.

Figure 6 shows the three illustrative types, 18th-century decorated delftware, white salt-glazed stoneware plates and creamware from Fort Moore. The data are from South (1972a: 111) (see Table 1). In this, as in the subsequent figures, 10 by 10 grid paper is used, the vertical axis representing years and the horizontal axis representing percentages. Below, the relative frequency (percentage) of these types in Fort Moore is represented as a standard seriation bar graph. In the upper part of Figure 6 the same types are plotted in the manner used in cumulative seriation. The width of the bar still represents the percentage of a given type in the site. The bar is not, however, of arbitrary height as in standard seriation. Height is plotted as a representation of the known occupational span of the site. The 18th-century delftware type was being manufactured prior to the beginning of occupation of the site and could have been present at the site at its initial date. We must assume that it could have been present at any time after its initial date of manufacture and thus it must be depicted as being present throughout the period of occupation. Although it is unlikely that there were no variations in the frequency of an individual pottery type at a site during its occupation, this cannot be detected. The type is therefore depicted at its maximum percentage for the entire occupational span. This should at least partially take into account the heirloom factor which Walker feels is inadequately accounted for in South's formula method (Walker 1972: 134).

White salt-glazed stoneware plates represent a type which did not appear until 1740, after the occupation of Fort Moore was under way. This type could not have been present during the early part of the occupation, but could have been present any time after 1740, and the height of the cumulative percentage bar is adjusted accordingly. Creamware was absent from this sample.

Figure 7 is a similar illustration of cumulative seriation bars compared with standard seriation bars, this time for all three illustrative types since all three are present at S-18 from Brunswick Town (S. South 1972a: 114).

The same three ceramic types from Fort Prince George (S. South 1972a: 112) are illustrated in Figure 8. In this case there is a necessary adjustment in the cumulative seriation bar. While types 49 and 43 were manufactured prior to the beginning of the occupation of Fort Prince George (1753-68) and thus could have been present throughout the occupation of the site, creamware type 22 was not manufactured until about 1762, after the occupation had begun. (Creamware was commercially produced by Wedgwood from 1760 [Griffiths: pers. com.] and its manufacture dates should be adjusted for most purposes. However, the 1762 date employed by South [1972a: Fig. 1] is retained here so that dating results will reflect differences, if any, between the modal estimate method and the original method rather than adjustment of the type dates.) This type could not have been present in the site prior to 1762 and therefore the cumulative seriation bar for the type is reduced in height to account for its known chronology.

In cumulative seriation the width of the bar graph represents the percentage of a given ceramic type at the site. The height of the bar represents the occupation span of the site, adjusted as necessary to reflect the date of origin of given ceramic types.

Figure 9 illustrates the cumulative seriation of the data presented in the previous three figures, with a conventional seriation diagram below. The "cumulative" seriation involves the overlapping plotting of the individual site bar graphs, using the vertical scale of years. Thus, instead of illustrating sites and their ceramic contents as sequential bars, the cumulative seriation plots the types and sites in their properly overlapping chronological positions.

Note that the cumulative seriation diagram takes into account site occupation spans and the known periods of type manufacture as well as the relative percentages of the types of the sites. Plotting the positions of the sites cumulatively according to their known chronologies also takes into account the overlaps in site occupations. This method thus controls the problems seen in a conventional seriation diagram.

A Pawnee pottery type, Nance flared plain, plotted as a cumulative seriation diagram, is seen in Figure 10. This was accomplished in the manner described above, using the site total percentages and the relative time spans illustrated earlier. Note the similarity of the cumulative seriation diagram on the right when compared with the original excavation unit seriation on the left. This similarity is a demonstration that the cumulative seriation method does not successfully reverse the flow and allow us to use relative site duration periods and site total percentages to produce a graphic representation of ceramic popularity comparable to that produced by a standard seriation of short term excavation units. In this case cumulative seriation appears to work.

A cumulative seriation of creamware is illustrated in Figure 11. The graph is shown in three different ways. On the left is the linear pattern of the entire series of overlapping lines of the individual site graphs for this type. On the right these are expressed as different density patterns: the darker the colour, the larger the number of sites in which the type appears in that time range. This core area reflects the greatest amount of simultaneous use of the type in the sites included in the seriation. The dark colour then represents the cumulative frequency of the type and is the modal period of type popularity. This method of graphing is a time-consuming way of determining the point of maximum popularity; it can be done directly from the linear chart by counting the number of overlapping bars. For simplicity in the following figures, the core area representing the greatest cumulative frequency will be illustrated as shown in the central part of Figure 11. For comparison, a standard seriation of creamware is shown below with the sites arranged in the sequence of known median occupation date. Note that the cumulative seriation presents an entirely different popularity curve.

The three illustrative types, decorated delftware, white salt-glazed stoneware plates and creamware, are all shown in Figure 12. In addition to the cumulative frequency graphs, the known period of manufacture for each type is shown as a vertical line, plotted by years, on the left of each curve. The mid-range date is indicated and we can assess the relationship of the popularity curves of these three types with their periods of manufacture.

In the case of the 18th-century decorated delftware, South's assumed 1750 median date appears to be approximately ten years earlier than the mid-point of the core of cumulative or modal popularity. A revised modal date of 1760 is therefore suggested for this type.

In the case of white salt-glazed stoneware plates, the mid-range manufacture date and the modal date appear to be at about the same point in time and no change in the 1758 median date is made.

In contrast, the peak of modal popularity of creamware appears to be about 21 years earlier than its 1791 mid-range manufacture date.

Thus the cumulative seriation curves indicate that the peaks of popularity for ceramic types may be earlier, later or coincide with the mid-range manufacture dates. These three types were chosen as good illustrations of the method and its results.

In this manner modal dates can be estimated for many types. There is interpretative latitude, but the cumulative seriation graphs at least provide a basis for evaluation.

Note also that there is an important correlation between the periods of manufacture and periods of both substantial popularity and modal popularity in white salt-glazed stoneware and creamware. Comparisons of these ranges will be done in more detail later.

The following figures, 13-19, illustrate the cumulative seriation graphs for the types represented in the 19 sites or units used in this study. Not all of the types in South's list (1972a: Fig. 1) are shown.

Spanish olive jars are present only at Castle Hill, Newfoundland, among the sites in this sample. In earlier calculations of the formula date for this site (Grange 1972; S. South 1972b), I used 1715 as the mid-range manufacture date for this type since these specimens at Castle Hill had characteristics of both middle and late styles (Grange 1972: 190). Cumulative seriation is not effective for a type represented only in a single site; in this case it would indicate a modal date of 1762. Another possible estimated mid-range date would be 1780, the arbitrary point of transition between the middle and late styles (Goggin 1964: 279). A compromise estimate for a mid-range date was obtained by taking the mid-point between 1715 and 1780, or a median date of 1748, for use in ceramic formula calculations. Any of these four alternative dates produces a reasonable formula date for the site, as does the alternative of omitting the type from date calculations. Present data do not permit an estimated modal date for the type. Calculations in this paper are based on the 1748 estimated date.

Type 49, 18th-century decorated delftware, has already been discussed; 1760 is selected as a modal date for the type in contrast to the 1750 assumed mid-range date (S. South 1972a: Fig. 1). In this and subsequent cases, the type number and mid-range dates are all taken from South (1972a: Fig. 1) and this citation will not be repeated.

Types 66, 65, 58 and 61 are too poorly represented to make an estimate of dates. Other types present only in Charlestowne (S. South 1972a) were not included in this study since the dates of that site do not overlap those used.

Types 39 and 26, Chinese porcelains, exhibit somewhat different patterns of popularity as represented in these sites. On the basis of cumulative frequency, it may be suggested that 1750 is a more appropriate estimate of a mean or a modal date than the 1730 mid-range dates. It is possible that the real peak of popularity of these types was as late as 1760 or 1770. Both continue to present some problems until more data are available. Until that time, I believe 1750 is an appropriate date to use for formula dating rather than to eliminate these types as South suggested (S. South 1972b: 217).

Type 56, combed slipware, appears to reach a mid-point of popularity about 1750; later than its 1733 mid-range date. The type is present in small quantity over a long period of time. A small amount of miscellaneous lead-glazed slipware is present at Fort Lennox. I have not specifically identified it yet and use the combed slipware mid-range date on a tentative basis.

Type 37, unglazed, sprigged refined red stoneware, is present in small relatively uniform percentages over a considerable period of time, the mid-point of which is about 1750 in contrast to its 1733 mid-range manufacture date.

British brown stoneware, type 54, is also present in fairly uniform percentages for a long period. The mid-point of its maximum cumulative frequency may be interpreted as about 1755, considerably later than its 1733 mid-range date.

Type 44, Westerwald stoneware, is also present over a long period of time. Its peak of popularity appears to be about 1755 although a date as late as 1765 could be argued. Either is later than its 1738 mid-range manufacture date.

Type 45, delft ointment pots with everted rims, is too poorly represented in the sample to revise South's 1750 median date.

Nottingham stoneware, type 46, appears to reach a peak in 1765 although it was not a common type in these sites. The 19th-century portion of this graph (Fig. 14) is based on shiny brown stoneware sherds from Fort Lennox contexts. These specimens lack the white slip layer typical of

Nottingham stoneware (Noël Hume 1970: 114) and perhaps should be graphed separately in the future.

Type 48 is too poorly represented for a date estimate.

The greatest cumulative frequency of Buckley ware, type 47, occurs at 1765 somewhat later than its median 1748 date.

Type 40, plain white salt-glazed stoneware, is interpreted as having a mid-point of cumulative frequency at 1765, very close to its 1763 mid-range date. In contrast, type 16, moulded white salt-glazed stoneware, is estimated at 1760, several years later than its 1753 mid-range manufacture date. In the case of this type, a peak of popularity may have been as late as 1785, but since that date is so much later than the termination of manufacture in 1765, I have selected a more conservative 1760 estimate. Future study may resolve this difficulty. Perhaps the grouping of all white salt-glazed stoneware types would be desirable.

The cumulative seriation graph shows an excellent peak at 1760 for type 36, "clouded" wares; slightly later than the median manufacture date.

Type 42 is too poorly represented for estimation.

Type 43, white salt-glazed stoneware plates, has already been discussed as one of the three example types with the 1758 mid-range being at the approximate point of maximum popularity.

The peak of popularity of Jackfield pottery, type 29, can be estimated at 1755 rather than at its 1760 mid-range date. The cumulative graph indicates, however, that 1760 is not far from the peak.

Scratch-blue white salt-glazed stoneware, type 34, appears to hit its peak at about 1760 which is also its mid-range date although there is some evidence of greater cumulative frequency as late as 1770. The later date may be more appropriate and should be studied further.

The peak in English porcelain, type 31, appears at 1760, some ten years earlier than the 1770 mid-range date.

Types 35 and 27 are too poorly represented for estimate. Type 33, green-glazed cream-bodied earthenware, shows its greatest density at 1767 which is also its median manufacture date.

Creamware, type 22, has already been discussed. Its peak of popularity, about 1770, is considerably earlier than its 1791 mid-range manufacture date. This type, more than any other, appears to have gained very rapid acceptance following its introduction.

Types 28, 24, 18 and 23 are too poorly represented for modal date estimation. As in other such cases, the mid-range dates should be used in formula dating.

Caneware, present at Fort Lennox, produces a graph partly consistent with its 1820 mid-range date calculated from a manufacture range from circa 1770 to 1870 (Hughes 1965: 50-51).

Type 15, lighter yellow creamware, produces a 1798 cumulative date, on evidence from two sites only, consistent with its 1798 mid-range date.

Type 21, debased Rouen faience is judged to be too poorly represented to alter its 1788 median manufacture date. If the cumulative graph were used, a date of about 1778 would be estimated.

A cumulative frequency date estimate of 1810 is suggested for type 17, underglaze blue hand-painted pearlware, rather than its 1800 mid-range date. Undecorated pearlware, type 20, shows a cumulative frequency peak at 1800, earlier than its 1805 mid-range point.

Type 19, blue and green shell-edge pearlware, also reaches a high point in its popularity about 1800, somewhat earlier than its 1805 mid-range date. The 1805 date is retained for miscellaneous pearlware specimens.

"Annular" decorated pearlware, type 13, appears in fairly constant percentage in the sites in this sample and the mid-point of its cumulative frequency is about 1810, somewhat later than the 1805 mid-range date.

Type 12, underglaze polychrome pearlware, may be interpreted as having a popularity mid-point about 1801 as opposed to a median manufacture date of 1805.

Willow pattern transfer-printed pearlware, type 10, is too poorly represented for certainty, but an estimate of 1825 rather than its median date of 1818 is suggested on the basis of long popularity. A modal estimate as late as 1835 could be made, but the sample is small.

Blue transfer-printed pearlware, type 11, is a common type with a popularity mid-point about 1813, somewhat earlier than the 1818 mid-range point.

The other later ceramic types (Fig. 19) are all represented only in Fort Lennox contexts and this is judged to be insufficient for cumulative date estimates at present. Additional Fort Lennox features to be examined later may add enough data to make some estimates. For all of these types, 1, 2, 3 and 6, the mid-range manufacture dates are retained for formula purposes.

The cumulative seriation study makes it possible to estimate popularity peaks for several of the ceramic types represented in this sample of sites. Table 2 serves as a summary of the modal date estimates. These may be either earlier than, later than or the same as the mid-range dates of manufacture.

(Table 2 is also an example of the worksheet I used in calculating modal date estimates. It should be noted that where modal type dates could not be calculated, the mid-range dates were used. The worksheet is arranged, as were the cumulative seriation graphs, with the types listed in the order of their initial manufacture dates. I find this more useful than arranging the types according to wares [porcelains, stonewares, etc.] or in the type numerical sequence as South [1972a] does. The order based on sequence of type introduction makes it possible to determine at a glance the missing types for South's interpreted date bracket method [S. South 1972a: Fig. 1] and readily provides an assessment of a site's chronological position.)

It has been suggested that, despite the false assumption of a unimodal curve for a ceramic type popularity, South's formula date method works (Stone 1972: 180; Walker 1972: 135). Such suggestions have speculated that the reason for this is that the variations between mean dates or modal dates and the mid-range dates is too small to greatly affect the calculations, that such deviations may cancel one another out, or both (Walker 1972: 135; Cleland 1972: 186). These evaluations appear to be correct. A comparison of the mid-range manufacture dates and estimated modal dates is presented in Table 3. Twenty-nine types for which modal dates can be estimated are listed in the tabulation. The difference between mid-range and modal dates is calculated. The range of the differences is from -21 to +22 years. Some 55.1 per cent of the types have a positive difference averaging 12.2 years, while 24.1 per cent of the types have a negative difference averaging -7.8 years. The remaining 20.7 per cent of the types show no difference between the median manufacture and estimated modal dates.

More significantly, the <u>mean of the differences</u> between the median or mid-range dates and the modal dates for these 29 types is 4.86 years. With a standard deviation of 10.34 years, a mean difference of this magnitude may be inconsequential in the calculation of ceramic formula dates except possibly in sites where certain types (creamware, for example) are heavily represented. This implies that the mid-range manufacture dates are not very different from the dates of modal popularity. On this basis I suggest that cumulative seriation, if it does nothing else, shows why South's formula dating method works so well.

A t-test of the difference between the means of the median type dates and the estimated modal type dates was calculated using an SPSS computer program (Nie et al. 1975: 267-75). The t-value of 2.53 with 28 degrees of freedom represents a significant difference between the means at the two-tailed probability of 0.017. Thus cumulative seriation has produced a small but significantly different date estimate for these 29 types. Further testing of the methods will be discussed later.

In addition to estimating dates of modal popularity, it is possible to compare the period of manufacture of ceramic types with their periods of popularity as determined by cumulative seriation. The graphs (Figs. 13-19) illustrate these comparisons and the comparative data are summarized in Table 4.

In the cumulative seriation graph it is possible to distinguish both a period of substantial popularity and a period of modal popularity. The latter is the period of greatest frequency of the "core" of the graph, within which the modal date is estimated. The period of substantial popularity is represented by the widest part of the outer boundary of the cumulative seriation graph. The period of substantial popularity is determined by inspection. The start and finish of these periods of substantial popularity and modal popularity can be compared with the period of manufacture by determining the differences between initial and terminal end points. These data are listed in Table 4.

Comparisons of manufacture period and popularity time ranges are expressed as numbers of years between given comparative points and are calculated as follows.

The time to reach substantial popularity (D-A) is the number of years elapsed between the initial manufacture date and the initial point in the period of substantial popularity.

The end of substantial popularity (E-B) is the number of years before (-) or after (+) the termination of manufacture.

The time to reach modal popularity (F-A) is the difference between the beginning of the modal period and the initial manufacture date.

The end of modal popularity (G-B) is the number of years before (-) or after (+) the termination of manufacture.

The time to reach modal date (H-A) is the number of years elapsed between the initial manufacture date and the estimated modal date.

The heirloom factor (I-B) is the number of years the latest cumulative seriation date falls after the termination of manufacture.

The modal date - mid-range manufacture date (H-C) is the difference in years between these two points.

These points of comparison are useful in the analysis and summarization of the results of cumulative seriation. Not all types can be included in this study. The best sample are those types whose period of manufacture is encompassed within the periods of occupation of the sites from which the ceramic data are drawn. Some types used in the study were manufactured long before the sites in the sample were occupied and the period of substantial popularity obviously cannot be determined for such types. Similarly, the period of manufacture for some types continues beyond the span of occupations present in the sample and neither substantial popularity nor modal periods can be estimated with the present sample. Other types are so poorly represented numerically in these sites that the validity of the data for broad comparative purposes might be questioned. The data in Table 4 are categorized with these limitations in mind.

It is also possible to group the data in Table 4 for the study of particular ware groups or other clusters of ceramic types. The results of such analysis are shown in Table 5 and the most important conclusions are summarized in Table 6 as well as being included in Table 4. These data are all expressed as means of differences in years.

As previously discussed for the total 29-type sample, one of the most significant results of this comparative study is the evidence that the difference between the mid-range manufacture dates and the estimated modal dates is not very large. Even more striking results are obtained from controlled type samples. The mean of the differences is only 0.9 years for the best sample of 19 types and is only 1.1 years for the 22 types in which the entire range of the manufacture period falls within the occupation span of the site sample. Mean differences for samples of 8 and 13 most popular types are -2.9 and -1.6 years respectively. These data support the conclusion that the average difference between modal and mid-range manufacture dates is so small that it is probably insignificant for most ceramic formula dating purposes. Although it is likely that modal date values will ultimately improve the level of accuracy for formula dating, the comparative data discussed here demonstrate that median or mid-range manufacture dates certainly can be used for formula dating purposes.

The comparison also reveals the close relationship between the period of manufacture of ceramic types and their periods of substantial and modal popularity. Means of the differences for various samples are listed in Tables 5 and 6.

These data can be interpreted as evidence that, on the average, ceramic types reached the beginning of a period of substantial popularity some 5.9 to 7.8 years after their initial manufacture date. Very popular types reached this point within 2.0 years, some possibly even during the first year of manufacture. Similarly, on the average, these ceramic types retained substantial popularity 10.6 to 20.3 years after the termination of manufacture while other types lost their popularity within 1.4 years of the terminal date or even before that point in time. Thus, the general period of substantial popularity began but a few years after the initial manufacture and lasted for only a few years after manufacture ceased.

The correlation of the period of modal popularity and the range of manufacture is also close. The modal period for most ceramic types appears to begin between 14.5 and 27.8 years after the start of manufacture while the time interval is close to eight or nine years for very popular types. Some types reached their modal period close to or during the initial manufacture year. The end of the period of modal popularity consistently appears to occur <u>before</u> the terminal year of manufacture although substantial popularity may continue after that point as already discussed. The end of the modal period is from 6.9 to 9.4 years <u>before</u> termination of manufacture in most of the sample categories.

Thus the period of modal popularity is consistently within the period of manufacture while substantial popularity is also closely correlated with the manufacture range dates. For this sample of New World sites, it therefore appears that the horizon aspect of the ceramic types is evident. Popularity periods are correlated with periods of manufacture and, on the average, English ceramics exhibit a broad and rapid spread in the New World. South asserted these characteristics on other evidence (S. South 1972a: 76) and these data confirm his conclusions.

The heirloom factor and its effect on the ceramic formula dating method has been questioned by some (Walker 1972: 134). The cumulative seriation graphs show that the heirloom factor does exist, but such sherds are few in quantity and do not appear to greatly affect ceramic formula dates. A comparison of the latest cumulative seriation date with the terminal manufacture date can be used to establish an heirloom factor. The range of heirloom dates is from 1 to 110 years (discounting the negative values for poor sample types) and the means of the differences or heirloom values for the best samples fall between 44.5 and 58.1 years. An heirloom factor of about 50 years would be a reasonable estimate.

The most popular types, as measured by the time required to reach substantial or modal popularity, appear to be white salt-glazed stonewares, creamwares and pearlwares. These data are recorded in Table 5.

Inspection of the modal periods of popularity in Figures 13-19 reveals a tendency for groups of ceramic types to have similar periods of modal popularity within loose limits. Types in such clusters of modal popularity may represent horizon complexes of ceramic types. Five such clusters or groups can be identified in Figures 13-19. Data concerning these groupings is also included in Table 5.

The first such horizon group consists of types which exhibit modal popularity in the period 1730-75. These types are:

49 18th-century decorated delftware
39 Chinese blue/white porcelain
26 Chinese porcelain
56 Combed slipware

37 Red stoneware

54 British brown stoneware

44 Westerwald salt-glazed stoneware

The second horizon group consists of types with modal popularity ranges in the period 1755-75. These are:

47 Buckley ware

40 White salt-glazed stoneware, plain

16 White salt-glazed stoneware, moulded

43 White salt-glazed stoneware plates

36 "Clouded" wares

31 English porcelain

29 Jackfield ware

A third period cluster of types are those with modal periods between 1760 and 1780+. These are:

33 Green-glazed cream-bodied earthenware

46 Nottingham stoneware

22 Creamware

A fourth horizon group of types having modal popularity in the 1730-1830 period are:

19 Blue and green shell-edge pearlware

15 Lighter yellow creamware

17 Hand-painted pearlware (blue)

20 Undecorated pearlware

13 "Annular" pearlware

12 Polychrome painted pearlware

11 Blue transfer-printed pearlware

The fifth such period cluster would include types within the 1820-75 time range on the cumulative seriation charts. These are insufficiently represented for the calculation of modal period data. The types in this group are:

2 Whiteware

1 Brown stoneware bottles

3 Ironstone

It is obvious from the above list that there appear to be some major ware categories associated with broad temporal periods. These may prove to be useful horizon markers.

An examination of the dates of introduction (initial manufacture) of the types included in these groups based on modal popularity indicates a general correspondence, with few exceptions, and a lag in the period of popularity as one might expect (see Table 7).

Three more inclusive ceramic periods can also be defined by combining some of the five groups discussed above.

These clusters of types may represent major horizon type groups in these New World sites. The groups are summarized in Table 8.

Such observations are by no means new, but they may have some interest because they are based on a graphic cumulative seriation analysis and because they illustrate the degree of correspondence between these seriation data and previous knowledge of type popularity.

The periods represented by ceramic types grouped according to their modal popularity time ranges may have some value as a rough estimate of the period of site occupation. In Table 9 the percentage of pottery specimens from several sites is listed by these ceramic horizon groups. A site date modal period can be estimated from these data and compared to the known occupation span of the site in the sample. The site modal period is the modal popularity period of the grouped type cluster in which more than 50 per cent of the site sample is found. In some cases it is necessary to combine ceramic clusters to arrive at these site occupation estimates. Comparison of the known occupation period is illustrated in the table. There is a reasonable correlation between the known occupation spans and the popularity period of type clusters which have 50 per cent or more of the ceramic specimens from the site. This method of estimating the site occupation spans is not as accurate as South's date bracketing method, but may be useful as a quick means of estimating an approximate period within which a site occupation probably falls. This is particularly true if the ceramic type tabulation sheet is arranged with types in chronological order and grouped in sequence by cluster as on the work sheet shown in Table 2.

Taking Fort Moore as an example, almost 80 per cent of the pottery from the site is represented by the complex of types which have their modal popularity in the 1730-75 period. Percentage data used in Table 9 is based on South's sherd counts (1972a) as summarized in Table 1 in this paper.

Testing Cumulative Seriation and Modal Dates

Cumulative seriation has been used to compare the relationships between periods of manufacture of ceramic types and the periods when those types were most popular in a small sample of North American sites. Modal popularity dates have been estimated for several ceramic types. It is not suggested that these estimated modal dates should be regarded as final, but rather that cumulative seriation is a method which can be used to produce such estimates. It is desireable to attempt to test the validity of this new method and formula dates based on the modal type estimates will be used for that purpose.

Walker (1972: 132) suggested that modal dates might produce more accurate site dating results if they were available. A test of the cumulative seriation method can be made by comparing modal site date results with those obtained by using South's median manufacture dates. It has already been shown above that there is a small but significant difference between the type median and modal dates for the 29 types for which the latter estimate could be made. Using significantly different factors in the ceramic formula could be expected to produce significantly different site dating results unless the estimated modal dates do have some valid relationship to the historical popularity of the types in question. If the modal dates are correct and the site dating results are better than, or at least as good as, site dating by median factors, then it may be argued that the cumulative seriation method must be a reasonable way to make estimates of modal dates for ceramic types. For this purpose dates have been calculated for the same series of sites South used in his analysis.

Table 10 lists the names of the sample sites, their known historic occupation ranges and their median or mid-occupation date. The latter is the expected date with which results of formula dating are compared. The 16 sites are the ones South used in his final refinement of the formula dating correction he developed (S. South 1972b: 215-7). Table 10 also lists the ceramic formula dates for the sample sites calculated by various methods. The first series of site dates, median unadjusted, are those which represent the dating results with the median manufacture date for each type and no correction or adjustment of the formula date result. It should be noted here that the median type dates presented by South do not represent the true mid-range manufacture dates for all types. In some cases the "manufacture" period listed by South was adjusted to reflect an assumed lag in importation and/or the absence of archaeological evidence verifying the "early" presence of some ceramic types in America (Ferguson 1975: 14). Corrections such as the one introduced by Ferguson would alter the median unadjusted site dates but the reason for not attempting to control this factor by making such corrections has already been discussed.

South concluded that the formula date approximation of the expected mid-occupation site date would be improved by adjusting the formula (S. South 1972b: 217): Chinese porcelain ceramics are omitted from the calculation and the calculated date is reduced by one year (-1.0). Dates calculated with this adjustment are listed in Table 10.

Table 10 also lists dates calculated by a different adjustment: where possible, modal type dates derived from cumulative seriation are employed. It should be noted that

Chinese porcelains are included in the calculation and there is no alteration of the date generated by the formula. One qualification should be noted; where types for which no modal date has been estimated are present in a site, the median type date is used in the formula with the sherd counts of such types. Thus most "modal" dates include some median type date factors. Possible control of this variable is discussed in a test described later.

All three types of formula dates, median unadjusted dates, median dates adjusted by South's method and dates adjusted by modal type factors, exhibit significant correlations with the expected mid-occupation dates of the 16 sample sites.

Pearson correlation coefficients were calculated by means of an SPSS computer program (Nie et al. 1975: 276-87) with the results shown in Table 11.

It is clear that there is a high correlation of the ceramic formula dates with the expected mid-occupation dates for these sites regardless of the type date adjustment method. South's median adjusted dates have the highest correlation but all are significant. Samples with more than the original 16 sites show similar results except that the modal date adjustments produce the highest correlation coefficient.

Another comparative test can be made by testing the significance of mean differences between the dating results and the expected dates with the t-test. South used this approach in developing the -1.0 year adjustment for median dates (D. South 1972: 168; S. South 1972b: 216-8). A tabulation of t-test results for various formula date adjustments with the expected dates is shown in Table 12. The t-test was performed by means of the SPSS program cited earlier and statistical tables in Hays and Winkler (1971: 875) were consulted for the appropriate critical values of t.

If the unadjusted median site dates are not accurate, we would expect to find a significant difference between the means of those site dates and the expected mid-occupation dates. As seen in Table 12, the t-value found is -2.68 and the difference between the means is probably a significant one. Therefore some kind of adjustment of the formula dating method is desireable as South demonstrated earlier.

South's adjustment (1972b: 217), as previously noted, omits the Chinese porcelains and subtracts one year from the result to arrive at the formula date. If this adjustment is effective, we would anticipate a significant difference between the mean of the adjusted dates and the unadjusted dates. In Table 12 it will be seen that the t-value of 4.25 represents a significant difference between these means and this supports South's adjustment as an effective one.

The alternative adjustment using the modal type date factors proposed here would also be expected to produce a significantly different result compared to the unadjusted median dates. The t-value 2.18 shown in Table 12 indicates that the difference between these means is probably not due to chance. The modal date adjustment also appears to be effective.

Both the adjusted median and the modal dates can be compared with the expected mid-occupation dates for the sites. If these methods of formula date adjustments are effective we would expect that differences between the means of the formula dates and the expected dates would not be significant.

The t-value in Table 12 for the median adjusted dates, -0.01, and the associated probability indicate that the mean difference between South's adjusted dates and the expected dates is probably due to chance. The difference is not significant.

Similarly the t-value, -0.14, for the mean difference of modal dates and the expected site dates is probably due to chance. Since there is no significant difference when compared to the expected results, the modal date adjustment appears to be an effective one.

A final comparison of the modal date and median adjusted date differences, shown in Table 12 with a t-value of -0.12, indicates that there is no significant difference between the two adjustments.

In terms of the expectations and tests outlined above, the modal date adjustment works as well as the median date adjustment. It was argued earlier that such a conclusion would imply that the modal popularity dates estimated for the ceramic types used in the modal formula calculations were reasonably correct estimates. That, in turn, implies that the cumulative seriation method used to make the modal type date estimates is a valid approach to the problem.

It is not contended here that the modal popularity dates presented are final estimates, but rather than the method outlined, if used with better site data, can be used to make estimates of ceramic popularity. In cumulative seriation we then may have the method Walker called for in his comments on South's formula dating paper (Walker 1972: 132).

Walker in fact suggested that better date factors might produce better site dating results. The tests above show no significant difference; modal dates are not better. It was mentioned above that many of the modal site dates include some median factors since not all ceramic types have an estimated modal date, in which case the median type date is used in the formula. Therefore the modal dates discussed above do not reflect "pure" modal adjustment. Control of this factor is possible.

Six sites where all types used in dating have modal date estimates are available. They are listed in Table 13. The t-test results pertaining to this sample are shown in Table 14. If modal dates were better predictors of the known mid-occupation dates we might expect significant difference in the means, but this is not the case. The differences are probable due to chance.

A larger sample of sites with less than 100 per cent of the sherds from modal dated types is also available as shown in Table 13. Thirteen sites with 4.0 per cent or less of the total sherds from non-modal estimate types can be seen in the list. This includes Fort Ligonier, not one of the original 16-site sample. The last four sites with 10.0 per cent or more median date factors in their modal site dates are eliminated from consideration. Table 14 shows the results of the t-test for the larger 13-site sample. Again there is no significant difference between the results of the median adjustment and the modal dates.

At present the modal type factor does not appear to produce better site dating results than South's median adjustment, unless the inclusion of Chinese porcelain in the modal date calculation is seen as an advantage. Thus far only 29 types have modal date estimates; results might be better if more types had such date estimates and a larger sample of dated sites was utilized. The significant point is not, however, whether modal dates are better than South's median adjustment, but that they are not significantly different and therefore that the cumulative seriation method is a valid approach to the problem of ceramic type popularity curve estimates.

Formula Dating As Seriation

Although South regards ceramic formula dating as producing historical rather than relative dates because it is based on historical chronology (S. South 1972a: 76), the formula method can be viewed as a special method of seriation (Grange 1972). Formula dating involves the multiplications of the number of sherds of a type by the mid-range date of the type and the division of the sum of such products by the total number of sherds (S. South 1972a: 83). These calculations can be made in another sequence. The number of sherds of a given type divided by the total number of sherds is simply the calculation of a percentage for a given type; this is the basic mathematical operation in a standard seriation. Multiplication by the mid-range date is then a correction of the percentage by a type date factor. Hence formula dating is a form of seriation calculation involving a chronological correction which permits the expression of relative site position in terms of years rather than only in relative time. This is not a criticism of the method; this is precisely the feature which makes it so useful. However, it is still producing a date which, like C-14 dates, is not an historical date but a chronometric estimate of the probable date. Fitting (1972: 161) suggested the standard deviation should be calculated for ceramic formula dates and I have found this to be very useful in more detailed site dating analyses (Grange 1974b; 1974c; 1975a; 1975b). Anyone who has done seriation with long strips of paper (Ford 1972: 42; Deetz 1967: 28, Fig. 4) will discover that the ceramic formula dating method is considerably more efficient at establishing the basic site or unit sequence. As a seriation-chronological tool it is very useful.

Figure 20 illustrates standard seriation graphs with site sequences based on ceramic formula dates. The upper three graphs, again using the three illustrative types, 49, 43 and 22, are based on South's formula dates for the sites. The lower bar graph illustrates the site sequence based on formula dates using the modal date correction. The latter sequence produces a more conventional unimodal curve for creamware than does the former. However, one could argue that the upper graph for creamware is the more accurate reflection of the popularity pattern for this type which was adopted with great rapidity upon its introduction.

The curve for 18th-century delftware is about the same for both graphs. The order based on South's dates produces a smoother, more conventional curve in white salt-glazed stoneware plates than does the modal correction graph. The standard seriation results are similar for both sequences and either would be acceptable if the site dates were unknown.

Thus both the mean dates and standard seriation graphs show that the results produced by calculations based on the modal type dates compare favourably with those based on South's original median type dates.

I have also made use of the formula dating method in the interpretation of various excavation units in Fort Lennox National Historic Park, Quebec. I have tested both median adjusted dates and modal adjusted dates there. Due to the later date of some of these occupations, numerous ceramic types not included in the cumulative seriation study were used in dating. In the case of these types I have not used cumulative seriation to estimate the modal popularity factors: instead, where possible, I have estimated modal popularity from the assessments of other researchers in various publications. Those extensive data cannot be repeated here, nor will the sherd counts. All of these data are in reports on the work at Fort Lennox (Grange 1974b; 1974c; 1975a; 1975b).

A summary of the expected dates and the formula dates for a series of selected fill zones, refuse layers and occupation floors are shown in Table 15.

Both median adjusted dates and modal dates for these units were compared with the expected dates. The results of t-tests of the differences between the observed and expected values shows no statistically significant difference between the median and the modal dating results, and differences from the expected dates in both cases are probably due to chance. Again, the modal dating method works as well as but not better than the median adjustment approach. Formula dating has been a useful tool in dating and seriating archaeological features at Fort Lennox. The formula dates can be used to arrange the excavation units in approximately the same sequence as that of the expected mid-occupation dates, especially when the overlapping, simultaneous nature of many of these occupations are taken into account. It should be noted that some of the expected mid-occupation dates - that of the McVey house, for example - are only approximations, the exact historical dates of the structure being unknown. I have used formula dating and other methods to estimate the date of such occupations (Grange 1975b) and it is in the analysis of sites or excavation units of unknown date that formula dating and seriation are most useful.

I believe that when cumulative seriation can be applied to 19th-century site data, more accurate modal type dates can be estimated for more types and possibly the formula dating results might be improved. At present, however, the evidence suggests that the median date factors will work very well, as do the modal adjustments where they can be made.

Other Applications of Cumulative Seriation

It is reasonable to suggest that regional, site, functional or social differences in ceramic utilization at different sites might result in different ceramic formula dates. Indeed, Ferguson has shown such a difference between two areas within Fort Watson (Ferguson 1975). As a check on such possible regional or functional variations, the t-test was employed to evaluate differences in dating results for controlled groups of sites. Military sites in the sample from the southeast were compared with those from the northeast, civilian sites were contrasted with military sites within the southeast and all military sites in the sample were compared with all civilian sites. The units in this comparison included Fort Ligonier (Grimm 1970) and two excavation units from Fort Lennox as well as the original 16-site sample.

No significant differences were found when the results of modal and median adjusted dates were compared with one another and with the expected site dates. This is not a surprising result since it has already been shown that such method differences produced no significant differences in the total site sample.

It is more likely that any differential in ceramic popularity of a regional or functional character would be revealed by some other method of analysis such as seriation.

Seriation graphs have most commonly been employed to place sites in chronological sequences. Such graphs can also reveal much of the dynamics of culture change. Plog has noted the neglected value of seriation technique in studies of culture change (Plog 1973: 191-2). In historical archaeology where site dates are frequently known, this graphic method of depicting culture change should be used more than it has been. One of the basic problems in using seriation diagrams for the study of culture dynamics is the distortion of the seriation curves by depicting long overlapping site occupations as single bars in a graph as discussed earlier in this paper. Cumulative seriation offers some control of these factors and should therefore be useful in producing seriograms which reflect more accurately the pattern of change through time.

An attempt to apply cumulative seriation for this purpose was made by comparing cumulative seriation graphs for groups of sites based on region and site function. Northern military sites in the sample were graphed separately from southeastern military sites, as were civilian sites in the southeast. Thus reduced from the total sample, the data were sufficient only for the comparison of six major ceramic types. Modal popularity for these ceramics was reached an average of 5.8 years later in the northern military sites than in the southeastern ones, and 13.3 years later than in southeastern civilian sites. The possibility of culture lag in the northern sites is seen in this trial.

Examination of a single ceramic type may be useful as an illustration. The period of modal popularity of creamware in the northern group of sites was 1770 to 1780 in contrast to 1763 to 1768 for the southeastern regional sample. The modal year for this type was estimated at 1775 for the northern group in contrast to 1766 in the southeast. Thus creamware appears to have become more popular more quickly in the southeast than in the north.

This test of cumulative seriation as a method of comparative analysis is mentioned to indicate the possibility of detecting different ceramic popularity dynamics on a regional or functional basis with the technique. However, I believe the present sample of sites and sherd counts to be too small for effective study and thus have not included these regional cumulative seriation graphs in this paper. The differences noted above may only reflect the dates of the sites readily available for study and a better sample is needed before analysis would repay the effort. The case is cited to illustrate the potential of the method; cumulative seriation could be more important for this purpose than for the refinement of formula dating factors.

Summary and Conclusions

This project began as part of a comparative study of the ceramics recovered in excavations at Fort Lennox National Historic Park, Quebec, in an effort to devise a ceramic chronology for dating and seriation of features excavated at the site.

South's ceramic dating formula method was employed as one of the methods of analysis. Various comments on South's method indicated that better dating results might be obtained if dates of modal popularity of the ceramic types were available instead of the mid-range of the manufacture period dates used in the dating formula. An effort was made to determine modal type dates. Standard seriation proved ineffective due to the fact that the standard method obscures overlapping site occupations.

Cumulative seriation is a new technique devised as a means of resolving this problem. Cumulative seriation is a graphic method in which the height of the bars on the seriation graph are used to reflect site chronology while their width reflects type percentage frequency. Long occupations overlap one another on the graph and the cumulative density effect resulting from the overlaps reveals the period of modal popularity of the ceramic type. Cumulative seriation resulted in the definition of periods of substantial popularity, modal popularity and estimated modal dates for 29 ceramic types based on a 16-site sample used by South in his original study. These modal date factors were used in the ceramic dating formula to calculate site dates as a means of testing the effectiveness of the cumulative seriation method.

South assumed a normal curve for the popularity of ceramics (S. South 1972a: 73). Walker suggested that other curves would be expected (Walker 1972: 132) and modal or other type dates could be used in formula dating if we had a method of estimating such dates. He went on to say:

> If these objections have any validity then why are South's dates as derived from his formula so accurate for apparently the whole of the eighteenth century? The answer is very likely that the potential variables noted above are either too small to alter things substantially, or that they cancel each other out, or that both contribute (Walker 1972: 135).

Cumulative seriation estimates of the popularity curves for ceramics demonstrated some non-normal curves for some types, creamware being the most notable and extreme example. Its peak of popularity came rapidly and was reached soon after its introduction, followed by a long period of decline. For the 29 types for which such estimates could be made, it was found that the modal popularity dates are the same as, earlier than and later than the median manufacture range dates for the types. The mean of the differences is small, 4.86 years, but statistically significant. However, other tests show that the modal adjustment does not make significant differences in formula dating results. Cumulative seriation then has been used to show that although not all types have a normal curve of historical popularity, the deviations are not sufficient to alter the formula dating results, just as Walker speculated. If nothing else, this cumulative seriation analysis has shown why South's method works so well.

Comparison of dating results has shown that the ceramic formula dates generated with modal type dates are as effective as those achieved with South's original method of adjustment; any differences in the dates produced by the two methods are probably due to chance. This has been used here to support the contention that cumulative seriation works as a method of exploring ceramic type popularity since erroneous modal dates would have been expected to greatly distort the ceramic formula dates for the test sites.

Although the modal date adjustment method is probably as effective as the approach South used, it has not been shown that modal site dating is any better; either adjustment method may be used for site dating with statistically equivalent results. One possible advantage to the modal correction factors is that, unlike South's median date method, Chinese porcelains can be included in the calculations and no -1.0 year correction is needed.

No regional or functional differences in site dating by median adjusted or modal formula dates was detected in the small sample of sites used in this analysis although such variations are anticipated. Cumulative seriation was tried as a technique for regional/functional comparison and some differences in the dates at which some ceramic types became popular were noted when northern and southeastern sites were compared. The sample used is too small for reliability and further study of this matter using cumulative seriation should be undertaken in the future with more data. What is perhaps worth noting is that cumulative seriation may be a useful tool for the comparative study of ceramic popularity, given the advantages of historical archaeology where site dates are often known.

It is not contended that the periods and dates of modal popularity of ceramic types presented here are final estimates. They may be used provisionally as long as the limitations of this study are understood. Most importantly, the method of analysis described here may be used for further refinement of such ceramic popularity curves and to develop modal popularity estimates for more ceramic types. With dates for more than 29 types and data from more sites improved formula dating might result.

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TABLES

Table 1. Tabulation of Ceramic Types, Sherd Counts and Percentages, by Site*

Sites†		Spanish Olive Jars	49. 18th-C Decorated Delftware	66. Deter. Bellar-mine Face Bottle	65. Plain White Delftware	58. Rhenish Decora-ted Stoneware	61. North Devon Gravel-Tempered	39. Chinese Under-glaze Blue Porcelain	26. Chinese Over-glaze Export Porce-lain	56. Lead-Glazed Combed Yellow Slip-ware	Misc. Lead-Glazed Slipware
First Fort Moore, 38AK4-15	No		64	39			42	38	1	16	
South Carolina	%		26.0	15.9			17.1	15.4	0.4	7.3	
Fort Moore, 38AK5-A	No.		17					18	1	4	
South Carolina	%		26.2					27.7	1.5	6.1	
Brunswick Town, S-15	No.		485					418	54	330	
North Carolina	%		21.6					18.6	2.4	14.7	
Fort Dobbs	No.		85					87			
North Carolina	%		31.6					32.3			
Goudy's Trading Post at	No.		1								
96, Cellar, 38GN1. S.C.	%		14.3								
Brunswick Town, N-1	No.		89					17	1	14	
North Carolina	%		42.0					8.0	0.5	6.6	
Brunswick Town, S-2	No.		373					103	14	91	
North Carolina	%		38.1					10.5	1.4	9.3	
Brunswick Town, S-7	No.		583					241	62	286	
North Carolina	%		25.8					10.6	2.7	12.6	
Fort Prince George	No.		123					68	25	21	
South Carolina	%		14.4					8.0	2.9	2.5	
Ft. Michilimackinac, Mich.	No.		18					26			
Feature 262, 265, 267, 297	%		15.8					22.8			
Ft. Michilimackinac, Mich.	No.		25		1			41			
Feature 296	%		16.7		0.7			27.3			
Paca House	No.		5					2			
Maryland	%		11.4					4.5			
Brunswick Town, S-18	No.		137					28	8	15	
North Carolina	%		15.8					3.2	0.9	1.7	
Castle Hill	No.	172	39					23			10
Newfoundland	%	16.2	3.7					2.2			1.0
Trebell Site Cellar	No.					1		50	101	1	
Virginia	%					0.1		4.2	8.6	0.1	
Brunswick Town, S-10	No.		16					37	13	56	
North Carolina	%		3.2					7.3	2.6	11.1	
Tellico Blockhouse	No.										
Tennessee	%										
Fort Lennox: Ditch Fill	No.		1					5	1	1	10
Quebec	%		0.1					0.8	0.1	0.1	1.6
Fort Lennox: Fill Above	No.		3					3	3	1	41
Ditch. Quebec	%		0.1					0.1	0.1	0.05	2.1
Fort Lennox: Ditch Fill,	No.										
5G49. Quebec.	%										

Table 1. Continued

Sites†		37. Refined Red Unglazed Stoneware	54. British Brown Stoneware	44. Westerwald Stamped Stoneware	45. Everted-Rim Plain Delft Ointment Pot	46. Nottingham Stoneware Lustred	Lustrous Brown Stoneware	48. Slip-Dipped White Salt-Glazed Stoneware	13. "Annular Wares" Pearlware	12. Underglaze Polychrome Pearlware	10. Willow Transfer Pearlware	11. Blue Transfer-Printed Pearlware	6. Mocha	9. Embossed Pearlware	Ironstone: Turner
First Fort Moore, 38AK4-15	No	1	4					1							
South Carolina	%	0.4	1.6					0.4							
Fort Moore, 38AK5-A	No.	2	6	4											
South Carolina	%	3.1	9.2	6.1											
Brunswick Town, S-15	No.	23	79	68		3						1			
North Carolina	%	1.0	3.5	3.0		0.1						0.1			
Fort Dobbs	No.														
North Carolina	%														
Goudy's Trading Post at	No.			1											
96, Cellar, 38GN1. S.C.	%			14.3											
Brunswick Town, N-1	No.		1	6											
North Carolina	%		0.5	2.8											
Brunswick Town, S-2	No.	5	31	45					3			1			
North Carolina	%	0.5	3.2	4.6					0.3			0.1			
Brunswick Town, S-7	No.	40	52	40											
North Carolina	%	1.8	2.3	1.8											
Fort Prince George	No.		16	15	72	10									
South Carolina	%		1.9	1.8	8.5	1.2									
Ft. Michilimackinac, Mich.	No.														
Feature 262, 265, 267, 297	%														
Ft. Michilimackinac, Mich.	No.														
Feature 296	%														
Paca House	No.	1		4		1									
Maryland	%	2.3		9.1		2.3									
Brunswick Town, S-18	No.	3	10	7								1			
North Carolina	%	0.3	1.1	0.8								0.1			
Castle Hill	No.		88	17		1	2								
Newfoundland	%		8.5	1.6		0.1	0.2								
Trebell Site Cellar	No.		71	1		2			25	62		88	5		
Virginia	%		6.0	0.1		0.2			2.1	5.3		7.5	0.4		
Brunswick Town, S-10	No.		15	12					32	44		136			
North Carolina	%		3.0	2.4					6.2	8.7		27.0			
Tellico Blockhouse	No.								1	111	6	23	1		
Tennessee	%								0.1	18.6	1.0	3.8	0.1		
Fort Lennox: Ditch Fill	No.		1						30	30	5	31	3	3	1
Quebec	%		0.1						4.8	4.8	0.8	4.9	0.5	0.5	0.1
Fort Lennox: Fill Above	No.						14		29	77	11	162	4	9	
Ditch. Quebec	%						0.7		1.5	3.9	0.6	8.2	0.2	0.4	
Fort Lennox: Ditch Fill,	No.								1	3		3			
5G49. Quebec.	%								2.6	7.9		7.9			

Table 1. Continued

Sites†		3. Ironstone and Granite China	47. Buckley Ware	40. White Salt-Glazed Stoneware	16. Moulded White Salt-Glazed Stoneware	36. "Clouded" Wares	42. Refined Agate Ware	43. White Salt-Glazed Stoneware Plates	29. "Jackfield" Ware	34. Scratch-Blue White Salt-Glazed Stoneware	31. English Porcelain	35. Coarse Agate Ware	27. Black Basaltes Stoneware	33. Green-Glazed Cream-Bodied Ware	22. Creamware
First Fort Moore, 38AK4-15	No							35	1						2
South Carolina	%							14.2	0.4						0.8
Fort Moore, 38AK5-A	No.							13							
South Carolina	%							20.0							
Brunswick Town, S-15	No.		52				1	532	63			2		37	96
North Carolina	%		2.3				0.1	23.7	2.8			0.1		1.6	4.3
Fort Dobbs	No.			24		6			18	45	4				
North Carolina	%			8.9		2.2			6.7	16.7	1.5				
Goudy's Trading Post at	No.							3	2						
96, Cellar, 38GN1. S.C.	%							42.8	28.6						
Brunswick Town, N-1	No.		2					64	7	8				3	
North Carolina	%		0.9					30.2	3.3	3.8				1.4	
Brunswick Town, S-2	No.		112			3		136	12	4				4	41
North Carolina	%		11.4			0.3		13.9	1.2	0.4				0.4	4.2
Brunswick Town, S-7	No.		28			55		327	9	32				25	483
North Carolina	%		1.2			2.4		14.4	0.4	1.4				1.1	21.3
Fort Prince George	No.		2	4		6		127	12	2	78			1	255
South Carolina	%		0.2	0.5		0.7		14.9	1.4	0.2	9.2			0.1	30.0
Ft. Michilimackinac, Mich.	No.			19				16			2				31
Feature 262, 265, 267, 297	%			16.7				14.0			1.7				27.2
Ft. Michilimackinac, Mich.	No.			12				3		4					59
Feature 296	%			8.0				2.0		2.7					39.3
Paca House	No.		3			1		9		1	2				14
Maryland	%		6.8			2.3		20.4		2.3	4.5				31.8
Brunswick Town, S-18	No.		4			8		73		11				6	558
North Carolina	%		0.5			0.9		8.4		1.3				0.7	64.2
Castle Hill	No.			162	36			12	1		3				473
Newfoundland	%			15.6	3.5			1.1	0.1		0.3				45.5
Trebell Site Cellar	No.														
Virginia	%														
Brunswick Town, S-10	No.		2					21						10	17
North Carolina	%		0.4					4.2						2.0	3.4
Tellico Blockhouse	No.										7				
Tennessee	%										1.2				
Fort Lennox: Ditch Fill	No.	48	3	3	3	4					11		1	4	94
Quebec	%	7.6	0.5	0.5	0.5	0.6					1.7		0.1	0.6	15.0
Fort Lennox: Fill Above	No.	250	1		1	2			3		50				158
Ditch. Quebec	%	12.6	0.05		0.05	0.1			0.1		2.5				8.0
Fort Lennox: Ditch Fill,	No.														6
5G49. Quebec.	%														15.8

Table 1. Continued

Sites†		28. Engine-Turned Unglazed Red Stoneware	24. Debased Scratch Blue Stoneware	18. Overglazed Hand-Painted Creamware	23. Transfer-Printed Creamware	Caneware	15. Lighter Yellow Creamware	21. Debased Rouen Faience	17. Underglaze Blue Hand-Painted Pearlware	20. Undecorated Pearlware	19. Blue and Green Edged Pearlware	Red Shell-Edge Pearlware	Blue Banded-Edge Pearlware	Misc. Colour Transfer-Printed Pearlware	2. Whiteware
First Fort Moore, 38AK4-15	No														
South Carolina	%														
Fort Moore, 38AK5-A	No.														
South Carolina	%														
Brunswick Town, S-15	No.														
North Carolina	%														
Fort Dobbs	No.														
North Carolina	%														
Goudy's Trading Post at	No.														
96, Cellar, 38GN1. S.C.	%														
Brunswick Town, N-1	No.														
North Carolina	%														
Brunswick Town, S-2	No.														
North Carolina	%														
Brunswick Town, S-7	No.														
North Carolina	%														
Fort Prince George	No.	2						12							
South Carolina	%	0.2						1.4							
Ft. Michilimackinac, Mich.	No.							2							
Feature 262, 265, 267, 297	%							1.7							
Ft. Michilimackinac, Mich.	No.			2	2			1							
Feature 296	%			1.3	1.3			0.7							
Paca House	No.								1						
Maryland	%								2.3						
Brunswick Town, S-18	No.														
North Carolina	%														
Castle Hill	No.														
Newfoundland	%														
Trebell Site Cellar	No.	6	3				434		19		309				
Virginia	%	0.5	0.2				36.8		1.6		26.2				
Brunswick Town, S-10	No.								1		47				45
North Carolina	%								0.2		9.3				8.9
Tellico Blockhouse	No.				7		116		71	154	101				
Tennessee	%				1.2		19.4		11.9	25.7	16.9				
Fort Lennox: Ditch Fill	No.					6			15	69	26		1	45	150
Quebec	%					0.9			2.4	11.0	4.1		0.1	7.2	23.9
Fort Lennox: Fill Above	No.					46			13	72	63	1		86	606
Ditch. Quebec	%					2.4			0.6	3.6	3.2	0.05		4.3	30.6
Fort Lennox: Ditch Fill,	No.									3	11				11
5G49. Quebec.	%									7.9	28.9				28.9

Table 1. Continued

Sites[†]		1. Brown Stoneware Bottles	Brown Stoneware Containers	Ironstone: St. Johns, P.Q.	Ironstone: Dunn, Bennett & Co.	Total
First Fort Moore, 38AK4-15	No					246
South Carolina	%					99.9
Fort Moore, 38AK5-A	No.					65
South Carolina	%					99.9
Brunswick Town, S-15	No.					2245
North Carolina	%					99.9
Fort Dobbs	No.					269
North Carolina	%					99.9
Goudy's Trading Post at	No.					7
96, Cellar, 38GN1. S.C.	%					100.0
Brunswick Town, N-1	No.					212
North Carolina	%					100.0
Brunswick Town, S-2	No.					978
North Carolina	%					99.8
Brunswick Town, S-7	No.					2263
North Carolina	%					99.8
Fort Prince George	No.					851
South Carolina	%					100.0
Ft. Michilimackinac, Mich.	No.					114
Feature 262, 265, 267, 297	%					99.9
Ft. Michilimackinac, Mich.	No.					150
Feature 296	%					100.0
Paca House	No.					44
Maryland	%					100.0
Brunswick Town, S-18	No.					869
North Carolina	%					99.9
Castle Hill	No.					1039
Newfoundland	%					99.9
Trebell Site Cellar	No.					1178
Virginia	%					99.9
Brunswick Town, S-10	No.					504
North Carolina	%					100.0
Tellico Blockhouse	No.					598
Tennessee	%					99.9
Fort Lennox: Ditch Fill	No.	7	15			627
Quebec	%	1.1	2.4			99.4
Fort Lennox: Fill Above	No.	31	151	6	83	1981
Ditch. Quebec	%	1.6	7.6	0.3	4.2	99.8
Fort Lennox: Ditch Fill,	No.					38
5G49. Quebec.	%					99.9

Table 1. Continued

*Numbered types from South (1972a: Fig. 1).

†Site data and sherd counts from the following sources:

First Ft. Moore: S. South 1972a: 110
Ft. Moore: S. South 1972a: 111
Brunswick Town S-15: S. South 1972a: 113
Ft. Dobbs: S. South 1972b: 211
Goudy's Cellar, 96: S. South 1972a: 111
Brunswick Town N-1: S. South 1972a: 113
Brunswick Town S-2: S. South 1972a: 114
Brunswick Town S-7: S. South 1972a: 89
Ft. Prince George: S. South 1972a: 112
Ft. Michilimackinac
  F. 262, 265, 267, 297: Stone 1972: 181, Table 2
  F. 296: Stone 1971: 181, Table 1
Paca House: S. South 1972a: 115
Brunswick Town S-18: S. South 1972a: 114
Castle Hill: Grange 1971: Table 50
Trebell Cellar: S. South 1972b: 213
Brunswick Town S-10: S. South 1972a: 115
Tellico Blockhouse: S. South 1972b: 214
Ft. Lennox: Grange 1974b

Table 2. Worksheet and Summary of Type Modal Dates*

Site/Operation/Unit: ______________________________

Historic date range: ______________ Historic median date: ________

Estimated date range: ______________ Ceramic formula date:. ________

Absent type date: __________ Ceramic terminus post quem: __________

Type No.	Name	Mfg. date range	Mid-date	Modal date	Date code	Sherd count	Product	Misc.
72	Delft apothecary jar	1580-1640	1610					
	Spanish Olive jar, M & L	1580-1850	1748					
49	18th cent. decor. delft	1600-1802	1750	1760				
70	Red marbelized slipware	1610-1660	1635					
66	Det. Bellarmine face	1620-1700	1660					
62	English delft bluedash.	1620-1720	1670					
64	Cylind. delft oint. pot	1630-1700	1665					
65	Plain white delftware	1640-1800	1720					
58	Spring, C.B.M. Rhenish stnw.	1650-1725	1668					
61	North Devon gravel temp.	1650-1775	1713					
39	Chinese exp. blue & white	1660-1800	1730	1750				
26	Chinese porce. polych.	1660-1800	1730	1750				
56	Combed slipware	1670-1795	1733	1750				
	Misc. leadglaze slipware	1670-1795	1733					
37	Ref. red stnw. ungl. sprig.	1690-1775	1733	1750				
54	British brown stoneware	1690-1775	1733	1755				
44	Westerwald SG stoneware	1700-1775	1738	1755				
45	Everted pl. delft oint.	1700-1800	1750					
46	Nottingham stoneware	1700-1810	1755	1765				
	Shiny brown stoneware	1700-1810	1755	1765				
48	Slip dipped white SG stnw.	1715-1775	1745					
47	Buckley ware	1720-1775	1748	1765				
40	White SG stnware. plain	1720-1805	1763	1765				
16	White SG stnw. moulded	1740-1765	1753	1760				
36	Clouded, creambody, ew.	1740-1770	1755	1760				
42	Refined agate ware	1750-1775	1758	1758				
43	White SG stnw., plates	1740-1775	1758	1758				
29	Jackfield ware	1740-1780	1760	1755				

Table 2. Continued

34	Scratch blue wh. SG. stnw.	1744-1775	1760	1760
31	English porcelain	1745-1795	1770	1760
35	Coarse agate ware	1750-1810	1780	
27	Black basaltes	1750-1820	1785	
33	Greenglaze creambod. ew.	1759-1775	1767	1767
22	Creamware	1762-1820	1791	1770
28	Engineturn. Unglaz. Red ST	1763-1775	1769	
24	Debased Scratch blue SG stn.	1765-1795	1780	
18	Overglaze enamle creamwr.	1765-1810	1788	
23	Trans. print creamware	1765-1815	1790	
	Buff. Caneware	1770-1870	1820	1820
15	Lighter yellow creamware	1775-1820	1798	1798
21	Debased Rouen faince	1775-1800	1788	
17	Underglaze blue handp. pw.	1780-1820	1800	1810
20	Undecorated pearlware	1780-1830	1805	1800
19	Blue & Green shelledge pw.	1780-1830	1805	1800
	Red shell edge pearlw.	1780-1830	1805	
	Bluebanded pearlware	1780-1830	1805	
	Misc. painted pearlware	1780-1830	1805	
13	Annular decor. pearlware	1790-1820	1805	1810
12	Undergl. polych. pearlware	1795-1815	1805	1801
10	Willow, blue trans. pw.	1795-1840	1818	1825
11	Misc. blue trans. prnt. pw.	1795-1840	1818	1813
6	Mocha ware	1795-1890	1843	
9	Moulded embossed pearlware	1800-1820	1810	
	Ironstone, Turner	1800-1806	1803	
3	Ironstone	1813-1900	1857	
	Mis. lt. blue and coloured trn. pw.	1818-1864?	1841	
2	Whiteware	1820-1900	1860	
1	Brownstoneware bottles	1820-1900	1860	
	Brown stoneware container	1820-1900	1860	
	Flowing blue trans. prt.	1840-	1850?	
	Ironstone, St. J. P.Q.	1873-1899	1886	
	Ironstone, D.B. & Co.	1875-1907	1891	

Totals:

Table 2. Continued

*Manufacture period and mid-range dates for all numbered types are taken from South (1972a: Fig. 1). Unnumbered type date ranges are derived from the following sources:

Spanish olive jar: Goggin 1964: 179

Misc. lead-glazed slipware: date range for type 56 (S. South 1972a) assumed

Lustrous brown stoneware: date range for type 46 (S. South 1972a) assumed

Buff caneware: Hughes 1965: 50-51

Red shell-edge pearlware: date range for type 20 (S. South 1972a) assumed

Blue-banded pearlware: date range for type 20 (S. South 1972a) assumed

Misc. painted pearlware: date range for type 20 assumed

Ironstone, Turner: Godden 1971: 96-7

Misc. light blue and coloured transfer-printed pearlware: Miller 1972; Collard 1967: 117-18

Brown stoneware container: dates for type 1 (S. South 1972a) assumed on basis of identity of ware. For form of these containers, see Davis 1967: Pl. 6

Flowing blue transfer print: Collard 1967: 118

Ironstone, St. Johns Quebec: Collard 1967: 281-90

Ironstone, Dunn Bennett & Co.: Godden 1971: 66

Table 3. Comparison of Mid-Range and Modal Dates

Type Number	Mid-Range Manufacture Date	Estimated Modal Date	Difference: Type Modal - Mid-Range Date
49	1750	1760	10
39	1730	1750	20
26	1730	1750	20
56	1733	1750	17
37	1733	1750	17
54	1733	1755	22
44	1738	1755	17
46	1755	1765	10
46a	1755	1765	10
47	1748	1765	17
40	1763	1765	2
16	1753	1760	7
36	1755	1760	5
42	1758	1758	0
43	1758	1758	0
29	1760	1755	-5
34	1760	1760	0
31	1770	1760	-10
33	1767	1767	0
22	1791	1770	-21
Caneware	1820	1820	0
15	1798	1798	0

Table 3. Continued

Type Number	Mid-Range Manufacture Date	Estimated Modal Date	Difference: Type Modal - Mid-Range Date
17	1800	1810	10
20	1805	1800	-5
19	1805	1800	-5
13	1805	1810	5
12	1805	1801	-4
10	1818	1825	7
11	1818	1713	-5
		Total	141

Mean of differences: 4.862

Table 4. Comparison of Manufacture Period with Substantial and Modal Popularity Periods; Means of Differences in Years

Type No.	Period of Manufacture A B	Mid-Range Mfg. Date C	Period of Substantial Popularity D E	Period of Modal Popularity F G	Est. Modal Date H	Heir-loom Date I	Differences: D-A	E-B	F-A	G-B	H-A	I-B	H-C
44	1700-1775	1738	1716-1880	1731-1776	1755	1830	16	5	31	1	55	55	17
46	1700-1810	1755	1753-1780	1763-1768	1765	1875	53	-30	63	-42	65	65	10
47	1720-1775	1748	1731-1780	1753-1776	1765	1875	11	5	33	21	45	100	17
40	1720-1805	1763	1720-1811	1754-1780	1765	1828	0	6	34	-25	45	23	2
16	1740-1765	1753	1740-1811	1759-1811	1760	1875	0	46	19	46	20	110	7
36	1740-1770	1755	1740-1780	1753-1768	1760	1875	0	10	13	-2	20	105	5
43	1740-1775	1758	1740-1780	1751-1776	1758	1730	0	5	11	1	18	55	0
29	1740-1780	1760	1751-1763	1753-1763	1755	1875	11	-17	13	-17	15	95	-5
34	1744-1775	1760	1744-1780	1744-1776	1780	1780	0	5	0	1	16	5	0
31	1745-1795	1770	1753-1780	1756-1763	1760	1875	8	-15	11	-32	15	80	-10
33	1759-1775	1767	1759-1830	1759-1776	1767	1830	0	55	0	1	8	55	0
22	1762-1820	1791	1762-1811	1762-1780	1770	1875	0	9	0	-40	8	55	-21
15	1775-1820	1798	1775-1826	1794-1807	1798	1826	0	6	19	-13	23	6	0

Table 4. Continued

Type No.	Period of Manufacture A B	Mid-Range Mfg. Date C	Period of Substantial Popularity D E	Period of Modal Popularity F G	Est. Modal Date H	Heir-loom Date I	Differences: D-A	E-B	F-A	G-B	H-A	I-B	H-C
17	1780-1820	1800	1794-1826	1794-1826	1810	1875	14	6	14	6	30	55	20
20	1780-1830	1805	1780-1829	1794-1807	1800	1875	0	-1	14	-23	20	45	-5
19	1780-1830	1805	1780-1830	1780-1828	1800	1875	0	0	0	-2	20	45	-5
13	1790-1820	1805	1790-1830	1790-1828	1810	1875	0	10	0	8	20	55	5
12	1795-1815	1805	1795-1830	1795-1826	1801	1875	0	15	0	11	6	60	-4
11	1795-1840	1818	1795-1830	1795-1828	1813	1875	0	-10	0	-12	18	35	-5
						Sub-Total	113	92	275	-132	467	1104	18
						Mean =	5.9	4.8	14.5	-6.9	24.6	58.1	0.9*
42	1740-1775	1758	1740-1776		1758	1776	0	1			18	1	0
Cane-ware	1770-1870	1820	1828-1875		1820	1875	58	5			50	5	0
10	1795-1840	1818	1795-1875		1825	1875	0	35			30	35	7

Table 4. Continued

Type No.	Period of Manufacture A B	Mid-Range Mfg. Date C	Period of Substantial Popularity D E	Period of Modal Popularity F G	Est. Modal Date H	Heir-loom Date I	Differences: D-A	E-B	F-A	G-B	H-A	I-B	H-C
						Sub-Total	58	41			98	41	7
						Mean =	19.3	13.7			32.7	13.7	2.3†
49	1600-1802	1750		1735-1776	1760	1875			135	-26	100	73	10
39	1660-1800	1730		1734-1780	1750	1875			74	-20	90	75	20
26	1660-1800	1730		1731-1768	1750	1875			71	-32	90	75	20
56	1670-1795	1733		1731-1768	1750	1875			61	-27	80	80	17
37	1690-1775	1733		1726-1776	1750	1780			36	1	60	5	17
54	1690-1775	1733		1734-1776	1755	1830			44	1	65	55	22
						Sub-Total			421	-103	545	363	106
						Mean =			70.2	-17.2	90.8	60.5	17.7††

Table 4. Continued

Type No.	Period of Manufacture A B	Mid-Range Mfg. Date C	Period of Substantial Popularity D E	Period of Modal Popularity F G	Est. Modal Date H	Heirloom Date I	Differences: D-A	E-B	F-A	G-B	H-A	I-B	H-C
					Total		171	133	696	-235	1110	1508	131
					Mean =		7.8	6.0	27.8	-9.4	39.6	53.8	4.7[§]
45	1700-1800	1750	1753-1768			1768	53	-32			-32		
48	1715-1775	1745	1716-1747			1747	1	-28			-28		
35	1750-1810	1780	1750-1777			1777	0	-33			-33		
27	1750-1820	1785	1759-1818			1818	9	-2			-2		
28	1763-1775	1769	1768-1826			1826	5	51			51		
24	1765-1795	1780	1768-1826			1826	3	31			31		
18	1765-1810	1788	1770-1780			1780	5	-30			-30		
23	1765-1815	1790	1770-1780			1780	5	-35			-35		
21	1775-1800	1788	1776-1780			1780	1	-20			-20		
9	1800-1820	1810	1800-1875			1875	0	55			55		

Table 4. Continued

Type No.	Period of Manufacture A	B	Mid-Range Mfg. Date C	Period of Substantial Popularity D	E	Period of Modal Popularity F	G	Est. Modal Date H	Heir-loom Date I	Differences: D-A	E-B	F-A	G-B	H-A	I-B	H-C
									Sub-Total	82	-43				-43	
									Mean =	8.2	-4.3				-4.3 §§	
									Grand Total	253	90				1465	
									Mean =	7.9	2.8				38.5 §§§	

* Types 44 to 11; 19 types; best sample, modal dates estimated. Manufacturing range within site sample.

† Types 42, 10 and caneware; 3 types; small sample.

‡ Types 49 to 54; 6 types; good sample but manufacturing begins before site sample.

§ All 3 groups above.

§§ Types 45 to 9; 10 types; sample too small to estimate modal dates.

§§§ All four groups.

Table 5. Comparison of Manufacture Period with Substantial and Modal Popularity Periods; Grouped Data; Means of Differences in Years

	Differences						
Type Groups	D-A	E-B	F-A	G-B	H-A	I-B	H-C
13 types. Grouped on basis of D-A=0 as a measure of popularity.	0	10.6	8.5	-3.8	18.6	50.3	-1.6
7 types. Grouped on basis of D-A=0 and F-A=0 as a measure of popularity.	0	9.4	0	-4.7	13.7	44.3	-4.2
White salt-glazed stonewares. Types 48, 40, 16, 43, 34, 24 grouped as a "ware."	3.8	10.8	16.0	5.7	24.7	32.7	2.2
Creamwares. Types 36, 33, 22, 18, 23 and 15 grouped as a "ware."	1.7	-0.5	8.0	-13.5	14.7	26.0	-4.0
Pearlwares. Types 17, 20, 19, 13, 12, 10, 11, 9, grouped as a "ware."	1.7	13.7	4.7	-2.0	20.6	48.1	0.4

Table 5. Continued

Type Groups	Differences D-A	E-B	F-A	G-B	H-A	I-B	H-C
8 types. Grouped on basis of modal % of 4% or more as a measure of popularity. Types 22, 15, 43, 20, 19, 11, 12, 44.	2.0	1.4	9.4	-9.6	21.0	44.5	-2.9
11 types. Modal %=4% or more. Includes 8 types above plus types 49, 39, 56. Latter three types mfg. period starts before site sample.	-NA	0	31.4	-13.6	38.0	53.1	2.2
3 types. Grouped on basis of reaching modal date in less than 10 years as a measure of popularity. Types 12, 33, 22.	0	20.3	0	-9.3	7.3	56.7	-8.3
Types grouped on basis of period of modal popularity							
Types 49, 39, 26, 56, 37, 54, 44, 34: 1730-1775	8.0	5.0	56.5	-12.6	77.0	52.9	15.4
Types 47, 40, 16, 43, 36, 29, 31: 1755-1775	4.3	5.7	19.1	-4.0	25.4	81.1	2.3
Types 33, 46, 22: 1760-1780	17.7	5.3	21.0	-27.0	27.0	58.3	-3.7
Types 19, 15, 17, 20, 13, 12, 11: 1780-1830	2.0	3.7	6.7	-3.6	19.6	43.0	-0.6

Table 5. Continued

Type Groups	Differences						
	D-A	E-B	F-A	G-B	H-A	I-B	H-C
Types grouped into three major periods of modal popularity							
<u>See above</u> for type numbers: 1730-1775	5.1	5.5	39.0	-8.6	52.9	66.1	9.3
<u>See above</u> for type numbers: 1760-1830							
Types 1, 2, 3: 1820-1875+? (insufficient data)	-	-	-	-	-	-	-

Table 6. Summary of Comparison of Manufacture Period with Substantial and Modal Popularity Periods; Means of Differences in Years

	19 Types. Best Sample.	8 Types. Highest Modal.	13 Types. Substantial Popularity in Initial Year.	28 Types with Modal Date Estimate Possible.	3 Types Reach Modal Date Within 10 Years.	1 Type. Single Most Popular Type.	22 Types. Modal Date Estimate and Range of Mfg. Included in Site Sample Span.
Time to Reach Substantial Popularity (D-A)	5.9	2.0	0	7.8	0	0	7.8
Time to Reach Modal Popularity (F-A)	14.5	9.4	8.5	27.8	0	0	14.5
Time to Reach Modal Date (H-A)	24.6	21.0	18.6	39.6	7.3	8.0	25.7
End of Modal Popularity (G-B)	-6.9	-9.6	-3.8	-9.4	-9.3	-40.0	-6.9
End of Substantial Popularity (E-B)	4.8	1.4	10.6	6.0	20.3	-9.0	6.0
Heirloom Factor (I-B)	58.1	44.5	50.3	53.8	56.7	55.0	52.0
Modal - Mid-Range Difference (H-C)	0.9	-2.9	-1.6	4.7	-8.3	-21.0	1.1

Table 7. Comparison of Period of Introduction and Modal Popularity Ranges

Period of Introduction of Types	Period of Popularity of Same Types
1600-1720	1730-1775
1730-1750	1755-1775
1750-1770	1760-1780
1770-1800	1780-1830
1813-1875	1820-1900 ?

Table 8. Major Ceramic Horizon Groups Based on Cumulative Seriation

Popularity	Periods	Types
1730-1775 1755-1775	1730-1775	delftware, slipwares and salt-glazed stonewares
1760-1780 1780-1830	1760-1830	creamwares and pearlwares
1820-1900	1820-1900	whiteware, ironstone and stoneware bottles

Table 9. Ceramic Percentages by Modal Popularity Period Horizon Groups

Site	Modal Periods Grouped Type Clusters: 1730-75		1760-1830		1820-1900	Estimated Site Date Modal Period	Known Occupation
	1730-75	1755-75	1760-80	1780-1830			
1st Ft. Moore	84.11	15.02	0.81			1730-1775	1716-1747
Ft. Moore	79.96	20.0				1730-1775	1716-1766
Brunswick Town S-15	66.85	29.11	5.91	0.04		1730-1775	1726-1776
Ft. Dobbs	63.93	36.04				1730-1775	1756-1763
Goudy's Cellar, 96	28.56	71.42				1755-1775	1751-1760
Brunswick Town N-1	60.36	38.19	1.41			1730-1775	1731-1776
Brunswick Town S-2	67.66	27.27	4.59	0.40		1730-1775	1731-1776
Brunswick Town S-7	57.57	19.90	22.44			1730-1775	1734-1776
Ft. Prince George	31.47	36.75	30.07	1.64		1730-1775 or 1755-1780	1753-1768
Ft. Michilimackinac F.262, 265, 267, 297	38.58	32.44	27.19	1.75		1730-1775 or 1755-1780	1754-1780
Ft. Michilimackinac F.296	44.65	12.66	39.33	3.32		1730-1775 or 1755-1780	1778-1780

Table 9. Continued

Site	Modal Periods Grouped Type Clusters: 1730-75		1760-1830		1820-1900	Estimated Site Date Modal Period	Known Occupation
	1730-75	1755-75	1760-80	1780-1830			
Paca House	27.26	38.62	31.82	2.27		1730-1775 or 1755-1780	1763-1780
Brunswick Town S-18	23.91	11.04	64.90	0.11		1760-1780	1763-1776
Castle Hill	29.84	18.55	40.49			1755-1780	1714-1811
Trebell Cellar	19.07	0.16		80.70		1780-1830	1868-1826
Brunswick Town S-10	29.54	4.55	5.35	51.56	8.92	1780-1830	1776-1830
Tellico Blockhouse		1.17		99.45		1780-1830	1794-1807
Ft. Lennox Ditch Fill	2.98	3.93	15.62	42.03	35.22	1760-1830	1759-1828
Ft. Lennox Fill Above Ditch	2.56	3.57	7.97	28.93	56.87	1820-1900	1819-1875

Table 10. Comparison of Ceramic Formula Dates*

Sites	Historic Range	Mid-Occ. Expected Date HD	Median Dates Unadjusted	CD-HD	Median Dates Adjusted (-1.0)	CD-HD	Modal Dates	CD-HD
Brunswick Town S-7	1734-1776	1755.0	1754.6	-0.4	1757.5	2.5	1759.0	4.0
1st Ft. Moore	1716-1747	1731.5	1726.1	-5.4	1729.0	-2.5	1733.4	1.9
Ft. Moore	1716-1766	1741.0	1741.7	0.7	1745.5	4.5	1755.0	41.0
Goudy's Cellar, 96	1751-1760	1755.5	1754.6	-0.9	1753.6	-1.9	1757.0	1.5
Ft. Prince George	1753-1768	1760.5	1763.0	2.5	1766.1	5.6	1760.8	0.3
Brunswick Town S-15	1726-1776	1751.0	1746.4	-4.6	1749.7	-1.3	1756.1	5.1
Brunswick Town N-1	1731-1776	1753.5	1750.1	-3.4	1751.0	-2.5	1757.7	4.2
Brunswick Town S-2	1731-1776	1753.5	1749.0	-4.5	1749.4	-4.1	1758.3	4.8
Brunswick Town S-18	1763-1776	1769.5	1776.2	6.7	1776.9	7.4	1765.7	-1.8
Brunswick Town S-10	1776-1830	1803.0	1794.0	-9.4	1800.8	-2.2	1795.6	-7.4
Trebell Cellar	1768-1826	1797.0	1788.9	-9.0	1796.6	-0.4	1791.3	-5.7
Tellico Blockhouse	1794-1807	1800.5	1802.7	2.2	1801.8	1.3	1801.1	0.6
Ft. Dobbs	1756-1763	1759.5	1747.4	-12.1	1754.8	-4.7	1756.9	-2.6

Table 10. Continued

Sites	Historic Range	Mid-Occ. Expected Date HD	Median Dates Unadjusted	CD-HD	Median Dates Adjusted (1.0)	CD-HD	Modal Dates	CD-HD
Ft. Michilimackinac								
F.296	1770-1780	1775.0	1763.0	-12.0	1774.4	-0.6	1762.2	-12.8
Ft. Michilimackinac								
F.262, 265, 267, 297	1754-1780	1768.5	1760.3	-8.2	1768.3	-0.2	1761.5	-7.0
Castle Hill	1714-1811	1762.5	1762.7	0.2	1762.0	-0.5	1762.3	-0.2
Total (16 sites)				-57.2		0.4		1.1
Mean Difference =				-3.575		0.025		0.0687

*CD -1.1: data, except dates for Ft. Lennox, taken from South (1972b, App. V). CD -1.0: dates calculated as suggested by South (1972b: 217). Cum. Ser. CD: dates based on cumulative seriation estimates of type dates as discussed.

Table 11. Pearson Correlation Coefficients: Sixteen-Site Sample

Dating Type and Correlation Pairs	Correlation Coefficient	Significance Level
Median unadjusted dates with known mid-occupation dates	0.9640	.001
Median adjusted dates with known mid-occupation dates	0.9852	.001
Modal adjustment dates with known mid-occupation dates	0.9558	.001

Table 12. Comparison of Different Dating Adjustments with Expected Results: Sixteen-Site Sample

Dating Methods/ Comparative Pairs	Difference Mean	Standard Deviation	Standard Error	T-Value	Degrees of Freedom	2-Tail Probability
Unadjusted median dates with known mid-occupation date	-3.5510	5.306	1.326	-2.68	15	0.017
Median adjusted dates with unadjusted median dates	3.5432	3.338	0.835	4.25	15	0.001
Modal dates with unadjusted median dates	3.3245	6.106	1.526	2.18	15	0.046
Median adjusted dates with known mid-occupation dates	-0.0078	3.226	0.816	-0.01	15	0.992
Modal dates with known mid-occupation date	-0.2266	6.446	1.611	-0.14	15	0.890
Median adjusted dates with modal dates	-0.2188	7.077	1.769	-0.12	15	0.903

Table 13. Per Cent of Sherds of Types Without Estimated Modal Type Dates

Site	Per Cent of Sherds of Types Without Estimated Modal Type Dates
Goudy's Cellar, 96	0
Brunswick Town N-1	0
Brunswick Town S-2	0
Brunswick Town S-18	0
Brunswick Town S-7	0
Ft. Dobbs	0
Brunswick Town S-15	0.1
Tellico Blockhouse	0.5
Trebell Cellar	1.0
Ft. Ligonier	2.0
Ft. Moore	4.0
Ft. Michilimackinac, F. 296	4.0
Ft. Michilimackinac, F. 262, 265, 267, 297	4.0
Ft. Prince George	10.0
Brunswick Town S-10	10.0
Castle Hill	17.0
First Ft. Moore	33.0

Table 14. Test of Results of Site Dating Based on Limited Samples: Dates Based on Modal Type Factors Alone Compared with Median Adjusted Dates

Comparative Pairs Sample Description	Difference Mean	Standard Deviation	Standard Error	T-Value	Degrees of Freedom	2-Tail Probability
6 Sites: Median 100%; Modal 100%						
Median adjusted dates with known mid-occupation dates	-0.6348	4.682	1.911	-0.33	5	0.753
Modal dates with known mid-occupation dates	1.2656	3.298	1.346	0.94	5	0.390
13 Sites: Median 100%; Modal 96%						
Median adjusted dates with known mid-occupation dates	-0.6553	4.266	1.183	-0.55	12	0.590
Modal dates with known mid-occupation dates	-0.033	6.831	1.894	-0.05	12	0.962

Table 15. Ceramic Formula Dating and Seriation: Fort Lennox Excavation Units Arranged in Formula Date Sequence

	Expected Results:		Observed Results:	
Stratigraphic or Occupation Unit	Historical Period	Mid-Occupation Date	Formula Date Modal Base	Formula Date Median Adjusted
1st British Fort: occupation refuse above ditch	1828-70*	1849	1842±27	1835
Right redoubt: late occupation refuse above blockhouse	1814-70*	1842	1837±31	1832
Porter's cottage: structure	1823-42†	1832	1837±26	1839
Civilian barracks - straw shed: structure	1816-52†	1834	1836±29	1839
Right redoubt: late occupation refuse above redoubt	1814-70*	1842	1834±33	1836

Table 15. Continued

Stratigraphic or Occupation Unit	Expected Results: Historical Period	Mid-Occupation Date	Observed Results: Formula Date Modal Base	Formula Date Median Adjusted
McVey house: floor	1829-42†	1835	1826±33	1825
1st British fort: demolition fill in ditch	1819-28*	1823	1825±37	1823
1st British fort: clay bottom	1759-1819††	1789	1791±50	1794
Right redoubt: blockhouse construction trench	1782-83††	1782	1786±42	1790
Redoubt No. 2: construction fill	1782-83§	1782	1770±0	1790
French fort: ditch fill and features	1759-60§	1759	1750±0	1749

Table 15. Continued

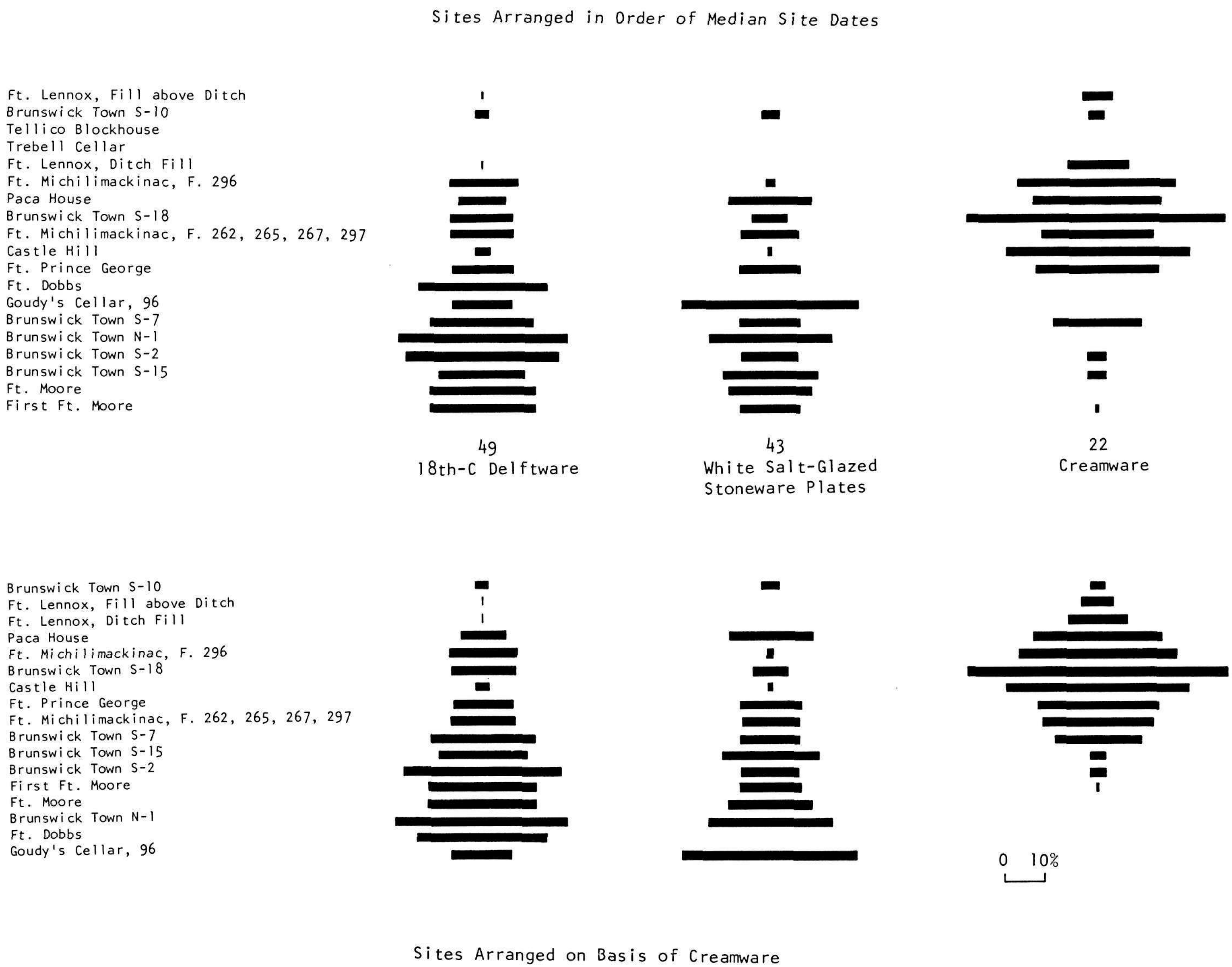
* Mixed content layer

† Good sample

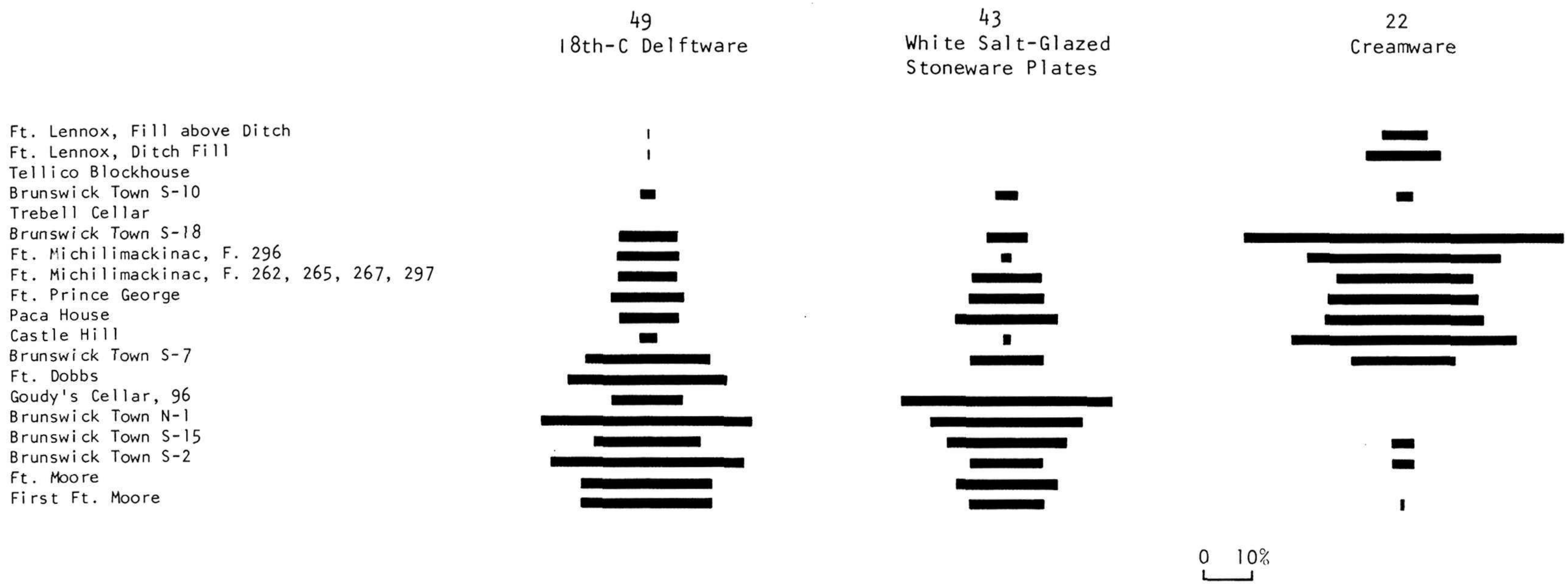
†† Small sample

§ One type only: very small sample

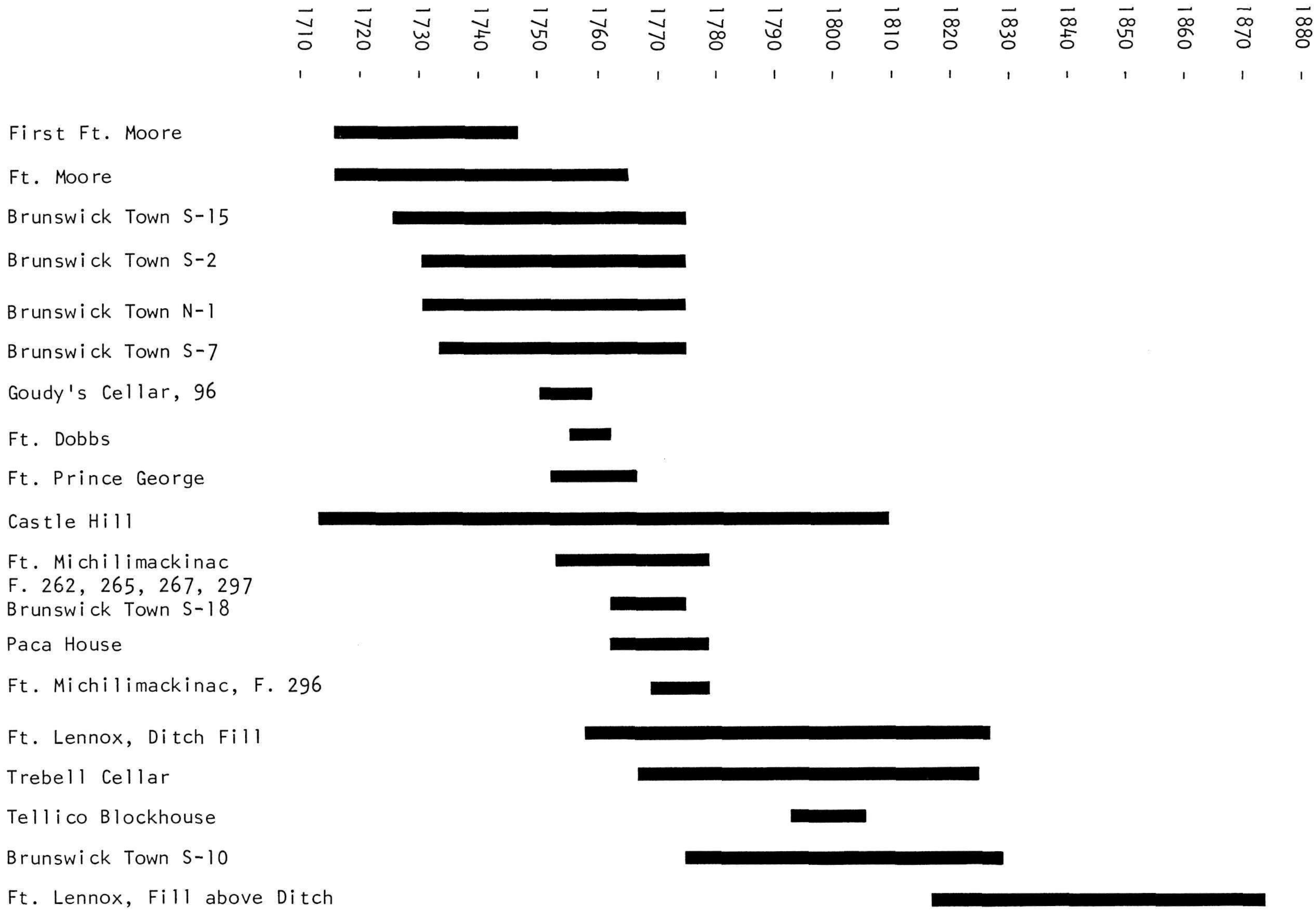
ILLUSTRATIONS



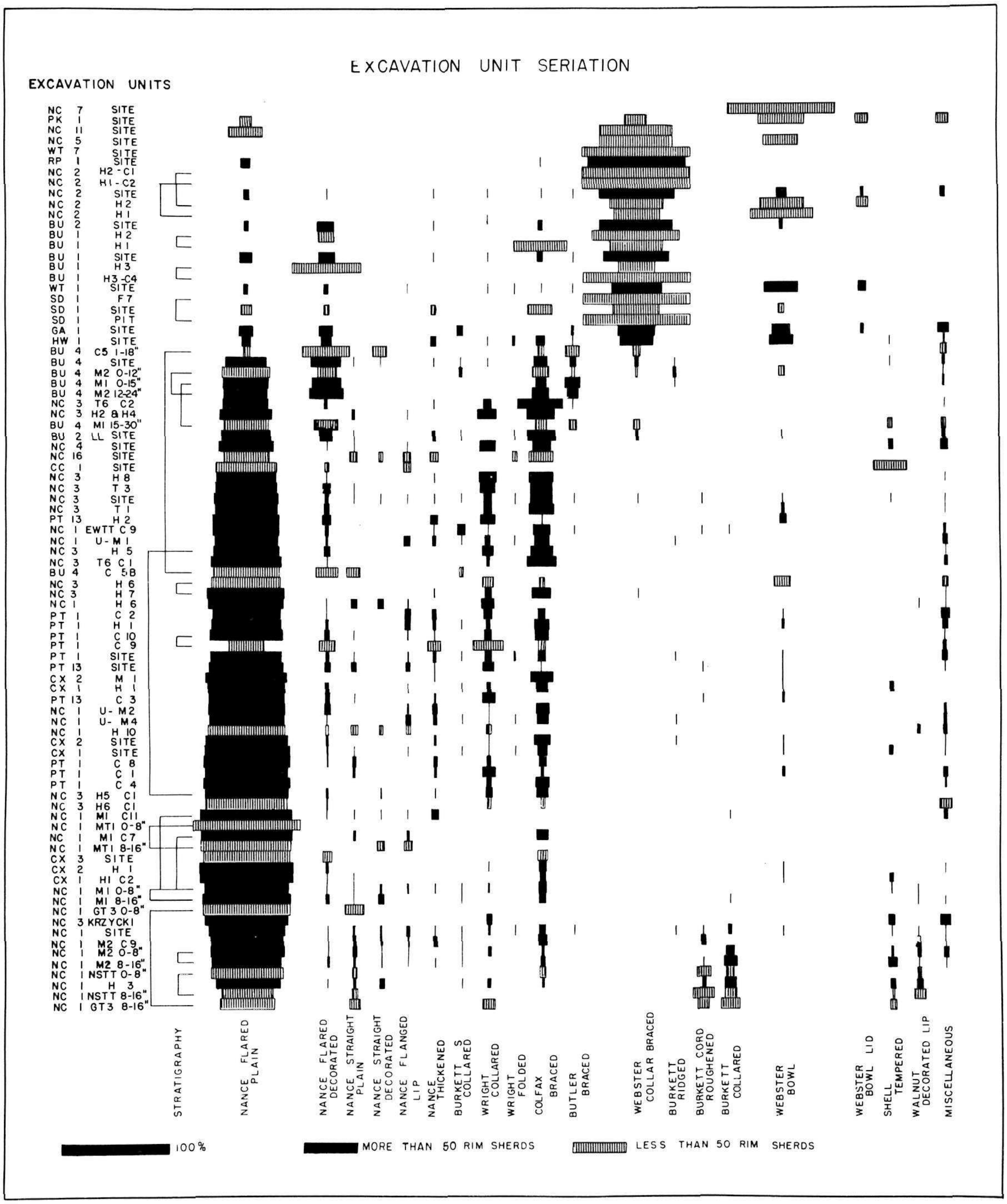
1 Standard seriation of three ceramic types. (Drawing by D. Kappler.)



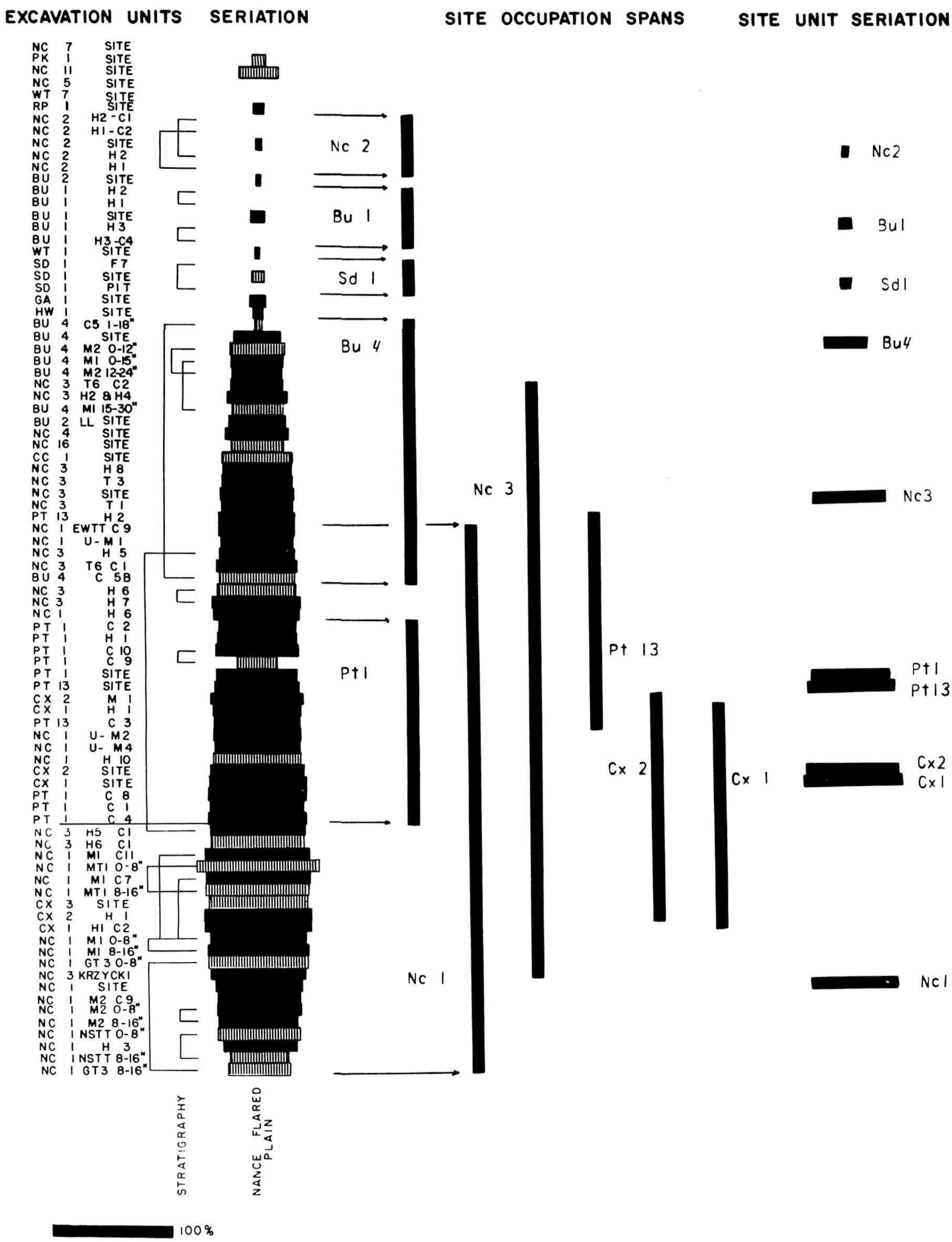
2 Standard seriation of three ceramic types based on ceramic formula dates. The sites are arranged in order of S. South's ceramic formula dates. (<u>Drawing by D. Kappler</u>.)



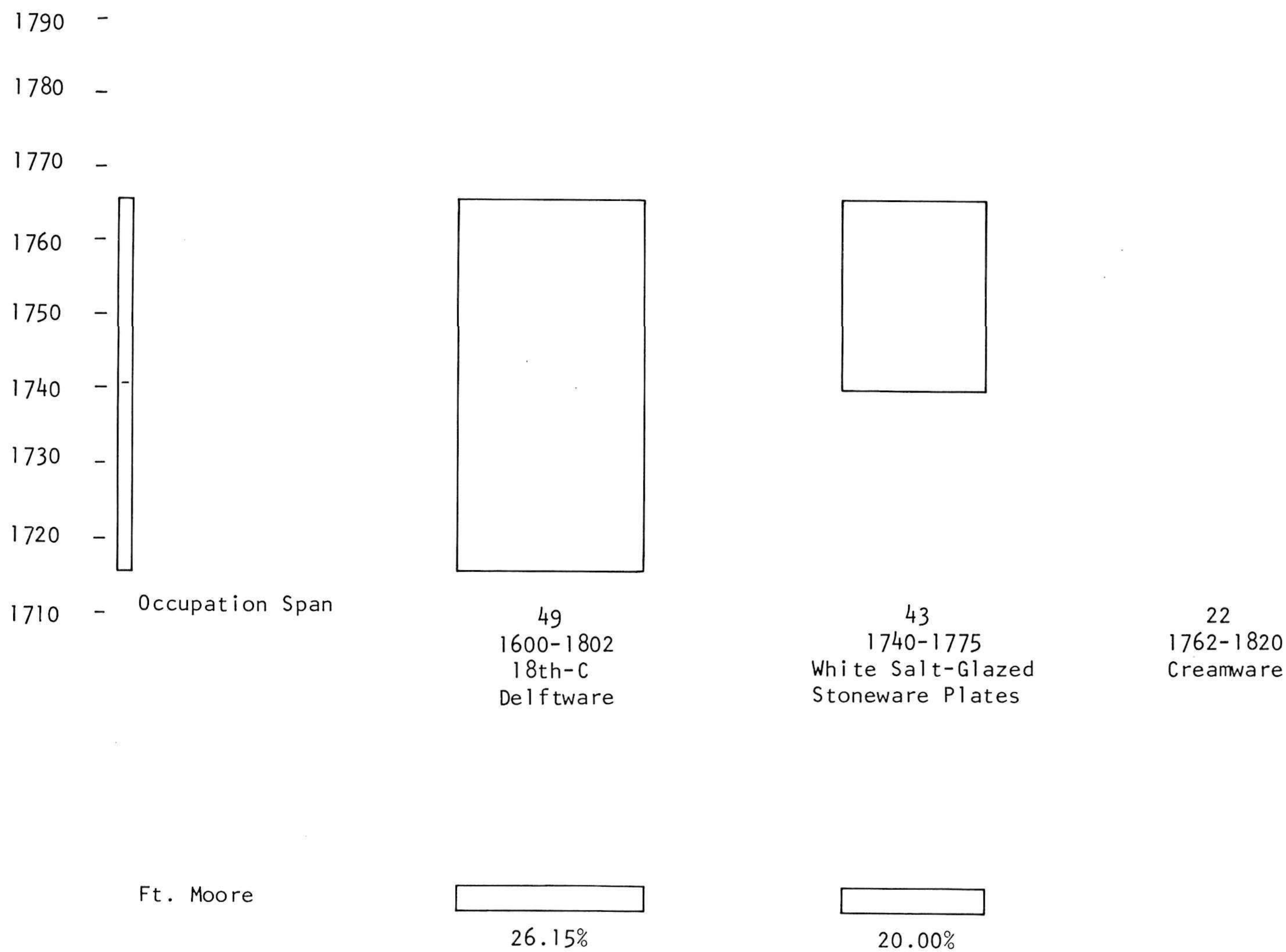
3 Site occupation periods. (Drawing by D. Kappler.)



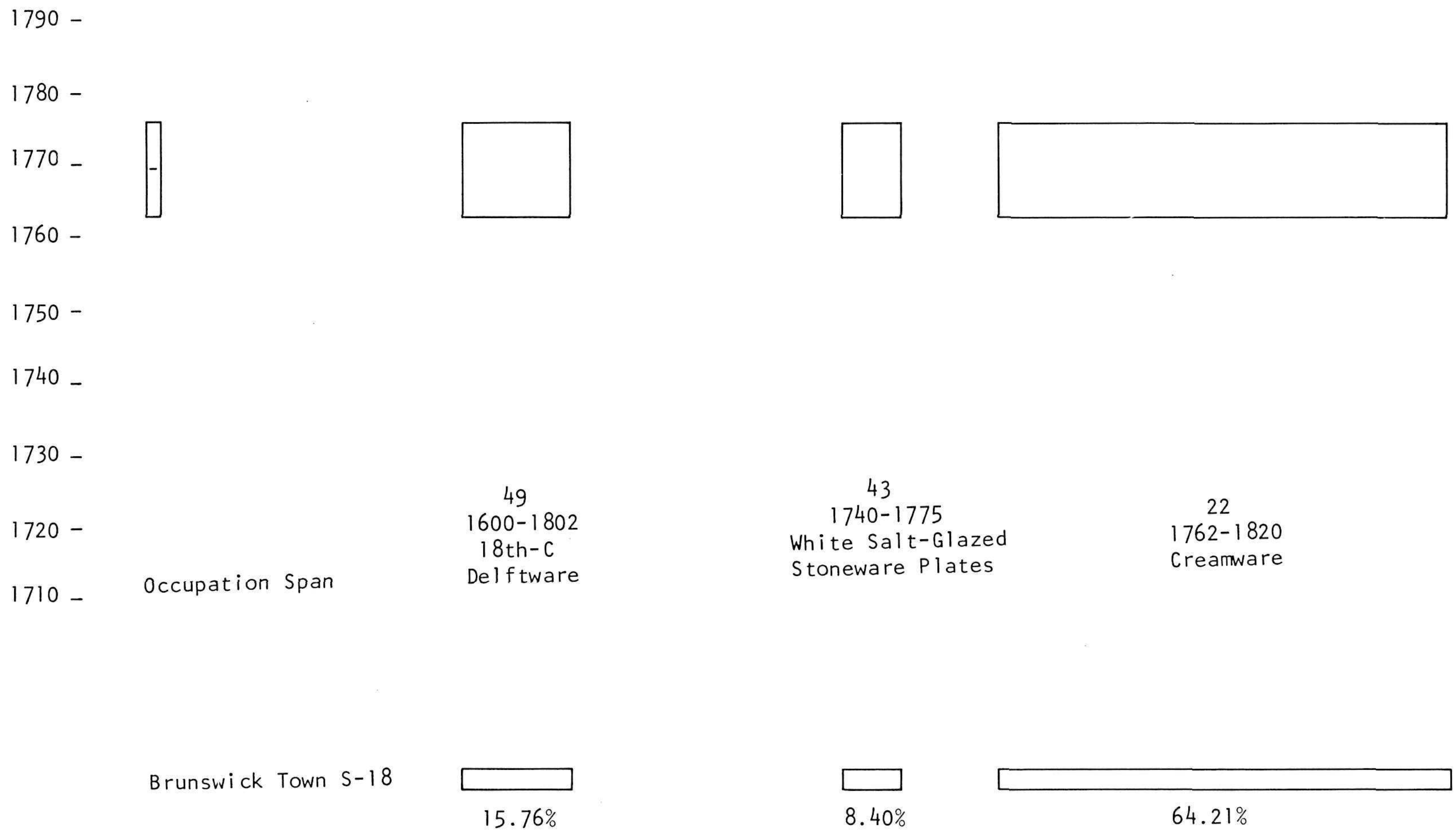
4 Excavation unit seriation of Pawnee and Lower Loup sites. (Roger T. Grange, Jr., "Pawnee and Lower Loup Pottery," Nebraska State Historical Society Publications in Anthropology, No. 3 [1968], Fig. 6.)



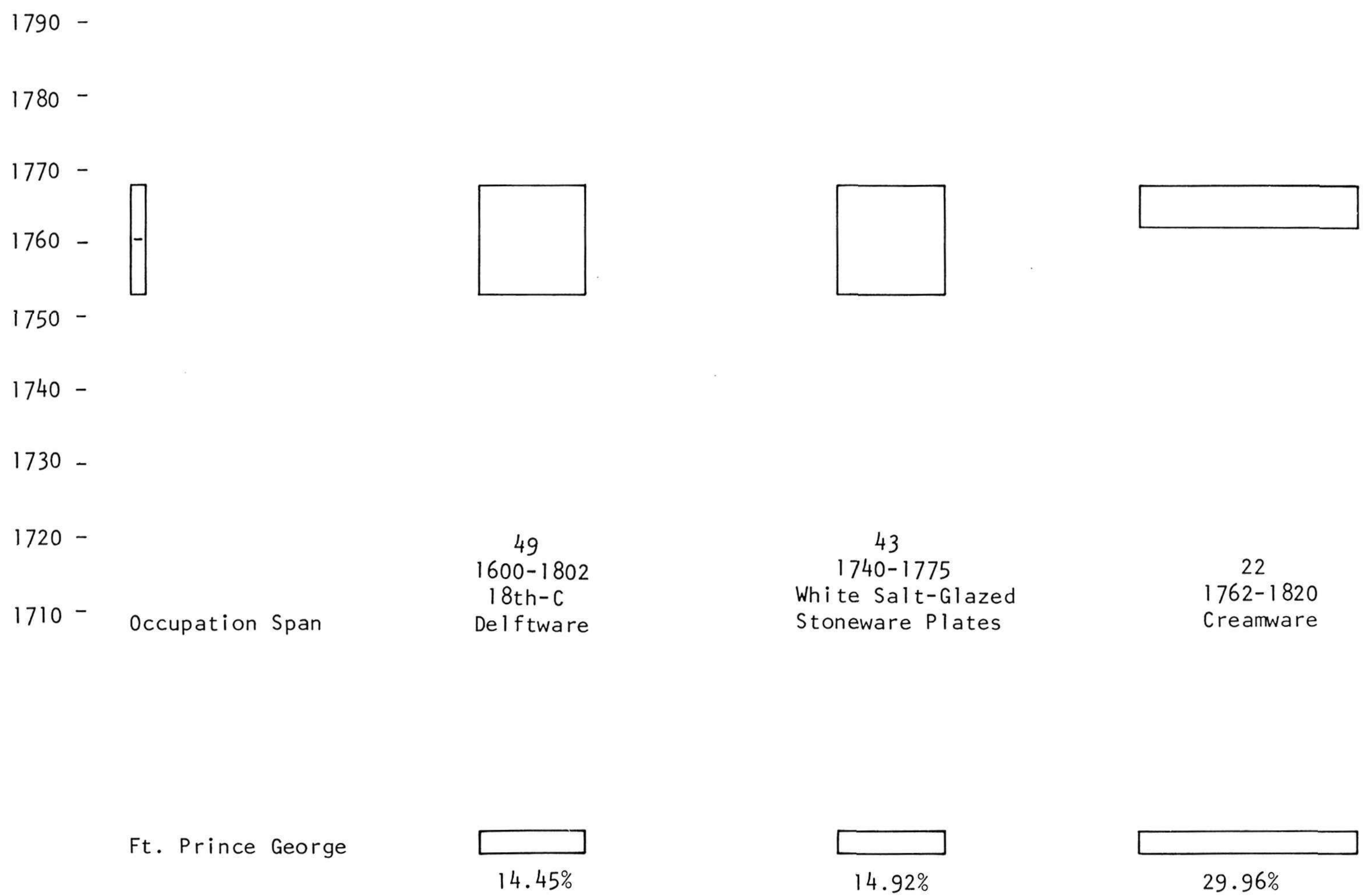
5 Occupation spans of Pawnee and Lower Loup sites. (Drawing by Roger T. Grange, Jr.)



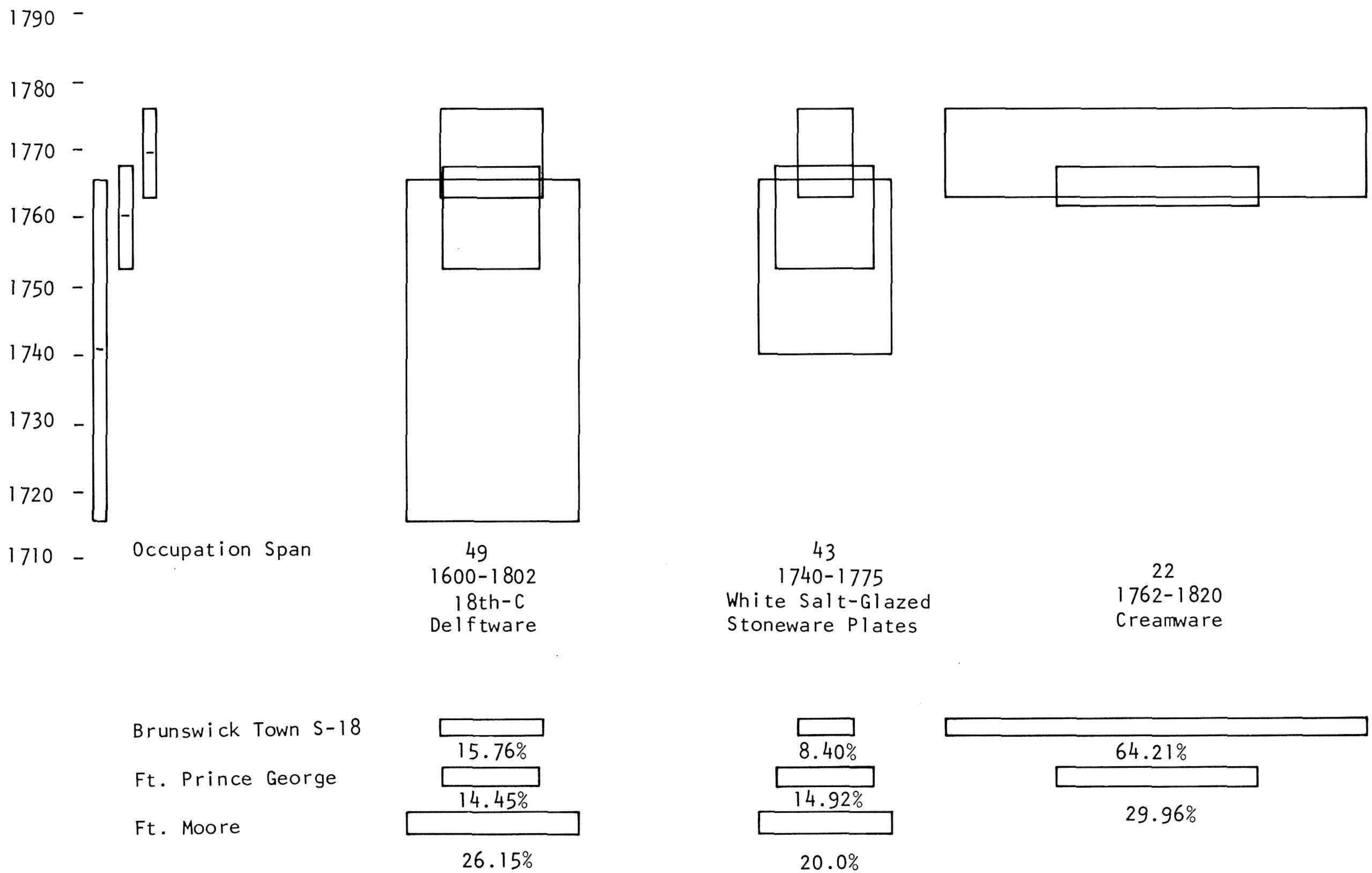
6 Cumulative seriation diagram for Fort Moore. (Drawing by D. Kappler.)



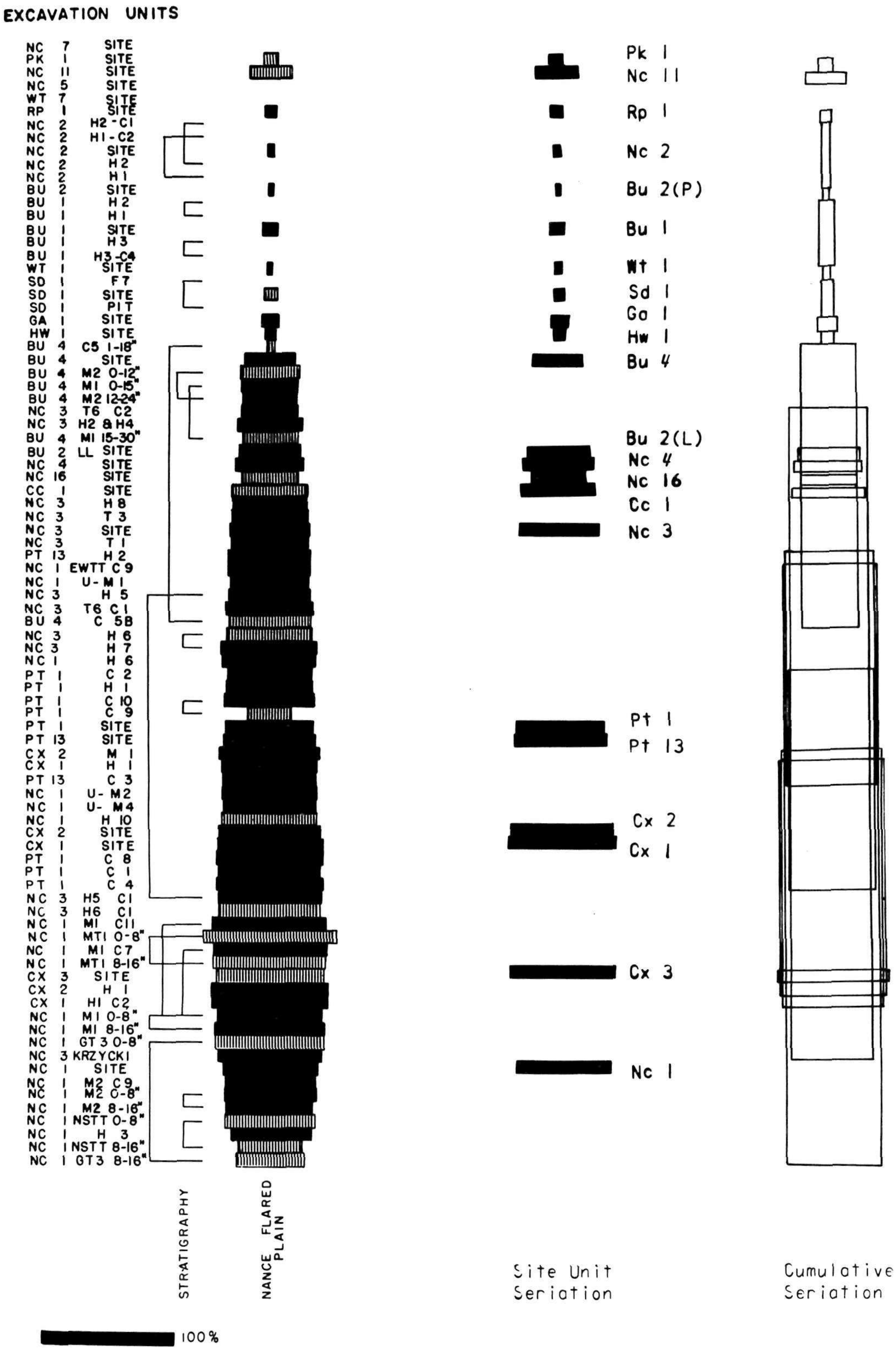
7 Cumulative seriation diagram for Brunswick Town S-18. (Drawing by D. Kappler.)



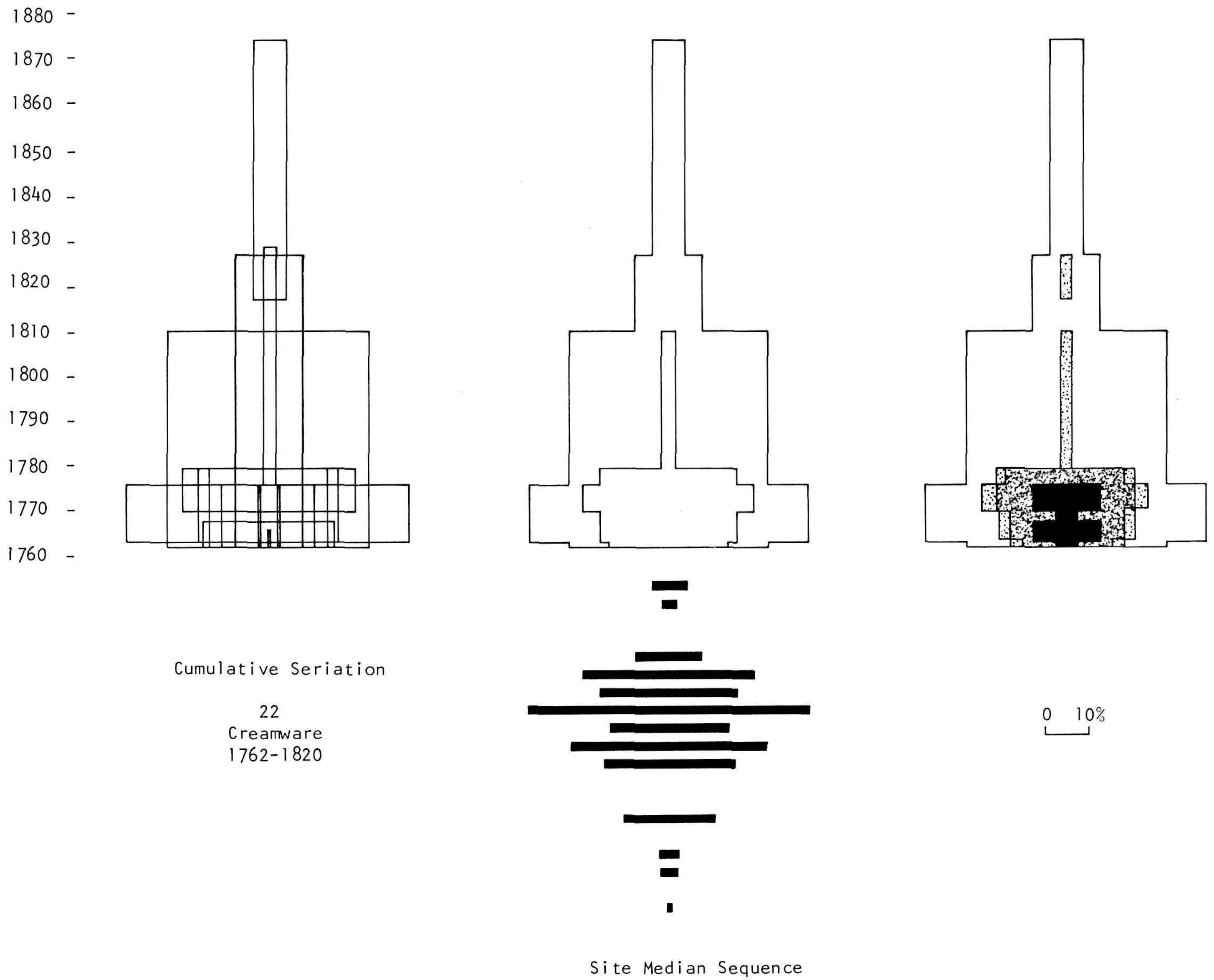
8 Cumulative seriation diagram for Fort Prince George. (Drawing by D. Kappler.)



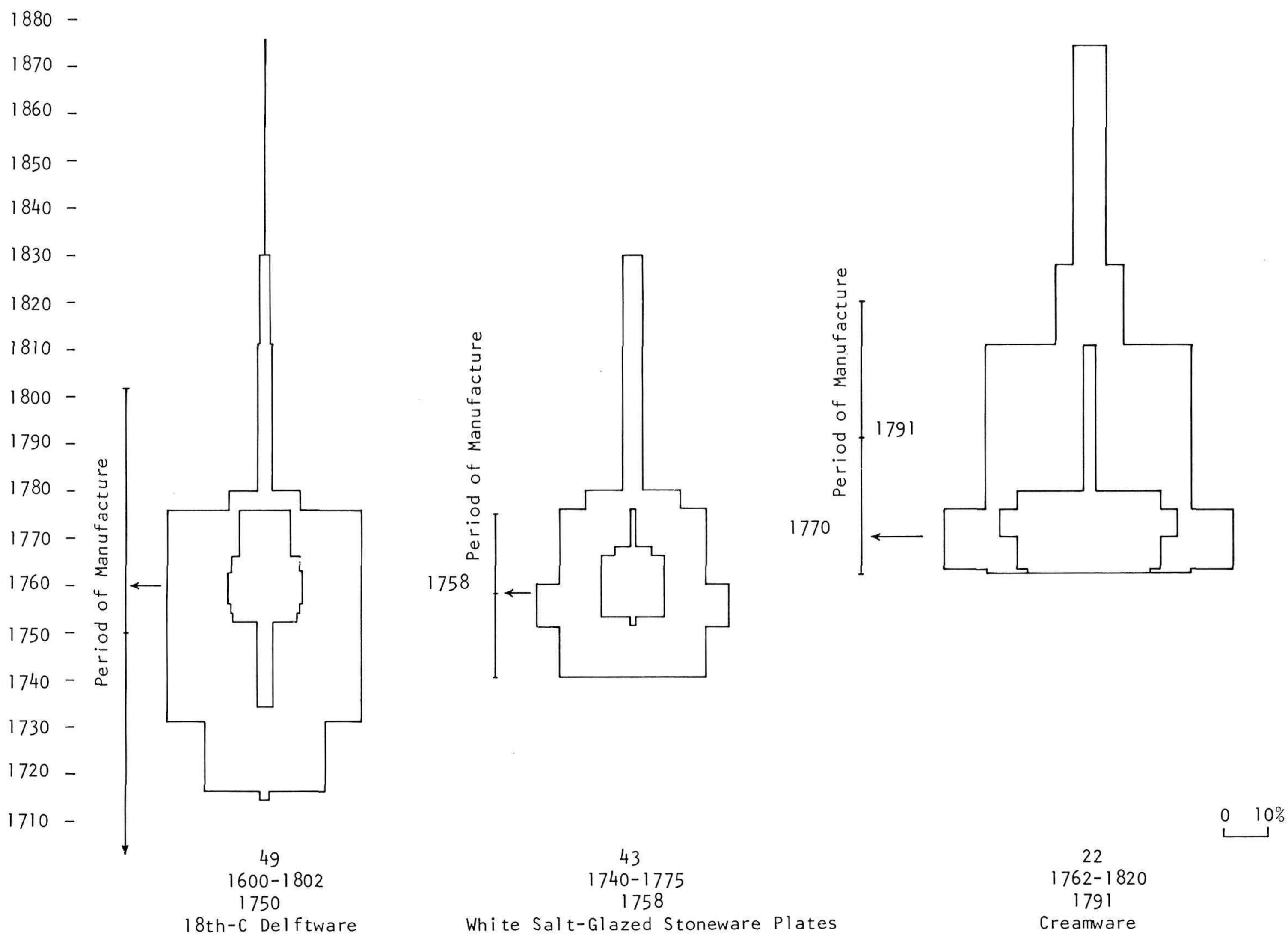
9 Cumulative seriation diagram for Fort Moore, Brunswick Town S-18 and Fort Prince George. (Drawing by D. Kappler.)



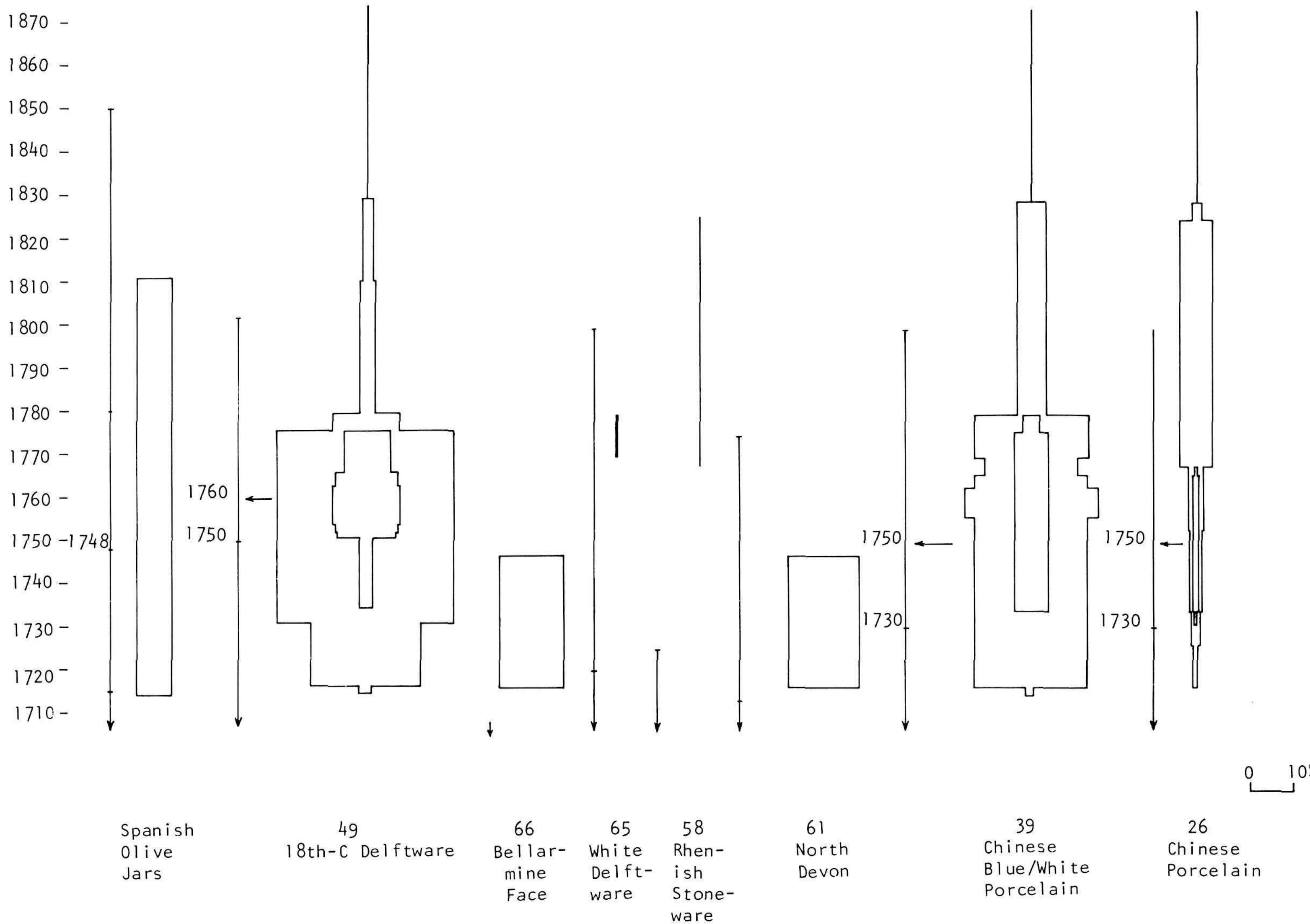
10 Cumulative seriation of Nance flared plain pottery. (Drawing by Roger T. Grange, Jr.)



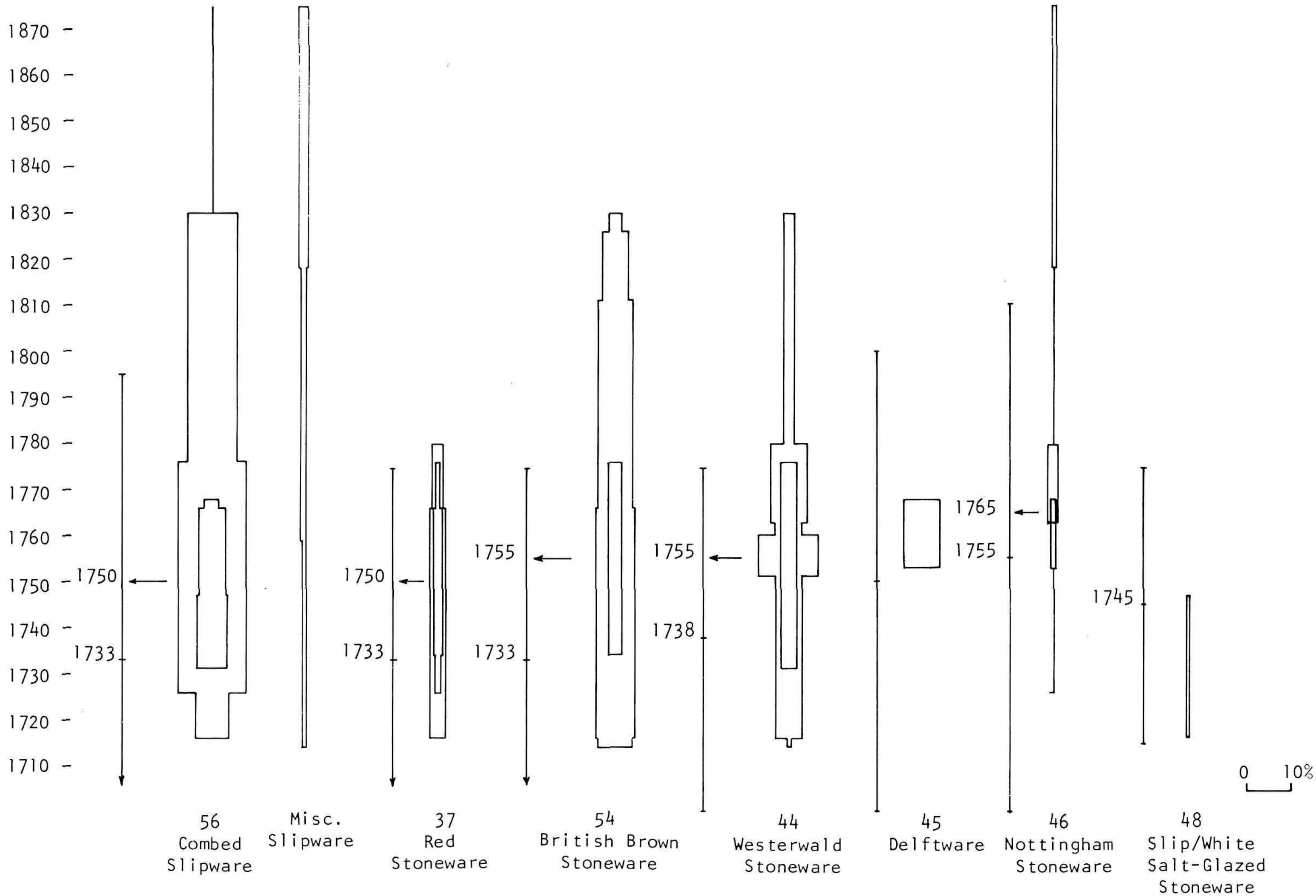
11 Cumulative seriation diagrams for creamware. (Drawing by D. Kappler.)



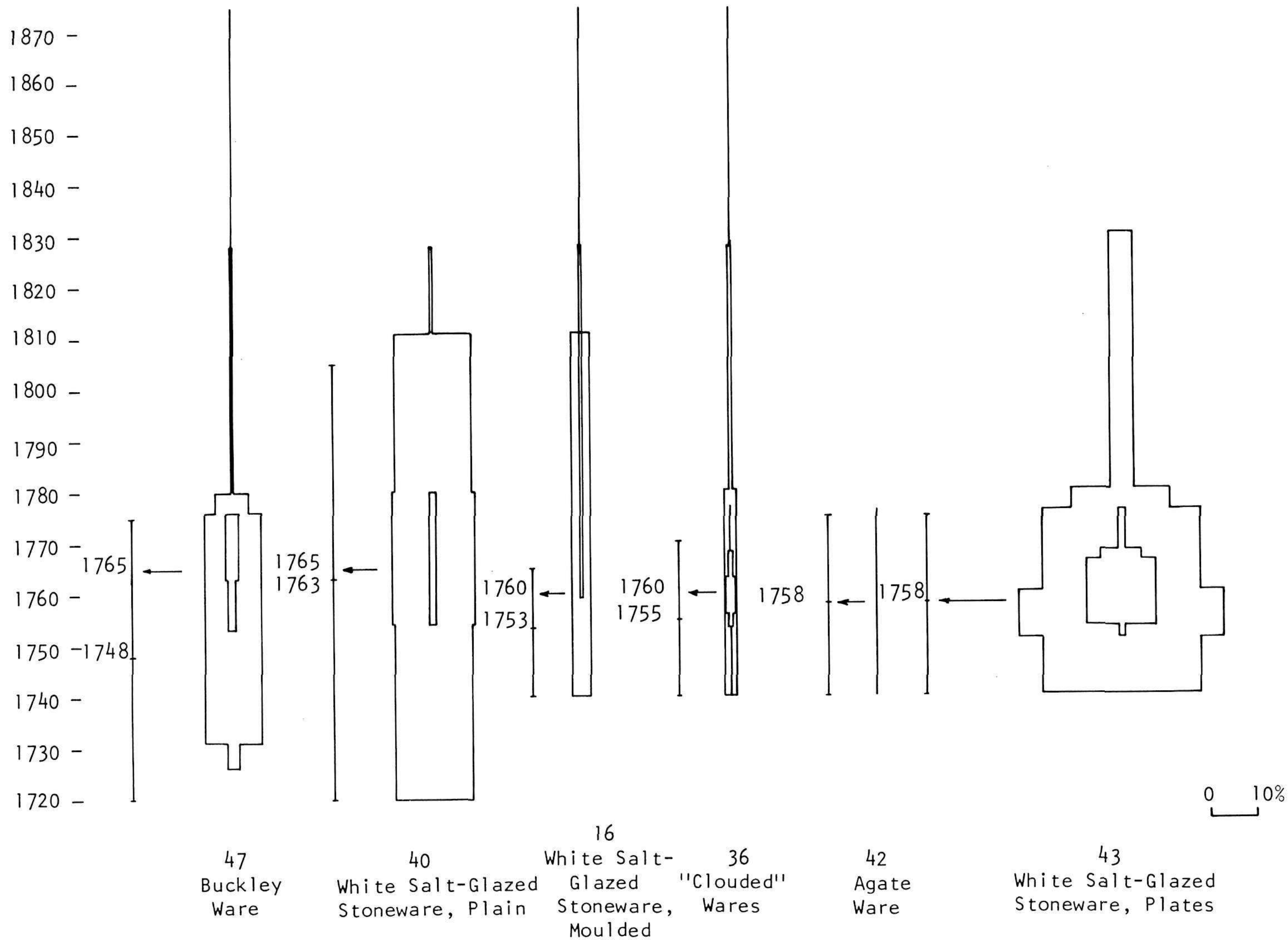
12 Cumulative seriation of 18th-century decorated delftware, white salt-glazed stoneware plates and creamware. (Drawing by D. Kappler.)



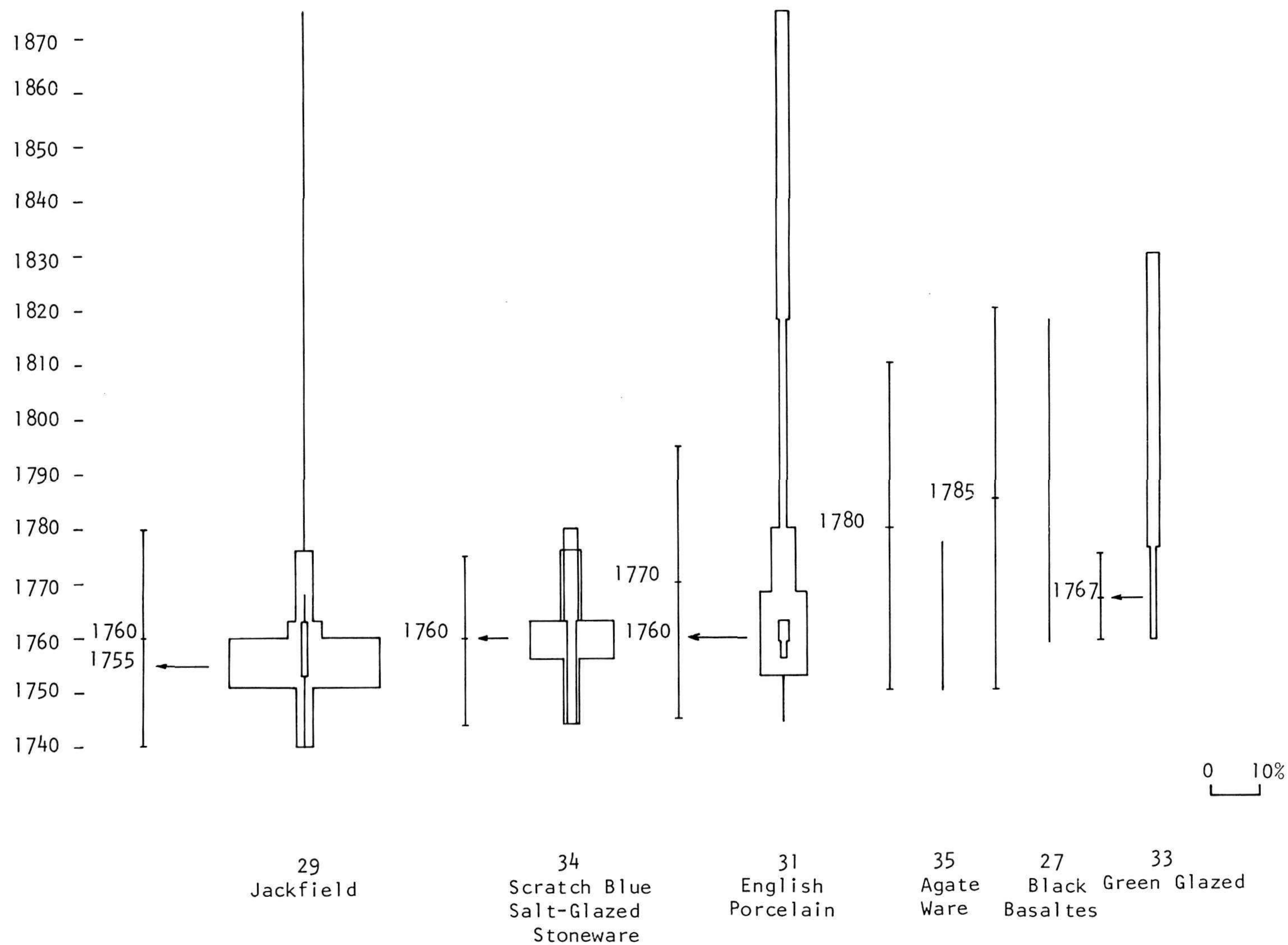
13 Cumulative seriation of types 49, 66, 65, 58, 61, 39, 26 and Spanish olive jars. (Drawing by D. Kappler.)



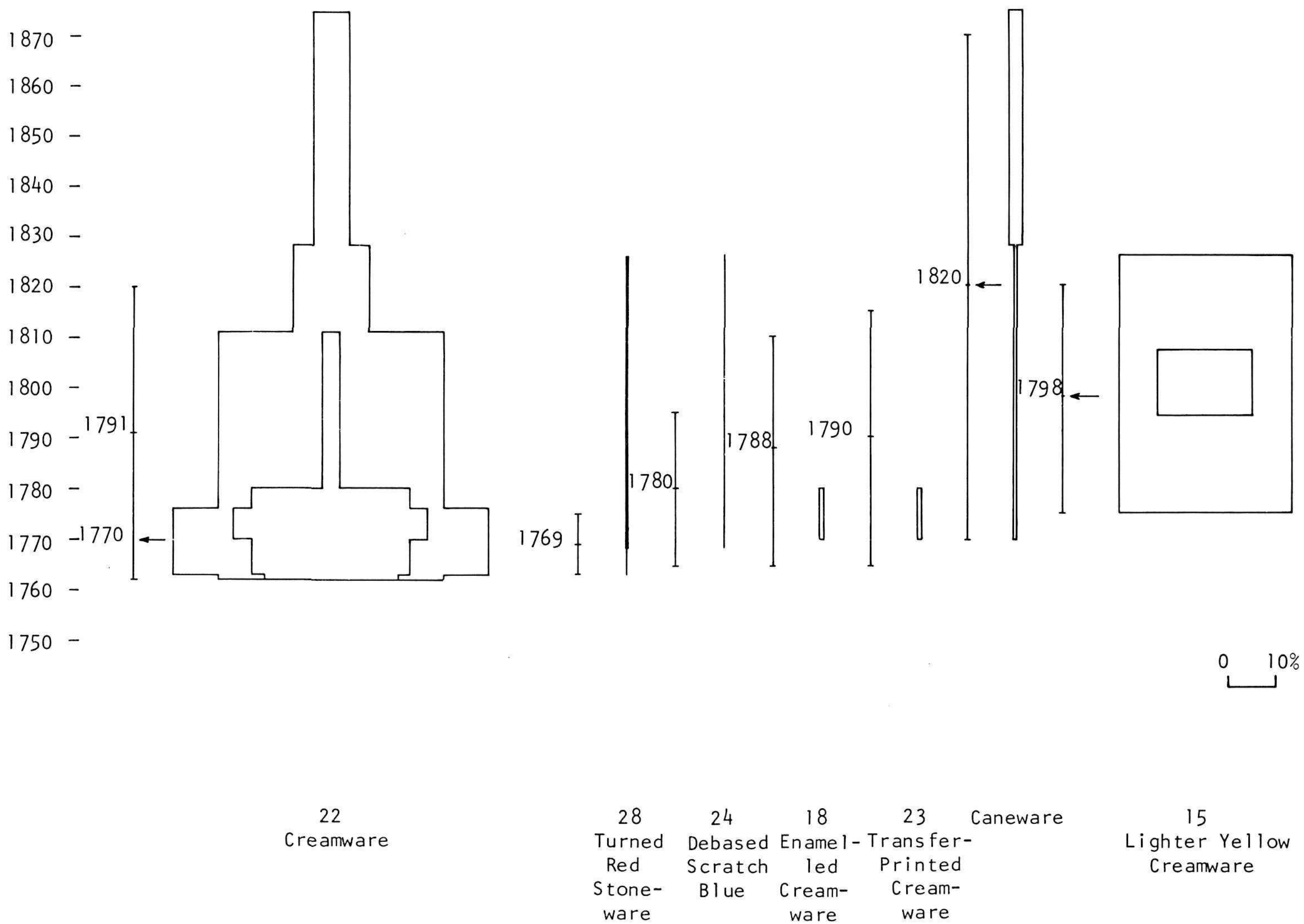
14 Cumulative seriation of types 56, 37, 54, 44, 45, 46, 48 and miscellaneous slipware. (Drawing by D. Kappler.)



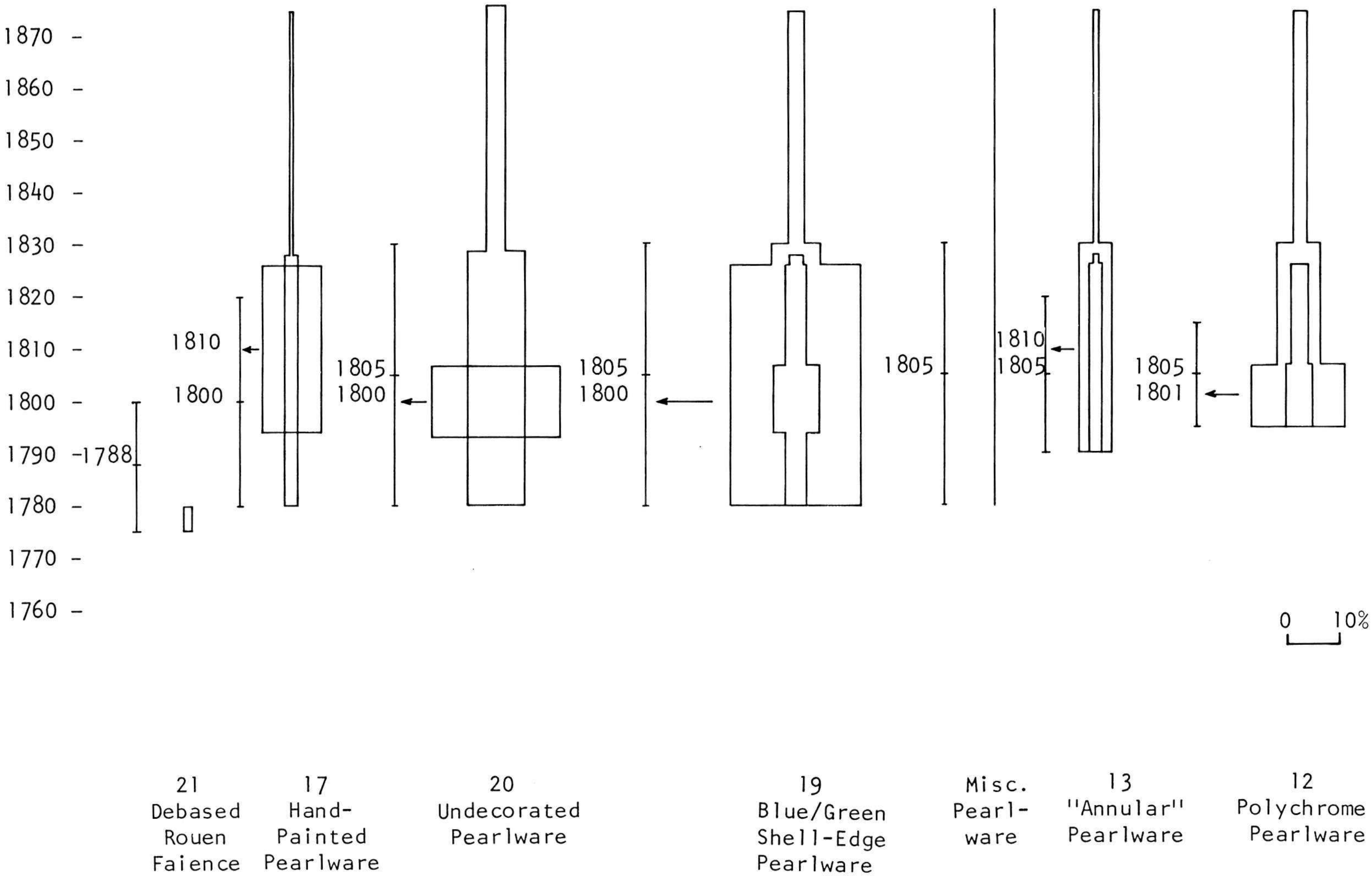
15 Cumulative seriation of types 47, 40, 16, 36, 42 and 43. (Drawing by D. Kappler.)



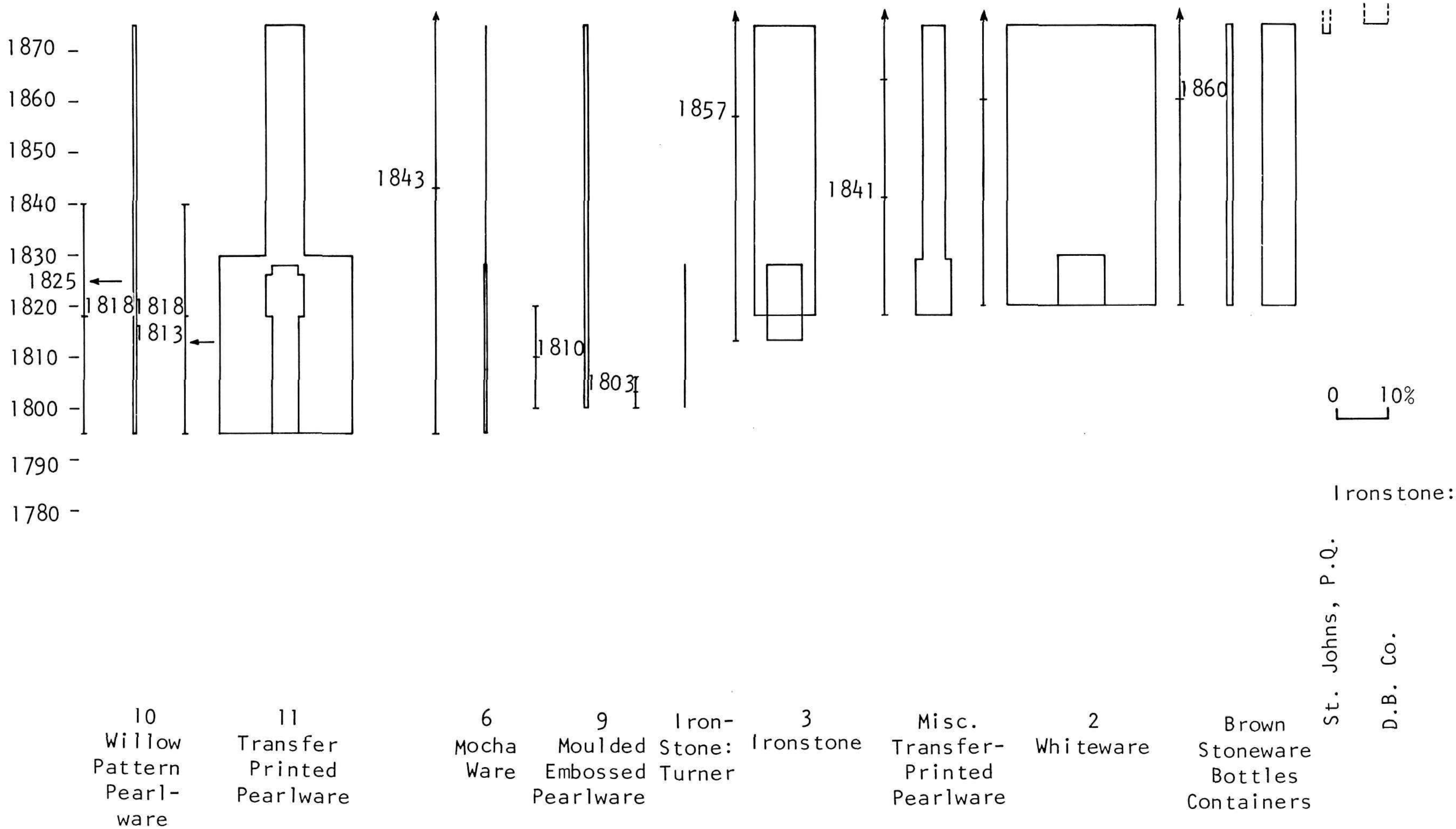
16 Cumulative seriation of types 29, 34, 31, 35, 27 and 33. (Drawing by D. Kappler.)



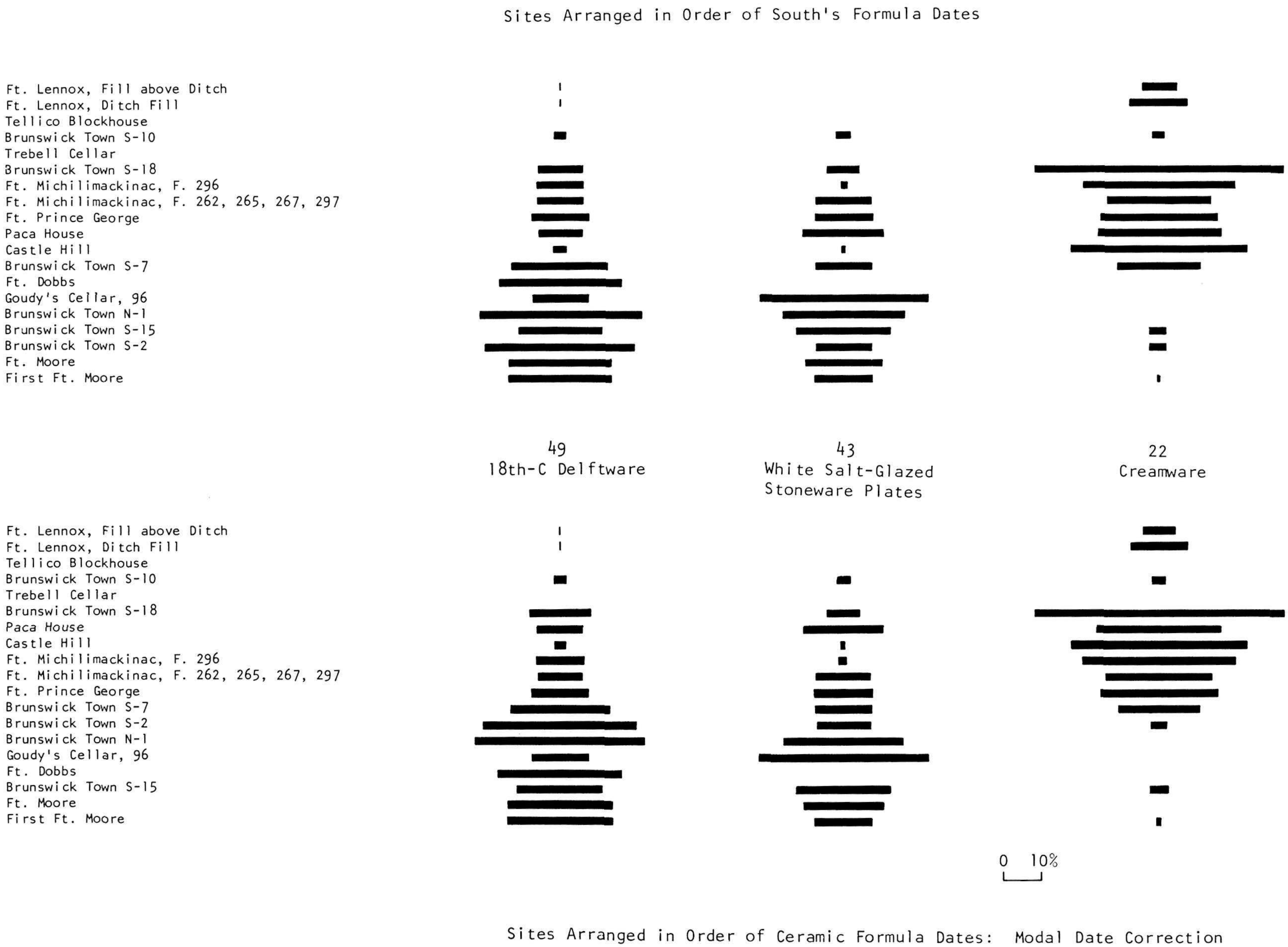
17 Cumulative seriation of types 22, 28, 24, 18, 23, 15 and caneware. (Drawing by D. Kappler.)



18 Cumulative seriation of types 21, 17, 20, 19, 13, 12 and miscellaneous pearlware. (Drawing by D. Kappler.)



19 Cumulative seriation of types 10, 11, 6, 9, 3, 2, 1, miscellaneous ironstones and miscellaneous transfer-printed pearlware. (Drawing by D. Kappler.)



20 Comparison of alternate standard seriations of three types. (Drawing by D. Kappler.)

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