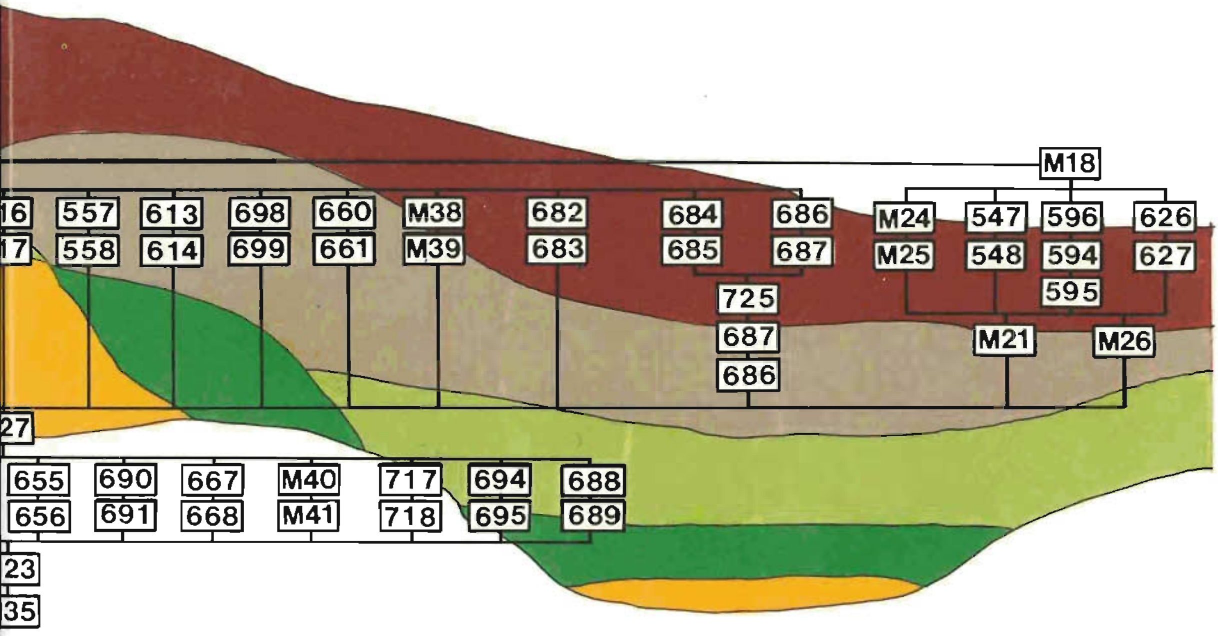
PRACTICES *of* ARCHAEOLOGICAL STRATIGRAPHY

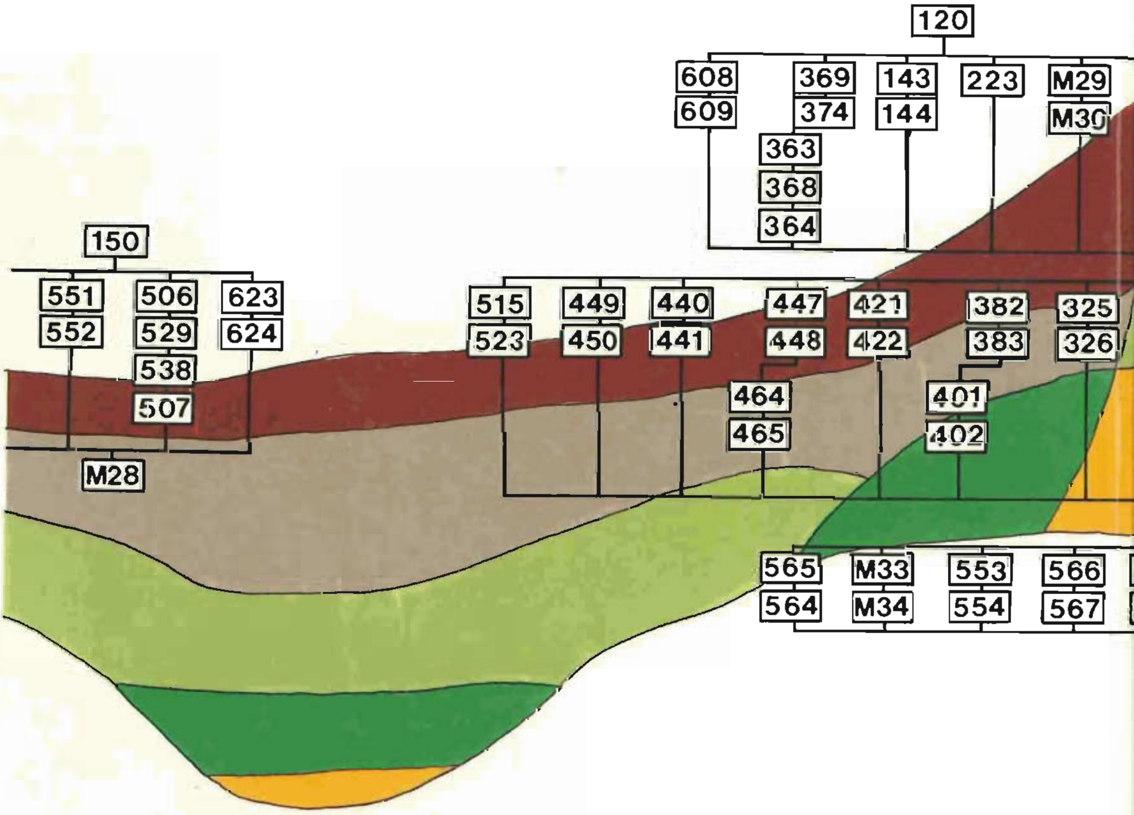
Edited by

Edward C. Harris, Marley R. Brown III,
and Gregory J. Brown



This book aims to bring together a number of examples which illustrate the development and use of the Harris Matrix in describing and interpreting archaeological sites. This matrix, the theory of which is described in the two editions of Edward Harris' previous book, *Principles of Archaeological Stratigraphy*, made possible for the first time a diagrammatic representation of the stratigraphic sequence of a site, no matter how complex. The Harris Matrix, by showing in one diagram all three linear dimensions, plus time, represents a quantum leap over the older methods which relied on sample sections only.

Here, seventeen essays present a sample of new work demonstrating the strengths and uses of the Harris Matrix, the first published collection of papers devoted solely to stratigraphy in archaeology. The crucial relationships between the Harris method, open-area excavation techniques, the interpretation of interfaces, and the use of single-context plans and recording sheets is clarified by reference to specific sites, ranging from medieval Europe, through Mayan civilisations to Colonial Williamsburg in the USA. This book will be of great value to all those involved in excavating and recording archaeological sites and should help to ensure that the maximum amount of stratigraphic information can be gathered from future investigations.



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Contents

Foreword

It is an honour to be asked to write a prefatory page to *Practices of Archaeological Stratigraphy*, a book which shows how widely Edward Harris's matrix concept has become used. In less than two decades the Harris Matrix has gone from being an esoteric recording format of the Winchester Research Unit to a generic research tool of archaeologists across the world. The applications in this book, by scholars working on sites from shell-middens in the Pacific Northwest to medieval towns in Poland, from the Maya of the Central American rainforest to the urban complexities of York with its two millennia of packed urban deposits, show how deeply Harris's ideas have penetrated our professional consciousness.

The idea of a stratigraphic diagram which was procedurally rigorous, forcing the excavator to account for every defined context in spatial and chronological relation to its neighbours, and thus to think honestly about what the evidence meant throughout a project rather than only at the stage of writing up, was both new and welcome when Harris first introduced it in 1973. The standing section was still the principal means of displaying stratigraphic data and elucidating its chronological and cultural significance, although some British excavators, notably Brian Hope-Taylor at Yeavering, and Martin Biddle and Birthe Kjølbye-Biddle at Winchester, had begun to argue for the primacy of the phase plan. The Harris Matrix was the ideal way of reconciling these two complementary, yet in some ways contradictory, methods of putting a site on to paper and making it comprehensible to others. It was value-neutral, not imposing anything on the excavator except an obligation to think clearly, denying nothing but the chance to fudge a difficult point. Its utility was not confined to ordering buried deposits, as some of the applications cited in the second edition of Harris's classic *Principles of Archaeological Stratigraphy* and some of the chapters in this book show, the matrix format is as relevant to the above-ground archaeology of standing buildings such as Sandgate Castle in England or the Bixby House in Massachusetts. In spite of the sniffy attitude taken by some geoarchaeologists, the matrix, as a simple way of enforcing ordered thinking, is just as capable of helping them to make sense of their deposits and interfaces.

The discipline imposed by using the matrix has resulted in some other important developments, notably the idea of single-context planning. If each context has to be accounted for separately in the matrix, then it should be plotted separately on site as well, with a congeries of logically associated contexts being assembled into a phase plan at the analytical rather than data-recovery stage, when a distanced perspective can be taken.

A second emphasis is on the interface as a distinct event horizon from the stratum which it bounds, or which overlies it. I would part company with Harris only in his terminology: while the surface of a stratum (context) may indeed be a *layer interface*, the *feature interface* is not necessarily a 'surface in its own right . . . formed by the destruction of stratigraphy' (*Principles of Archaeological Stratigraphy*, 2nd edn, p. 54). This is making a false distinction between the *context*, be it positive (a layer) or negative (a cut such as a posthole), and the *feature* as a logical collocation of contexts, thereby obscuring the distinction between units of observation and superordinate units of analysis. Such disagreements, however arcane they may seem to those unconcerned with the precise ordering and explanation of archaeological stratigraphy, are important; in accepting the rigour imposed on our thinking by the matrix format we forgo Humpty Dumpty's privilege of having a word mean just what *we* say it means, neither more nor less.

That precision in terminology is worth arguing over, however, is partly due to the precision in recording that Edward Harris has urged upon us: in the same way that Lewis Binford's *A Consideration of Archaeological Research Design* (1964) made us think about why we did what we did, and David Clarke's *Analytical Archaeology* (1968) made us clean up our fuzzy vocabulary and concepts, so Harris's *The Stratigraphic Sequence: A Question of Time* (1975) and his subsequent books have made us think more deeply and clearly about the vital process of converting the evidence of archaeological stratification into the observations and interpretation of archaeological stratigraphy.

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SECTION I
Introduction

The purpose of this book is to bring together some of the new ideas and methods which have evolved in the subject of archaeological stratigraphy since 1975. In that year appeared the first paper on the so-called Harris Matrix, which ushered in a new era in archaeological thought, and upon which the articles of this book are largely founded. For the first time in archaeological stratigraphy, through the use of the Harris Matrix, it was possible for archaeologists to show the stratigraphic sequence of a site in a diagrammatic form, no matter how complex an individual sequence might prove to be.

Prior to 1975, section drawings were used to demonstrate stratigraphic sequences, but on complex sites they can only show a small portion of the sequence, which is true perhaps only for the plane along which the section was cut. The standard section drawing is a two-dimensional representation of a portion of the stratigraphic sequence of a site, as evinced by deposits and stratigraphic features in superposition. It shows the thickness and length of the various deposits on a particular plane through the site. The width, or full horizontal area, of each stratigraphic unit, which represents its third dimension is, on the contrary, only to be found in a plan drawing of its surface. The chronological interpretation, in relative time (i.e., which came first?), of the stratigraphic unit introduces the fourth, or time, dimension into the equation, the result of which is the determination of the stratigraphic sequence of the site.

The pre-1970s stratigraphic standard for archaeology was the section, which thus gave the discipline a two-dimensional paradigm for its notion of stratigraphy. This world view was shattered by the introduction of the Harris Matrix, by which method it became possible to show the entire stratigraphic sequence of an archaeological site in a single diagram. Such a diagram represents all four dimensions of the stratification of an archaeological site; this type of illustration has therefore changed the paradigm of archaeological stratigraphy from a two- to a four-dimensional model. The papers in this volume are a direct result of this shift in the paradigm for archaeological stratigraphy and represent the beginnings of major revolutions in archaeological thought in the late 1970s and throughout the 1980s.

These essays are, however, but a sample of new work which has been taking place in archaeology on sites around the world as a result of this revolution in the philosophy of archaeological stratigraphy. We regret that it is not possible to publish more than is represented in this volume, which does not include any papers from classical sites (e.g. Paice 1991). Regrettably, it does not have any of the important work carried out by Italian archaeologists, who were one of the first large groups outside England to adopt the new ideas (e.g. Manacorda 1983; Carandini 1981; Carandini *et al.* 1985). Its shortcomings aside, however, this is the first volume of collected papers ever published in archaeology entirely devoted to the subject of stratigraphy. That this is so should not be taken as praise for its publication, but as an indictment of the complacent and often irresponsible attitude that archaeological scholars have taken towards this subject, which is the foundation of our trade and the firmament upon which our ideas of the Past must be based. Throughout the papers, a number of fundamental notions will appear and it may be of value to summarize them at this point.

First, it is now axiomatic that sites must be excavated by the stratigraphic method, that is to say by the recognition of the unique surface of each deposit, its record before excavation, and its removal by excavation in stratigraphic order, the later deposit being dug before the next earlier one. As argued by Praetzellis in his essay (Chapter 5), there is a place for excavation by pre-determined, or arbitrary, levels in undifferentiated deposits of some depth and extent. If applied, however, to a clearly stratified site, this method will destroy the only opportunity the archaeologist will have to recover the unique stratigraphic sequence of the site.

Secondly, and concomitant with stratigraphic excavation, is the efficiency of the open-area method of delineating a site. By this system, developed in Europe and advocated by Philip Barker from the 1960s onwards, the entire area to be excavated is approached as a single unit, without the clutter imposed upon a site by the baulks of the older grid system devised by Sir Mortimer Wheeler. The importance of the open-area method lies in the fact that the archaeologist can see the entire area to be excavated at any time. For the purposes of argument, an open area could be an excavation area of any size, provided that its internal space is not encumbered with unexcavated baulks of stratification: that is, one of the ten-feet square boxes of a Wheelerian excavation could be viewed within itself as an open-area excavation. What is therefore of importance in this method is that it is *not* a method of actual excavation, but of defining an excavation area, which is to be dug without internal baulks (on a large excavation, the sides of the area are baulks).

The ideal for good archaeological stratigraphy is thus open areas excavated by the stratigraphic method. There is, however, one last point about the open-area method, for which archaeology should be indebted to excavators such as Philip Barker. By emphasizing the open-area approach to an excavation, Barker and his contemporaries, perhaps unwittingly, were laying the groundwork for another important change in the paradigm of archaeological stratigraphy, namely, from a reliance on baulk faces for stratigraphic data to that to be found in the surface area of each deposit. In essence, open-area methods tell us to examine the site from a horizontal, or surfacial viewpoint, and not from its sides, or vertical aspects, as held in the profiles of baulks. This heresy ultimately led to the creation of single-layer planning, with its emphasis on the details of the interface, or surface, of a deposit, as opposed to its underlying contents.

The third item of overriding importance in archaeological stratigraphy is the notion of what we refer to as the interface. An interface may be represented by the area of the surface of a deposit, or the upstanding face of a wall, or it may represent the stratigraphic feature which is nothing but an interface or surface. This last type of stratigraphic unit is typically a hole or incline which has destroyed pre-existing stratification, but which itself is a separate event in the formation of the site. These pits, ditches, graves, foundation trenches, rodent burrows and so forth, occur on a majority of archaeological sites, especially those in urban contexts.

As they are only represented by surfaces and whereas contrarily each deposit has its material content and a surface, there will be more individual interfaces on a complex site than there will be deposits. Yet in the past, the non-deposit interfaces have not been given full value in stratigraphic studies, so much so in some instances that it may be said that the stratigraphic record of many sites has been undervalued by over 50%. In the stratigraphic method of excavation, or more importantly – as this type of interface cannot be excavated as it has no material form – in the method of recording, these non-deposit interfaces must be treated as individual units of stratification. They each must be given a layer, or context, number and must be recorded on individual single-context plans.

Again, we may point to this emphasis on the interface as another paradigm shift, which began in the 1930s, but which reached fruition after the advent of the Harris Matrix. One of the greatest contributions that Dame Kathleen Kenyon and Sir Mortimer Wheeler made to the theory of archaeological stratigraphy was their emphasis on the analysis of stratification by the study of interfaces. Yet they remained locked into the vertical paradigm of stratigraphic analysis by the study of soil profiles on the faces of baulks, as pre-determined by the use of the Wheelerian grid system of excavation.

The stratigraphic sequence of a complex site cannot be determined by the sole use of section drawings, but it may be completely understood by the sole use of single-context, or interfacial, plan records. Furthermore, it would be very difficult to retain enough baulks and record enough section drawings to allow for the topographical, or interfacial, reconstruction of a complex site, if a site is to be excavated in a reasonable period of time. Yet with single-context planning, sections can be reconstructed along any given plane on the site. For these reasons, the study of section drawings for stratigraphic purposes to the exclusion of the horizontal evidence of the interfacial surfaces of stratigraphic units was the major factor limiting the advancement of archaeological stratigraphy into the 1970s. After the mid-1970s, the stratigraphic paradigm had to shift and the single-context plan replaced the section drawing as the most important item in the analysis of stratification on archaeological sites.

This fourth notion of consequence, the single-context plan, in its simplest form, shows the contour of the surface of a stratigraphic unit by a record of spot heights and it has lines which encompass its full extent, as limited only by the area of the excavation. These lines, which mark the boundary of the unit, can only be partially represented in any given section drawing, and therein lies the drawback of sections: the boundary of the unit defined in a plan shows its full horizontal coverage; the boundary of the unit shown in a section can never be more than a partial view. Consequently, stratigraphic analysis, by looking at the superimposition of stratigraphic units, can be most efficiently and completely done by the overlaying of single-context plans. Section drawings cannot be overlaid for such analysis because there will always be a gap of stratigraphic data representing the unrecorded soils between each section. As a section is a composite drawing of a block of stratification, it is of little use until the site has been excavated to bedrock, at which time the whole section can be stratigraphically analysed. This approach is perfectly valid if excavation consists of the summary removal by a machine of the stratification adjacent to the section: in such an instance, the section will be all that one has of the stratigraphic record of that area.

Thus single-context planning is essential to, and moreover compatible with, proper stratigraphic excavation and analysis. As the horizontal extent of each unit is identified, it is drawn on a single-context sheet and its stratigraphic relationships with the deposits and features underlying it will be noted. As the plane is fixed in space to the survey grid of the site, its stratigraphic coverage can be re-examined at any time by the overlaying of the accumulated plans of the individual units in its area of a site. Provided that the excavator has correctly identified its boundaries and its stratigraphic position, it is axiomatic that the recording of each unit by a single-context plan will help to determine and will take place at the same time as the stratigraphic sequence, in the Harris Matrix form, is being slowly compiled. These two methods can thus be done simultaneously, whereas if one relies on sections to determine the stratigraphic sequence, one must wait for the completion of the excavation to ascertain that sequence.

This leads us to the fifth major ingredient of stratigraphic import, namely, the stratigraphic sequence, often referred to in this book as the matrix, or matrices, of a site. The stratigraphic sequence of a site represents the physical development of an excavated area through relative time. As it is a representation of time and not of the physical world, it can only be shown in an abstract diagrammatic form, as a calendar, for example, respresents the days and months of a year. The Harris Matrix allows for the creation of such abstract diagrams by the interpretation of the stratigraphic (relative time) relationships between the superimposed units in the excavated area. A stratigraphic sequence, therefore, may be inferred from a section drawing, but that two-dimensional record of the physical characteristics of the stratification appearing on that particular plane through the site is not itself a stratigraphic sequence. Prior to the invention of the Harris Matrix, archaeologists relied upon section drawings, erroneously thinking such sections to be stratigraphic sequences. Sections, however, may be open to various interpretations, which is why it is important that the archaeologist composes the separate stratigraphic sequence diagram, in order that an unequivocal view of the sequence is to be found within the records of the excavation.

Since 1973, the Harris Matrix method has proven to be a simple way in which stratigraphic sequence diagrams can be made and its efficacy is marked by its use on many types of sites around the world. In order to compile the stratigraphic sequence, the archaeologist must use all the stratigraphic data from the site, of which sections are only one part. There will also be the notes made about stratigraphic relationships and the data to be obtained from the single-context plans. The Harris Matrix diagram combines all that data into a single stratigraphic sequence for the excavated area, giving the archaeologist the testing pattern against which all other analyses of the site may be viewed. The stratigraphic sequence of every site is unique and is undesignedly commemorative of the stratigraphic events of that site. Therein lies its great value to archaeology, for it is a testing pattern which the excavator has deduced from the stratification, and not one, such as produced by arbitrary excavation, which the excavator imposes on the site and therefore on the archaeological record for all time.

By undesignedly commemorative, we mean that stratified deposits are an incidental outgrowth of life in the past: people, in other words, did not decide to build archaeological sites in the process of building their houses and living out their lives. Archaeological stratigraphy is but a fortunate by-product of life in the past, and if the stratigraphic sequence of a particular site is correctly interpreted by an excavator, then that sequence will be an undesigned view of the site, independent of the excavator's personal biases. Only if the site is excavated by the stratigraphic method can these matrix drawings be compiled during the fieldwork, which is the best time for them to be done. If problems occur in their compilation, the single-context plans can be overlaid in stratigraphic order and it is more than likely that that exercise will solve the problems.

Finally, there is the matter of other new methods which are auxiliaries to the five topics just discussed. Foremost among these is the single-context recording sheet, which is a loose-leaf format for making written notes about each stratigraphic unit. The single-context sheet replaces the site notebook of earlier generations and is better for analysis as each unit is on a single page, which can be easily shuffled into phase or period groupings in later analysis. These sheets may take various forms or they may in some instances be on computer. They will contain written information about the nature of the deposit or feature, its stratigraphic relationships and any other relevant data.

In all of this new work, the computer takes an increasingly larger role. Single-context plans, for example, are electronically digitized into drafting programs and may be manipulated to be combined into phase and period plans. Other workers have devised computer methods for drawing matrix diagrams, replacing the tedium of compiling them by hand. Computerized survey equipment is also now an important tool for work on excavations. These and other auxiliary methods are but additional tools which the excavator may use to increase the efficiency of work on a site, and in its later topographical and artefactual analyses. Thus in their own way, they are increasingly changing archaeological methods, usually for the better.

Speaking stratigraphically, however, these auxiliary methods would have been of little value without the fundamental changes which have taken place in the paradigms, or exemplars, of stratigraphic method since the late 1940s and in a revolutionary fashion since the early 1970s. The collected papers in this volume result from these changes and often represent new methods and ideas stimulated by this process of development.

We may summarize the major paradigms of archaeological stratigraphy as follows. First, the process of excavation should be carried out by the stratigraphic method, with an open-area format providing the best view of an excavated area; secondly, in stratigraphic analysis, the study of the interface is paramount; thirdly, stratigraphic data are best captured by attention to the horizontal extent of interfaces and the data are best recorded on single-context plans and single-context recording sheets; fourthly, sections should be recorded where convenient on a site, or when they represent the only stratigraphic data of a site, but in the first instance they cannot be relied upon to produce but a partial picture of the full stratigraphic sequence of a site; fifthly, stratigraphic sequences are separate entities from the data held in sections, plans and site notes, and should be compiled for each site during the excavation period.

All of these concepts represent the major paradigm shift in recent archaeological thought from a vertical, planar view of sites to seeing sites from a horizontal, or topographic (that is to say, interfacial), viewpoint. This shift to a horizontal viewpoint is more compatible with the way in which sites developed, i.e., by a topographical, superimposed, accretion of strata and interfaces, and mirrors the manner in which we should excavate them, not from the side (as in a sectional viewpoint), but from top to bottom, from late to early by the stratigraphic method of removing the later layers first. By adhering to the old sectional view, derived unaltered from geology in the nineteenth century, we have unwittingly destroyed, largely without record, over half the archaeological data from nearly all the sites which were excavated prior to the 1970s.

This indictment of archaeology comes largely from the fact that we have refused until now to consider archaeological stratigraphy as a science in its own right, though even now there are archaeologists and geologists who think we err in suggesting such a thing. It is our hope that this volume, with its many weaknesses, will continue to stimulate debate and development on the science of archaeological stratigraphy, which one might say is but two decades old.

This volume is divided into six main sections. One paper is included as a part of this introduction by Marley Brown and Edward Harris (Chapter 1): it discusses the notion of the interface in archaeological stratigraphy and is intended in part as a rebuttal to the criticisms levelled at the Harris Matrix by various advocates of the geological approach to stratigraphic study in archaeology. The second section looks at historical trends in stratigraphic thought, using examples from England, Poland, Spain and the United States. The third section concerns stratigraphic analysis during excavation, and the fourth concentrates on phasing and structural analyses. The fifth section discusses some aspects of post-excavation analyses as they relate to stratigraphy. In the sixth and concluding section, we present the paper by Peter Clark (Chapter 17), which looks back at a 'pre-matrix' site, but in so doing looks forward to questions of how we may recover some of the stratigraphic data found in the archives of earlier excavations and how such exercises will be salutary for archaeologists working today in the field.

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1 Interfaces in archaeological stratigraphy

MARLEY R. BROWN III and EDWARD C. HARRIS

Introduction

On 28 February 1973, an archaeological tool, which became known as the 'Harris Matrix', was invented as a result of post-excavation analysis of site records compiled in the late 1960s at Winchester, the ancient capital of England. The first academic publication of this new method of stratigraphic analysis was in June 1975 (Harris 1975). This was followed four years later by Edward Harris's seminal work, *Principles of Archaeological Stratigraphy* (Harris 1979a). That edition was translated into Italian (Harris 1983), with an important introductory article by Daniele Manacorda. A Polish translation by Zbigniew Kobyliński appeared (Harris 1989a), along with a Slovene edition under the supervision of Mitja Gustin (Harris 1989b). A second English edition was published by Academic Press (Harris 1989c), which was translated into Spanish by Isabel G. Trócoli (Harris 1991).

Twenty years on, the Harris Matrix has proven its practical worth, and has been susceptible to further development, as demonstrated in the papers of this volume. It was taken far afield by British archaeologists (appearing, for example, in the Americas on one of Norman Hammond's Mayan sites as early as 1974) and has found acceptance in the excavation of many sites of different chronological and cultural periods. The principles of archaeological stratigraphy expounded by Harris, as an outcome of the development of the Matrix, are based upon the notion that they are of universal application of archaeological sites. They reflect the ideas of superposition and relative time, which ask and answer the question, 'Which came first?', of any two contiguous layers or features. This fundamental question is now applied not only to buried features, but to the analysis of the stratification of standing buildings, the archaeology of which is above ground and surrounds us in our daily lives.

The Harris Matrix is a simple way in which the relationships between stratigraphic units can be seen in a single diagram, which reflects on paper the stratigraphic sequence of the site as found during excavation. It has supplied archaeology with an invaluable analytical method which was not derived from any known geological system of illustrating stratigraphic sequences. This invention, independent of geological sources, is perhaps one reason why its major critics are to be found in geological circles (see Bobrowsky 1991). The purpose of this introductory article is to examine and answer a few of these critics, who seem largely unaware of the great advances made in archaeological stratigraphy in the last 15 years, which they may now surmise from the papers in this collection.

Practices of Archaeological Stratigraphy
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Living within the laws of geology

In 1984, William R. Farrand took Harris and his supporters (e.g. Fedele 1984) to task, for Harris's *Principles of Archaeological Stratigraphy* 'has concerned me for several years, and this seems to be the proper time and context in which to discuss it' (Farrand 1984: 3): that context was the publication by Gasche and Tunca (1983) of a supposedly alternative system to the Harris Matrix. According to Farrand, Harris's first error was that he believed that 'most archaeological stratification is man-made and is not directly subject to the laws of geological stratigraphy'. Harris is slated for asserting that 'most archaeological strata are not of sedimentary origin' and that archaeologists should develop their own laws and methods of stratigraphy. Having stated that he thinks geological axioms are not appropriate for modern archaeology, Harris is accused of not understanding geological methods. Farrand suggests that he go back to school by spending 'some time in the field with Quaternary geologists who are dealing with unconsolidated terrestrial (riverine, glacial, or eolian) strata' (Farrand 1984: 5). What, one might ask, would be the response of Quaternary geologists if they were told to go and work on an archaeological site in London or New York, in order to bone up on *geological* methods?

Into the 1970s, archaeologists mainly used one geological maxim, namely, the 'law of superposition'. At the same time, however, they were developing archaeological methods of recording stratification, which, it might be said, were far more advanced than those used by geologists working with unconsolidated strata. The development of refined section drawings by Sir Mortimer Wheeler, Dame Kathleen Kenyon and their disciples at places such as Winchester, London and York is without parallel in other stratigraphical fields. The same may be said of the composite plans which arose out of the tremendous advances in recording techniques in the 1970s at Winchester (Biddle and Kjølbye-Biddle 1969) and elsewhere, inadequate though we now know composite plans to be on their own in stratigraphic analysis. These archaeologists have not been criticized for developing the methods of archaeological recording, which *of scientific necessity* have diverged from geological norms.

Yet Farrand contends that:

> Harris has done a disservice to both archaeologists and geologists that is potentially divisive just at the time when the mutual benefits of geoarchaeological interaction are coming into their own. Harris clearly does not understand geology except on a rather superficial level. He cites ancient authorities (Lyell, Grabau, etc.) and thinks of geology essentially in terms of consolidated marine sedimentary rocks of vast lateral extent. He categorizes all unconsolidated sediment in an archaeological site as 'soil', and does not realize that an anthropogenic sediment is every bit as much a sediment as a natural (geologic) one (Farrand 1984: 5).

Farrand's objections seem to be grounded partly in the assumption that if archaeologists *borrow* a concept from the discipline of geology, they are *obliged* to live 'within the law' (his phrase) and use that concept without alteration. However, 'it is always a danger to borrow technical terms without observing their definition or without redefining them' (Barzun and Graff 1970: 164). It is our view that the geological notions of stratigraphy are important as a starting point, but they must be redefined for archaeological purposes. The failure to do so until the 1970s has resulted in the destruction of much of our cultural heritage through sites badly excavated and recorded by incompetent archaeological stratigraphers.

Farrand also places an undue emphasis on the objects contained within deposits, all of which, including artefacts, are referred to as 'sediments'. (This primary interest in the contents of strata, and not in their topographical form (interfaces), is continued in J.K. Stein's lengthy exposition on 'Deposits for archaeologists' (Stein 1987).) Supporting another object-oriented system, Farrand claims that the 'Guide to Archaeostratigraphic Classification and Terminology' (Gasche and Tunca 1983) is 'a big step in the right direction', which means to him that the 'time has come to unify our thinking on stratigraphic practice' (Farrand 1984: 5).

This system is a complicated method the purpose of which is to bring archaeological findings into correlation (or into line) with geological standards, and its preparation was undertaken 'in the context of the International Geological Correlation Programme' (Gasche and Tunca 1983: 325): in other words, the unified thinking will be geological, not archaeological. Thus we are introduced to 'archaeostratigraphy', being 'used for stratigraphy related to archaeology', and 'ethnostratigraphy', being a 'stratigraphic classification whose units are characterized by their contents of anthropic origin, i.e., by artefacts'. 'Chronostratigraphic Classification', on the other hand, is the 'systematic organization of sequences of strata from an archaeological site' (Gasche and Tunca 1983: 300). 'Stratigraphic ruptures' have a place in this proposal and 'are numerous in an excavation'. Oddly, in order to support their points for this overt geological work, the authors rely on section drawings of sites with the remains of masonry buildings.

The Gasche and Tunca method is primarily an object-based system. Thus, 'all the lithologic units that can be characterized with the same classes of artefacts are then regrouped in the same ethnostratigraphic unit' (Gasche and Tunca 1983: 332). It is admitted that the 'classifier might run up against problems associated essentially with the complex nature of archaeological sedimentation, such as stratigraphic interferences, reworked strata, displacements of artefacts, etc. The choice of the artefacts that characterize each unit and that distinguish it from adjacent units depend upon their relevance' (Gasche and Tunca 1983: 332). No explanation is given of how to accomplish the finding of 'relevance', i.e., the determination of which artefacts are residual, infiltrated, or indigenous (Harris 1979a: 93), for only the last type appears to be relevant to their system.

On their idea of 'chronostratigraphy', they say that it is a 'stratigraphic classification in which the units are characterized by their duration and by their temporal relationships' (Gasche and Tunca 1983: 329). As they do not appear to be writing of stratigraphic relationships in relative time, neither the duration of temporal relationships can be defined without the presence of artefacts, unless they think the reused geological rocks, pebbles, sands and 'sediments', etc., of indeterminate age, can be used to provide dating evidence in archaeological contexts produced by human action. Again section drawings are used to bolster their arguments, which are not an adequate substitute for the one crucial ingredient missing in their 'Guide'. This is the notion of the stratigraphic sequence, as defined by Harris (1975) for complex archaeological contexts created by the activities of people, and demonstrated by other authors in the present book.

Farrand and his supporters cannot defend the fact that geology has not given us any methods by which the complex stratigraphic sequences of archaeological sites can be displayed. Yet illustrations of such sequences must form the testing pattern for any of the notions expounded by Gasche and Tunca, if their ideas are to have any merit for archaeological sites without massive geological components. How can one decide the 'relevance' of classes of artefacts without such a testing pattern? The fundamental requirement that the stratigraphic sequence of archaeological sites must be constructed in the first instance without reference to artefacts or sediments, but by an analysis of stratigraphic interfaces, has been missed by these critics. Stratigraphic sequences cannot be derived from artefacts because these objects are found *within* deposits, which are, as it were, encapsulated by their interfacial boundaries. The analysis of stratigraphic relationships takes place on those boundaries, without and exterior to the artefact content or soil composition of the deposit. A thousand artefacts cannot make a stratigraphic sequence, but a group of interfaces can – without the presence of a single datable artefact within the associated deposits.

The great value of the stratigraphic sequence as a testing pattern is that it is '*undesignedly* [original emphasis] commemorative of former events' (Lyell 1875: I, 3). Those former *events* refer in the first instance to the interfaces of the stratigraphic record and only secondarily to its contained remains. If we can capture that data which are 'undesignedly' (not contrived or purposely built by people, as happens with arbitrary excavations) commemorative of series of former events by our careful archaeological dissection of the earth, then we will produce stratigraphic sequences, or testing patterns, which are independent of our subjective opinions and upon which we may make sound archaeological judgements, especially when later analysing the portable artefacts of a site.

The role of the interface

There are three types of stratigraphic event on an archaeological site, whatever its source or composition: the deposit, which has a material mass which may contain artefacts; the surfaces or interfaces of deposits; and other interfaces, such as pits, which are stratigraphic units in their own right. Exemplifying current thinking in geoarchaeological circles, S.N. Collcutt and J.K. Stein find little merit in the idea of interfaces, which are so crucial to the stratigraphic interpretation of archaeological sites and consequently to their artefact-based approaches.

Collcutt rejects 'the separatist approach' supposedly found in *Principles of Archaeological Stratigraphy* (Harris 1979a), finding himself 'in full agreement with Farrand' that Harris has done a disservice to the profession (Collcutt 1987: 11). He tells us that he has applied the Hedberg (ISSC 1976) ideas to archaeological sites, 'and found much which is of great value'. Discussing terms, Collcutt widens the concept of 'particle' as being 'any object that is of interest to us for a specific reason'. This leads naturally to the definition of a 'sediment' as 'a collection of particles', What relevance this has to the world of human artefacts is difficult to tell. Collcutt refuses to accept the assertion that the 'importance of man and society as users and producers of discontinuities constitutes perhaps the single main area of divergence between cultural and entirely natural systems, between archaeological and geological stratigraphies' (Fedele 1984: 12). He says that Fedele is 'only begging the question when the [*sic*] suggests: "Its basis [that of 'analytical stratigraphy'] is an attention for *the smallest stratigraphic* [original emphasis, according to Collcutt] events, discontinuities in particular"' (Collcutt 1987: 13). He concedes that 'geologists perceive the same need' to recognize and record interfaces, quoting geologists

Collinson and Thompson (1982: 177), who wrote that 'the feature of measured sections most commonly ignored is the nature of contacts between units' (Collcutt 1987: 13).

The fact that the inability to *see* and record interfaces has been a major problem in archaeology seems to have eluded Collcutt, as witnessed by the following extraordinary statement, which incorporates the two main totems of this group of critics, namely, the obsession with artefacts (i.e. particles) and a penchant for ignoring the interfacial aspects of stratification.

> Man is just as much a destroyer of discontinuities as he is a user or producer, and in this he is not markedly different from earthworms, rabbits, trees, wind or running water. In this connection, I find the ideas concerning 'living floors' of many researchers (e.g. Le Tensorer 1984) most simplistic. From my geoarchaeological point of view, man does not live on surfaces, he 'lives' (i.e. evidence of his occupation is found) in a formerly superficial band of pre-existing sediments, nearly always 3–10 cm, and sometimes over a metre, thick (Collcutt 1987: 13).

By this analogy, Collcutt would have people living in houses, for example, the floors of which were never cleaned, but comprised a thick layer of muck in which the occupants waded, leaving behind the only evidence of such a lifestyle as artefacts in the mud around their feet. In his view, interfaces ('living floors') are not a valid part of stratigraphic interpretation, albeit that they usually form more than half the archaeological record. It is that half on most sites which probably represents more the passage of time than do all the deposits, a point forced upon geological thinking by Charles Darwin in the mid-nineteenth century.

Collcutt's attempt to play down the importance of interfaces, as represented by the living floor, and his celebration of the deposit as defined in terms of its contents, are typical of the rhetoric used by geoarchaeologists to promote the importance of their specialty. In this application, it would appear that geology, let alone archaeology, has yet to recognize the full value of the interface, which was so important to the early advance of geology, because prior to James Hutton (1795), geological observers had 'failed to see a single unconformity' (Tomkeieff 1962: 392).

We are reluctant to accept these propositions of critics like Collcutt, if only because our experience with the often complex stratigraphy of historic sites has taught us that the deposit itself, defined in terms of its constituent parts, is not an appropriate starting point for stratigraphic analysis. There is no question that the discipline of geoarchaeology, 'archaeology pursued with the help of geological methodology' (Rapp and Gifford 1985: 15), or 'archaeological geology', 'geology pursued with an archaeological bias or application' (Butzer 1982: 5), has much to offer the interpretation of many specific contexts encountered by field archaeologists. But they are no substitute for the kind of practical methods, such as the Harris Matrix, and vital notions for stratigraphic interpretation, such as the interface, needed to sort out the complex histories of archaeological sites created in the main by human activity.

The view from the deposit

Still, there are those who would turn all archaeologists into sedimentologists, again by promoting the deposit as the focal point of inquiry. This is a position perhaps best represented by J.K. Stein (1987), whose recent work has sought to standardize the way that archaeologists define deposits and describe and interpret their contents using techniques that are directly borrowed from the geological study of sediments.

Along with Farrand and Collcutt, Stein attempts to re-impose upon sites produced largely by the actions of people a new but unneeded mantle of geological stratigraphy. The 'deposit' thus becomes a universal phenomenon in geological and archaeological circumstances. We are informed that 'In geology and archaeology, a bed or deposit is an aggregate of sedimentary particles. Sediments are particulate matter that has been transported by some process from one location to another ... all particles (including artefacts) found in archaeological deposits can be viewed as sediments' (Stein 1987: 339). She proceeds to describe some of the classic geological attributes of sediments: that they are formed by chemical action, e.g., 'compounds precipitating out of solution, such as salt deposits', or that they are clastic deposits, 'formed mechanically from the detritus of pre-existing rocks' (Stein 1987: 339–40). In underlining the supposed place of artefacts in this wondrous natural process, she states that the principles of sedimentation are found in the cyclical processes of 'weathering, transport, deposition, post-depositional alteration' (Stein 1987: 340).

Putting aside geological sites which contain artefacts or human remains, sediments (in the classic geological sense) have little to do with either the formation of stratification produced by human agency (deposit *and* interface – not the one without the other), or the manufacture of artefacts and their ultimate placement in archaeological contexts created by people. Archaeologists, the majority of whom are not working on geological sites, would be out of business if our artefacts ('sediments') underwent sedimentary transformations, becoming salts or other natural phenomena. On the stratigraphic side, it is difficult to imagine an archaeological site, say the City of London, the Great Wall of China, an American Indian pueblo or even the most humble shell midden, which has been clastically reduced to geological rubble (sediments) and passed downstream, still retaining any of the human-inspired virtues of a classic archaeological site. If a block of stone from the Great Wall of China, cracked in weathering and losing its manufactured shape, were to fall into a river and come to rest as a number of rounded pebbles miles downstream, it would have lost all its attributes as an artefact and have become geological sediment of no particular archaeological significance.

Stein also tells us that the laws of the universe are unchanging and that 'the physical and chemical processes operate according to laws defined by continuum mechanics and atomic theory. The process operating on an infinite number of sedimentary particles, produce uniform physical characteristics in the past, the present, and the future' (Stein 1987: 341). The purpose of Stein's assertions in this regard is to lull the archaeologist into accepting the definition of all archaeological strata as uniform, universal, geological entities.

We agree with Stein that the laws of the universe, once discovered, help us to interpret the past, be it in the heavens or under the ground. Stein, however, fails to understand that archaeological stratification produced by people forms an entirely distinct phenomenon in the universe of knowledge. As such, it has its own laws, which must be discovered and defined, and we submit, as noted in the 'The Laws of Archaeological Stratigraphy' (Harris 1979b), that those laws of archaeological stratigraphy are different from geological maxims, although derived in part from geology in the mid-ninteenth century. It is one of the greatest failures of modern archaeology that its practitioners have not freed themselves from the umbilical cord of geological notions of stratigraphy: it should be of great concern to 'dirt archaeologists' that Stein and other promoters of deposit constituent analysis are now attempting to reintroduce, rather than sever, this worn-out association.

Stein suggests that it is possible to devise a universal system of classification for archaeological deposits, along geological lines. In this she agrees with the system proposed by Gasche and Tunca, claiming that they were the first to separate the interpretation of stratification into the identification of deposits by their physical characteristics, artefact content and place in a stratigraphic sequence (Stein 1987: 347). Such a system, however, is bound to fail on archaeological sites created by human action because of the limited extent and unique character of their deposits. She suggests that this is what Harris set out to do:

> Harris would like to classify deposits on the basis of the interpretation of the agents involved in the history of all sedimentary particles in the deposit [no reference is given for this assertion], but defining all the possible interpretations for any given deposit would be difficult. He will need a large number of terms to name the large number of possible combination[s] of agents contributing to the deposition of every deposit (Stein 1987: 349).

Since Harris has never agreed with the 'sediment' approach to archaeological stratigraphy, it is difficult to understand how Stein could have come to the above conclusions. Harris was well aware of the problem implicit in her statement, namely that the interpretation of deposits from an historical viewpoint would indicate that each unit was a unique phenomenon and that it would therefore be *impossible* to set up a classification system for archaeological deposits by name, in the style of geology. This was why the notion of *non-historical* attributes was brought forward, because 'units of stratification, such as pits and layers, recur in the same general stratigraphic forms, they have non-historical and repetitive aspects' (Harris 1979: 124).

It is worth repeating that 'the principles of archaeological stratigraphy must rather treat with the non-historical attributes of stratification because it is they which are of universal application ... many individual units of stratification, as historical features, are of no universal importance, since it is mainly by a comparison of the cultural and artefactual sequences, not the stratification, of various sites that the archaeologist studies the development of past societies' (Harris 1979: 32). Out of this idea arose the notion of 'units of stratification', the layers and interfaces of the Harris thesis. This fundamental concept, which proved its worth in archaeology *after redefinition,* was borrowed from a modern geological source:

> The Grand Canyon or any gully is unique at any one time but is constantly changing to other unique, nonrecurrent configurations as time passes. Such changing, individual phenomena are historical, whereas the properties and processes producing the changes are not (Simpson 1963: 25, quoted in Harris 1979: 32).

Since Stein also has difficulty with the notion of the (non-historical) interface, a crucial unit of archaeological stratification, it is necessary to quote her at length.

> A problem with the classification system of Harris is assigning the subdivisions of the layer interface and the feature interface. A pit could contain both horizontal [*sic:* layer interfaces] and vertical feature interfaces [*sic:* these would signify other

> intrusion pits] that grade into each other as the slope of the pit boundary changes. A deposit may have no boundaries that are horizontal layer interfaces, upstanding layer interfaces, horizontal feature interfaces, and vertical [feature] interfaces. The definitions of these terms do not provide the precise information needed to assign the term in an archaeological situation (e.g., angles of dip above or below which one assigns the name of vertical or horizontal layer interface). Thus even if archaeologists agreed on the attributes that should be used to distinguish a change in depositional regime (conformity) from an erosive event (unconformity), the assigning of the subdivisions of Harris's term[s] would be subjective (Stein 1987: 355–6).

With this specific critique, we can see what is perhaps the critical difference between a uniquely archaeological approach to stratigraphic interpretation and one based on the purported 'objective' technique of sedimentary particle analysis. The matter can be brought into focus if we restate Stein's thoughts as follows: 'Archaeological stratification, if seen in a cross-section, is a bewildering arrangement of layers and other material objects, such as walls, and a collection of interfaces, which often grade into one another; it is a major problem to sort out the deposits from the interfaces and Harris's system does not provide the method by which this can be done, except subjectively'.

No amount of sieving, measuring and counting the various constituents, artefactual and sedimentological, of deposits, will absolve the excavator of the obligation to 'read the dirt'. Practical experience, as noted in the papers of this volume, has proved the efficacy of the Harris methods. We contend that by using those principles, the *competent* archaeologist will seek to distinguish the changes in the deposits of the site, which will provide the keys to the unravelling and division of its interfaces into those associated with the surfaces of the deposits and those, such as pits, which are units of stratification in themselves, without associated deposits. In this way both aspects of a site, its material remains in the bulk and contents of its deposits, and its immaterial evidence, the interfaces upon which (contrary to Collcutt) people lived out their lives and participated in the diverse activities of their culture, are professionally observed and recorded.

Stein's problem is not so much one of interpretation, or of the Harris Matrix system, but one of the competence of the archaeologist as a stratigrapher and stratigraphic excavator. If a researcher has competently recorded the stratification of a site, all of its interfaces will be present. If a mistake was made in defining the limits of a particular pit or other interface, this is but a wrong conclusion. It can be reanalysed by comparison with other data and the stratigraphic sequence of the site, in the Harris Matrix style, can be adjusted, without destroying the integrity of the site records, which are the last and only witnesses of the past in that locale after the fact of excavation. If the archaeologist has not recorded the interfaces, then there is no possibility of making a correction, for the primary evidence of the interfaces was destroyed through incompetence.

Along with her colleagues who have criticized the Harris Matrix, Stein is primarily interested in artefact analyses – and by this we mean the analysis of any objects which make up a deposit. As this is viewed from a geological and geomorphological stance, much in her approach is properly concerned with the attributes of sediments; in itself, this is a worthy subject, but it is inappropriate to a majority of archaeological sites formed by people and not the work of nature. It would be of much greater use to us if Stein had given some discussion of how to 'objectify' the process by which the interfaces of an archaeological site are to be 'subdivided', since she takes exception to the Harris Matrix methods. In addition, it would be of value to have had her ideas, and those of other geoarchaeologists, on how to meaningfully represent the stratigraphic sequence of complex man-made sites, if she and her geological colleagues have such devices in their analytical tool-boxes.

Stratigraphy by and for the archaeologist

Let us here make a clear distinction, which appears to have eluded some stratigraphers. If an archaeologist is working on a site which contains archaeological remains, but the formation of which was the result of geological forces, then the worker should have a reasonable understanding of geological stratigraphy. Better still, the archaeologist will elicit the support of a geologist who specializes in the locality and the types of geological formations it is known to produce. Yet that geologist cannot be expected to provide the archaeological knowledge which will provide the ultimate conclusions about the site for archaeological purposes.

In other words, the geology provides but one of many strands which it is incumbent upon the archaeologist to weave into a sensible picture of the site. On such classic natural sites, geologists must be involved in the interpretation of the stratification and the archaeologist is a fool who would ignore their help. At the same time, it may be suggested that the demonstration of the stratigraphic sequence of such sites can be made in the Harris Matrix style, since there appears to be no geological equivalent to that system. The application of this simple method would probably help both archaeologist and geologist to understand the stratigraphic development of the site, even if there is not one deposit of human construction within its boundary.

Indeed, what archaeologist in a correct frame of mind would study such naturally-formed sites without the assistance of geologists, geomorphologists and a plethora of allied disciplines, so that the archaeological potential of the site can be fully exploited? In this work and in other areas, the 'geoarchaeologist', as introduced by Butzer (1973), and elaborated by Gladfelter (1981), has a role to play. This specialized individual has made it a profession to combine a knowledge of earth sciences, such as geology and geomorphology, with an interest in archaeology, thereby making a contribution to the study of some types of sites with archaeological remains.

While there is no reason that a geoarchaeologist could not work on any archaeological site, it is a fact of life that their value to the project may be vital in the context of a geologically stratified site, but it may quickly decline on sites stratified by the activities of people. Gladfelter (1981: 357) suggests that 'an archaeologist cannot achieve the expertise of a geomorphologist anymore than the reverse', and most archaeologists will take help from any quarter, if the result is a better understanding of the site.

We do not wish to denigrate in any way the results which geoarchaeologists and other specialists may make to archaeological projects in geological settings. It is simply that, unlike Stein and other advocates of geoarchaeology, we do not think that these geological methods can be extended to a majority of archaeological sites, which are those stratigraphically fabricated as a by-product of human society. Nor do we think that the theory underlying those methods can be suitably applied to the discipline of archaeological stratigraphy, if only for two fundamental reasons.

First, these critics ignore the overriding importance of the interface in archaeological stratigraphy. The interface is fundamental to the interpretation of archaeological stratification, simply because there are generally more interfaces than deposits on most archaeological sites. In recognition of their importance, the Harris Matrix directly incorporates them into the reconstruction of the stratigraphic sequence of complex archaeological sites, thereby giving the archaeologist the ability to distinguish consistently between deposits, their contents, and most importantly, the actions that created them.

Secondly, the specialty of geoarchaeology has produced no workable systems for the construction of stratigraphic sequences, as archaeology has in the Harris Matrix. We cannot imagine how an archaeologist could unravel the complex stratification of archaeological sites created largely if not exclusively by human action using the geological system proposed by Gasche and Tunca, or the 'deposit' approach advocated by Stein.

It seems clear that what bothers geoarchaeologists most about the Matrix and the principles and excavation strategies upon which it is based is that it is a 'separatist approach' to stratigraphy, one developed for archaeologists by an archaeologist. It does not depend on the specific analytical techniques used in the analysis of soils or sediments, and it does not pretend to be scientifically precise in the same way that the measurement of particle attributes or classification of soil texture would appear to be. We recognize and appreciate the need for specialist studies such as these, but we do not accept them as some universal panacea for stratigraphic interpretation in archaeology. They are but one of many such specialties, such as archaeobotany, palynology and zooarchaeology, that the archaeologist selectively draws upon in appropriately applying the interdisciplinary approach.

By choosing to emphasize the concept of the interface and centralizing its interpretation at the expense of the deposit, the Harris Matrix may have run a foul of some of geoarchaeology's more strident advocates during the past decade. Nonetheless, we believe that this system of stratigraphic interpretation has been proven to provide the necessary framework for meaningfully studying the specific contents of layers and features, whether they be the work of people, of nature, or a combination of the two.

An alternative to the Harris Matrix?

In reviewing recent criticism of the Harris Matrix, it should be noted that not all of the concern has been expressed by proponents of geoarchaeology. Some archaeologists have found fault with this approach to stratigraphic interpretation, often as a prelude to offering their own version of an improvement. One illuminating case is provided by Martin Carver's attempt at an alternative scheme, appropriately called the 'Carver Matrix' (Fig. 1.1). Although Carver observes that 'stratigraphic analysis, particularly in deep sites, took important steps forward in the 1970s, when excavators began to illustrate the sequence of all stratigraphic units on a diagram' (Carver 1990: 97), he suggests that 'the majority of such diagrams use the single stratigraphic unit [i.e., Harris Matrix] but others distinguish between contexts, features and structures'. He claims that the difference between the two methods, his and that developed by Harris, 'has been exaggerated, and it could be said that both are models of the stratigraphic sequence but place slightly different emphasis on what is presented' (Carver 1990: 97).

Showing a slight misunderstanding of the concept of the 'stratigraphic sequence' in

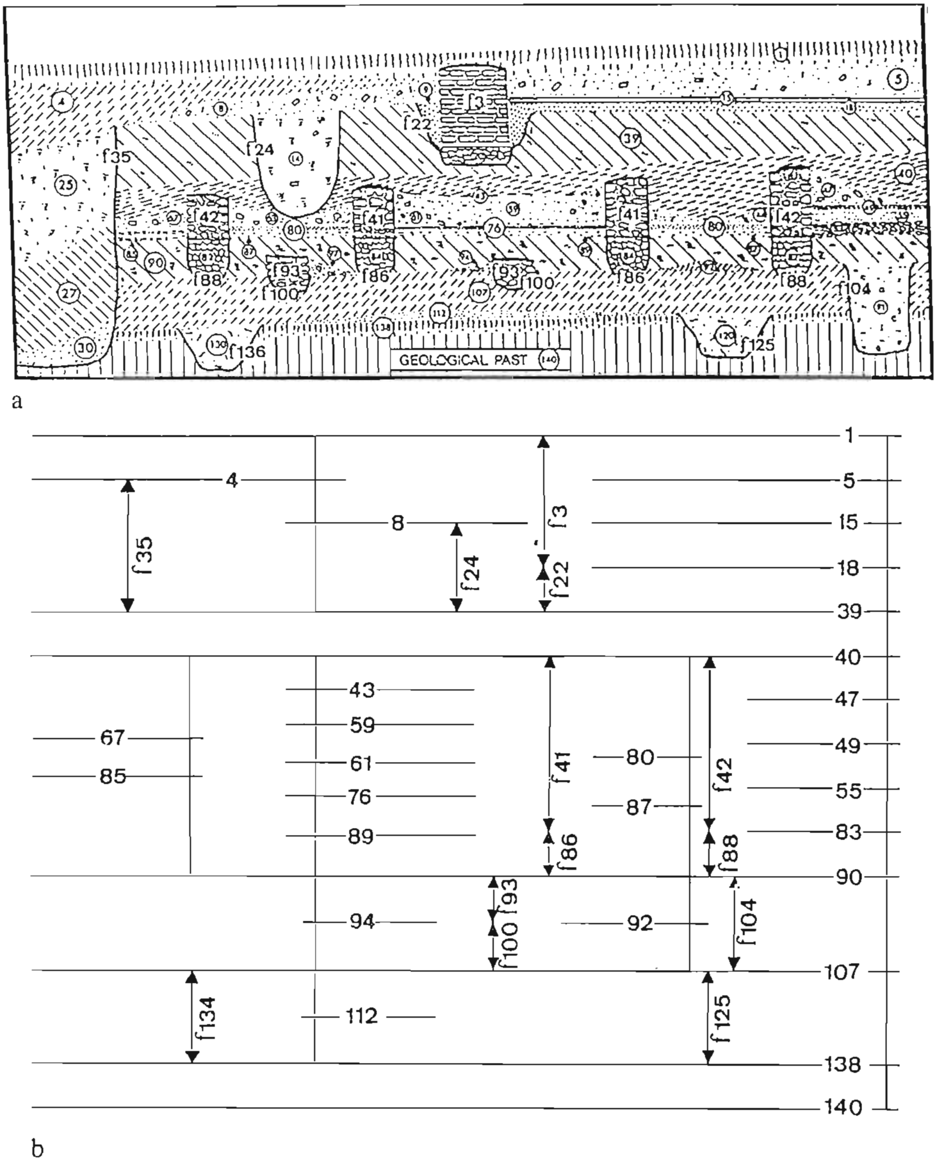

Fig. 1.1 (A) shows a section drawing, which in (B) is illustrated as a 'Carver Matrix'. The vertical lines with arrows are intended to show the duration of some of the units of stratification, referred to as Features (from Carver 1990: fig. 24).

archaeological stratigraphy, Carver states that 'the "Harris" Matrix [*sic*] is a direct statement of the physical relationships of stratigraphic units. Thus each context is viewed as a deposit which happened only once, and instantaneously. This can lead to anomalies ... [where] the floor of a building is shown as "happening" after its walls' (Carver 1990: 97).

On the contrary, it is section drawings, not stratigraphic sequences, which are direct statements of the physical relationships of the stratigraphic units – and that is precisely why sections are useless in themselves as representations of complex stratigraphic sequences. A stratigraphic sequence is a diagram of *relative time*: it shows all four dimensions of the stratigraphic accumulation of a site, unlike the two-dimensional image of the physical world of stratified deposits seen in a section. Because a stratigraphic sequence is a type of calendar, an 'image' of time, it will always be an abstract, diagrammatic representation of the physical nature of stratification. A Harris Matrix diagram is to archaeological stratification what a normal calendar is to the days and weeks of a year.

The situation which Carver describes as an anomaly is no such thing: it is a stratigraphic fact that in relative time ('Which came first?') the floor is later than the wall. One compelling reason for demanding that stratigraphic sequences be worked out during the excavation is so that any 'anomalies' and mistakes can be sorted out at that time.

Another concern expressed by Carver is that readers of archaeological reports will not understand a Harris Matrix diagram. He asserts that his 'new' system (Fig. 1.1) makes it easier for scholars to understand stratigraphic sequences:

> The Carver system assumes that a Harris Matrix (or equivalent) has been already drawn up, but then proceeds to group sets of contexts into their features as determined on the site. The features are represented by vertical arrows, thus showing that they have duration ('life') within a sequence [see Fig. 1.1]. This mode of presentation is a model of what happened through time, rather than a model of how the stratigraphic units were disposed in the ground (Carver 1990: 97).

In fact, the 'Carver Matrix' is but a restatement of the sectional view of stratification and it is based upon a number of outdated archaeological ideas. First, it is assumed that non-layer items, such as walls, pits and ditches, are more significant than simple deposits of soil: this harks back to the hunt for structures rather than stratification. Secondly, it ignores the fact that every single unit of stratification has a duration, or 'life', so that there should be gaps between all his units. In other words, there should be 'time-span' arrows within all the deposits *and between all the interfaces*, or between the surface of one unit and the under-surface of the next, since the interfaces often represent more passage of time than do the innards of deposits. A wall (deposit) might be built in a week but its surfaces may remain in use for a hundred years.

If Carver's diagram was redrawn to reflect that fact, it would be very confusing just representing his given section, let alone the stratification of a whole site. He claims that a Harris Matrix for a large site would 'cover the four walls of a lecture theatre, so it is hard to see how it could ever be published in any case' (Carver 1990: 97). The Carver system is so full of interruptions (and therefore anomalies) imposed by the archaeologists, that it may be impossible to use except on very simple sites with few deposits. By the same token, there is no particular need to publish an entire stratigraphic sequence, and Hammond (this volume, Chapter 9) suggests alternatives to the problem.

The major difference between the two systems is fundamental: the Harris Matrix method is based upon stratigraphic principles and is of universal application; the Carver system is based upon the individual judgement of the excavator as to what units are more culturally or historically important than others. His system, therefore, is not of universal application, but relates to a given site and the questions, biases, and types of analysis the individual excavator may be momentarily engaged upon. The Carver system is but the last in a line of pre-Harris Matrix phasing diagrams, which were based on section drawings and did not consider the entire stratigraphic sequence of a site, being dependent on such parts as appeared fortuitously in the recorded section. Several authors in this book suggest that less than 50% of all units appear in such records.

As indicated in several other papers in the present volume, the Harris Matrix diagrams can be lengthened, shortened, or otherwise reordered to give some indication of duration of deposits and interfaces, which seems to be Carver's object. By computerizing the sequence, in conjunction with single-context plans of a site, archaeologists are already doing what Carver suggests in his alternative system, but they are using the background of the simple and proven method of the Harris Matrix.

Replacing the sectional view of stratigraphy

Unfortunately, many of the critics of the matrix, including some field archaeologists who are used to dealing with complex stratigraphic settings created by human action, appear to see the world of stratigraphy from the perspective of a section, or stratigraphic soil profile, a vision which slowly became obsolete in the 1960s and was destroyed with the invention of the Harris Matrix in 1973. As these critics have not incorporated the notion of single-context plans into their world view, it is consistent that their thinking ignores or devalues the interface in stratigraphic work in archaeology. They have failed to take cognizance of the many other ideas, other than the Harris Matrix, which now form the foundations of modern practice in archaeological stratigraphy.

While some geoarchaeologists continue to find comfort in geological maxims which are largely unsuitable for sites made by people, and some archaeologists still expect to 'see it in the sidewall', the discipline of archaeological stratigraphy is moving with rapidity into the computer age. The use of single-context plans, possibly the most important invention after the Harris Matrix, is highly compatible with computerized Geographical Information Systems, as developed, for example, by Dominic Powlesand, and implicit in the efforts of Bryan Alvey, the latter demonstrated in this volume (Chapter 14). Single-context planning and GIS data are largely about the display of information about the interface – those surfaces upon which people lived, but whose existence is so problematic for many geoarchaeologists.

The approaches advocated by these critics is the easier half of archaeology, in that it is simpler to understand the innards of deposits, with their soils, sediments, artefacts and other multifarious inclusions which can be taken back to the laboratory. It is quite another matter to study the immaterial aspects of archaeological stratification, viz., the world of the interface, in which no artefacts, sediments or any material objects are to be found. We can see and know the deposits and their contents: it is the interfacial aspects of stratification which we must capture on record and reconstruct in our analyses, if we are to do justice to the duality of archaeological sites by stratigraphic excavation and research.

We must indeed 'map the interfaces', if the contents of the deposits below their surfaces are to have any wider significance. If we seek to know 'what *happened* in history', we must look beyond 'what was *buried* in history'. In this endeavour, the notion of the interface in archaeological stratigraphy is paramount, and only proper attention to its details will give value to the secondary historical witnesses of the artefacts, sediments and other material remains contained in the layers and features of an archaeological site.

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SECTION II
Historical trends

The development of stratigraphic thought in archaeology began to accelerate in the mid-1970s, after the concept of stratigraphic sequences in Harris Matrix form was introduced. The process of change, however, may have been stultified, if not halted, had not some archaeologists been willing to experiment with the new proposals. Craig Spence, in his article which heads this section, discusses the invaluable work carried out in this regard in London from 1974 onwards. Under the Museum of London and its Director, Max Hebditch, the Department of Urban Archaeology, headed by Brian Hobley, was willing to try out new methods proposed to them by Edward Harris on rescue sites in the City of London. In part, as traced by Spence, the adoption and development of the new methods helped to make the Department of Urban Archaeology a model for archaeologists working under extreme pressures due to commercial development and it demonstrated the value and efficiency of the new methods. (It is a pity to note, as this book goes to press, that the Department of Urban Archaeology has been largely destroyed as a working entity by state archaeological authorities for almost entirely political reasons arising out of the battles engendered by the discovery of the Shakespearean theatre in south London a few years ago.)

The next two papers, one on Catalan archaeology by Isabel G. Trócoli, and the other on Polish medieval archaeology by Zbigniew Kobyliński, discuss the effect that the Harris Matrix and other new ideas have had on the archaeological profession in their particular countries. In this regard, readers are also referred to the important introductory article on Italian archaeology in this regard by Daniele Manacorda in the 1983 Italian edition of *Principles of Archaeological Stratigraphy*. Following the Museum of London, many Italian archaeologists soon took up the challenge presented by post-Harris Matrix thinking and we regret that a paper from this source is not included in this volume.

The final article in this section is by Adrian Praetzellis, who with Mary Praetzellis, introduced the Harris Matrix to archaeology on the West Coast of America. Praetzellis's paper dwells upon the notion of arbitrary excavation, which has become a strong signature of much archaeology in the American West. He attempts to show how the search for artefacts and cultural chronologies comprised by a study of portable objects led excavators to ignore the site and its stratification as being artefacts in themselves. Consequently, while much was learned about objects, the topographical history of many sites has been destroyed by archaeologists without any hope of recovery in post-excavation work.

In his concluding notes, Praetzellis cites the oft-noted Wheelerian phrase that 'there is no right way of digging, but there are many wrong ways'. In this day and age, it is clear that there is one right way of digging and that is the stratigraphic method, so highly advocated by Wheeler himself: without using that method, the stratigraphic sequence of a site cannot be obtained. The arbitrary method still falls largely into the category of the 'wrong way', although as Praetzellis points out, it is a useful method of controlling the digging of large single deposits of wide extent and/or depth. In the end, however, if only one deposit was recognized on a site, that constitutes its stratification and all the fancy manipulation of artefacts assigned to arbitrary units within that single deposit will never change that unitary stratigraphic record.

2 Recording the archaeology of London: the development and implementation of the DUA recording system[1]

CRAIG SPENCE

Introduction

Any attempt to describe the structure and function of an archaeological recording system is bound to be a difficult process, as central elements which seem no more than common sense to those who use the system on a daily basis need to be carefully explained and clarified. Attempting to chart the development of a complex recording system, from its origins, through its various stages of use, refinement and redesign, would therefore appear to be beyond the scope of a single short paper. This, however, is the objective of the current text. The review made in this paper of the recording system employed by the Department of Urban Archaeology (DUA) of the Museum of London[2] is as a consequence necessarily brief. However, I hope to be able to show that there is a great deal to be learnt concerning the form of the final archaeological record by reviewing the detailed development of the archaeological recording system used to create it.

In charting the development of the recording system used by the DUA, from its origins in the early 1970s through to its recent redesign and current implementation, some of the following subjects will be discussed: the circumstances in which the system was originally formulated, its links with the development and use of the Harris Matrix, the integration of associated excavation processes, and its later refinement and further development during London's excavation boom of the late 1980s. In order to complete the picture the following topics also need brief mention: post-excavation procedures, archives and, where pertinent, the relationship between the recording system and the management of archaeological work.

A short history of London's recording systems

The archaeological record of the City of London has been the focus of academic enquiry for well over 200 years. As early as the mid-eighteenth century the antiquarian William

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[1] An earlier draft of this paper was presented to a conference on the Harris Matrix and recording systems hosted by the Catalan Archaeological Society in Girona, Catalonia, in late 1989.

[2] Following internal reorganization during December 1991 the DUA was amalgamated with the Department of Greater London Archaeology and is now known as the Museum of London Archaeological Services Division (MoLAS).

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Stukeley had published a map of Roman London. Some elements of this map may have been based on field records created by even earlier observers such as Sir Christopher Wren. It is only in the last 20 years, however, that modern excavation and analytical techniques have been able to provide a picture of early London with a degree of accuracy Stukeley and Wren would not have believed possible. This information has been produced as a result of the work of a very large number of archaeologists and other specialists known collectively as the DUA. The primary element of the DUA's analysis of London's past has been field excavation. Such field excavation has been controlled by a consistently uniform and yet highly adaptable recording system, a system based upon single-context recording and the Harris Matrix.

Initially the details of the recording system can be placed to one side and a review of the conditions under which archaeological work in London has been undertaken should be recounted. This is important as these conditions have been manifestly responsible for much of the structural design of the recording system, though not its basic tenets, and have clearly defined its practical implementation.

In London modern archaeological work began in the 1950s, some earlier twentieth century work had been carried out but this was unfortunately spasmodic in coverage, suffered from very limited resources and often took place by chance rather than design. Later work did at least differ in approach if not in circumstances. Resources were unfortunately also limited in post-war London when the late Professor Grimes undertook his pioneering rescue excavations against London's cityscape of bomb-sites and hurried reconstruction. Indeed despite much public interest and a clutch of major discoveries, such as the Temple of Mithras and the Cripplegate Fort, sufficient resources, and more importantly access, were still absent. Thus by the 1960s little in the way of comprehensive field work could be said to have taken place. The small staff of the old Guildhall Museum undertook occasional observation work when sites became available but it was not until the property development up-turn of the early 1970s that the face of London's archaeological service was to change significantly.

In 1972 redevelopment of a waterfront area of the City revealed the substantial remains of the mid-fourteenth century Baynard's Castle. The resulting excavation uncovered not only masonry structures but also an assemblage of artefacts not previously equalled in either quality or quantity from within the London area. Unfortunately time and money were once again in short supply and the excavation, despite much popular interest, had to be carried out in far from ideal conditions. It was following this episode that the Guildhall Museum was prompted to establish the DUA. The concept of the department was that a permanent unit of professional archaeologists, even if low in numbers, would be able to manage the resource requirements of modern archaeological work more effectively, as and when suitable sites became available for excavation.

In 1975 the department became integrated into the new Museum of London, a venture which combined both the London Museum and the Guildhall Museum, thus providing a coordinated museum service for the whole of the Greater London area. From that date forward, chiefly under the guidance of the then-Chief Urban Archaeologist Brian Hobley, relations with City developers prospered to the extent that today virtually all City excavations are funded by direct grants from the implicated developer. Through detailed negotiation access and monies are made available for not only field excavation but also the expense of finds and environmental work and most importantly the post-excavation analysis of the site records.

Indeed the developers of the City of London have been particularly generous in their grants towards the costs of archaeology, for example in the period 1988–89 they donated a total of £6.56 million towards the work of the DUA. From the very earliest excavations undertaken by the DUA attempts were made, in response to this generosity, to make the excavation process as efficient as possible. This efficiency both reduced excessive costs and, most importantly, ensured that the excavation work itself did not unnecessarily delay the developer's construction programme. It can be seen that these objectives were in some ways a motivating force at the time of the primary development of the DUA single-context recording system.

A major developmental aspect of the professional work of the DUA has therefore been the design of an efficient and consistent archaeological recording system. It became clear as early as 1974 that recording by composite, or phase, plans of the complex and deeply stratified urban deposits found in the City of London was not a satisfactory way of recording under the constraints imposed by the new system of developer-funded rescue excavation. It is of course also the case that such composite plans produce an incomplete record which often adversely affects later attempts to provide logical and justifiable interpretations, a fact that has been well demonstrated by Harris (1989: ch. 9). It was also felt that much precious excavation time was lost attempting to define so-called archaeological phases and structures during excavation. While it was accepted that all excavation relies to some extent on the establishment of such information, thus allowing logical informed excavation to progress, the actual process of recording was often found to be have been impeded by such detailed on-site interpretational analysis.

Fortunately, for the DUA, it was the previous year, 1973, that saw the emergence of the Harris Matrix at Winchester. In 1975 the General Post Office site in the heart of the City of London became available for excavation. This site presented a large area of very complex archaeological deposits that required rapid excavation (in fact more than 12 000 individual contexts were eventually recorded). In response to this need the DUA instituted a single-context recording system with all contexts, or stratigraphic units, having individual plans and written records compiled and all stratigraphic relationships recorded on a Harris Matrix. Thus the Harris Matrix provided the key to the integration of the various paper records that were made of the primary archaeological record.

The requirements of such a system within a complex urban rescue environment placed a greater responsibility on individual excavators than had previously been required. Each member of the excavation team was expected to define, plan, record and excavate their own contexts. Such an arrangement imparts a number of important advantages over systems which employ excavating staff, planning staff and recording staff in separate roles. By allowing the archaeologist who excavates a particular deposit/context to undertake the associated recording procedures at least two important recording qualities are promoted. Firstly, a more accurate descriptive record, updated throughout the excavation process, is compiled, and secondly the interpretive description of the context will benefit as the archaeologist making the interpretation generally has a better and closer understanding of the archaeological sequence in that particular part of the site. One further benefit to the recording process that this staffing structure provided is in the area of excavation efficiency. The excavation of complex stratigraphy on deeply stratified sites, as deep as 7 m on some London sites, in very short periods of time requires a system of continuous excavation, and consequently needs a recording system that can keep pace with a very high speed of deposit/context removal. That a single archaeologist can have direct control over the planning, recording and excavation of any given context is quite simply the most efficient way of excavation under such circumstances. This approach to recording consequently resulted in the establishment of a non-hierarchical staffing structure. Aside from the 'Site Supervisor', who oversaw general progress, all aspects of recording and excavation were undertaken by the 'Site Assistants'.

The recording system established in the early 1970s was comprehensive, efficient and uniform in implementation from site to site. The simple logicality of the system was its strength. The single-context records were easily inter-related through the use of the Harris Matrix and extensive interpretational questions of sequence could be delayed until post-excavation, thus saving valuable excavation time. Such a system appeared to be foolproof and on many occasions produced adequate sets of records; however, after some 15 years of use, significant doubts were raised about the accuracy and efficiency of the recording system as it was operated on site. These doubts were latterly addressed and after numerous debates and field trials a revision of the recording sheets was instituted. This revision did not, however, affect the overriding principle on which the system was based: single context records linked through a Harris Matrix.

The single-context system – the first decade

That the structural development of this system was partly in response to the practical circumstances of urban rescue excavation conditions can be demonstrated by detailing the basic requirements of the system. Other elements of the system were based on a critical appreciation of what makes an archaeological record both valid as data and functional as an interpretational tool. The basic requirements of the recording system were that it would:

1. Be able to capture large quantities of objectively recorded archaeological data accurately, comprehensively and quickly.
2. Establish stratified archaeological sequences.
3. Allow verification of all recorded stratigraphic relationships.
4. Incorporate sufficient collection of artefactual and environmental material both to provide the established sequence with a relative chronology and to support context interpretation.
5. Finally, all of these factors should be applicable no matter what features were encountered or what the practical conditions of excavation actually were.

The recording system devised to fulfil these requirements consisted of the following main elements for each and every excavated context:

1. A single-context plan (except in the case of fills within such features as postholes and which were thus physically constrained).
2. A single-context written description, comprising an objective description and a subjective interpretation.
3. The establishment of stratigraphic relationships for each context.
4. The taking of environmental samples from each context when considered suitable.
5. The collection of all artefacts from each context.
6. The photography of each context when it was considered to form part of a significant feature.

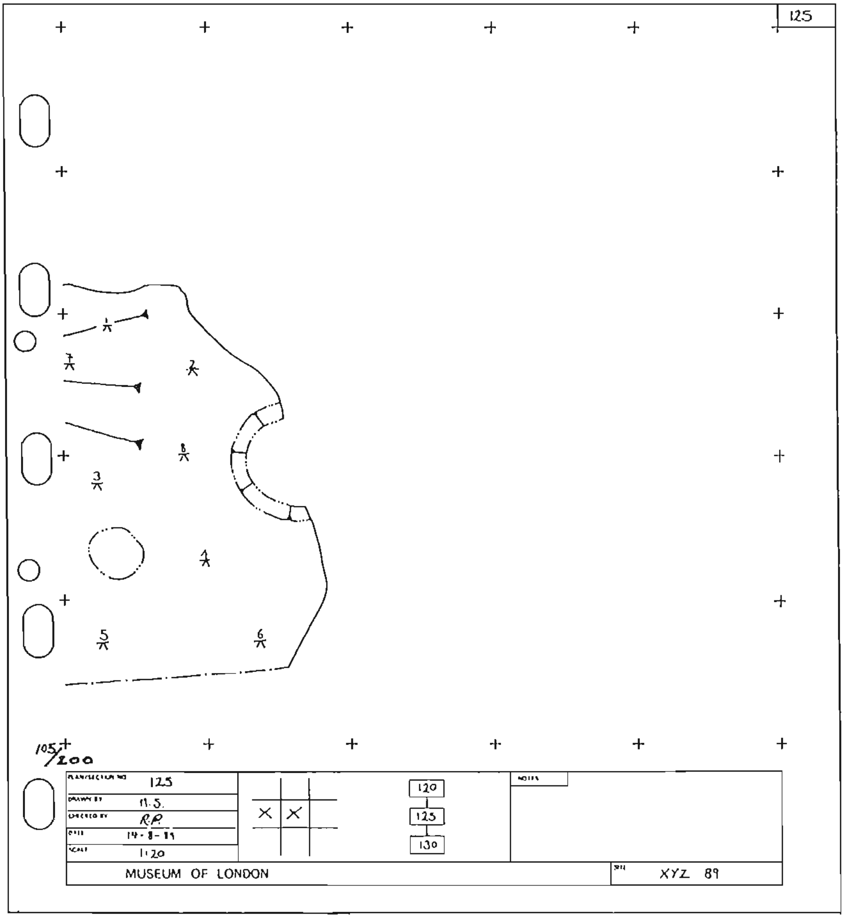


Fig. 2.1 An example of a single-context plan. (Courtesy of Museum of London.)

To expand upon these headings we can begin with the single-context plan (Fig. 2.1). The DUA system was based upon a 5 m survey grid against which all contexts were separately planned and surveyed, at a standard scale of 1: 20. This created an individual two-dimensional record of the extents of each and every context which when combined with surveyed spot heights formed a three-dimensional record. Also, through the use of the Harris Matrix, such plans allowed immediate verification of all stratigraphic relationships. The routine for planning was both fast and efficient, easily facilitating the consequent recording and excavation steps.

As mentioned above the process of single-context planning allows the creation and verification of the stratigraphic relationships of each context. Initially separate plan matrices, based on each individual 5 m grid square, can be established and these in turn integrated to form an overall site matrix. The production of such a matrix will allow verification of sequence, resolution of recording anomalies and most importantly provide the tool by which the site sequence can be subsequently analysed, understood and described.

Physical relationships, as has been noted elsewhere by Harris and others, are not of any significance in the establishment of site sequence. Such relationships are coincidental and of no sequential value, they therefore have no facility in the study of stratigraphic sequence.

The written description was compiled on a pro-forma recording or context sheet (Fig. 2.2). This sheet was designed to hold six significant groups of information relevant to each particular context. The information groups were: unique identification data (context number, grid square reference, context type, etc.); objective description (compaction, colour, composition, dimensions, etc.); stratigraphic relationships (only those immediately earlier than and later than that specific context); ancillary data links (cross-references to plans, finds, environmental samples, photographs, etc.); excavation process information (method of excavation, name of excavator and date); and finally interpretation (subjective comments on the form and/or function of the context in question).

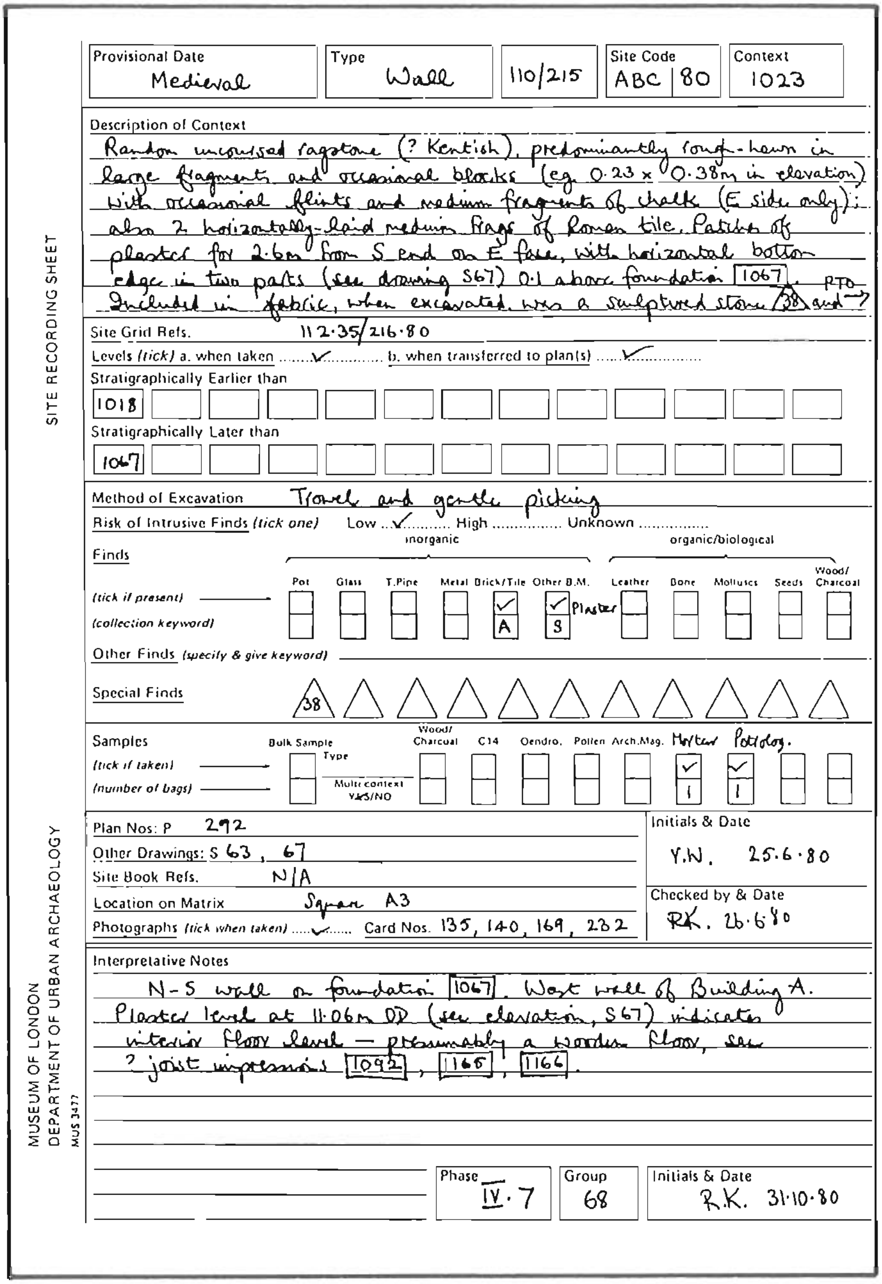
To expand upon the structure and design of the original DUA context sheet it can be seen that on the top line of the sheet a variety of identification information was provided. The most important piece of data amongst this information was the context number. Each context was allocated a single unique identifier from a continuous number sequence beginning at 1. Each site was identified by means of a three-letter (site address), two-number (year) code.

Below this information line there was an area for the objective description of the context to be recorded as free text. Deposits, cuts and timbers, for example, were described using differing terminology; however, within each of these categories a standard method was applied to the structure of the description. Thus a cut would be described in terms of its shape in plan, the change of slope from top to sides, the steepness of the sides, the change of slope from sides to base, the shape and form of the base and the overall depth. By separating such objective description from the more subjective interpretation of the context it was hoped that the descriptions would be consistent enough to make the paper record a truly valid reflection of the primary archaeological record.

In order to provide a cross-reference for the stratigraphic sequence and to help with both the immediate checking process and later post-excavation analysis a record was made of those contexts which were stratigraphically earlier or later than the context in question. These relationships were replicated on the base of each single-context plan. However, in this case only those contexts that had actually been planned were noted.

The first version of the DUA recording sheet had a large area devoted to finds information. Types and approximate quantities of finds were noted together with descriptive comments regarding artefacts considered to have been of particular importance. The single-context plans within this system were usually allocated an identical number to that of the context number, and cross-reference to this plan number and any other additional records, for example sections or elevations, were consequently noted on the recording sheet. The collection of environmental and other types of samples was briefly noted. Tick boxes were completed when levels had been read and if photographs had been taken. The excavator's name, the date, and method of excavation were recorded as a means of assisting the Site Supervisor to correct errors or omissions through the process of record checking.

At the base of the sheet an area was provided for the excavator to enter a subjective interpretation of the form and/or function of the particular context. This area was also used to cross-reference to other associated contexts and to make more general comments regarding the archaeological sequence. Site Supervisors were able to make subsidiary



SITE RECORDING SHEET

Provisional Date	Type		Site Code	Context
Medieval	Wall	110/215	ABC | 80	1023

Description of Context

Random uncoursed ragstone (? Kentish), predominantly rough-hewn in large fragments and occasional blocks (eg. 0·23 x 0·38m in elevation) with occasional flints and medium fragments of chalk (E side only): also 2 horizontally-laid medium frags of Roman tile. Patches of plaster for 2·6m from S end on E face, with horizontal bottom edge in two parts (see drawing S67) 0·1 above foundation 1067. PTO

Included in fabric, when excavated, was a sculptured stone 38 and →

Site Grid Refs. 112·35/216·80

Levels *(tick)* a. when taken ......✓........... b. when transferred to plan(s) ......✓...............

Stratigraphically Earlier than

1018

Stratigraphically Later than

1067

Method of Excavation Trowel and gentle picking

Risk of Intrusive Finds *(tick one)* Low ...✓.......... High .... Unknown ....

Finds

	inorganic						organic/biological				
	Pot	Glass	T.Pipe	Metal	Brick/Tile	Other B.M.	Leather	Bone	Molluscs	Seeds	Wood/ Charcoal
(tick if present)	☐	☐	☐	☐	☑	☑ Plaster	☐	☐	☐	☐	☐
(collection keyword)					A	S					

Other Finds *(specify & give keyword)*

Special Finds △38 △ △ △ △ △ △ △ △ △ △

Samples

	Bulk Sample	Type / Multi context ~~YES~~/NO	Wood/ Charcoal	C14	Dendro.	Pollen	Arch.Mag.	Mortar	Petrolog.		
(tick if taken)	☐		☐	☐	☐	☐	☐	☑	☑	☐	☐
(number of bags)								1	1		

Plan Nos: P 292

Other Drawings: S 63, 67

Site Book Refs. N/A

Location on Matrix Square A3

Photographs *(tick when taken)* .....✓...... Card Nos. 135, 140, 169, 232

Initials & Date Y.W. 25·6·80

Checked by & Date RK. 26·6·80

Interpretative Notes

N-S wall on foundation 1067. West wall of Building A. Plaster level at 11·06m OD (see elevation, S67) indicates interior floor level — presumably a wooden floor, see ? joist impressions 1092, 1165, 1166.

Phase	Group	Initials & Date
IV·7	68	R.K. 31·10·80

MUSEUM OF LONDON
DEPARTMENT OF URBAN ARCHAEOLOGY
MUS 3477

Fig. 2.2 An example of the original recording or context sheet (1980). (Courtesy of Museum of London.)

comments concerning the validity of such interpretations in this same area. The placing of this area at the base of the sheet was in the hope that the recorder would be encouraged to separate physically their objective description from their subjective interpretive comments.

Although the general-context recording sheet was used to record details of most types of archaeological features a divergence from the use of this sheet occurred in relation to the recording of human skeletons. It was felt that human skeletons required such specific types of data to be gathered that a differently structured recording sheet should be employed. This was in no little part due to the repetitive nature of multiple inhumation excavation and recording. The major difference in the skeleton recording sheet was the inclusion of a large diagram of a distorted human skeleton which was used to indicate the extent of the skeleton when excavated. The rest of the sheet required the excavator to record various elements of the burial in a descriptive fashion. Apart from the top line for context identification data no further uniformity of structure was to be found in the designs of the general and the skeleton recording sheets.

The flexibility of the recording system was quickly to be proved, as excavations during the period ranged from Roman masonry structures through to medieval timber waterfronts and even encompassed standing buildings. Such recording exercises often utilized staff drawn from a general pool but usually assembled into new teams for each new project. Staff, once trained in the use of the system, were able to tackle a wide range of archaeological situations with both skill and efficiency. Thus the ease of transfer of the recording system from one site to another was clearly proved. The system was simple to learn and required the minimum of supervisory intervention to control. Excavations, even under the extreme conditions of salvage watching briefs on construction sites, were completed on time and with a respectably comprehensive paper record as the result.

During post-excavation the single-context recording system linked to a Harris Matrix came into its own. The study of the records through an analysis of the matrix, as described by Pearson and Williams in this volume (Chapter 6), provided a relatively subjective-free approach to the preparation of the site sequence. Freed from the immediate problems of incomplete and ambiguous data and the danger of preconceived interpretations, Site Supervisors were able to prepare comprehensive archive reports based on the site records and the verified stratigraphic sequence. The preparation of such reports also helped in human resource coordination; Site Supervisors having completed post-excavation archives could be quickly redeployed on new excavations. The publication activity of the DUA was consciously relegated to an on-going publication programme which incorporated excavation results into major thematic projects; individual site reports were generally not published.[3]

Towards the end of the 1970s and in the early years of the 1980s attempts were made to define the structure and mechanics of the many varied elements of the DUA system. A series of manuals was prepared; this was almost exclusively for internal use and covering such topics as the pottery archive (Orton 1978), finds procedures (Groves 1984a) and identifying building materials (Groves 1984b) among others. As far as the field recording system was concerned the major work produced at this time was the *Archaeological Site Manual* (Schofield 1980). This modest volume contained basic directions in the methods used to record various archaeological features using the DUA recording/context sheets.

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[3] For a description of the DUA publication programme, see Schofield (1987).

Attempts were made to produce a manual describing the methods used in post-excavation, but although many copies were circulated for internal use, no clear consensus could be obtained on a definitive DUA approach to this question. The resulting document was considered too controversial for general publication and thus the opportunity to disseminate this important information at an early stage was missed.[4] Apart from a brief resurgence of manual writing in 1986/87, associated solely with the content of and access to the growing archive of excavation reports (Museum of London 1986, 1987), no further manuals were produced concerning the recording system until 1990.

The problem of fossilization

During the period 1975–87 the system was used in an unmodified manner on all DUA excavations. The system appeared to work, excavations were usually completed within schedule and an extensive sheaf of papers, together with hundreds of bags of artefacts, suggested that the primary archaeological record had been successfully converted into a secondary record of structured data. That the data were structured there was no doubt; the strict use of stratigraphic excavation techniques with sequence relationships expressed through the Harris Matrix confirmed this to all who might question. Whether the data held within the paper record formed an unequivocal transcription of the primary record was, however, beginning to be questioned. Of course, no recording system can claim to provide a 100% duplication of the data contained in the primary archaeological record, but this hypothetical standard must nevertheless be continually strived for. So what was actually going wrong with the DUA system?

Part of the problem lay with the DUA's success. Site after site, some 330 by 1990, was negotiated, funded, recorded, excavated, analysed and archived. But as this apparently successful system came to be implemented without question a degree of fossilization within the operational method set in. It may have been as a result of a blind dogmatic faith in the system or more simply a reluctance to contemplate change brought about by the safety of the routine but, whatever the explanation, operational errors and data omissions began to occur. Four main problem areas can now be identified: recording failure, objective/subjective differentiation, data verification, and ancillary record integration.

Recording failure occurred with increasing regularity as the years passed and the system became habitual. Excavators were increasingly, and uncritically, overreliant in using their past experience of the operation of the system to assist them in the completion of the site record. This attitude occurred in conjunction with influxes of new untrained staff who were usually expected to learn the system on the 'shop floor'. These new recruits were to be trained by existing staff who by this time were coming under increasing pressure from the large number of excavations taking place within ever shortening developer timetables. Whether staff received adequate training came to depend on the intensity of construction pressure on their first excavation and the variable attitude of the 'old hands' already in post toward such training.

The most obvious form of recording failure was data omission. This occurred in many areas of the system but was probably most prevalent in the objective context description.

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[4] For the draft manual, see Williams (1984); a revised version of this manual is currently being prepared under the authorship of A. Westman.

For example, when recording deposits, compaction was almost routinely omitted; unless noted as being particularly loose or hard, no description tended to be entered. This would mean, for example, that if during post-excavation a deposit was re-interpreted as possibly having functioned as a surface a primary piece of supporting or disproving evidence, deposit compaction, was missing. Thus such an interpretation remained virtually unsupportable. Similarly with even relatively simple contexts such as short lengths of brick walling a failure to record the standard brick dimensions would make reliable correlations, during post-excavation, between truncated sections of such walling almost impossible.

The causes of the second problem are less easy to define; this is because the core of the problem, objectivity versus subjectivity, continues to remain a thorny question among archaeologists. This is not to say, however, that some aspects of the problem of objective/subjective differentiation were not very straightforward to identify – in such cases the interpretational text simply was not there. Omission of context interpretation became acute as the system went into overdrive to cope with the increased volume of rapid excavations. Experienced staff abbreviated their interpretations to chronically shortened functional epithets, while new staff often lacked the confidence to offer any interpretation at all. As omissions began to occur in the structure of the objective record, as noted above, attempts appear to have been made to bolster this element of the record with the inclusion of more clearly subjective interpretational comments. Thus the objective description lost its empirical solidity as a degree of interpretational text appeared within that part of the record. On the other hand, the area of the recording sheet purposefully set aside for an exposition of the excavator's rationale of interpretation remained blank or brief to the point of redundancy.

In order to understand why these forms of system failure, which in some instances were so clear to see, remained relatively unnoticed at the time, the third cause of system failure must be discussed: that is, data verification. The Senior Archaeologist in charge of any project has three primary roles during the excavation phase. The first is to secure the logistical requirements of the excavation process; the second is to direct the overall course of the excavation with reference to the archaeological record as it is revealed; and the third is to verify the content, quality and completeness of the paper record as it is produced, in other words, checking the site records. All records are checked and if errors or inconsistencies are found the archaeologist responsible is asked to correct, or at least justify, such errors or inconsistencies. The Senior Archaeologist has one other vital role within the data verification process, that is the checking of the site matrix for stratigraphic integrity, so ensuring that the paper record is an accurate representation of the recorded archaeological sequence.

With the additional burdens placed upon archaeologists in charge of excavations which had unfeasibly short time-scales, too few or too many staff, and the presence of uncooperative construction workers on the same site, a modicum of sympathy can be extended to those who allowed data verification to fall to the bottom of their obviously highly stressful routine. This shortcoming was, however, crucial to the effect the first two causes of system failure would have on the resulting paper record. As has been noted elsewhere in this volume (see Pearson and Williams, Chapter 6) the checking of records must and can only take place on site during the excavation process and consequently time and resources must be made available for this function. That Senior Archaeologists fell behind with, or omitted, record checking during excavation meant that many of the excavators' more cavalier methods of record completion went unnoticed until post-excavation. By this stage failures were almost always too late to correct and thus excavators were not brought to task over sloppy records. Such errors at best lead to serious delays in the post-excavation programme (usually the most poorly funded part of any rescue excavation), or at worst introduced unresolvable errors or omissions which rendered the record of the excavation relatively inaccurate and so in effect unreportable.

The final cause of system failure was more clearly associated with the original design of the system rather than its later implementation. The inclusion of simple tick boxes for differing classes of finds on the original context sheet required excavators to do nothing more than tick the relevant box as differing categories of artefact were placed in the finds bag. This inevitably resulted in excavators failing to take due account of the potential information available from *in-situ* artefact studies and other more extensive sampling routines. An even worse situation was found with regard to environmental studies. Such studies were hampered by both a lack of a coherent sampling strategy and a uniform appreciation by those on site of the approaches to sampling necessary for a viable collection of environmental data. This failure of method caused a large number of opportunities for a greater understanding of the archaeological record to go to waste. Indeed many of the environmental samples that were taken, for example, were later found to be unsuitable for analysis. To summarize, the integration of the production of the stratigraphic record with the needs of a successful artefact and environmental sampling programme were not properly addressed and thus many important sampling opportunities were lost.

The single-context system – the second decade

Although the real change in the structure of the DUA recording system was to come about in the late 1980s, some indication that the form of the context recording sheet was inadequate can be found as early as 1981. During an excavation at St Peter's Hill in the City a monumental masonry structure of Roman date was revealed (Williams, forthcoming). The masonry foundation was supported by a rammed chalk raft beneath which several hundred timber piles had been driven. In order to increase both the speed of recording of these piles and to ensure a regularity of method the standard context recording sheet was modified. The Site Supervisor undertook the following alteration: the area of the sheet available for description was replaced with a number of prompts and boxes in which to enter data relevant to timber pile recording (for example diameter, tool marks, species, presence or absence of bark). This amended sheet was then photocopied and used when recording the numerous timber piles.

The advantages of such an alteration to the standard sheet were several. The sheet was easier to complete and meant that no, or at least limited, specialist skills were required of the excavator. The information collected was directly relevant, consistent from pile to pile, and noted in a regular concise form. During post-excavation the analysis of the information recorded was greatly facilitated and data tabulations could be rapidly compiled. The divergence from the standard recording sheet was however minimal, only the objective description area was restructured, all other elements of the sheet remained as before. Similar adaptions for pile recording were later employed on other excavations, for example the Billingsgate excavations of 1982 and in 1986/87 at the City of London Boys' School site on Victoria Embankment.

Another example of such an adaption of the established recording system came in 1985 when the major Early Modern cemetery site at Broad Street Station came to be excavated (Malt, in progress). The original skeleton recording sheet was found to be inadequate on a number of counts. It was too dependent on free text and so failed to ensure consistent recording between one burial and another of basic definitive traits, simple information which was better conveyed graphically was required to be described as text and information pertinent to the efficient excavation and post-excavation processing of each skeleton was not specifically requested. Just prior to the excavation at Broad Street a similar inhumation removal operation had been undertaken in the crypt of Christchurch Spitalfields (Reeve and Adams 1988). This non-Museum of London project had not only, due to the exceptional conditions involved, been obliged to formulate its own skeleton recording sheet but had devised a coffin-specific recording sheet as an element of the project's recording system. This aspect of the Spitalfields crypt project was considered to have been very succesful and was thus adopted, in a more simplified form, by the Senior Archaeologist of the Broad Street Station excavation. Consequently the adapted DUA recording procedure incorporated both minor changes to, and a restructuring of, the standard skeleton recording sheet and introduced a new type of recording sheet in the form of the coffin recording sheet (Fig. 2.3).

Throughout the late 1980s, archaeologists working on records during post-excavation came to be more and more convinced that the standards of data recording were falling. Analysis and interpretation were often hampered by the omission of key data. In general terms the records appeared to become less incisive and devoid of much interpretive thought on the part of the excavator. That this was actually the case and not simply an impression gained by those in post-excavation was made clear when attempts were made to enter site records into computers. The computer input programs were compiled with reference to the standard methods of description as published in the *Site Manual* (Schofield 1980). The questions presented to the data inputer required certain types of responses, but more often than not within particular areas of the record no response could be given because a specified piece of the descriptive pattern had not been recorded on site. This confirmation that the context recording sheet was failing to capture all the required data prompted a series of debates concerning the structure of the recording sheet and ways in which recording standards could be improved.

It was decided that the recording system probably needed some form of overhaul. The drawn part of the record was briefly reviewed but was found to generally be both effective and uniformly applied. The written record, as noted above, was felt to have had several failings. Therefore the emphasis of redesign fell upon the structure and compilation of the written record. At about the same time the Museum of London had begun to employ staff in more specialized archaeological roles, for example a site environmentalist, timber specialist and masonry recorders all began to have a beneficial input into the excavation process. These specialists were therefore able to offer their particular objectives in data collection toward the general process of redesign. Finally, because this period coincided with the growth in the United Kingdom of competitive contract or tender-based archaeology, it was considered important, for several reasons,[5] that the DUA be able to secure excavation tenders in the City at the expense of outside contract units. A well

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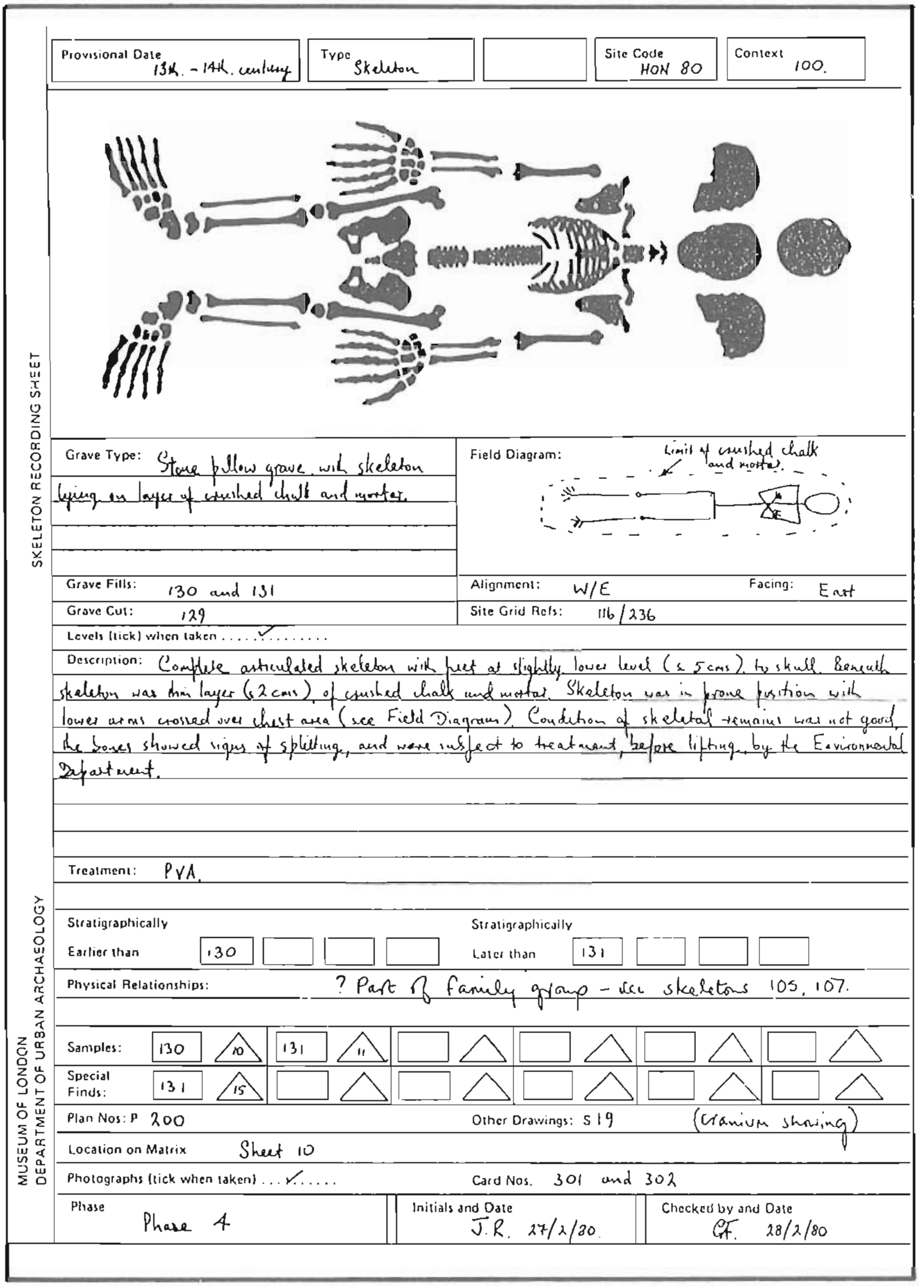
[5] Reasons given for the need to maintain DUA control over City excavations ranged from the maintenance of a skilled and knowledgeable archaeological work force within the City area through to the vital task of maintaining archival standards of record compilation.



SKELETON RECORDING SHEET

MUSEUM OF LONDON
DEPARTMENT OF URBAN ARCHAEOLOGY

Provisional Date: 13th. - 14th. century

Type: Skeleton

Site Code: HON 80

Context: 100.

Grave Type: Stone pillow grave with skeleton lying on layer of crushed chalk and mortar.

Field Diagram: Limit of crushed chalk and mortar.

Grave Fills: 130 and 131

Alignment: W/E

Facing: East

Grave Cut: 129

Site Grid Refs: 116/236

Levels (tick) when taken .....✓.........

Description: Complete articulated skeleton with feet at slightly lower level (c. 5cms) to skull. Beneath skeleton was thin layer (c.2cms) of crushed chalk and mortar. Skeleton was in prone position with lower arms crossed over chest area (see Field Diagram). Condition of skeletal remains was not good, the bones showed signs of splitting, and were subject to treatment, before lifting, by the Environmental Department.

Treatment: PVA.

Stratigraphically Earlier than: 130

Stratigraphically Later than: 131

Physical Relationships: ? Part of family group - see skeletons 105, 107.

Samples: 130 △10 131 △11

Special Finds: 131 △15

Plan Nos: P 200

Other Drawings: S 19 (Cranium showing)

Location on Matrix: Sheet 10

Photographs (tick when taken) ...✓.....

Card Nos. 301 and 302

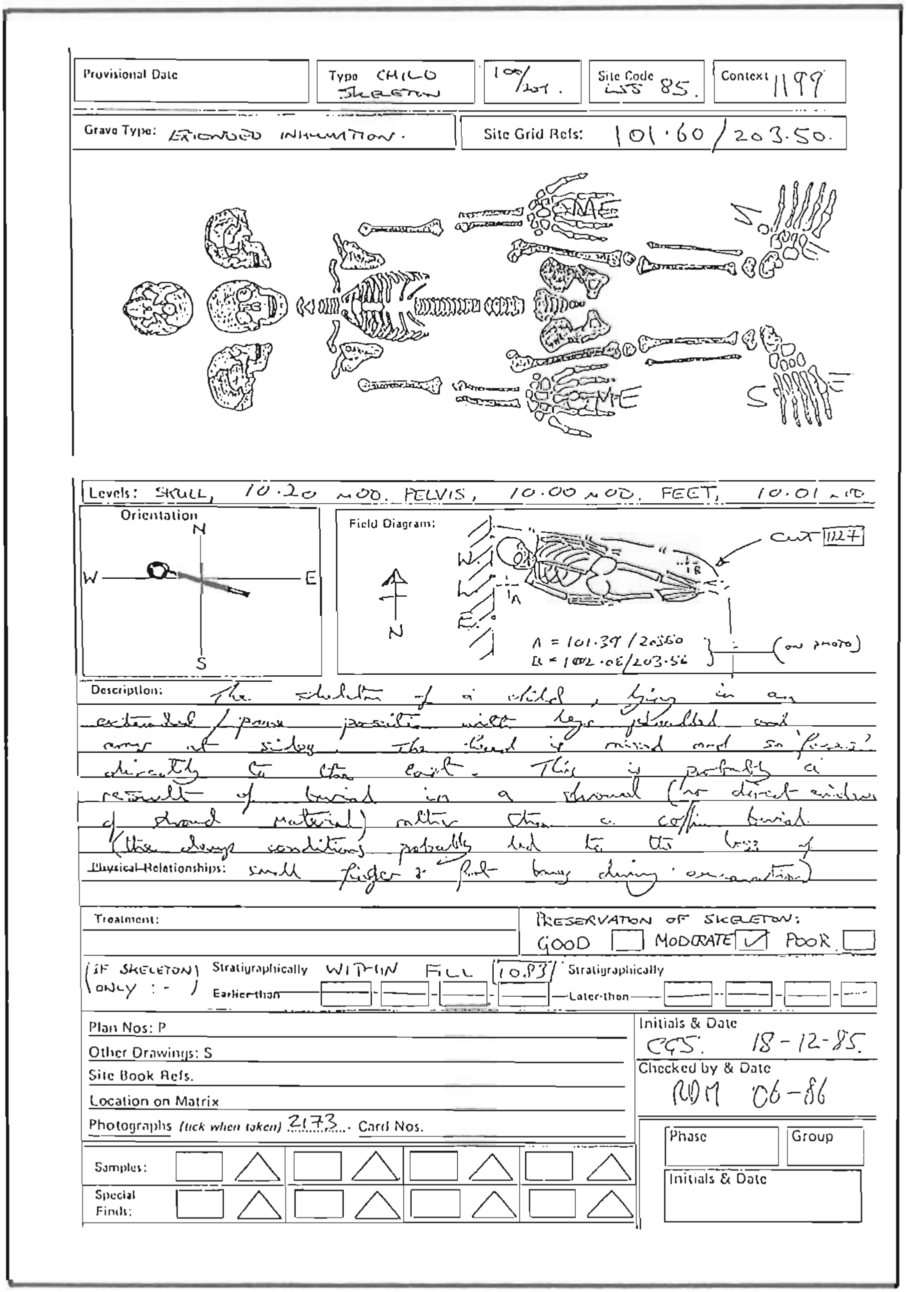
Phase: Phase 4

Initials and Date: J.R. 27/2/80

Checked by and Date: G.F. 28/2/80

A

Fig. 2.3 Illustration of (A) original skeleton recording sheet (1980); (B) adapted (Broad Street Station) skeleton recording sheet (1985); (C) redesigned skeleton recording sheet (1990). (Courtesy of Museum of London.)



Provisional Date

Type CHILD SKELETON

100/201.

Site Code LSS 85.

Context 1199

Grave Type: EXTENDED INHUMATION.

Site Grid Refs: 101·60/203·50.

Levels: SKULL, 10·20 mOD. PELVIS, 10·00 mOD. FEET, 10·01 mOD

Orientation

Field Diagram:

A = 101·39/203·60
B = 102·08/203·56 (on photo)

Description: The skeleton of a child, lying in an extended / prone position with legs extended and arms at sides. The head is raised and so 'faces' directly to the east. This is probably a result of burial in a shroud (no direct evidence of shroud material) rather than a coffin burial. (The damp conditions probably led to the loss of small finger & foot bones during excavation)

~~Physical Relationships:~~

Treatment:

PRESERVATION OF SKELETON: GOOD ☐ MODERATE ☑ POOR ☐

(IF SKELETON ONLY :-) Stratigraphically WITHIN FILL 1083 Stratigraphically

Earlier than ☐ ☐ ☐ ☐ — Later than ☐ ☐ ☐ ☐

Plan Nos: P

Other Drawings: S

Site Book Refs.

Location on Matrix

Photographs (tick when taken) 2173 Card Nos.

Initials & Date CGS. 18-12-85.

Checked by & Date RDM 06-86

Phase

Group

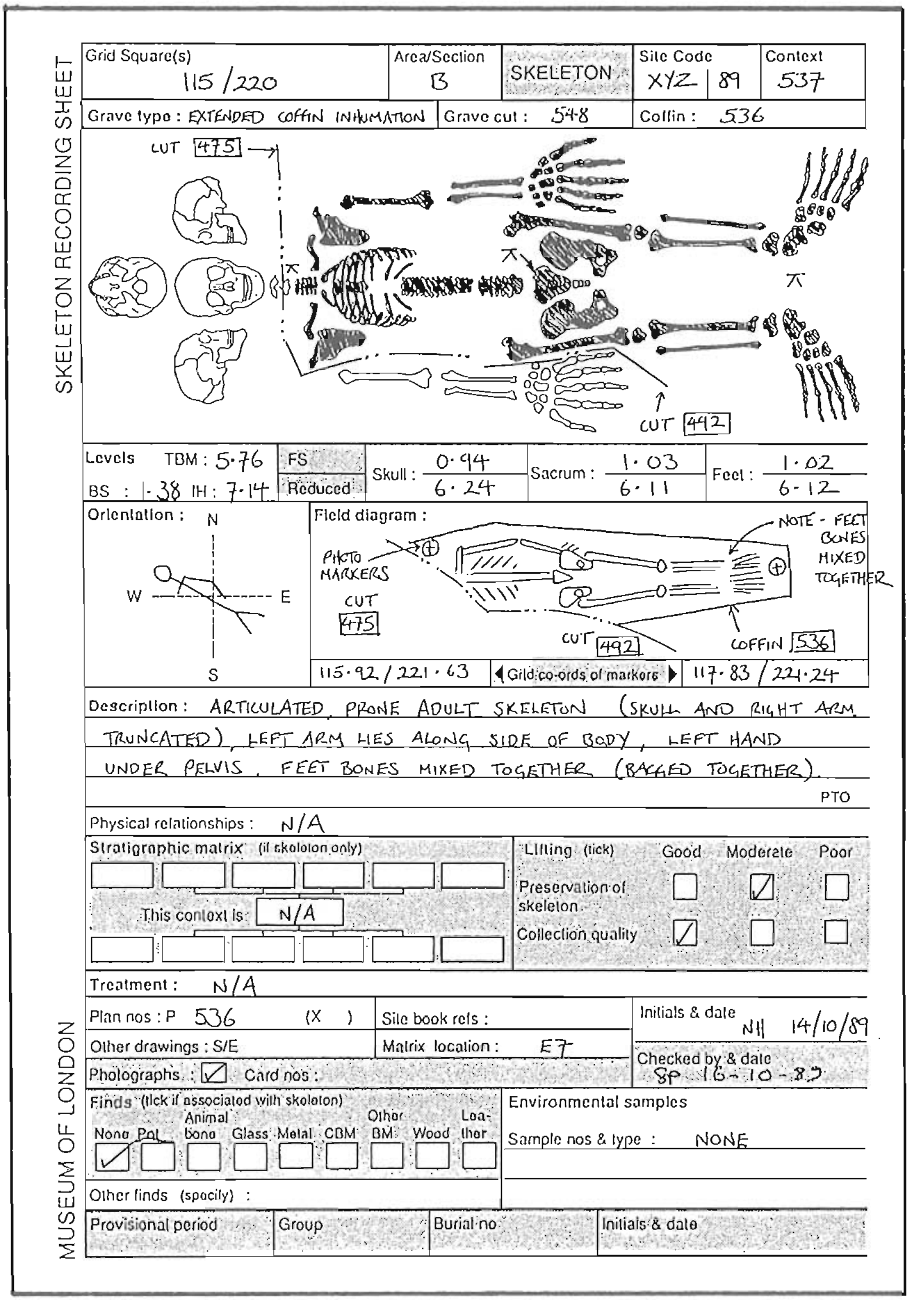
Initials & Date

Samples: ☐ △ ☐ △ ☐ △ ☐ △

Special Finds: ☐ △ ☐ △ ☐ △ ☐ △

B

Fig. 2.3 (B).



SKELETON RECORDING SHEET

Grid Square(s) 115 / 220	Area/Section B	SKELETON	Site Code XYZ | 89	Context 537

Grave type : EXTENDED COFFIN INHUMATION
Grave cut : 548
Coffin : 536

Levels TBM : 5·76 BS : 1·38 IH : 7·14	FS Reduced	Skull : 0·94 / 6·24	Sacrum : 1·03 / 6·11	Feet : 1·02 / 6·12

Orientation :

Field diagram :

115·92 / 221·63 ◀ Grid co-ords of markers ▶ 117·83 / 224·24

Description : ARTICULATED, PRONE ADULT SKELETON (SKULL AND RIGHT ARM TRUNCATED), LEFT ARM LIES ALONG SIDE OF BODY, LEFT HAND UNDER PELVIS, FEET BONES MIXED TOGETHER (BAGGED TOGETHER).

PTO

Physical relationships : N/A

Stratigraphic matrix (if skeleton only)

This context is: N/A

Lifting (tick)	Good	Moderate	Poor
Preservation of skeleton	☐	☑	☐
Collection quality	☑	☐	☐

Treatment : N/A

Plan nos : P 536 (X)	Site book refs :	Initials & date NH 14/10/89
Other drawings : S/E	Matrix location : E7	
Photographs : ☑ Card nos :		Checked by & date SP 16-10-89

Finds (tick if associated with skeleton)

None	Pot	Animal bone	Glass	Metal	CBM	Other BM	Wood	Leather
☑	☐	☐	☐	☐	☐	☐	☐	☐

Other finds (specify) :

Environmental samples

Sample nos & type : NONE

Provisional period	Group	Burial no	Initials & date

MUSEUM OF LONDON

C

Fig. 2.3 (C).

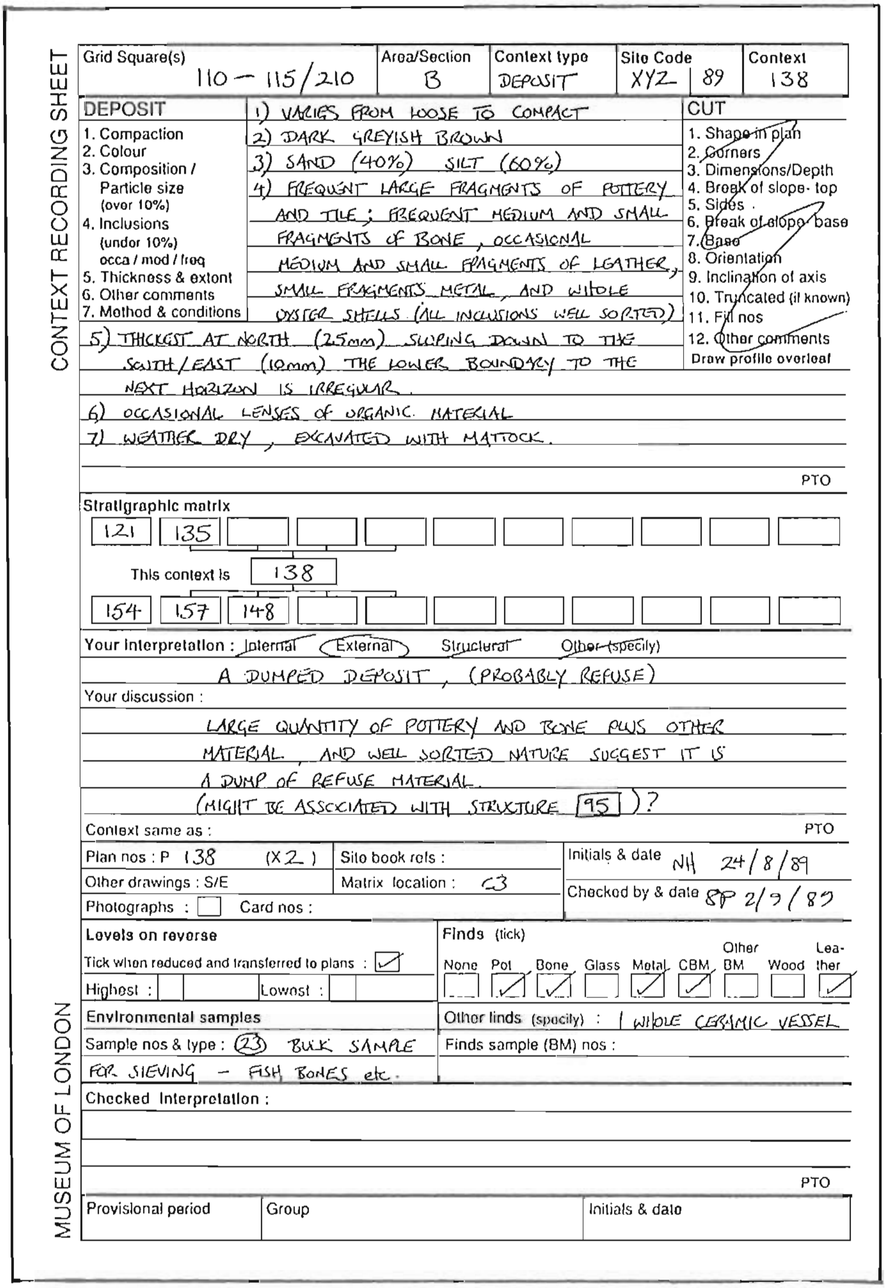
structured and clearly defined recording system was therefore seen as a valuable adjunct to the tendering process.

Suggestions were put forward by a number of archaeologists working at the Museum concerning the form and structure of any new recording sheets. These suggestions ranged from relatively minor changes to the structure of the existing sheet through to a total change, away from free text, with the introduction of a machine-readable questionnaire type record sheet. Clearly archaeologists are not simple automatons processing abstract data and it was consequently felt that this most extreme change was too far removed from the natural role of the archaeologist as an interpreter of the archaeological record. In order to facilitate a real improvement in archaeological recording and not simply a cosmetic alteration of context recording sheet design several informal interest groups set about devising new sheets. A smaller group of staff was assigned to collate all the suggestions and after numerous revisions a definitive set of recording sheets was compiled and field trials began.

The revisions to the recording system may at first glance seem radical, but as it was always felt that it was important for archaeologists working in the field to be able to use the new sheets immediately, attempts were made to minimize the impact wrought by any major alterations. The basic principles concerning the nature of the records produced were founded on the methods outlined in the first edition of the *Site Manual*. The main changes that were eventually instituted are summarized below:

1. Instead of a single record sheet (plus the skeleton recording sheet) five different types of sheet were introduced. They dealt with deposits/cuts, masonry, timber, skeletons and coffins.
2. Simple keyword prompts were added to the descriptive area of the sheets.
3. The stratigraphic relationships were more clearly represented.
4. Greater emphasis was placed upon the interpretation element of the record.
5. The rest of the sheet was redesigned with post-excavation practices clearly in mind.
6. The reverse of the sheet was printed with boxes for recording spot height/level information.
7. Ancillary sheets of similar design were created for the recording of environmental/finds samples.

If these seven points are described in greater detail it will become clear why these particular changes were made and why the system was considered to have thereby been improved. The first point notes that five sheets replaced the two sheets (general and skeleton) previously used. It was felt that as certain regularly occurring archaeological features differed structurally from each other, the recording of such features inevitably required different approaches of data interrogation. All the context sheets were designed to retain a similarity of style (Fig. 2.4), yet were structured in such a way that they would direct the attention of the archaeologist to the specific questions that needed to be answered if a suitable record were to be compiled of a specific type of context. However, it is important to note that the differing designs of context sheet in no way detracted from the overriding principle that all contexts must be seen as of equal status in terms of the stratigraphic sequence. While most contexts will fall into the deposit or cut category and thus could be recorded on the new general recording sheet archaeological material such as timber and masonry required a different approach and so required differing recording



CONTEXT RECORDING SHEET

Grid Square(s)	Area/Section	Context type	Site Code		Context
110 – 115/210	B	DEPOSIT	XYZ	89	138

DEPOSIT

1. Compaction
2. Colour
3. Composition / Particle size (over 10%)
4. Inclusions (under 10%) occa / mod / freq
5. Thickness & extent
6. Other comments
7. Method & conditions

1) VARIES FROM LOOSE TO COMPACT

2) DARK GREYISH BROWN

3) SAND (40%) SILT (60%)

4) FREQUENT LARGE FRAGMENTS OF POTTERY AND TILE; FREQUENT MEDIUM AND SMALL FRAGMENTS OF BONE, OCCASIONAL MEDIUM AND SMALL FRAGMENTS OF LEATHER, SMALL FRAGMENTS METAL, AND WHOLE OYSTER SHELLS (ALL INCLUSIONS WELL SORTED)

5) THICKEST AT NORTH (25mm) SLOPING DOWN TO THE SOUTH/EAST (10mm) THE LOWER BOUNDARY TO THE NEXT HORIZON IS IRREGULAR.

6) OCCASIONAL LENSES OF ORGANIC MATERIAL

7) WEATHER DRY, EXCAVATED WITH MATTOCK.

CUT

1. Shape in plan
2. Corners
3. Dimensions/Depth
4. Break of slope- top
5. Sides
6. Break of slope- base
7. Base
8. Orientation
9. Inclination of axis
10. Truncated (if known)
11. Fill nos
12. Other comments

Draw profile overleaf

PTO

Stratigraphic matrix

121 135

This context is 138

154 157 148

Your interpretation : ~~Internal~~ [✓ External] ~~Structural~~ ~~Other (specify)~~

A DUMPED DEPOSIT, (PROBABLY REFUSE)

Your discussion :

LARGE QUANTITY OF POTTERY AND BONE PLUS OTHER MATERIAL, AND WELL SORTED NATURE SUGGEST IT IS A DUMP OF REFUSE MATERIAL.

(MIGHT BE ASSOCIATED WITH STRUCTURE [95])?

Context same as :

PTO

Plan nos : P 138 (X2)	Site book refs :	Initials & date NH 24/8/89
Other drawings : S/E	Matrix location : C3	Checked by & date SP 2/9/89
Photographs : ☐ Card nos :		

Levels on reverse

Tick when reduced and transferred to plans : ☑

Highest : Lowest :

Finds (tick)

None	Pot	Bone	Glass	Metal	CBM	Other BM	Wood	Leather
☐	☑	☑	☐	☑	☑	☐	☐	☑

Environmental samples

Sample nos & type : ㉓ BULK SAMPLE FOR SIEVING – FISH BONES etc.

Other finds (specify) : 1 WHOLE CERAMIC VESSEL

Finds sample (BM) nos :

Checked Interpretation :

PTO

Provisional period	Group	Initials & date

MUSEUM OF LONDON

Fig. 2.4 Redesigned general context sheet (1990). (Courtesy of Museum of London.)

sheets. As already discussed, the skeleton recording sheet was altered much in the form of the sheet developed for the Broad Steet Station excavation and the coffin sheet introduced then was formally adopted into the recording system.

Probably the major incentive for the redesign of the recording sheets was the hope that greater quantities of relevant information might be collected in the field. It was to this end, therefore, that the series of keyword prompts were added to the objective description area of the sheet. These simple prompts helped to standardize the order in which the various elements of the description were entered onto the sheet, while the presence of the keyword prompts prevented the unconscious omission of any particular aspect of the description from the record. The prompts were kept small and to one side of the sheet both to maximize the area available for descriptive text and with the intention of not offending the professional skills of those archaeologists who felt that such *aide-memoires* were, in their case, unnecessary.

The stratigraphic relationship area of the sheet was improved by the printing of a small section of 'Harris Matrix' style boxes. A single central box was provided in which the relevant context number could be entered, further boxes allowed earlier and later relationships to be added as appropriate. This redesign also aided in the transfer of the relationships recorded on the context sheets to those noted on the overall site matrix. The direct copying of what were in effect small segments of matrix onto a larger matrix meant far fewer errors as a result of the simple misreading of figures.

The area of the sheeet provided for the archaeologist's interpretation was moved up from the base of the page to a more prominent position. Additional text was added to the area as an encouragement to the excavator to explain their interpretations in greater detail. The word 'Your' was added to make the archaeologist concerned aware that it was their own personal interpretation that was required. Simple keywords relating to land-use were added to secure an aspect of interpretation often omitted as a result of its routinely obvious nature. Again the individual archaeologist's personal interpretation was requested by asking for a 'discussion' of the rationale that lay behind the attributed interpretation. This extremely valuable information can be used in the re-interpretation of a context during post-excavation analysis.

Consideration was given to the use of the context recording sheet during post-excavation and the rest of the sheet modified accordingly. The need to know upper and lower levels was thought to be of use, while the extent of finds and environmental information requested was tailored to the primary need during post-excavation, that of cross-reference to other types of record. Consequently, extensive lists of recovered artefacts were felt unnecessary, particularly as complete and detailed computer-held listings could be obtained from the finds staff. Again the need for environmental information was reduced to a simple cross-reference to the parallel records of the environmental samples. Finally, the base of the sheet was supplied with an area specifically for the use of the Senior Archaeologist who could now, during record checking, add additional, and in a sense secondary, interpretive comment to the sheet without altering or removing those primary comments made by the actual excavator.

The reverse of the sheet was supplied with a set of printed boxes which could be used to note the readings of spot-heights. This ensured that all relevant readings were clearly recorded and that the operation of spot-height measurement and recording was made more efficient. A grided area was also printed allowing the archaeologist to make sketches and other graphical notes in a more controlled way. Prompts were added to ensure that vital information such as the direction of north and grid coordinate references were consistently recorded.

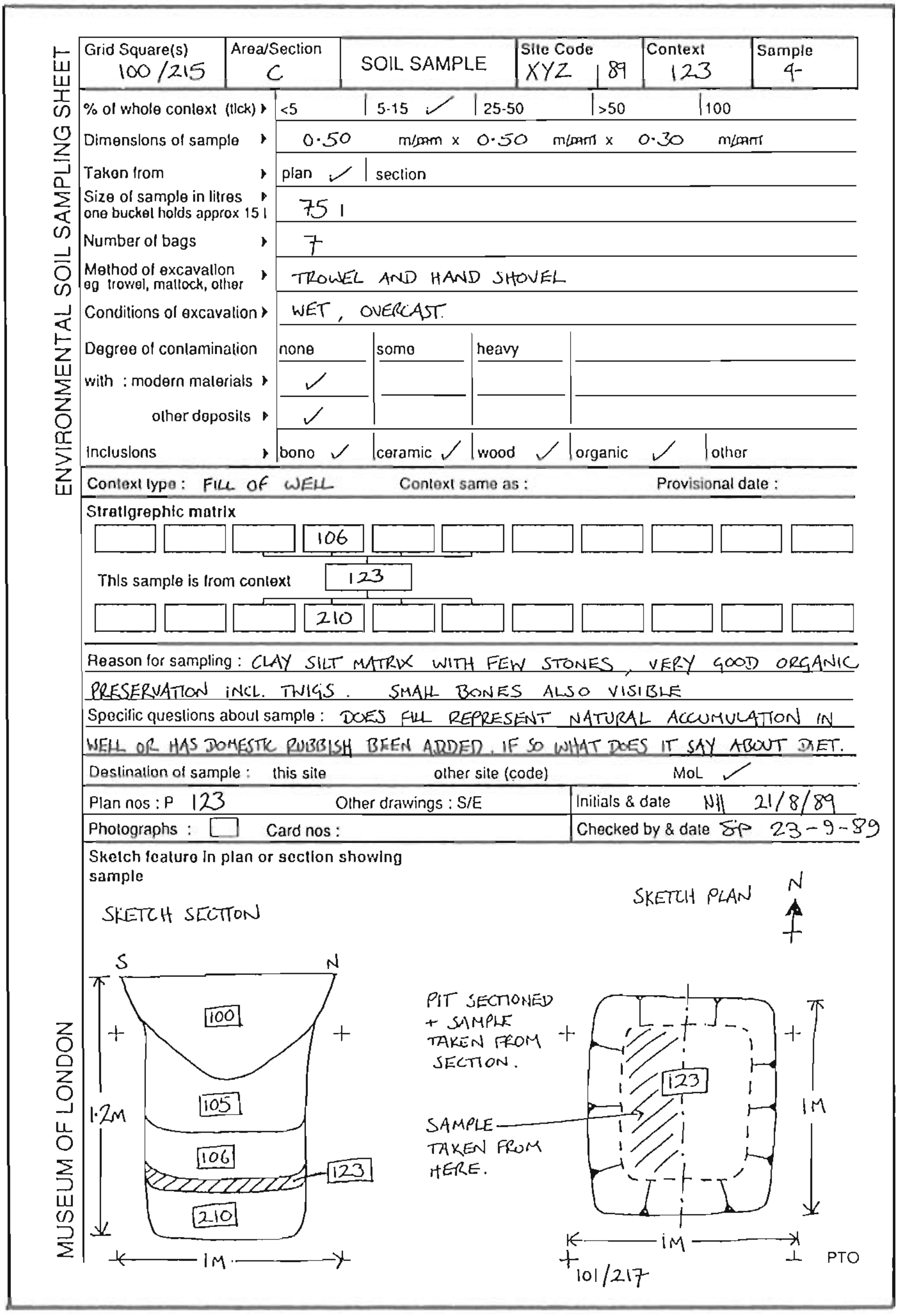
Samples taken on site were recorded on sample sheets which closely resembled the design of the general context recording sheet (Fig. 2.5). Information common to both types of record were placed in identical positions on the sheet, thus simplifying the actual copying process and ensuring fewer errors occurred during data transfer. The sheets were designed to ask specific questions of the sample taker, the answers to which would aid the environmental or finds staff in assessing the value of the sample for further processing even if specialists had not been available to inspect the sample *in-situ*.

The redesign of the sheets took a number of months to complete. A computer-aided design package helped to speed the process of design alteration but the major obstacle to a rapid introduction of the new recording sheets was the difficulty in gaining a consensus view among the design working party. Much time was spent discussing such questions as whether the boxes for level/spot-height recording should be on the front or back of the sheet and whether a particular piece of information was relevant to the site recording process or more closely associated with post-excavation activities. This particular question was to some extent resolved by the overlaying of blocks of light shading indicating that such areas of the sheet were to be completed during record checking or post-excavation. Eventually a deadline for further comment was set and commercial printing of the new sheets then undertaken. A high quality paper was chosen in order to help archive stability, an improvement over the early adapted sheets which were reproduced using poor quality photocopier paper.

While the basic structure of the recording system remained unchanged the introduction of multiple forms of context sheet did require some explanation. It was felt that for this and several other reasons an attempt should be made to rewrite the *Site Manual* first produced in 1980. Following a process of general discussion the form of the new manual was decided and production commenced. The manual attempted to define what the single-context record consisted of, how each context was related to the stratigraphic sequence of a site by use of the Harris Matrix and to provide more detailed guidance to the methods of description and excavation of certain classes of context, artefact and environmental material.

The second edition of the *Archaeological Site Manual* (Spence 1990) was an essential adjunct to the introduction and use of the revised DUA single-context recording system. The more specialized recording sheets and renewed emphasis on logically structured and consistent recording allied with a greater encouragement to make interpretive comment were all seen as being coordinated elements of this new unified system. The structure of the system was therefore both defined and publicly expressed through the content of the *Site Manual*.

The alteration of the recording sheets cannot, however, be considered to have been the sole response to the problem of recording system failure. A completed recording sheet is only as good as the archaeologist who compiled it. It was for this reason that the DUA also undertook a wide ranging programme of staff training, thereby improving the skills and ability of all its archaeological staff. This training involved a range of activities including basic instruction in record sheet compilation, artefact studies and instruction in environmental sampling techniques, health and safety training, methods of post-excavation analysis and departmental wide training in computing skills. Thus the revision of the recording sheets can be seen to have taken place against a background of general



ENVIRONMENTAL SOIL SAMPLING SHEET

Grid Square(s)	Area/Section		Site Code	Context	Sample
100/215	C	SOIL SAMPLE	XYZ 89	123	4

% of whole context (tick) ▸ <5 | 5-15 ✓ | 25-50 | >50 | 100

Dimensions of sample ▸ 0·50 m/mm x 0·50 m/mm x 0·30 m/mm

Taken from ▸ plan ✓ | section

Size of sample in litres ▸ one bucket holds approx 15 l: 75 l

Number of bags ▸ 7

Method of excavation ▸ eg trowel, mattock, other: TROWEL AND HAND SHOVEL

Conditions of excavation ▸ WET, OVERCAST

Degree of contamination	none	some	heavy	
with : modern materials ▸	✓			
other deposits ▸	✓			

Inclusions ▸ bone ✓ | ceramic ✓ | wood ✓ | organic ✓ | other

Context type : FILL OF WELL Context same as : Provisional date :

Stratigraphic matrix

106

This sample is from context 123

210

Reason for sampling : CLAY SILT MATRIX WITH FEW STONES, VERY GOOD ORGANIC PRESERVATION INCL. TWIGS. SMALL BONES ALSO VISIBLE

Specific questions about sample : DOES FILL REPRESENT NATURAL ACCUMULATION IN WELL OR HAS DOMESTIC RUBBISH BEEN ADDED. IF SO WHAT DOES IT SAY ABOUT DIET.

Destination of sample : this site other site (code) MoL ✓

Plan nos : P 123 Other drawings : S/E

Initials & date NH 21/8/89

Photographs : ☐ Card nos :

Checked by & date SP 23-9-89

Sketch feature in plan or section showing sample

PTO

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Fig. 2.5 The newly designed sample sheet (1990). (Courtesy of Museum of London.)

improvement in the skills of the DUA's archaeological staff. This leads in turn to a greater understanding of the processes of recording and excavation and particularly contributed to a much increased integration of artefact and environmental sampling within the aims and methods of field excavation.

The single-context system – in post-excavation

The practical use of the single-context recording system within the post-excavation process has been ably discussed elsewhere (see Chapter 6 in this volume). The employment of single-context records linked through a site-wide Harris Matrix has rendered post-excavation analysis both easily accomplished and importantly replicable. The interpretations applied to the record by any given archaeologist could later be reassessed and if necessary reinterpreted without altering in any way the structure or content of the original field record, clearly a very important consideration. In theory such work could be carried out quickly and efficiently and, if structured guidelines were followed and sufficient monitoring provided, the process of archive report production was rapid and later inter-site comparison made simpler and more direct.

That said it is probably worth reviewing briefly the success or failure that such work has engendered in the London case. Prior to the mid-1980s the DUA had a rather lackadaisical approach toward post-excavation management. Little or no supervision was provided for archaeologists working on report production and thus the quality of the finished archive reports varied enormously. They ranged from superbly produced reports of almost a publishable standard to a simple ordering of site data; however, on regrettably more than one occasion no reports at all were produced. The introduction of a standard format for report structure and a more consistent monitoring system around 1987 was intended to encourage authors to address the more interpretive issues of their work without worrying too much about how they should set out the text on the page. To some extent this regularization of the post-excavation system was a success: more reports were produced to a standard accessible format than had been previously achieved. Archaeologists were also encouraged to address interpretational problems during their analysis; however, on this point success was of a more variable nature.

Despite these improvements in the production of post-excavation reports a number of criticisms can be made of the DUA's post-excavation system. Such criticisms are rather more to do with the mechanics of implementation than with archaeological technique; nevertheless these are problems to which a greater or lesser extent still remain. Such problems can be summarized as follows:

1. Critical analysis could be replaced by an overtly routine approach to the processing of the field records as the mechanics of archive report presentation became over-structured.
2. The insistence upon identical formats of archive report production occasionally resulted in archive reports remaining unfinished when project-related resources became exhausted.
3. A persistent disregard for an intrinsic research design meant that greater interpretive statements failed to be made at the conclusion of post-excavation work and so the application of critical objectives to future excavation projects within a City-wide context became untenable.

The first point made above is something of which users of single-context recording systems are often accused, that is allowing the mechanics of the system to impair their intellectual method. Although, as I have already made clear, this argument can now be easily repudiated at the data collection level, it is possible for this situation to arise during post-excavation analysis. The resulting reports tend to be little more than an orderly collection of field observations accompanied by a spattering of interpretive comment, and deeper discussion of a theoretical nature is not entertained. A well structured report is of course a great aid to future research, but if the details of the presentation come ro overwhelm the intrinsic content of a report then its value for research obviously becomes diminished. The major associated problem with this greater structuring of presentation was that archaeologists could, if they so wished, produce reports that described what was found during excavation but to a greater or lesser extent avoid the more difficult questions of interpretation. A more recent move toward the writing of a detailed integrated synthesis of dated site sequence did make significant inroads into the problem of mechanical report presentation by encouraging a more interpretive and critical description to be made of a given site's history.

Point 2 has to be seen against the background of a large rescue unit carrying out numerous excavations with limited resources. In the case of the DUA this situation lead to a stretching of such resources too thinly across the spectrum of excavation projects. Thus small projects lacking enough data to provide truly significant intra-site results were allocated full resources allowing them to be written up to the standards of much more significant excavations. Conversely, large projects were encouraged to expend their resources in a similar process of detailed report presentation; in virtually every such case this has resulted in large projects failing to meet their post-excavation deadlines and, more importantly, meant that important questions of an interpretive nature remain unaddressed. The answer to this point lies in the efficient management of post-excavation project funds across the entire department, with the ability to reallocate resources actively where necessary and within the framework of a clearly described research design.

However, this introduces the issue raised in point 3, the failure to institute a well considered and effectively implemented research design. In the case of the DUA the absence of a departmental research design can be seen to have been damaging to the archaeological process from the initial access/resource negotiation through staffing policy and on into post-excavation strategy. Despite frequent calls for such a statement of archaeological policy to be made the issue was never seriously taken up by senior management. This resulted in what should have been a tightly inter-woven system of site evaluation, investigation and analysis becoming disjointed and dependent upon the vagaries of site-specific resource allocations. Such a failure is not, however, a failure of the system; it is more properly defined as a failure of senior management.

A final and very important point to note is the lack of the DUA archive, of both primary site records and post-excavation reports, to be properly utilized as a research tool. This, however, is not a criticism of the DUA, in fact the DUA has done much to make known the existence of the archive and to make it accessible to researchers.[6] This particular fault can only be laid at the door of the archaeological community as a whole. Academic researchers, and the like, should be making use of this tool; students and others must be encouraged to use not only the DUA archive, but all such archaeological archives. The

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[6] For a discussion of the use and value of the DUA archive, see Schofield (1987) and Cunliffe (1990).

failure to do so may result in economic pressures to resist the production of such valuable resources. A structured archive of single-context records, linked to a stratified sequence by a Harris Matrix and cross-referenced to environmental and artefact collections, represents a virtually complete translation of the primary archaeological record, no longer extant in its primary form, into an available assembled form of data that can be recalled, studied and transmitted.

But, to be more positive on these issues, it must be re-emphasized that it has now been demonstrated that a well structured and well managed post-excavation programme can lead to significant improvements in both data presentation and interpretive critique. If a rational approach is taken to the post-excavation processing of records, giving due regard to their significance with reference to a stated research design, then the product of such work will be an archive which will form a major archaeological data resource for future study. And it is in this direction that some of the more recent developmental work in the DUA has taken place, for example the introduction of matrix-based land-use diagrams provides an important access point for the interrogation of inter-site data. Similarly the utilization of computer graphics linked to an archaeological database will provide the test-bed for the future implementation of a Geographical Information System containing City-wide archaeological data. However, such projects will only come to fruition if they are based on a significant research design and a determined approach to the effective management of all available resources.

In conclusion

The single-context recording system used by the DUA has been the product of many years of excavation and post-excavation experience of many people, while the particular circumstances of intensive urban rescue excavation have lead to continual attempts to refine and improve the system as a whole. The current structure of the system has been critically reviewed and given time and future years of use will no doubt be improved further. The introduction of the system was at a time when construction work was carried out at a relatively slow speed and, therefore, a generous amount of time could be taken in the recording and analysis of archaeological data. Current construction techniques require the recording system to be ever more adaptable and to be able to capture large quantities of data rapidly in an accurate manner. It is hoped that the recent revisions described in this paper will satisfy this need.

In post-excavation the analysis of single-context records linked by a Harris Matrix has allowed reports to be produced rapidly and within a coherent structure. Intra- and inter-site research can be facilitated through matrix analysis, whether approached from stratigraphic, artefactual or environmental standpoints. Although some problems relating to this element of the system have been discussed above I hope it is clear that the system, if properly managed, can provide an unrivalled method of data verification, analysis and presentation. The step from archive to publication is relatively straightforward, if all the aforementioned factors are satisfied, and thus the single-context archaeological recording system undoubtedly presents a truly seamless method of progression from archaeological deposit to paper archive.

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3 The contribution of the Harris Matrix to the development of Catalan archaeology

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Classical Catalan archaeology was the first in Spain to adopt the Harris Matrix. This article will attempt to determine the circumstances which brought about this change, as well as sketching the current situation in the light of the effect which Harris's works have had on the development of methodological concerns in Catalonia, in northeastern Spain.

The decade of the 1980s was a decisive period for classical Catalan archaeology, in that innovations came about very quickly. This left almost no time for a concomitant effort of reflection and assimilation, resulting in tremendous confusion with regard to new concepts and current archaeological needs.

I am therefore grateful for the opportunity to publish these preliminary reflections on the effect which the Harris Matrix has had on a scientific community characterized by a dearth of methodological literature. This situation is curious, nonetheless, when we consider the intense, even inordinate, amount of excavation which has recently taken place in Catalonia. This archaeological activity ought to have engendered a productive debate on methods and techniques, as they underlie and are implicit in day-to-day archaeological practices (G. Trócoli and Sospedra, 1992).

Historical development

Until the middle of the nineteenth century, Catalan archaeologists tried to reconcile Biblical history with the information gleaned from Greco-Roman sources, in order to understand the monuments still extant. This was the era of the great Romantic voyagers and the *incunabula* of scientific systemization, derived from enlightened thought. The excavations which went on during these centuries were little more than plunder aimed at sating the curiosity of scholars and filling the pockets of unscrupulous treasure-seekers. The first 'institutional' excavations did not take place until the middle of the nineteenth century, in the Greco-Roman city of Empúries. With few exceptions, the methodological and technical concerns in the initial stages of such institutional work were hardly different from those adopted by individual scholars or treasure hunters.

The Catalan language and culture, outlawed and repressed under Spanish domination from 1714, had given rise to one of the most thriving literatures of the Middle Ages. The national recovery movement, or *Renaixença*, during the second half of the nineteenth

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century, helped to arouse public interest in cultural heritage, such as archaeological sites, as a resource capable of reawakening the collective memory and supporting the nationalist movement. During this period, classical Catalan archaeology was still heavily influenced by epigraphy, philological and architectural studies; one notable (but unfortunately short-lived) example is worthy of mention: the figure of Bonaventura H. Sanahuja (1810–91), the origin of whose stratigraphic interest is unknown to us. Sanahuja, in numerous scientific publications, insisted on recording the placement of objects in the ground. He recommended excavating in horizontal layers, never advancing vertically, so as 'to avoid covering and confusing objects which appeared in each of the zones and to facilitate elucidation of the periods and peoples to which they belonged' (Sanahuja 1868: 439). Based on the section made in 1863 of an excavation carried out in Tarragona – itself a unique example of its time – Sanahuja emerges as an excellent stratigrapher whose writings reveal interesting thoughts on the non-historical aspects of stratigraphy. His conviction that it was Divine Providence which governed the deposition of strata perhaps soured the advance of some of his thinking, which was ahead of the times.

The first decade of the twentieth century saw the organization and institutionalization of every aspect of archaeology, beginning with local administration. It witnessed the creation of the Institut d'Estudis Catalans which took charge of spelling out clear criteria for the planning and the diffusion of archaeology in Catalonia – a task which is performed masterfully at a time when the boundaries between different scientific displines were still indistinct. The Institut d'Estudis Catalans not only gave impetus to excavations already being carried out by some cultural societies, but it created new and innovative research programmes, which laid the foundations for modern Catalan archaeological research (Marc 7 1986: 60). At the same time the local administration of Barcelona undertook excavations again at Empúries, one of the sites most representative of planned archaeology.

It was as this time that the concept of 'stratum' began to be heard, by which was meant a layer of earth corresponding to an historical period, or ethnic origin, as in the 'Roman stratum' or the 'Iberian stratum'. The architectural study of monuments began to be accompanied by an identification of the 'humble shards of pottery which, in the geology of that historical period, are equivalent to fossils in the older layers' (Sanahuja 1868: 414), with the aim of differentiating various cultural stages.

With the establishment of the *Mancomunitat,* a regional government with a reasonable level of autonomy, Catalonia 'detached' itself from the rest of Spain, acquiring a contemporary mien comparable to that of many European countries. The *Renaixença* gave way to the blossoming of *Noucentisme*, a cultural movement dominated by the Catalan bourgeoisie, authors of the *Mancomunitat*. During this new stage, into the 1930s, preceding developments were further incorporated and consolidated into Catalan archaeology.

It was during these years that Pere Bosch-Gimpera, an emblematic, quasi-mythical figure of Spanish archaeology, emerged on the scene. Bosch-Gimpera, with his solid Germanic training, invested Catalan archaeology with an international character by linking research projects underway with the dominant trends in European research. Until 1923 it was a 'golden age', with the development of the 'Barcelona School' around Professor Bosch-Gimpera. His vast works brought to light Spain's 'multinational' character since remotest times, that is to say, the 'diversity of the peninsula's ethnic and cultural substrate' (Guitart and Riu 1989: 28). This scholarship cost Bosch-Gimpera half a lifetime in exile during the Franco dictatorship.

During these fruitful years, intense research and excavation went hand-in-hand with a policy of public diffusion of archaeological information, including the editing of scientific publications. At this stage the German influence on Catalan archaeology was very strong: Dragendorff had visited Empúries in 1907 and Cazurro (1909–10) praised the ceramological studies carried out in the camps of the German 'limes'. Concurrent with the architectural and philological methods which dominated the classical Catalan archaeology of that time, ceramological studies began to appear prominently. These studies – the cornerstone of Catalan archaeological research to this day – were once a sign of prestige and progress, but with time became but a yoke from which our profession has yet to free itself.

Concepts such as 'inverted stratigraphy' began to be heard, and exhaustive written and graphic records of the data were thought indispensable. The realization emerged that professional archaeology was somehow different from archaeology practised by amateurs. Although archaeology was still considered an historical succession of levels, at that time there was an awareness of the lack of value of archaeological studies based on non-stratigraphic records.

In 1923, the dictatorship of Primo de Rivera placed the first curb on this process, inhibiting all activities related with Catalanism, among them archaeology. The Empúries site was singled out in that it had become a symbol of the Hellenic origins of Catalans, in contrast to the other inhabitants of the Iberian peninsula. Excavations in the Greek city were paralysed along with the activities of the Institut d'Estudis Catalans, which continued to provide its services secretly through other institutions with greater freedom to manoeuvre (Marc 7 1986: 59). With the proclamation of the Spanish Republic in 1931, Catalonia recovered its self-government and a state of autonomy for the first time since 1714. Archaeological policy resumed the course curtailed in 1923. Bosch-Gimpera continued his superb work, which would be the incontrovertible framework for reference 40 years later with the passing of the Franco dictatorship.

Archaeology under Franco

The Civil War (1936–39) and the establishment of the Franco dictatorship (which lasted 40 years) resulted in an attempt to annihilate every vestige of Catalan culture, language included. State control of archaeological policy, based on certain assumptions, was introduced by Martín Almagro, who made his entry into Barcelona with the Francoist occupation forces, usurping the responsibilities of Bosch-Gimpera. The latter, having carried out a laudable policy of protection and evacuation of the cultural heritage during the war years, was forced to seek exile in Mexico where he died in 1974. Almagro did not disregard all of the work done by Bosch-Gimpera; he 'emptied it of its ideological content and used it as a platform for dissemination serving Francoism' (Marc 7 1986: 61). He could hardly afford the luxury of doing without that excellent group of scholars of the Barcelona School, Bosch-Gimpera's colleagues.

The post-war years were characterized by a conspicuous scarcity of resources and state ideological control. As Bosch-Gimpera himself was to say years later: 'Catalan university archaeology did not escape the material and cultural poverty of the postwar period; subjected to the prevailing ideological imperatives of academic historiography, it took refuge in the ostensible innocuousness of positivism' (Bosch-Gimpera 1971: 67–8). During those years the official organ of archaeology in Catalonia was the magazine *Ampurias* (Spanish for Empúries), founded by Almagro in 1939. In the memorable fascist proclamation for the magazine, it was said to be dedicated to 'exclusively serving the ideals of the new national State led by "the Caudillo"' (Almagro 1939). The articles which appeared during the first years of the magazine apparently demonstrated that nothing was learned from the prior years; archaeology had been plunged into the most absolute typological mediocrity, giving rise, in turn, to the most absurd hypotheses. The brilliant, inspiring example initiated by Bosch-Gimpera was obstructed and obliterated without much trace. Classical Catalan archaeology thus entered one of its darkest periods. Renewed excavations were undertaken in Empúries – significantly in the Roman city, while work in the Greek city was abandoned. It was the army which carried out excavations: trenches dug along walls, a multitude of unfinished sondages, prospecting, excavation of myriad holes and the systematic emptying of the richest sites were the order of the day.

The year 1947 marked a major turning point, with the establishment of the Empúries International Prehistory and Archaeology Courses, an activity which continues to this day. The idea was to make Empúries a permanent training centre for Spanish archaeologists. In the first year the star was Nino Lamboglia (1912–77), an Italian researcher strongly influenced by German ceramological studies, and a proponent of Almagro's ideological beliefs. Lamboglia, who had been put in charge of the Istituto di Studi Liguri, established close ties with Catalan archaeology, and his institution was to become a pivotal point for ongoing studies among Spanish, Italian and French researchers. Lamboglia, like his mentor Giacomo Boni, the precursor of stratigraphic archaeology in Italy, was first and foremost a stratigraphic technician interested in ceramological dating, a fact which distanced him from official Italian archaeology, at that time exclusively interested in the monumental approach. It was Lamboglia who introduced the thought and method of Sir Mortimer Wheeler to Catalonia, although Carandini (1981: 33) dubbed him a 'post-Wheelerian ante-litteram', referring to his preference for excavating without baulks. As the years went by, the excellent work of the much-maligned Lamboglia achieved the recognition it deserved in the three countries of the Ligurian arc around the Gulf of Lions; in Catalan archaeology, his ideas and teachings persisted almost until the 1980s.

The first effects of the fertile collaboration with this Italian researcher became apparent in the study of the 'Decumanus A' of Empúries which, as Almagro recalls, was excavated using the ditches which the 'red hordes' had wantonly dug during the war (Almagro and Lamboglia 1959: 3). Strata were studied not as a reflection of cultural horizons but as a result of human actions, marking the beginning of an emphasis on the non-historical aspects of stratigraphy. In fact, what the Catalan researchers found so impressive about Lamboglia were the astounding results he achieved in monumentally poor sites such as Albintimilium (Lamboglia 1949). As Almagro said, 'Lamboglia shows us how a good excavator, through his method and meticulousness, may provide – if not extensive or valuable artistic findings – certainly very useful historical and chronological information ... the method followed in excavating was to observe the grounds' strata, gathering absolutely all pottery fragments; these were later classified and culled, and subsequently published in the form of small drawings' (Almagro 1952: 290). Such was the panorama offered by Catalan archaeology in 1952.

During the 1960s, Bosch-Gimpera's disciples reinstituted the Barcelona professor's chair, and the specializations of prehistory, archaeology and ancient history were created at the university. However, these disciples, now professors at the Catalan University, were unsuccessful in carrying on the prestigious work of the Barcelona School, which Bosch-Gimpera had initiated. The years which went by until the 1980s may be summed up in the following words uttered by Professor Lamboglia, days before his death: 'having come here in 1947 preaching the importance of pottery I am now alarmed to see that young people today are no longer archaeologists but mere ceramologists; yet this is absurd, for I have always stressed the importance of pottery – but coupled with an understanding of epigraphy, city planning and archaeological problems in general. Now everyone here has gone in for pottery. I almost feel as though I'm to blame. Never did I dream – he told me – that this might have such negative consequences' (Cortadella, in press).

Thus in the typical archaeological publication of the early 1980s, it is impossible to decipher the recording system used, and digging technique and strategy are questionable at best. One percent of the publication is a description by sector of the architectural structures which had appeared, another 1% are plans and sections (usually only a general plan and the major 'stratigraphic section', together with a map situating the site within the district or region and an occasional photograph), 94.5% is an inventory of the pottery found (lists and drawings), 3% is an analysis of materials (classification and typologies) and 0.5% – as an innovation conferring prestige on the publication – is a list of animal bones identified. The main criterion in determining the site's periods is pottery, which takes precedence over stratigraphic interpretation.

Introduction of the Harris Matrix

The first years of democracy in the late 1970s saw a renewed Catalan national autonomy and at the same time concepts such as open-area excavations, recording sheets and the Harris Matrix began to be heard in the archaeology of the region. The new European currents were primarily introduced into Catalonia through Andrea Carandini, an Italian researcher who had had direct access to the works of the British mission in Carthage, then under the leadership of Henry Hurst (Manacorda 1983: 16). Furthermore, Simon J. Keay (now professor at the University of Southampton), a British student who had worked with Carandini at Settefinestre (Carandini *et al.* 1985), acted as liaison between the Universities of Bradford and Durham and the Catalan universities, with the aim of starting a collaborative Catalan/British project to excavate the Roman villa of Vilauba (Girona). In 1979 Carandini himself gave two lectures in Barcelona heralding for Catalan archaeologists the advent of techniques and ideas which had been evolving in British urban archaeology for some years past. These consisted of a supplanting of Wheelerian methods, the emergence of the stratigrapher-archaeologist to the detriment of the archaeologist-scholar-historian, a concept of the archaeologist's duties and obligations to society, and a clear standardization of archaeological recording and excavating techniques for projects as a whole, as opposed to the absurd concept of training archaeologists to specialize in excavations by period (Manacorda 1983). The dearth of translations of methodological works and the failure of the universities in Catalonia to investigate these new ideas impeded a productive assimilation of the innovations, which were transmitted orally and by mimicry without serious philosophical reflection.

Urban archaeology and rescue digs were the protagonists of this new stage. The error of considering them an escape valve to relieve unemployment among young archaeologists – recent graduates with little experience – was offset by the latters' enthusiasm in converting an outmoded, traditional archaeology which was poorly equipped to solve the problems raised by urban archaeology. The need to assimilate in a few years, and against considerable odds, what other countries had been working with for decades, left Catalan archaeology with a plethora of 'semi-adaptations' and superficial attainments which are at the root of the contradictions which plague our profession today.

The name of Edward Harris, whose work began to be known in Catalonia as a result of the rudimentary translations prepared and distributed by students (Ruíz de Arbulo 1992), was associated from the very start with the torrent of innovative ideas which flooded the Catalan archaeological landscape. In Catalonia, as a result, the 'Harris method' automatically brings to mind the open-area excavation with sheet recording of stratigraphic units arranged according to a diagram or matrix. Although as mentioned earlier, the first experiments in this regard were carried out in the Roman villa of Vilauba, it was the extensive site of Empúries which constituted the major 'testing ground'. The new system of sheet recording, as opposed to the traditional notebook, the new excavation strategy, and the valuable working tool which the Harris Matrix turned out to constitute, permitted speedy publication not only of the results but of the graphic register and matrix. This work was a great innovation in the light of the muddled archaeological publications of the time, 99% of which consisted of a study of materials. From this point on, the 'Harris method', as it was called, was gradually adopted on most classical and protohistorical sites, as well as some medieval excavations. Use of the 'Harris method', then as now, constituted a guarantee of a quality excavation in the eyes of fellow researchers, and became a source of Catalan pride and prestige before the remainder of the Spanish archaeological community, still bogged down in an outmoded Wheelerism.

However, ceramological training exercised and continues to exercise an undue influence on Catalan archaeological research. In the excavation and recording process, the interpretation and dating of stratigraphic units through pottery is understood to go hand-in-hand with the filling in of recording sheets; in most cases, the error is committed of delaying construction of the matrix, or stratigraphic sequence, until the post-excavation period. In fact, contrary to popular opinion, the true 'Harrisian' stage has yet to be reached as there is still only an indirect, superficial acquaintance with what is locally referred to as the 'Harris method'. For example, an individual record of stratigraphic units is scrupulously kept, but the written information entered is redundant and – paradoxically – insufficient, since the sheets are either very rudimentary and poorly detailed, or overly involved and difficult to comprehend. Likewise, graphic information is still based on composite planning rather than single-context planning.

The excess of interpretative zeal in excavations (which admittedly is difficult to avoid in programmed digs) generates a pressing need to identify, in the field, the interfaces corresponding to the so-called 'levels of circulation' or floors, surfaces upon which life took place. Because of it, we may cite Harris: 'Here, we perhaps ought to be guided by the notion that the stratification of a site represents its *present state* and not necessarily its *original condition*; it is the former which we must record and on such observations make deductions about the latter' (Harris 1977: 105). This is why the first point which Catalan Archaeology should begin to consider is that the matrix is divested of value if the excavation technique and data recording system are not as exhaustive and objective as they should be. If the database is not good, the stratigraphic sequence is useless.

Current trends in Catalonia

The consequences of the whirlwind development of modern Catalan archaeology coupled with a lack of reflection were recently brought to light at 'Harris Matrix: Sistemes de registre en Arquelogia', a seminar held at Barcelona and Girona in November 1989. Newly emerging from his university cocoon with its nineteenth-century traditions, the Catalan archaeologist has two options. One is archaeology as a summer hobby, a result of the inordinate development of field archaeology in which individual archaeologists may carry out their own excavations (permits being fairly simple to obtain from the local administration), according to their historical preferences. The only requirement imposed by the administration is that within two years of completion of excavation, a report be filed. Little importance is attached to the recording system used on the excavation since what is really of interest to the administration in the report is a description and interpretation of the findings unearthed. Thus, another archaeologist wishing to review those conclusions would surely be unable to do so for lack of the necessary instruments with which to interpret the data recorded. What is more, such digs – funded exclusively through government subsidies – entail considerable public expenditure, money spent gainlessly which might have been used instead for rescue excavation of the many sites which are destroyed each year with impunity, for lack of the economic means (and political will) to save them from destruction.

The other option available to the Catalan archaeologist – though only to the most fortunate – is to get a job as a professional (not a simple prospect given a high unemployment rate) in rescue digs in urban areas, excavations which until recently had never received anything but public funding. I am referring specifically to the case of the City of Barcelona, where the recent Olympic Games, and the frenzy of construction and remodelling they have unleashed, have been a stimulus to large-scale urban excavation, but have also pre-supposed extensive destruction of our cultural heritage. In the midst of this dramatic increase in new fieldwork, we find young archaeologists, who in specializing in one historical or prehistorical period are suffering from stress brought about by the enormous, complex sites they faced, the stratification of which often spans 20 centuries or more.

Our initial assumption is that anyone familiar with the recording system used in the Harris Matrix could excavate any site, regardless of its period. If the Harris Matrix is as prevalent in Catalan archaeology as it seems, why do archaeologists come a cropper when excavating a site which does not correspond to their historical specialty? One answer is that the figure of the 'archaeologist-as-stratigrapher' has not yet been created; owing to his academic training the archaeologist is still thought of as the fervent discoverer and scholar of material culture. This problem was brought to light at the Barcelona meeting mentioned above, which empirically rejected the notion of the stratigrapher as a technician specializing in the mechanics of excavation and meticulous recording, incapable of experiencing, for example, the thrill of a Roman archaeologist upon unearthing a shard of pottery which gratifyingly corroborates his hypothesis. While this may be a satisfying feeling, in rescue archaeology there is no time for complacency or reverie. Furthermore, the feelings of satisfaction enjoyed by certain archaeologists during excavation do not necessarily come from the conviction that their data recording is reliable and exhaustive, but rather, from being able to interpret as they dig.

Archaeologist-as-stratigrapher

Stratigraphers may understandably be accused of employing the 'method for the method's sake', or making construction of the matrix an end in itself, but one thing is clear: while the interpreting errors of an archaeologist-as-stratigrapher during post-excavation work can be remedied, the recording errors of an excavator who considers himself an historian first and a stratigrapher second, cannot. Furthermore, the archaeologist-as-stratigrapher, as Carandini says, is a specialist in the iconography of excavation/construction/destruction actions and a typologist of excavations, regardless of his familiarity with repertories of materials. Notwithstanding, the contrary is cause for concern (Carandini 1981).

In my view, the work of a dispassionate stratigrapher is preferable to that of an impulsive Romanist or 'period archaeologist'. However, greater importance continues to be attached to the objects taken from the strata than the logic of human actions – and behaviour – in a given locality (Carandini 1981). It is absurd that a medievalist excavating a medieval site should require assistance from another archaeologist because evidence from a different period is found (D'Agostino 1981). Naturally, a medievalist will be more comfortable identifying actions and models typical of that period than someone who has never excavated medieval levels, but it should go without saying that an archaeologist should be capable of recording the exact placement and characteristics of evidence so that any other researcher may, by reviewing his records, call his conclusions into question, or otherwise. Unless it is acknowledged that the archaeologist must be a stratigrapher first and foremost, our work will be unproductive, irresponsible and destructive.

In the end, the problem is no more than the need to redefine the nature, horizons and objectives of the archaeological discipline, renouncing the insistence on a sterile battle between two poles: the archaeologist-stratigrapher versus the traditional archaeologist-historian-scholar (Manacorda 1983). This brings us back to the thought expressed by Lamboglia when he lamented that Catalan archaeologists were not archaeologists but simple ceramologists. The result is that – and in this regard all of the Mediterranean countries are alike – Catalan archaeology has always been, and continues to be, characterized by a total absence of methodological literature and translations because, when all is said and done, few seem very interested in techniques and methods. Nor does it come as any surprise that the first meeting on methods and techniques in Catalonia was only held at the late date of 1983, and was a failure as far as results were concerned (Ruíz de Arbulo 1992). If there is no change in mentalities, the conception of our profession and the policy of research institutions, all of the efforts to improve our technical expertise will be to no avail. The absence in Catalonia of a research body with sufficient moral weight to unify attitudes and efforts has permitted the persistence of this technical 'autodidacticism'. The thinking that it is unnecessary, in reports or scientific publications, to deal with the method and strategy used in excavation has served to camouflage an unstructured methodology and the confusion surrounding its application: as early as 1939, Kathleen Kenyon called attention to this poor scientific habit (Manacorda 1983).

The University, rooted in the past, a veritable school of historical erudition turning out armchair archaeologists for lack of research programmes, appears to persist in the outdated idea that archaeology is not taught in the classroom but through practice in the field. This argument, by passing the buck, effectively dispenses with teaching something which it does not know. Is the single-context recording system impossible to teach? And what about the laws of stratification? Not to mention the Harris Matrix (Manacorda 1983).

The non-existent archaeological experience of recent graduates is dangerously compounded by the senselessness of making them responsible for rescue digs; to make matters worse, there is no requirement that they elucidate their working methods.

From Mediterranean archaeologists one often hears the argument that if techniques have not been developed in this region, it is because our ancient civilizations built solid stone constructions which could easily be excavated and complemented with the abundant epigraphic and literary evidence, whereas the British and North Europeans have been the pioneers in perfecting recording systems because their archaeological evidence is difficult to identify, thus obliging them to glean what they can from stratification. As early as 1956, this thought was expressed by Antonio Arribas in the magazine *Ampurias,* in a review of *Archaeology from the Earth* by Sir Mortimer Wheeler (Arribas 1955). While praising Wheeler's excellent work he cannot help remarking sarcastically on the popular archaeology dissemination campaign undertaken by Wheeler in England from his comfortable position as a university archaeologist. Although Carandini's comment 'With Romans available, what use could Mussolini possibly have for the Vilanovians and Lombards?' (Carandini and Settis 1979: 104) is true that the tendency has always been toward momumental study as being easier to finance, he is also justified in stating that rather than being so absurdly smug about our monumental ruins, we should recognize this fact has only nurtured our indolence with regard to recording systems and techniques. The main reason for this dichotomy between the Mediterranean archaeological tradition and that of countries with a longer history of industrialization resides foremost in socio-cultural differences (Carandini and Settis 1979), but that would be the subject of another article.

In conclusion, I would like to suggest that if all of the archives containing excavation records in Spain were to be published, it would come as no surprise to find that a great number of archaeologists – and here I do not refer only to Catalans – who claim to abide by the strictest Harrisian orthodoxy, are in fact years away from understanding the true philosophy of the Harris Matrix.

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4 Polish medieval excavations and the Harris Matrix: applications and developments

ZBIGNIEW KOBYLIŃSKI

Introduction

Stratigraphic observation and recording have an old and illustrious tradition in Polish archaeology. In tracing back the earliest examples of the understanding of the stratigraphic nature of archaeological sites, it is necessary to go back to 1876 when Kalikst Jagmin, during his excavation of a grave mound at Łęgonice on the Pilica River, made an accurate and quite modern drawing of a cross-section of the site in which the identified layers are well distinguished graphically and are numbered and described (Jagmin 1876; see Urbańczyk 1987). However, deliberate theoretical consideration on the stratigraphy of multi-layer archaeological sites, with resulting developments in excavation methods, took place in Polish archaeology no earlier than the end of the Second World War. In the late 1940s and early 1950s, most of the Polish archaeological community took part in general discussions on the methods of fieldwork, the most important propositions being put forward by Włodzimierz Hołubowicz (1947, 1948), Witold Hensel (1949) and Tadeusz Żurowski (1947, 1949).

Hołubowicz, for example, had advocated the use of a square grid of standing sections on multi-layer sites, and he also suggested that the grid should be denser in the case of more complicated stratification. He claimed that all layers were equally important, regardless of their thickness or artefactual contents. He also stressed the method of three-dimensional recording of all the finds, a practice which had been applied by Józef Kostrzewski and Zdzisław Rajewski during the 1934 excavations of the famous Iron Age lake village at Biskupin.

Development of the 'Polish School'

All of these scholars mentioned above also agreed that the right way of excavating archaeological layers was to follow their real contours, and that excavation by the so-called 'mechanical levels' of pre-determined thickness was incorrect and highly unproductive. From the late 1950s, a growing awareness that stratigraphical decisions must be made by archaeologists during excavations resulted in the emergence of the 'Polish school of recording'. In comparison to the stylistic work presented in Jagmin's 1876 drawing, the

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efforts of this school can be described as hyper-realistic. The essence of this matter of recording was highly coloured multi-feature plans, without boundary lines for many of the stratigraphic layers in evidence, and the drawing and colouring of profiles in which the deposits were without interfacial lines. In practice, the emphasis on over-recording began to mean the avoidance of any decisions with respect to the understanding of the stratigraphic sequence of the site during excavation, leaving this vital task to be done later during the post-excavation stages.

In the 1960s, a large numer of archaeological sites were excavated intensively in connection with the millennial anniversary of the Polish state, making it necessary to employ inexperienced volunteers and field-workers to make progress in the digging. As a result, it became common practice to excavate stratigraphically complex sites by mechanical levels of equal thickness, which any worker could do, and to record the stratification by the hyper-realistic method. These methods were thought to be a guaranteed way of connecting the finds with the real layers, which would be distinguished by the post-excavation analysis of the section and plan records. In the second half of the 1970s, this unfortunate situation in archaeology in Poland began to change, and the rate of these changes accelerated in the 1980s.

Activity at Warsaw

A prominent role in initiating the process of change was played by scholars at Warsaw, particularly those at the Department of Methodology of Archaeological Research of the Institute of the History of Material Culture, a part of the Polish Academy of Sciences. This group of young archaeologists, led and inspired by Professor Stanisław Tabaczyński, was the first in Poland to learn of the ideas contained in the publications of Edward Harris. It was also the first Polish team to apply the ideas in field practice. Tabaczyński and his colleagues (Maetzke *et al.* 1978) were also the authors of the first proposal in Polish archaeology for the use of pre-printed sheets as the basic method of recording every single stratigraphic unit and its relationships with adjacent stratification.

The reception of Harris's concepts happened to coincide with the independent realization by Polish archaeologists of the inappropriateness of previous methods of exploring and recording multi-layer sites, which often contained non-horizontal stratification, as in the deposits of a rampart. It is perhaps significant that this dissatisfaction with excavation by mechanical levels related to very complex medieval sites, mostly of the early urban or stronghold setting.

The introduction and acceptance of Harris's ideas in Poland also gave way to a renewed interest in local traditions of stratigraphical studies, especially in the works by Hołubowicz and Żurowski of the late 1940s. For example, Przemysław Urbańczyk (1980, 1987; Bertelsen and Urbańczyk 1985) emphatically called attention to the quite forgotten 'stratigrapho-topographic' method proposed in 1947 by Żurowski, but never applied in practice. This method consisted of drawing contour lines in such a way as to make the drawing and retention of standing profile baulks unnecessary. As sources of stratigraphical inspiration, attempts were then made to join the Polish traditions with the Harris Matrix concepts. Some Polish scholars strongly advocated that this form of union would produce the ideal method of recording the units in archaeological stratification. The essential core of such an ideal system of documentation would therefore be a colour plan of each stratigraphic unit, drawn in a realistic manner, with the relief represented by contour lines (Urbańczyk 1987). It seems, however, that this method was never put into practice.

By contrast, it appears that the principles of archaeological stratigraphy found in Harris's works, as for example, the excavation of a site following the true, rather than arbitrary, morphology of layers, drawing of single-layer plans, and the use of the Harris Matrix for illustrating stratigraphic sequences, are becoming very common in Polish archaeology. Due to the participation of a new generation of students on excavations where the system is used, this method has a good chance of being dispersed even further. A crucial role in the dissemination of this approach was also played by the publication in 1989 of a Polish translation of Harris's *Principles of Archaeological Stratigraphy.*

Polish archaeologists abroad

Polish archaeologists have also played an important part in the exportation of the Harris Matrix to other countries. Thanks to the cooperation between the Institute of History of Material Culture at Warsaw, and universities at Salerno in southern Italy and Tromsø in northern Norway, it has been introduced as the main form of recording and presenting stratigraphic relationships on archaeological sites. The main difference between the Harris methods and those used by this group of Polish archaeologists lies in the still strong emphasis on the retention of standing baulks during excavation and in the use of colourful drawings in a realistic manner, but with interfacial or boundary lines marked.

The first Polish attempt to use the Harris methods abroad came through the work of Tabaczyński and his team with Italian archaeologists from Salerno University. The early medieval Longobardian castle at Civita di Ogliara and the medieval town of Capaccio Vecchia had been excavated by this Polish and Italian crew in the 1970s and in presenting the stratigraphy of these two sites, the Harris Matrix was used. The results of the 1974–80 fieldwork at Capaccio Vecchia were published in Italy (Caputaquis Medievale 1984). Here for the first time appeared examples of Harris matrices compiled by Polish archaeologists (Fig. 4.1), one by S. Tabaczyński for Orto della Mennola and another by A. Buko for the site at Sagrato.

The next published matrix again had international significance. It was a diagram (Fig. 4.2) compiled by Reidar Bertelsen and Urbańczyk (1985) for the medieval farm mound at Soløy in Arctic Norway. By contrast, the third published example – and the first to appear for a Polish site – was published by Urbańczyk in 1989. This diagram was for the early medieval (eleventh to fourteenth century) hillfort at Czersk, near Warsaw, and it contained 1211 units arranged into 14 phases.

Current fieldwork

Many more studies of a similar type are now in progress. Some are completed and ready for publication, as, for example, the diagrams for the medieval sites at Sandomierz. There the sequence for the courtyard at the site Castle I was compiled by Andrzej Buko. At

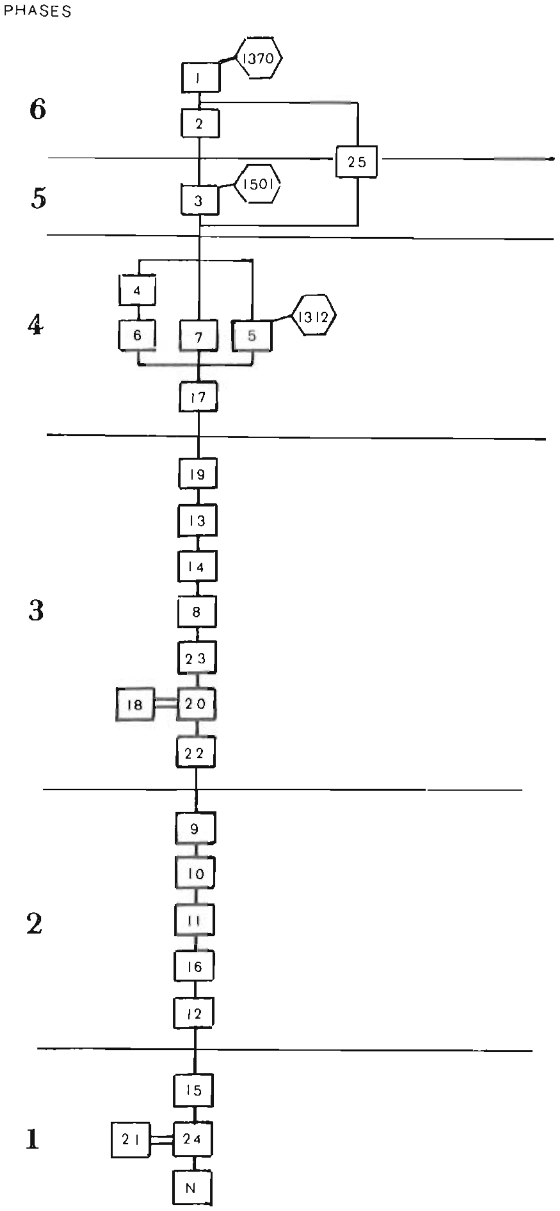

Fig. 4.1 Capaccio Vecchia, Italy, the site at Orto della Mennola, square CCC 19. Diagram of the stratigraphical relationships between the units, as compiled by Stanisław Tabaczyński.

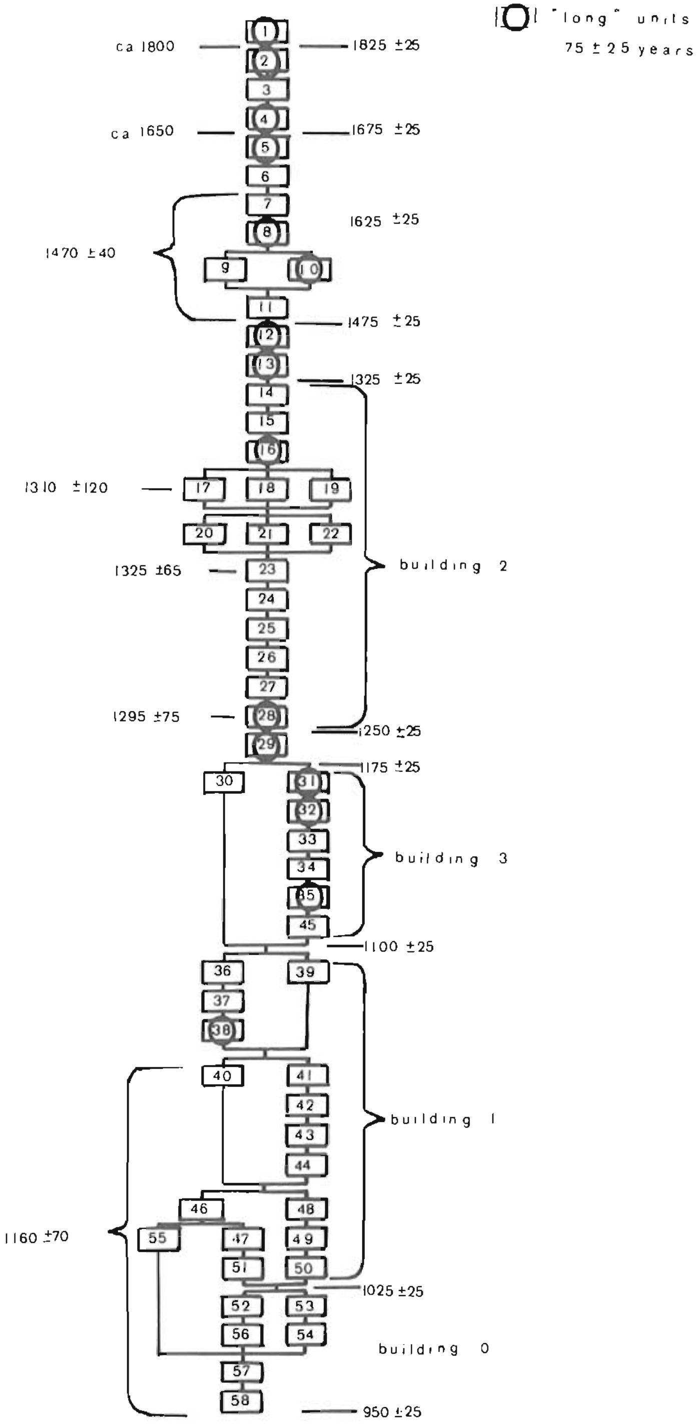

Fig. 4.2 Soløy, Norway, a diagram of (left) the stratigraphic matrix with radiocarbon and artefact datings and (right) suggested datings. Compiled by Reidar Bertelsen and Przemysław Urbańczyk.

Castle II, which comprised the outer slope of the defences including earthen and wooden construction, a diagram of over 300 units had been made by S. Tabaczyński. Another sequence is available for Collegium Gostomianum at Sandomierz, compiled by Malgorzata Gula, Henryk Rysiewski and Teresa Rysiewska. For the Isle of Murano in Venice, Italy, a sequence of around 200 units relating to the early medieval baptistery and cemetery was drawn up by Tadeusz Baranowski, Maria Elisabetta Gerhardinger and Jadwiga Rauhut. Again in Poland, the stratigraphic sequence for the early medieval village settlement at Wyszogrod has been compiled by the author.

Other examples are to be found on fieldwork in progress, both at home and abroad. Work by Bertelsen and Urbańczyk at Storvågan in northern Norway continues by using the new methods. In Poland, in Kalisz, the site of Zawodzie, an early medieval hillfort from the ninth to the fourteenth century, is being excavated by Baranowski, with work just started in 1989 by Rysiewska at Sandomierz on the site known as St Paul Hill II. At Haćki in eastern Poland, the author is recording a hillfort with occupational periods in the fifth to the fourth century B.C. and the sixth to the seventh and the eleventh to the twelfth century A.D. There are, however, very few sites, such as Storvågan in Norway (Bertelsen *et al.* 1987), or Wyszogrod in Poland, where the system proposed by Harris has already been used during the excavation. Many of the sites listed above were excavated in the early 1970s, before Harris's concepts existed (i.e. pre-1973) and before they were introduced in Polish archaeology after publication in the middle of that decade. In most cases, not only the stratigraphic sequences, but also the defining of the stratigraphic units, had to be created after the fact of excavation, based on the site records, e.g., the sites of Collegium Gostomianum or Czersk. In other instances, stratigraphic units were distinguished during the excavation, but in the process of making correlational diagrams for the whole site, these units had to be redefined and renumbered; here may be noted the sites of Capaccio Vecchia, Italy, Soløy, Norway and Haćki in Poland. This was sometimes due to the fact that the sites were excavated in two phases, namely, before and after the Harris methods were introduced to Polish archaeology.

The difficulties with the application of the Harris Matrix to the stratigraphic analysis of sites excavated and recorded in a completely different manner can be well illustrated by the example of the study by Gula, Rysiewski and Rysiewska on the stratigraphy of Collegium Gostomianum at Sandomierz, which was excavated from 1969–73. Thirty 5 × 5 m squares and three rectangular trenches, 5 × 10 m and 5 × 15 m, were cut into the site and revealed a complicated multi-layer and multi-phase sequence, beginning with a Neolithic settlement, an early medieval settlement of the eleventh and twelfth centuries, a cemetery spanning seven centuries into the 1800s and the remains of churches from the fourteenth to the nineteenth century. Interspersed with the layers were many structural features. During the excavation, only general chronological and functional units had been distinguished, but fortunately realistic coloured drawings were made routinely. Fifteen years after the excavations, these records allowed the archaeologists to define over 2000 stratigraphic units, but the process of constructing the Harris Matrix, or stratigraphic sequence, was quite different than that used during the course of an excavation. First, the phases had to be defined for the entire site. The scholars then tried to distinguish structures within the phases, and the stratigraphic units within the structures. A considerable problem arose with the location in the stratigraphic sequence diagrams of those units which were not connected with any structures. The experience at Collegium Gostomianum showed that although it can be a difficult and lengthy process, the reanalysis of older stratigraphic records is possible and often worthwhile. If the Polish experience could be taken as a lesson for the archaeology of other regions, it should be stressed that a Harris Matrix compiled after excavation from stratigraphic archives, no matter how detailed they may be, is hardly more than a potentially elegant drawing in a site report, if the process of excavation and recording did not follow the principles so clearly presented by Harris. One of the major problems in this regard is that if the units were not identified correctly during the excavation, it will often prove impossible to join such units (which may have been defined subsequently and thus appear in a matrix diagram) with the find assemblages from the diggings. In a way, this problem with stratigraphic archives is another form of the difficulties presented by attempting to join assemblages collected by mechanical levels with the true deposits in which they were located.

Improvements on the Harris Matrix

Archaeologists in Poland have not only applied the ready solutions proposed by Harris for stratigraphic analyses, but have tried to make some improvements on the original form of the Harris Matrix. Tabaczyński, for example has suggested that in correlating sequences for separate trenches on a site, three forms of correlation (and their respective graphic symbols) should be used. Under his notions, a triple line indicates that two or more units (with different numbers) are actually the same unit, such as a wall; a double line is used when two units are different, but both are parts of a single structural unit of higher level, e.g., they are two walls of the same building; and finally, a single line would connect units which are different morphological types, but which can be correlated on the basis of chronological or functional arguments.

Tabaczyński also suggested that symbols denoting structural units should be shaded in the matrix diagrams, to help in reading the sequence. These innovations are now used by many of his students and colleagues, primarily in Italy and at home in Poland. Elsewhere, in diagrams representing the stratigraphic sequences of medieval towns, another simple improvement has been employed in that the shape of the unit in the drawing is changed according to its function. Oval symbols thus distinguish graves from other deposits and features. Scholars working on these innovations also graphically show whole structural units, such as pits and fills, or crypts and graves, by different symbolic shapes. Urbańczyk has added the use of coloured symbols for different functional types of stratigraphic units in Norway and Poland.

All these useful improvements are, however, just slight alterations or perhaps more aptly, embellishments on the general idea of the diagrams, and they in no way affect the basic stratigraphic sequence of a site. As with many ideas which have evolved from the original matrix, they help the archaeologist to understand and analyse a site in more efficient, but also more expansive ways. Perhaps more important are attempts to show not only the temporal relationships of units in a sequence diagram, but also their physical and spatial relationships. Independent of Harris's ideas, such a diagram was created in 1975 by Rysiewski for the cemetery at Sandomierz (Fig. 4.3), with others by the author for the stratified fills of settlement features at Wyszogrod. From these experiences, it is clear that diagrams presenting all the temporal and geographical relationships between the units of a site can be constructed, but their usefulness is limited to sites with a small

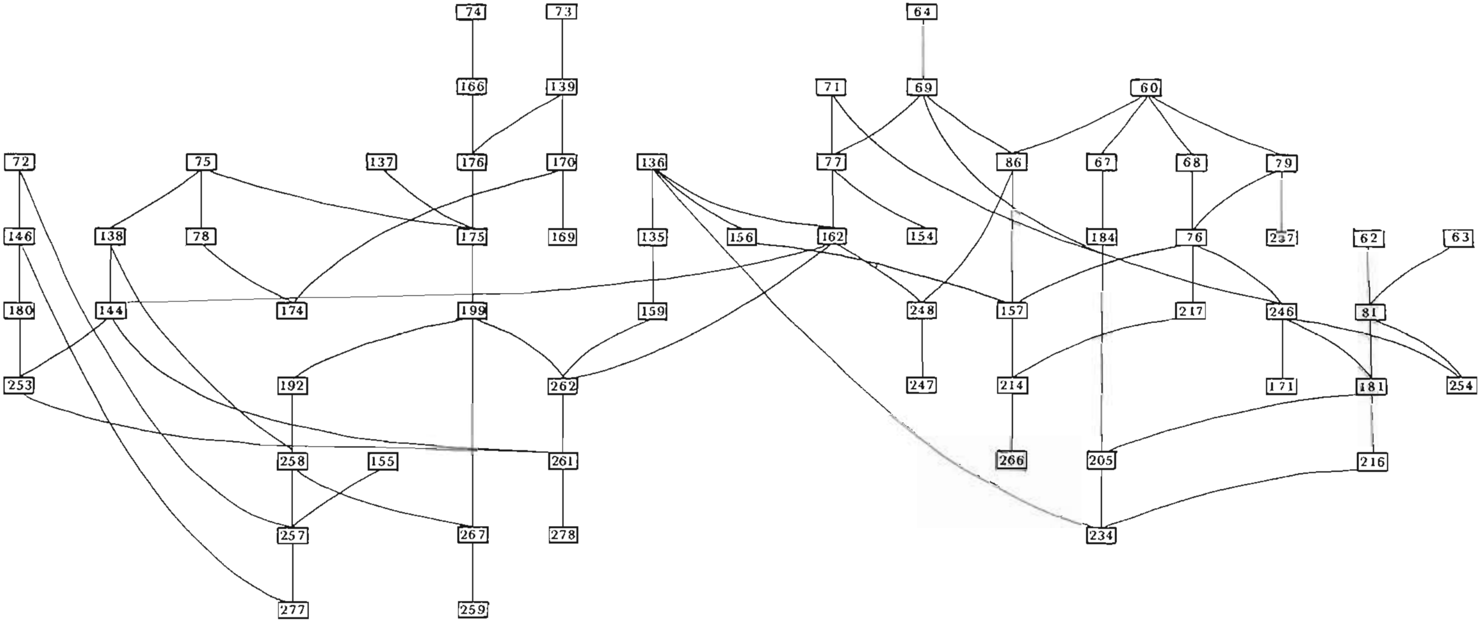

Fig. 4.3 Sandomierz, Poland, the site of Collegium Gostomianum, square N 16. A diagram presenting the relative chronology and spatial relationships of the graves, as compiled by Henryk Rysiewski.

number of deposits, for they become increasingly indecipherable as the number of stratigraphic units expands. The most serious stratigraphical difficulties usually appear when attempts are made to correlate separate sequences for different trenches on the same site. An interesting example of correlating procedures in the case of non-adjacent trenches has been published recently in connection with the stratigraphic analysis of Castle Hill at Czersk (Urbańczyk 1989). To identify and correlate the equivalent units from different trenches, Urbańczyk proposed three types of criteria: first, the similarity of morphological characteristics between the units was considered; secondly, the relative depths at which they occurred was examined; and finally, the repetition of various sequences of layers from trench to trench was analysed. Using these three criteria, it was then possible to correlate a given layer, or even a group of deposits, from one trench to the next.

Another important experiment was done in recording during the Polish/Norwegian excavations at Soløy in 1981 (Bertelsen and Urbańczyk 1985). To simulate the process and problems of correlating stratigraphic sequences from separated trenches, the single excavation area at Soløy was divided abstractly into small squares, each 1 m^2. The stratigraphic units were defined and recorded separately in each square (as if it was a separate trench), even though they might have appeared over the whole surface of the entire excavation area. In this way, the process of excavation and recording simulated work on a site with disparate trenches and the results could be used for modelling the procedures of correlation. Problems arose both on the excavation and in the correlation stage of this experiment (including a necessary renumbering of some units) and gives a further argument for excavating in one large area, instead of digging in smaller, isolated trenches. A similar problem with the correlation of seaparate sequences has been faced in excavations of an early medieval settlement of the sixth to the eighth century at Wyszogrod. Over 30 isolated, but internally stratified features were exposed, most of them probably being the remains of sunken houses. The most important question to be asked was on the relative chronology of neighbouring features of different functional types. In addition to morphological arguments, the artefacts found in the units of the different features were studied (including the laborious rejoining of pottery sherds) as a part of the correlation process. This allowed non-stratigraphic data and evidence to be included in the sequence drawing (Fig. 4.4), and in many instances increased the probability of a proper correlation of the separate features and units.

Conclusions

The time dimension of past events is given to the archaeologists in a form reduced to a spatial configuration of material remains, which resulted from those events and were thus deposited in a particular order. The stratigraphic sequence, which is deduced from the order of the material remains, determines the direction of time on a site, but it can say nothing about the length of intervals between the deposited units, nor about the passage of time which was necessary for their formation. A very interesting attempt in using the Harris Matrix as the basis for deducing absolute time, or chronology, of stratigraphic units has been published in connection with the excavations at Soløy (see Fig. 4.2). The authors (Bertelsen and Urbańczyk 1985) performed both morphological classification and an analysis of the pattern of the contents of the stratigraphic units and defined functional

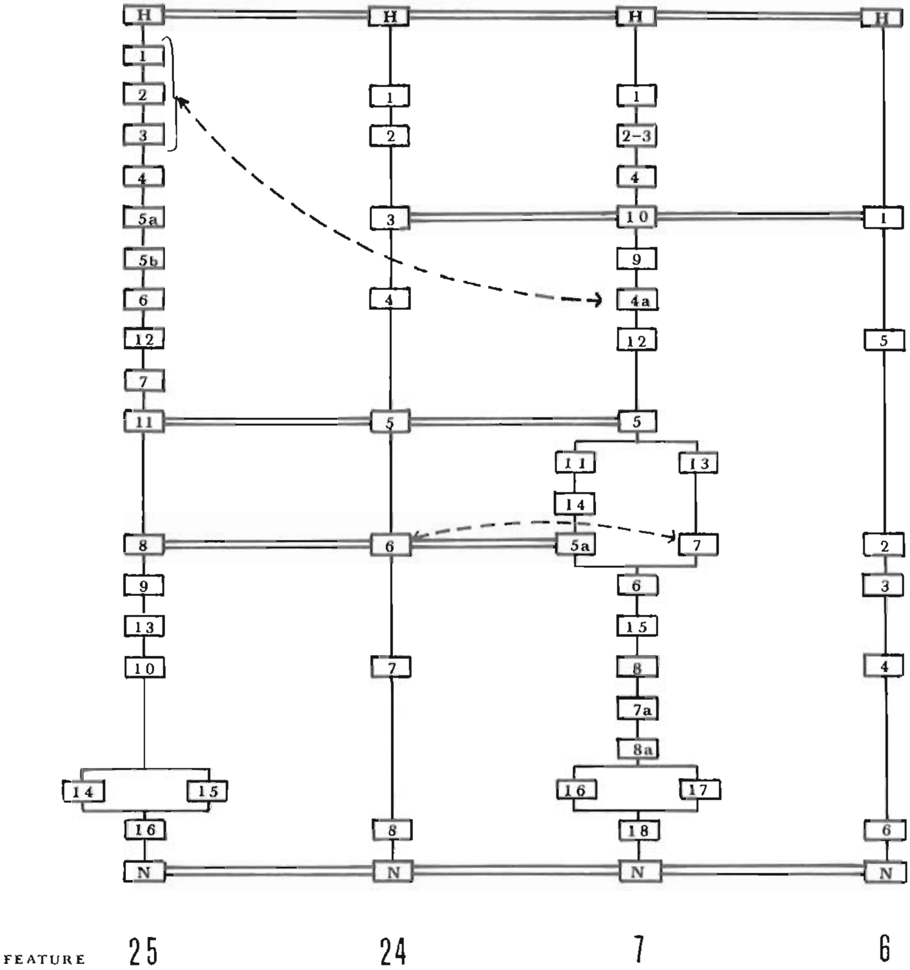

Fig. 4.4 Wyszogrod, Poland, site 2A. A diagram showing the correlation of the stratigraphic sequences of features 6, 7, 24 and 25. Joinable sherds of pottery are shown with broken lines.

types on this basis. They developed the notion of 'long' and 'short' units, ascribing to them, on the basis of historical and ethnographical data, the values of 75 (the average life expectancy of a turf house) and 0 years respectively. The suggested dates which resulted from this form of analysis were suprisingly consistent with radiocarbon dating for the site, which may confirm this method as a reasonable approach in certain areas.

The application of the Harris Matrix as the primary form of presentation and analysis of stratification in many of the above cases led to further developments of consequence for Polish archaeology. The search for joinable pieces of pottery from isolated features as a basis for the correlation of layers at Wyszogrod later resulted in an innovative study on the depositional and post-depositional determinants of the spatial distribution of pottery sherds. At Soløy, the attempt to add a chronological aspect to the compiled Harris Matrix resulted in an interesting multivariate statistical analysis of the various aspects of the stratigraphic units, leading to their functional definition. The introduction of Harris's ideas into Poland gave not only a strong impulse to revise the existing methods of excavating and recording, but served to remind Polish archaeologists of their own, somewhat forgotten, stratigraphic traditions. In addition, as an excellent analytical tool, the Harris Matrix has widened our horizons into new and often unexpected areas of research.

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5 The limits of arbitrary excavation

ADRIAN PRAETZELLIS

> The basic unit of archaeological information is the artefact (Chartkoff and Chartkoff 1984: 360).
>
> Using appropriate excavation tools, the archaeologist proceeds to isolate archaeological materials and clear away their encasing matrix (Sharer and Ashmore 1979: 210)
>
> He knew how to dig a hole and pluck artefacts from the ground like plums from a cake, and that was all that mattered (Noël Hume 1968: 12).
>
> If a single outstanding fact has become evident in our survey, it is the great value of stratigraphy (Kidder 1924: 351).

Introduction

Should archaeological field method continue to be an important topic of discussion among practitioners? Or is continuing debate simply a way of avoiding dealing with 'questions that count?'

In a keynote address, the distinguished archaeologist Charles Cleland came down on the side of the latter conclusion, stating that '... archaeology has mastered this level of methodology and dwells upon it' (Cleland 1988: 15). Yet a perusal of archaeological site reports from North America suggests that one of the few techniques endorsed in most modern field manuals – excavation by physical strata – is not practised as widely as one might expect.

In an example from the American South, a colleague directing the investigation of a physically stratified site complains that it is impossible to convince a certain eminent archaeologist, the director of a field school that is 'helping' on the site, to excavate according to the layers in the ground; the professor insists that his students dig in arbitrary levels, believing that the artefacts are 'the thing'. In the Far West, an historic period archaeological site is investigated by means of several 1 × 1 m units; although the resulting artefacts are analysed with great technical skill, the behavioural and chronological interpretations are meaningless since this physically stratified site was dug in arbitrary levels.

From Thomas Jefferson on, American archaeologists have recognized that the layers of soil that make up their sites have interpretive significance. Yet, while some influential nineteenth and early twentieth-century field workers were vigorous stratigraphers, many

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who came later were more concerned with artefacts than with site structure as the key to interpretation. Although some American archaeologists (e.g. Lyon 1975) have enthusiastically condemned the thoughtless use of what is known in the Americas as 'arbitrary' or 'metrical' excavation and in Britain as the 'planum' technique (Barker 1982), British-trained excavators have been the most critical (Wheeler 1954; Harris 1979, 1989).[1] In response, American archaeologists have insisted that the British just did not understand (Ford 1962; Thompson 1955).

Is there a middle ground of understanding, if not agreement, between the do-or-die stratigraphers and the archaeologists trying to decipher unstratified sites that insist on having multiple cultural components? How did the arbitrary excavation technique become so popular in the first place, and how has it managed to cling on so tenaciously in situations both appropriate and inappropriate? These are the questions that this chapter will address.

Terms and terminology

It has been said that the British and the Americans are two peoples separated by a common language.[2] This is certainly true in the case of some archaeological terms where the same words have different meanings on either side of the Atlantic. This situation has contributed to misunderstandings in the trans-Atlantic debate which the following paragraphs will attempt to clear up.

Stratigraphy and stratification

In North America, 'it is possible to have stratigraphy without stratification and vice versa' (Phillips *et al.* 1951: 241); to the British archaeologist, this sounds like an oxymoron. The term 'stratification', as used in North America, is, in part, equivalent to the 'layer' or 'stratum' in the vocabulary of Europeans. It refers to the separate and distinct zones of soil or other material that constitute the physical structure of an archaeological site. In addition, however, it may be used to refer to the horizontal slices of arbitrary thickness that some employ in excavation. The term 'metrical stratigraphy' is applied to sites excavated in arbitrary ('metrical') units. Thus, even sites that have no discernible layers and that were excavated in arbitrary levels are sometimes described in the scholarly

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[1] A portion of this criticism has been based on a 'poor relation' attitude on the part of some British archaeologists to North American archaeology in general. Of the 'New Archaeology' movement, for example, Glyn Daniel wrote that it

> stems, of course, from the bareness of the pre-Columbian record of archaeology: for centuries nothing happened of general interest ... no Stonehenge, no Maltese temples. American archaeologists, dismayed by their archaeological record, have sought refuge in theory and methodology ... no steps were taken to the establishment of a higher culture of civilization in North America and there were no incentives to persuade students of North American archaeology that they were dealing with events in the mainstream of history. In the Old World this was very different (1975: 371–2).

[2] This remark is attributed to George Bernard Shaw, who also wrote 'How can what an Englishman believes be heresy? It is a contradiction in terms' (*Saint Joan*, Scene ii).

literature as having been subject to stratigraphic excavation. When Haag (1986: 68), for example, wrote that the 'concern with careful stratigraphic excavation was to enhance our chronology' he was referring to stratigraphy of the metrical variety. A belief in the interpretive significance of these horizontal units of excavation have made it possible for archaeologists from Nels Nelson (1916) onward to use the principle of superposition, together with techniques such as seriation, to establish relative chronology even on metrically-excavated sites.

While archaeologists world-wide would agree that 'stratification' is a descriptive term that refers to the units by which archaeologists impose order on their sites during the process of excavation, the analytical correlate, 'stratigraphy', is used differently. Edward Harris (1989: 155) has written that stratigraphy 'is concerned with the sequential and chronological relationships of strata and feature interfaces, with the topographical shape, soil composition, artefactual and other types of contained remains, and with the interpretation of the origins of such stratigraphic features'. If stratification is what one finds in the ground, then stratigraphy is how one interprets it. No problem so far.

However, in North America, when site content and stratification – metrical or otherwise – are interpreted as reflecting the presence of successive cultural groups or separate phases of occupation, the term 'cultural stratigraphy' is sometimes applied (Hole and Heizer 1969: 103; Moratto 1984: 124, 388). Thus, in Willey and Sabloff's *History of American Archaeology* (1975), for example, a 'stratified site' may either (1) be physically layered, (2) have been excavated in arbitrary levels, or (3) contain the superimposed remains of several occupations.

In this context, the notion of cultural stratigraphy naturally led to a concept of 'horizontal stratigraphy' whereby, in the absence of superpositional relationships, phases of occupation on a site are placed relative to each other in time on the basis of their content. The idea of horizontal stratigraphy took a particularly firm hold in the spacious American West where archaeological sites are often shallow and extensive. Here, successive peoples who took up residence in the same general spot would often re-occupy only part of the previous site or set up camp nearby. In the Great Basin of Nevada and Utah, for example, native peoples who followed the receding pluvial lakes created series of chronologically 'stratified' sites down the sides of Great Basin valleys. Horizontal stratigraphy, according to Harris (1989: 128), is a misnomer since it is not based on superposition but on the analysis of artefacts.

North American archaeologists base their claim to a liberal use of 'stratify' and its variations on American English usage which includes 'to divide into a series of graded statuses' (*Webster's Dictionary*). Conversely, British English usage conforms more to a strict, superpositional interpretation (*Oxford English Dictionary*). Thus, part of the vehemence with which Europeans have attacked their colleagues in the New World is an issue of simple word use rather than of epistemology.

The stratigraphers care so much about what they believe to be the inappropriate use of the concept because the Principle of Superposition is such a powerful interpretive tool. As others have pointed out, in theory, there are no exceptions to Superposition as gravity ensures that a lower unit must have already been deposited before an upper could have settled on it. The use of the term in situations that do not involve an immediate or derived superpositional relationship is seen as a rhetorical 'appeal to authority', whereby archaeologists make use of the coat-tails of the concept of Superposition to validate entirely separate analyses.

Archaeological deposits as non-historical phenomena

North American archaeologists have traditionally viewed archaeological stratification as historical phenomena. John Rowe, for example, has written that 'the observation of superposition has virtually no archaeological significance unless the cultural contents of the deposition units are contrasted'. Here Rowe writes as one concerned with the 'effectiveness of stratigraphic analysis as a way of establishing cultural sequences' (Rowe 1961: 325). The important thing to note here is that the concern is less with reconstructing the historical events that occurred on a site than with working out the site's place in a regional cultural sequence.

In contrast, the British-trained practitioners who have been most critical of arbitrary excavation are 'historical archaeologists', in the sense that they work in a general context in which the cultural sequence is known through the documentary record. Here, the archaeologists' principal task is said to be the 'identification and correlation of the strata which represent the successive phases in the archaeological "history" of a site' (Wheeler 1954: 43). For this reason, British-trained field workers from Wheeler and Kenyon on have emphasized the interpretation of individual site structure, in addition to content. The latest contribution in this tradition is the work of Harris (1989). Harris contends that although every site is historically unique, archaeological site structure itself is repetitive and non-historical, and is, therefore, subject to formal analysis in the total absence of data from either artefacts or historical documents. In Harris's scheme, the evidence of artefacts is used later in the analysis to convert a non-historical statement about a site – what Harris calls the stratigraphic sequence – into a historical statement by dividing it into phases and periods. One objection to terms such as 'cultural stratigraphy' is that they blur the distinction between the non-historical and historical – the observational and interpretive – aspects of stratigraphy.

Of layers and levels

'Layer', 'natural level', 'cultural level/layer', 'arbitrary level/layer', 'stratigraphic level/layer'. The terms used to describe units of excavation – defined either arbitrarily by the excavator or self-defined as physically discernible strata – are legion and have different meanings on either side of the Atlantic.

The terms 'level' and 'layer' are largely synonymous in North American archaeology. They are applied to the 'demarcation of associated remains by natural (geological), cultural (for example, buildings), or arbitrary events (excavation techniques)' (Hole and Heizer 1969: 103). In Britain, where the best contemporary field manual (Barker 1982) spends no more than two sentences on arbitrary excavation and the term 'level' has evolutionary implications, 'layer' refers to both human-made and geologically derived units of stratification.

In North America, Mortimer Wheeler and Kathleen Kenyon would be thought of as enthusiasts for digging in 'natural levels'. The units are considered 'natural' because they exist as units of stratification in the ground. To Harris, however, a 'natural layer' is one 'formed by geological processes' (1989: 158). This definition is derived from the British archaeological colloquialism 'the natural', which for many years has been applied to the undisturbed soils that underlie archaeological deposits. In the New World, 'natural levels' are contrasted with arbitrary or metrical levels, which are of standard dimensions decided by the excavator.

If a natural level may, in fact, be created by humans, then what might a 'cultural level' be? Not surprisingly, the usage is variable; but the term is basically parallel to 'phase of occupation' (Hole and Heizer 1969: 103). Thus, when Michael Moratto wrote that a site contained 'no fewer than nine cultural and natural levels' (1984: 99), he was referring to the stratigraphy and stratification, respectively. The oft-used phrase 'stratigraphic level [or layer]' is a simple redundancy; it implies neither an arbitrary nor a self-defined unit.

Methods and goals in North American archaeology

According to Willey and Sabloff the causes behind the differences between American field methods and those of Europe are 'uncertain and open to speculation' (1975: 98). However, the resolution of this mystery seems all too clear in the light of the relationship between goals and field methods in the history of American archaeology.

Site structure in the arid west: a constraint on method

It is appropriate that this paper should emerge from California for, if Wheeler and Harris are right, there is precious little hope for American prehistory and almost none for that of the arid western United States where most sites are not physically stratified. Further, Wheeler's reproof of 'the old outworn system, with its mechanical "unit/levels"' (1954: 53) was directed specifically at a field manual edited by Robert Heizer of the University of California at Berkeley (Heizer 1950). There is no doubt that Wheeler had arbitrary excavation in mind when he wrote that 'there is no method proper to the excavation of a British site which is not applicable – nay, must be applied – to a site in Africa or Asia' (1954: 22); but was he right with respect to North America, where he had never worked?

Heizer (1958: 44) noted that most Central California prehistoric sites consist of 'soft, homogeneous and unstratified dark midden deposit of indefinite depth, often overlaid by a shallow layer of sterile topsoil and underlain by sterile subsoil which is usually gray, yellow, or red clay'. The processes of construction, demolition and filling, which contribute so much material to archaeological deposits of technologically advanced societies in Europe and Asia, are minor components of many sites in the western United States. Here, layering tends to represent natural processes rather than cultural ones: in depositional soil regimes, soil may be brought onto the site by alluvial, aeolian or other natural forces. A cave roof may shed material over many years, burying artefacts and features as the site 'grows'. Complex stratification may develop as streams change their courses, sand blows in from the beach, colluvial and rodent action churns the upper horizons, and alluvium creeps down from the hills. Conversely, in an area of residual soil, sites commonly 'deflate' as wind action removes the matrix, leaving only artefacts that may sit on low pedestals of middenized soil.

In short, while deep, physically complex sites with a plethora of structural remains exist in the American Southwest, most western archaeological sites would not have aroused much interest on the part of Wheeler if he had seen them.

Stratigraphy, seriation and classification

In the late nineteenth century, students of North American native cultures were overwhelmed by the diversity and quantity of the objects of their study. Traditional Native American ways of life were apparently coming to an end all over the continent, and scholars and antiquarians alike scrambled to record old-time practices and beliefs. Like their colleagues, the ethnographers, archaeologists concerned themselves with collecting the remains left by an untold number of peoples from the past. In the early twentieth century, collecting and describing artefacts gave way to classifying materials with the goal of placing archaeologically defined cultures in time. The tightly woven method of this 'classificatory-historical approach' (Willey and Sabloff 1975) involved stratigraphy, seriation and classification. Its goals influence archaeological field methods to the present day.

Early stratigraphic excavations, metrical and otherwise

Richard Wetherill's cave excavations in Grand Gulch, Utah by physical layers in the mid 1890s was among the earliest stratigraphic digging in North America (Rowe 1955; Wetherill 1893–94). However, Max Uhle's 1902–03 excavation of a shellmound on the San Francisco Bay shoreline was the first such work to attempt to decipher the natural agents that created the layers themselves, thus recognizing the site itself as more than a simple repository of artefacts: Uhle recognized numerous strata that were 'probably formed of alluvial deposits of the creeks' (1907: 12). These he lumped into seven prominent layers (Fig. 5.1). Most significantly, his analysis of the artefact types proceeded according to these layers on the principle that 'if we attribute to the shellmound an age representing many centuries, cultural differences should be indicated in the successive strata' (Uhle 1907: 36).

According to Wheeler (1954: 53) the method of arbitrary excavation was first used in 1865 by W. Pengelly in southern England. In what may be the first modern manual of archaeological excavation, J.P. Droop of Cambridge University recommended the judicious use of arbitrary divisions (Droop 1915: 11–12). Significantly, Droop's field experience was exclusively in the Near East where this method had been used for some years. Droop's comments on the importance of stratigraphic excavation are some of the most sophisticated in print at this time:

> But because where strata do not exist digging is easy, and because where strata do exist digging is most difficult and the results of digging most fruitful in knowledge, I believe that to be able to dig a stratified site well is to have attained to the highest and most remunerative skill in this particular work; therefore I make no apology for laying stress on the importance of stratification; its presence should always be assumed until the worst is known. . . . (Droop 1915: ix).

Arbitrary excavation was probably introduced into the New World by Nels Nelson, who worked with Alfred Kroeber and Uhle at the University of California at Berkeley. It is believed that Nelson saw the method used in the excavation of Castillo Cave during a visit to Spain in 1913 (Nelson 1915: 237, 1937: 2). At the Pueblo San Cristobal, in New Mexico, Nelson believed that he had discovered a suitable location to apply the method:

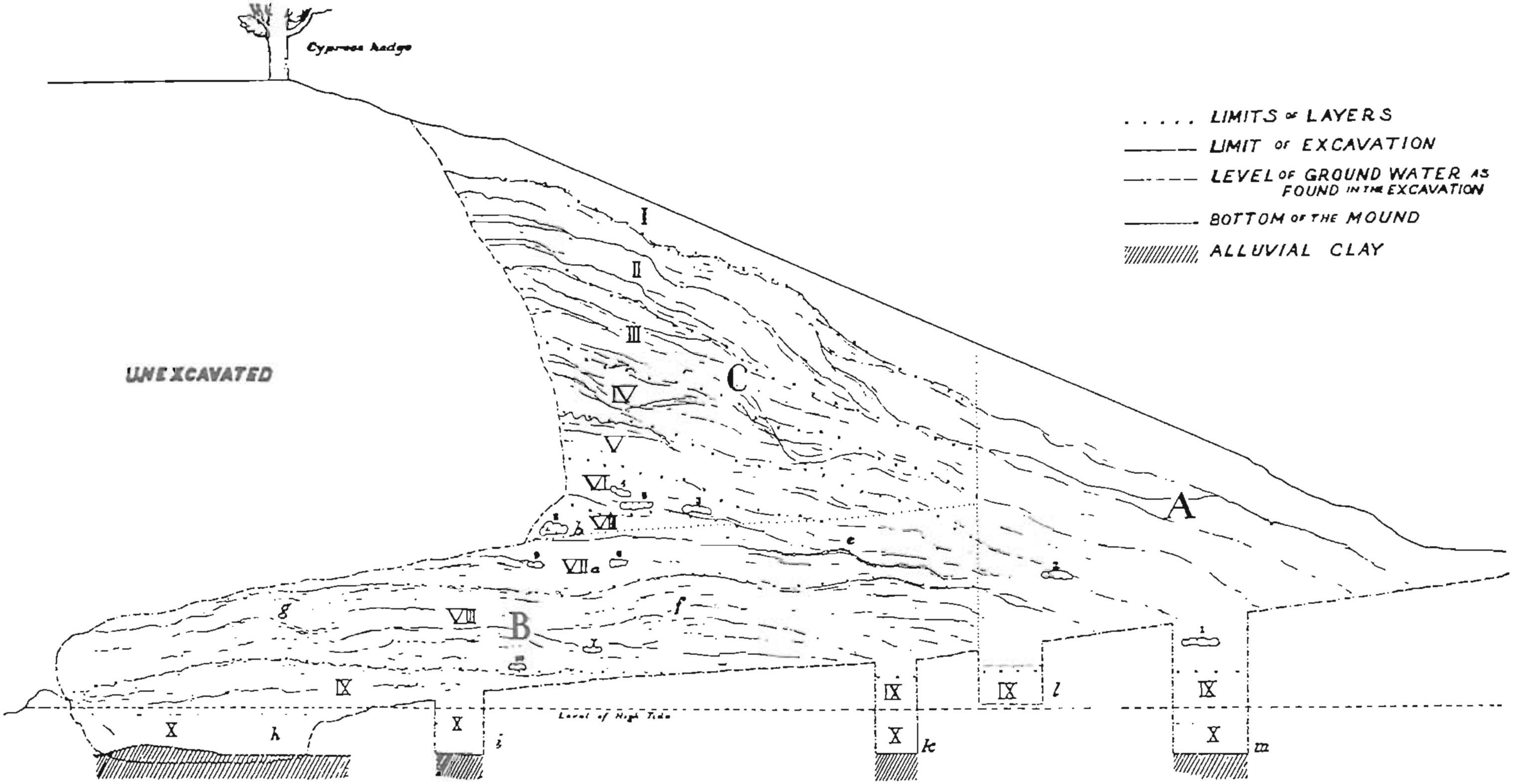

Fig. 5.1 This cross-section drawing of the Emeryville shellmound, made by Max Uhle in 1902 or 1903, is one of the earliest depictions of archaeological stratification in North America. Uhle recognized that although the layering – labelled I to X – was the result of alluviation, it was important for the interpretation of artefacts from his site. (Illustration from Uhle 1907.)

the site was deep and its physical layers were thin and horizontal, and consequently would fit nicely into 12-inch levels (Nelson 1916).

But why, with Uhle's example behind him and the opportunity in front of him, did Nelson choose the arbitrary method? In his previous work, at the Ellis Landing site on San Francisco Bay, Nelson claimed that he chose the method because his site contained 'no well-defined statra'; however, his section drawing of the site contradicts this assertion (Nelson 1910: 374, plate 49). It may be that Nelson's visit to Castillo Cave, whose stratification was text book-like in its definition, convinced him that less perfect layering was interpretively insignificant (Nelson 1915: 237; Osborn 1916: fig. 79). From Nelson, arbitrary excavation passed to Kroeber, who referred to it as the 'European model' (Rowe 1962) and taught it to his students at Berkeley, including Waldo Wedel. In one of the earliest examples of the use of the method in California, Wedel employed 12-inch thick arbitrary levels in his 1933 investigation at Buena Vista Lake; Wedel also screened the matrix through $\frac{1}{4}$-inch mesh to recover small artefacts (Wedel 1941: 20).

With the innovative work of Uhle doomed to be forgotten, the constraints of working with physically unstratified deposits meant that the development of the method of stratigraphic excavation was left to another archaeologist working in the Southwest: In 1916, the same year that Nelson published the results of his metrical excavations at various physically stratified sites in New Mexico, Alfred Kidder was in his second field season at Pecos. Here, Kidder was assisted by Carl Guthe, whom he credited with reconstructing the history of the site, from construction through abandonment, by 'very careful observation of the stratified fillings.... The methods developed by Dr Guthe ... form a distinct addition to archaeological field technique' (Kidder 1924: 103). Kidder's cross-section through the Pecos site (Fig. 5.2) shows carefully interpreted stratigraphic relationships

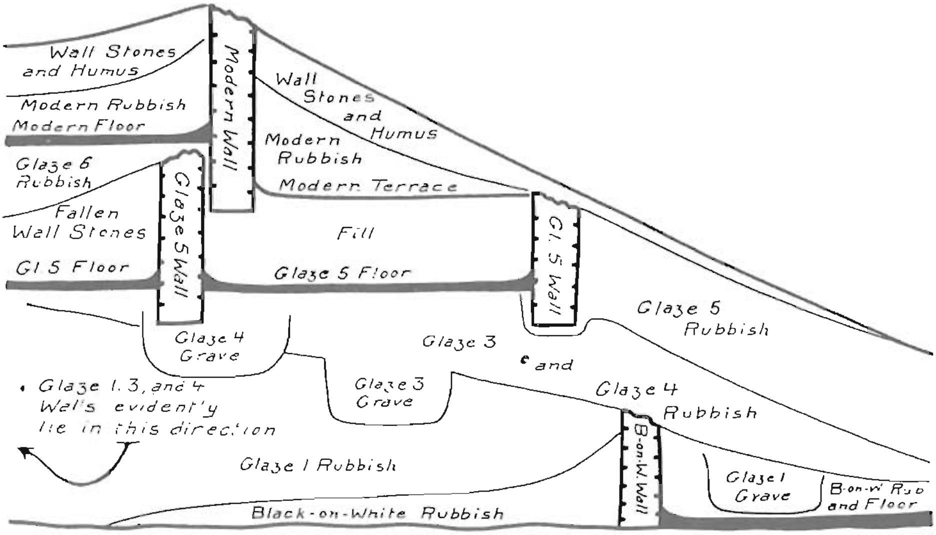

Fig. 5.2 Alfred Kidder, who is often cited as the 'father' of stratigraphic excavation in North America, drew this cross-section through part of the Pecos site, in New Mexico, which he excavated between 1916 and 1920. Unlike many of his contemporaries, Kidder dug exclusively in 'natural levels'. (Illustration from Kidder's *Introduction to the Study of Southwestern Archaeology*, Copyright © 1924 [1962] Yale University Press. Used by permission.)

between three construction phases and their associated occupation, refuse disposal and demolition layers (Kidder 1924: fig. 8). This concern with the historical interpretation of individual layers emerged from the influence of Near Eastern archaeologist G.A. Reisner, from whom Kidder had taken a field methods class at Harvard in 1911–12. According to Kidder's account (Rowe 1955), it appears that Reisner's treatment of stratigraphic excavation was significantly more sophisticated than that expressed in Flinders Petrie's much lauded publication *Methods and Aims in Archaeology* (Petrie 1904).

Kidder was a stratigraphic excavator in the Wheeler–Kenyon sense and was the first to use the method on a large scale in the Americas. However, although Kidder's excavation methods were different from Nelson's, his goals were the same: to establish a sequence of ceramic types, based on their stylistic similarities and differences, that reflected the area's cultural history. Thus, we arrive at the second technique in these archaeologists' tool kit: seriation.

Seriation

In an era before artefacts could be physically tested for their absolute age, similiary and frequency seriation were the principal tools for relative dating. They are still important methods of analysis. Seriation was developed by Flinders Petrie for the analysis of excavated Egyptian ceramics, and apparently brought to North America by Max Uhle who introduced it to Alfred Kroeber (Rowe 1954). With Kroeber's (1916) study of 'Zuni Potsherds' seriation was off and running as an important tool. The earliest combination of seriation and metrical excavation can be found in Nelson's Southwestern studies (e.g. Nelson 1916) which prefaced the work of a generation of archaeologists for whom the techniques were the key to establishing relative chronology.

A leader in the type frequency seriation approach was James Ford, who described what he did as the creation of 'percentage stratigraphy' (1962: 5). Ford's technique was to tally the percentage occurrence of types within an artefact class for various proveniences within one site – for example, A, B and C wares within ceramics from levels 1, 2 and 3 from the X Pueblo – on a bar graph. The paper would then be cut into strips, each representing a different type, and moved around until battleship shaped patterns emerged. The relationship between these patterns was taken as representing the sequence of popularity of the wares. Once individual sites had been seriated, the method could be extended to establish relationships between sites.

Type frequency seriation and the excavation of physically stratified remains using arbitrary units are closely allied methods. If one's goal is the creation of a frequency-based seriation of artefacts that will reflect long-term, gross-level changes that can then be fitted into a regional scheme, it makes little sense from a cost-effectiveness standpoint to excavate each layer separately. Artefacts will be sorted by class and type in the lab regardless of their exact stratigraphic provenience. It appears that the only advantage that Ford saw in stratigraphically controlled excavation – in the metrical or any other sense – was that, in its absence, it is impossible to tell 'which end is up' on the series of battleship curves (Ford 1962: 44).

In short, the type frequency method is not dependent on stratigraphic excavation – in the Wheeler–Kenyon sense – as the reconstruction of site history is largely irrelevant for interpreting the data. In fact, Ford felt that stratigraphic excavation allows the tail to wag the dog, and is 'an archaeological variety of cataclysmic geology' (1962: 45). It is absurd, according to Ford, to allow one's analysis to be dictated by the layers that make up an archaeological site since they are created by 'chance historical events'. This comment further serves to emphasize that Ford was not interested in the history of events at individual sites, only in the place of sites in a regional model of chronology. Thus, he could justify arbitrary excavation because 'the chance that a neighboring site, occupied for the same span of time, was subjected to the same sequence of events seems remote' (Ford 1962: 45). To Ford and his followers, the significance of the layers in the ground only becomes evident after material excavated using arbitrary levels is graphed out and examined in relation to the layers. Once again, this makes sense to the degree that the archaeologist's goal is developing data for a specific form of intersite comparison.

Strong and Corbett's work at Pachacamac, Peru, demonstrates that it is quite possible, as Ford suggested, to develop a convincing artefact sequence from material dug in arbitrary units on a physically stratified site (Strong and Corbett 1943). Here, part of a heavily stratified site was divided into standard sized units and dug in arbitrary, horizontal levels (Fig. 5.3A, B). Although many units took in material from more than one layer, the actual sequence of deposition is indeed reflected in the resulting distribution of ceramic types because the layers were more or less horizontal (Fig. 5.3C). While Strong and Corbett destroyed much stratigraphic data that could be used to reconstruct the site's own history, their technique was undeniably appropriate in relation to their broad goals and frequency-based method of analysis. William Duncan Strong (Fig. 5.4) was a student of Kroeber during the 1920s, putting him in the direct line of communication about arbitrary methods: Nelson to Kroeber to Strong.

While some archaeologists may be guilty of seeking to answer all questions with the trowel, it may be that one reason for the popularity of type frequency seriation is that it can be done in the comfort of one's lab after the field work is over. Field notes may be lost, unintelligible, or suggest poorly controlled excavation, but archaeological artefacts usually survive with sufficient provenience information for type frequency analysis.

New life for the 'old outworn system of unit/levels'

By the late 1950s, years of painstaking typology, seriation and the newly introduced method of ^{14}C dating paid off in a basic chronological outline for the prehistory of the Americas (Willey and Phillips 1958). With this achievement behind them some archaeologists felt that either their goals had to change or they would have to content themselves with filling in local chronological blanks.

The New Archaeology movement, which emerged at this time, injected a sense of place into archaeological field work as more researchers began to feel it legitimate to study the activities and events that lead to the creation of individual sites (e.g. Schiffer 1972). On the negative side was a tendency to let statistical 'tests of significance' upstage professional judgement – derisively labelled 'intuition' – in matters of interpretation. In North America, the New Archaeology made minor changes to the way in which sites were dug: excavation units and arbitrary levels were now measured in the metric system. Screening the soil became *de rigeur*. In short, a new orthodoxy was established that continues to denote the way in which prehistoric sites are investigated. The 10 cm arbitrary level and the 1 × 1 m excavation unit dug to sterile (or 'natural') soil has been the 'industry standard' in North

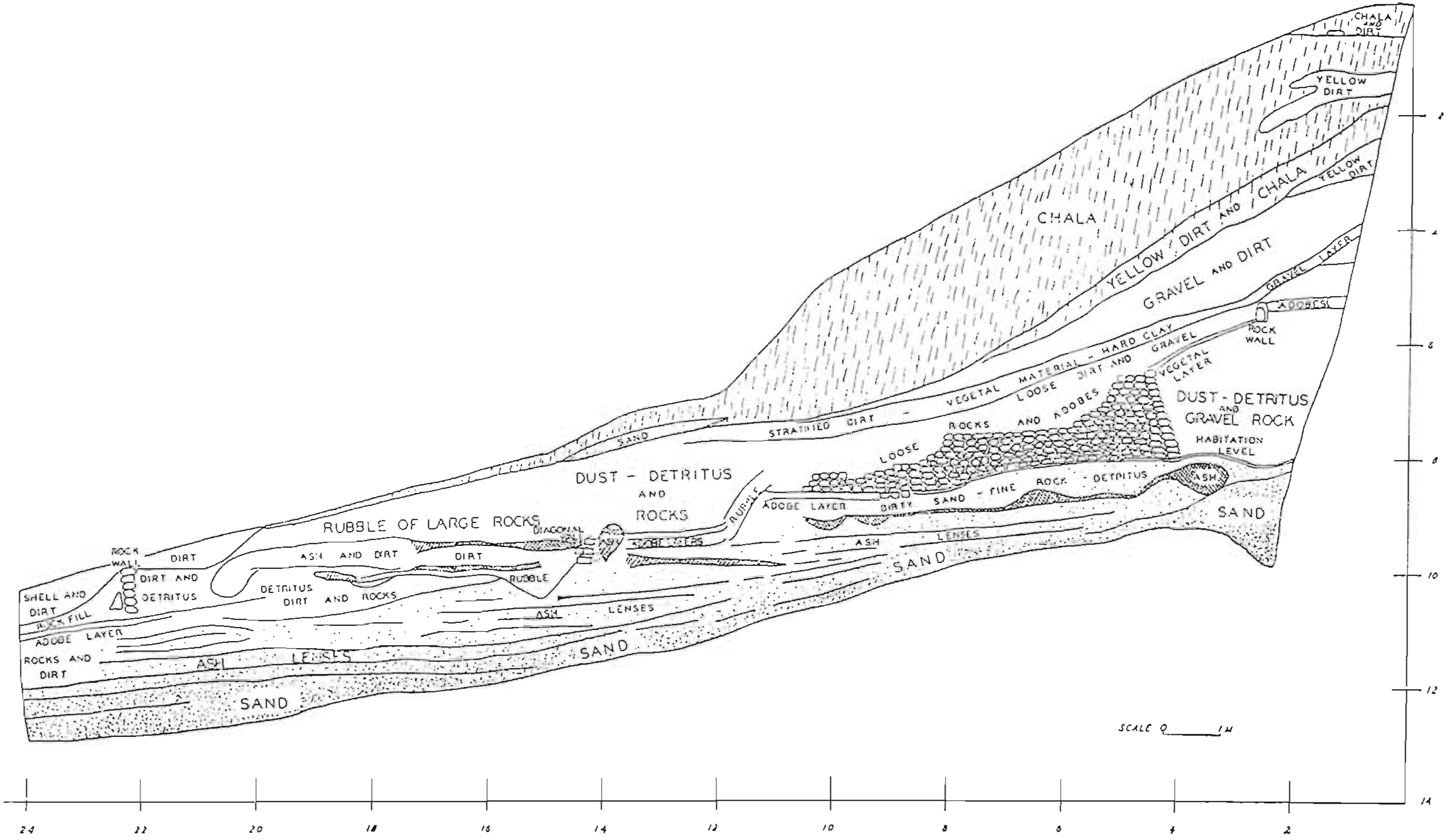

Fig. 5.3 These cross-sections depict (A) the physical structure, (B) placement of arbitrary excavation units and (C) occurrence of ceramic types in Strong and Corbett's 1941–42 investigation of the Pachacamac site, Peru. Although one can argue with their methods, these excavators were admirably explicit about their goals and the rationale for their approach to field work. (Illustration from Strong and Corbett, *Ceramic Sequence at Pachacamac*, Copyright © 1943 Columbia University Press. Used by permission.)

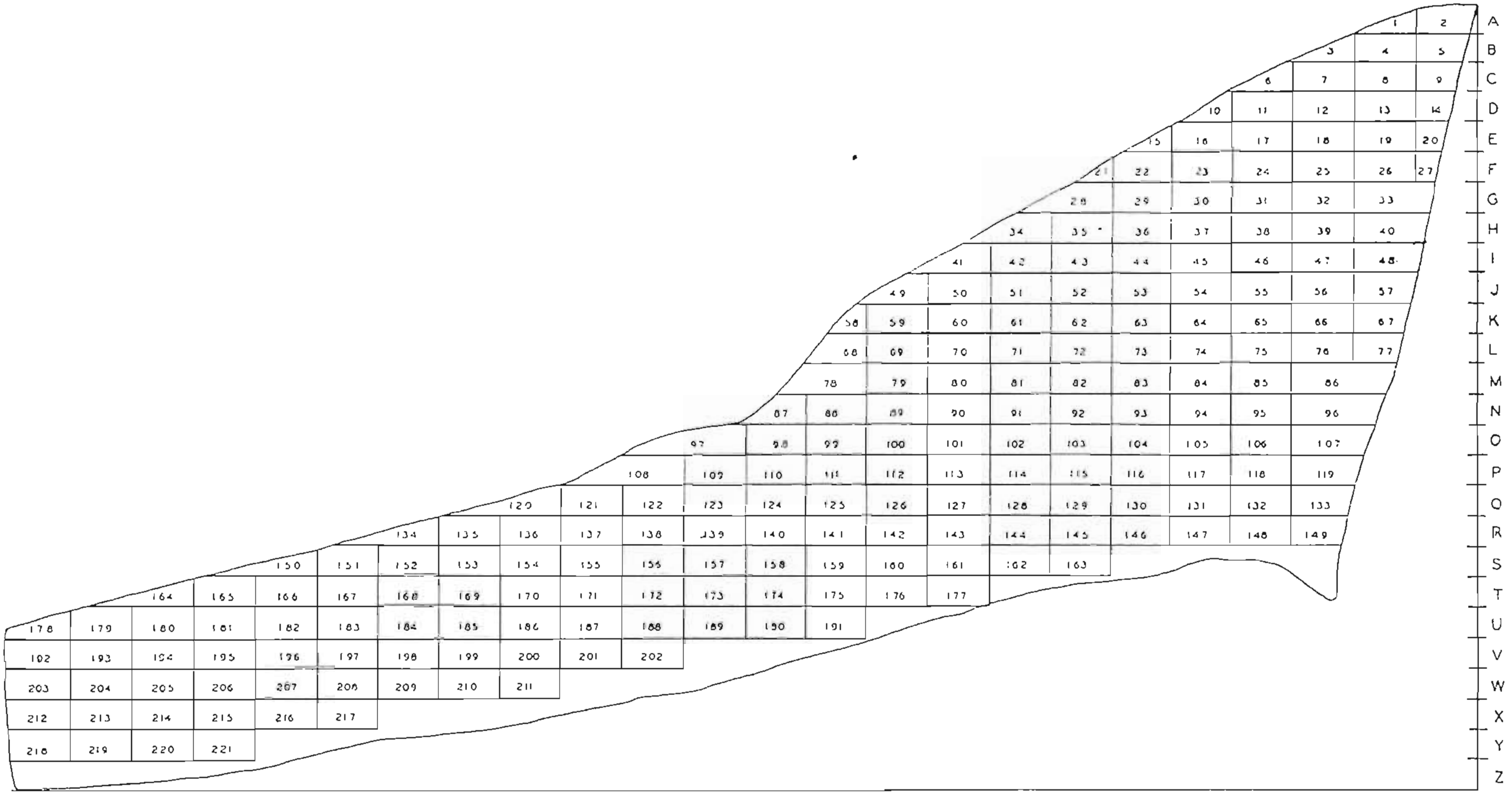
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Fig. 5.3 (B).

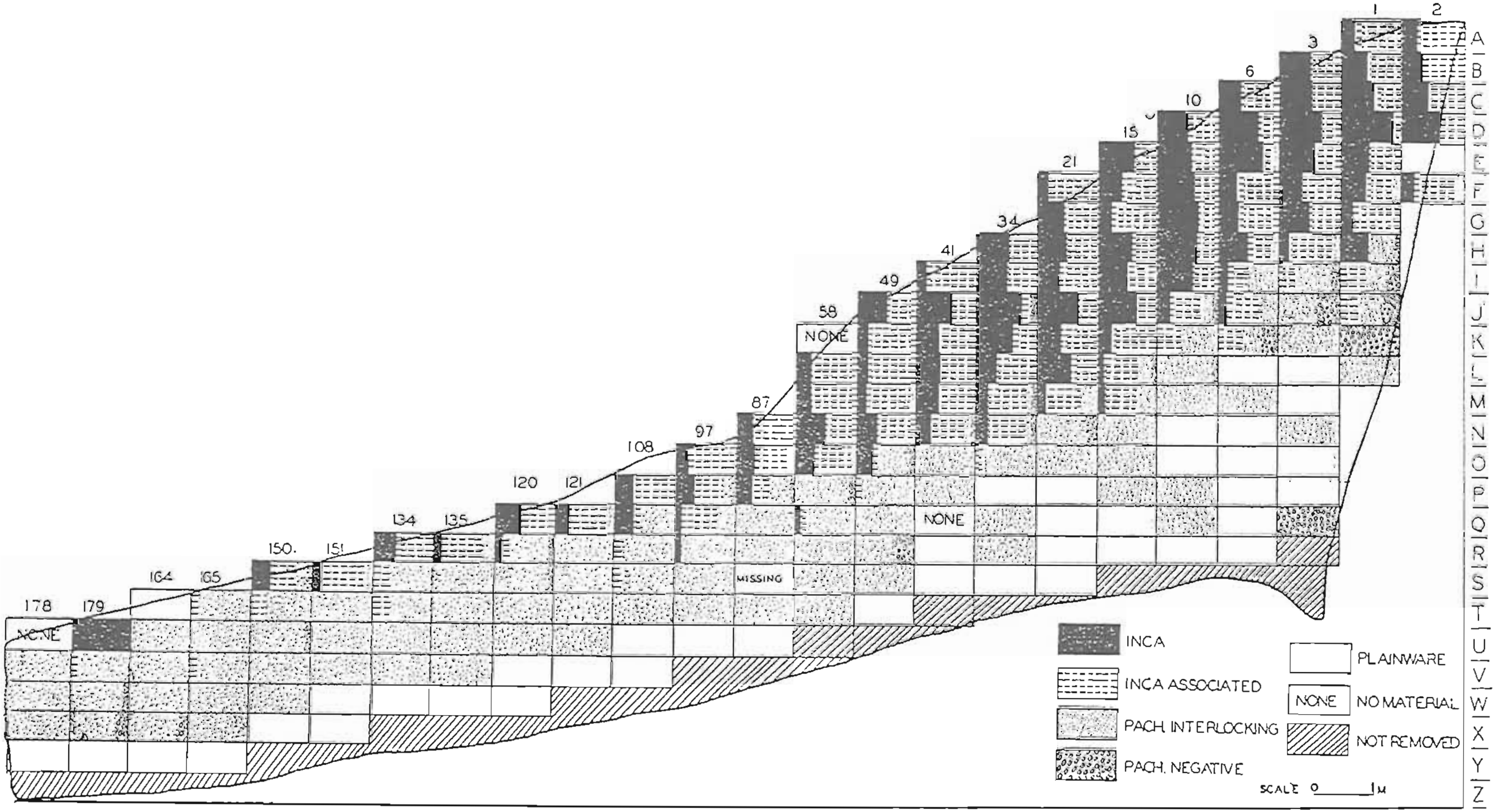
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Fig. 5.3 (C).

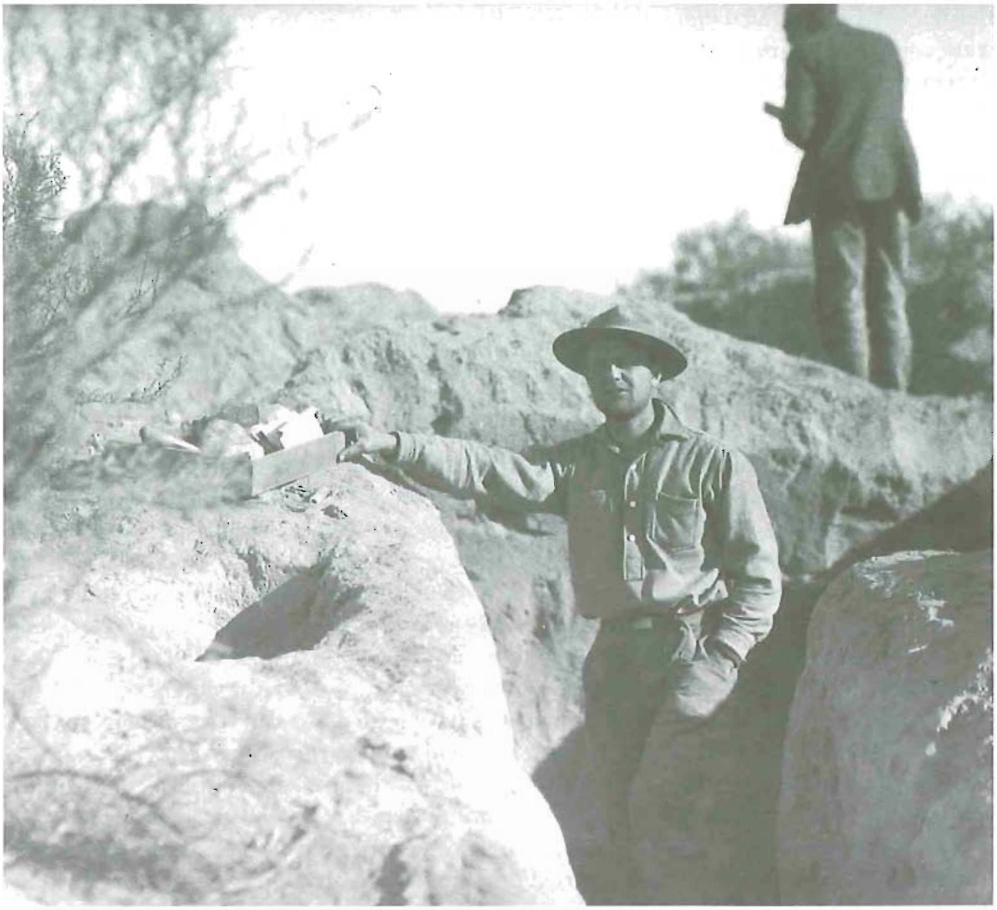

Fig. 5.4 William Duncan Strong (1899–1962) in a southern California archaeological trench during the winter of 1925–26. Strong learned the technique of arbitrary excavation from A.L. Kroeber at the University of California, Berkeley. Alfred Kroeber referred to metrical digging as the 'European method'; Kroeber probably learned it from Nels Nelson, who himself may have first encountered the method in Castillo Cave, Spain. (Photograph by E.W. Gifford; Courtesy of the Lowie Museum of Anthropology, University of California at Berkeley.)

America for some years. Beginning with Nels Nelson, this technique emerged as a scientific-looking way of detecting changes in relatively deep sites at a time when chronology was king in American archaeology. Later, when statistics began to be applied to excavation data, excavators felt that the standardized units would ensure comparability of data sets. Gradually, the standard became a mould that was rigidly applied regardless of individual circumstances or changing research questions.

An important turning point in the practice of North American archaeology came in the late 1960s and early 1970s with the passage of laws on both the federal and state levels that required archaeological studies in advance of development projects. Whereas archaeological survey had been a fairly casual process by which archaeologists simply looked where they knew sites were most likely to be, formal standards were now developed that ensured more thorough coverage (e.g. King *et al.* 1973). As a result, archaeologists were confronted with a range of prehistoric sites reflecting many different activities. From the perspective of investigation approach, the most important characteristic of these newly discovered sites was their horizontal character. For whereas the villages and cemeteries that had been archaeologists' traditional objects of study had significant depth, if not much in the way of physical stratification, many of the new sites were largely surface phenomena. In recent years an innovative field technique was developed that made use of the arbitrary level to tackle these types of sites that had been previously ignored.

During the 1960s, the idea that prehistoric sites were neither vertically nor horizontally homogeneous became increasingly important to field workers in the western United States. These archaeologists now wanted to examine site functions and activity areas over time on shallow, extensive but unstratified sites that the new survey techniques were turning up by the hundreds. Clearly, the standard field method was hopelessly inadequate to deal with questions of variability since its rationale was an assumed homogeneity that would be reflected in the results from a 'statistically significant' number of deeply excavated units. The problem was to develop a technique that would be appropriate to the structure of these surface sites. Thus, in 1975, with opposition from colleagues trained in 'the method', some archaeologists began experimenting with Surface Test Units (STUs). The STU differs from standard excavation units in that it is not necessarily square but may be rectangular; but more importantly, it is 10 cm or less in depth. By using STUs, field workers could sample a much larger area more intensively than with standard units. The validity of the STU technique is based on the observation that the content of the top 10 cm or so of soil will be a reliable indicator to deeper materials. The principle seems to work because of the great amount of artefact displacement caused by rodents in the shallow sites of the Far West. The approach also recognized that prehistoric peoples' seasonal use of an area does not necessarily bring them back to precisely the same spot in successive years. As a result, changes over time are often reflected in 'horizontal stratigraphy', rather than in superimposed layers of soil. As the approach is still relatively new and controversial the following case study is offered to demonstrate its application.

Archaeological site CA-MNO-566 is located in California's northeast corner. It consists of a scatter of stone tools and debitage distributed over an area of about 0.75 km^2. The conventional way to assess such a site's content would be to employ 'the method' to excavate standard units to culturally sterile deposits in areas of the site that showed the most surface materials, with additional units placed randomly. However, as the STU approach allows for the excavation of many more units than does the conventional method, it was possible to excavate 99 STUs, each 2 m × 50 cm × 10 cm deep. These sondages were placed at regular intervals across the site so that the quantities of material could be charted on a computer-generated map of the site (Fig. 5.5). The resulting contour map shows several distinct clusters of artefacts which physical analysis have shown to be of different ages (David Fredrickson, personal communication, 1989).

By recognizing that this type of site is a horizontal phenomenon rather than a vertical one, and adjusting their field methods accordingly, the excavators have asserted the same principle as the archaeological stratigraphers of earlier years: they dug the site on its own terms, not theirs. In the same way that Uhle and Kidder recognized that their sites contained interpretively important layers that grew by vertical accretion, the excavators of CA-MNO-566 put into action the knowledge that their site was created across the ground's surface over time. Although they excavated in arbitrary levels, even Mortimer

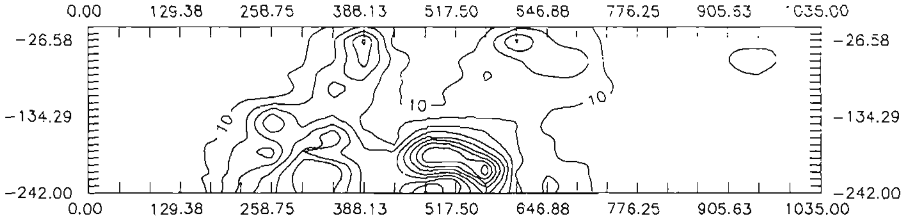

Fig. 5.5 The contour lines on this computer-generated map of site CA-MNO-556 represent the occurrence of stone tool-making debris in increments of 10 flakes per square metre. Each of the three concentrations of material, two above and one below, represents a separate occupation of the site identified by an excavation strategy called Surface Test Units or STUs. (Courtesy of David A. Fredrickson.)

Wheeler may have approved of these archaeologists' methods, for they were based on an appreciation of the way in which the site was created, not by the impositions of its investigators.

The limits of arbitrary excavation

If it is appropriate to dig by arbitrary units on a site that has no physical layering, why is the technique looked down on when it comes to stratified sites? From the limited discussion of this issue in archaeological field manuals and texts it appears that most archaeologists believe this to be self-evident. However, as the principal aim of the writer is to encourage archaeologists in the American Far West to dig by physical strata on historic period archaeological sites, an explicit statement is essential.

Archaeological excavation is formalized destruction. All archaeologists would endorse this axiom; yet a nodding acceptance of the principle is belied by practice. Since what they do is destructive, archaeologists' first duty is to document the record of the ground itself in such a way as to allow for a variety of approaches to the interpretation of the site (Atkinson 1946: 165). This record consists of artefacts and their relationship to each other and to the structure of the site; environmental data, such as pollen, soils, parasites, etc.; and the stratigraphic record in which is contained the history of events on the site. The key issue here is that excavating according to physical layers does not compromise alternative ways of understanding the site; conversely, using the arbitrary method negates the possibility that the site history will ever be fully reconstructed.

Hypothetically, one can conceive of archaeological research designs – such as those of the early chronology builders – that do not have reconstructing site history as a goal. In these cases, it may have been enough to chart large scale developments in artefact types.[3]

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[3] The author remains dubious of the value of studies of archaeological artefacts that are done without considering the evidence of the ground but admits the possibility of such approaches for the sake of discussion. While proportional artefact 'patterns' (e.g. South 1977) will reflect activities on the site if the analysis is carried out on individual strata or interfaces, it is difficult to understand how such an analysis performed at the level of the entire site can be of interpretive value. Although James Deetz (1986) has pointed out that changing the 'scale' of one's research questions can make archaeological collections with broad proveniences interpretively useful, he insists that this observation should not be used as a justification for sloppy excavation technique.

However, on sites of the historic period the primary research question *is* site history. Other issues are either solved through documentary research or will hinge upon the relationship between the archaeological remains – both site structure and content – and the documentary record; the research potential of a refuse-filled pit, for example, may be contingent on the degree that it can be associated with a particular household of historically documented demographic, cultural and economic characteristics. On historic archaeological sites, the artefacts themselves have little or no importance outside of their stratigraphic context because of the relatively short period of occupation that is represented on the site: in Sacramento, California, for example, most of the non-Native American archaeological record reflects the period from about 1849 to 1900. Without rigorous stratigraphic controls it would be impossible to distinguish between the numerous discrete episodes that contributed to the creation of sites and which alone give meaning to the artefacts.

Some archaeologists believe that it is perfectly acceptable to excavate a stratified site using carefully measured arbitrary levels because the levels can be correlated to the physical layers after the excavation is over by using section drawings. The advantage of this approach is said to be that field work can proceed rapidly in the absence of highly skilled excavators who could distinguish between the various strata and record their relationships. The work of Gordon Willey and Charles McGimsey at Monagrillo, Panama, demonstrates the disadvantages of this approach as well as being a testimony to the creativity of the two men who tried to make the method work (Willey and McGimsey 1954). Jeanette Schulz's painstaking effort – aptly titled 'Salvaging the Salvage' – to make sense of the stratigraphy of a physically stratified site arbitrarily excavated by others, demonstrates that after-the-fact reconstruction is simply not possible (Schulz 1981).

There are three principal difficulties with the approach: First, it is very inefficient and needlessly squanders data, since material collected from arbitrary proveniences that later analysis shows to have included more than one layer cannot be used in layer-based interpretation; the artefacts from these mixed proveniences are refuse in the generally accepted use of the word. Furthermore, even in theory the method could only work on sites where the units of deposition are perfectly horizontal; although this is not an uncommon occurrence in geological sediments, on archaeological sites it is the exception rather than the rule. Finally, by letting the tape measure decree the bottom of the units of excavation, the site's living surfaces – what Harris (1989) calls the 'interfaces' – are lost. Since these are the planes on which people actually lived, failing to record them is a giant blow to the possibility of reconstructing site history.[4]

Black hats and white hats

In this chapter it has been suggested that neither the British-trained stratigraphers nor the North American artefact manipulators should be considered either naïve fools or intellectually dishonest for going about their different jobs in different ways. 'There is no right way of digging, but there are many wrong ways' (Wheeler 1954: 1). One of the wrong ways may be to use methods developed for one set of goals in an entirely different

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[4] Harris has stated that 'once a stratum is deposited, its innards are, by definition, "out of use", as they are buried' (1989: 68) – thus, the importance of the archaeological interface as the dimensional plane on which life was lived.

context. The history of American archaeology shows that arbitrary excavation was developed with narrow goals in mind: the soil layers were conceived of as mere matrix to be 'cleared away' (Sharer and Ashmore 1979: 210) in the search for artefacts. As objectives change, so should methods.

Yet, regardless of its dubious past, arbitrary excavation will continue to be a valuable tool when it is used with an understanding of site structure and not as part of an inflexible archaeological orthodoxy.

Acknowledgements. The author gratefully acknowledges his intellectual debt to John Howland Rowe and David A. Fredrickson who, although they may not agree with everything in it, improved this paper by insights gained from their long experience in the field. I would also like to thank Gene Prince for guiding me through the Lowie Museum's photograph archive on this and other research projects.

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SECTION III
Analysis in excavation

This section contains four papers on the use of various aspects of the new stratigraphic methods on archaeological sites excavated since the mid-1970s. The first article, by Nicky Pearson and Tim Williams (Chapter 6) discusses single-context planning on sites in the English city of York, which along with London has taken a leading role in the development of new methods under the directorship of Peter Addyman of the York Archaeological Trust. Pearson and Williams outline how these methods are used routinely on excavations so that proper and complete site records are the result of efficient stratigraphic work. They then discuss a method for phasing the stratigraphic material, i.e., arranging it into phase and period groups of stratigraphic units, as part of compiling the permanent Archive Report for the site.

Their paper properly stresses that this analysis is done without reference to the finds, but that the phased sequence is the testing pattern which should be given to finds specialists prior to the commencement of their particular artefactual analyses. This has proved to be of value at York and represents a significant departure from older ways in which the results of finds analyses controlled the stratigraphic record. This is an area in which major new work will continue to concentrate and should produce new and more reliable data about the relationships of finds and stratification.

The second paper comes from excavations at Konstanz, Germany, supervised in recent years by David Bibby. His article (Chapter 7) deals with the fundamental issue of making stratigraphic sequences during the course of an excavation, from which many interesting observations and guidelines emerge. Bibby says in effect that it is the job of the archaeologist to discover the nature of the stratification of a site as it exists when found, and to then explain how the site came to be by an explanation of its stratigraphy. He rightly claims that in archaeology, the main foundation of such interpretations is stratigraphic data, which is recovered ironically at the very time in which it is being destroyed (excavated) by the archaeologist. For this reason, he determined that the stratigraphic sequence should be compiled as excavation took place and not after the fact.

Bibby's experiment led him to various conclusions, for example that the use of the Harris Matrix forces excavators into rigorous stratigraphic thinking on the site. The method serves as a constant check on stratigraphic relationships and interpretations and ensures that every unit of stratification is given its due equal value in the process of recording. He notes that at Konstanz up to 40% of recorded units do *not* appear on section drawings, but all appear and may be viewed simultaneously on matrix diagrams. As with Pearson and Williams, Bibby sees the final sequence diagrams as the starting point of all later analyses.

In the third paper of this section, Barbara Stucki (Chapter 8) examines some stratigraphic problems associated with shell middens, using an example from a prehistoric rockshelter site in the western American state of Washington. Her approach is innovative in this particular sphere of archaeology as it attempts to look at the site largely from a stratigraphic, rather than artefactual, viewpoint. In this instance, the rockshelter had very complex stratification, but very few deposits were significant enough to indicate major changes in activity on the site. Additionally, the artefacts consisted primarily of small bone points of a type common to many artefact assemblages over the last 1200 years on the Northwest Coast of America.

In essence, Stucki faced a problem of the phasing of a site which, unlike most urban settlements, contained but a few stratigraphic markers, such as a building trench, for example, which would allow for the division of the site into phases and periods of activity. Unlike many excavators on such prehistoric sites, Stucki decided to try and apply the Harris Matrix methods and to use the stratigraphic development of the site to give some of the required answers. By analysing the recorded stratification, it was found that the site had a very complex, multilinear sequence of deposits. The separate strands of development in this sequence indicated different areas of activity which produced the disparate groups of deposits. Stucki then identified what she called a 'reference sequence', which was the longest sequence of deposits on the site. Against this sequence, the others in the multilinear group could then be compared and some correlations made between the various unilinear areas of stratification.

It is of course an indication of the value of this interesting study, yet at the same time an overdue criticism of the way in which many prehistoric sites of this type have been examined, when the author declares that because 'there are likely to be many more layers than artefacts in these middens, it is important to take full advantage of the detailed stratigraphic record of site formation when studying the spatial organization of past human behaviour'. One may therefore wonder what has happened on many sites which contained much stratification but few, if any, portable artefacts.

The final paper in this section is by Norman Hammond (Chapter 9) and is reproduced with the kind permission of the *Journal of Field Archaeology*. Professor Hammond was probably the first archaeologist to use the Harris Matrix in the New World, in 1974 at a Mayan site in Belize. The paper given here appeared in 1991 and represents some of the most elegant published versions of matrix diagrams. His site was a very complex one and, due to that fact, Hammond and his colleagues devised various additions to the coding of data in these stratigraphic sequences. Where sequences were too complex to publish in one diagram, the units of certain features were reduced to a single notation in the correct stratigraphic position, while the detailed sequence for the particular features was maintained separately. The use of shading and other symbols to indicate major structures within a sequence was another embellishment seen in this paper. All in all, Hammond and his associates give clear indication of the flexibility and diversity of the Harris Matrix, in its basic stratigraphic sequence, or phase sequence, forms. They also demonstrate that it can handle a site of any level of complexity without any difficulty.

6 Single-context planning: its role in on-site recording procedures and in post-excavation analysis at York

NICKY PEARSON and TIM WILLIAMS

Introduction

This paper is an attempt to outline the structure and rationale behind a recording and post-excavation procedure designed by the authors and others. This technique was developed to enable excavators to record archaeological data from deeply stratified urban sites efficiently, accurately and logically. The evidence is presented so that analysis can be undertaken in order to provide a straightforward route to publication.

The method itself is divided into two parts. The first concerns itself with the routine operations that are undertaken during excavation to produce ordered and complete site records. The second proposes a method for phasing and suggests a structure and nomenclature for the Archive Report.

For the purposes of this discussion the Archive Report is a derailed analysis of all of the contexts from the site and their inter-relationships within the stratigraphic sequence. It is concerned solely with this category of information and excludes finds evidence, dating or otherwise, and other classes of information, notably environmental evidence. This is for two reasons. Firstly, such information is considered secondary to the story of the development of the site as told by the stratigraphic sequence. Secondly, it is considered that a logical report based solely on this sequence is something which should be given to every specialist working on material from the site, prior to the commencement of their study. It is hoped that by using such a report their contribution to the analysis and interpretation of the evidence will be more valuable and lead to an impressive and worthwhile publication synthesis.

Part 1. On-site procedure

The rationale behind the procedure

The formula proposed below has three main elements:

Firstly it imposes a series of logical steps on the excavator which provides for the routine production of site data, which can then be analysed in post-excavation work, leading to the production of the Archive Report.

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Secondly, data are checked regularly for correctness, completeness and logicality, to ensure that they are permanently up-to-date and consistent.

Thirdly, the planning separately and entirely of every context or unit of stratigraphy must take place. This process is termed 'Single-Context Planning'. The resultant sequence of plans is then used to test the validity of the stratigraphic relationships in order to produce a Harris Matrix. Stratigraphic integrity is tested by the simple means of physically overlaying the plans.

The single-context plan is seen as an essential ingredient of this procedure not only for the above reasons, but also as discussed by Harris (1979) in *The Principles of Archaeological Stratigraphy*. He described the single-context plan as the 'basic requirement in archaeological stratigraphy'. Not only is it quick and simple to produce it also provides us with a complete drawn record of each element of the site. The counter or more traditional method of recording using composite plans and sections is seen as inadequate for a number of reasons. Neither sections nor composite plans provide us with a complete record of the archaeological database. Sections can be badly positioned and therefore misleading and rarely include all of the excavated deposits. Composite plans involve the planning together, but often only in part, of deposits which may belong to different phases or periods. Those parts of deposits that were hidden at the time of planning frequently remain unrecorded. The resultant plans and sections are however all that is available in post-excavation work and not only are they frequently confusing they normally form the basis for the publication drawing, despite their inadequacies.

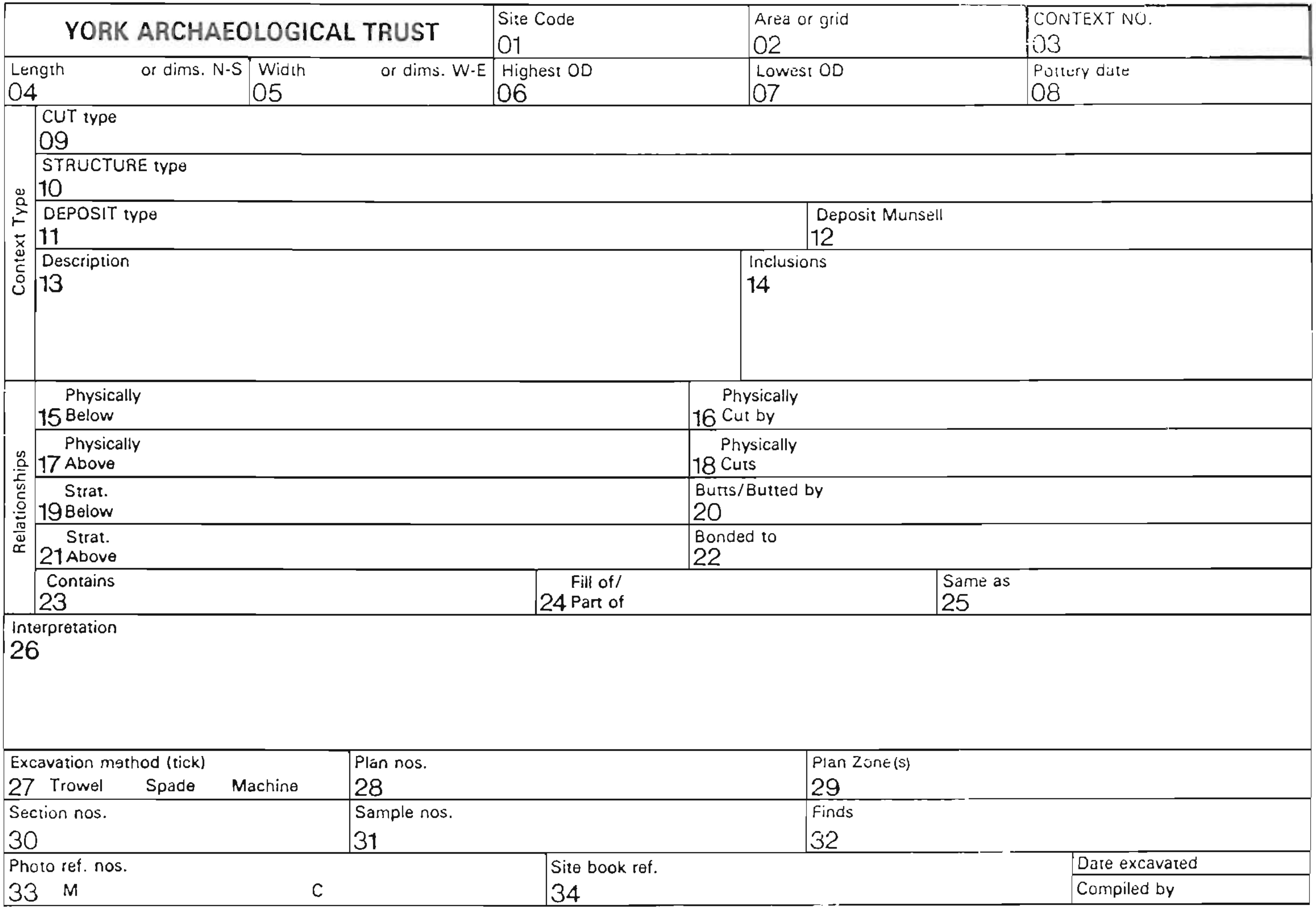
For practical planning purposes the site is divided into conveniently sized zones, which in York have been deemed as 5 m squares. The individual contexts or parts of contexts which lie within each zone are planned and a Harris Matrix is produced for each planning zone as excavation progresses. Each context is added to the matrix at the time of its excavation. These plan-zone or plan matrices should then be checked at least on a daily basis. In tandem with this, a site-wide matrix is produced by the integration of the separate plan matrices. This should also be checked on a daily basis.

The reason for the production of a number of separate plan matrices is that these can be produced quickly by the overlaying of plans from the zone and can be checked relatively simply. The production of a site-wide matrix directly from the written record or from all of the individual single-context plans from the site, either at the time of excavation or at a later date, can be a very complex operation and is likely to lead to inaccuracies and omissions.

The written record that is used here to illustrate the method is based on the York Archaeological Trust (YAT) context card and a prompt sheet which was designed to be compatible with that card (see Figs 6.1 and 6.2). It must be emphasized, however, that the use of the method is not restricted to these particular formats. It could be adapted to suit many of the recording procedures currently in use in archaeology. It is not the precise terminology that is important, it is the imposition of the series of logical steps throughout excavation and post-excavation work, coupled with the checking procedures, which is essential to the successful use of the system.

The recording process

The site recording prompt sheet is the centrepiece of a pack of printed sheets which include prompt sheets and thesauri of approved terms for cuts, deposits, structures and



YORK ARCHAEOLOGICAL TRUST

Site Code 01

Area or grid 02

CONTEXT NO. 03

Length or dims. N-S 04

Width or dims. W-E 05

Highest OD 06

Lowest OD 07

Pottery date 08

Context Type

CUT type 09

STRUCTURE type 10

DEPOSIT type 11

Deposit Munsell 12

Description 13

Inclusions 14

Relationships

15 Physically Below

16 Physically Cut by

17 Physically Above

18 Physically Cuts

19 Strat. Below

Butts/Butted by 20

21 Strat. Above

Bonded to 22

Contains 23

24 Fill of/ Part of

Same as 25

Interpretation 26

Excavation method (tick) 27 Trowel Spade Machine

Plan nos. 28

Plan Zone(s) 29

Section nos. 30

Sample nos. 31

Finds 32

Photo ref. nos. 33 M C

Site book ref. 34

Date excavated

Compiled by

Fig. 6.1 The York Archaeological Trust context recording sheet.

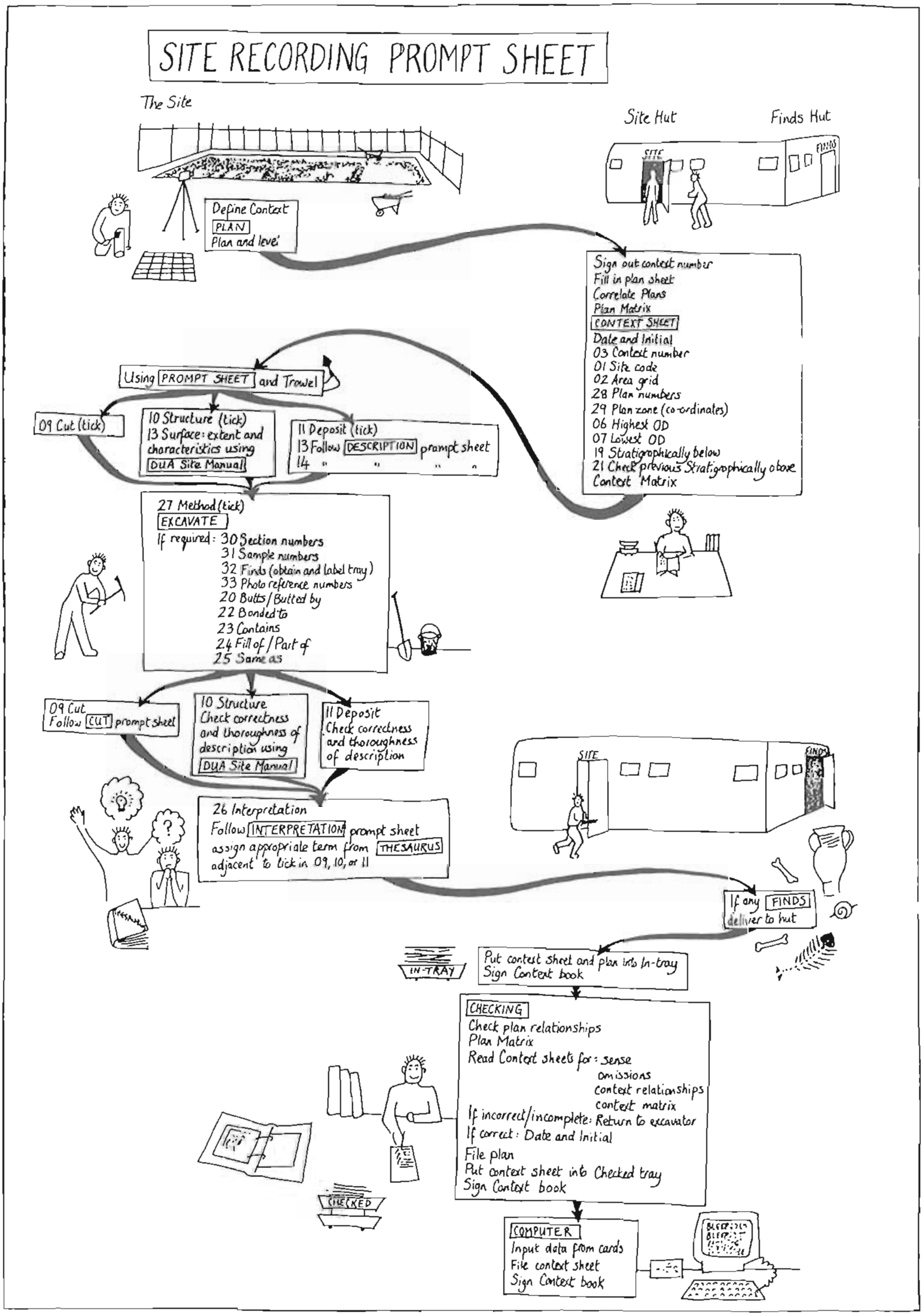


Fig. 6.2 The site recording prompt sheet.

interpretation. It is designed to divide the activities of the excavator into defined steps which take a logical route from the initial definition of the context to the complete recording of the on-site data.

The recording process begins when the topmost context or single-layer in the stratigraphic sequence is identified, planned and levelled. After this the first stages in the written recording of the deposit take place. Firstly a number is assigned to the context from a signing-out book. This book comprises a list of contexts in numerical order and includes such details as the name of the excavator concerned with its recording, the date it was excavated, the date recording was completed, the date it was checked by the supervisorial staff and the date it was computed. The purpose of this cross-referencing is to ensure that there is no duplication of numbering and that all of the stages of the recording procedure are completed.

At this stage the context number is also entered on the relevant plan matrix or matrices, which are normally stored at the front of the respective plan-zone folder(s).

It is now possible to begin the completion of the context card (see Fig. 6.1). The initial entries comprise simple already known factual information. These include the site-code ([01]), the area of grid of the site within which the context is located ([02]), the context number ([03]), the length and width of the context ([04] and [05]), the highest and lowest levels ([06] and [07]), the plan-number ([28]), the plan-zone coordinates ([29]), the initials of the excavator and the date of excavation. Although some of the above information is clearly crucial, other fieldworkers may wish to exclude some of the above or include other data particular to their types of site. What is important is that only simple already known factual information is recorded.

It is possible also at this stage to record what the context is stratigraphically below ([19]), by superimposition of plans of previously excavated contexts. This in addition gives an opportunity for the recording of those previously excavated contexts which are stratigraphically above ([21]). The stratigraphic position of the context under consideration should also be entered on the site-wide Harris Matrix.

It should be noted that despite their occurrence on the YAT recording card, physical relationships ([15], [16], [17] and [18]) are not recorded. This system is an attempt at defining and recording the development of the stratigraphic sequence and the physical proximity of contexts to one another is not relevant to that consideration. Also not discussed in this paper are the pottery date ([08]), the Munsell number ([12]) and the site book page reference number ([34]).

Once the excavator has ensured that the above-mentioned factual information has been recorded, (s)he can begin to consider the actual nature of the context. The initial decision is whether it is a cut, a structure or a deposit. The context card is then ticked in the appropriate place ([09], [10] or [11]) and the excavator follows a different course of action depending on its type. The surface characteristics and extents of deposits and structures should be described now, prior to their excavation ([13] and [14]). At this stage all the information recorded is descriptive, according to agreed formulae. No attempt is made at interpretation. Cuts are in a slightly different category in that they are only revealed after the removal of one or more deposits and it may not be possible to assess their nature prior to the removal of their infilling material.

Following the excavation of the relevant structure or deposit, or the removal of the deposits from within a cut, the recording process can be continued. There are a number of factors which are common to all contexts and which will have become known as a result as the process of excavation. Some of these are essentially cross-referencing in nature and may include: method of excavation ([27]); section numbers ([30]); environmental sample numbers ([31]); the presence and number of finds ([32]); and photographic reference numbers ([33]). There are also a number of relationships which may be relevant in addition to the stratigraphic relationships already mentioned. These include butting ([20]) and bonding ([22]), which may be pertinent to types of structures, as well as contains ([23]) and fill of/part of ([24]), which can be relevant to any type of context. Whether or not a context is the same as another ([25]) is something that can also be noted at this stage.

Having recorded the information which has arisen by virtue of the excavation of the context, it is now possible to complete its description ([13] and [14]). In the case of deposits and structures it will be necessary to ensure that the pre-excavation description is correct and adequate. It is likely for instance that the percentage of inclusions present in a deposit will only be determined during the excavation process. Cuts should be described at this stage using the prompt sheet.

Once the context has been recorded and described in the above manner, the excavator uses the interpretation prompt sheet. On the basis of his/her knowledge of the context as a result of recording, excavating and describing it, (s)he now considers its nature, the nature of the activity represented by it and the description of that activity. Having considered these points and completed the relevant section on the context card ([26]), the excavator assigns a term for the context from a pre-determined list. This term is then placed on the card against the tick that was assigned prior to excavation ([09], [10] or [11]).

The final action of the excavator is to place the context card and relevant plans in the checking-in tray, initial the context signing-out book and deliver any finds to the finds assistant.

The intention behind this brief outline of the recording and excavation process is to show that information is recorded as it becomes available and that evidence is carefully considered to ensure that description is not based on any pre-conceived idea as to function, but rather that function gradually becomes more evident. The culmination is a consideration of the interpretation of the available evidence resulting in the assigning of a label from an available thesaurus. It is felt that this part of the method has two clear advantages. Firstly, the excavator will have a better chance of understanding the nature of the material that (s)he is dealing with. Secondly, the clear and easily visible division between description and interpretation may enable other researchers to analyse the evidence and perhaps re-interpret a site excavated and published by another.

As stated at the start of this paper, thorough checking of the data is integral to the method. The bulk of the checking procedures should take place as soon as possible after the context card has been checked-in by the excavator, ideally on the same day. The procedure involves checking both the plans and the context cards for sense, omissions and accuracy. Stratigraphic relationships are checked against the site-wide Harris Matrix and each of the individual plan matrices. This process is intended to ensure that at the beginning of post-excavation work there is a complete and correct account of the site data.

When a context is satisfactorily checked the card and the plan are signed by the supervisor, as is the context signing-out book. Once computerization of the record has taken place the card is filed and the signing-out book is initialled to show that the process has been completed.

If the above procedures have been carried out correctly post-excavation work commences with a complete set of checked context cards and an already checked and complete Harris Matrix. This forms the basis of the Archive Report structure.

Part 2. Post-excavation procedures

Introduction

The function of the Archive Report is to provide a full discussion of all the contexts or stratigraphic units, presenting sufficient data to justify the resultant conclusions, with that data clearly separated from any interpretative comments. It is used as the basis for the discussion of the dating evidence and the resultant phasing provides a key to the analysis of the site by specialists. It also forms the link between the publication text and the site data.

The Archive Report should limit itself to the site in question and should not engage in detailed topographic analysis. Discussion of a more widespread nature is part of the research leading up to the production of the publication text.

Nomenclature

The Archive Report should be designed to allow researchers the maximum facility to analyse and question its conclusions. They must be able to see how the author(s) arrived at these conclusions and the evidence upon which they were based. The nomenclature and structure imposed on the stratigraphic sequence should be clearly outlined:

> Context-series. Any number of contexts with close stratigraphic links that are interpreted as forming a single 'activity'.
>
> Groups. An amalgamation of a number of context-series to form a discussion point within the text. These provide convenient points at which to bring in the correlation of various context-series.

It is suggested that context-series should be numbered from 1 onwards within each Group. Groups would also be numbered from 1 onwards, for example, 2.1, the first context-series in Group 2, reflecting the hierarchical nature of the divisions.

All context-series must be allocated to a Group. The number of Group divisions will be dependent upon the nature of the stratigraphy. On a single sequence site a number of site-wide horizons may be readily definable. On more complex multi-sequence sites such correlations will be more difficult to define. In such cases it may not be possible, or desirable, to impose site-wide horizons, hence the abandonment of the 'period/phase' nomenclature which embodied chronological concepts. It may be necessary to phase the separate stratigraphic sequences from different areas independently, correlating them at a later stage in the analysis. Such correlations are often of a higher interpretative level and this is reflected by leaving them to the Group or Inter-Group Discussions (see below), or indeed to the publication text itself.

Phasing the matrix

Primary route. The first procedure is to define a primary route through the matrix, a simple example is shown in Fig. 6.3A. In this the longest available sequence of contexts is isolated, without regard to their type, character or interpretation. The primary route in this case is 1, 6, 7, 8, 9, 10, 12, 13, 14, 15, 19, 20, 21 and 22. (Note that 16, 17 and 18 could interchange with 13, 14 and 15 to produce the same primary route length. The choice between the two sequences should be random rather than selective.) It is not necessary to consult either the context or plan data when producing such a route. The primary route can then be phased. This involves the isolation of a series of 'activities' (context-series), which can contain any number of contexts. At this stage it is necessary to analyse the data on the context cards and plans, dividing the route with a number of horizontal lines, the beginnings of the context-series divisions (Fig. 6.3B). Contexts are divided on interpretative/functional grounds. For example a floor surface would be divided from overlying fire debris because although the latter may have derived from the same structure it represents destruction rather than construction/use. Creating artificial divisions within a sequence should be avoided, for example between a number of pits and their fills if no definite reasons can be advanced for their separation. Dating evidence is not used at this stage as it includes interpretative factors outside the control of the descriptive and stratigraphic data. In general the process is simple and requires only basic interpretations to be attached to the contexts on the primary route.

Integration of subsidiary routes. Following the division of the primary route into a series of basic context-series the rest of the stratigraphic units can be integrated into the sequence by analysing the secondary, tertiary, etc., routes. These are selected by identifying the route with the next highest number of contexts which, at some point, joins the primary route. For example, in Fig. 6.3A, the secondary route would be [2], [3], [4] and [5]. This would then be integrated with the primary route. It is this integration that provides the next level of analysis. It is necessary to compare the context data, including correlations of levels and spatial distribution, to attempt to decide where the units are most likely to correlate.

The contexts do not have to be forced into existing context-series as formed by the primary route, they may represent entirely separate activities and thus form the basis for new context-series. The flexibility of the context-series system allows one or more contexts to 'float' with respect to each other as dictated by the matrix. In Fig. 6.3C, for example, the primary route as illustrated in Fig. 6.3B is merged with the subsidiary strands from the initial matrix of Fig. 6.3A.

Correlating contexts on different stratigraphic strands is problematic. It is not desirable to form intransigent rules governing when contexts can be amalgamated in one context-series. Their correlation will often depend on a variety of factors such as spatial distribution and composition. For example, in Fig. 6.3C, the placing of context [5] in the same context-series as that of [9] and [10] is considered reasonable given their nature and the short stratigraphic route to reunion. Contexts [8] and [11] can also be linked on the same basis. However, the placing of [4] in the same context-series as [8] and [11] is perhaps questionable as the stratigraphic link is weaker.

However, contexts should not be placed in the same context-series if they belong to discrete stratigraphic strands which do not unify at any juncture. Amalgamation of contexts

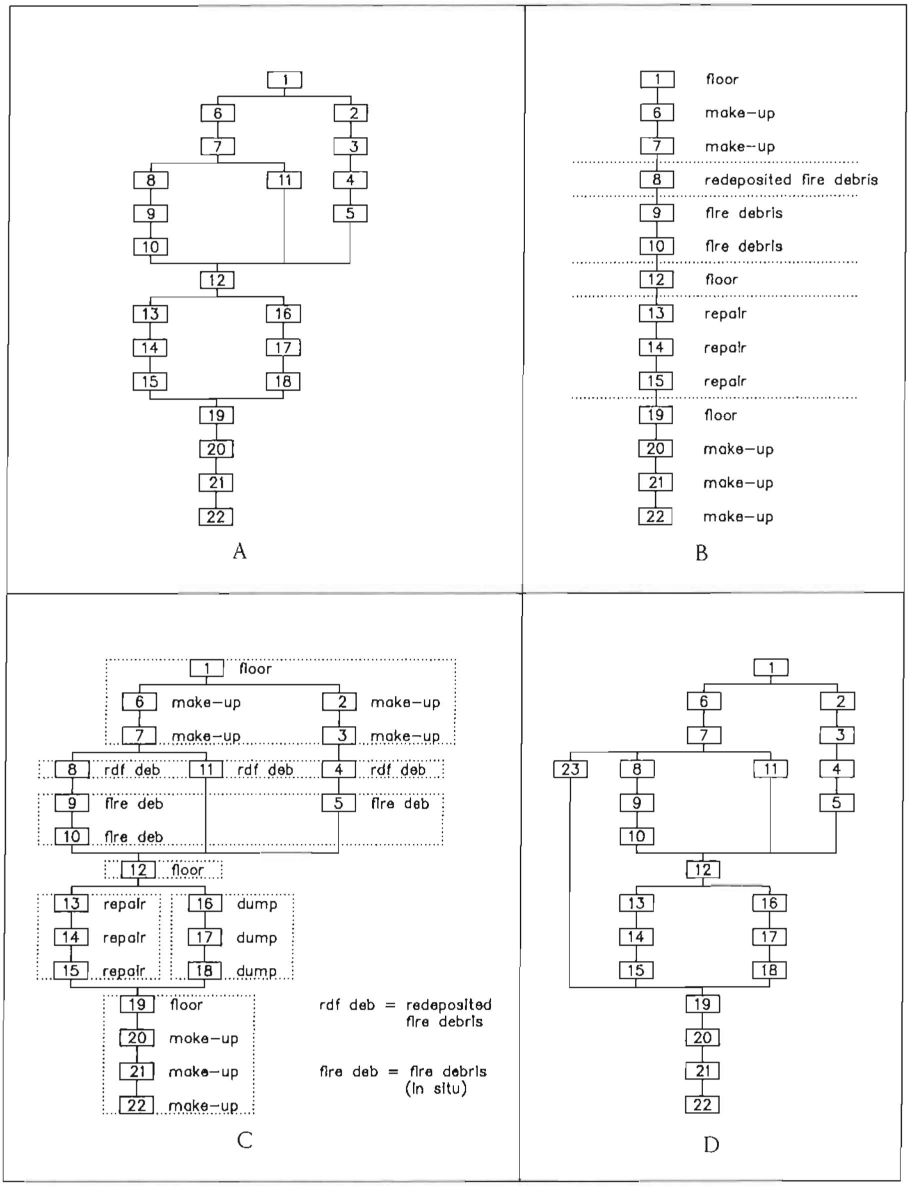


Fig. 6.3 (A) Part of a site matrix. (B) Primary route through matrix shown in (A), with simple interpretations and divisions. (C) Context-series after subsidiary routes have been incorporated. (D) Context [12] forms a limited nodal point, with only context [23] not respecting it.

from separate strands into one context-series could only be based on intepretative criteria and would cause problems for later analysis and integration of the dating evidence. If correlations made at the Group level are subsequently thought to be incorrect the basic unit for analysis, the context-series, with its integral stratigraphic links and low-level interpretative association, is not undermined. For example when fire horizons from a number of physically discrete areas of the site are placed in the same context-series it dictates the structure of the subsequent context-series and the re-interpretation of a single deposit, or area, can invalidate the entire structure. If the dating evidence suggests that the fire debris from one area was of a significantly different date the phasing structure would be undermined. If, however, the contexts were placed in independent context-series, clearly shown to float against each other in a context-series matrix (see Fig. 6.5), then any subsequent reappraisal would not interfere with the basic interpretative unit, the context-series, but merely alter the way they had been combined in the Group Discussion. This system clearly allows, indeed forces, the author(s) to articulate their interpretative correlations by clearly stating them within the Group Discussion, after all of the basic interpretative groundwork has been completed in the context-series.

Nodal points. In an extremely complex matrix it may be necessary to isolate 'nodal points'. These are defined as single contexts which all of the stratigraphy in that area either pre- or post-dates. A nodal point enables subsidiary routes to be incorporated at more frequent intervals enabling easier analysis and correlation. In Fig. 6.3A context [12] forms a 'nodal point'.

In some cases no nodal point will be available. If the matrix is sufficiently complicated then a less exact point (limited nodal point) may be established. If Fig. 6.3D context [12] now forms a limited nodal point, due to the addition of context [23]. In this case [23] would initially be analysed with the later, post [12] block. However, it should also be compared with the earlier block in an attempt to ascertain the best interpretative correlation for the context, or to establish its independent positioning. If more than a few contexts are 'floaters' around a limited nodal point its efficiency would be severely reduced.

Grouping and multi-sequence sites. The above processes will result in the matrix being divided into a number of context-series representing a series of inter-related activities (Fig. 6.4A). At this stage the construction of Groups can be considered. On a single sequence site this may be a relatively simple operation requiring the identification of major interpretative events which may not necessarily be site-wide. Figure 6.4B shows the same sequence after the imposition of Group divisions.

As stated above, it is important that activities in different areas of a multi-sequence site are placed in independent context-series. Their correlation is properly part of the Group or Inter-Group Discussions. This allows the individual context-series to remain as the basic level of interpretative association. The advantage of the group hierarchy is that it can remain considerably more flexible than period boundaries and its numbering does not imply an absolute chronological progression.

The above procedure on a multi-sequence site may result in no site-wide groupings. Group boundaries may be imposed on each of the individual areas, in effect treating each as an independent site, using the Inter-Group Discussion at the end of the Archive Report to offer any correlations that the author(s) feel can be justified. If the level of interpretative correlation is high the author(s) may wish to extend some of the Group boundaries across various strands of the context-series matrix, whilst maintaining independence in other areas.

In Fig. 6.5 the similarity of the context-series 1.1, 1.2 and 1.3 led to them being placed in the site-wide Group 1. The structural evidence for Building 1 (2.2 and 2.5) was sufficiently similar, along with their common destruction by fire (2.3 and 2.6), to allow

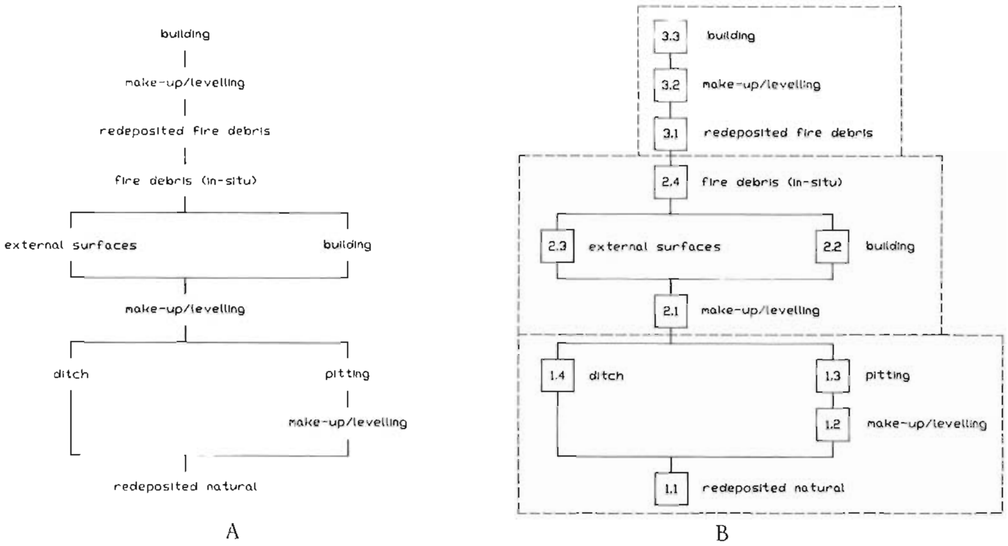


Fig. 6.4 (A) The context-series on a simple single sequence site before Group divisions are imposed. (B) Simple Groups are then placed on this framework to form convenient discussion points.

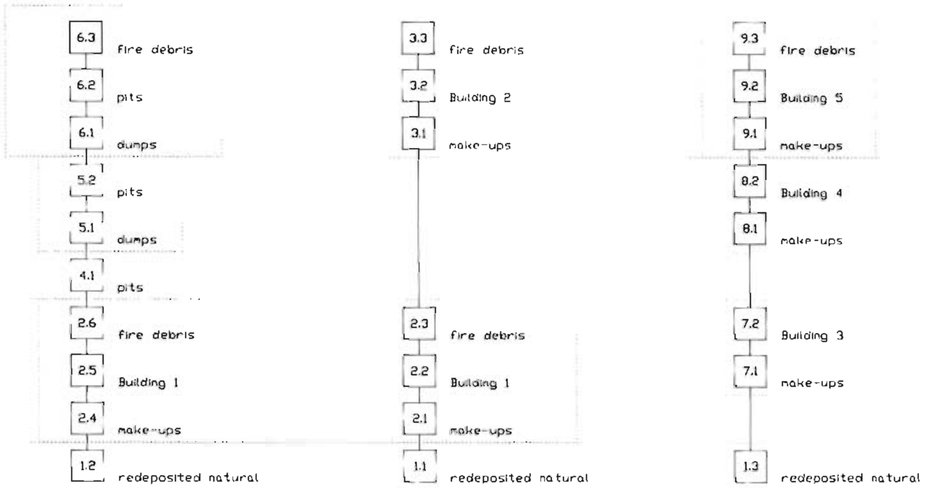


Fig. 6.5 Multi-sequence context-series/Group matrix.

them to be placed together in Group 2. However, the building sequence, Buildings 2 to 5, did not have the same degree of association and as such were placed in independent Groups. At the Inter Group-Discussion level it was suggested that Buildings 2 and 5 were at least in contemporary use immediately prior to the fire horizon (3.3, 6.3 and 9.3) which sealed them. The other buildings can clearly be seen to 'float' in their association with the building sequence in Groups 2 and 3 and the pit sequences in Groups 4, 5 and 6. The possible correlations can be discussed at the Inter-Group level after their individual interpretations have been fully detailed. The fire horizon (3.3, 6.3 and 9.3) was not placed in a single site-wide Group because of the differing character of the material in each area. Although this was probably a direct result of the spatial variations in the character of the material from which it derived, it was considered to be more appropriate to link them within the Inter-Group Discussion rather than with a Group of their own.

The flexilibity of the Group system over a more rigid site-wide periodization is apparent. The above example illustrates how the system can be used to express both the level of interpretative argument whilst providing a rigorous framework for the text.

Interpretations

The interpretative comments resulting from the data should be discussed in a strictly hierarchical form, allowing the author(s) to present their conclusions logically with direct reference to the supporting data or hypotheses. This hierarchical ordering within the report allows the various levels of discussion to be analysed in their own right. It also allows a reader to examine the various levels of interpretation independently. This is particularly useful if the reader wishes to question the overall conclusions regarding the development of a particular site without challenging the construction or interpretation of the context-series, simply correlating the context-series in a different pattern within the parameters defined by their stratigraphic inter-relationships as expressed in the context-series matrix. Alternatively the reader might wish to examine the detailed arguments concerning the interpretation of a context as a floor, which can quickly be found within the appropriate context-series discussion.

There are a number of levels at which interpretations can be made. It is important that these are clearly defined and that the various discussions embodied within the text are inserted at the appropriate time, following a logical order. The justification for all of the discussion sections is that they can only be given when all the supporting data and hypotheses upon which they draw have already been presented.

The basic interpretations of contexts. Basic interpretations are placed immediately after the context data if they are being tabulated or summarized. These comments should be restricted to discussion of the deposition/function of the individual context, for example, the interpretation of a deposit as a floor surface.

Context-series discussion. Placed at the end of a context-series, this involves the discussion of all of the contexts within the series. It will be here that the rationale for the context series is most clearly laid out, for example that the contexts represent levelling activities. It is at this stage that interpretative terms such as ‘Building 1’ can be introduced. Their introduction will depend upon the organization of the context-series. If the evidence is contained within a number of context-series then it will normally be drawn together in the Group Discussions.

Group Discussion. In the Group Discussions a more wide-ranging dialogue can develop. It should form a relatively self-contained unit and draw together all of the context-series contained in the Group and discuss their inter-relationships with the aid of the context-series matrix (Fig. 6.5). It would normally include a full discussion of the relationship of various structures/areas and their development.

If no Groups have been imposed upon the sequence the discussion will take place at the end of the report, although this is usually only left to such a late stage with relatively small sequences.

Inter-Group Discussion. This usually takes the form of a very generalized discussion of the site bringing together the various strands within the sequence, which may have been written up in a number of independent Groups. It will discuss the major changes and 'periods' of land-use suggesting how the Groups might correlate within this interpretative framework. A Group matrix (including context-series), such as Fig. 6.5, should be used to support this discussion.

Dating evidence, periodization and later analysis

Once the above analysis of the structural sequence has taken place and the Archive Report has been written, the dating evidence can be examined. It is imperative that this evidence, which is in itself interpretative, does not influence the formation of the structural sequence.

A *terminus post quem* is established for each context-series from the available date-ranges of the contexts within it. Table 6.1 shows an example.

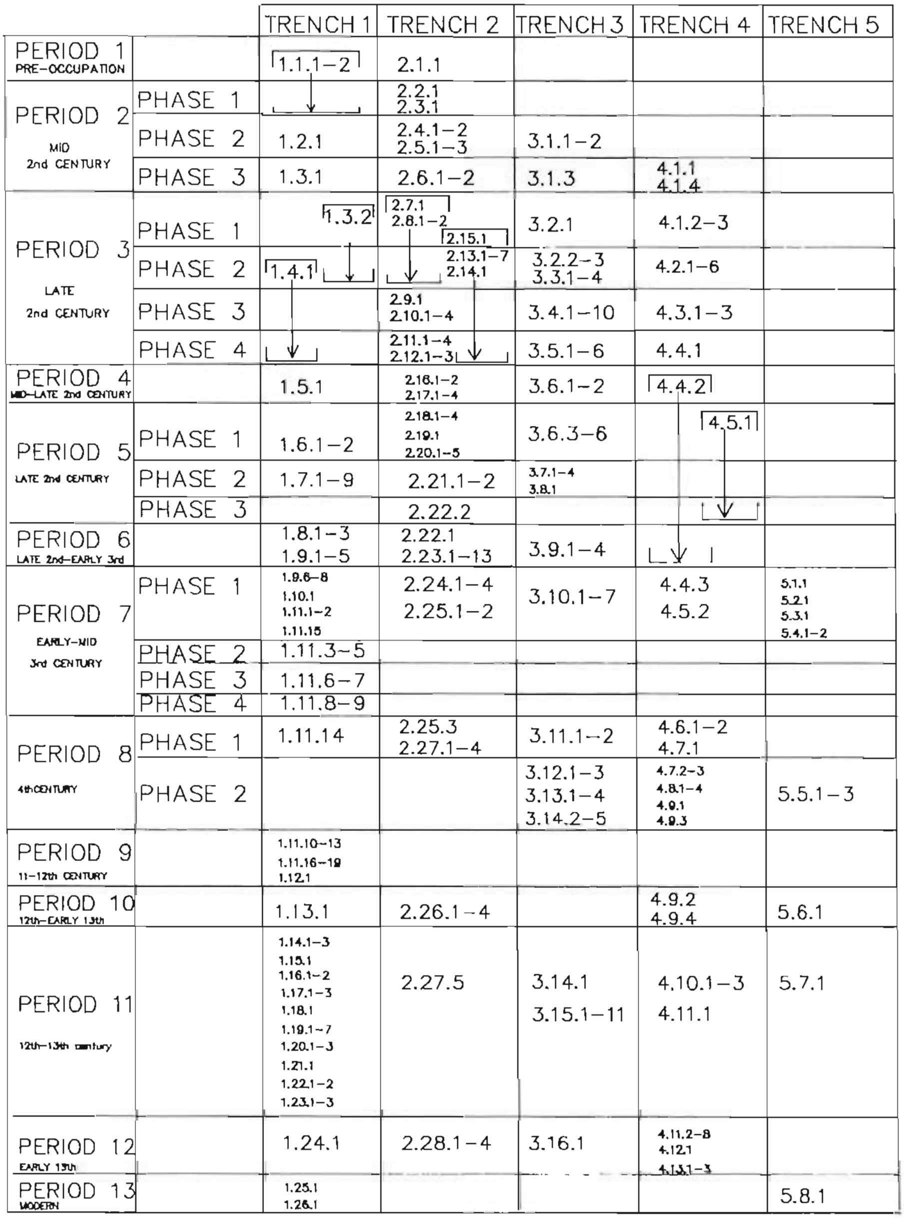
The *terminus post quem* for this context-series is A.D. 55. This date is then compared with those of stratigraphically earlier context-series to establish its potential usefulness. For example, if the stratigraphically preceding context-series had a *terminus post quem* of A.D. 70, then the earlier date of A.D. 55 would be meaningless.

Having established the *terminus post quem* for each context-series these should be listed and included in a chapter on dating evidence, placed after the main body of the report. This should include a discussion, the nature of which will depend on the quality of the dating evidence and the complexity of the sequence. Whatever conclusions are drawn, the structure of the Archive Report should not be altered. If the dating has elucidated some elements of the stratigraphic sequence, suggesting for example a truncation horizon not previously recognized, this should be clearly stated and discussed.

Once the structural sequence and the dating evidence have been analysed in the above manner it is possible to formulate dated periods or phases, which will form the basis of the publication text. If these are expressed in a tabular form (Fig. 6.6) then this information, along with lists showing which stratigraphic units are included within each context-series and Group, may be supplied to the individual specialists who are to analyse the related

Table 6.1 Context-Series 1.1

Context	Earliest date (A.D.)	Latest date (A.D.)
123	40	*c.* 200
134	55	80
167	55	150
180	40	70



		TRENCH 1	TRENCH 2	TRENCH 3	TRENCH 4	TRENCH 5
PERIOD 1 PRE-OCCUPATION		1.1.1–2	2.1.1			
PERIOD 2 MID 2nd CENTURY	PHASE 1		2.2.1 2.3.1			
	PHASE 2	1.2.1	2.4.1–2 2.5.1–3	3.1.1–2		
	PHASE 3	1.3.1	2.6.1–2	3.1.3	4.1.1 4.1.4	
PERIOD 3 LATE 2nd CENTURY	PHASE 1	1.3.2	2.7.1 2.8.1–2 2.15.1	3.2.1	4.1.2–3	
	PHASE 2	1.4.1	2.13.1–7 2.14.1	3.2.2–3 3.3.1–4	4.2.1–6	
	PHASE 3		2.9.1 2.10.1–4	3.4.1–10	4.3.1–3	
	PHASE 4		2.11.1–4 2.12.1–3	3.5.1–6	4.4.1	
PERIOD 4 MID–LATE 2nd CENTURY		1.5.1	2.16.1–2 2.17.1–4	3.6.1–2	4.4.2	
PERIOD 5 LATE 2nd CENTURY	PHASE 1	1.6.1–2	2.18.1–4 2.19.1 2.20.1–5	3.6.3–6	4.5.1	
	PHASE 2	1.7.1–9	2.21.1–2	3.7.1–4 3.8.1		
	PHASE 3		2.22.2			
PERIOD 6 LATE 2nd–EARLY 3rd		1.8.1–3 1.9.1–5	2.22.1 2.23.1–13	3.9.1–4		
PERIOD 7 EARLY–MID 3rd CENTURY	PHASE 1	1.9.6–8 1.10.1 1.11.1–2 1.11.15	2.24.1–4 2.25.1–2	3.10.1–7	4.4.3 4.5.2	5.1.1 5.2.1 5.3.1 5.4.1–2
	PHASE 2	1.11.3–5				
	PHASE 3	1.11.6–7				
	PHASE 4	1.11.8–9				
PERIOD 8 4thCENTURY	PHASE 1	1.11.14	2.25.3 2.27.1–4	3.11.1–2	4.6.1–2 4.7.1	
	PHASE 2			3.12.1–3 3.13.1–4 3.14.2–5	4.7.2–3 4.8.1–4 4.9.1 4.9.3	5.5.1–3
PERIOD 9 11–12th CENTURY		1.11.10–13 1.11.16–19 1.12.1				
PERIOD 10 12th–EARLY 13th		1.13.1	2.26.1–4		4.9.2 4.9.4	5.6.1
PERIOD 11 12th–13th century		1.14.1–3 1.15.1 1.16.1–2 1.17.1–3 1.18.1 1.19.1–7 1.20.1–3 1.21.1 1.22.1–2 1.23.1–3	2.27.5	3.14.1 3.15.1–11	4.10.1–3 4.11.1	5.7.1
PERIOD 12 EARLY 13th		1.24.1	2.28.1–4	3.16.1	4.11.2–8 4.12.1 4.13.1–3	
PERIOD 13 MODERN		1.25.1 1.26.1				5.8.1

Fig. 6.6 Period and phase groupings showing context-series and Groups expressed in a tabular form.

material. They will of course also be supplied with a copy of the Archive Report and access to site data. (In the example shown in Fig. 6.6 the evidence has been considered on a trench-by-trench basis; there are no site-wide Groups.)

The route to publication of all aspects of the site involves close cooperation between all those concerned in the further analysis of the evidence. This is a vital part of the research and may be particularly so, on those sites where the dating evidence is inconclusive and where it may be possible to assign context-series and Groups to more than one dated phase or period. The function of the Archive Report in this process is to provide, firstly, a solid stratigraphic framework within which re-interpretation can take place, and secondly, a clear discussion of the way that the published interpretations were derived, in a form that can be readily understood and challenged. It thus provides the vital link between the published interpretation and the original site data.

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7 Building stratigraphic sequences on excavations: an example from Konstanz, Germany

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Before discussing some practical aspects of stratigraphic recording and sequence-building during the ongoing excavation, it is worth considering the historical events leading to the development of any site stratification. It is inquisitiveness about these events which causes the archaeologist to dig and it is excavation which causes the creation of stratigraphy. The stratigraphy itself is the fundamental basis for the interpretation of the history of any archaeological site.[1] Fowler (1977: 87–90) has described some possible historical events thus:

> During the use of a site, layers are disturbed by man's activities. He digs parts of layers away and redeposits the material elsewhere. He digs trenches, graves, pits and postholes. He excavates ditches and builds banks with the spoil, he alters the bank's construction, he replaces wooden structures with stone: he alters the shape, size and functions of buildings, he lays floors on top of existing ones, he digs cellars with floors well below his contemporary ground surface by cutting down into its earlier levels and redistributing their material in later contexts. All the time he is fighting a battle with the rising tide of his rubbish: he buries it, he heaps it up, he spreads it around, he dumps it elsewhere. . . .

Despite its lucidity and its implicit understanding of human activity as the main agent in the formation of *archaeological* stratification, this description can, of course, be nothing more than an oversimplification: a selection from a myriad of factors involved in the build-up of stratification. Extant site stratification can be very complex indeed. This is especially true of urban sites, where the results of perhaps millennia of human (not forgetting animal and vegetable) activity combine with the effects of natural forces to shape the intricate stratigraphical lattice of layers, postholes, pits, ditches, drains, walls and streets, to name but a few. Yet it is the ultimate aim of every excavation to discover the nature of the historical events which gave rise to the stratification as it exists today and if possible, to go beyond the events and explain the reasons for them.

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[1] Throughout this paper Harris's practice of making a distinction between 'stratigraphy' and 'stratification' has been followed, stratification being understood to be the arrangement of contexts extant in the earth – whether or not they be excavated by an archaeologist, stratigraphy being the study of those contexts: i.e., the recording and analysis of them.

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The *main foundation* of such historical interpretation, model-building or whatever the process might be called, is the stratigraphic data, the source of which is at its most immediate and accessible at the point of interaction between stratigraphy (on paper) and stratification (in the earth): i.e. at any and every moment during the ongoing excavation. It thus followed that detailed stratigraphic recording should take place during the excavation, from day to day or hour to hour, as and when relationships between contexts become clear.

Any number of systems have been developed in the hope of ensuring accurate and detailed stratigraphic recording. The mainstay of the majority of modern recording strategies is the context-sheet – essential for recording the types of stratigraphic relationships (above, below, cuts, filled by, etc.) – as well as descriptive data about the physical properties of the context and perhaps interpretative comments. Despite the amount of detailed information which can be present in context-sheets (augmented of course by detailed plan and section drawings), they alone are not a sufficient basis for precise stratigraphic recording of a type which both encourages clear thought on site and is immediately intelligible for the purposes of post-excavation work. As every excavator knows, as the number of contexts increases, so do the intellectual difficulties of grasping the complexity of the stratigraphy.

The recognition of this problem during the latest campaign of excavations on the 'Fischmarkt' in Konstanz (see Appendix B to this chapter) led to the introduction of the Harris Matrix as an integral part of the recording system to be used *during* the excavation process. Some initial experience had been gained in converting the conventional stratigraphic record (based on a context-sheet system) into a stratigraphic sequence using the Harris Matrix. This was found to be useful though extremely demanding, and it was realized that this step could be done away with, if the Matrix could be integrated into the recording system in daily use on the excavation. It is the simplicity of the Harris system in reducing all possible forms of stratigraphic connections to four basic relationships – or more properly, three relationships and one non-relationship – and then using them to build up complete stratigraphic sequence diagrams piece for piece (Figs 7.1 and 7.2), that makes it ideally suited for use on site. Experience in Konstanz has shown that once introduced to the system and after some initial guidance, experienced excavators with responsibility for an area or trench were capable of producing accurate sequence diagrams of their area on a context for context basis without difficulty. The developing sequence was checked at regular intervals by the site supervisor. The same workers, however, were faced with a more difficult task when asked to create sequence diagrams of areas dug earlier, where the Harris Matrix had not been employed and stratigraphic recording had taken place only on context sheets and drawings.

The construction of stratigraphic sequence diagrams on site using the Harris Matrix has a number of advantages to offer – both for the daily excavation strategy and the final analysis and publication of the excavation. The following list does not claim to be exhaustive:

1. The use of the Matrix forces the excavator into a rigorously logical approach to complicated stratigraphic situations which might, at first sight, seem unsolvably illogical. The 'clear and logical thinking' that Wheeler expected of those undertaking 'the task of identification and correlation of the strata or layers . . . of a site' (1954: 43) has a powerful aid in the Harris Matrix.

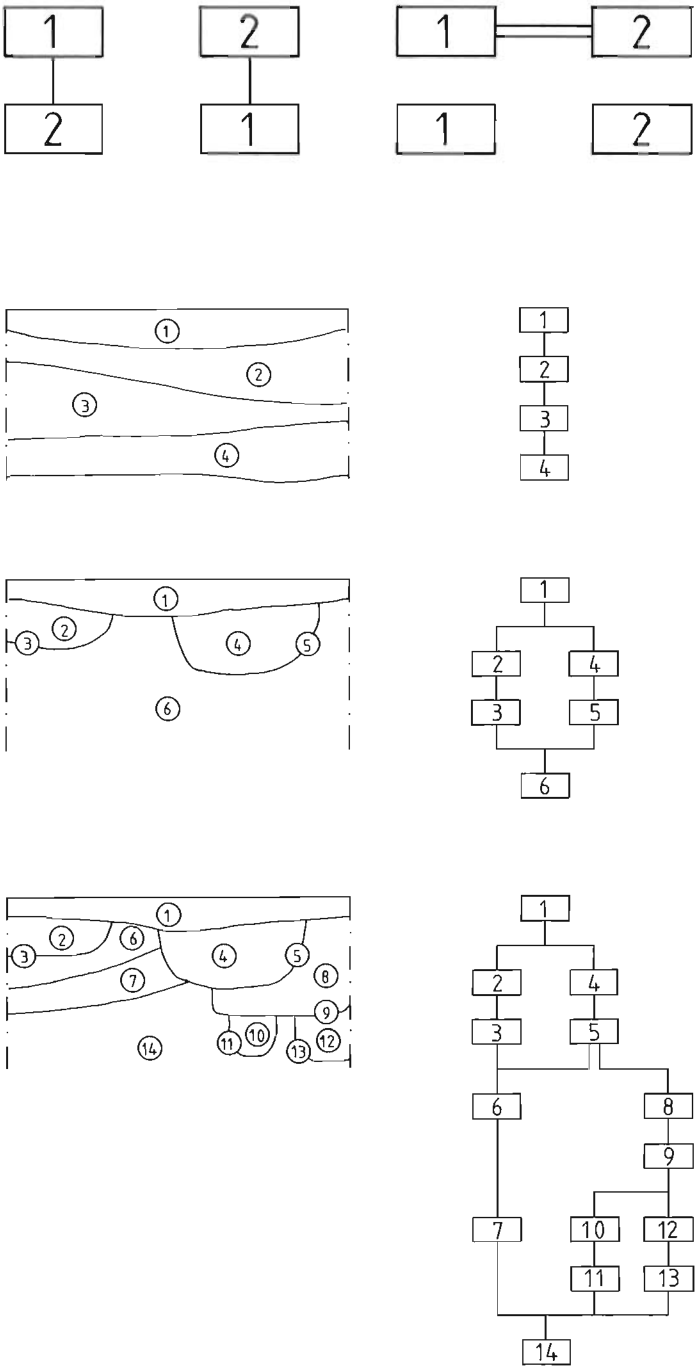


Fig. 7.1 (Above) The four basic rules of stratification *and* stratigraphy: 1 is later than 2; 2 is later than 1; 1 and 2 are of identical date; 1 and 2 have no direct temporal relationship. (Below) Three increasingly complicated sections with corresponding sequence diagrams constructed on the basis of the four rules above.

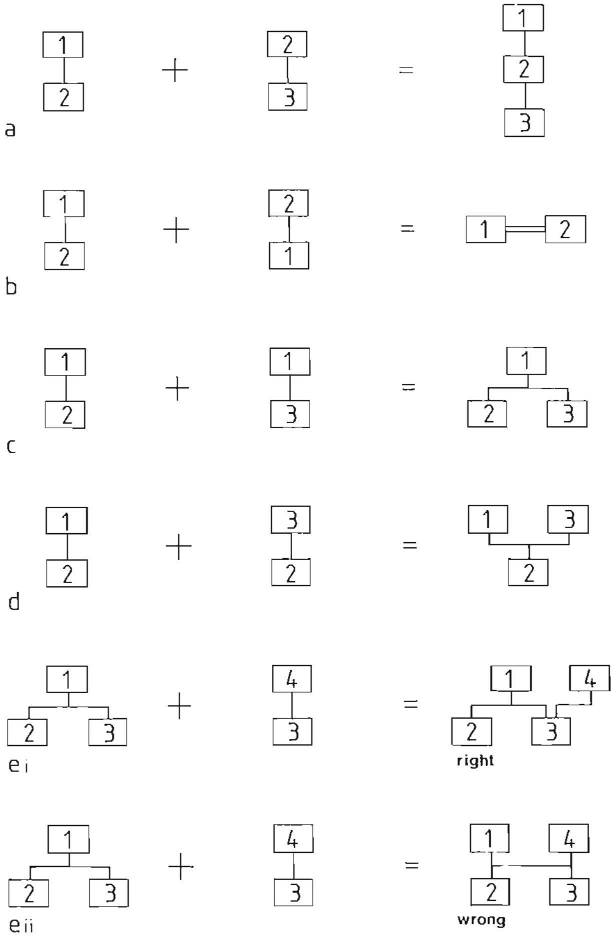


Fig. 7.2 Combining individual stratigraphic relationships to form the stratigraphic sequence (after Orton 1980: Figs 3.2 and 3.3.)

2. The use of the Matrix functions as an automatic check on the stratigraphic thinking of the excavator. Stratigraphic problems must be solved on site and be included in the developing sequence diagram. That is not to say that the recognition of stratigraphic relationships on site is always easy. However, the chances of success are far greater than when an attempt is made to solve stratigraphic problems on the draughting table, long after the excavation has ended, armed only with the written, drawn and photographic record and fading memories.

3. The construction of the sequence diagram will quickly indicate wrongly understood relationships: 'vicious circles', for example, which might otherwise go unnoticed, stand no chance of inclusion in the stratigraphic sequence (Fig. 7.3).

4. The Matrix is a great 'leveller', guaranteeing that each observed unit of stratification 'from major defensive ditches to small spreads of charcoal' (Lynch 1977: 97) is included in the stratigraphic sequence and will therefore be given due consideration in interpretational analysis.

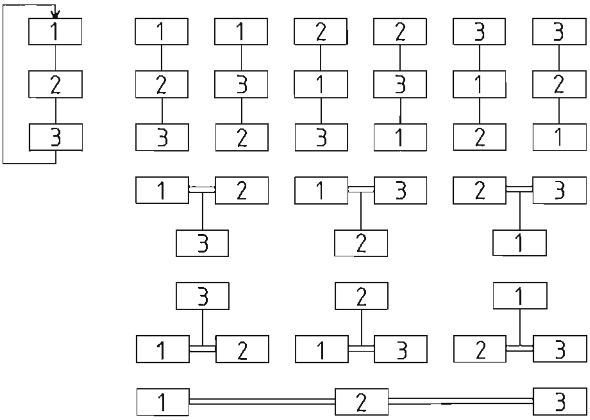


Fig. 7.3 Wrongly understood stratigraphy. A 'vicious circle' consisting of 1 lies over 2 lies over 3 lies over 1. Any one of the 13 stratigraphically correct sequences deriving from the 1–2–3–1 sequence may be the right one.

5. The construction of the sequence diagram ensures that the stratigraphy is built up only on the basis of direct earlier–later relationships between individual units of stratification. It clarifies the distinction between direct relationships of immediate stratigraphic significance and non-direct physical contacts of far less stratigraphic importance. This is not to dismiss non-direct physical contacts as being of no importance –it is quite possible that such observations will be important for the historical interpretation of a site. As far as stratigraphic recording is concerned, the correct 'route' between two contexts separated from each other by other contexts can only be *via* those separating contexts. Direct lines between such contexts cause stratigraphic 'short-circuits' and therefore do not belong in the sequence diagram. In the author's experience it is this distinction that causes the newcomer to the system the most problems – though it does not usually take too long for it to become apparent that failing to adhere to the four basic principles mentioned above simply results in a chaos of 'crossed wires' (Fig. 7.4).

6. In contrast to conventionally published stratigraphical representations in the form of section drawings, the Harris sequence diagram enables all contexts composing a stratigraphy as well as their relationships to each other to be viewed *simultaneously*. Recent analysis in Konstanz has shown that up to 40% of recorded contexts do not appear in any of the section drawings – whether they be of pragmatically laid sections across specific contexts or the sides of trenches. In the face of the obvious practical and financial impossibility of reproducing a complete set of complimentary layer plans and section drawings for publication, a combination of a selection of informative plans and sections, showing the *nature* of contexts and their relationships, together with a sequence diagram of the complete site stratigraphy offers an ideal solution.

7. The sequence diagram serves as an excellent basis for the final 'phasing' of the site: i.e. the grouping together of individual contexts into blocks representing historical events (see below). The existence of the stratigraphic sequence guarantees the stratigraphic integrity of the site and allows the phasing to be as detailed as necessary to answer questions posed (see Fig. 7.10).

Having considered some aspects of the theoretical background to the Harris Matrix and

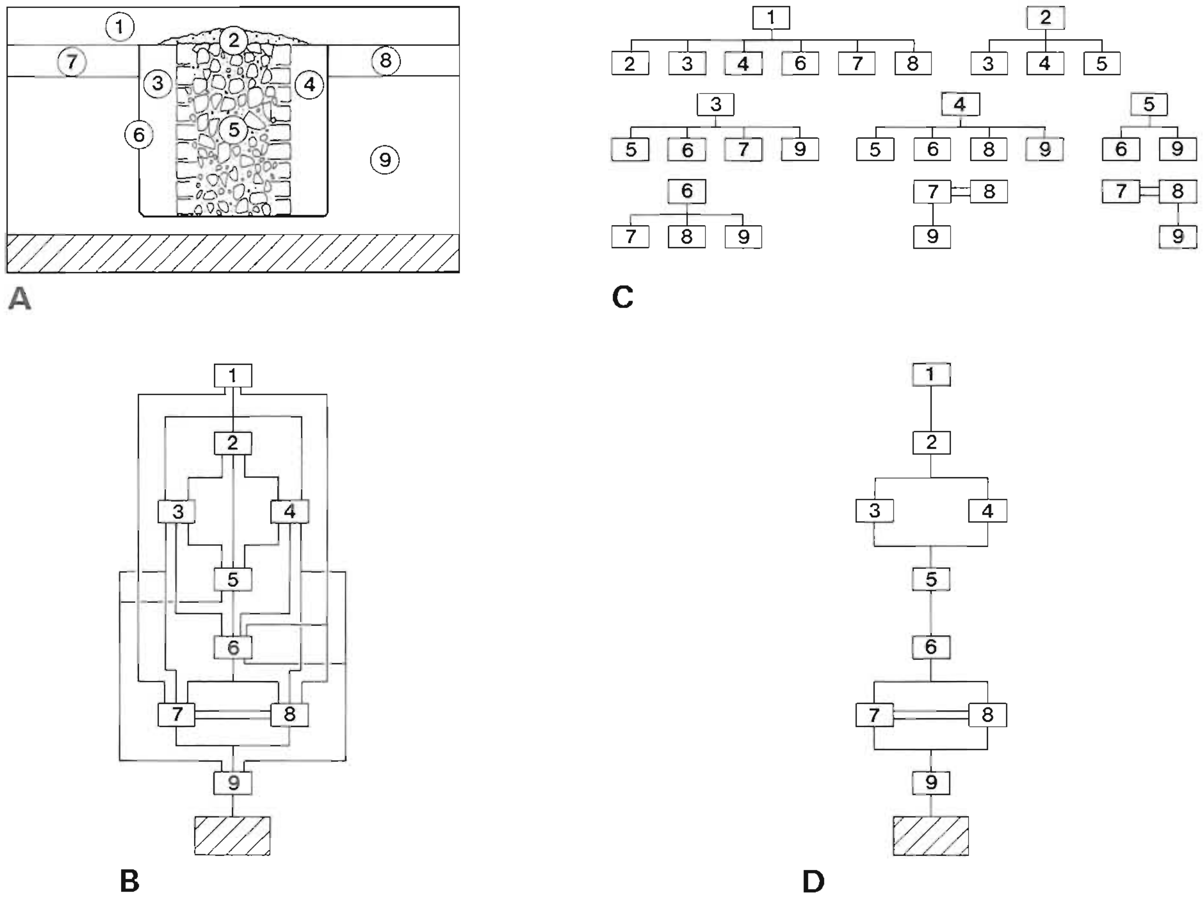


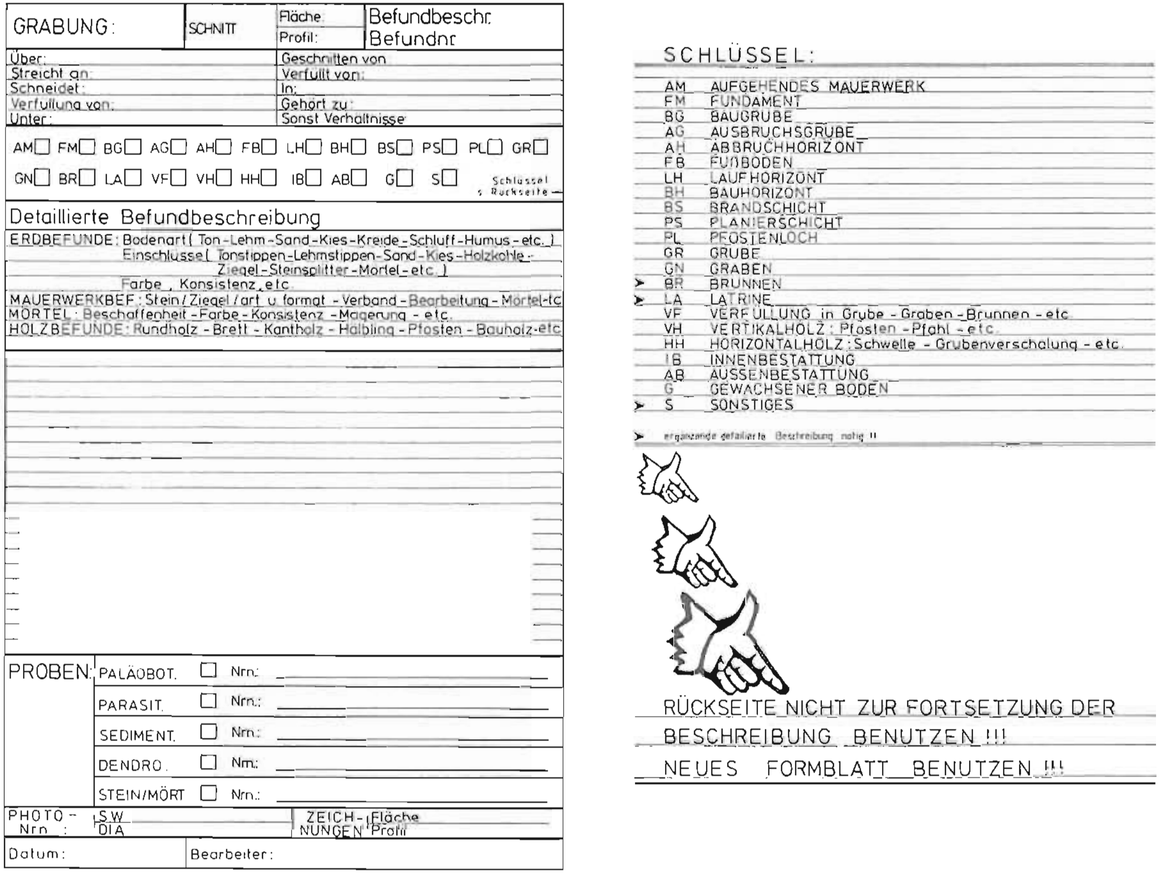
Fig. 7.4 The difference between direct temporal relationships of immediate stratigraphic significance and physical contacts of far less stratigraphic importance: B and C show all physical relationships present in section A; D is the 'pure' stratigraphic sequence showing only immediate temporal relationships. (After Harris 1979: Fig. 28.)

advantages to be gained by integrating it into the daily excavation record, it is now possible to turn to the practical aspects of excavation technique and recording which should ensure a complete and accurate stratigraphic record. At this point it must be stressed that other aspects of recording (of a non-stratigraphic nature) need in no way be sacrificed in favour of stratigraphy. The system should be such that all types of ongoing excavation recording are treated as equally important. By no means does it have to be weighted in favour of stratigraphy; rather stratigraphic recording, as far as the ongoing record is concerned, should be weighted equally with other types of recording and receive equal daily attention. This is in contrast to excavation strategies where stratigraphic correlation is considered to be an exclusively post-excavation activity.

Little needs to be said about the actual technique of excavation in Konstanz. It can simply be stated that it is stratigraphic, ideally each site being taken apart, context for context, in reverse order to its original (historical) development. Constraints on this strictly stratigraphical approach are of a non-archaeological, logistical or political nature – a wall which is physically impossible to remove with the means at our disposal, or a structure which is considered to be of public interest and therefore worth conservation. Naturally, even the most rigorous application of stratigraphic theory cannot, in the face of the 'human factor', guarantee error-free digging. It does, however, raise the chances that any errors will be recognized early and the stratigraphic sequence put right whilst the dig is still in progress – at the latest during the final check of the sequence.

At the centre of the Konstanz recording system is a context sheet (Fig. 7.5), which was originally developed specifically for conditions of inner city excavations in Konstanz. It has since found wide acceptance and has been used successfully on other urban excavations in Germany (e.g. Ulm, Biberach, Flensburg). A simple numbering system is employed, each context being treated equally as an individual unit of stratification, no distinction of separate numbering systems existing for different kinds of contexts. Every context recognized as such is numbered and recorded on an individual context sheet. As soon as the stratigraphic relationships to the adjacent contexts become clear the context number is added to the stratigraphic sequence being built up on the pre-printed Harris Matrix sheet (Harris 1989: fig. 8). The relationships filled in on the context sheet and the inclusion of the context number in the developing sequence function as essential checks on each other. In common with most modern excavations, the excavation diary as the main repository of excavation data has been dispensed with, thus eliminating the time-consuming and error-ridden post-excavation reorganization of data necessary to retrieve complete information on each individual context. The employment of a context-related system rather than a chronologically oriented one is of major conceptual importance and is worth stating explicitly: only by treating each context – each unit of stratification – as an individual and unique entity *during* the excavation and recording it as such, is it possible to construct stratigraphy on a daily basis. This is in direct contrast to the day-book approach which implies by its very nature that the construction of 'the stratigraphy' is an exclusively post-excavation activity.

The following example from the Fischmarkt excavation serves to show the development of the Harris Matrix during the ongoing dig. Schnitt 10 (Figs 7.6–7.8), one of 15 trenches fully excavated between 1984 and 1986, offers an interesting though not unduly complicated stratigraphy and is ideally suited for the following demonstration. The order of excavation and the development of the stratigraphic sequence as it took place are reconstructed here – as far as that is possible on paper.



GRABUNG:

SCHNITT

Fläche:

Profil:

Befundbeschr.

Befundnr.

Über:

Streicht an:

Schneidet:

Verfullung von:

Unter:

Geschnitten von

Verfullt von:

In:

Gehört zu:

Sonst Verhaltnisse

AM☐ FM☐ BG☐ AG☐ AH☐ FB☐ LH☐ BH☐ BS☐ PS☐ PL☐ GR☐

GN☐ BR☐ LA☐ VF☐ VH☐ HH☐ IB☐ AB☐ G☐ S☐

Schlussel s. Ruckseite —

Detaillierte Befundbeschreibung

ERDBEFUNDE: Bodenart (Ton - Lehm - Sand - Kies - Kreide - Schluff - Humus - etc.)
Einschlusse (Tonstippen - Lehmstippen - Sand - Kies - Holzkohle - Ziegel - Steinsplitter - Mortel - etc.)
Farbe, Konsistenz, etc.

MAUERWERKBEF.: Stein / Ziegel / art u. format - Verband - Bearbeitung - Mörtel - etc

MÖRTEL: Beschaffenheit - Farbe - Konsistenz - Magerung - etc.

HOLZBEFUNDE: Rundholz - Brett - Kantholz - Halbling - Pfosten - Bauholz - etc

PROBEN:
- PALÄOBOT. ☐ Nrn.:
- PARASIT. ☐ Nrn.:
- SEDIMENT. ☐ Nrn.:
- DENDRO. ☐ Nrn.:
- STEIN/MÖRT. ☐ Nrn.:

PHOTO-Nrn.: SW / DIA

ZEICHNUNGEN: Fläche / Profil

Datum:

Bearbeiter:

SCHLÜSSEL:

	AM	AUFGEHENDES MAUERWERK
	FM	FUNDAMENT
	BG	BAUGRUBE
	AG	AUSBRUCHSGRUBE
	AH	ABBRUCHHORIZONT
	FB	FUßBODEN
	LH	LAUFHORIZONT
	BH	BAUHORIZONT
	BS	BRANDSCHICHT
	PS	PLANIERSCHICHT
	PL	PFOSTENLOCH
	GR	GRUBE
	GN	GRABEN
➤	BR	BRUNNEN
➤	LA	LATRINE
	VF	VERFÜLLUNG in Grube - Graben - Brunnen - etc.
	VH	VERTIKALHOLZ: Pfosten - Pfahl - etc.
	HH	HORIZONTALHOLZ: Schwelle - Grubenverschalung - etc.
	IB	INNENBESTATTUNG
	AB	AUSSENBESTATTUNG
	G	GEWACHSENER BODEN
➤	S	SONSTIGES

➤ ergänzende detaillierte Beschreibung notig !!

RÜCKSEITE NICHT ZUR FORTSETZUNG DER BESCHREIBUNG BENUTZEN !!!

NEUES FORMBLATT BENUTZEN !!!

Fig. 7.5 The Konstanz context-sheet.

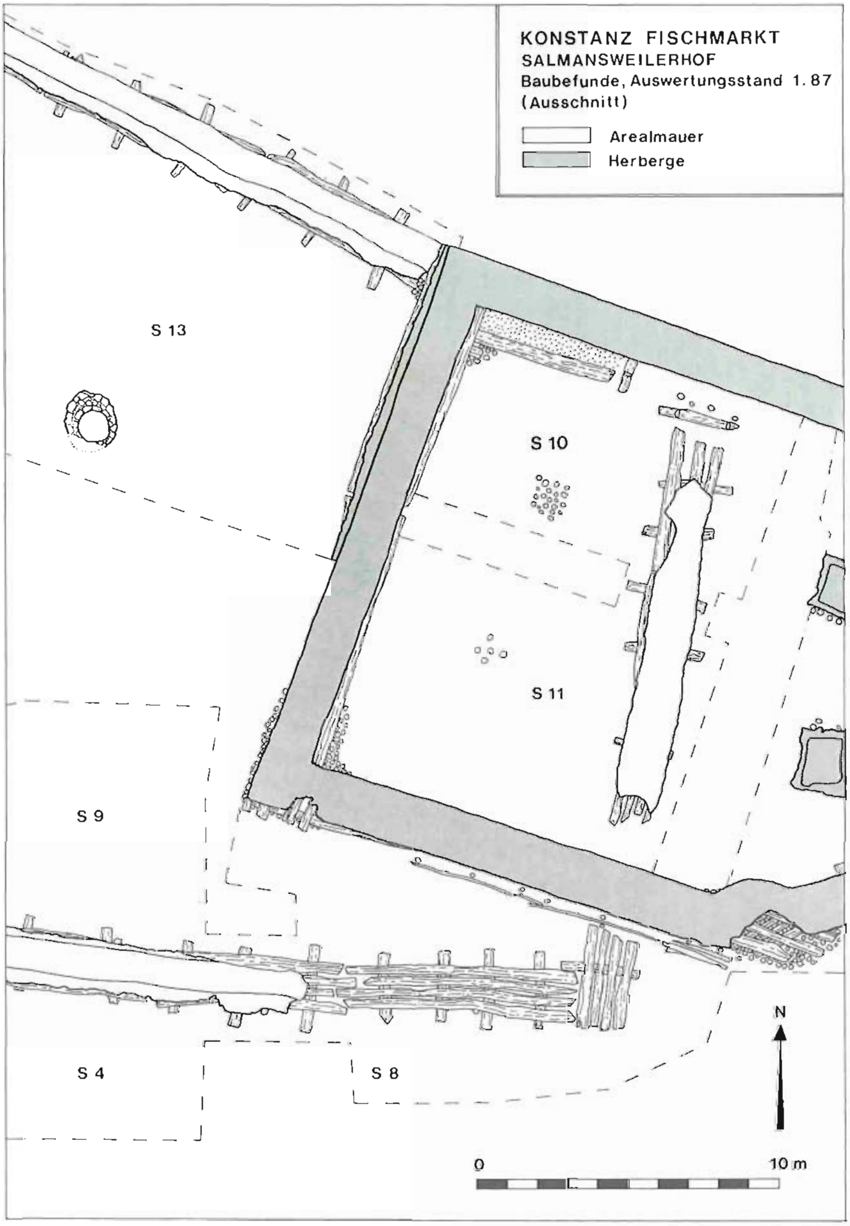


Fig. 7.6 Excerpt from the Fischmarkt plan, showing the position of trench S 10.

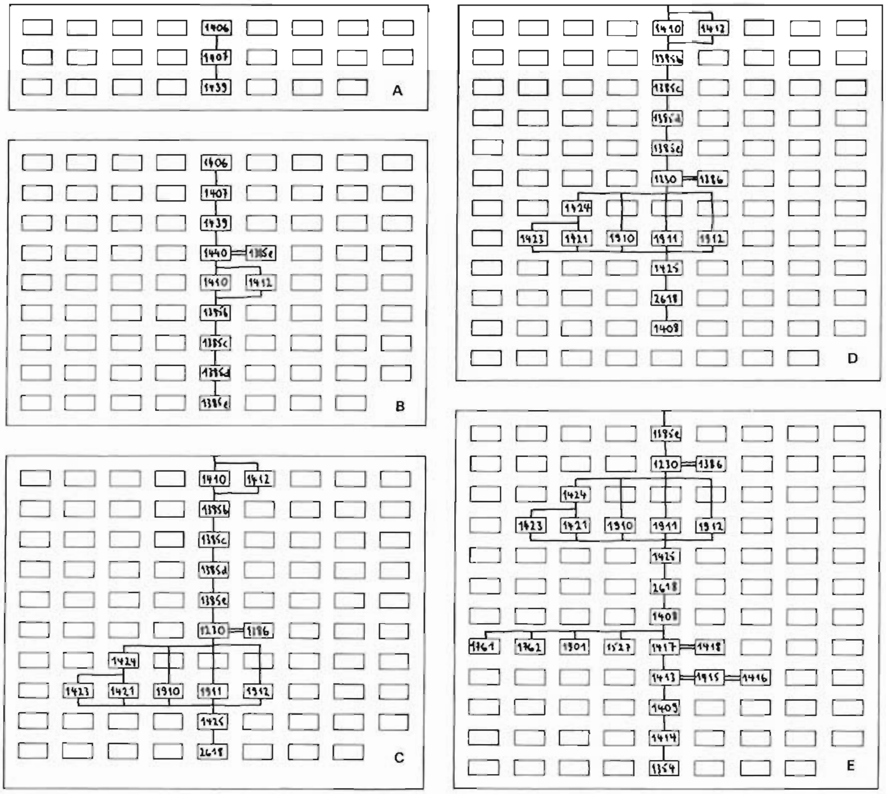


Fig. 7.7 Fischmarkt trench S 10: The development of the stratigraphic sequence during the ongoing excavation.

Step 1. The latest undisturbed medieval contexts were to be found on and in an earth 'ledge', approx. 1 m wide, running N–S along the inside of the west wall of the 'Herberge'. The three latest contexts – row of stones (1406), sand (1407) and gravel (1439) – lay superimposed *over* the fill of the Herberge's foundation trench. They gave only indication of a possible original interior floor-level of the Herberge (Fig. 7.7A).

Step 2. After the three layers above (step 1) had been removed, the uppermost fill of the foundation trench itself (1408) (in Harris's terms a *vertical layer interface*) and the latest layer through which the foundation trench was cut (1417–1418) could be identified. The foundation trench-fill consisted of five superimposed layers, (1440 = 1385) to (1385b–e). In two areas, the surface of 1385b was heavily compacted. These areas of compaction (1410 and 1412) were taken to indicate trampling within the partially filled foundation trench and as such, though having no substance of their own, were treated as contexts in their own right, pure *horizontal layer interfaces* (Fig. 7.7B).

Step 3. After the removal of the foundation trench-fill the stratigraphic relationships of the construction elements of the west and north walls of the Herberge could be recorded and added to the ongoing sequence (1230 = 1386, 1421, 1423, 1424, 1425, 1910, 1911, 1912, 2618). The wall, in conformity with stratigraphic theory, should at this point have been

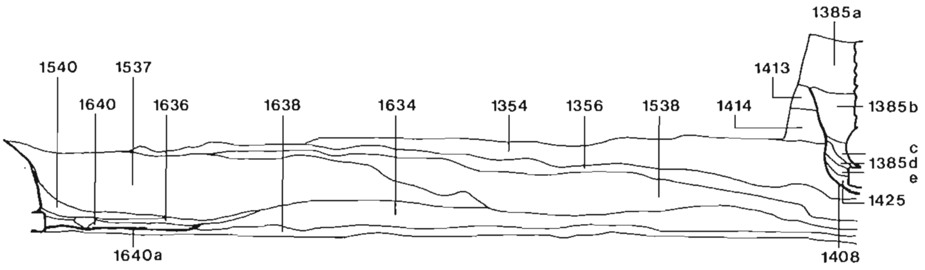


Fig. 7.8 Fischmarkt trench S 10: The main south section, showing only layers and interfaces.

removed. It was not: the reasons being purely logistical, the excavation team having no means at its disposal to undertake the 'demolition'. After the dig had ended, the contractors building the underground car park which had made the excavation necessary, were forced to use explosives to rid themselves of the Herberge wall, it having defeated their heavy machinery (Fig. 7.7C).

Step 4. The *vertical feature interface,* the original cut of the foundation trench (1408) was added to the Matrix (Fig. 7.7D).

Step 5. Five identifiable superimposed layers of sand and gravel, through the uppermost of which the foundation trench of the Herberge had been cut, were excavated layer for layer (1354, 1409, 1413–1415–1416, 1414, 1417–1418) and in turn added to the sequence. Under the undermost fill of the foundation trench and outside the line of the north wall of the Herberge were four wooden posts (1527, 1761, 1762, 1901), apparently truncated by the trench itself, though they had no direct stratigraphical relationship with any of the layers (above) through which the cut was cut. The *raison d'etre* of these posts was not understood at this stage; they were, however, drawn into the sequence – in their correct stratigraphic position *under* the foundation trench interface (Fig. 7.7E).

Step 6. The removal of the undermost layer excavated in step 5 (1354) revealed two layers of tightly interlatticed branches and twigs (1356, 1540), separated by the muddy deposits (1358, 1359, 1536, 1537). These layers were interpreted as repeated attempts to combat flooding of the original building-site caused by seasonal fluctuations of the water level in Lake Constance (see Fig. 7.9).

Step 7. The removal of the undermost layer of branches revealed further muddy deposits, identifiable as two distinct, superimposed layers (1635, 1636).

Step 8. (1635) and (1636) were in turn excavated onto the surface of the easily recognizable peaty layer (1634), which had in turn been cut by the foundation trench (1640b) of the original enclosing wall of the 'Salmansweiler Hof'. The filling of the foundation trench (1640) was excavated and details of the wall-construction added to the sequence (1355, 1524, 1525, 1526, 1534, 1640, 1641, 1642, 1759, 1760). At this point it was realized that the posts (1527, 1761, 1762, 1901), which had already been added to the sequence but not understood at step 5, belonged to this building-phase and could therefore now be correctly positioned.

Step 9. The final excavation step entailed the straightforward removal of each of the peat layers (1634, 1637, 1639) onto the natural clay (N).

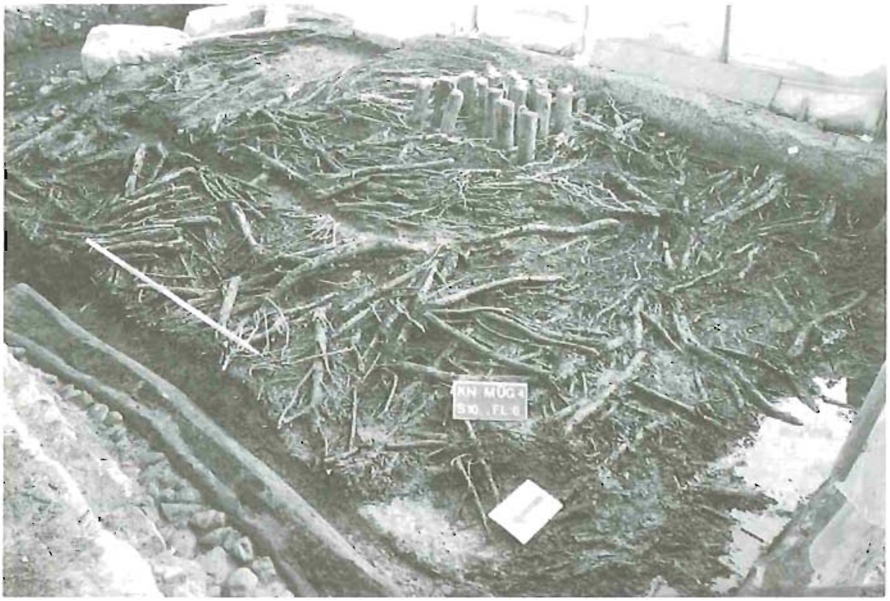


Fig. 7.9 Branch and twig layer, no. 1356.

After completion of the excavation, the stratigraphic sequence, plans, sections and context sheets were checked against each other and the sequence was redrawn in ink to facilitate post-excavation analysis (Fig. 7.10). At this stage the final 'phasing' – the interpretation of the historical events represented by the present-day stratigraphy – was added. This phasing, which can only be finalised after completion of the excavation, is by no means an exclusively post-excavation activity – it is much more a case of testing the interpretation which grew up during the excavation against the stratigraphic sequence, which is complete only when the last archaeological context has been removed.

The completed stratigraphic sequence for Fischmarkt trench S 10 is illustrated in Fig.7.10, which is a translated and revised version of a sequence diagram first published in a German paper (Bibby 1987: Abb. 10) and included by Harris in the second edition of *Principles of Archaeological Stratigraphy* (Harris 1989: Fig. 11). It should be noted that, although the phasing shown here is slightly different from that of the original diagram, this in no way affects the stratigraphic sequence, which was created during the excavation and cannot and indeed does not need to be changed now.

The stratigraphic sequence is divided into six phases, each of which groups together individual contexts and represents a particular historical event which led to the creation of stratification. Phases 2, 3 and 5 are further divided into sub-phases, purely to allow description of the building techniques used for the enclosure wall (phase 2a–d) and the wall of the Herberge (phase 5a–f) and the relationships of the building components to each other, as well as to show waterlogging of the original (enclosure) building-site and attempts to combat it (phase 3a–d). Induced in the phased stratigraphic sequence are two *Period Interfaces*. These Period Interfaces are considered to represent surfaces which remained in existence for periods of time in which little or no activity took place to cause

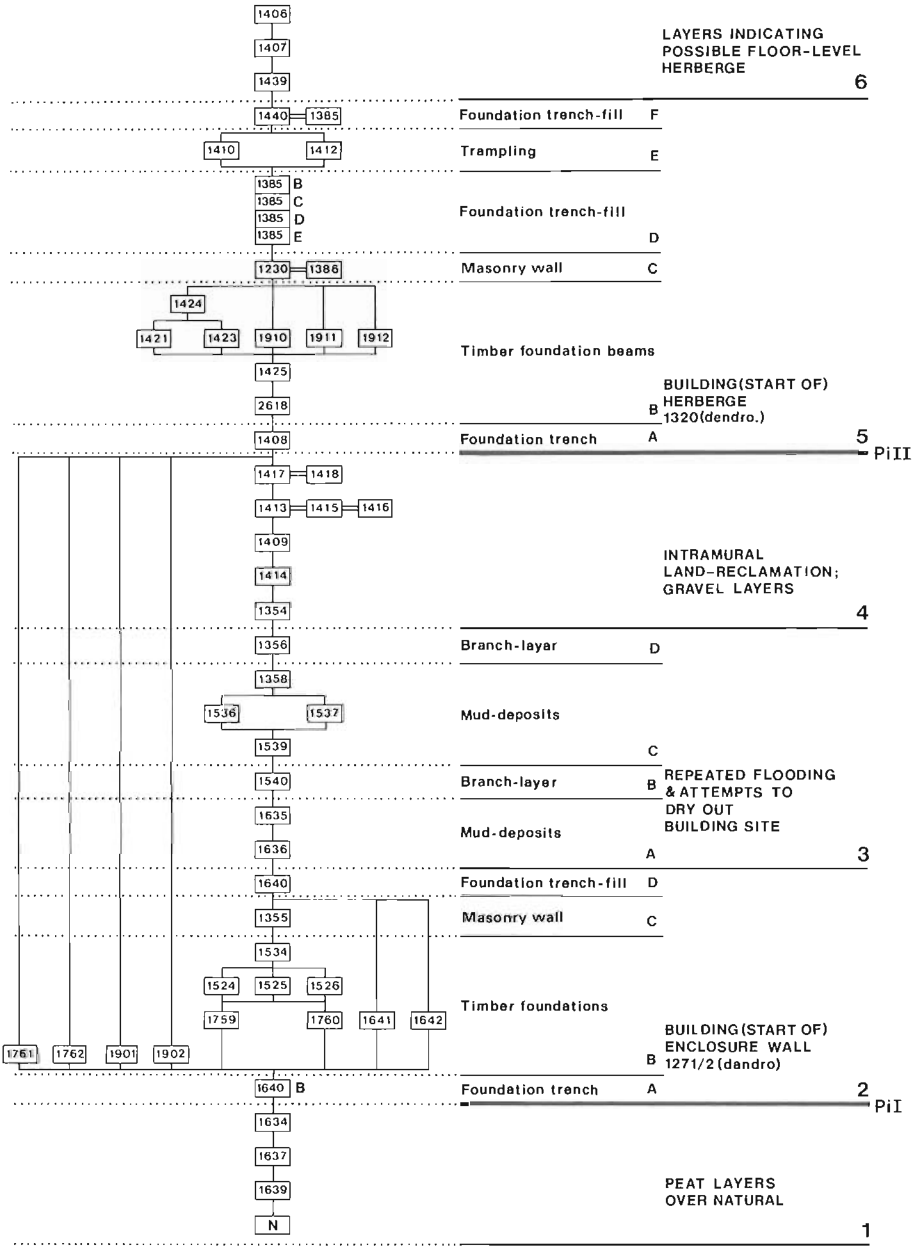


Fig. 7.10 Fischmarkt trench S 10: The completed, phased stratigraphic sequence.

the build-up of stratification – or the destruction of already existing stratification for that matter. Period Interface I represents the lakeside setting prior to any building activity on the site, whilst Pi II represents a static period after the completion of building work on the enclosure wall and land reclamation within that enclosure, lasting until the start of construction work on the Herberge.

Through dendrochronological dating of the oak foundation-timbers of both the original enclosure wall and the Herberge it was finally possible to fix two points of absolute time into the floating stratigraphic sequence. The sequence had originally been built-up on-site and phased alone on the basis of the physical properties of the contexts in combination with their stratigraphic relationships. The addition of the absolute dates, which only became available after the phasing was finished, conflicted neither with the original sequence nor with the phasing.

A fairly simple example was chosen for this paper to illustrate the construction of the stratigraphic sequence during the ongoing excavation, for the sake of clarity. In the 15 years or so since the publication of the first of Harris's papers, it has become clear that the Harris system continues to work on sites much more complex than the example cited here – indeed, it is on complex sites that it really comes into its own. As an irreducibly simple tool for the recording of individual stratigraphic relationships and in turn the construction of complete stratigraphic sequences, the advantages it offers are not open to question. These practical advantages simply mirror the laws of archaeological stratigraphy as systematized by Harris. Armed with a thorough understanding of these laws and the ability to apply them in the construction of the stratigraphic sequence, the archaeologist is in possession of a powerful intellectual weapon to guide his approach to any excavation, no matter how complicated the stratification may be.

Acknowledgements. This paper would not have been possible without the help and enthusiasm of the excavation director, Dr Judith Oexle of the Landesdenkmalamt Baden-Württemberg.

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Appendix A. Semiotic suggestions

The stratigraphic sequence constructed using the Harris Matrix displays the stratigraphic position of each identified and excavated context more than adequately. As a tool which was originally conceived to do just that – nothing more and nothing less – it does not, in its raw form, display any information as to the *types* of contexts displayed within this sequence. The inclusion of non-stratigraphic, descriptive information to the sequence may be desirable; for, as the excavation progresses and increasing numbers of contexts are added to the sequence, it can become tiresome finding – for whatever reason – one or another individual context. At that moment when a context is of particular interest and needs to be found swiftly, it develops a strong tendency to lose itself somewhere in the stratigraphic sequence. This phenomenon is not due to any weakness in the system. In fact the opposite is true. It is precisely because the Harris system is capable of coping with an unlimited number of contexts, that the sheet size of the stratigraphic sequence can become daunting.

In route-finding around large stratigraphic sequences, 'signposts' or 'flags' indicating context-types can be a great help. They should however be discreet and in no way distract from the primary function of the stratigraphic sequence. They should also be simple to use and easy to understand. For this reason the rectangles containing the context numbers should not be shaded or coloured, as this tends to confuse the overall appearance of the sequence. The scheme suggested here is one whereby linear symbols or ideograms are added around the *outside* of the context-number rectangles. They can be drawn lightly in pencil and can be easily moved together with their context number should this prove necessary.

Such context symbols, as well as three symbols representing different forms of context-contemporaneity, are suggested in Fig. 7.11A. These symbols are of course influenced by the specific excavation conditions familiar to the author – room for the development of other symbols to meet the conditions of other excavations is limited only by the imagination of the excavator. Of particular interest and practical use is the fact that the symbols suggested here may easily be combined with each other, so that a wall, for example, in its foundation trench with filling would appear as shown in Fig. 7.11B(iii) (bottom three contexts).

Looking at Fig. 7.12 and comparing it with Fig. 7.10, the similarity between the phases in Fig. 7.10 and the combined ideograms of Fig. 7.12 will be immediately apparent. This suggests that the symbols added to the stratigraphic sequence as the nature of each context becomes clear, during the excavation, can function not only as 'signposts' in the sequence but also as important aids to the phasing of the site.

Appendix B. Excavations on Fischmarkt, Konstanz 1984–86: short summary

The excavations on the Fischmarkt in Konstanz took place prior to the building of an underground car park. The site lies on low ground close to the shore of the Bodensee (Lake Constance) to the east of a higher sandy ridge, which appears to have been settled as early as the second century B.C.

The Fischmarkt excavations have resulted in new evidence for land reclamation and development of the lakeside site in the thirteenth and early fourteenth centuries. Documentary sources confirm Cistercians from Salem Abbey (founded 1134) on the north shore of the Bodensee as owners of the land and perpetrators of this reclamation.

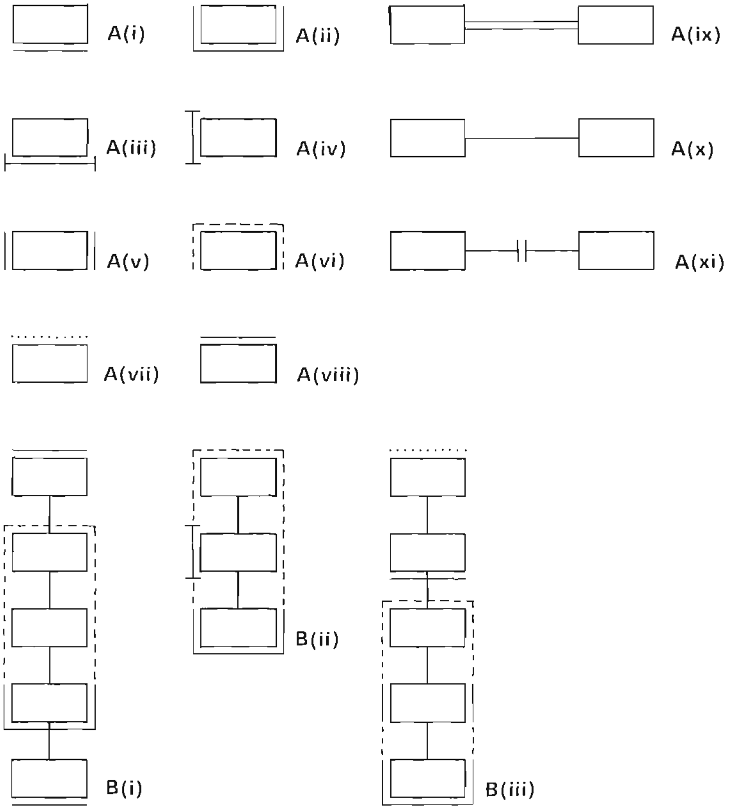

Fig. 7.11 Some suggestions for 'flags' indicating context-types and contemporaneity-forms. (A) Individual flags: (i) earth layer; (ii) vertical feature interface – posthole, pit, trench, etc.; (iii) horizontal timber; (iv) vertical timber; (v) masonry/brick wall; (vi) fill (of posthole, pit, trench, etc.); (vii) layed floor – cobbles, tiles, etc.; (viii) trampled earth floor; (ix) two contexts with individual context-numbers, considered to be identical in both makeup and date; (x) two contexts of identical date, one being an inclusion in the other; (xi) two contexts of different makeup butting against each other in such a way that no earlier–later relationship may be recognized. (B) Combined flags: (i) pit cutting an earth layer, filled by two superimposed fills and sealed by a trampled earth floor; (ii) posthole with original post and fill surviving *in situ*; (iii) masonry wall in foundation trench with trench fill; trench fill covered by an earth layer (say sand) upon which a cobbled floor has been laid.

The earliest structure on Fischmarkt was a strong enclosure wall, the foundations of which consisted of horizontal rows of oak beams up to 8 m long. The foundations were further strengthened on the underside by piles and cross-beams set at regular intervals. Dendrochronological dates indicate that building work did not begin before winter 1272/73. The wall, which served to delimit the area owned by the Salem monks, also functions as a barrier, limiting the spread of sterile sand and gravel layers, which were systematically tipped to a height of over 2 m, in order to raise the ground level inside the wall. Between 30 and 50 years after the building of the enclosure wall its eastern end was partially destroyed, when the 'Herberge' was erected. The Herberge, later known as the

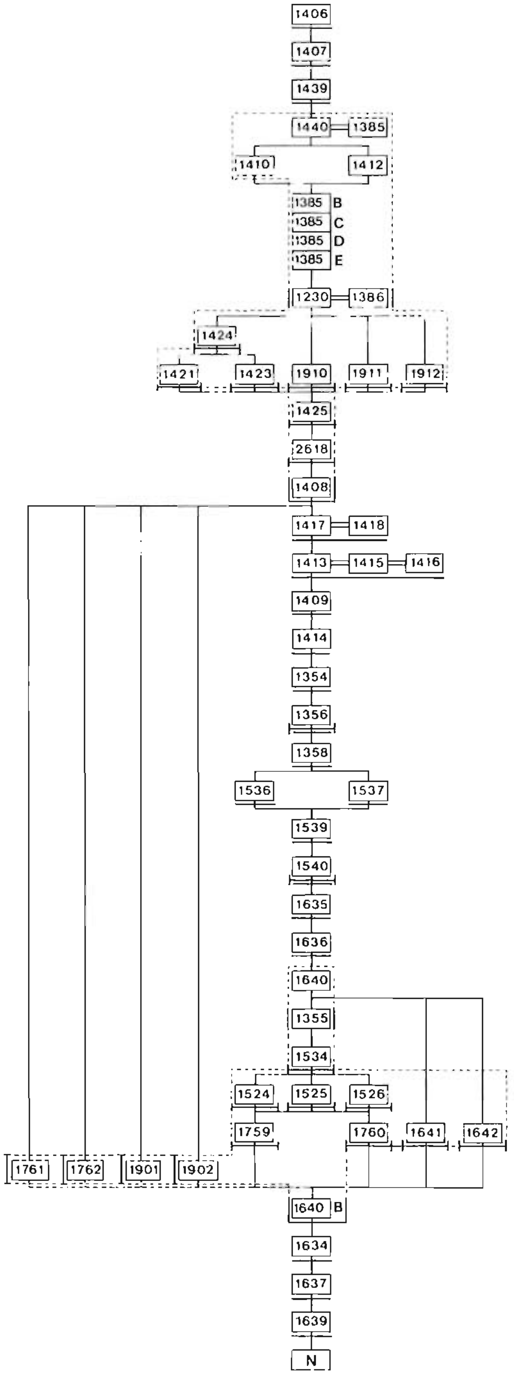

Fig. 7.12 Fischmarkt trench S 10: the completed stratigraphic sequence with flags as suggested in Fig. 7.11 added.

'Salmansweiler Hof' was a well documented building, only demolished in 1865 and previously thought to have been built in the fifteenth century. During the excavations the unusual five-sided ground-plan of the Herberge was completely revealed. As with the enclosure wall, the double-skinned walling had been built on a foundation of oak beams. Under the beams at each of the five corners were pile-rafts of up to 450 individual softwood piles, driven into the soft natural clay. To the east of the Herberge was a double-sided, clay-filled wooden dam, apparently contructed to combat flooding of the building-site, which in early summer lay up to 1.5 m below Bodensee water level. That the builders of the original enclosure wall had had similar problems with flooding is illustrated by the interlatticed layers of branches belonging to phase 3 of trench S 10 (Fig. 7.9). Excavations to the south of the enclosure wall revealed a series of find-rich and detrital layers, containing large quantities of household and 'industrial' rubbish – approx. 500 000 individual objects. This material had also been used for land reclamation, though it contrasts with the sterile gravel employed by Salem Cistercians inside their enclosure. It seems that the citizens of Konstanz, having watched the monks reclaiming land on the shore of the lake, adopted the idea and emulated them, using whatever material was at their disposal to raise the ground level, thus creating for themselves badly needed new building land in the rapidly expanding town of the High Middle Ages.

8 Three-dimensional assessment of activity areas in a shell midden: an example from the Hoko River Rockshelter, State of Washington

BARBARA R. STUCKI

Introduction

A main thrust in the study of spatial patterning in archaeological sites has centred on correlating remains from past activities. The ability to link cultural refuse in time and space depends on (1) the identification of factors influencing the spatial association of refuse, and (2) the time frame of the analysis. Ethnoarchaeological and taphonomic studies describe a wide array of processes that affect the formation and alteration of site deposits (e.g. Kent 1984, 1985; Spurling and Hayden 1984; Gould 1978; Woods and Johnson 1978). In contrast, little attention has been focused on developing methods to calibrate the temporal relationships among cultural debris (Harris 1979a; Chang 1967: 23).

The measurement and scale of time used in a spatial analysis plays an important role in the identification of past behaviour. A study of activities requires a time scale with short intervals to detect variability at the level of individual events. Behaviourally meaningful spatial distributions reflect the routines of daily life that became patterned in space. A comprehensive chronology of deposition at a site is needed to discover such consistent use of space. Stratified sites have a detailed record of relative time documented in the sequence of site deposits. However, traditional approaches to intrasite spatial analysis rarely include the temporal dimension of behaviour because of the complexity of the stratigraphy at such sites.

This paper describes a stratigraphic technique which can be used to investigate the temporal patterning of activities at a site. It was developed to link cultural remains in time and space for a more comprehensive, three-dimensional analysis of activity areas. The technique is particularly suited to those sites where there are no apparent breaks in the depositional sequence that might demarcate different periods of site use. This method builds on the Harris Matrix approach, which places the stratigraphic relationships of all layers in a site into relative chronological order. A stratigraphic time scale is constructed from this sequence of deposits.

The technique was used to analyse the distribution of cultural sediments and features in the shell midden at the Hoko River Rockshelter site. In this paper, I use this method to answer the following broad questions: Was refuse deposited uniformly throughout the Hoko Rockshelter or are there localized areas of deposition? If such areas exist, are there variations in the types of features and refuse among different areas of activity? Can site

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structure be detected from patterns in the spatial arrangements of these areas? Is there evidence of a trend through time in the types of refuse deposited in the rockshelter or their location?

Identifying activity areas in shell middens

The stratigraphic record of activities

Archaeological sites which contain a high proportion of shell among their cultural materials are characterized as shell middens. Sediments at these sites are often primarily cultural in origin. Shell is a durable, bulky form of refuse that accumulates rapidly into distinct deposits (Meehan 1982). As a result, debris from short-term activities such as a family meal often have relatively high archaeological visibility. Layers of shell are also resistant to the effects of trampling and scuffage, which mix refuse from different activities (Hughes and Lampert 1977).

Many shell middens contain a bewildering array of deposits, and the stratigraphy at these sites can be very complex. In habitation areas, layers are often small, thin, and widely scattered. Specially prepared 'living floors' or features may also truncate refuse layers. Shell middens which were repeatedly inhabited for the seasonal exploitation of marine resources consist of refuse from many different periods of site occupation.

From activities to activity areas

Complex stratigraphic relations among refuse at shell middens make it difficult to correlate cultural items. As a consequence, conventional archaeological research at these sites tend to describe prehistoric activities rather than site structure (Waselkov (1987) provides a recent review of the literature). In addition, most studies of shell middens rely on extensive samples of deposits to evaluate economic activities and site use (e.g. Peacock 1978; Ascher 1959; Bailey 1975; Koloseike 1970). Researchers who use this approach often assume that there is a high degree of homogeneity in the structure and content of a site (Treganza and Cook 1948; Ambrose 1967; Bowdler 1983).

Recently, archaeologists have begun looking beyond activities to an analysis of the spatial organization of behaviour. Research by Wessen (1982), Heulsbeck (1981), and Gleeson *et al.* (1979) in the Pacific Northwest suggest that the arrangement of artefacts and faunal remains in prehistoric houses at the Ozette site may reflect the social ranking of the families who occupied them. Spatial patterning of high status items was also discovered in a historic Haida house by Fladmark (1973). Miller (1983) and Peter (1986) outlined the boundaries of habitation and processing areas at the surface of the Hoko Rockshelter site. Living areas in sites with multiple occupations have been analysed by Coutts (1970) and Ham (1985). Barber (1983) identified shifts in the location of habitation and refuse discard areas.

Strategies for delimiting activity areas

When correlating prehistoric remains to define activity areas, archaeologists want to group cultural debris into clusters which have some behavioural significance. Given the complex relationship between behaviour and the archaeological record (e.g. Binford 1983; Schiffer 1972, 1976; Ammerman and Feldman 1974), there are two basic strategies by which to approach this task (Hill 1970). One strategy seeks the most direct link between behaviour and refuse by isolating the remains of activities that were performed in the past. The spatial distribution of these activities can then be used to partition a site into activity areas. An alternative approach starts by looking at how cultural remains accumulated in a site. Recurrent deposition in specific areas may indicate a stable arrangement of behaviour, or the effects of the contextual framework within which space was organized (Yellen 1977; Binford 1978; Simek 1984; O'Connell 1987). Evidence of specific activities and their context can then be discovered in the patterning of debris embedded in different areas.

A traditional intrasite spatial analysis uses the distribution of artefacts on prehistoric 'living floors', to delineate the boundaries activity areas (see Carr (1984) for a recent review of methodology). This approach is difficult to apply to complex, stratified sites such as shell middens. One important reason for this are the problems archaeologists face when correlating refuse in time as well as space at these sites (Avery 1974; Brennan 1977; Sanger 1981).

A basic assumption of spatial analysis is that the remains being associated are contemporaneous. In sites where many activities do not leave a distinct archaeological record, a considerable amount of time may be compressed within a thin 'living floor' (Binford 1981: 197; Gould 1980: 197). The paucity of deposits resulting from a slow rate of site formation can thus give an illusion of contemporaneity among artefacts. In contrast, the distinctiveness of shell layers and their rapid rate of accumulation increases the resolution of debris from individual activities. In shell middens, a single occupation may consist of hundreds of layers. The complex stratigraphic relations among these deposits clearly show the cumulative effect of activities performed in the past.

Before attempting to infer the arrangement of behaviour in shell middens, it is thus important to first assess the time equivalency of cultural debris. Spatial associations among refuse linked in time can then be used to delimit areas of activity. One way to incorporate the temporal dimension into an intrasite spatial analysis is to examine how refuse accumulated in a site through time. This strategy, which focuses on areas of recurrent deposition, was used to analyse the organization of space at the Hoko Rockshelter.

The technique

The technique presented here uses the stratigraphic record at a site to identify patterns in the accumulation of cultural refuse. Areas of activity are defined based on the temporal relationships among debris. Cultural remains within each area provide clues as to how different portions of the site were used through time.

The technique is divided into three tasks. The first task is to establish a relative time chronology for the site. This is accomplished by placing all layers in a site into sequential order. The second task is to locate these layers in space, following the sequence of accumulation defined by the relative chronology. This serves as the basis for identifying distinct areas of recurrent deposition. The third task is to correlate different areas of activity within a stratigraphic time framework. This is important because events at one location cannot be considered independently of those in adjacent areas.

Defining the stratigraphic sequence

The graphic method developed by Harris (1975, 1979b) was used to diagram the sequence of deposition at the Hoko Rockshelter. There are several steps involved in this approach. First, all layers exposed in profile are mapped for each section. A description of the composition of each layer is also recorded. Every layer that is drawn is assigned a unique number. Next, the stratigraphic position of layers are carefully evaluated based on the physical relationships among adjacent layers. Successive deposits in each section are placed in sequential order. Finally, individual sequences are combined to build the relative chronology for the entire site.

The Harris Matrix aproach provides an exact method for charting the sequence of accumulation of deposits at a site. The Harris diagram displays all stratigraphic relations of each layer to every other layer in a site. This is particularly important for complex, stratified sites where the stratigraphic relations among many, widely scattered layers must be considered to identify areas of recurrent deposition.

Establishing a stratigraphic time scale

Areas of activity are derived from relationships which are characterized by their position along a sequence. In sites where successive layers accumulate one after the other like beads on a thread of relative time, chronological relations are represented by a unilineal stratigraphic sequence. In unilineal sequences, the temporal arrangement of activity areas is derived in a straightforward manner, following the law of superposition. Remains of the oldest activity area are recorded at the base of the sequence, while those of more recent areas are closer to the top of the sequence.

Deposits in complex, stratified sites do not accumulate following a unilinear sequence. Instead, activities may take place in several locations in the site. Some of these activities may overlap in time. Where there is such a complex pattern of site use, there are many threads of relative time. These are woven together into an intricate web of temporal relations among deposits at a site. This web is represented stratigraphically by a multilineal sequence.

The succession of areas of activity cannot be inferred directly from a multilineal sequence. This is because deposits from adjacent areas are not directly superimposed. Therefore, to establish a chronology of site use, the archaeologist must first determine the degree of correspondence in the stratigraphic position of different areas of activity. Various methods of correlation are available to establish time equivalent intervals in multilinear stratigraphic sequences. The most precise way to correlate areas of activity is to use a dating method which gives the absolute age of cultural remains. Radiocarbon dating works well if there is a wide range in the ages of the deposits between areas. However, since the time span of most site occupations is short, radiocarbon dates may not be sufficiently precise to distinguish time differences among various areas. Under these circumstances, archaeologists must rely on a stratigraphic time scale to correlate areas of activity.

A stratigraphic time scale is contructed based on the relative chronological ordering of deposits. The passage of time is measured by changes reflected in the succession of layers. The smallest unit used for measuring time is the layer. Within a given period, a sequence with many layers will provide finer divisions of stratigraphic time than one with only a few deposits. The resolution of temporal relationships among cultural remains increases as divisions of the time scale become more refined.

It is important to have the highest possible resolution of relative time to correlate areas of activity. This is accomplished in a multilinear sequence by tracing out the thread of relative time with the most layers. The path so defined provides the finest divisions of the stratigraphic time scale. It is used as the reference sequence for the site. Various other threads of activity through time can be correlated stratigraphically in relation to this reference sequence.

Application of the technique: the Hoko River Rockshelter site

Description of the site

The Hoko River Rockshelter (45CA21) is located at the mouth of the Hoko River, on the Strait of Juan de Fuca, about 30 km from the northwest tip of the State of Washington. This large shelter is situated in a cliff, with its base about 7 m above mean low tide (Fig. 8.1). It was occupied from about 900 to 100 B.C. (Croes and Hackenberger 1988).

A diverse assemblage of refuse fills the interior of the rockshelter (Fig. 8.2). Six types of deposits were identified (Wigen and Stucki 1988). These are: (1) humus 'floors' – layers consisting primarily of humus with low concentrations of other remains; (2) hearth deposits – layers of dense charcoal, ash or mixed charcoal and gravel; (3) shell deposits – shell, sometimes mixed with humus; (4) hearth refuse – mixtures of charcoal, ash and humus; (5) 'general' refuse – a diverse mix of debris where no one constituent predominates; and (6) other deposits – rare combinations of sand, shell, humus and pebbles. Layers of dense shell were deposited outside and to the back of the rockshelter. Except for a few, distinct rodent burrows, the deposits do not appear to have been extensively turbated. In addition, the rockshelter is out of the range of tidal action or the effects of winter storm waves. It has thus been protected from extensive erosion.

An analysis of faunal remains (Wigen and Stucki 1988) and shell (Hurst 1986) indicate a fall/winter occupation of the rockshelter during the time period included in this study. Despite evidence of intermittent use, it is not possible to distinguish different site occupations. There are no major sedimentological changes or evidence that the site was abandoned for periods long enough to accumulate a distinct layer of roof-fall. Humus 'floor' deposits are too small to define extensive living surfaces (Samuels 1983). Artefacts consist primarily of thin, bone points (Croes 1985). These are common in artefact assemblages on the Northwest Coast within the last 1200 years (Mitchell 1971).

The stratigraphic sequence at the Hoko Rockshelter

The spatial analysis was restricted to 757 layers which were deposited on interior of the rockshelter, stratigraphically between Layer 838 and Layer 4. These deposits contain remains from the most recent site occupations. They range in depth from 10 cm to 95 cm.

Figure 8.2 provides an example of how the Harris Matrix sequence was derived from the stratigraphic record at the site. Physical relations among adjacent layers were first

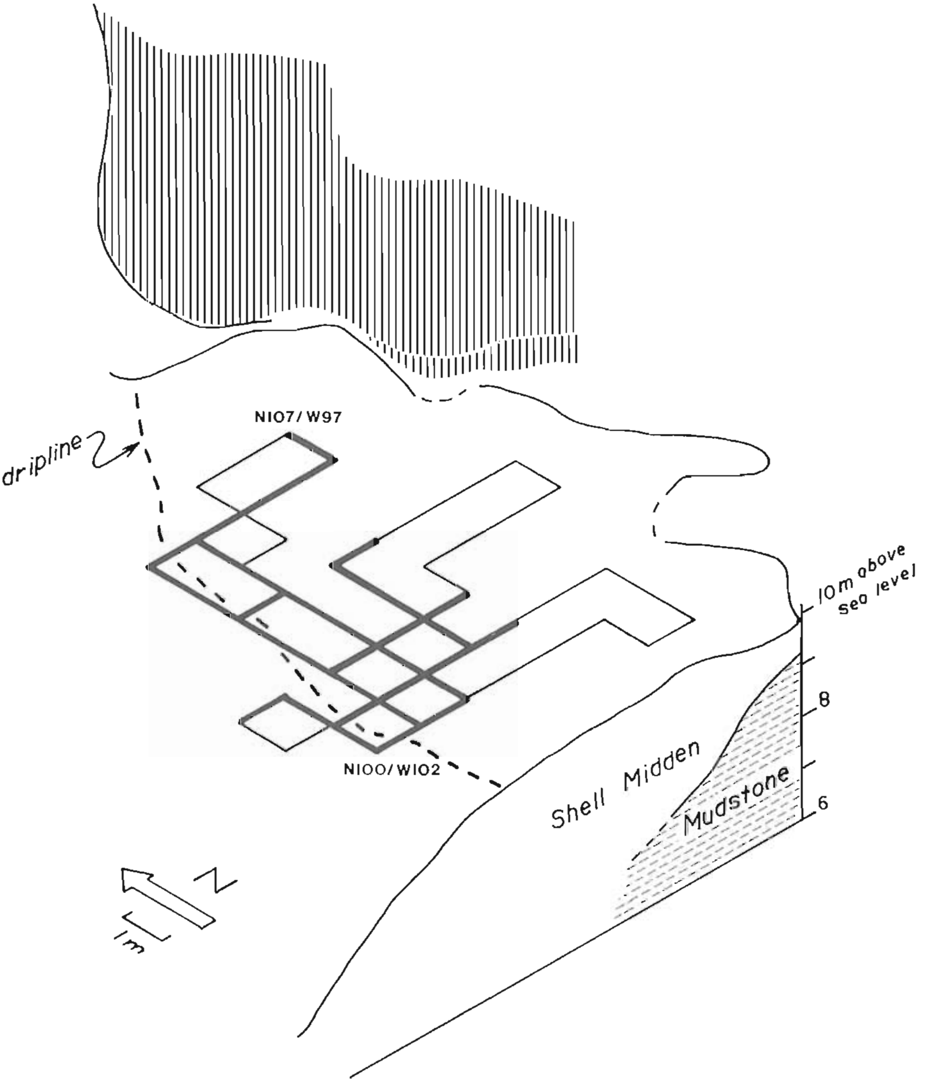

Fig. 8.1 Isometric view of the Hoko River Rochshelter site, showing the location of the excavation units on the interior of the shelter. Bold lines delineate the location of stratigraphic profiles which were used in this study.

carefully analysed and recorded in the field. Abrupt boundaries between deposits, which can be located within a few millimetres, are represented by solid lines. Dashed lines are used where contacts between adjacent layers are more diffuse and temporal relations are less evident. Each layer identified in the field was assigned a unique number. Deposits from a stratified pit or hearth were grouped as a single depositional event (such as pit 'AK'). The Harris diagram of unit N102/W100 charts the relative position of these various layers and places them into sequential order.

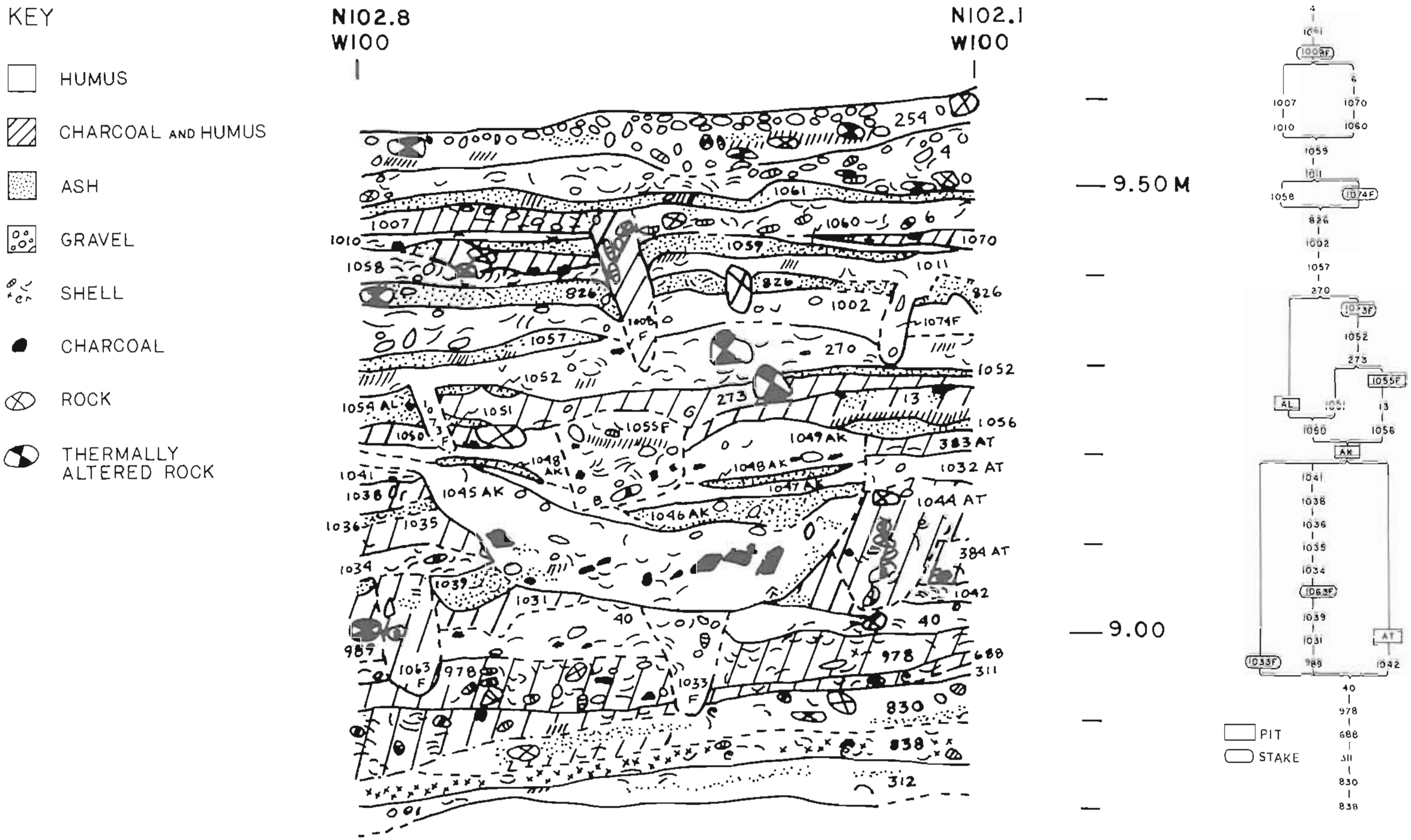

Fig. 8.2 The stratigraphic sequence of unit N100/W102 shown in a Harris diagram. This sequence includes layers which were deposited stratigraphically between Layer 838 and Layer 4. Such individual sequences were combined to build the relative chronology for the entire site.

Correlating activities to define site structure

This study is based on an analysis of deposits from 34 linear metres of recorded microstratigraphy. When stratigraphic sequences from individual sections are incorporated into a Harris diagram for the entire site, the result is a very complex, multilinear sequence (Fig. 8.3A). The many threads of activity represented in this diagram clearly indicate that there are numerous areas where refuse accumulated in the rockshelter.

To untangle the web of temporal and spatial relations among these areas of activity, I next identified the reference sequence for the site. This was accomplished by tracing out the path with the greatest number of layers (Fig. 8.3B). The chronicle of refuse accumulation outlined by the reference sequence was used to identify areas of recurrent deposition. Nine areas of activity (S5–S13) were defined by following successive layers of cultural debris to identify shifts in the location of deposits through time.

Other areas of activity were identified in relation to the reference sequence. For example, in the Harris diagram there are several threads of activity that represent deposits which accumulated some time after the formation of Layer 838 and before construction of Feature CO (Fig. 8.3A–L4A). These layers of refuse were all deposited in one area within the

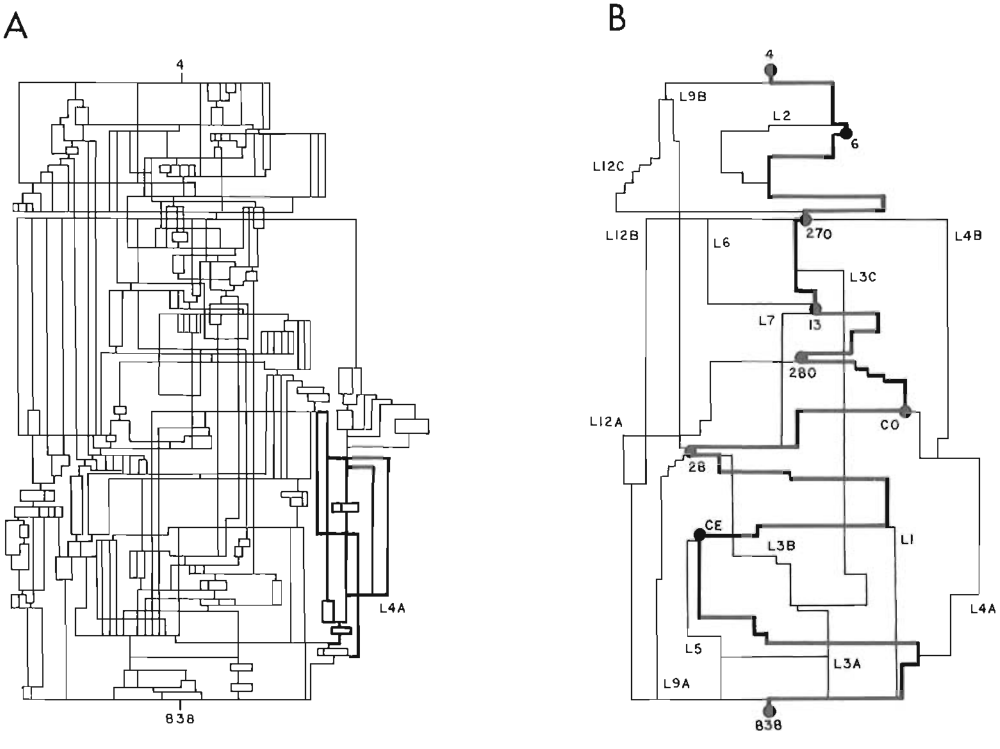

Fig. 8.3 (A) Stratigraphic sequence of deposits on the interior of the Hoko Rockshelter. The chronological position of individual layers have been removed from this diagram to highlight the many, distinct threads of activity. (B) The multilinear sequence is reduced to a matrix diagram which outlines different areas of recurrent deposition (L1–L12). Layers 28, 13, 270, 6 and features CE and CO of the reference sequence (bold line) are key time markers to correlate areas of activity.

rockshelter. This area of recurrent deposition was designated as 'L4A'. A total of 17 distinct areas of activity were located following this procedure.

Layers 28, 13, 270 and 6 are important junctures on the reference sequence. These key layers can be traced over a wide area, and thus serve as time markers to correlate refuse stratigraphically through the rockshelter. Figure 8.4 presents a further simplification of the Harris diagram. This chart shows the degree of correspondence in the stratigraphic position of all areas of activity.

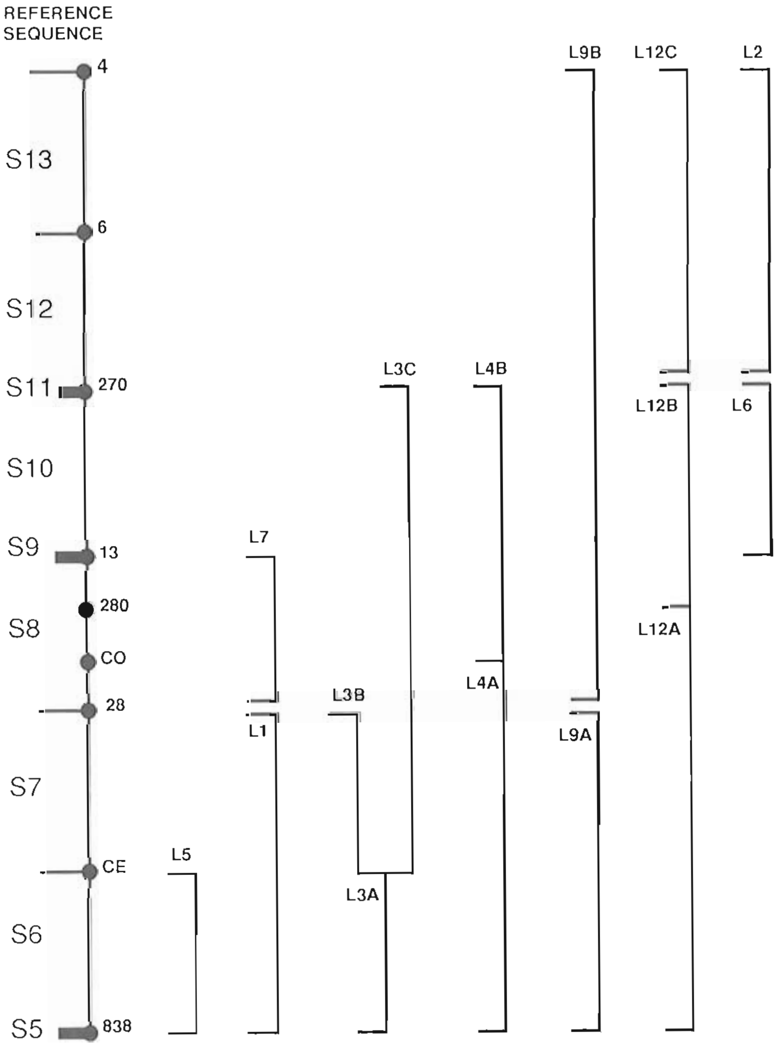

Fig. 8.4 Stratigraphic time scale of the Hoko Rockshelter showing the degree of correspondence in the relative chronological position of different areas of activity. The reference sequence is partitioned into nine stratigraphic units (S5–S13) which also represent areas of recurrent deposition.

Patterns of site use

The location of areas of activity through space and time is outlined in Fig. 8.5. Near the base of the sequence (S6–S8), these areas consist of many layers (represented by the thickness of the area of activity). This pattern of deposition suggests that there were periods when the organization of space in the rockshelter was relatively stable. More recent areas of activity, which are closer to the top of the sequence (S9–S13), contain fewer deposits. During this time, the site may have been occupied for short intervals or by only a few people. Deposits from these areas of activity may thus represent a period of declining use of the site prior to its final abandonment.

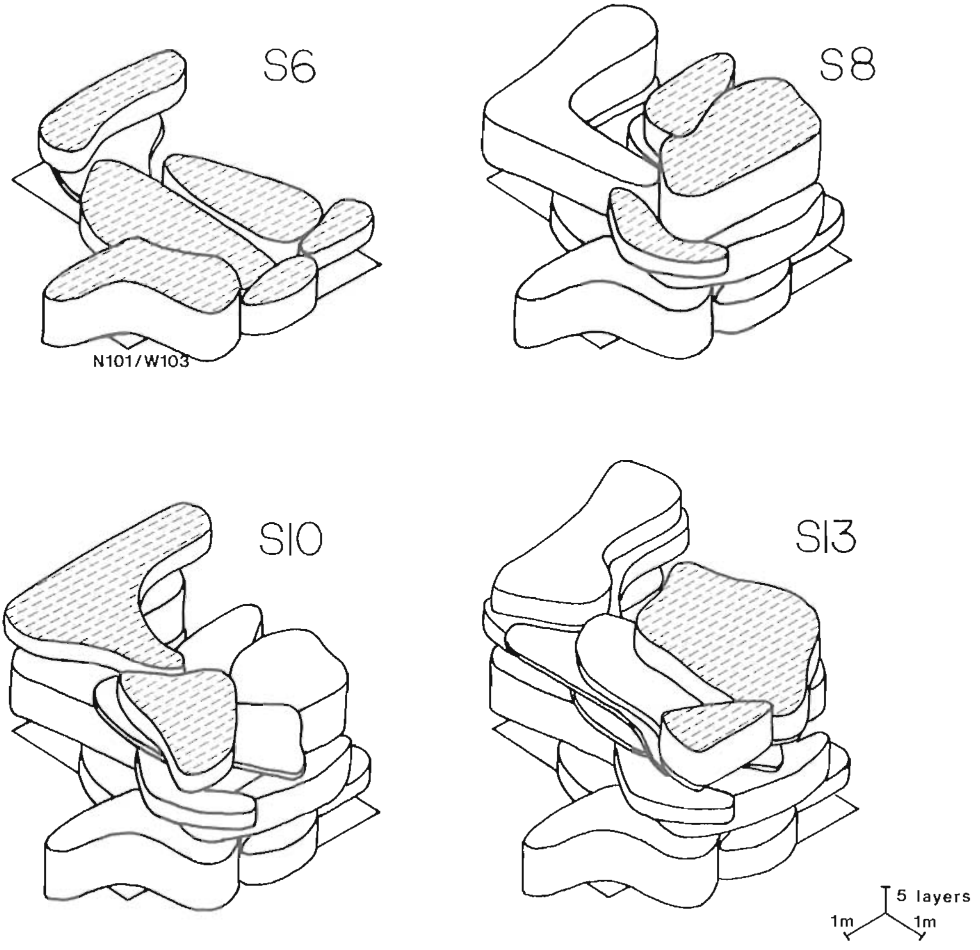

Fig. 8.5 Formation of the Hoko Rockshelter site, showing the location of areas of activity at various points in time. The thickness of each area of activity represents the number of layers that were deposited in sequence at that location.

Table 8.1 Composition of areas of activity based on the percentage of different types of layers (excluding features)

Area	N	Layer types (%)					
		Humus 'floor'	Hearth deposit	Shell	Hearth refuse	General refuse	Other
S5	5	20.0			40.0	40.0	
S6	12	25.0	33.3	8.3	8.3	8.3	16.7
S7	30	13.3	30.0	20.0	10.0	23.3	3.3
S8	19	26.3	26.3	26.3	10.5	5.3	5.3
S9	6	33.3	16.7	33.3		16.7	
S10	21	28.6	14.3	14.3	19.0	19.0	4.8
S11	6	16.7	16.7	33.3		33.3	
S12	11	9.1	18.2	9.1	18.2	45.5	
S13	32	28.1	37.5	3.1	15.6	15.6	
L01	6	16.7	16.7	66.7			
L02	23	47.8	8.7	17.4	8.7	13.0	4.3
L03A	11	18.2	27.3	18.2	18.2	18.2	
L03B	32	43.8	21.9	15.6		6.3	12.5
L03C	27	40.7	14.8	7.4	11.1	22.2	3.7
L04A	18	44.4	27.8		11.1		16.8
L04B	10		60.0	10.0	10.0	10.0	10.0
L05	20	5.0	20.0	20.0	30.0	15.0	10.0
L06	10	30.0	40.0	20.0		10.0	
L07	10	30.0	50.0			20.0	
L08	7	28.6	28.6			42.9	
L09A	15	20.0	60.0	6.7	13.3		
L09B	2	50.0			50.0		
L10	7	42.9	57.1				
L11	2	50.0	50.0				
L12A	45	37.8	8.9	24.4	11.1	11.1	6.6
L12B	17	35.5	41.2	5.9	11.8	5.9	
L12C	25	32.0	24.0	8.0	28.0	4.0	4.0

The nature of activities conducted at the site was determined from the features and debris embedded in different areas of activity. Most areas consist of a wide variety of deposits, though certain types of refuse tend to predominate (Table 8.1). The proportion of hearths and pits relative to other layers also varies by area (Table 8.2). Hearths and hearth type deposits tend to concentrate in the centre of the rockshelter (Fig. 8.6). This central region is surrounded by areas with a high density of pits, or pits and hearths. Areas with an abundance of humus 'floors' are located at the northern end of the rockshelter, while areas with many humus and hearth type layers predominate further south.

Discussion of results

Initially, I posed several questions that I hoped to answer using the stratigraphic relations among site deposits. From the results presented above, it appears that for most of its

Table 8.2 Percentage of hearth and pit features per area of activity*

Area	Total N	Feature type			
		Hearths		Pits	
		N	%	N	%
S6	14	1	7.1	1	7.1
S7	32	1	3.1	1	3.1
S8	22	3	13.6	1	4.6
S10	21	5	19.2	0	
S11	7	0		1	14.3
S12	12	0		1	8.3
S13	34	1	2.9	1	2.9
L01	6	0		0	
L02	28	2	7.1	3	10.7
L03A	11	0		0	
L03B	33	0		1	3.0
L03C	32	1	3.1	3	12.5
L04A	20	2	10.0	0	
L04B	11	1	9.1	0	
L05	22	2	9.1	0	
L06	11	0		1	9.1
L07	12	1	8.3	1	8.3
L08	8	1	12.5	0	
L09A	17	2	11.8	0	
L09B	2	0		0	
L10	8	1	12.5	0	
L11	2	0		0	
L12A	47	0		2	4.3
L12B	17	0		0	
L12C	31	1	3.2	5	16.1

* Stake- and postmoulds were not included in this analysis. This accounts for the low frequency of layers in some areas.

history, the Hoko Rockshelter was partitioned into several contemporaneous areas of activity. The structure of the site consists of a centrally located hearth surrounded by areas which might have been used for other domestic activities, temporary storage and walkways. In general, the organization of behaviour in the rockshelter remained relatively stable through time. However, the duration of intensity of site use may have declined before the rockshelter was finally abandoned.

This preliminary study outlines some broad changes in the use of the rockshelter. Future analyses of fauna remains and artefacts will help clarify our understanding of the spatial organization of behaviour at the site. As we begin to focus more on activities, it is important to remember that the cultural items which cluster within an area of recurrent deposition are not necessarily the result of a specific prehistoric task. In fact, the diversity of layer types and features embedded within such an area suggests that a variety of activities were performed in the same location.

A fundamental difference between the areas of activity presented here and traditional

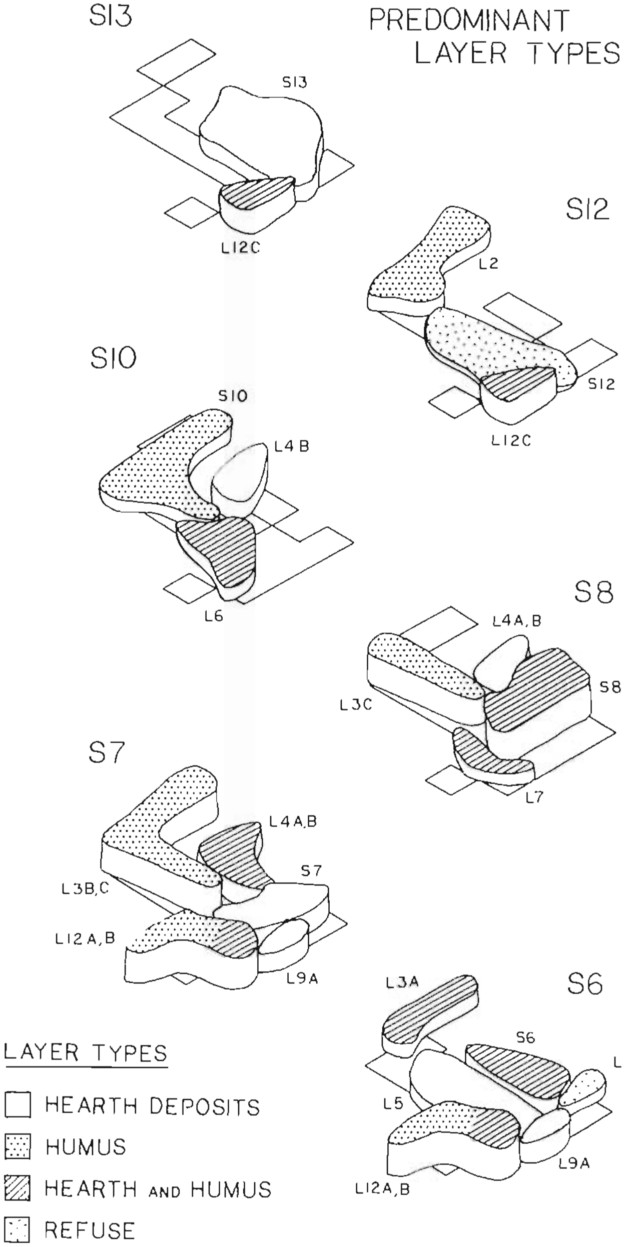

Fig. 8.6 Characteristic deposits and features of different areas of activity in the rockshelter through time.

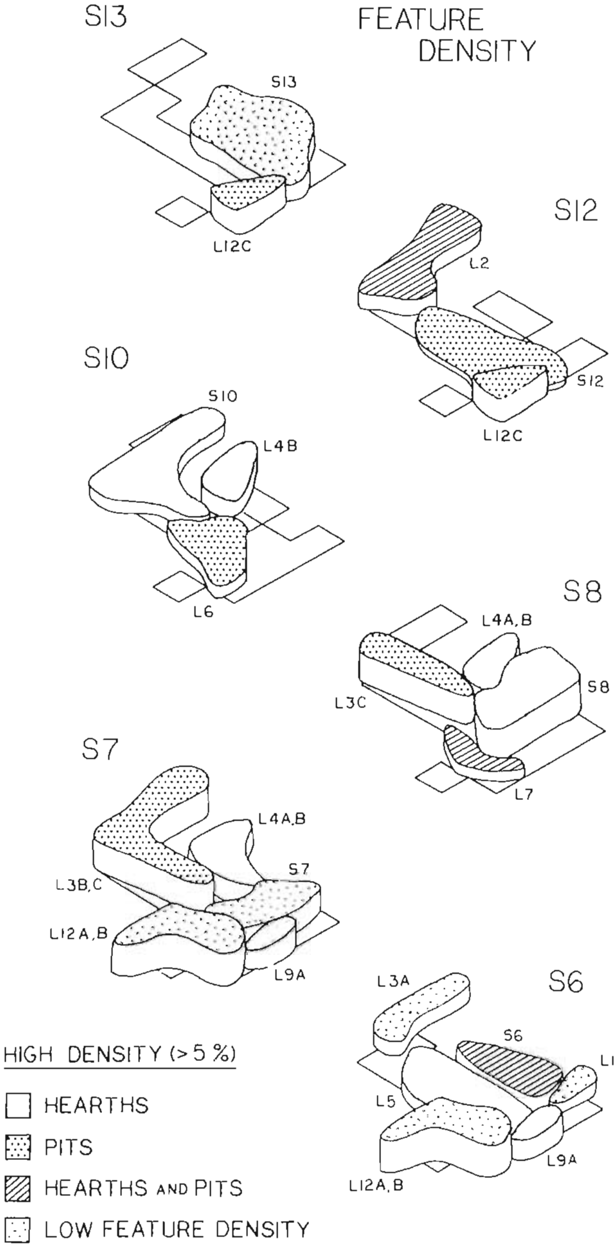

Fig. 8.6 *Continued.*

'activity areas' hinges on assumptions made about the processes which aggregated pre-historic remains. Covariant sets of artefacts, which result from an activity performed in the behavioural past, determine the boundaries of a traditional 'activity area' (Carr 1984: 114). In contrast, an area of recurrent deposition represents the actual location of depositional events through time. Areas of activity are delimited following the sequence of accumulation defined by the relative chronology, without relying on prior assumptions about the behavioural significance of the aggregated remains. Using this stratigraphic approach, it is thus possible to assess the effects of a wide array of midden formation processes. This may prove to be particularly useful because of the complex relationship between behaviour and the archaeological record.

Conclusions

The technique presented here provides an alternative approach for the study of intrasite spatial organization in complex, stratified sites. It identifies areas of contemporaneous activity, thus reducing the need to rely on assumptions about the synchroneity of past events. This method allows the archaeologist to study the spatial patterning of behaviour in sites where it is difficult or impossible to isolate distinct 'living floors'. It can be used to identify breaks in the stratigraphic record that were not visible during excavation. These sedimentological changes may reflect different periods of site use. This method also provides a detailed relative chronology of individual depositional events. Such a comprehensive record of midden formation is necessary to identify significant variations in ancient routines of daily life through time and space.

In shell middens where deposits are mostly cultural in origin, sediments are important souces of information about past behaviour. Since there are likely to be many more layers than artefacts in these middens, it is important to take full advantage of the detailed stratigraphic record of site formation when studying the spatial organization of past human behaviour.

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9 Matrices and Maya archaeology[1]

NORMAN HAMMOND

Introduction

The idea of stratigraphy – the ordering and description of deposits vertically in space and forward through time – developed as part of the early history of archaeology, from the first explanations of geological stratification as a key to relative chronology by George Owen in his *History of Pembrokeshire* of 1570 (which remained unpublished for over 200 years: Owen 1796) and Nicolaus Steno (Nils Steensen) in the *Prodromus* (Steno 1669; English translation 1671), to the observation and illustration of archaeological sections by Olof Rudbeck at Uppsala in the 1680s (Klindt-Jensen 1975: 30–1) and by William Stukeley in 1723 (Piggott 1985: plate 18) and the explicit description of a stratigraphic sequence by Frere in 1797 (Frere 1800) at Hoxne. Such ordering was not applied systematically until the early twentieth century, however, in the work of R.E.M. Wheeler at Segontium (Wheeler 1922: fig. 11; see Piggott 1965), Verulamium, and Maiden Castle, and in the Americas with less lasting impact by A.V. Kidder (e.g. 1924; fig. 8) in the Southwest.

Urban archaeology in Britain in the 1960s and 1970s, particularly with the open-area methods advocated by Biddle and Kjølbye-Biddle (1969) and practised by them at Winchester, resulted in sites and even single trenches in which the number of separate contexts mounted into the hundreds and sometimes thousands. To order this mass of data chronologically, particularly in the absence of standing sections, Edward C. Harris of the Winchester Research Unit in 1973 devised a matrix work-sheet (Harris 1975: fig. 24) onto which stratigraphic superpositions and equations could be plotted. A 'Winchester–Harris Matrix' was constructed for each trench, and separate trenches then reconciled to produce a master matrix. The development of what has become known simply as the Harris Matrix has been detailed by its deviser in a number of articles (Harris 1975, 1977, 1979a) and a book (Harris 1979b), and the method is now widely used, although less often in some parts of the archaeological world than it deserves.

Essentially, the Harris Matrix classifies the relationships between a series of archaeological contexts, showing 'in what relation one layer stood to others in the sequence ... it assumes that any two units of stratification have either no stratigraphic connections, or they lie in superposition or may be correlated as parts of an originally single deposit. These simple assumptions are of course the essence of the notions of relative time' (Harris 1979b: 117–8). The matrix diagram, in its series of linked boxes, each of which shows

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[1] Originally published in *Journal of Field Archaeology* (1991, 18: 29–41); used (with corrections) by permission of the Trustees of Boston University.

a defined context in relation to its immediate neighbours, is a formalized picture of the stratigraphic sequence of the site.

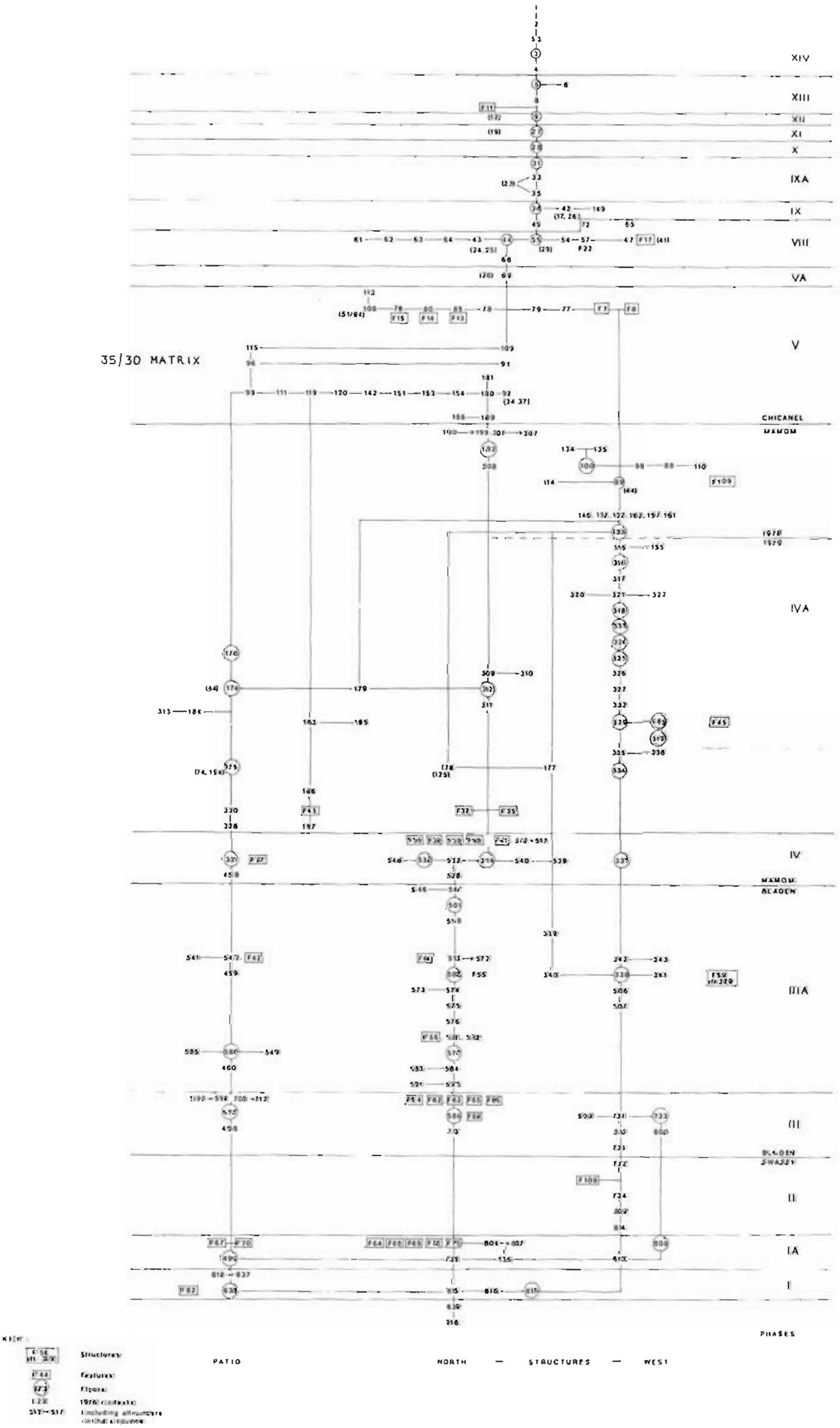
Probably the first application of the Harris Matrix in American archaeology was in 1974, at the Maya site of Nohmul in northern Belize, when with Harris's blessing the author and Iris Barry used it to document the sequence of Nohmul Structure 139. The published matrix (Heighway *et al.* 1975: fig. 2.4) included a column of explicit interpretation as well as the vertical relationships and inter-area equation of numbered contexts, although it lacks the neatly arrayed boxes of the canonical Winchester model.

The box format was adopted for the matrices depicting the stratigraphic sequence at Cuello in 1976; test excavations in 1975 at this Maya site some 20 km south of Nohmul had revealed a deep and complex succession of Preclassic deposits in Platform 34, with radiocarbon dates suggesting initial occupation in the early second millennium B.C. (Hammond *et al.* 1976). In 1976 two catercornered 5 m × 5 m trenches (grid squares 30/30 (Area A) and 35/35 (Area B)) were dug to bedrock. The two matrices (first published as Donaghey *et al.* 1976: fig. 25) were used in conjunction with a series of phase plans (Donaghey *et al.* 1976: figs 3–16) and standing sections (Donaghey *et al.* 1976: figs 17–24), and owe a clear visual as well as conceptual debt to Harris's 1975 article. Inter-area equations were marked with dashed lines linking the two matrices, however, and some contexts (e.g. #34 in Area B) were shown also in the other area in a dashed box to illustrate equation. Burials were given only a single context number and marked with a 'B'. Annotation in the form of perceived construction and destruction phases was superimposed on the matrix (cf. Harris 1975: fig. 27K), and an innovation at Cuello was the addition of radiocarbon dates attached to the context from which samples had come. Dates that were considered unacceptable were enclosed in square brackets, but all dates run were published on the matrix. In a subsequent article the dates were additionally shown arrayed against the sequence of phases and ceramic periods and against a tree-ring calibrated timescale, and the matrix was matched with a sample standing section (Hammond *et al.* 1979: figs 1–3).

The emphasis of the Cuello publications in the 1970s was on chronology and thus on vertical succession of deposits. These included occupation and fill layers, but also plaster floors which sealed everything below them and defined successive architectural phases, as well as burials and cached offerings. The standard Harris Matrix format, in which each context was represented as a rectangular box, did not allow this variety to be shown, and in the 1979 season a number of new illustrative conventions were introduced. Figure 9.1 shows the matrix for grid square 35/30, a 5 m × 5 m area immediately north and west of the two 1976 trenches, and Fig. 9.2 the west and north standing sections left by the excavation. Contexts shown in the west section are on the right-hand side of the matrix, those in the north section in the centre, and the centre and left-hand sides include contexts excavated in plan within grid 35/30 that did not extend to the margins of the area.

In Figs 9.1 and 9.3, the chronological sequence is ordered in terms of stratigraphic Phases I–XIV, which are labelled up the right-hand side of the matrix, together with the

Fig. 9.1 Nineteen seventy-nine matrix for grid 35/30 at Cuello: plaster floors are marked by circles enclosing their context numbers. Features such as buildings, burials and caches are in boxes, 1976 equations in parentheses; neither the internal matrices of Features nor all context numbers in continuous sequence are shown.


35/30 MATRIX
XIV
XIII
XII
XI
X
IXA
IX
VIII
VA
V
CHICANEL
MAMOM
1978
1979
IVA
IV
MAMOM
BLADEN
IIIA
III
BLADEN
SWASEY
II
IA
I
PHASES
PATIO
NORTH — STRUCTURES — WEST
KEY:
Structures
Features
Floors
1976 contexts
Including all numbers in that sequence

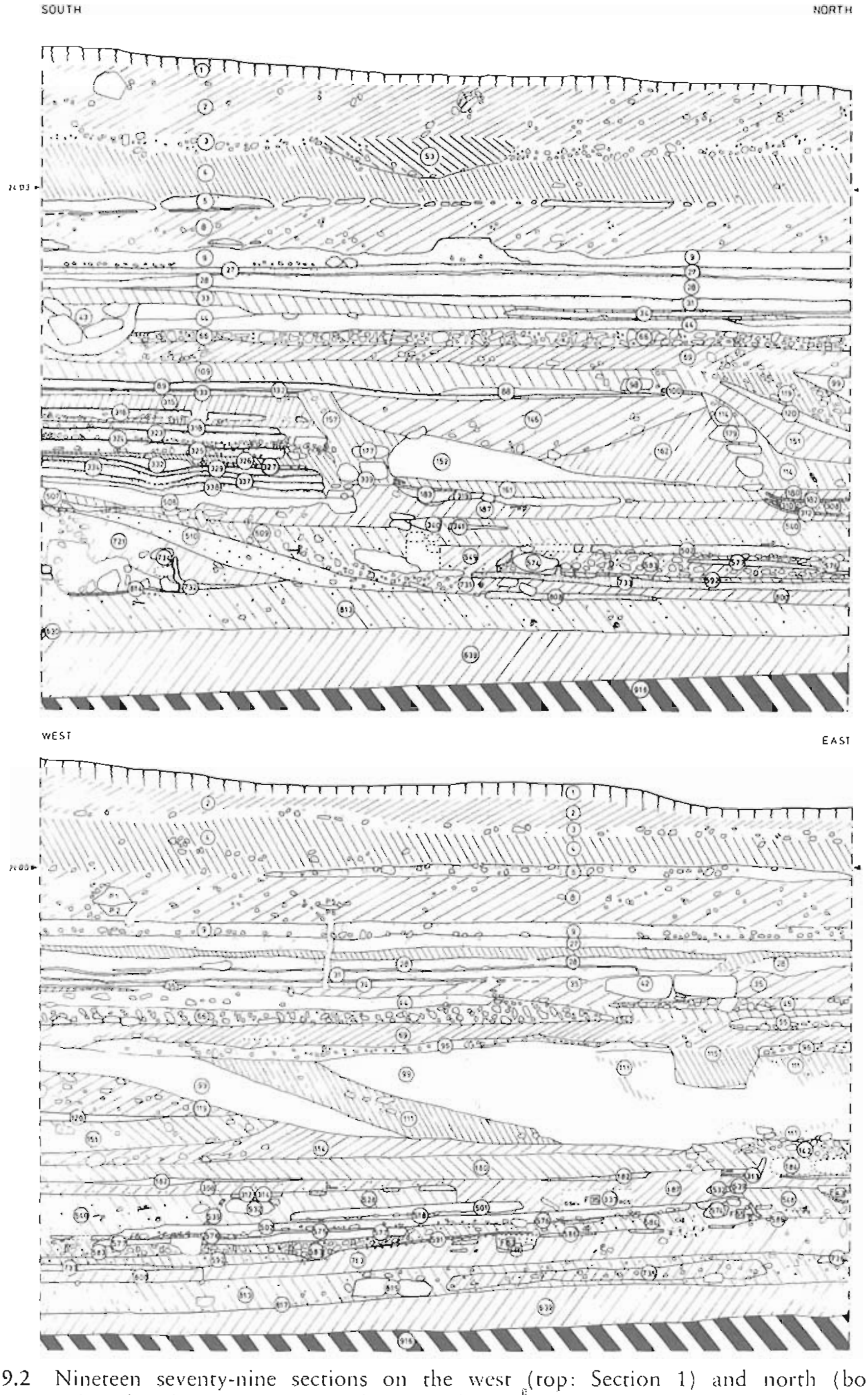


Fig. 9.2 Nineteen seventy-nine sections on the west (top: Section 1) and north (bottom: Section 2) sides of grid 35/30: correspondences with Fig. 9.1 are most apparent in the central and right-hand columns of the matrix, while contexts away from these sections appear in the central and left-hand columns.

beginning and ending points of the successive ceramic complexes, but without their absolute dates (Swasey, 1200–900 B.C.; Bladen, 900–600 B.C.; Lopez Mamom, 600–400 B.C.; Cocos Chicanel, 400 B.C.–A.D. 250) since this information does not derive from the stratigraphic sequence. At the base of the sequence, bedrock (context 916) lies below the buried soil (639): context numbers were assigned on a site-wide basis in the order 1 ... *n*, so that only a few numbers will appear on any one matrix diagram. Plaster floor context numbers are enclosed in a circle, those of Features (infra) in a box, and all other context numbers are now shown without enclosure; in Fig. 9.1, where a long succession of context numbers occupy quasi-identical positions on the matrix, only the first and last numbers linked by an arrow are shown; also, equivalent contexts from the 1976 excavation of the adjacent grids 30/30 and 35/35 are added in parentheses.

Taking Fig. 9.3 as a simple example of this matrix format, in Phase I in grid 30/35 a plaster floor (630) is present, together with a Feature [82] – in fact a building substructure – and a series of other contexts, including occupation build-up. In Phase 1A, two Features [F52, 53] are shown above floor (608) because they are cut into it, and are thus stratigraphically later. They are sealed by context 500, which is in turn overlain by 497 and 496 before the latter is cut by a firepit [F51]; this is subsequently sealed by the fill and surface of floor (477).

Over this floor a series of occupation layers builds up, cut by the burial [F49], which is sealed by the fill and plaster surface of floor (331). Another succession of occupation and fill deposits, of which 455–457 are coeval (and thus shown at the same level on the matrix), underlies floor (175), which is then buried by a massive rubble deposit, 92, into which burials [F31, 33] are inserted. Further floors – (55), (28), (27), (9), (5), and (3) – are superimposed, two of them sealing caches [F27, 30] in their fills. The top of the matrix comprises the subsoil, 2, and topsoil, 1.

A Feature was defined as 'a collocation of contexts forming an apparently coherent and meaningful analytical unit'; a simple example would be the contexts forming the grave cut, human remains, grave goods, fill, and capping of a burial. In many cases a short-term Feature formed a kind of stratigraphic capsule within the larger sequence of the excavation, and in these circumstances it was displayed as a 'mini-matrix', either in the margin of the main matrix, as with the simple sequence of grid 30/35 (Fig. 9.3), or separately where there were numerous mini-matrices to be accommodated (as with grid 35/30). Some complex Features were recognizable buildings, which were numbered in the Cuello site catalogue as Structures, and in this case the Structure designation could be added to that of the Feature on the matrix (e.g. F59/Str.329 in Fig. 9.1). This innovation, together with the display of radiocarbon dates on the matrix, was later dropped in the interests of visual clarity.

In the 1980 season of the Cuello Project, two 10 m × 10 m areas north and south of that investigated in 1976–79 were excavated, covering the grid from 20/30 to 25/35, and from 40/30 to 45/35. These were dubbed the North and South Squares for ease of reference, the formerly-dug area becoming in retrospect the Central Square (cf. Gerhardt 1988: fig. 3). Within these larger open excavations a series of superimposed, plaster-surfaced buildings was uncovered (Fig. 9.4), and these were shown on the matrix (Fig. 9.5) by using a Letraset/Zipatone overlay. Each building also had heavily inked L-brackets at the corners of the overlay, to allow for fading of the tone in photocopies, and was labelled with its Feature number at the top left corner. Floors, features and other contexts within a building were shown within the overlain area, others outside it: on Fig. 9.5 the succession

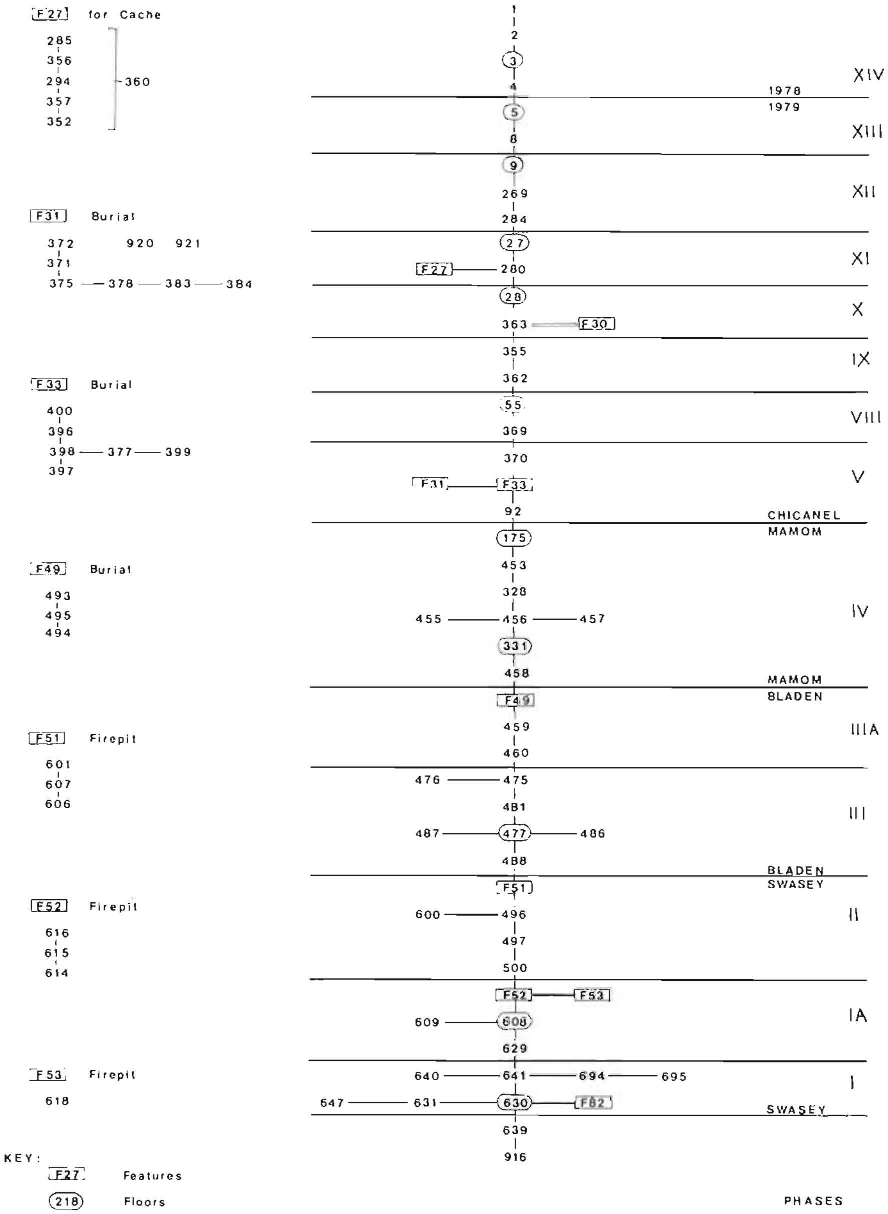


Fig. 9.3 Nineteen seventy-nine matrix for grid 30/35 at Cuello, showing the use of internal mini-matrices for Features such as caches, burials and firepits.

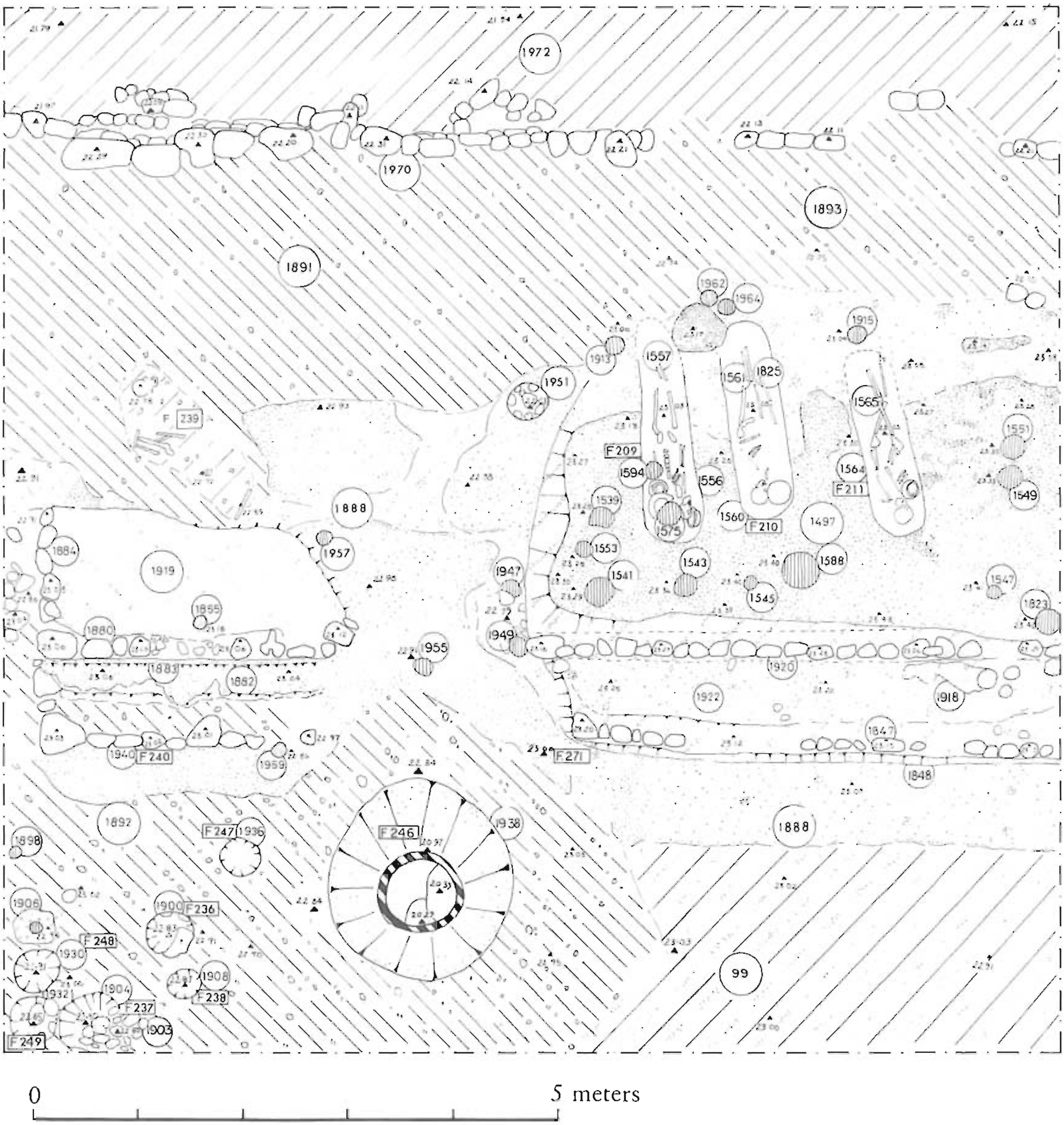
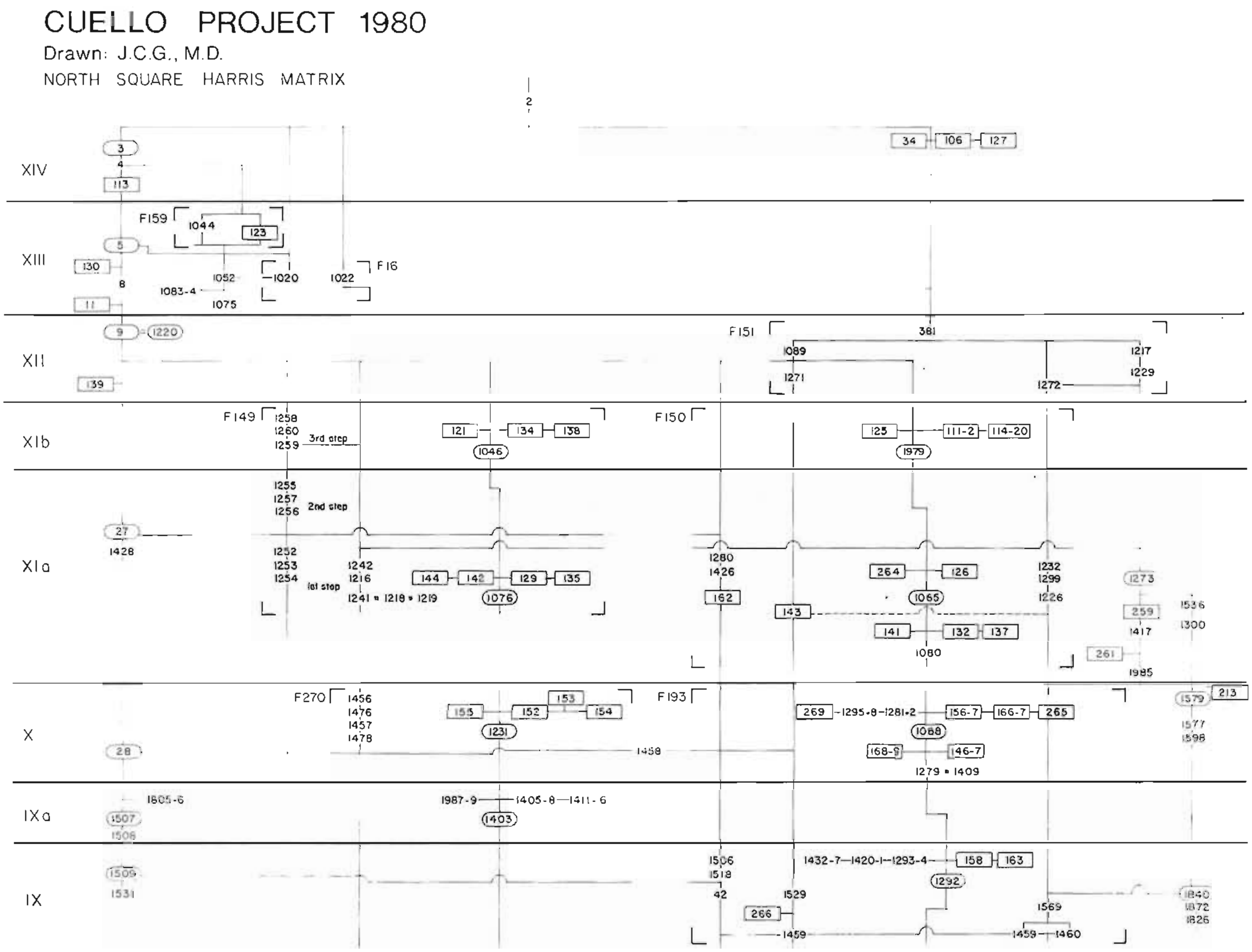


Fig. 9.4 Nineteen eighty plan of the North Area (Square) at Cuello in Phase Vc, to show the detail embraced within one portion of the matrix (Fig. 9.5), including two plaster-surfaced building platforms (F240, F271) with interior burials (F239, F209–211), several exterior firepits (F236–238, F247–248), and a deep *chultun* storage chamber dug into bedrock (F246). (North is at the top of the plan; the recent final revision of the Cuello stratigraphy now places these features in Phase VA.)


CUELLO PROJECT 1980
Drawn: J.C.G., M.D.
NORTH SQUARE HARRIS MATRIX
XIV
XIII
XII
XIb
XIa
X
IXa
IX
2
3
4
113
34
106
127
F159
1044
123
5
130
8
1052
1020
1022
F16
1083-4
1075
11
9
1220
F151
381
1089
1271
1217
1229
1272
139
F149
1258
1260
1259
3rd step
121
134
138
1046
F150
125
111-2
114-20
1979
1255
1257
1256
2nd step
27
1428
1252
1253
1254
1st step
1242
1216
1241 = 1218 = 1219
144
142
129
135
1076
1280
1426
162
264
126
1065
143
141
132
137
1080
1232
1299
1226
1273
259
1417
261
1985
1536
1300
F270
1456
1476
1457
1478
155
152
153
154
1231
1458
F193
269
1295-8-1281-2
156-7
166-7
265
1088
168-9
146-7
1279 = 1409
1579
213
1577
1598
28
1805-6
1507
1508
1987-9
1405-8
1411-6
1403
1509
1531
1506
1518
42
1432-7—1420-1—1293-4
158
163
1292
1529
266
1459
1569
1459
1460
1840
1872
1826

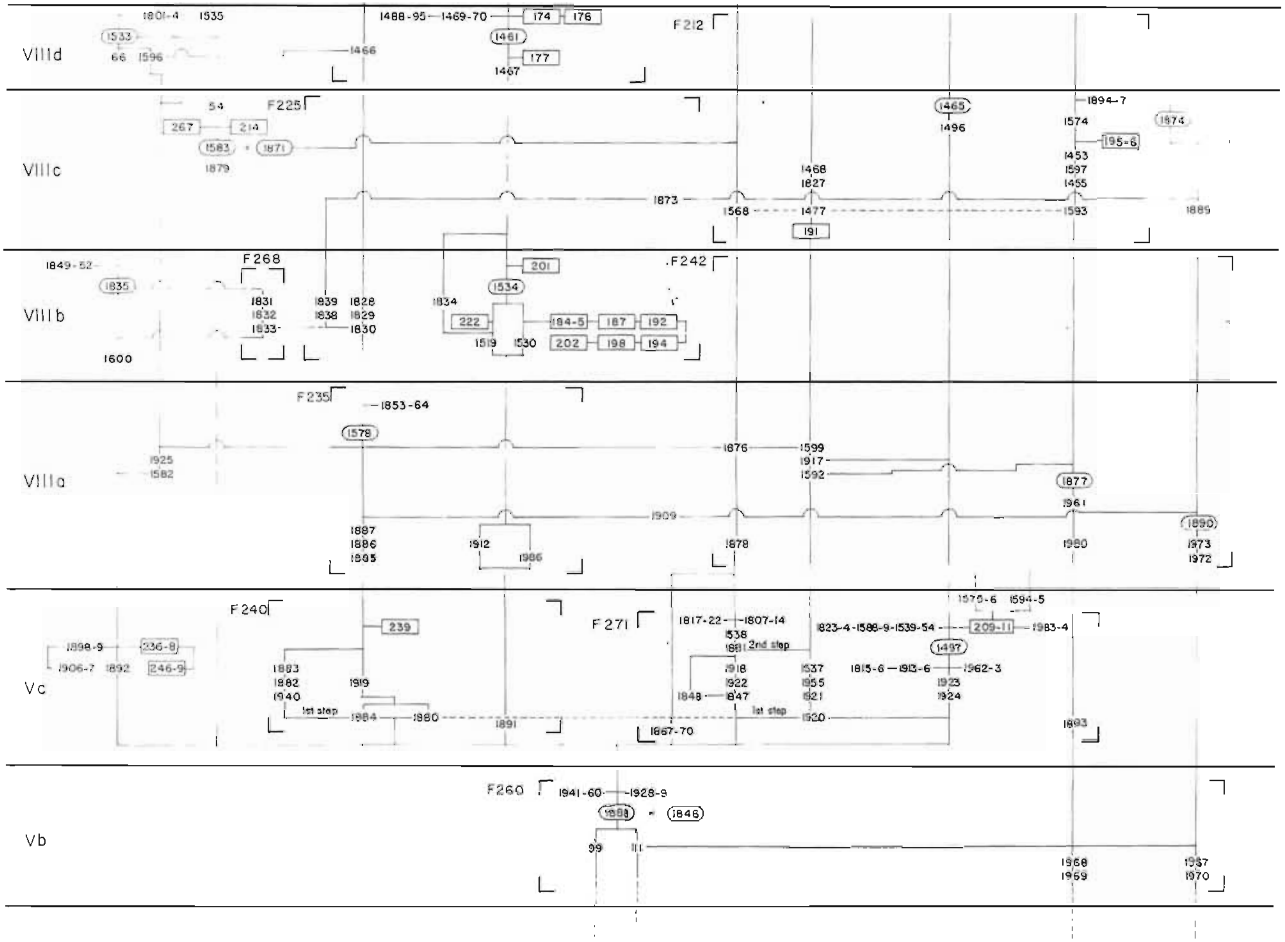


Fig. 9.5 Nineteen eighty matrix for the North Square, showing the succession of superimposed plaster-surfaced building platforms (in tone, with interior contexts and features) of Phases Vb–XIII. The internal mini-matrices for all Features are published on separate plates of the report. Plaster floor contexts are now in apsidal cartouches to accommodate four numerals. The plan data for Phase Vc are illustrated in Fig. 9.4.

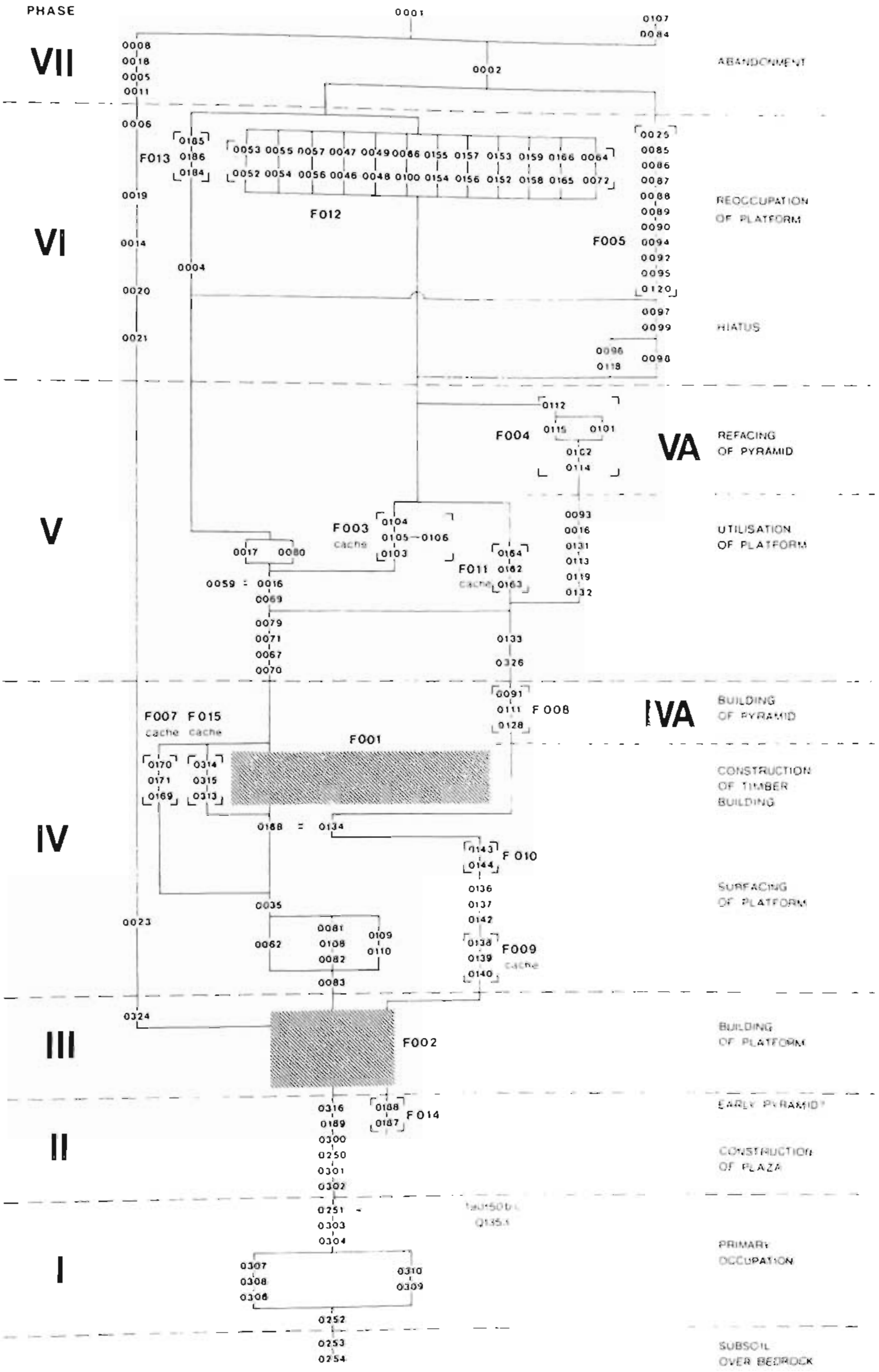


Fig. 9.6 Nineteen eighty-three matrix for Operation A at Nohmul, the 35 m × 5 m trench into the 'acropolis' platform (Structure 1). The 'task' construction of the 10 m high platform, F002, and the multiple postholes of the 23 m long timber building (F001) built on its top surface in the Terminal Preclassical period *ca* A.D. 250 are both shown as solid blocks of tone to avoid overwhelming the matrix with repetitive data. For a section of F002 and a plan of F001 see Hammond *et al.* (1985: figs 13–14).

of plaza floors is in the left-hand column. With the context number sequence now into the thousands, the plaster floor icon was changed from a circle to an apsidal cartouche to accommodate four digits.

In addition to the area matrices, a 'master matrix' was developed for the entire main trench, which had been excavated in portions between 1976 and 1980. This included Structures, but not Features encapsulated within them; the plaster surfaces of the successive patios or plazas enclosed by the buildings; Features such as burials and caches laying outside Structure limits; and selected salient contexts. The 1978–80 master matrix (see Robin 1989: fig. 7) includes one column with the superimposed Structures below the pyramid, Structure 35, on the west side of the group; a second column including the north and south side structures; a third with the floors; and an overall 22-phase relative chronology to which the successive architectural plans were keyed.

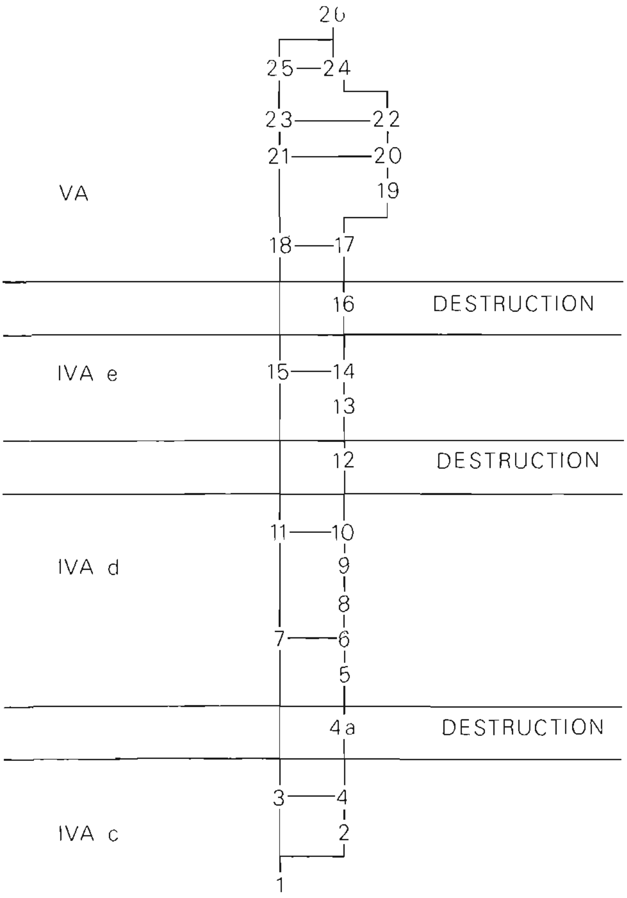


Fig. 9.7 Nineteen eighty-seven group matrix for the North Square at Cuello, Phases IVAc–e and VA. The context numbers (see Table 9.1) are compacted into quasi-coeval groups 1–26, each representing a coherent process or event, and these groups are then related in a standard Harris Matrix. Major construction/use and destruction phases are imposed on this matrix. Note that exterior surface 4058 remains in use from group 1 to 23.

Table 9.1 Constituent contexts of the 26 groups in the 1987 Cuello group matrix

Group number	Context numbers (in stratigraphic order)	Description
26	4206, 4207, 4053, 4054, 4056, 4057, 4055, 4097, 4012, 4068, 4182, 4000	Later contexts and clearance
25	4119, 4108, 4126, 4101, 4092	Exterior surface
24	4109, 4118, 4100, 4112, 4115, 4114, 4098, 4116, 4073, 4090, 4089, 4082, 4096, 4095, 4098, 4093, 4094, 4075, 4067, 4066, 4065, 4117	Levelling up for new platform
23	4058	Exterior surface
22	4147, 4148, 4149, 4150, 4151, 4152, 4153, 4154, 4155, 4156, 4145, 4146, 4121, 4181, 4144, 4143	Ritual end of platform
21	4058	Exterior surface
20	1980 contexts, 4048, 4085, 4086	Use of platform
19	4048, 4002, 4001, 4047, 4111	Plaster platform 34
18	4058	Exterior surface
17	4113, 4110, 4071, 4188, 4083, 4076, 4074, 4107, 4105, 4081, 4106, 4080, 4104, 4079, 4103, 4078, 4102, 4091, 4064, 4059, 4072, 4077, 4088, 4063, 4003, 4010, 4030, 4087	Levelling up for new platform
16	4027, 4050, 4045, 4043, 4041, 4039, 4037, 4062, 4033, 4029, 4007, 4016, 4020, 4022, 4024, 4052, 4009, 4138	Destruction of timber superstructure
15	4058	Use of exterior surface
14	4013, 4014, 4025, 4026, 4060, 4004	Use of timber superstructure
13	4142, 4070, 4031, 4070, 4005, 4049, 4044, 4042, 4040, 4038, 4036, 4061, 4032, 4028, 4006, 4034, 4046, 4137, 4015, 4019, 4021, 4023, 4051, 4008, 4035, 4011	House platform and timber superstructure
12	4131, 4134, 4135	Destruction of masonry building and platform
11	4058, 4196, 4132	Use of exterior surface
10	4122, 4123, 4124, 4125, 4160, 4161, 4162, 4163, 4164, 4127, 4128, 4129, 4157, 4158, 4203, 4204, 4205	Use of masonry building
9	4133, 4194, 4195, 4193, 4069, 4201, 4132, 4196, 4208, 4136	Construction of masonry building and platform
8	4130, 4159, 4166, 4168, 4170, 4172, 4174, 4176, 4178, 4184, 4186	Destruction of timber superstructure
7	4058	Use of exterior surface
6	4122, 4133, 4124, 4125, 4160, 4161, 4162, 4163, 4164, 4127, 4128, 4129, 4157, 4158, 4203, 4204, 4205	Use of house platform and timber superstructure
5	4191, 4190, 4189, 4140, 4139, 4141, 4187, 4136, 4165, 4167, 4169, 4171, 4173, 4175, 4174, 4177, 4183, 4185	House platform and timber superstructure
4a	4200, 4211	Destruction
4	4199, 4198, 4210, 4209, 4192, 4197	Use of house platform
3	4058	Use of external surface
2	4202, 4192	House platform
1	4058, 4099	Exterior surface overlying old land surface and bedrock

By 1980 the Cuello area matrices were becoming rather complicated, with clarity preserved only by stripping out all internal feature contexts into separate pages of mini-matrices: when excavations resumed at Nohmul in 1982 this problem became even more pressing with the excavation of the Preclassic 'acropolis', Structure 1 (Hammond 1985: 586–95). A trench 35 m long, 5 m wide, and 10 m deep demonstrated a seven-phase sequence of activities which included the erection of a massive limestone platform, constructed in the form of numerous abutting 'tasks', and the construction on it of a long timber-framed building at least 23 m × 7 m, with numerous post holes cut into the platform surface and later infilled. Presentation of every task unit and posthole as a separate mini-matrix, or even a separate Feature (an unjustifiable use of this designation), within the overall matrix would have overwhelmed the record with inconsequential detail, to the detriment of understanding it. The acropolis trench matrix (Fig. 9.6; published in Hammond 1984: fig. 8.51) was therefore drawn with the limestone platform F002 and the timber hall F001 each represented by a single solid block of tone without internal structure. The complexity of F002 was made clear by the published section (Hammond 1985; fig. 8.52) and that of F001 by the plan (Hammond 1985: figs 8.52, 8.62; see also Hammond *et al.* 1985: figs 13–14), while the overall sequence of construction, remodelling, cache deposition, abandonment and re-occupation was brought out in the matrix.

At Cuello in 1987, the idea of consolidating numerous contexts into a single bloc was developed further with the introduction of the 'group matrix', already in use in Britain. In the group matrix, a quasi-coeval set of contexts is designated by a group number (Table 9.1), and the relationship between the groups is then drawn in standard matrix format (Fig. 9.7). In this way the 200 contexts recorded in the 1987 excavation of the Lopez Mamom (600–400 B.C.) deposits of the North Square are reduced to 26 groups, which can be annotated with a phase sequence and interpretation in the usual way.

The utility of the Harris Matrix as a model for stratigraphic ordering is demonstrated by its development over some 15 years, both in British archaeology and elsewhere. The modifications described here have made the basic concept more widely useful in the context of Maya archaeology, but are themselves perhaps of broader applicability. As Harris's invention approaches its majority, the revised edition of *Principles of Archaeological Stratigraphy* (Harris 1989) is to be welcomed.*

Acknowledgements. I am grateful to Ed Harris for giving me an advance copy of his 1975 paper and the chance to use the matrix concept in the field in 1974; to Iris Barry, Kate Clark, Amanda Clarke, Sara Donaghey, Juliette Cartwright Gerhardt and Mark Horton for their help in developing the successive versions of the matrix used at Cuello and Nohmul over the past 15 years; to Mike Davenport, Justine Hopkins, Sheena Howarth and Jan Morrison, as well as some of those above, for drafting the illustrations used in Figs 9.1–9.7; and to the National Geographic Society and the Trustees of the British Museum for providing major funding for the excavations at Cuello and Nohmul. The Cuello chronology used here is that now accepted; previous versions began the Swasey phase as early as 2500 B.C.

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* Note added in proof: This paper was written in 1989, shortly before the publication of the revised edition of Principles of Stratigraphy (Harris 1989).

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SECTION IV
Phasing and structural analysis

The three papers of the section discuss aspects of phasing and periodization of historic sites containing large building remains and intensively used properties. The first article, by Gregory Brown and David Muraca (Chapter 10), represents an important departure from traditional methods in American urban archaeology, using examples from the Historic Area of Colonial Williamsburg. They note that many American archaeologists still hold to an individualistic stance on recording methods, which in many instances will devalue the stratigraphic record of some sites. They also suggest that many American archaeologists consider the Harris Matrix methods as little more than technical gimmicks, in spite of considerable evidence to the contrary from other archaeological fields.

The situation of Colonial Williamsburg is in part a mirror of the historical development of stratigraphic methods elsewhere. When the reconstruction of the town began in the 1920s, excavations were done with the purpose of finding the original footings of buildings, along with such artefacts found on the way to this architectural object. The general stratification was all but ignored on these sites until the late 1950s, when Ivor Noël Hume brought over Wheelerian methods of excavations. Those methods contained the failures discussed elsewhere by Harris and were largely replaced in the 1980s by the new ideas associated with the Harris Matrix. Brown and Muraca point out that fine attention to the details of every stratigraphic unit should be axiomatic on recent historic sites, since the phases and periods must be considered in years or decades, unlike the phasing in hundreds or thousands of years of other types of sites.

In considering the phasing of the Williamsburg site, data were put onto computers against a large geographic information system (GIS) for the entire town. This method then leads to the analytical possibilities of comparing one site with another in the town and to the possible construction of 'super-matrices', which would represent the stratigraphic and phase sequence over the entire town. Such approaches to the topographic and geographical history of a town and even its surrounding countryside offer exciting possibilities for future archaeological analysis, but at the same time, they heavily underscore the need to use single-context planning and to compile proper stratigraphic sequences, for these two types of data are the foundation blocks for any higher level analysis such as proposed by the authors.

The second paper by Martin Davies (Chapter 11) comes from an Australian context. In this article, based on earlier seminal work, Davies sets out to apply Harris Matrix methods to standing structures, which are but upstanding examples of archaeological stratification. Davies suggests that any investigation of a building must begin by determining its sequential evolution – and by this he clearly means its stratigraphic sequence. By so doing, he has opened up a new area in the philosophy of archaeological stratigraphy in which the founding tenet of superposition takes on new meaning and must be expanded beyond its uage for deposits buried in the ground.

The Law of Superposition essentially supports answers on questions of relative time, i.e., the lower of any two deposits is the earlier. This law, however, does provide for contradictions in its axiom, for it assumes that there has been no later alterations affecting the given two deposits. When alterations have occurred, the Law of Superposition is oriented to ask, 'Which came first'?, or, 'Which unit has been imposed upon (placed under, attached to, and so forth)'? This is similar to the question asked by geologists when faced with a possible overturning of rock strata, namely, 'Which way is up?'.

The interpretation of standing structures thus demands a broadened sense of the Law of Superposition and Davies suggests various methods by which this is done. Aside from his Antipodean examples, he notes the work of John James on the structural (stratigraphic) interpretation of Chartres Cathedral, in which previous constructional sequences were based upon stylistic grounds. Looking at the buildings as a stratigraphic entity, James was able to show that all the previous sequences were incorrect.

The final paper in this section is based upon work at the historic village of Sturbridge in Massachusetts by David Simmons, Myron Stachiw and John Worrell (Chapter 12). Independent of Davies, these archaeologists decided to dissect an historic building from roof to foundation. Again using a wider application for the Law of Superposition, they considered layers of paint as stratigraphic units, for example, and thus treated the entire Bixby House as if it were simply a stratigraphic entity. Upon removal of the house to another part of the historic village, excavation then took place under the area of the building. The final stratigraphic sequence thus extending from bedrock to rooftop, showing a remarkably creative use and extension of the Harris Matrix principles.

The papers by Davies and Simmons *et al.* should be given serious consideration by any archaeologists working with sites which contain standing buildings, for it is now clear that our responsibilities as stratigraphers and archaeologists do not end at the usual levels at which excavations begins, but extend rather to the whole dominion of structures erected and landscapes transformed by people through the course of time. Combined with our traditional skills in stratigraphy and taking full advantage of GIS computer programs, the papers of this section point the way forward for archaeological stratigraphy as far more than a digger's dream (or nightmare) but as a maturing and evolving science with endless and exciting possibilities for fruitful research on the many facets of our alteration and additions to the surface of the planet.

10 Phasing stratigraphic sequences at Colonial Williamsburg

GREGORY J. BROWN and DAVID F. MURACA

American archaeologists, perhaps more than their European colleagues, seem to value individualism in their approaches to recording archaeological sites. Units of stratification are described, when they are described at all, using a bewildering variety of terms and to enormously varying degrees of sophistication. 'Layers', 'features', 'zones' and 'strata', or some combination of these, abound in descriptive site reports, and imposing strings of identification numbers are labelled on thousands upon thousands of artefacts. But with relatively rare exceptions, there is often precious little concern with field recording methods and the philosophical assumptions behind them.

Unfortunately, the details of field recording techniques are rarely taught in university classrooms, and the methods used on many summer field projects, where a large proportion of American archaeologists are trained, leave much to be desired. Many professionals view the 'Harris method'[1] of site recording and stratigraphic interpretation as an overly technical exercise with little to offer beyond the tried and true methods of past years. Others view it as an attempt to impose too rigid a structure on archaeological creativity.

We disagree, and quite simply we have found the Harris method indispensible for dealing with complex stratigraphic situations. In this paper we will attempt to demonstrate what we consider the practical value of the Harris method for running an excavation, speeding up the pace of interpretive insights, and simplifying the post-excavation analysis leading to site reports and inter-site comparative studies.

Methods of recording in American historical archaeology

Historical archaeology in the United States is done for many purposes, in many areas, and on many types of sites. Although this paper focuses on one area – 'colonial-period' archaeology of Eastern North America – we realize that in recent years American historical archaeologists have taken a great number of approaches toward recording and interpreting depositional sequences. Some are fortunate enough to work in underpopulated rural areas,

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[1] By the 'Harris method' we mean the whole range of techniques advocated by Edward Harris in his book *Principles of Archaeological Stratigraphy* (1979, 1989), including not only the Harris Matrix but also open-area excavation, recording based on the context-record sheet, single-context planning, and attention not only to soil features themselves but also the 'interfaces' between them.

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or the sites of former towns that have since been converted to farmland, where later ploughing is the only significant disturbance on essentially single-component sites. On such sites the stratigraphic sequence can be relatively straightforward, particuarly where ploughing has eradicated the 'messy' stratigraphic evidence of recent periods, and horizontal spatial relationships are often the primary focus of analysis (e.g. King and Miller 1987). Many times, in fact, the later heavily disturbed stratification is simply bladed away with backhoes in the interests of reaching relatively intact features cut into subsoil.

Typically, however, those who work in American towns and cities face more complicated stratigraphic problems. Stratification is in many cases intact, even if highly dissected by recent activities. Earlier layers, pits, trenches and walls are often damaged by later intrusions, but aside from significant mechanical earth-moving or grading the stratigraphic sequence is not destroyed as with ploughing.

An additional problem relates to the fineness of the necessary temporal scale. Because of the presence of an often detailed written record, historical archaeologists work not on the level of centuries or millennia, as many colleagues are forced to do, but on the level of decades or even years. Many research questions require the isolation not only of occupation phases but of specific households in the site assemblage. However, while many useful synthetic studies have appeared in recent years (Cressey *et al.* 1982; Rubertone 1982; Zierden and Calhoun 1986; Staski 1987), the difficulties of isolating specific individuals or households in the urban archaeological record has proved enormous. Part of this has to do with social mobility, changing residence patterns, and a lack of permanent structural features on many urban sites. A great deal, however, has to do with stratigraphic complexity and the difficulties of recording, isolating, and anlysing comprehensive groups of related contexts amongst the abundance of fairly undatable features. Often miscellaneous postholes, refuse layers, and otherwise 'mixed' deposits are simply left out of the interpretation and attention is focused on large features such as cellar fill, wells and trash pits.

This is not to underestimate the difficulty of deciphering the stratification, whatever method is used. As many researchers have pointed out, archaeology in urban areas is complicated and frustrating. All too often later occupations obscure important evidence of features and relationships, and layers tend to be jumbled and highly contaminated. Stratification is difficult to sort out, as discontinuous layers and partially-disturbed features abound. It is sometimes necessary to resort to complex methods of periodization which rely more on the proportions of datable artefacts than on the nature of the soil itself (e.g. Wise 1976; Mrozowski 1984).

The complexity of dealing with a multitude of different periods and activities, however, is all the more reason that on-site stratigraphic analysis of *all* contexts is crucial to interpretation. It is not enough to rely solely on artefactual evidence, as some American historical archaeologists do, and it is certainly not enough to presume that the sequences will sort themselves out back at the lab. Field drawings are rarely as clear-cut as one imagines them when they are drawn, and records filled out in haste are too often incomplete. Looking at the artefactual content of the features is often no help at all; time after time important features contain no datable material, or only ubiquitous artefacts which were manufactured and used over decades if not centuries – not to mention residual and/or infiltrated artefacts.

For these reasons, field excavations at Colonial Williamsburg are performed with an explicitly stratigraphic approach. Matrix diagrams following the Harris (1979) method are prepared while in the field, and both single-context and composite plans are used quite heavily in post-excavation analysis. Based mostly on stratigraphic evidence, with artefactual (and sometimes documentary) data providing dates for specific events, sites can usually be divided into periods or phases of as little as a decade or two. Such periodization is used in all subsequent analysis of the finds. This process is particularly helpful in assessing archaeological evidence relating to household chronology, the domestic development cycle, the sequence of production activities, and status or occupation (see Wilk and Rathje 1982; Beaudry 1984).

The history of stratigraphic excavation at Colonial Williamsburg

This intense concern with stratigraphy has not always characterized excavations at Colonial Williamsburg. Beginning in the 1920s, several hundred buildings were restored or reconstructed to their supposed eighteenth-century appearance, making it the largest outdoor museum in the United States. Excavations in support of these reconstructions were first run by the architects and draughtspersons. Although for a short time trained archaeologists were hired to supervise the work, the lack of time and the necessary commitment to finding brick foundations for the reconstructions quickly resulted in an almost complete lack of attention to soil stratigraphy. Foundations were, to a certain degree, 'phased' on the final plans by assigning them to particular construction periods, but (in the absence of the actual intrusion of one foundation into another) this phasing was based solely on notoriously unreliable attributes of brick size, brick colour, mortar type, or bonding pattern. While in retrospect remarkably good in terms of relative chronology, this phasing often broke down, with the result that many buildings were in fact reconstructed to the wrong period.

In 1958, English archaeologist Ivor Noël Hume arrived in Williamsburg to take over the archaeology programme. His work, which has helped to train a generation of American historical archaeologists, relied on careful stratigraphic excavation using the square-and-baulk technique. Stratification units were meticulously described in the field notes, and excellent composite plans were prepared and disseminated in his descriptive site reports.

Excavations in Williamsburg since 1982, when Marley R. Brown III took over the bulk of excavation responsibilities, have demonstrated an even more explicit concern with stratification. The concept of 'context', largely borrowed from English archaeologists, was introduced to replace the very similar E.R. (Excavation Register) number used by Noël Hume and his colleagues. The square-and-baulk method was replaced with 'open-area' excavation, where stratification is recorded as one digs rather than from standing sections. Single-context planning was introduced to simplify recording and to allow the creation of a wider variety of composite plans. Finally, the Harris Matrix was used to impose order on the sometimes complicated stratigraphic sequence.

In very recent years, archaeologists in Williamsburg have come to rely more and more on the analysis of data using microcomputers. We now use a sophisticated geographic information system, GEOSYS, developed by English archaeologist Dominic Powlesland. All data, including stratigraphic information, is loaded into computer databases. Each context is recorded in detail, and associated artefacts, if any, are entered into a linked file. Geographic information is obtained by electronically piece-plotting – recording the exact location of – each artefact and context using a combination laser theodolite/ electronic distance measurer. Each single-context plan is digitized using a computer-aided drafting and design (CADD) package.

Recording excavations during the last ten years

The new recording methods at Colonial Williamsburg have had several direct benefits. In most cases we perform a modified form of 'open-area' excavation (Biddle and Kjølbye-Biddle 1969; Barker 1986), where relatively large areas are removed simultaneously with no intervening baulks or standing sections. Pit and trench features are drawn in plan and profile as they are excavated; layers are mapped in plan sequentially and then removed.

The value of the open-area approach has been realized by many other historical archaeologists, although traditional test-pitting and square-and-baulk excavation remain quite common. Open-area excavation, however, requires a systematic method for recording the vertical and horizontal relationships that are thus exposed. Use of the Harris Matrix is an essential procedure which puts this information into an organized and understandable order.

The context sheet is the basic recording mechanism for all units of stratification. Each unit, whether it be a layer, a fill deposit or a 'cut' (what Harris calls a 'vertical feature interface'), is assigned a sequential individual number. The context record is completed by the excavator, carefuly checked by the site supervisor, and entered into a bound notebook kept on-site. Almost immediately afterward, the same day or at least the same week, the records are entered into a computer database, and any errors or omissions that slipped through the initial checking process are caught at this time.

A Harris Matrix diagram is kept on-site and updated whenever a new unit of stratification is discovered. A field on the context record is reserved for verification that the matrix has been updated and, as a further check on stratigraphic thinking, the principal stratigraphic relationships of that particular context are recorded on the form as well.

For convenience, both during excavation and more importantly in post-excavation, related contexts are aggregated using two designations – the 'master context' or 'macro-feature', and the 'period'. The former applies to first-level groupings such as the postholes making up a fence line, the structural remains of a building foundation, etc. The 'period', on the other hand, is a higher grouping encompassing all those contexts which, it is believed, were generated by a single household and/or date to a single historical period of occupation. It is interpretive in the sense that non-stratigraphic evidence can, and indeed must, be considered in creating these groupings, and in fact during post-excavation analysis several potential arrangements can be tested out.

Single-context plans are made in the field as each context is revealed, and are brought daily to the laboratory to be digitized using AutoCAD™ computer-aided drafting software. Because each plan is stored in a separate computer file, labelled with the number of context (e.g. '10AA0230.DWG'), it is possible to generate composite plans as necessary simply by creating a 'script file' which tells AutoCAD to overlay a certain number of drawings atop base data such as excavation boundaries, modern contours, etc. Final composite plans can easily be generated from the Harris Matrix itself.

Three examples from recent projects will demonstrate some of the details of our version of stratigraphic recording using the Harris Matrix. Two were performed within the context of salvage or rescue work, where time limitations were a major concern, while the other was a university-sponsored summer field school, aimed at training undergraduate and graduate students in archaeological techniques.

Correlating and phasing limited excavations

One of the first clear demonstrations of the value of the Harris method occurred in late 1988, when the planned waterproofing of an original foundation provided an opportunity to reconstruct the history of that building. Now called the Grissell Hay Lodging House, this restored structure was once thought to date to the decade 1710–20, but recent architectural evaluation suggested that it was probably built around 1770. The location of an earlier house on the property, built around 1715 by wealthy surgeon and merchant Archibald Blair, was not known.

Excavations in the winter and spring of 1988–89 took place on three sides of the house, including the area beneath two existing porches which protected the strata from most twentieth-century disturbances. For various reasons, it was not possible to excavate these areas simultaneously, but it was clearly necessary to consider the stratigraphic evidence in each to develop a reasonable interpretation. To accomplish this, matrix diagrams were prepared for the 1 m wide test trenches in each area.

Analysis of the stratification in each area reveals a series of well-defined phases of activity (Fig. 10.1), which can be linked on the master matrix. The earliest phase (Phase I), represented under the front porch by a thin sequence of silt and loam layers, probably resulted from activities in the area well before 1715 or so, when the property was presumably unoccupied. A small trench or scaffolding hole found on the east side of the house also dates to this period. All were sealed by a 10 cm thick, dark brown sandy loam layer (18), probably original topsoil at the time when the property was first occupied.

At the beginning of Phase II, around 1715, a cellar hole was excavated and the foundation of the earliest house was laid. The stratigraphic evidence described below suggests that this house was smaller than the one currently standing, but that one portion incorporated into the later building was the lower portion of the south wall. The builder's trench for this portion (17) was seen under the front porch, although all other traces of it along the south wall had been destroyed by later waterproofing and foundation repair. Atop the topsoil layer outside this portion of builder's trench, however, was debris which indicates that there was some construction at this time, including a thin layer of brick dust (16) which partially sealed the fill of the builder's trench. On top of this lens, and overlying the topsoil layer in the undisturbed areas on all other sides of the house, was a layer of sticky yellow clay mottled with sandy loam (15) – probably remnants of the excavation of the cellar hole and subsequent levelling of the area.

Cut into this fill layer, possibly fairly soon after, was a bulkhead entrance into the cellar (14). Since the foundation wall was later torn out and repaired from inside the cellar, this bulkhead was not bonded to the house foundation and it is unclear whether it represents the original cellar entrance or a somewhat later addition. In any case, it stood for some of the 50 to 80 years of the use of the house.

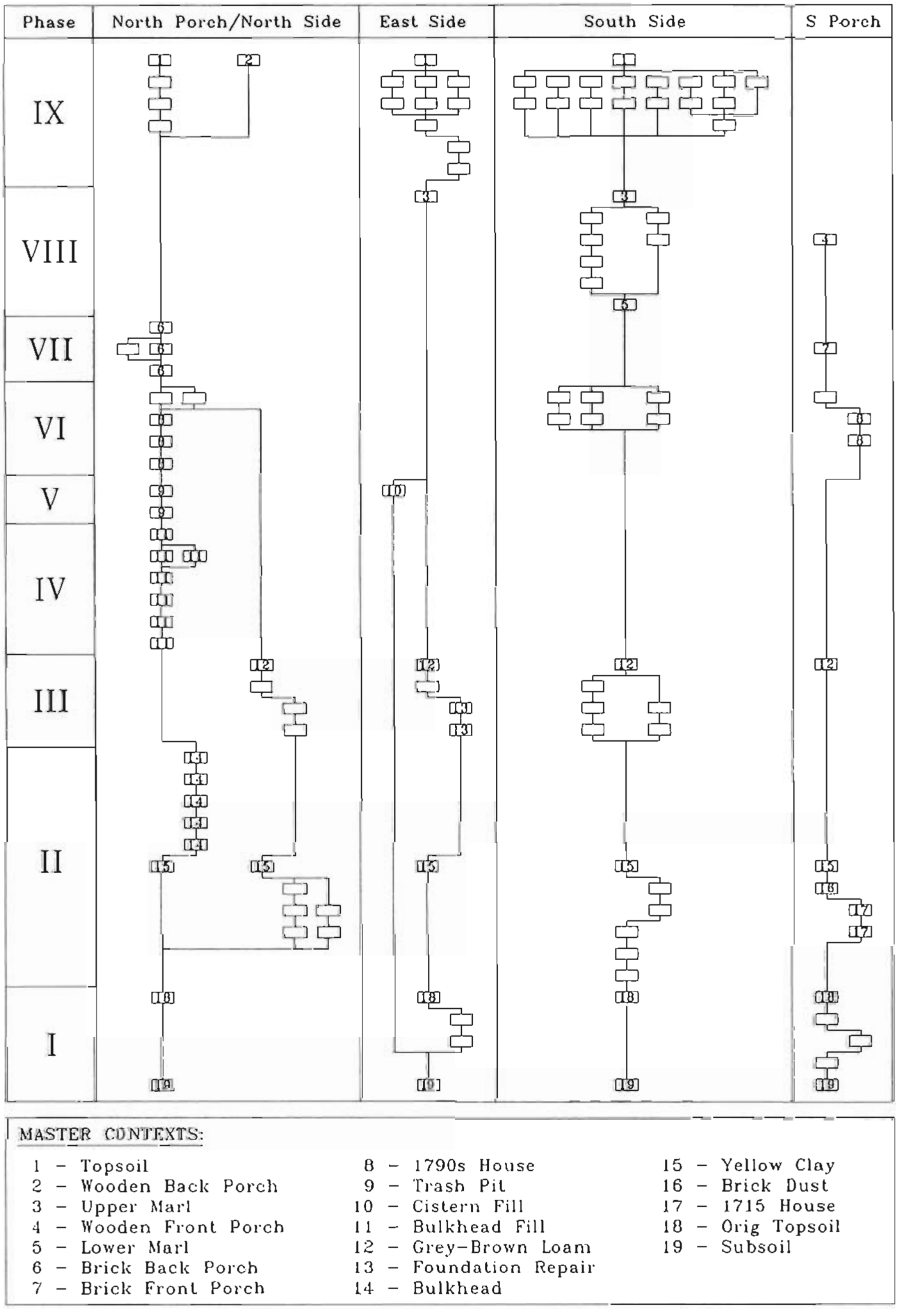

Fig. 10.1 Phase matrix for the Grissell Hay site, showing the reconciliation of sub-matrices from four excavation units. Context numbers are omitted; master context numbers are shown instead for units of stratification discussed in the text.

Phase III represents the occupation of this house, and is seen in a 35–40 cm thick, mixed grey-brown sheet refuse layer (12). A few postholes and at least one attempt at foundation repair (13), occurred at some time during this process.

During the fourth phase, the house was probably levelled and the bulkhead entrance was filled in. The destruction was seen only in the bulkhead fill (11), which comprised varying amounts of yard refuse, rubble, and a blackened area at the bottom of the steps which may possibly indicate burning.

Phase V was the period between the levelling of the first house and the construction of the second. It is represented by some sort of trash pit or other filled hole (9) which contained, among other things, a 1773 English half-penny and an assortment of ceramics typical of the period 1770–90.

In Phase VI, the second house was erected; builder's trenches (8) were seen under both the front and back porches. It appears that this second house incorporated some of the lower part of the foundation of the earlier building, but was enlarged by adding an entirely new foundation wall on the north side. This new portion of the wall sat atop a cistern (10) whose fill had a *terminus post quem* date of 1787. As this filling must have occurred before the second house was built, this later structure could not have been built around 1770 by Grissell Hay, as was once believed, but was probably built in the early 1790s by clergyman and then-owner James Henderson.

At some point, brick-based porches were added (Phase VII) in the front and back. Part of the brick front porch (7) remained intact until it was carefully dismantled and recorded in 1988; the back porch (6) had been destroyed and buried in the past.

Sometime around 1820, a Greek Revival wooden porch (4) was added to the front of the house, covering but not destroying the earlier brick porch. This addition, which survives today, thus sealed the stratigraphy underneath; any further renovations in this area occurred above ground. Two marl paths (3 and 5) were apparently laid at various times across the front of the house, extending up to the porch and presumably serving as walkways.

The final phase of occupation (Phase IX) is the Colonial Williamsburg period. The present wooden back porch (2), which sealed the stratigraphy below, was built when the house was restored though it has no archaeological precedent. Other activities include the installation of underground utility lines, the planting of flower gardens and the repair of damaged parts of the foundation wall.

By building partial matrices for each separate excavation trench, it was possible to link stratification units which were separated physically, and thus understand these very fragmentary views of the site as a whole. Analytically, the Harris method allowed us to demonstrate a clear historical sequence based on the stratigraphy alone, with very little help from the artefacts other than to provide 'anchors' in time for certain phases. Practically, it streamlined recording immeasurably.

Phasing a computer-generated Matrix

The second example of the value of Harris-based recording is in the context of summer 1990–91 archaeological field schools at the site of a colonial blacksmith. This programme was among the first at Colonial Williamsburg to use a computer-based geographic information system approach. All artefacts were piece-plotted electronically, and all drawn feature interfaces were entered into a CADD system. This increased reliance on microcomputers affects the recording of stratigraphic data in two ways.

First, the Harris Matrix, maintained in the field on a large blackboard, was immediately entered into the CADD package. The practical advantages were that the matrix could be stretched, widened and redrawn much more easily than in the past, and that context numbers, descriptions in plain English, *terminus post quem* dates and other relevant information could be placed on separate 'layers' in the drawing and displayed when needed. The typical multilinear sequence (see Fig. 10.2) could be easily adjusted by moving strata up or down based on non-stratigraphic criteria, such as artefact dates, within the limits imposed by the strict stratigraphic relationships.

Second, the production of composite plans was greatly simplified. Each feature interface was created as a separate CADD file, labelled with its context number. Using the master matrix, it was possible to create phase plans simply by drawing all feature interfaces on a given level of the matrix, along with shaded images of all later features higher on the matrix. By looking at a series of these plans, 'floating' strata on the matrix can once again be adjusted up or down depending on horizontal spatial patterns (for instance, aligned fence postholes can, in the absence of evidence to the contrary, be assumed to be contemporaneous).

Telling the story

A final use of the Harris approach is to simplify the transmission of stratigraphic information to colleagues and to the public. A typical case involves the Shields Tavern site, a major excavation conducted in 1985–86. The tavern was re-opened in 1987, and it was decided that serving staff would be asked to convey to visitors some sense of the history of the area. A training programme was put into place, and the archaeologists amongst others were asked to briefly summarize our conclusions about the site.

Like almost all other properties in Williamsburg's central core, Shields Tavern had a rich history. The property was occupied between 1708 and 1751 by two generations of tavern keepers, and later used as a tenement house between 1769 and 1800. Documentary research revealed that the tavern was operated by Huguenot immigrant Jean Marot between 1708 and his death in 1717, by his wife Anne Marot Sullivant betwen 1717 and 1738, and by his daughter Anne Marot Ingles Shields (and her husband James Shields) between 1745 and 1751 (Brown *et al.* 1990). After a gap of some 15 years about which little is known, the property was converted to a two-dwelling tenement, one half occupied by blacksmith and farrier John Draper between 1769 and 1780, and the other by Portuguese physician John de Sequeyra between 1770 and *circa* 1795. Like most other properties in this part of town, the lot continued to be occupied in the nineteenth and early twentieth centuries, until it was acquired by Colonial Williamsburg in the early 1950s.

A fully detailed Harris Matrix of this property, encompassing over 1500 contexts, is extraordinarily imposing at first glance and, while clearly the best method yet devised for stratigraphic analysis by the archaeologist, is not necessarily the best way to convey to others a simple picture of the site's development. By having the matrix on the computer, however, it is possible to create a version easily which can be simplified as a powerful

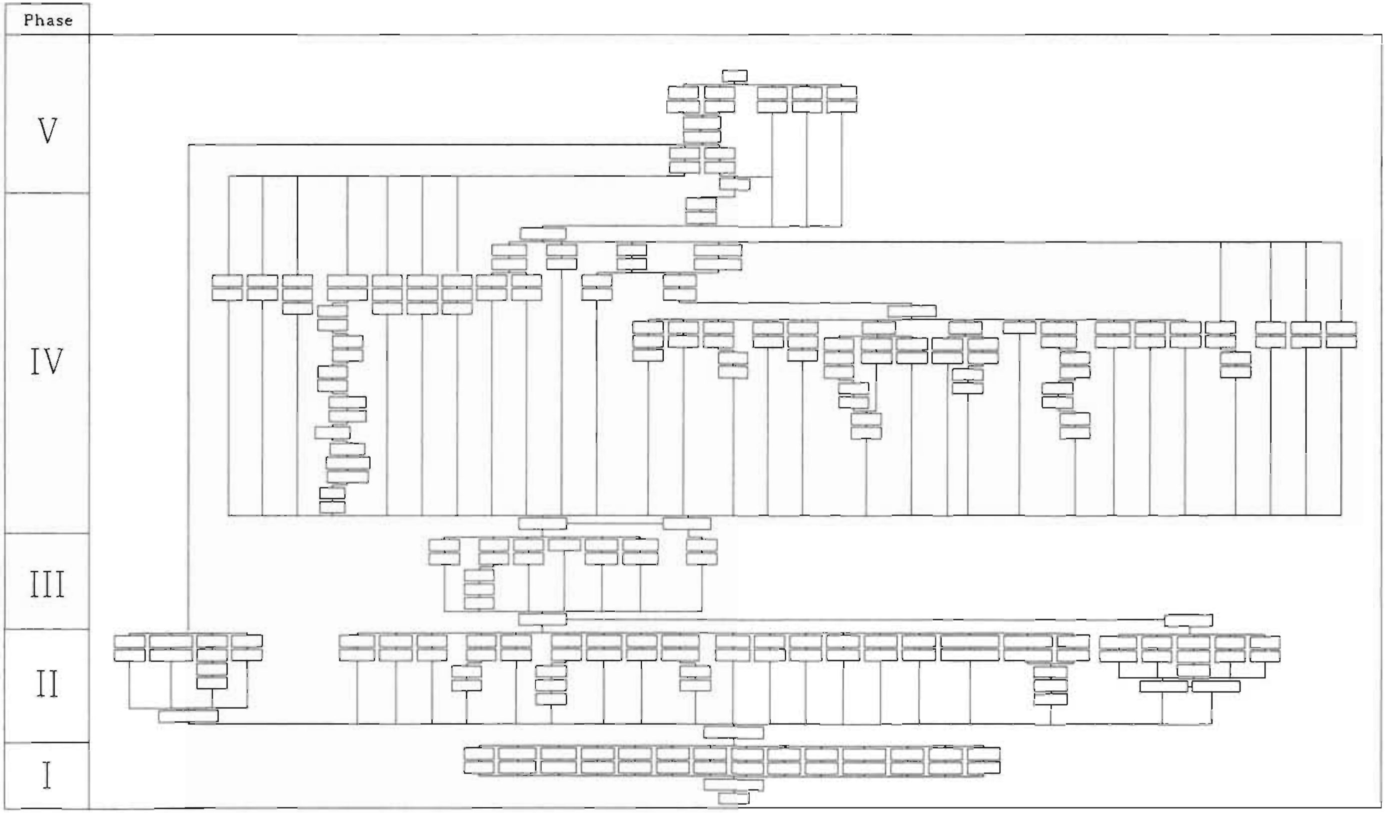

Fig. 10.2 Outline of the partially phased matrix for the Anderson Forge site, showing the large numbers of separate lines or 'strands' typical of an urban site. The different-sized rectangles are used to contain shorthand English descriptions of the features, which can be viewed using the zoom feature on the computer screen or printed on a large-size plotter. In this drawing, the descriptions have been omitted for the sake of clarity.

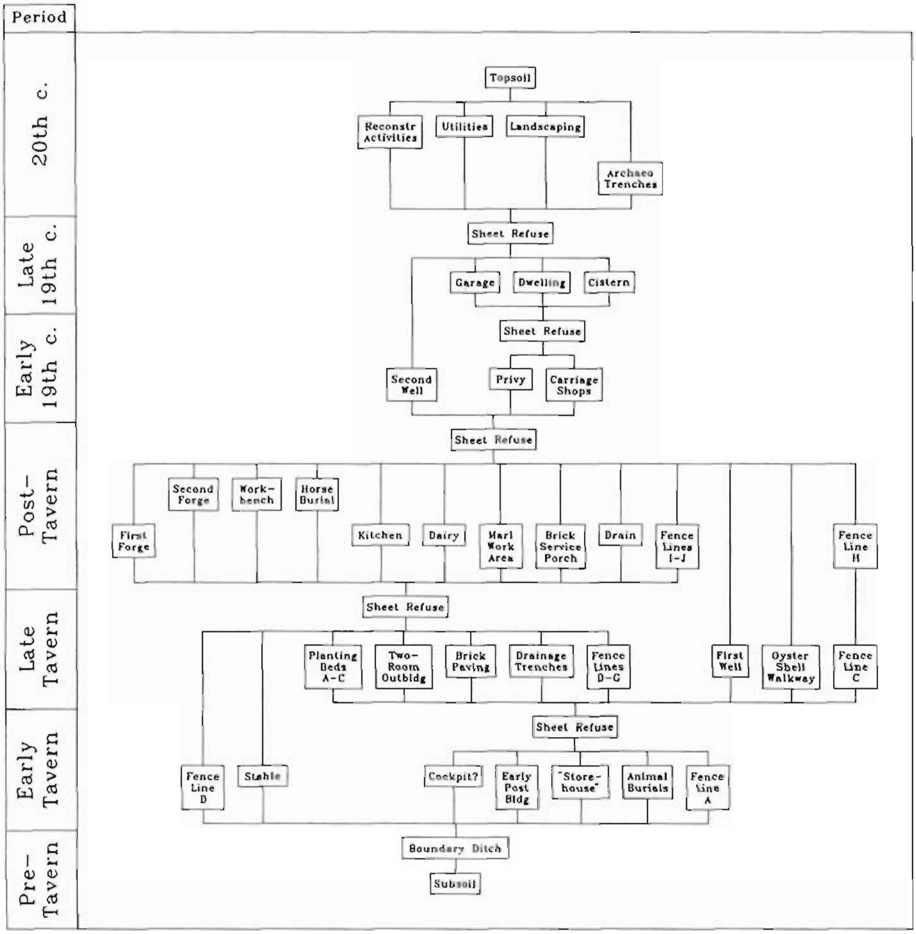

Fig. 10.3 Greatly simplified phase matrix for the Shields Tavern site. Features are shown at their earliest appearance (generally the feature interface); a long line above indicates a feature that persisted for some time before being abandoned or destroyed. For clarity, occupation surfaces ('sheet refuse' layers) are rather simplistically shown as sealing all features abandoned in any one period.

explanatory tool (Fig. 10.3). The sequence of major activities can be shown by combining related contexts and replacing the individual numbers with a larger box containing a shorthand English description of the activity (e.g. 'Building Construction'). This box is placed, arbitrarily, at the stratigraphic position where the feature first appeared (its 'interface'), with the line above representing in some senses its persistence through time. In this way the essence of the stratigraphic sequence is maintained and clearly displayed, without the excessive detail which is not of interest to the public. Of course, for the archaeologist involved with site interpretation this is no substitute for the full Harris Matrix, which must be consulted both in the construction of this simplified chart as well as all other aspects of site analysis.

For example, it can be seen in the lower part of the chart that in the earliest period ('Pre-Tavern'), only one major feature existed on the property – a long but shallow boundary or drainage ditch which probably formed a property division in the period before the town was established in 1699. In what is termed the 'Early Tavern' period, encompassing the occupations of Jean Marot and his widow Anne between 1708 and 1738, many more features were added, including the tavern building itself (not shown on the matrix), three outbuildings in the back yard, two fence lines or boundary divisions, several animal burials, and a circular ditch that is thought to represent an outdoor cockpit. Sheet refuse occupation layers deposited in and around these features separated them from those of the 'Late Tavern' period, representing the occupation of the tavern between 1738 and 1751. During this time two of the older outbuildings were probably lost, although the stable continued in use, and it appears that one new two-room outbuilding, possibly a laundry/slave quarter, was established. A kitchen garden with surrounding fence (Planting Beds A–C and Fence Lines D and E) was added, and a series of drainage ditches in the eastern yard apparently indicates its use for exterior service functions. A well was dug, connected to the house with an oyster shell walkway.

More notable changes occurred in the 'Post-Tavern' tenement period, when blacksmith John Draper constructed at least two forges and a workbench complex, and generally converted the western half of the yard into an industrial zone. In the meantime, his neighbour John de Sequeyra constructed, or had constructed for him, an exterior kitchen building and dairy, along with a brick service porch and marl-covered domestic work area.

As shown at the top of the diagram, during the next 150 years, later occupants constructed at least one privy, a new well, a pair of carriage shops, a concrete garage, several fence lines and a bungalow-type dwelling. When Colonial Williamsburg decided to reconstruct the property, the landscape underwent even more major changes. Archaeological cross-trenches, construction activity, landscaping and the installation of utility lines were simply the final acts in the stratigraphic sequence.

The future role of stratigraphic analysis in Williamsburg

As these examples demonstrate, the use of matrix diagrams is a valuable tool for site interpretation. Of course, almost all sites – whether urban or rural, continuously or intermittently occupied – exhibit complex stratigraphy. In fact, the continuous building of new features and partial or total destruction of old ones is the very nature of the archaeological record (Binford 1981). But where the temporal unit of study is often no more than a decade, stratigraphic evidence is particularly essential. Stratigraphic periodization and phasing not only forms the basic chronology, but also guides the subsequent analysis of artefacts, animal bones, floral remains and soil constituents by providing a framework by which household sub-assemblages can be derived.

Clearly, however, the approach also has value at the other scales of analysis. Until now the Harris Matrix has been used solely as a tool for intra-site comparisons. But there is no reason that 'super-matrices' cannot be constructed for a series of geographically contiguous sites. Cross-mending of artefacts has suggested, for instance, that fill from the Grissell Hay site was dumped across the street at another property, the Peyton Randolph lot, excavated by Colonial Williamsburg in the early 1980s. By linking several sites together with a single matrix, it may be possible to phase and periodize very large-scale events – obviously an approach which holds great analytic promise.

Once stratigraphic changes are understood on a relatively large geographic scale, archaeological analysis can be used to answer larger, perhaps ultimately more significant questions. Along with examining lot development through time, one can look at block, neighbourhood or even regional activities. Equally importantly, the distinct assemblages and sub-assemblages derived from the stratigraphic approach can be used with confidence to investigate the broader-scaled historical and anthropological questions that are occupying many American historical archaeologists today (Brown 1987).

As the excavation of Colonial Williamsburg continues, special attention will be paid to geographic relations and inter-site depositional patterns. Already a useful and proven tool, stratigraphic analysis using the Harris Matrix plays and will continue to play a vital role in the daily work of archaeological research.

Acknowledgements. The principal advocate for the Harris Matrix approach at Colonial Williamsburg has been Director of Archaeological Research Marley R. Brown III. Many of our ideas and interpretations, of course, came from our colleagues at Colonial Williamsburg; we would particularly like to thank our fellow field archaeologists Andrew Edwards, Patricia Samford and Meredith Moodey.

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11 The application of the Harris Matrix to the recording of standing structures

MARTIN DAVIES

Standing structures and the Harris Matrix

The archaeological research potential of standing structures has been clearly demonstrated by the work of John James (1981) on the contractors and the contracting organizations in medieval France, and of Henry Glassie (1975) on cultural change and attitudes of a population in Virginia, in the United States. Both used explicit methodologies to deal with complex transformations of structures, James on Chartres Cathedral and Glassie on the folk housing of Middle Virginia, and recognized that these transformations were value-laden in archaeological terms.

A structure, in much the same way as an archaeological site, is the result of numerous activities: combinations of construction, destruction, repair, alteration and reinstatement, which occur at specific periods of time. The notions of stratigraphic deposition, disturbance and relationships, although central to excavation theory and practice on archaeological sites, can be equally applied to standing structures. Fabric can be overlaid by later fabric, and fabric can be cut and later fabric introduced. The concept of feature interfaces also applies to standing structures: an interface of destruction is formed when fabric is removed. In some cases traces are left to indicate the nature and extent of this missing fabric, in other cases there are none. However, the stratigraphy of a structure is complicated by the fact that later fabric is regularly introduced leaving little or no disturbance to existing fabric (for example window glass).

Whilst there are a number of manuals and methodological procedures in the archaeological literature which discuss excavation techniques, there is a lack of similar works on standing structures. Measured drawings, photography and photogrammetry, although sufficient to record the spatial relationships of the various components of a structure, fail to record a host of other information – the evidence of sequential development and dating. It is these data which are crucial to the future analysis and interpretation of structures and to an understanding of those who designed, built, occupied and altered them.

The key exercise in any investigation of a standing structure is to determine its sequential development (i.e. its stratigraphic sequence) and to place this within a chronological framework. Without this it is impossible to place the structure or any of its component elements within any historical, technical or social framework. Such an exercise can be equated with the central task of identifying the stratigraphic sequence in an archaeological excavation.

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The data which are relevant to determining and dating this sequential development are as follows:

1. Stratigraphic relationships: whether an element is introduced before or after its adjoining elements.
2. Building materials: the fabric of which an element is made; the sources from which it was obtained.
3. Manufacturing technology of the building materials: the process by which the materials were made or transformed for use.
4. Construction technology: the way elements fit together, including their methods of attachment, size and dimensions.
5. Direct dates: date plaques, foundation dates, manufacturers's marks, graffiti.
6. Use-wear patterns: the evidence of functions and extent of use.
7. Style: architectural form, layout and design, and ornamental detailing.

To these can be added evidence from comparative analyses, historical sources and archaeologically excavated subsurface material.

The development of a structure can be revealed by ordering all the activities in the sequence in which they occurred. Studying the stratigraphic relationships between elements allows a relative dating sequence to be established. The absolute chronology is provided by studying the evidence of manufacturing technologies of the building materials, contruction technology, style, etc. and by applying the dating logic of the *terminus post quem* and *terminus ante quem*. Historical sources can assist in formulating both the relative sequence, by depicting, describing or alluding to elements which are no longer *in situ* and for which all physical evidence has been obliterated, and the absolute chronology by providing dates and/or date ranges. Evidence derived from archaeological excavation can also assist in determining both the relative sequence of the standing structure, by elucidating stratigraphic relationships and by incorporating subsurface features and deposits in the sequence, and the absolute chronology by providing dates obtained from artefactual analyses.

An explicit methodology is required to articulate all the relevant data and present it in such a way that the activities and events are clearly defined. This has been achieved by using the Harris Matrix, albeit with two suggested modifications.

It is a common occurrence in a structure that, although some elements are stratigraphically *under* adjoining elements, they are chronologically *later* than these overlying adjoining elements, for example concrete underpinning of a sinking foundation. The concrete is stratigraphically under the foundation but, as it has been introduced after the foundation, it is chronologically later than the foundation. Similarly, supports for sagging roof rafters would be stratigraphically under the rafters but chronologically later than them. Harris appears not to be particularly concerned with this situation as his work related primarily to buried sites in which it would seldom occur. It appears that in accordance with Harris's method, these chronologically late elements would be placed in the matrix below the elements they physically support. The modification to Harris's method is made that, where the evidence is sufficient, these chronologically late elements in the matrix are placed above the elements they physically support. For example, the concrete underpinning would be shown in the matrix above the foundations; the roof supports would be shown above the rafters. Thus chronological factors are being introduced in establishing the relative sequence. Although it would be more sound to

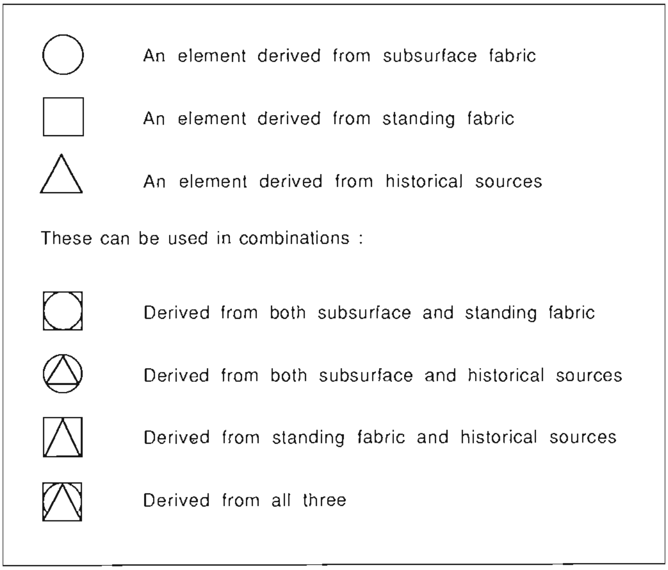


Fig. 11.1 Codes used in the matrix to identify sources of an element.

separate the pure stratigraphic evidence from the chronological evidence, as Harris states with respect to archaeological excavation, in practice it has proved simpler to consider the two jointly. The consequences of this modification are that the matrix reflects the actual sequence in which elements were introduced and activities took place. On sites for which historical records are available this allows for the changes to the structure and their frequency through time to be correlated with historical events such as changes in occupancy and function.

A further modification to Harris's method is the use of coded symbols to denote how each element has been identified (Fig. 11.1). The advantage of this code is that it immediately indicates how incomplete the sequence and the understanding of a structure would be if only one source of evidence was employed. The use of these codes is shown in Fig. 11.3.

Although its primary application is to order the various stratigraphic relationships, the matrix can be used to unravel potentially complex and confusing structural situations. If the matrix is constructed as the physical stratigraphic evidence is recorded, and it is advisable that it is, there are two advantages. Firstly, it identifies which relationships have not yet been recorded and, secondly, it identifies any inconsistencies in the sequence. The latter occur where the stratigraphic relationships have been identified as follows: Element C is above (i.e. later than) Element B. Element B is above Element A, and Element A is above Element C. This results in a loop in the matrix (as is shown in Fig. 11.5A). Such an inconsistency immediately indicates that either an error has occurred in identifying or recording the stratigraphic relationship between A and C, or A and C were incorrectly identified as representing the one context or 'unit'. It is this initial task of identifying or defining discrete 'units' in a structure which is crucial to constructing a matrix and in turn to interpreting correctly that structure. The task is eqivalent to defining units of stratification in an excavation. It should be recognized that the processes of formation of a structure are as complex as those which have formed an archaeological site. Given the vast number of individual elements which constitute a structure, it is impractical to consider each as a separate unit and list its stratigraphic relationships. As a consequence, identical elements can be grouped and considered as a single unit such as boards in a floor or shingles in a roof. This corresponds to regarding a buried brick wall in an excavation as a single unit of stratification rather than each brick as a separate unit. It is this procedure, the grouping of elements, which if incorrectly carried out will produce inconsistencies in the matrix. For example, a floor consisting of three separate sections (identified by differences in board size) represents three separate units and would be recorded and entered in the matrix accordingly.

There is usually an initial temptation to group elements rapidly in order to simplify the sequences. However, the rationale for the grouping must be recorded and accordingly such grouping is best done during the analysis as part of the phasing operation. James masterfully demonstrated this in his research on Chartres Cathedral (James 1981). Prior to his work, researchers had discussed and disputed the constructional sequence of the major sections of the building (nave, choir, transepts and porches). Their arguments were based primarily on stylistic criteria. James examined the structure in terms of its stratigraphic relationships and demonstrated that all the previously proposed sequences were incorrect. He adopted a procedure which recorded not major groupings of elements but individual minutiae such as mouldings, coursing heights, stone finishes and, most importantly, the actual geometry and standard measures used in creating these features. He discovered that certain patterns emerged consistently throughout the whole structure. By plotting their location he concluded that the entire edifice was raised as a whole in a series of building campaigns and that the patterns were due to each campaign being the work of a single contracting crew.

Problems can also be encountered by the re-use of building materials. Although an element may appear to have an early chronological date (as determined by some of its datable attributes) and appear in an early stratigraphic position (as determined by its stratigraphic relationships), on closer examination it may in fact be re-used and thus have a late introduction date. An early position in the evolutionary sequence would thus be incorrect. There are no simple guidelines by which to identify re-used elements. However, in general, if there are surface finishes (paint, wallpaper, etc.) and traces of earlier attachments whose existence cannot be explained by the present location or function, then the element has been re-used. For example, floorboards which have their undersides limewashed and have nail holes which do not correspond to the present nailing pattern would be identified as re-used. Another way to identify re-used elements is to determine the present method of attachment and establish whether the date of this method matches that of the element itself. If not, then the element has been either re-used or stored for a period of time and then used. For example, if undressed pit-sawn timbers are attached to circular-sawn structural members, with bullet-headed steel wire nails, then one would conclude that as the date of the method of attachment (mid–late twentieth century) does not match the date of the timbers (*c.* pre-1870s) then the pit-sawn timbers have been re-used or, though more unlikely, stored for a period of time and then used.

Although outside the scope of this paper, it should be noted that these data are recorded and filed as part of a structural recording system, the original of which was formulated by the Port Arthur Conservation Project (Davies and Buckley 1987). It was designed to record a wide range of structural information including the diagnostic data outlined above and to complement the various archives which record spatial relationships: photographs, measured drawings and photogrammetry. The system regards the traditional methods of depicting structural change (composite plans and series of overlays showing the structure at various periods) as the presentation of the final interpretation of the evidence, not the means of recording it.

Worked example

Figure 11.2 depicts a cross-section through a hypothetical structure with the various stratigraphic units (in this particular instance individual building elements) ordered in a matrix.

In this example the units have been identified and numbered. On large complex structures such an exercise facilitates the recording and construction of the matrix, though, as the second case study will show, on more limited investigations this numbering exercise may not be necessary.

The investigation process itself would roughly be as follows. The first step would be reconnaissance, involving examination of the construction techniques, detailing joinery and in particular breaks and junctions in elements and materials. The recording stage involves the spatial relationships being recorded via measured drawings, photographs and/or photogrammetry, and the discrete stratigraphic units being initially identified. The various diagnostic attributes of each unit are entered onto a recording sheet (in the Port Arthur recording system called a 'structural element data sheet'), while the stratigraphic and associated dating information (from historical source material) is entered on a second sheet (a 'structural evolution data sheet') on which the matrix is also constructed.

The analysis and interpretation stages then follow with the unit matrix being phased and the various activities which compose each phase being recorded and arranged chronologically in a matrix on a third sheet (a 'structural evolution interpretation sheet'). Depending on the size and nature of the structure these phases would be incorporated in a final structure matrix. In a large structure it is advantageous to subdivide the structure into overlapping 'areas' to make the matrices more manageable with the numbering of units being done according to either the whole structure or to the various 'areas'. In such a case phased matrices are prepared for each 'area' and finally synthesized into a single matrix for the entire structure.

To the right of the matrix in Fig. 11.2 the various phases have been identified, though in this particular instance numbering the phases has been omitted.

Case studies

Two nineteenth-century case studies, both Australian colonial sites, are presented. The first is the Commandant's Residence at Port Arthur, Tasmania and the second 'Dundullimal', a homestead at Dubbo, New South Wales. The former provides an example of the matrix's use to unravel a complex evolutionary sequence, whilst the latter demonstrates a micro-application to unravel construction and decision-making processes.

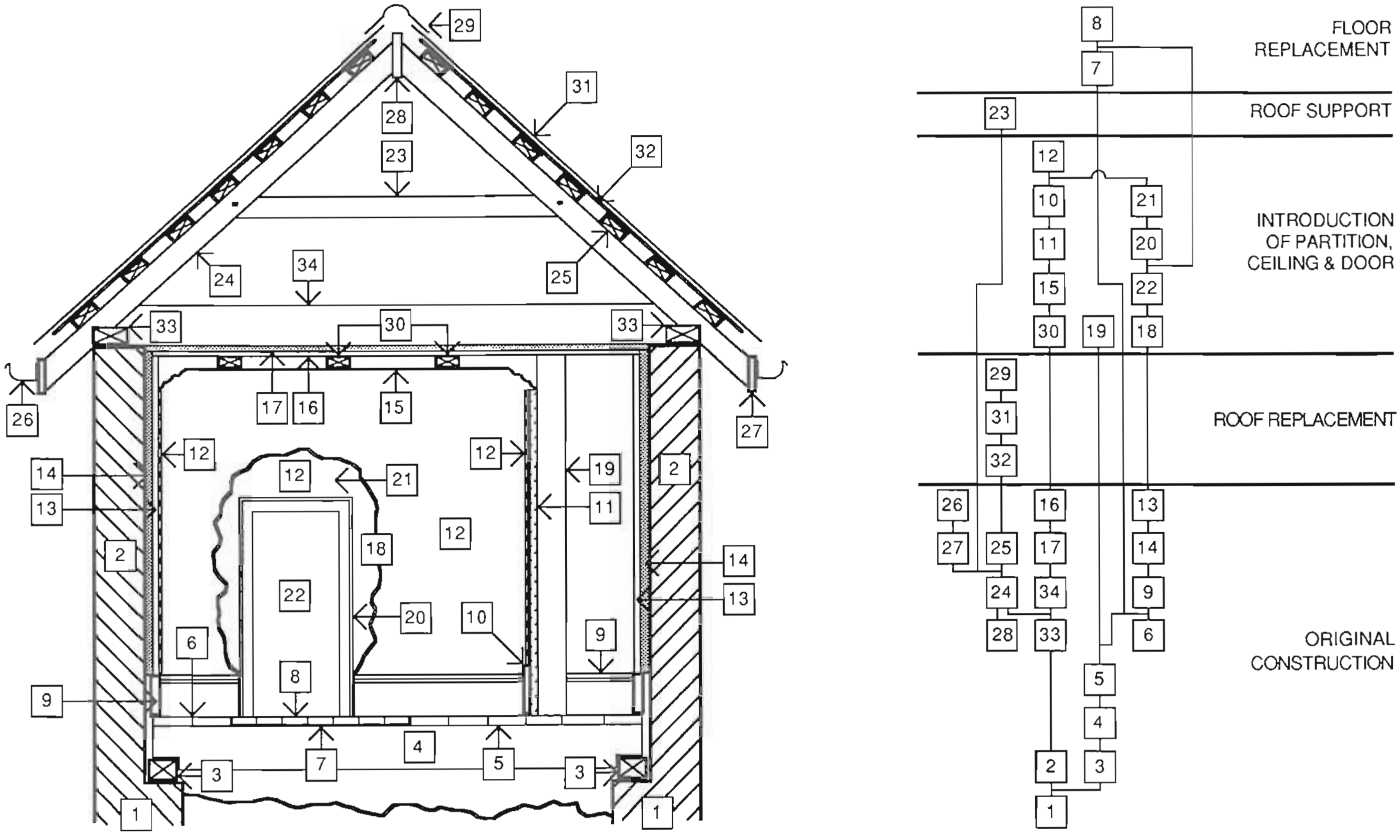


Fig. 11.2 Section through a hypothetical structure and its stratigraphic unit matrix. Units 7, 18 and 32 represent feature interfaces: removal of flooring, removal of paint, plaster and wall, removal of shingles respectively; Units 12, 13 and 16 are paint layers; Units 11, 14, 17 and 21 are plaster coats; Units 3, 4, 5, 6, 9, 24, 25, 27, 33 and 34 are pit-sawn timbers; Units 8, 19, 23 and 30 are circular-sawn timbers; Units 10 and 20 are band-sawn.

Commandant's Residence, Port Arthur

Port Arthur is the site of a British penal settlement. It is situated on the isolated Tasman Peninsula in southeast Tasmania. The prison establishment lasted from 1830 to 1877, after which the site served as a tourist destination, building material quarry, a local administrative centre and more recently as a designated Historic Site.

The largest, though by no means the grandest, domestic structure on the site is the Commandant's Residence. An initial examination of the building revealed a complex structural evolution. Reference to historical sources confirmed that both an early weatherboard timber cottage and brick detached kitchen had survived, albeit with internal alterations, within the present structure. Subsequent alterations had converted this four-roomed cottage into what can best be described as a random hodgepodge consisting of some 25 separate spaces (rooms, attics, halls, verandahs, etc.).

Faced with such complex transformations, the structure and its environs became the focus of archaeological investigations undertaken under the auspices of the Port Arthur Conservation Project. It was recorded stratigraphically and a phased matrix for not only the house but its immediate environs constructed. This final phased matrix is shown in Fig. 11.3. As can be seen from the coded symbols, it incorporates not only the evidence from the standing fabric but the subsurface evidence recovered by archaeological excavation and evidence gleaned from historical source material.

Examination of the matrix immediately indicates the major construction programmes. The first, in 1833–34, consisted of Phases 5–22 (erection of the four-roomed cottage, its outbuildings and creation of its formal garden). The second programme, in 1844–45, consisted of Phases 38–49 (construction of two large rooms – 'pavilions' – on either side of the four-roomed cottage, which necessitated numerous internal alterations as well as re-adjustments to the layout of the grounds). Further programmes, though less extensive than the previous two, were Phases 55–57 (a new kitchen block), Phases 62, 63 and 70 (embellishing the front facade), Phases 65–69 (garden alterations) and Phases 71–74 (erection of new outbuildings). What is also obvious from the matrix is that the post-convict work consisted not of large-scale building programmes but of individual works, largely undertaken in various unrelated parts of the structure.

A dwelling for the Commandant (and military officers) was one of the first buildings erected at the Port Arthur site though this structure is known only from brief historical references (this structure is identified in the matrix as Phase 3). Within a few years a new four-roomed weatherboarded cottage was built on the up-hill side behind the early building, the latter being demolished and formal gardens established in its place. The new structure had an 'I'-shaped ground plan with living quarters and kitchen linked by a covered-way (P 9, 8 and 7 respectively). Within a few years a second detached kitchen block was erected and the original kitchen was converted to a study (P 17). Later still a three-room brick addition was erected replacing the covered-way (P 24). The building during this time was occupied by Commandant Charles O'Hara Booth and, during that time, was described in a contemporary account as 'small and badly planned; certainly unfit for the residence of a Commandant' (Davies and Egloff 1986: 53).

With the arrival of a new Commandant, William Champ, numerous changes were undertaken, primarily the two pavilions flanking the original timber structure (P 38 and 42). It is interesting to note that Champ decided to augment the existing structure rather than build something grander, there being ample flatter land for the purpose. After

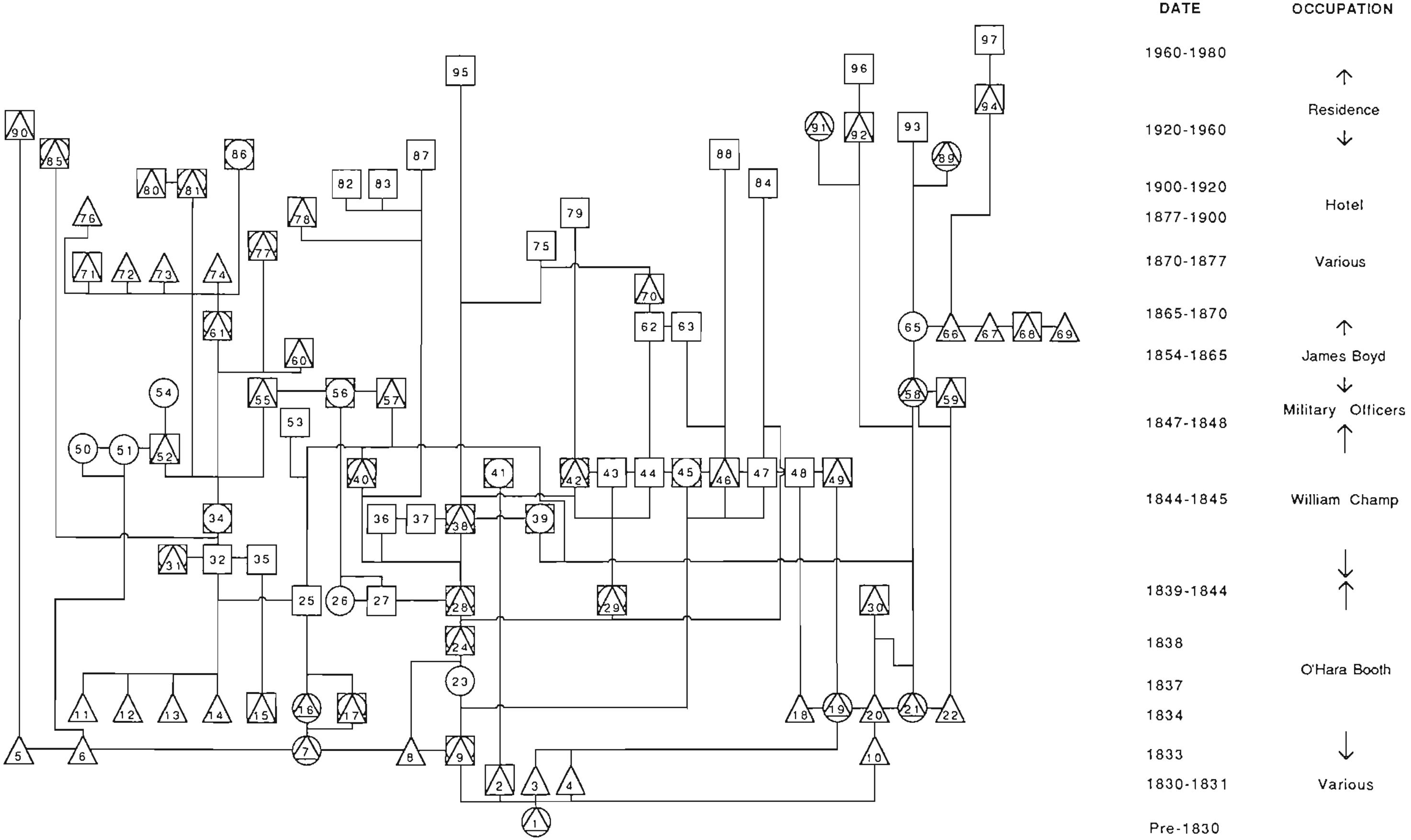


Fig. 11.3 Commandant's Residence, Port Arthur. The phased matrix for the complex. It should be noted that the matrix, as it is arranged chronologically, allows the known occupants to be slotted into the sequence. Relevant historical plans and illustrations can similarly be introduced into the matrix. In addition the configuration of the site at any particular period of time can be established by determining the vertical relationships which are intersected by a horizontal line at the required date. Such a procedure allows a series of interpretative plans to be drawn which graphically depict the structure's evolutionary development.

Champ's departure in 1848 a change in the administration of the settlement took place with the post of Commandant being replaced by a Superintendent. The latter chose to live in a more spacious and certainly better executed house elsewhere on the site. This period corresponds to a general decline in the state of the Commandant's Residence which at that time was appropriated for the use of two military officers.

In 1854 the office of Commandant was reinstated and the new incumbent, James Boyd, chose to leave the relative anonymity of the Superintendent's house and return to the more prominently sited Commandant's Residence. Boyd re-established the gardens (P 65–69) and ornamented the front facade by altering the pitch of the verandah roof, adding an Italianate porch and plastering Champ's two pavilions (P 62, 63 and 70 respectively).

Thus what had begun as a simple and unpretentious 'rustic' cottage evolved through a series of transformations which aimed at heightening the structure's grandiose qualities, certainly indicating a change in each occupant's perceptions of their role as Commandant.

The post-convict period saw the structure used firstly as a hotel and later as a private dwelling. Throughout this time numerous internal partitions were erected, a detached dining room built and various laundry and kitchen facilities introduced. This time is also associated with a decline in the house and its environs.

Given its complex nature, it was the Commandant's Residence on which the application of the Harris Matrix to a standing structure was first attempted. The matrix's potential was initially demonstrated by being used to unravel the various alterations to a single window. Following this success the matrix was then applied to the investigation of the entire structure.

Dundullimal

Dundullimal homestead is located on the south bank of the Macquarie River 4 km upstream from the town of Dubbo in central New South Wales. It is situated on a low knoll on the edge of a terrace which runs parallel to the river. It was the head station of a large squatting sheep run (called 'Dundullimal') which was established in the 1830s in what was then the Wellington Squatting District.

The homestead, in stark contrast to the Commandant's Residence, is a relatively small nine-roomed structure (Fig. 11.4) constructed of vertical split slabs inserted into channelled wall plates. However, it was apparent that at some early stage an internal stud wall, constructed of pit-sawn timbers, had been introduced. The evidence, which is cited below in simplified form, indicated that the east and west slab walls of S5 originally extended across the passage space (S2/3), these being removed to allow the stud wall to be introduced.

The stratigraphic evidence for (S2 only) is as follows:

1. The S2 floor is in two sections: north–south boards in the east half, and east–west boards in the west (which extend into S6 and S7).
2. Separating these two flooring sections is an infilled section of flooring consisting of a reversed skirting board.
3. This infilled floorboard is attached to short sections of joists which rest on a buried channelled wall plate and link the joists in the west half with those in the east.

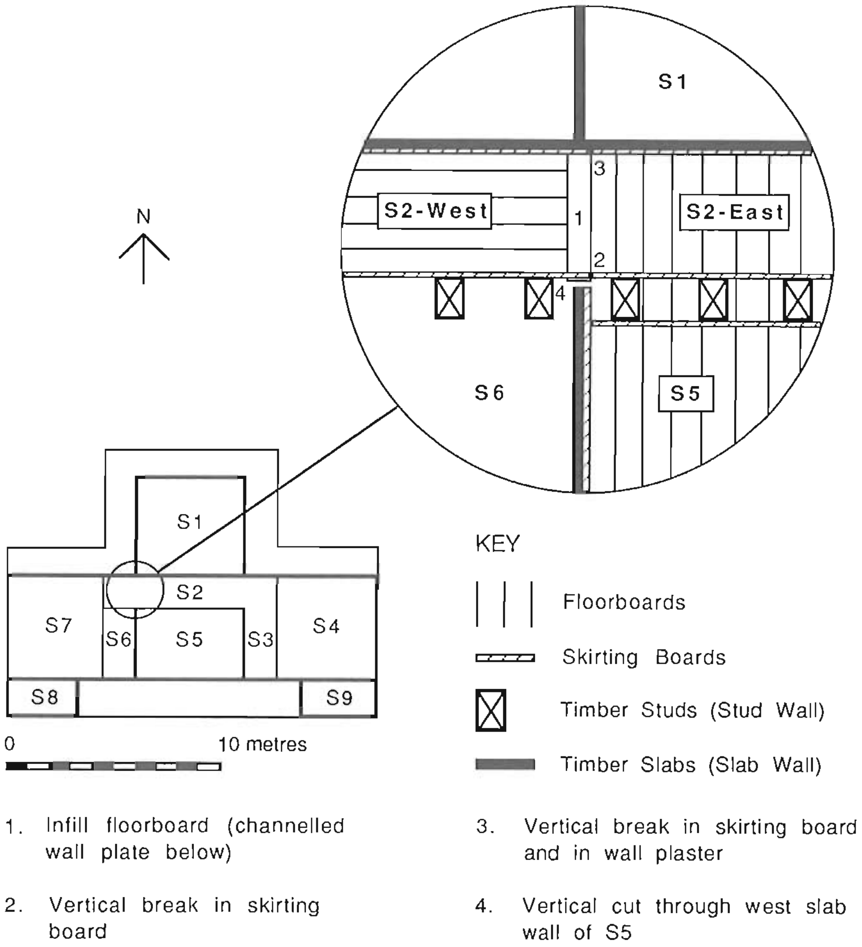


Fig. 11.4 Dundullimal. Ground plan showing the space numbers and structural elements referred to in the text.

4. The floorboards throughout are contemporary with the joists as indicated by the single nailing patterns.
5. This east section of flooring pre-dates the south stud wall of S2 (i.e. between S5 and S2) as the studs rest on the floorboards.
6. This stud wall is contemporary with the stud walls of S6 and S7 (or at least the lath and plaster finish is) and post-dates the west slab wall of S5 (its plaster and studs abut the plaster on the slab wall).
7. This west slab wall of S5 (the slabs, laths, plaster and skirting) terminates in a vertical cut (made by a saw).
8. The flooring in the west end of S2 post-dates the stud walls.

When this evidence was ordered stratigraphically, the matrix shown in Fig. 11.5a resulted. It was therefore obvious that a problem lay in the sequence of the removal of

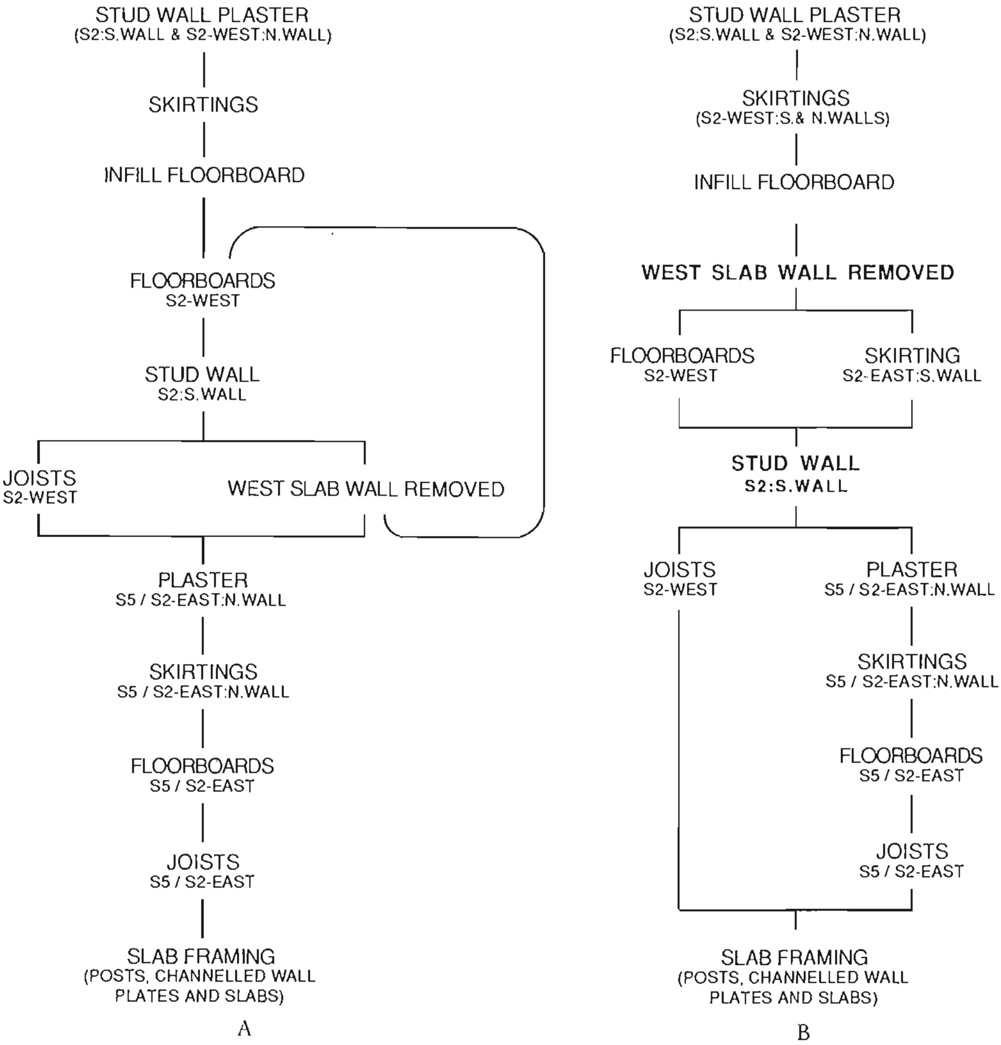


Fig. 11.5 Dundullimal. S2 Matrices. (A) Stratigraphic units initially arranged in a matrix showing the inconsistency in the sequence. (B) Stratigraphic units logically arranged in matrix but which fails to take constructional practicalities into account.

the slab wall and laying of the floorboards. The infilled section of floorboard indicates that the two sections of flooring in S2 were *in situ* prior to removal of the slab wall. When the latter was removed the gap was then roughly infilled. If this was the case, then the south stud wall of S2 must also pre-date removal of the slab wall as it pre-dates the west section of flooring.

Additionally in the north wall of S2 there is a break in the skirting at the west end of the east section of flooring. This would be expected if the west slab wall of S5 had met the north wall at this point and, after the north section of this wall was removed, to create the passage (S2), a new section of skirting installed on the north wall beyond the existing skirting. Similarly it should be expected that the south stud wall of S2 would have a continuous skirting along its entire length (assuming the slabs had been removed earlier). However, this is not the case: an identical vertical break occurs in the south stud wall skirting matching that on the north wall. This appears to indicate that the slab wall was still *in situ* when the stud wall was erected and the skirting cut accordingly, i.e. the skirting on the south wall of S2-east pre-dates removal of the slab wall.

It was only after the stud walls (or more precisely the studs themselves) had been put into position and both the south wall skirting of S2-east and the west floorboards introduced that the section of slab wall was removed. Rather than the stud wall being built after the slab wall was removed, the reverse in fact occurred: the stud wall was built *prior* to removal of the slab wall. This situation is shown in Fig. 11.5B.

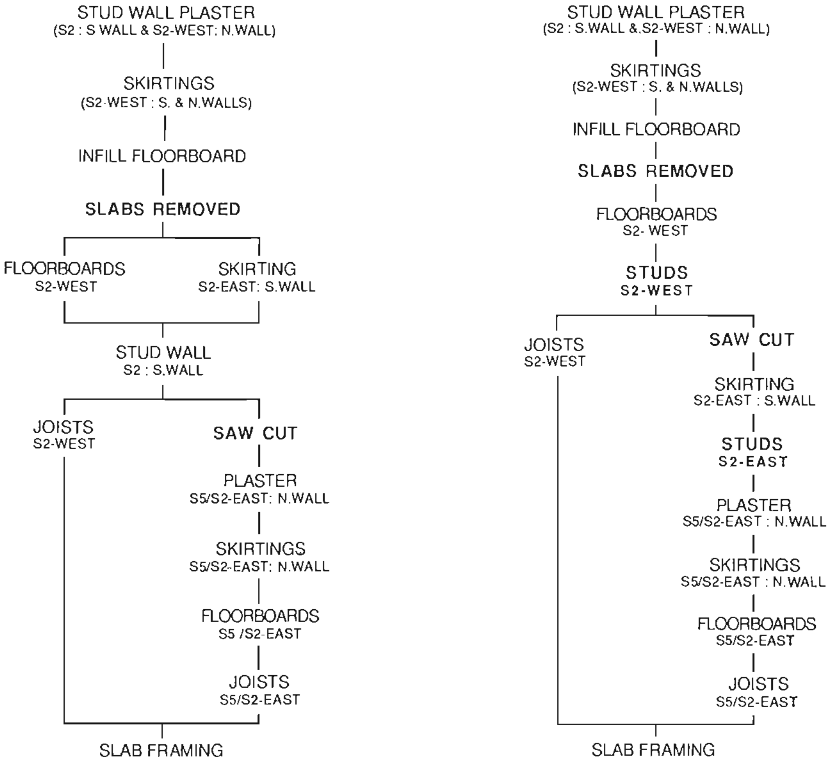
Now whilst this logically orders all the stratigraphic relationships, there exists another problem: constructional practicalities. Such a constructional sequence is physically impractical as removal of the section of slab wall involved cutting through the lath and plaster between two adjoining slabs with a saw. There is no space between the studs to allow the insertion of a saw, let alone use one.

This problem requires resolution and it can be best done by reference to the matrix. The problem seems to lie in the initial identification of the stratigraphic 'units'. There are two possible solutions. The first involves having to regard the 'west slab wall removed' as two separate units – 'saw cut' and 'slabs removed'. If the saw cut through the slab wall was made prior to the erection of the stud wall then, once the latter was in position and the associated flooring laid, the section of slab wall was removed (Fig. 11.6A). This would indicate that the decision to remove the section of slab wall was made prior to erection of the stud wall, although this is not a particularly plausible scenario given the existence of the break in the stud wall skirting.

However, if the stud wall of S2 is also regarded as two units – 'studs, S2-east' (i.e. the section east of the slab wall) and 'studs, S2-west' (i.e. the section west of the slab wall) – then a more plausible solution presents itself (Fig. 11.6B). In this case only the eastern section of the stud wall would have been initially erected, the slab wall cut through from the western side, the remainder of the stud wall erected, the flooring laid, then the slab wall removed and the gap in the flooring patched.

This second solution indicates a change in design intent as the decision to remove the section of slab wall may have been made *after* the eastern section of the stud wall was erected. It may have been the original intention to construct only this eastern section but once erected (and the skirting fitted), it was decided to continue the wall westward and form S6/7. Such a decision necessitated the removal of section of the slab wall but, as the physical evidence shows, it did not occur until the western stud walls and flooring was in place. Only then was the section of slab wall removed and the stud walls plastered. This may indicate a desire to continue utilizing the truncated S5 space (which was already plastered, floored and limewashed) in some fashion until such time as the works had progressed sufficiently in the western part of the house to allow the removal of the slab wall.

Perhaps it should be noted that a third solution does exist: the various inconsistencies and idiosyncratic constructions are merely due to mistakes and/or poor workmanship. However, it is all too easy to interpret physical evidence as being due to these two factors. Such interpretations may in fact be correct in some instances, but those instances should be identifiable by an analysis in which the stratigraphic relationships can not be ordered in a logical chronology. If such solutions are too readily mooted, then it casts serious



A B

Fig. 11.6 Dundullimal: S2 Matrices. (A) Solution 1 matrix after separating the 'west slab wall removed' unit into 'saw cut' and 'slabs removed'. (B) Solution 2 matrix after also separating the 'stud wall, S2: S. wall' unit into 'studs, S2-east' and 'studs, S2-west'.

doubt on what is perceived to be the logical evidence: it too may be due to mistakes and by coincidence may apppear to fit an ordered chronology.

In this particular case study, the absolute chronology was indeed secondary to the relative sequence as none of the diagnostic evidence indicated anything other than contemporary construction.

Conclusions

The Harris Matrix has shown itself to be an adaptable archaeological tool on historical structures of varying scale and complexities and has shown its flexibility in being able to be applied on either the 'macro' or 'micro' scale. Its use ensures that sequential inconsistencies can be readily identified and can direct research onto areas of a structure in order to determine specific stratigraphic relationships. The matrix provides a firm methodological footing for structural investigations and, in conjunction with a rigorous recording system, has the ability to organize the vast array of data which can be generated by such investigations.

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12 The total site matrix: strata and structure at the Bixby Site

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Introduction

The evasive evidences of past cultural processes manifest themselves in a diversity of forms. That is both good news and bad news for the social scientist trying to reconstruct the cohesive dynamics of bygone cultural systems and events. The good news is that the broader the range of available information resources, the fuller the potential for a comprehensive understanding of what transpired and why. The bad news is that the methods for organizing and interpreting the respective resource sets have usually been developed independently of each other, using theoretical and technical conventions that are frequently less than compatible. Thus, linking disparate data sets responsibly and convincingly presents one of the most perplexing interpretive problems before us.

It should be self-evident that the persons who constructed, occupied and altered the structural components of a site are those whose traces are discernible in its stratified soils and in the documentary traces they left. Therefore, in order to understand the people and processes of the past, questions should be addressed in common to those different material resources. With a few notable exceptions, this has not frequently been the case as architectural historians, dirt archaeologists, social historians, material culture specialists and preservationists have often continued to operate in splendid isolation from each other. However, the recent interest and advances in landscape archaeology have begun to extend the limits of archaeological investigation beyond the functional study of activity areas to the realm of cognitive and symbolic aspects of landscape design and the integration of the buildings, landscape and ideology (Carson *et al.* 1981; Neiman 1986; Beaudry and Mrozowski 1987a, b; Reinke and Paynter 1984; Worrell 1980; Yentsch *et al.* 1987; Leone 1987; Kelso 1989; Stachiw and Small 1989; Garrison 1991).

Archaeologists are familiar with the advantages of soil stratigraphy for organizing their data according to sequences that have tangible and demonstrably consistent internal relationships. The extensive attention we devote to developing and refining matrices derives from the ordering imperative and the natural advantage that the principles of soil developments provide. Into this system we fit such varied material distributions as artefacts, ecofacts, the physical and chemical properties of soils, and 'features' – a category in which we usually include structures of any sort and vestiges thereof. As archaeologists, we devote excruciating attention to created, non-architectural remains such as dooryards,

Practices of Archaeological Stratigraphy
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trafficways, grade alterations, boundaries such as fences and barriers, and particular functional spaces. All of these rivet our attention and we have become ingenious in developing techniques for observing, analysing and interpreting them. However, standing structures such as the barn and outbuildings, and especially the house, are frequently left to the scrutiny of specialists pursuing their own interests. Such destructive conceptual dissection of the material record of a site fails to admit that the fabric of a structure contains evidence of the changing configuration of shaped space, functional organization, use patterns, and cognitive preferences that are one piece with those found in the dirt. The doors opened through the walls, allowing actual persons to pass from functional areas inside to ones outside in processual patterns which must be understood together if we are to reconstruct the lifeways and their material accoutrements which are so dear to our research.

The organization of data: the total site matrix

To redress the shortcomings of the standard disciplinary approach effectively, an integrated perspective must be evident in the research design, technical procedures, seriational and analytical devices as well as in final interpretations. In formulating a strategy for the investigation of the neighbourhood and the domestic and work sites of a rural, early nineteenth-century blacksmith, Emerson Bixby, and his family, we have developed a method by which to combine these various data sets. At the site level this has involved the use of an elaborated Harris Matrix to create a 'total site matrix' capable of systematically describing, integrating and interpreting the recovered archaeological and architectural information.

Organization of archaeological and architectural data at the Bixby site was carried out according to established principles of stratigraphic excavation and recording. Excavation of the homelot was extensive, and the system for observing and recording the data was elaborate (Simmons 1986a, b; Worrell *et al.* 1992). Central to our recording scheme has been the compilation of the stratigraphic archive of the site – the recording, on locus sheets, of contextual relationships which, following Harris's lead, were woven into an interpretive matrix. Nearly 400 different loci, excavated in over 2100 sub-units, or lots, were identified and sequenced. A similar 'archaeological excavation' of the standing architecture was also carried out. Prior to and while the dwelling house was being partially dismantled for removal and during subsequent restoration in the museum, we 'excavated' the structure. Layers of paint and wallpapers, shadows or ghosts of elements no longer extant, door and window patches, sheathing and framing details, and all other clues bearing on the construction, embellishment, and functional and spatial reorganization of the house were recorded in a specifically revised version of the system employed in the traditional archaeological investigation of the site. The resulting architectural loci were similarly sequenced and diagrammed, linking stratigraphically and sequentially the numerous alterations to the architectural fabric of the structure and its finishes from room to room. Careful analyses of the artefactual content of both archaeological and architectural strata, combined with specific information gleaned from the documentary record on the timing of certain architectural changes, allowed the archaeological and architectural sequences to be linked in a single comprehensive matrix (Small 1986; Stachiw forthcoming).

Analysed according to a unified system, therefore, the material components which together comprise the functional site systematically describe the spatial environment which shaped – and was shaped by – the persons and activities that we were intent on discovering.

This finely tuned reciprocal strategy, when combined with careful and extensive documentary research and analysis, has gone beyond the description of physical and functional changes in the site. It has produced a revealing biography that details and links to the material record a number of significant changes in community and family structure and in the dynamics of social interaction; in the patterns and nature of economic exchange, from the household to the wider community; and in preferences in selection, utilization and disposal of material culture. In effect, it has turned flat description into dynamic interpretation.

Site biography: the physical and documentary evidence

The house, homelot and shop site of blacksmith Emerson Bixby, located in the former agricultural neighbourhood of Four Corners, Barre, Massachusetts (Fig. 12.1), were ideally suited for such a highly focused study of the material and cultural transformations of everyday economic life in rural New England during the early nineteenth century. The Four Corners represented a cohesive economic neighbourhood that was materially preserved and sufficiently documented in public and private records to permit comprehensive analysis. Most importantly, Bixby's account books for 1824–55 survived, and his house, homelot and shop site had scarcely been altered during the last century.

The story that has emerged is striking and amazingly complete. It spans nearly eight decades from initial settlement of the neighbourhood in the 1770s, through a period of social and economic growth and vitality in the opening decades of the nineteenth century, to a period of neighbourhood fragmentation, economic decline, and restructuring in mid century.

Phase I: *c.* 1800–15

The earliest use of the land later occupied by Emerson Bixby and his family was agricultural. The site, a part of Daniel Hemenway's farm, was cleared and recontoured for agricultural use in the late eighteenth century. An English-type barn with an attached shed and at least one other building were erected on the site. By 1809 a small, one-storey dwelling house was built near the barn, and the buildings and one acre of land were sold to Daniel's son, Rufus. The construction of this house and subdivision of the larger parcel were part of the process by which members of the neighbourhood's younger generation were settled on their fathers' land (Fig. 12.2A).

Analysis of the structural fabric of the house and excavations in the dooryard indicated that considerable time elapsed between the initial raising of the structure and its being finished in the modern sense of architectural completeness. Weathering patterns on its original sheathing suggested that the house had neither clapboarding nor finishing trim for an extended period. Inside, the discoloration on ceiling joists caused by hearth smoke

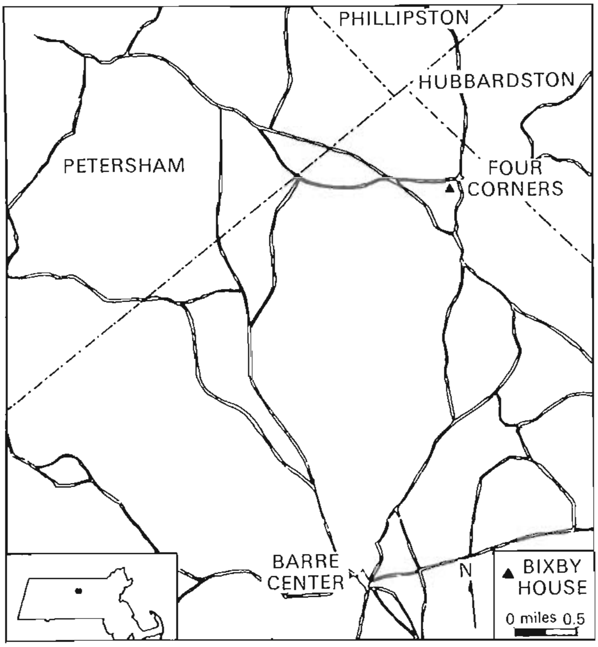

Fig. 12.1 Location of the Bixby Site in Barre Four Corners, Barre, Massachusetts. (Drawing by Nora Pat Small.)

demonstrated that the interior, as well, remained unfinished for some time. While the ceilings of the kitchen, passage and sitting rooms were lathed, it was several years before they received coats of plaster (Small 1986).

In the side dooryard of the dwelling house further evidence to support a long construction phase was discovered. Found immediately upon a terrace of mixed glacial till excavated for the house cellar was a stack of 12 window panes, which had been salvaged from elsewhere in anticipation of reuse in the new structure. Their presence at this stratigraphic junction tantalizingly suggests that they may have been laid out of the way during construction. Perhaps a window had been intended for this side of the house but was never built, the yard grew over the panes, and they were forgotten.

The decorative scheme and asymmetrical form of this three-room plan house – with the kitchen extending across the north side, two unevenly sized rooms on the south, and an off-centre chimney stack – were a common expression of the area's vernacular building tradition and were repeated in many of the neighbours' houses (Fig. 12.3A). The walls of the kitchen and passage were decorated sparingly in dark shades of red, blue and brown, or with unpainted, horizontal sheathing; the sitting room walls, also horizontally sheathed, were covered with wallpaper and painted. Only the best room showed any efforts at a finer finish. Its ceiling and walls were plastered and papered from the outset. The baseboards, chair rail, and door and window casings were ornamented with more ornate, planed mouldings. And only in this room was the panelled chimney breast outfitted with a classically detailed chimneypiece (Stachiw and Small 1989; Stachiw forthcoming).

The open floor plan of this small structure offered no mediation between the outside

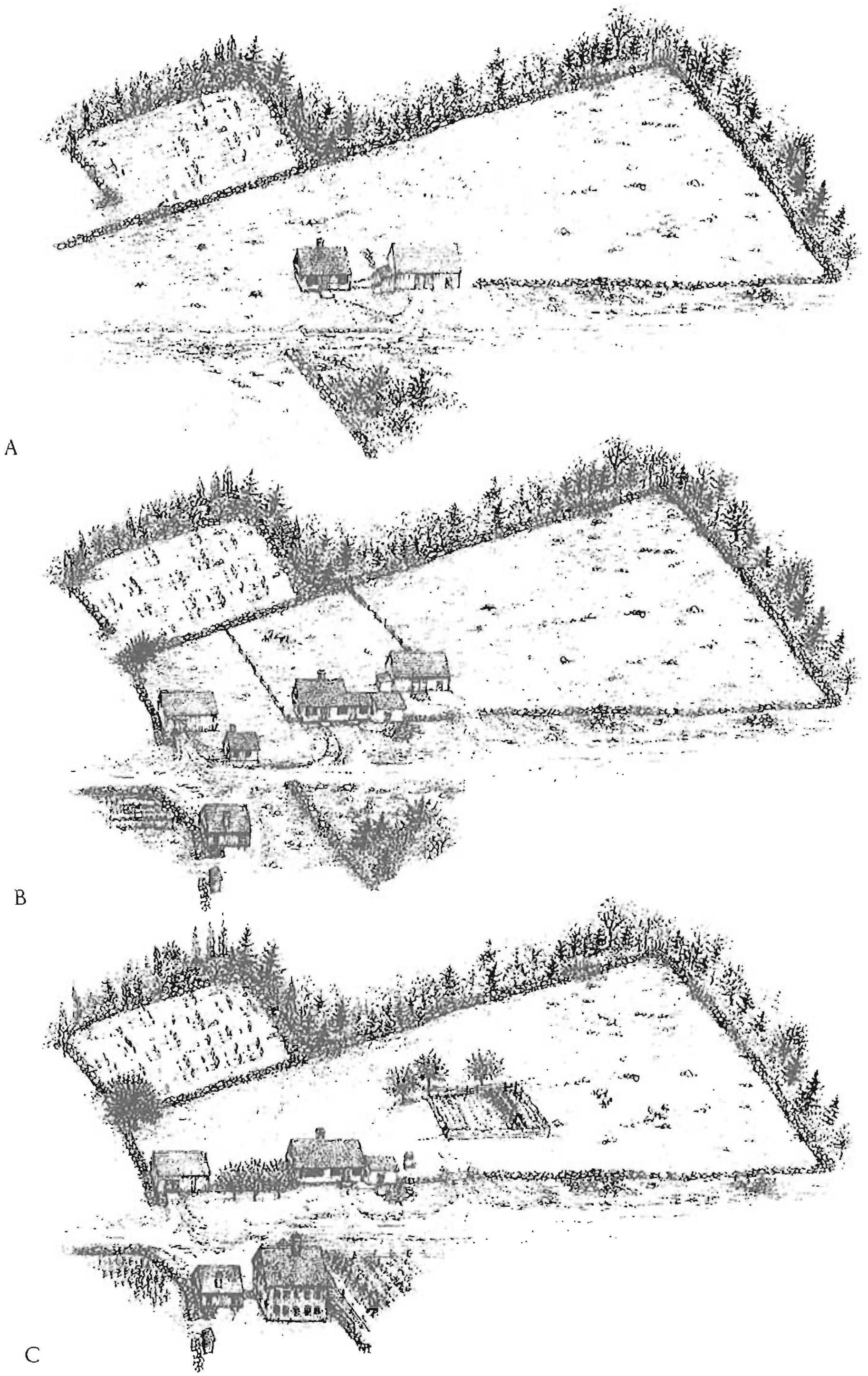

Fig. 12.2 Arrangement of structures at the Bixby Site: (A) Phase I, *c.* 1809–15; (B) Phase II, *c.* 1815–38; (C) Phase III, *c.* 1838–45. (Drawings by Melanie Shook.)

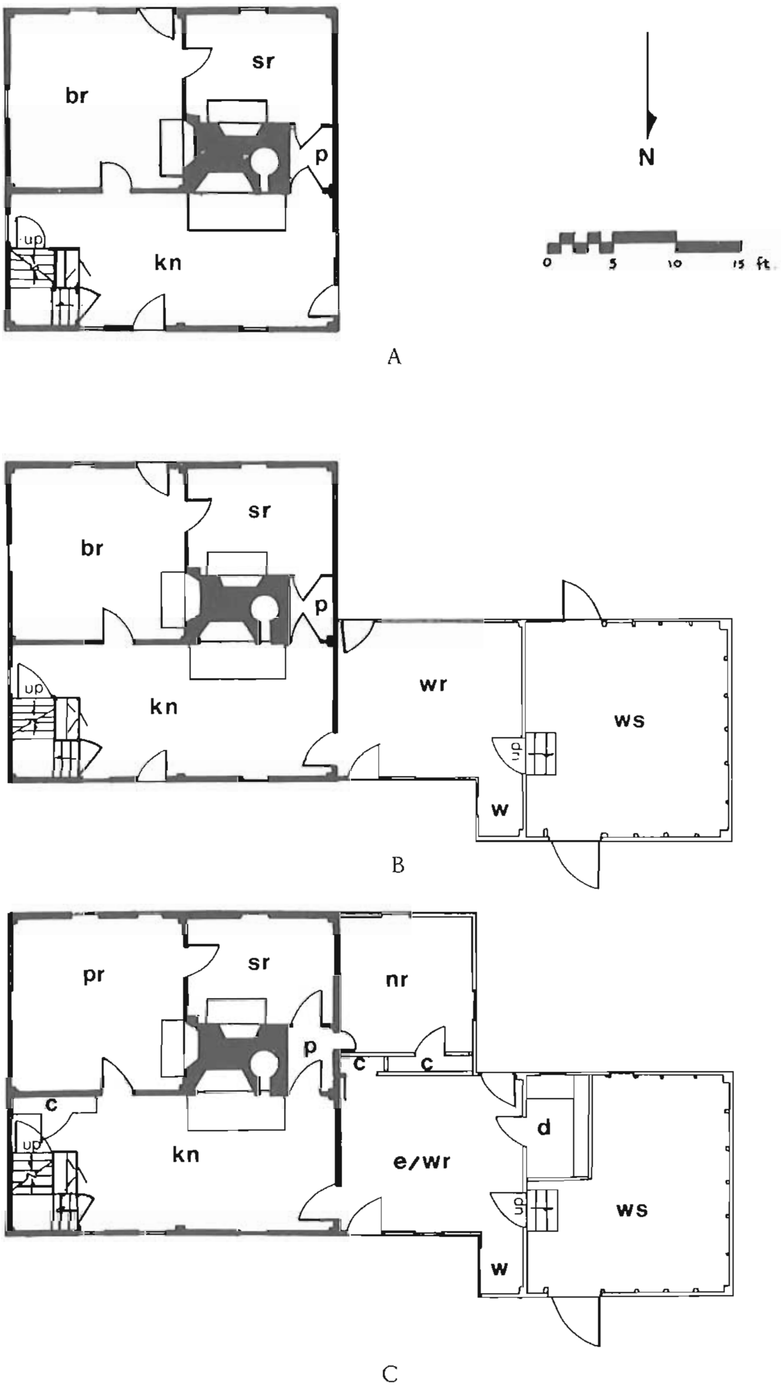

Fig. 12.3 Floor plans of the Bixby House: (A) Phase I, *c.* 1809–15; (B) Phase II, *c.* 1815–38; (C) Phase III, *c.* 1838–45. *Key:* br – best room; c – closet; d – dairy; e/wr – entry/workroom; kn – kitchen; nr – new room; p – passage; pr – parlour; sr – sitting room; w – well; wr – work room; ws – wood shed. (Drawing by Myron O. Stachiw.)

world and the intimate family spaces within. Two doors allowed direct access to the kitchen – one facing the road on the north, the other on the west side opening toward the well and barn. A third door on the south side of the house provided entry directly into the best room, which served the functions of bedroom, dining room, and parlour. The road-facing kitchen door was equipped only with a simple wooden step structure, evidenced by a small rectangular loess deposit and nail concentration, while that at the rear, or south-facing, side of the house was clearly the formal entry, having a large stone doorstep founded on a substantial cobbled pad. While excavation provided very little evidence of activity around the front doorway and moderate at the best room door, the dooryard toward the barn and well manifested strikingly heavy use. Extensive rubbish disposal, compacted pathways, regularly deposited hearth cleanings, even the evidence and remains of chicken activity and the former woodpile location all demonstrated that this was the family door. It was here and in the slight depressions left by the earlier buildings in the side front yard that the site's initial ceramic scatters were heaviest. In sum, the house and yard were a tight complex designed for maximum practicality during their first domestic phase; they were largely devoid of considerations of privacy or fashion. Their similarity in form, decoration and function to the houses and lots of their neighbours suggests a group aesthetic, a shared way of living in this tightly knit agricultural neighbourhood (Glassie 1986; Stachiw and Small 1989; Stachiw 1988; Garrison 1991).

Phase II: *c.* 1815–38

The second phase of the domestic occupation of the site was marked by a major exterior and structural reorientation. It was begun within the first decade after the construction of the house and was initiated by moving the barn farther back into the lot. A detached building was erected just to the west of the kitchen dooryard. Later in this phase it was connected by a wing to the house (Fig. 12.2B). The new, nearly enclosed agricultural complex was now more removed from the road and public, yet it was still relatively close to the living quarters.

The move of the barn occasioned a series of alterations to the house's western terrace in order to accommodate the diverted flow of traffic. The terrace was buttressed on two sides with low, stone retaining walls, a step off of the terrace was created, and another low stone feature, related to traffic flow and drainage, was also constructed. The stratigraphic sequence places these together as a single, extensive site alteration. All are, as well, fortuitously tied together through the lateral distribution of more than 100 sherds from a distinctive earthenware mug that apparently was broken and scattered during this peak of activity. Its assemblage clearly defines stratigraphic sequencing of segregated strata (Fig. 12.4).

Coterminous with these changes, the area formerly occupied by the barn shed was scraped and levelled in preparation for yet another building. The east and west foundations for the earlier shed were rebuilt, the south foundation was reconfigured, and a new north foundation was prepared. The stratigraphic sequence, combined with analysis of artefacts and documentary information, places construction of the new building between 1810 and 1815.

Use of the dooryard between the house and new outbuilding continued to be intense.

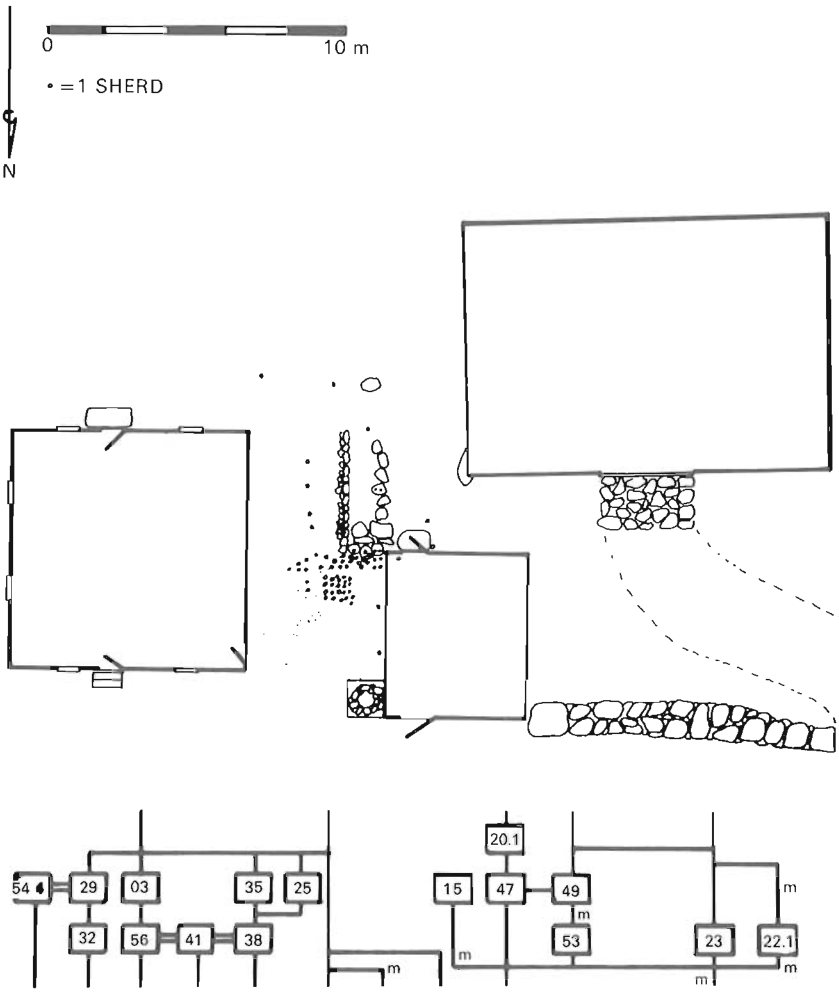

Fig. 12.4 Distribution of sherds from one vessel which stratigraphically and chronologically linked alterations to the dooryard terrace. The matrix illustrates the features and strata linked by the presence of the sherds (m). (Drawing by David M. Simmons and Charles Pelletier.)

This area remained the primary receptacle for household refuse and the primary access to and from the barn and to the well. In fact, traffic was so heavy here that a cobbled pathway was created to bolster further the area near the step-down off the terrace.

This formerly active exterior space became sealed beneath the floor of the wing added to the house's west gable end (Figs 12.2B and 12.3B). The initials 'RH', carved onto a sheathing board, suggest that Rufus Hemenway built the wing sometime after his marriage in 1815 but before his sale of the property in 1824. This addition enclosed the well within its walls and incorporated the area of the newly built shed. It is unclear whether the construction of the wing included a completely new structure for the shed or merely incorporated portions of the existing shed frame. The new framing of this addition, designed to accommodate a chimney stack at its west end, suggests that it was intended to function as a kitchen wing. That intention, however, went unrealized, as the wing, never ceiled nor fully sheathed on its interior, simply served to expand the storage and work space of the small house, attaching the earth-floored woodshed at its west end. The connected structural complex now bifurcated and clearly delineated the front and rear yards; moreover, it inserted yet more distance between public and private spaces.

For four years we wrestled with the sequencing of these two structures – the shed and the wing – trying to determine if they were built as a single unit or, if one preceded the other, which came first? The documentary record was largely silent, and the architectural evidence, even matricized, was inconclusive. It was only through meticulous excavation, recording and sequencing of archaeological strata with the Harris Matrix, that the correct sequence of construction emerged, indicating the erection of the free-standing shed prior to the construction of the wing.

It was this arrangement of spaces, closely configured both inside and out, that young Emerson Bixby, his wife and infant daughter inherited when they purchased the property in 1826. The combined artefactual, archaeological and architectural evidence provide little to suggest that the Bixbys departed from the living and working patterns of their predecessors during their first decade in the house. The best room, its entrance away from the road, continued to be the site of a disparate array of activities, from dining and entertaining to use as a bedroom and occasional work space. The kitchen and sitting rooms, augmented by the room in the new wing, continued to be the primary domestic work spaces for food storage, processing and preparation, shoe stitching, and later, for straw and palm leaf hat braiding.

The late 1820s through to the mid 1830s were a period of growth and prosperity in the region and Bixby and his neighbours shared in these good times. The Four Corners, full of young, enterprising families, attained its greatest population during these years and its households became tightly intertwined through marriages of their younger members. The neighbourhood contained an active district school, a store, a carriagemaker's shop, a scythemaker's works, saw and shingle mills, and a number of thriving farms. In this setting Emerson Bixby's blacksmithing business expanded rapidly. By 1830, he was maintaining active trading relations with more than eighty individuals (Stachiw 1988).

The nature of Bixby's economic relations was no different than those practiced by the majority of rural farmers and artisans in New England. In a society overwhelmingly agricultural and poor in cash, economic life was based on long-term relationships between partners. Labour and goods were periodically exchanged to meet standing obligations, often carried on for years before formal balancing of accounts occurred. The mediating structure in this system was the account book into which the farmer, artisan or storekeeper wrote the name of the trading partner, the date and nature of the exchange, and its value (Larkin 1988a; Geib 1981).

Analysis of Bixby's account book indicates that his business and income expanded steadily through the 1820s and into the mid 1830s, earning the equivalent of nearly $400 annually by 1835. During these years Emerson and Laura Bixby had two more children, both daughters; they purchased 32 acres of farmland; and they increased their livestock holdings.

The Bixbys were also becoming increasingly aware of the openness of their living and work arrangements and they initiated some physical and procedural adjustments to the appearance and use of their homelot. One of the more striking exterior changes effected during the second occupational phase – that following the construction of the wing –

centred upon refuse scatter. During this phase, considerably less domestic refuse was deposited in front of the structural complex. Increasingly, it was moved to the rear yard spaces, in the direction of livestock quartering. By the mid 1830s, after a decade of Bixby occupation, the primary disposal of ceramics, glass, and faunal material was in the area beneath the connecting wing. Thrown into its crawlspace through a hole in the foundation, the majority of domestic refuse was now completely removed from public view.

Phase III: *c.* 1838–45

It was during the third domestic phase that the Bixbys made their most significant mark on the house and lot, effecting major transformations of site organization, room function and fashion (Figs 12.2C and 12.3C). These occurred in several stages between 1838 and 1845, highlighted by numerous account book entries from those years listing exchanges of building materials and labour.

The interplay of the architectural and archaeological matrices was pivotal to a fuller understanding of the nature of the physical and cognitive changes that occurred at the site during this phase. The two matrices, created independently, effectively positioned the stratigraphic relationships among the many 'events' or loci encountered during both archaeological excavation of the houselot and architectural research and restoration processes. Every locus encountered in the ground – whether a soil layer, sub-surface disturbance, significant artefact concentration, structural feature or the ghost of an event – was assigned a number and arranged by discrete excavation area with regard to the loci lying beneath, above and adjacent to it. The creation of the architectural matrix followed a similar procedure: with each layer of paint or wallpaper, each addition or removal of architectural fabric, a number was assigned to the event and then a stratigraphic chart generated for each distinct room, exterior surface and framing system (Winter and Schulz 1990). Both relative and absolute dating and phasing of the two types of matrices was accomplished by combining information gathered during artefact-specific research and analysis of documentary records, with the stratigraphic sequences generated from the different archaeological areas and architectural spaces.

The individual, room-by-room architectural matrices were joined at the points of intersection of identical paint colours or wallpapers used in different spaces, or at common points of alteration to architectural fabric, as on both sides of a door or window. This larger, combined architectural matrix was then joined to the archaeological matrices at similar points of intersection: where soil strata were disturbed during, and/or artefactual content was effected by, architectural alteration.

The result of this integrative process of analysis is a matrix that allows correlation of causal relationships between architectural configurations and archaeological patterns of site use and deposition. For example during the third phase, the combined matrix clearly illustrates that the intensity of stratigraphic change shifted from representation in soil strata to that within the structure itself (Fig. 12.5). The archaeological matrices for the kitchen dooryard and other areas closest to the house are heavy for Phases I and II, but become sparse in Phase III. As functional areas were farther removed, refuse deposits themselves were removed or concentrated in single locations. The architectural matrix, on the other hand, is very thin for Phases I and II, expanding greatly in Phase III as much

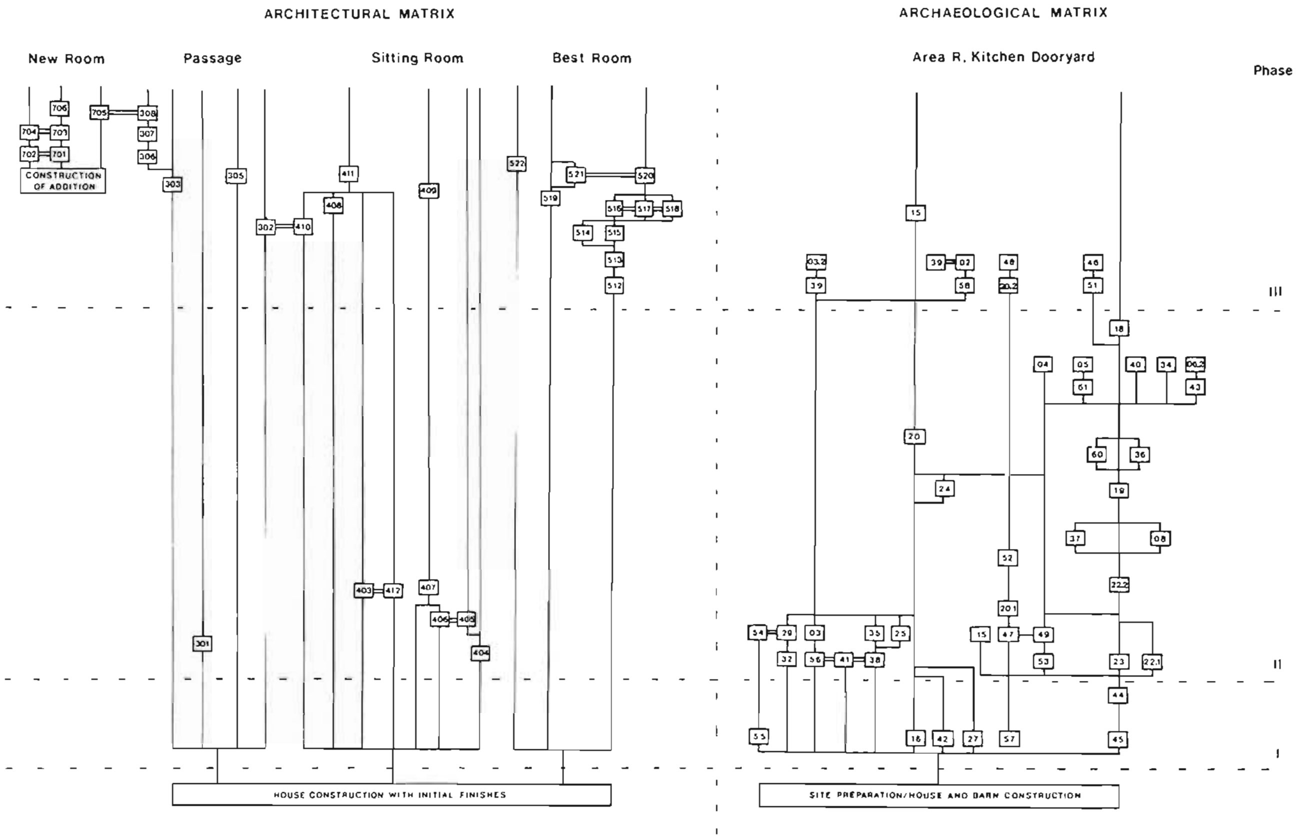

Fig. 12.5 A portion of the archaeological and architectural matrices for the Bixby site and house. The matrices depict the changes to the kitchen dooryard and to several spaces within the house subsequent to original site preparation, construction of the house and barn, and application of original finishes to the interior of the house. (Drawing by Myron O. Stachiw and David M. Simmons.)

more attention was focused on the house through changes in the arrangement, finish and use of interior spaces. Either matrix alone is at best partial; only together do they graphically reveal a larger portion of the story.

Among the earliest changes in Phase III was the replacement of the original front and rear doors with windows (Fig. 12.5, Best Room, 512–515). Entry into the house was now restricted through only one door. Opening from the kitchen into the wing, it offered an insulating layer of controlled access and privacy to the home (Downing 1850: 44). While the closing of the north, road-facing door effected little change in distribution of refuse in the dooryard – there having been little previous activity there – the closing of the best room door caused a significant shift in the disposal of ceramics, in particular, through that portal. Where previously much domestic debris had been swept into the rear dooryard, especially during Phase II, few sherds and other refuse were discarded into that area after the doorway was closed up (Figs 12.6A, B). This shift also signals several changes in room functions consequent to important shifts in household organization and domestic economy (Sloat 1988).

The structural alterations were accompanied by changes to the interior finish of the house. The dark surface colours were replaced by a uniformly light spectrum of paint and wallpaper on the interior walls and floors of the house (Fig. 12.5, Best Room, 516–522; Sitting Room, 409–411). These lighter colours, combined with the significant increase in available sunlight through the new windows, worked to drastically change the ambience of the small interior spaces (Stachiw forthcoming).

In 1841 Bixby purchased a small parcel east of his house, which included the former shop of Ethan Hemenway, the carriage maker with whom Bixby began his Barre Four Corners smithing career ironing wagon bodies in 1824. Hemenway's business was one of the neighbourhood casualties of the economic depression of the late 1830s. Bixby converted the former carriage shop on that newly acquired parcel to be his barn, dismantling the old one near the house. As a result, the barnlot was again farther removed from the domestic sphere. The area near the old barn now became the site of a garden and small orchard (Fig. 12.2C).

In 1844 and 1845, the construction of a major addition expanded the Bixby living spaces and further altered the functions and use patterns of the house's interior. Two rooms, both plastered, papered and fully finished, were added to the house, one upstairs in the garrett and one on the ground floor (Fig. 12.3C; Fig. 12.5, New Room, 701–705, Passage, 303–308). The parents moved their sleeping quarters from the semi-public best room to the new ground floor room, now the most secluded of the downstairs spaces. This room was furnished with a built-in closet, allowing clothing to be stored out of the sight of visitors and in a clean, protected space. The best room probably assumed full function as a parlour at this time, a formal setting for the increasingly popular social rituals of entertaining. Finally, the daughters were provided with a finished, plastered chamber in the garrett instead of the open, unfinished attic they formerly inhabited for sleeping quarters.

During this final phase of structural changes to the house and yard a small dairy room was built within the wing and shed complex. The construction of this room reflected the growing importance of dairying to the Bixby household economy, an activity made possible by the labours of the three teenaged daughters. Throughout the house new window sash were installed, some exterior trim was replaced, and the entire exterior received new clapboards. The previously unpainted house, wing and shed were then painted white,

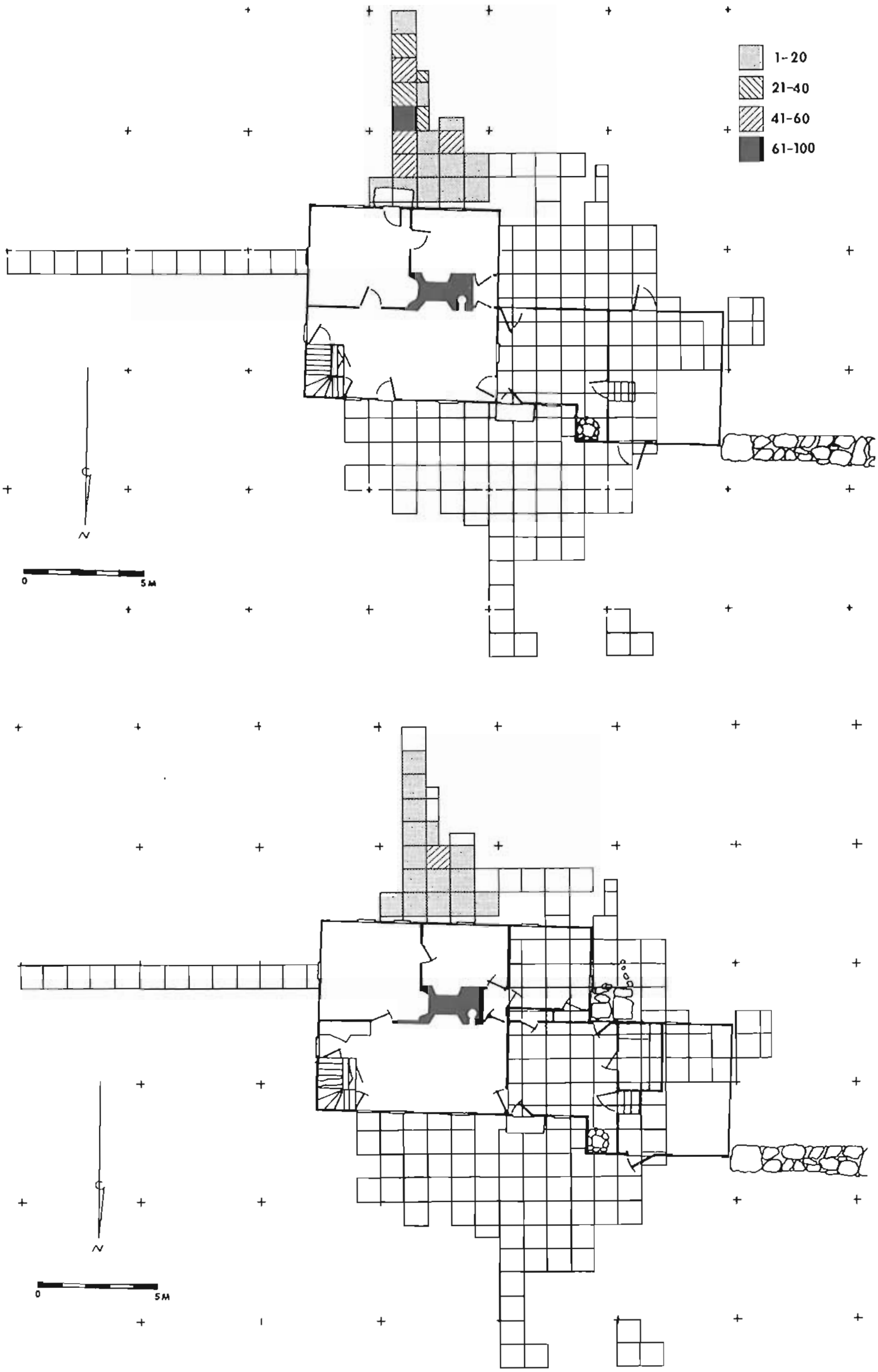

Fig. 12.6 Distribution of ceramic sherds in the area outside of the best room door: (A) Phases I and II when the doorway was open and in use; (B) Phase III, after the doorway was closed and replaced with a window.

bringing them in line, at least visually, with the more fashionable houses of the Center Village and countryside.

The patterns of refuse disposal also changed markedly during this phase. With the addition of the dairy room, the crawlspace beneath the wing was made inaccessible and the disposal of refuse there ceased. It was now primarily discarded into the area outside the rear door, near the mid-nineteenth century privy, onto the floor of the shed itself, and, significantly, farther afield – against and even within the stone walls in the cultivated western part of the property. Like the intra-site traffic patterns during this phase, refuse disposal had become less intensive and more diffuse.

Conclusion

The lightening of both interior and exterior spaces, increased segregation and compartmentalization of activities in the house and on the homelot, and the tidying of the yard – all effected by the Bixbys during this third phase – were parts of a cultural process of rural reform which was similarly enacted within the houses and upon the homelots of Bixby's neighbours and throughout the New England countryside during the first half of the nineteenth century (Larkin 1988b; Stachiw and Small 1989). The complex dynamics of this general process are made more comprehensible through a careful analysis of the social and economic context of the specific material changes made by the Bixby household.

During the late 1830s and early 1840s, the very nature of community and economic life for Emerson Bixby and his neighbours was changing. The Four Corners neighborhood, remarkably stable for more than two decades, began to decline in population, as its households matured, young people increasingly married out of the community, and few new households were created. The financial crisis of 1837 and subsequent depression further weakened the community and neighbourhood. Center Village storekeepers, factory and mill owners, farmers and craftsmen suffered financial setbacks and even ruin during the crisis. In the Four Corners the triphammer shop and carriagemaker's shop were closed and several farmers and the owner of a sawmill were brought to the brink of insolvency.

The impact of these events on Emerson Bixby's economic life was reflected in a recorded decline in the amount and value of blacksmithing work he performed after the late 1830s. By 1845 his annual income, as compiled from his written accounts, had fallen below $180; by 1850 it totalled less than $50. However, this dramatic decline in income did not necessarily signal the financial failure of the rural blacksmith and his family. On the contrary, the material record and other documentary sources indicated marked changes in household furnishings and in the size and arrangement of the house, outbuildings, and yard space; an increase in livestock; the purchase of 32 acres of farmland; and the growing involvement of Laura Bixby and her three teenage daughters in market-oriented domestic work including dairying, straw braiding, shoe binding and palm leaf hatmaking. A careful analysis of Bixby's accounts during these years indicated that the *frequency* and *value* of work performed for individual trading partners did not decline significantly. Instead, the *number* of trading partners with whom exchanges were recorded in the account book fell off sharply, becoming limited only to his closest neighbours and longest-standing trading partners. Taken together, this evidence strongly suggests that after the late 1830s, increasing numbers of Bixby's customers were paying in cash for his labour immediately, rather than deferring payment by having the transactions recorded in Bixby's ledger for future balancing. The traditional system of long-term obligations between trading partners to exchange goods and labour when needed or available was reserved only for a trusted few, those most frequently seen and with whom this cooperation was most comfortable (Stachiw 1988; Larkin 1988a).

The convergence of these various changes was no coincidence. They were the result of a series of closely linked events and developments within the wider community, neighbourhood and Bixby household. The consequences of the Panic of 1837 and following depression seriously curtailed the widespread continuation of traditional credit relationships and encouraged the use of cash. The shrinking of the traditional economic network was paralleled by a weakening of neighbourhood cohesion and economic vitality and the increased social activity and involvement of Bixby's teenaged daughters in market-oriented production heightened their knowledge of, desire for, and ability to acquire the material goods and new rules of social behaviour then becoming increasingly fashionable. This shift coincided with a gradual loss of vitality and favour for locally defined, traditional models of material and social life (Larkin 1988b; Brown 1989).

Barre's bustling Center Village – home to merchants, lawyers, fashionable Greek Revival homes, a newspaper, cash – had undergone a material, cultural and economic transformation long before its surrounding hinterland. The Four Corners neighbourhood, four miles distant from the centre, was separated not only by physical impediments – deeply rutted roads and a steep incline, known today as Christian Hill – but also by the social and material conditions of everyday life. The physical and cultural remove which so long divided the two clusters was mirrored, on a micro scale, in the stratigraphic separations within the house and its surrounding homelot, which have been our primary focus. The cultural distance between the formal and cognitive dimensions of Phases I and III was extreme. The use of the Harris Matrix has allowed us to map the physical distance, separating specific events, general activities, entire episodes, and has allowed us to find pattern, attach meaning, and, melding a diversified data set, build a far-reaching interpretive framework that goes beyond the site to offer an active, rather than passive, explanation of the transformation of economic life in rural New England in the early nineteenth century.

The biography of the family and site has been worked together from the full battery of resources. Perhaps the most significant factor in this entire reconstruction, however, is the diverging conclusion that would have been drawn from each disparate line of research in isolation. The documentary materials, both public and private, generally suggested a confusing picture of a family sharing in the decline of a remote, backward neighbourhood. Architectural and archaeological analyses provided a very different picture: the transformation and modernization of the family living space and material accoutrements at precisely that same time. In light of this evidence, re-evaluation of the documentary research revealed not an economic decline, but rather a significant transformation in the social relations of economic life. The establishment of cash-based exchange in the wider community, and its adoption into Bixby's household economy and blacksmithing business, combined with changes in community structure to reorient the sources and models of acceptable social and economic behavior in Barre Four Corners. This synthesis has provided the scaffolding by which the total picture has become not only reconciled but consistent and informative at both the family and the broader cultural levels. Less than a total site perspective would have ensured interpretation that was at best partial, and in some respects, even false.

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SECTION V
Post-excavation analysis

The four papers of this section consider post-excavation analyses in relation to stratigraphic sequences compiled in the Harris Matrix style. The first paper by Irmela Herzog (Chapter13) concerns the making or generation of stratigraphic sequence diagrams by use of a computer program devised by the author and her colleagues in Germany and elsewhere. Shortly after the invention of the Harris Matrix, attempts were made in England to computerize stratigraphic data so that sequence diagrams could be printed by machine. However, it was not until the personal computer came into being in the mid-1980s, that this matter could again be approached with a great chance of success.

Herzog and her colleagues have now devised a computer program, the Bonn Seriation and Archaeological Statistics Package, which allows for the collection of stratigraphic data from a site and its arrangement into a stratigraphic sequence diagram. The program was developed in cooperation with the archaeologist C.J. Bridger, who wanted a Harris Matrix for a site in Germany with a little over 1000 layers, as such a diagram had not been constructed during the excavation. Moving from the notion given by Orton that such diagrams were 'partially ordered sets', Herzog overcame many other difficulties which the computerization of stratigraphic sequences entailed. The result is an efficient, user-friendly, computer program which is now available commercially at low cost.

That this program will be of value on current excavation is obvious, but it may prove invaluable when archaeologists attempt to reanalyse pre-Harris Matrix excavation records in which the compilation of stratigraphic sequences was not able to be considered as we now understand such methods. This computer program also begins to grapple with the problems of phasing multilinear stratigraphic sequences, as discussed by Harris and Dalland in 1984. Herzog also writes of sequences which have crossed lines, which some archaeologists think may mean that the sequence is defective at that point. If it is remembered, however, that the Harris Matrix diagrams represent the four dimensions of a site and that it is possible to represent such diagrams in an isometric manner, then crossing lines will never occur. They only occur in the usual Harris Matrix diagrams because these are usually shown in a two-dimensional drawing: therefore the crossing lines may be seen not as crossing, but running behind or in front of the line apparently crossed.

The paper by Bryan Alvey (Chapter 14) underlines this last point, for his computer program, 'Hindsight', is a three-dimensional application of these methods. Developed in conjunction with archaeological work at the Museum of London, Alvey's program is based upon the single-context planning system, which is tied in with the stratigraphic sequence of a particular site. In this program, the single-context plans are fed into the computer by digitization; each plan or feature may thus appear on the screen showing the full extent of its surface.

There is at least one major advantage of this system and it is opposed to the older system of the composite or period plan which was drawn during the course of excavation. Such composite plans presupposed that the archaeologist was able to recognize a period interface on the site prior to receiving the absolute dating evidence from a study of the artefact, such studies usually taking place after the end of the excavation. This arrogant presumption was contrary to stratigraphic principles because the site was built from the bottom up, and not *vice versa,* which is the way in which it must be excavated.

Alvey and his colleagues rightly concluded that it was not possible to construct phase or period plans until the bottom of the excavation was reached, and some input from finds analysis was obtained. This was especially true on complex sites with multilinear stratigraphic sequence in which many deposits were separated in space. Alvey insists that the phase plans should be made from the earliest levels on a site and proceed upwards to the later, thus reflecting the way in which the site itself developed. Using his program connected with the ordering of stratigraphic sequence, a phase plan can be made by a mechanical plotter – in the extreme example – as if every new deposit on a site represented a new phase. As the author notes, the phase or period plan is a composite plan, that is to say, it is composed of the surfaces or parts of surfaces of a group of stratigraphic units which together form the overall surface of the site at a given date. It is the composite or period plan which will be used in publications to illustrate the topographical history of the site, and their compilation and draughting by the computer saves a great deal of time and labour in post-excavation work.

Finally, the Hindsight type of program can be used by find specialists who wish to compare their findings and assumptions with the stratigraphic context from which the artefacts came. This program makes such comparisons easy and will ultimately lead to a great and more fruitful collaborations between excavating archaeologists and their other colleagues who are skilled in the many other aspects of the archaeological endeavour.

The last two papers in this section are about the relationship of artefacts to stratification and they are among some of the first examples to look at artefact studies in relation to Harris Matrix stratification sequences. Richard Gerrard (Chapter 15) uses material from Fort York at Toronto for a statistical study of the diversity of ceramic assemblages from stratified contexts which have been arranged into true stratigraphic sequences. He uses matrix-based stratigraphic data, which are compared and analysed with mean ceramic dates and diversity indices, on the grounds that such statistical methods are easier and faster than the old manual methods of cross-mending and match of ceramics from different strata.

Matrix-based stratigraphic analysis and mean ceramic dates are known in archaeology, but Gerrard draws on taphonomy and palaeoecology for diversity indices. As he points out, archaeological deposits in an urban context are subject to many possibilities of alteration by later processes in the formation of the site. The archaeologist thus faces a major problem in artefact analyses in distinguishing between objects which are contemporaneous with the formation of deposits, and those other two categories which may be accidentally infiltrated into deposits at a later date, and those objects which are residual, having been reworked into the new stratum from earlier deposits on the site or from elsewhere.

Of these artefactual matters, the problem of post-depositional disturbances is probably the greatest, as so many factors come into play to alter the original artefact assemblage of the original deposit. Aside from cultural disturbances, such as new building and landscaping, natural processes such as frost and tree roots can alter the assemblage, often without stratigraphic trace. Gerrard makes the important caveat that archaeological excavation is also a process that can inadvertently change an assemblage. He suggests that excavation by arbitrary levels is a major way in which archaeologists can inadvertently change the nature of an assemblage by collecting in a single mechanical spit the remains of any number of separate, real stratigraphic units. The same can occur when sloppy excavation by the stratigraphic method fails to distinguish properly between one deposit and another.

It is Gerrard's contention that by using these statistical methods in conjunction with stratigraphic sequences, one can detect the non-indigenous material in an assemblage more efficiently than has previously been done by hand. As all our costs rise in archaeological projects, such ways of assessing the content of artefact assemblages will be of increasing value: this pilot study may point the way for future studies of this nature.

Interestingly, the second paper which deals with artefacts and stratigraphic analysis is also from Canada, with John Triggs (Chapter 16) using examples from Kingston, Ontario and from Dame Kathleen Kenyon's excavations at Jericho. Triggs deals with the subject of phasing stratigraphic sequences, which as he notes is one of the least understood methods in archaeology. On sites where walls, as upstanding strata, create ambiguous stratigraphic relationships, multilinear sequences are a direct result, due to separate developments within and without a building. Triggs turns to a computerized incidence seriation program in order to assign dating values to deposits on the separate strands of the multilinear sequence. He notes that the Harris Matrix makes it possible to represent schematically the entire site stratigraphy and shows the range of possible stratigraphic relationships where walls produce separate lines of stratigraphic development within the sequence.

By analysing the artefact content of the separate stratigraphic strands, Triggs contends that it is possible to identify infiltrated and residual remains if they occur in significant numbers. This sorting of the chaff from the wheat then allows for the indigenous artefacts to come to the fore and assist the archaeologist in the correlation of deposits which are not otherwise stratigraphically connected.

13 Computer-aided Harris Matrix generation

IRMELA HERZOG

Programs for Harris Matrix generation

Shortly after the Harris Matrix had been invented, the first attempts were made to produce the diagram with the help of computers (Bishop and Wilcock 1976). The reason for this was the enormous number of layers and their relations on large building sites coupled with the fact that on rescue excavations little time is left to draw the final Harris diagram but only to document the individual relations. Bishop and Wilcock's STRATA program required first the transfer of the stratigraphic information to data sheets and then the coding of the data sheets onto punched cards. As a result, data entry and change was very tedious; errors detected by the program could only be corrected by the program or by starting a new run with manually corrected punched cards. The output diagram did not show any links but only the positions of the layers. It is easy to understand that Harris (1975b) objected to the use of the computer in preparing the sequence diagram at that time.

There was a standstill in research concerning computer-aided Harris Matrix generation for about a decade until the PC became popular. Some excavators may have used two-dimensional drawing programs allowing changes to be made with less effort than on paper and the output to be published without redrawing. But the drawing programs do not provide any facilities to check the consistency of the resulting diagram, and with large data sets only a small section of the diagram can be seen on the computer screen, and the general view is lost.

Day (1987) developed the PC program GAMP, which allows the user to define the layers and their relations interactively and to pose questions concerning the data set, for example, whether a given layer is above another given layer. However, the program calculates the positions of the layers in the diagram; only their depth can be altered interactively. It is possible to view parts of the diagram on the screen, but no printed diagram output is provided. Layer identifiers may solely be numbers in the range from 1 to 1000. Only above and below relations can be processed.

Ryan (1988) produced GNET, which emphasizes the graphic aspect of Harris Matrix generation and bears some similarity to a drawing program. A PC version is available which requires a graphic card (CGA or better) and a mouse. The resulting diagram can be printed on a PostScript laser printer. The program has a modern user interface with a lot of options for the graphic display. Above, below and equal relations are supported, but two equal layers may be positioned on different depth layers, contrary to my contemporary or equal concepts described below. Zooming helps somewhat to overcome

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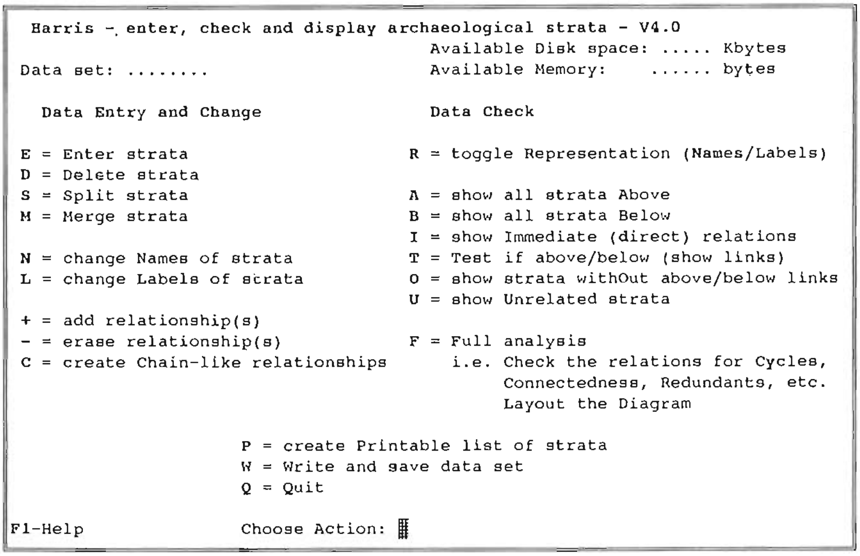
problems with large data sets. The user has to determine the position of each layer as part of its definition, later automatic layout of the layers may be chosen. The automatic layout appears not to minimize crossings.

The user interface of the Bonn program

The aim of the Bonn Harris Matrix computer project was to create a program which would run on almost any PC with diagram output on nearly all printers. The minimum requirements for the program are a PC with 512 kb memory, a hard disk and a printer able to print the graphic characters of the IBM graphic character set or an HPGL plotter. The program was developed in close cooperation with C.J. Bridger, who wanted to draw a Harris diagram for a Roman site in Xanten, Germany, with about 1000 layers, there having been no opportunity to draw the diagram at the time of excavation (Bridger and Herzog 1991).

Firstly, a powerful and user-friendly user interface was needed. The layers had to be uniquely identified by numbers or names. I provided a system which allows the automatic creation of layer identifiers comprising numbers within any given range, as well as the possibility to define individual names, such as *256a* or *Sand#1*. Additionally, a description field may be used for comments for each layer. This field may be left empty and need not be unique for each layer. For example, several layers might have the label *late Roman ditch*. To deal with the layers efficiently, it was necessary to create a structure similar to a data base. The relations between the layers had also to be stored. The user interface allows the following operations on the layer data (Fig. 13.1): new layers can be defined; existing layer names or description fields may be changed; two layers may be merged;



```
 Harris - enter, check and display archaeological strata - V4.0
                                       Available Disk space: ..... Kbytes
Data set: ........                     Available Memory:     ...... bytes

  Data Entry and Change                Data Check

E = Enter strata                     R = toggle Representation (Names/Labels)
D = Delete strata
S = Split strata                     A = show all strata Above
M = Merge strata                     B = show all strata Below
                                     I = show Immediate (direct) relations
N = change Names of strata           T = Test if above/below (show links)
L = change Labels of strata          O = show strata withOut above/below links
                                     U = show Unrelated strata
+ = add relationship(s)
- = erase relationship(s)            F = Full analysis
C = create Chain-like relationships      i.e. Check the relations for Cycles,
                                              Connectedness, Redundants, etc.
                                              Layout the Diagram

                          P = create Printable list of strata
                          W = Write and save data set
                          Q = Quit

F1-Help                   Choose Action: █
```

Fig. 13.1 The main menu of the Bonn Harris Matrix program.

single layers can be split into two layers; layers may be deleted. Additionally, relations between layers may be added or deleted. It is also possible to define the layers as one proceeds, i.e. when establishing a relation. The excavator may also pose questions concerning his or her data set (see Fig. 13.1). User interaction is facilitated by context sensitive help and a handbook.

The mathematical structure of the 'is later than' relation

A Harris Matrix helps to clarify the relative chronological development of a site. Thus, I first implemented the most important time relations '*is earlier than*' and '*is later than*'. As Orton (1980) notes, the mathematical structure underlying a Harris diagram with these relations is a partially ordered set. That means that 'is later than' is transitive: if layer 1 is later than 2, and 2 is later than 3, then naturally 1 is later than 3. In Harris Matrix generation it is common practice not to draw relations like '1 is later than 3' in my example, because this relation does not enter new information into the time relation system. Relations of this sort are often called *redundant*. The later relation is also *asymmetric*, i.e. if layer 1 is later than 2, layer 2 cannot be later than 1. Finally, layer 1 cannot be later than itself, a condition which is called *irreflexive*. In computer science and mathematics, partially ordered sets are often visualized by directed graphs that bear a lot of similarity to the Harris Matrix. A directed graph consists of nodes designated by numbers in circles and arrows signifying the relations connecting the circles.

There are other applications of partially ordered sets visualized by directed graphs which are related to archaeology. One example is a genealogical table, another is project management for archaeological tasks. Project management may help to plan the building of a new museum by listing the tasks which must be done and their time dependencies. In this case, the tasks are the nodes of the graph and the relation is '*must be done later than*'. If it were necessary to finish each task before starting a new one and if the sequence of the tasks were fixed, one would speak of a fully ordered set. In reality, the contractor may choose the sequence in which certain tasks are completed, but the sequence of other tasks is fixed. So it makes sense to speak of a partially ordered set.

As the Harris diagram is similar to a directed graph, I use data structures designed for these graphs to store the earlier and later relations of the layers. For each layer two sorted lists are maintained, the list of layers that are earlier and the list of layers that are later. The sorting of the lists helps to prevent double entries. If the relation 'layer 1 is later than 2' is established, layer 2 must be entered into the later-list of layer 1 and layer 1 inserted into the earlier-list of layer 2. A situation whereby a layer gets into its own earlier- or later-list must be prevented, because of the irreflexivity of the later relation. These lists are built up dynamically, so that the amount of memory needed is dependent on the number of layers and their relations. An alternative data structure proposed for graphs are adjacency matrices as used by Desachy and Djindjian (1991) for the solution of stratigraphic problems. The disadvantage of this data structure is that the storage requirement increases far too rapidly with the number of layers processed.

With these data structures, methods taken from graph theory can easily be implemented to find problems in the data set. One basic problem is to answer the question whether there is a path of later relations connecting two given layers. Graph theory offers two different methods to solve this problem: *depth first search* and *breadth first search*. Depth first search starts with the layer assumed to be earlier, then moves along later relations chosen arbitrarily until it encounters the layer looked for or a layer with no further later relations. But, of course, the desired layer may be found on another path of later relations starting at the layer assumed earlier. Therefore, whenever a layer is encountered on the path with more than one later relation, this layer, together with its relations not followed on the current path, is stored. If the current way leads to a dead end without finding the layer looked for, depth first search takes the relation entered most recently out of the store and proceeds along this path. The new path may branch again, so that new layers and their relations have to be put in store. Once all the paths in store have been followed, the store is empty and all the transitive later relations of the layer assumed earlier have been checked. Thus, a list of all layers later than a given layer can also be created easily using this method.

The alternative search method, breadth first search, has the advantage of finding the shortest path from one layer to a later layer. This is done by following the alternative ways in parallel. First, one stores all the layers immediately later than the first layer. In the next step, each layer in the store is replaced with the layers which occur immediately later, and care is taken that layers which have already been entered into the store will not be entered again. If the layer looked for has been found, the process halts, otherwise it halts when the store is empty, since the final layers do not have any later relation. Depth first search follows only one path at a time and, therefore, it is easier actually to name the layers on the path found from the earlier to the later layer. With breadth first search, during which the paths are followed in parallel, this is slightly more difficult.

Equal and contemporary relations

After some experimenting with a Harris Matrix consisting of earlier and later relations only, I thought it useful to have equal and contemporary relations as well. The original Harris publications seem not to have differentiated between the two terms.

Equal relations are useful if a single layer has been observed in two different trenches and given different numbers. They are therefore very similar to the principle of correlation described by Harris (1989: 105–6). The drawing of correlation relations manually shows some lack of systematization. A later relation which has been observed for two equal layers is drawn only once and is assigned at will to one of the layers. If the later relation has been observed for only one layer, it is drawn starting at this layer. However, one never knows whether this relation was observed once or several times with equal layers, because in both cases it is drawn only once. To avoid difficulties with translating this complicated procedure into a computer algorithm, in my program, if two layers are set equal, their later, earlier and contemporary relations are merged and the layers will be connected with a horizontal double bar in the diagram. In the Harris Matrix, only one of the equal layers retains all the relations. Mathematically speaking, it would do to merge the relations of the two different observations and to retain one of the names, but in practice the excavator wants to be able to find any layer name used on the excavation also in the diagram, and, therefore, the equal relation was introduced.

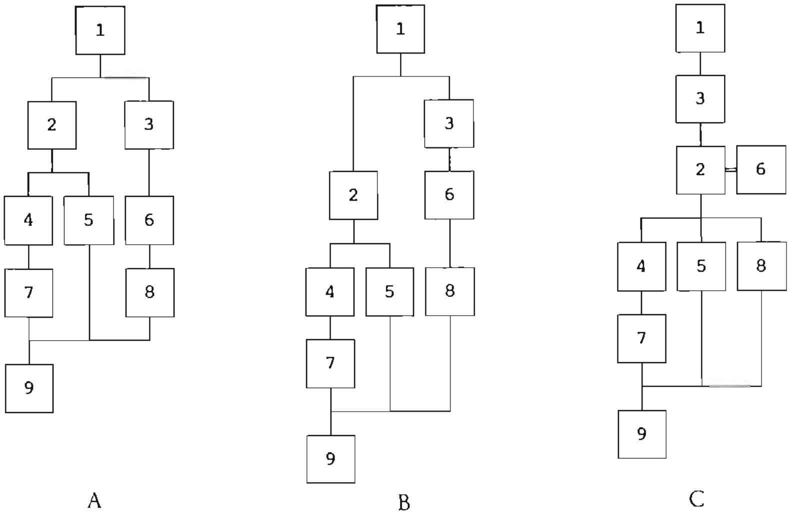


Fig. 13.2 (A) Small Harris diagram without contemporary or equal relations. (B) Diagram as in (A), but layers 2 and 6 are placed contemporary. (C) Diagram as in (A), but layers 2 and 6 are placed equal.

In my definition, two layers which are contemporary will be set on the same horizontal height of the Harris diagram (Fig. 13.2). Contemporary relations are useful to fix the position of so-called floating sequences. These are groups of layers whose position as a group is not fixed by the earlier/later relation system and is a problem inherent in partially ordered sets. In my project management example floating sequences mean that the building contractor may choose to start a task at will within a certain time interval. But in stratification floating sequences often have time relations with other layers which are not observed via physical relations in the field: two layers with approximately the same distribution of sherds may be assumed contemporary, and at times the archaeologist has other *a priori* knowledge which can also be used to fix floating sequences.

Harris (1989) states that the stratigraphic sequence can and should be constructed without reference to the artefactual contents of the strata. Thus, when creating the first Harris diagram of a site, there will probably be very few contemporary relations. When it comes to phasing, however, the excavator has to fix the floating sequences, and therefore he will insert new contemporary relations into the matrix. There is another practical use of contemporary relations: if the excavator is in doubt as to whether two different layers are part of the same construction destroyed later, the two layers in question can be set contemporary for trial purposes. If any contradictions in the data set occur as a result of this trial relation, the contemporary relation can be resolved with less effort than an equal relation.

The mathematical term for a relation with the properties of '*contemporary with*' is an equivalence relation. The relation is transitive: if layer 1 is contemporary with 2 and 2 contemporary with 3, then layers 1 and 3 are contemporary. If layer 1 is contemporary with 2, 2 is contemporary with 1; this property is called *symmetry*. The relation '*contemporary with*' is also *reflexive*, i.e. every layer is contemporary with itself. These

a) Contemporary list for each layer:

1 : 2, 3, 4
2 : 1, 3, 4
3 : 1, 2, 4
4 : 1, 2, 3

b) Contemporary list stored only once:

Layer	Starting contemporary layer	Next contemporary layer
1	1	2
2	1	3
3	1	4
4	1	0

Fig. 13.3 Example of the two ways to store contemporary relations. In the example, the layers 1, 2, 3 and 4 are contemporary.

properties will appear trivial to many readers, but they help to find errors in the data set. Consequently, one is no longer dealing with a pure partially ordered set induced by the later and earlier relations, but within this set there is an embedded equivalence relation.

Standard graph theory does not deal with these structures, but the methods for directed graphs can be readily extended. First, I had to modify the data structure so that contemporary relations could be stored as well. For each layer I maintained three sorted lists, the later, earlier and contemporary list. Owing to the symmetry of the contemporary relation, it is not possible to define redundant transitive relations, and therefore I stored all the contemporary relations of a layer in its contemporary list. This means that a new contemporary relation between two layers may affect the contemporary lists of other layers as well: if layers 1 and 2 are contemporary and the relation 2 is contemporary with 3 is newly entered, 3 must be entered into the contemporary lists of 1 and 2; 1 and 2 are entered in the contemporary lists of 3. An alternative involving less storage space stores the contemporary list only once: each layer has a pointer to the starting layer of its contemporary list and a pointer to the next element of the list; the pointers are zero, if no such relation exists. When a layer's contemporary relations are searched for, first the starting layer of its contemporary list is looked for, then the next element of the starting layer, then the next element of this element and so on until zero is encountered. This latter data structure was actually used to store the equal relations which are also, mathematically speaking, equivalence relations. The programming effort needed to maintain these two data structures does not differ very much but should not be underestimated (Fig. 13.3).

The algorithms had to be adapted for contemporary relations. For example, in my program the excavator may choose to include or exclude contemporary relations when asking the question if a certain layer is later than another given layer. In the former case, the search procedure is modified as follows: whenever a layer is to be stored, all the layers contemporary with this layer are stored as well. Thus, for the starting layer, all the paths via later and contemporary relations are checked.

If the excavator enters the relation '1 is later than 2', the program automatically establishes the relation '2 is earlier than 1'. Similarly, if 1 and 2 are already set contemporary and the user sets 3 contemporary with 2, then the program knows that 1 and 3 are contemporary. Any direct relation may be deleted. This is quite easy for later or earlier relations. But if a contemporary relation is erased, a more complex operation results: for example, if 1, 2, 3 and 4 are contemporary and the relation '1 is contemporary with 2' is to be deleted, the user must decide whether 3 and 4 are contemporary with either 1 or 2. If an equal relation, say between 1 and 2, is deleted, then the user must decide for each earlier or later relation of 1 and 2, whether it belongs to only one or both layers. The contemporary relations of two layers whose equal relation is being deleted are dealt with in two different ways, depending on whether the layers remain contemporary or not.

Automatic data checking

When the excavator has entered all the data into the computer and checked them by asking questions, then he or she will wish to see the diagram. In practice, a little patience is needed, because the layout must be preceded by some checks. First, the program finds out if all the layers form a connected set, because sometimes two or more unrelated Harris diagrams can be generated from one data set. This is often due to omitted relations. Testing the connectedness of a graph is again a standard procedure in graph theory and is similar to the path searching method. Starting at an arbitrary layer, all the layers which can be reached via simple earlier, later or contemporary relations are stored and marked, then the unmarked layers, which can be encountered starting from the layers in store, are stored and marked, and so on until the store is empty. If unmarked layers remain, the diagram is not connected. To find the next so-called connected component, the program recommences with an arbitrary unmarked layer and marks the layers reached differently. By this method a list of layers sorted according to their connected component can be created easily. It is not vital for the program to have only one connected component, because it can create an artificial layer, the surface layer, which is later than any other layer and therefore connects all layers. If several components are encountered, the excavator may proceed with them separately, or missing links can be inserted manually to create a single connected component, or the program continues and connects the components with the help of the artificial surface layer.

Cycles are a more serious problem. Mathematically speaking they are contradictions of the principle of irreflexivity of the later relation, i.e. there exists a path of later relations which starts and ends at the same layer. Such contradictions are either due to lenses or to errors in observation or in typing while entering the data. In the case of lenses, I recommend splitting the layer surrounding the lens into two parts, i.e. the layers above and below the lens receive separate identification. All other errors must be corrected by the excavator after checking the excavation archives.

The cycle checking algorithm is able to assign depth coordinates to the layers in the Harris diagram as it proceeds, which will help to speed up other checks. The idea is quite simple and has been introduced into stratigraphic analysis by Magnar Dalland (1984): all layers which have no later relations are placed at depth number one; all later relations which end at a layer at depth number one are removed from consideration; all layers which therefore have no later relations are placed at depth number two; this procedure continues until no layer without later relations is found. Once all layers have been assigned a number, no cycle is present. However, if there is a set of layers without depth assignment, there exists at least one cycle within this set.

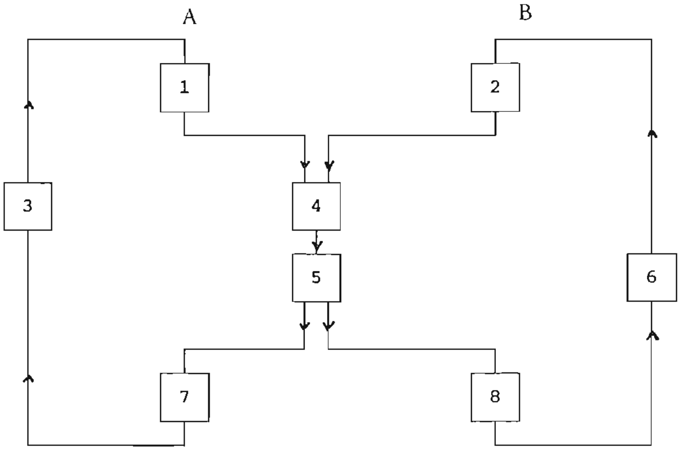


Fig. 13.4 Two cycles that have two layers in common: (A) 1, 4, 5, 7, 3, 1; (B) 2, 4, 5, 8, 6, 2.

A layer can be involved in several cycles, as Fig. 13.4 shows. Graph theory offers algorithms for finding a fundamental set of cycles or all cycles (Reingold *et al.* 1977: 346–53). It suffices to list the fundamental set of cycles, because all other cycles are combinations of the fundamental cycles. For example, one could make a round trip on a figure-of-eight path, but one could also make two circular round trips on this path. Matters are even more complicated when structures like pretzels or Olympic Rings are considered. All the relations within a single cycle have equal probability of being erroneous, but the probability increases if a relation occurs in several cycles. The excavator is responsible for identifying the erroneous relation; it is quite unacceptable to cut an arbitrary relation in the cycle, as some Harris Matrix analysis programs do.

After all cycles have been resolved, the layers are placed at their latest possible position without taking the contemporary relations into account. In order to place the layers on their earliest possible position, one has to start with the layers without earlier relations and move upwards from the bottom as described by Dalland (1984).

The preliminary depths help to reduce the effort when looking for redundant links. For each later relation (from layer 1 to layer 2) a check is made to find out if another path connects these two layers. Using depth first search, the program follows all paths from source layer 1 (except the direct path to 2) until these paths hit the preliminary depth of 2. When 2 is encountered, the relation 1 later than 2 is redundant and therefore erased.

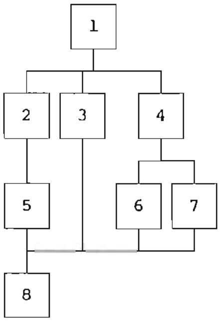
It is also necessary to eliminate bad contemporary relations that are in conflict with later or earlier relations. For example, if the excavator defines the relations '1 later than 2', '2 later than 3', and '1 contemporary with 3', then the contemporary relation will be considered bad by the program and will be deleted (Fig. 13.5). In my view, later or earlier relations have a higher priority than contemporary relations, because the former are based on physical observations, whereas the latter can be based on more subjective conclusions and are therefore more open to error. When performing this check, the program again benefits from the preliminary depth coordinates. When checking whether '1 is contemporary with 2' is a bad contemporary relation, either:

(a) 1 and 2 have the same depth coordinates. Then 1 cannot be later than 2 and 2 cannot be earlier than 1, therefore, the contemporary relation is not bad; or

```
a) bad contemporary
   relation:

   1 contemporary with 5

   1 and 5 cannot be
   placed on the same
   depth line because
   of their earlier/later
   relation.
```



```
b) conflicting contemporary
   relations:

   2 contemporary with 6
   4 contemporary with 5

   resulting cycle:
   (≈ means contemporary with)

   2, 5 ≈ 4, 6 ≈ 2
```

Fig. 13.5 Harris diagram example to illustrate bad and conflicting contemporary relations.

(b) the depth coordinates are different, e.g. the depth of 1 is less than that of 2. Then, as in redundancy checking, all paths from 1 down to the level of 2 are generated. If 2 is encountered, the contemporary relation is considered bad.

Conflicting contemporary relations must also be resolved. If, as in Fig. 13.5, it is requested that 2 be contemporary with 6 and 4 be contemporary with 5, then it is not possible to draw a diagram which allows these conditions. In this case, the two contemporary relations are called *conflicting* and again the excavator is asked to choose the erroneous relation. In my example, a cycle including contemporary relations results; 2 is later than 5, 5 is contemporary with 4, 4 is later than 6, and 6 is contemporary with 2. Therefore, it is obvious that conflicing contemporary relations can be found via an extension of the normal fundamental cycle finder.

The data checking phase may take several minutes for a data set with several hundred layers. Therefore, it is not practical to check after the establishment of each new relation whether or not the data set remains consistent.

Layout problems

The layers and the relations in general do not lead to a unique representation in Harris diagram form. There may be variations in the horizontal sequence of the layers as well as in their depth position, as Fig. 13.6 shows. Excavators drawing a Harris diagram tend to choose the horizontal sequence of the layers so that spatially close layers in the field appear near one another in the drawing. The Harris diagrams I have seen in publications (Harris 1975a, 1977, 1989; Orton 1980) do not show any crossings except if redundant relations are shown as well. But I soon found that crossings do exist in practice and I thank C.J. Bridger for providing me with a simple example of a situation with seven layers which cannot be translated into a Harris diagram without crossing (Fig. 13.7).

Contrary to graphs used in mathematics and computer science, the Harris diagram may use structures such as in Fig. 13.8A, which I call H-structures because of their form. In order to minimize crossings in the diagram, it is necessary to detect these structures. Unfortunately, combinations of H-structures may occur, so that the detection of H-structures become quite difficult (see Fig. 13.8B–D). Computationally the problem is

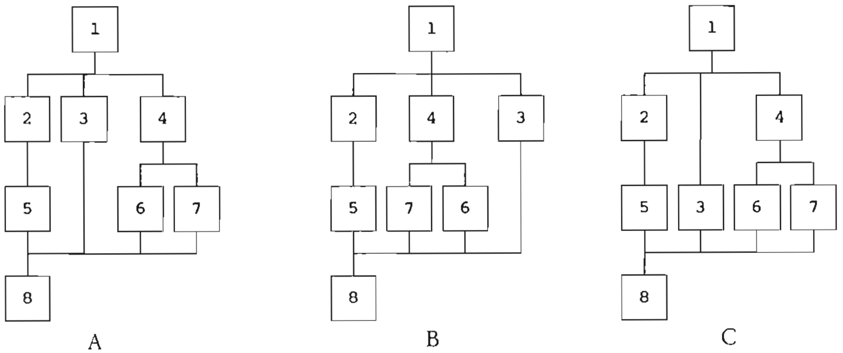


Fig. 13.8 (A) A simple H-structure. (B) An H-structure combined with a later relation. (C, D) Two examples of combinations of H-structures.

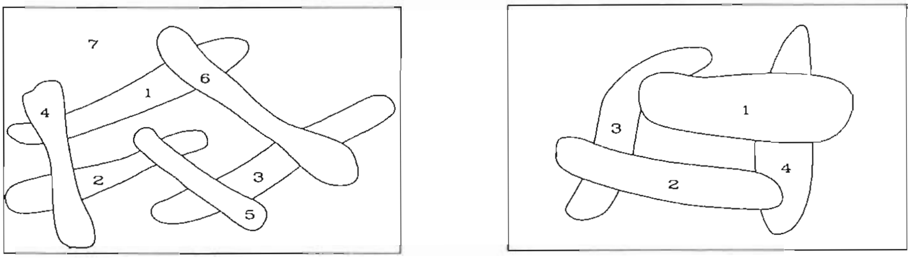
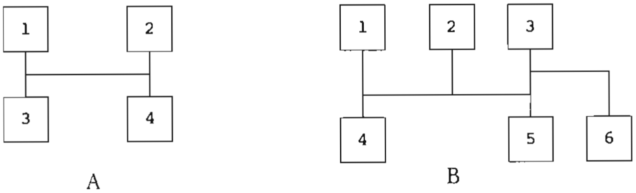
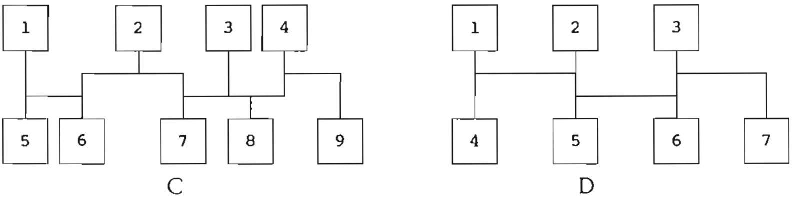


Fig. 13.7 A Harris diagram for the situation on the left cannot be drawn without crossing. The Harris diagram of the four layers on the right results in an H-structure as in Fig. 13.8A.



```
1 is later than 3, 4
2 is later than 3, 4
```

```
1 is later than 4, 5
2 is later than 4, 5
3 is later than 4, 5, 6
```



```
1 is later than 5, 6
2 is later than 5, 6, 7, 8
3 is later than 7, 8
4 is later than 7, 8, 9
```

```
1 is later than 4, 5, 6
2 is later than 4, 5, 6
3 is later than 5, 6, 7
```

Fig. 13.8 (A) A simple H-structure. (B) An H-structure combined with a later relation. (C, D) Two examples of combinations of H-structures.

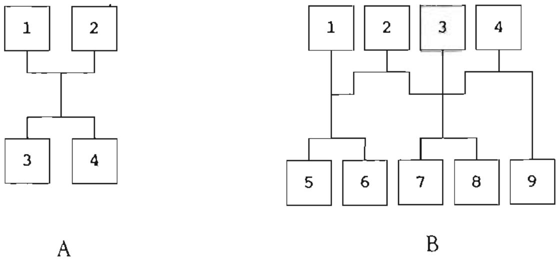


Fig. 13.9 Program representation of H-structures: (A) Fig. 13.8(A); (B) Fig. 13.8(C).

solved by creating a pseudo-layer for each H-structure which is represented on the output as shown in Fig. 13.9.

The assignment of horizontal layer sequences in the diagram is by far the most difficult problem in processing the Harris Matrix. At first, I programmed a user-driven layout method: the diagram is scanned linewise starting with the top line, and, whenever a 'parent layer' has more than one relation to the layers in the following lines, the excavator is asked to enter the sequence of these 'child layers'. The program stores the user-selected sequences so that they become the default at the next interactive layout, and the excavator can improve the layout progressively. But with large data sets the excavator will most likely get lost in a jungle of relations, owing to the fact that the offshoots of a layer are assigned to different depths in the diagram.

Therefore, I looked for an automatic layout method. Mathematically speaking, the Harris Matrix is a directed graph with the property that all connecting arrows point downward. These graphs are called *k*-level hierarchies (Di Battista and Nardelli 1988; Tamassia *et al.* 1988). Tamassia *et al.* discuss several aesthetic criteria which can be used in laying out a hierarchy, such as minimizing the space used by the graph, equal distribution of layers or minimization of crossings. I decided on the aesthetic of minimizing the number of crossings. Unfortunately, this problem is NP-complete (Di Battista and Nardelli 1988). The abbreviation NP stands for *non-deterministic polynomial* and refers to the immense processing time increase for every newly added layer: in order to find the configuration with the minimum number of crossings, all layer sequences must be tried for each line. For a Harris diagram with five depth lines and five layers per line, $5!^5$ (i.e more than 10 billion) configurations have to be checked, which is unfeasible even for medium-sized diagrams. Therefore, a heuristic method was employed. The algorithm by Di Battista and Nardelli is able to create a layout without crossings, provided the structure of relations allows this. The idea is quite simple: in a diagram without crossings, the 'parent layers' of a given layer together with the 'child layers' form consecutive groups of layers. These groups should be positioned directly above or below the given layer.

A data structure to process the consecutive groups of layers problem can be constructed as follows: first, each layer in a depth line is assigned an arbitrary position; for each group restriction on this line a row is built up consisting of ones and zeros, the ones designating the position of layers within the group, the zeros indicating layers not in the group; these rows are stacked in a matrix and such a matrix is created for each Harris diagram depth line. The task is to swap simultaneously the columns in the matrices so that in the rows consecutive ones will appear and it is assured that the child group sequence corresponds to their parent layer sequence. Anyone familiar with mathematical applications in archaeology will see that this problem is related to the theory of seriation. Wilkinson (1974) reorders the columns of so-called pre-P matrices so that the ones in the matrix rows occur consecutively. He uses the Fulkerson and Gross (1965) algorithm to do the reordering. Later, PQ-trees were invented by Booth and Lueker (1976), solving the consecutive ones problem more efficiently. These data structures and their transformation methods form the basis of the layout algorithm by Di Battista and Nardelli. Wilkinson also established a connection between the consecutive ones and the travelling salesman problem by considering each column of the matrix as a point in *n*-dimensional space. The shortest path connecting these points results in an order of the columns with consecutive ones in the rows. This can be readily extended to the general seriation problem where consecutive ones cannot be achieved but the ones should be as condensed as possible. Conversely, if one tries to minimize the fragmentation of the child and parent groups in the diagram, the translation into matrices with zeros and ones leads to the same problem. The general travelling salesman problem is one of the best-known NP-complete problems and, therefore, it is not surprising that the minimization of crossings is NP-complete, too.

In the Di Battista and Nardelli algorithm, the earlier relations are successively entered into the diagram. First, for each layer a relation to a later layer is established. The resulting image is similar to a tree and does not include any crossings. Then, the rest of the earlier relations are entered one by one within each depth line. If a newly inserted relation leads to an unavoidable crossing, this relation is excluded from consideration. But the tree relations which are established first are never broken. Unfortunately, an unfavourable tree relation may lead to many crossings. Therefore, different tree configurations can be chosen via a random process.

In this connection it might be interesting to apply a method called simulated annealing, which practically 'solved' the travelling salesman problem, according to Press *et al.* (1986). Simulated annealing is designed especially for problems in which a factorially large number of configurations is possible. The name is derived from the slow cooling of metal which leads to a more stable situation than quick cooling. In the case of crossing minimization, this would allow for the number of crossings to increase at times during the minimization process, but ensuring that this number decreases in the long run. Simulated annealing requires a generator of random changes in the configuration, and a different choice of tree relations could provide such a generator. This procedure will be quite slow but, if the original Di Battista and Nardelli algorithm leads to a large number of crossings with several random tree configurations, simulated annealing may be able to reduce the number of crossings further.

After the horizontal sequence of the layers in each line has been determined, the actual horizontal positions must be calculated and the connecting lines drawn in order to produce a printable Harris diagram. These procedures are straightfoward. The excavator can view part of the Harris diagram on the screen and print or plot it.

Phases and structures

After the first Harris Matrix has been printed for a given data set, the excavator may want to introduce a phasing concept for the data. According to my definition, a phase consists of one or more horizontal levels of the Harris diagram. Floating sequences often lead to ragged borders of the phases in the first Harris diagram, and therefore it would be useful to include the information on the phases in a second layout of the diagram. Each layer can be assigned to one phase only. The administration of phases should also include the generation of new phases, deletion, splitting and merging of existing phases. The phases must be tested for connectedness, i.e. it is not possible that a layer of phase A is later than a layer of phase B which is itself later than another layer of phase A. Moreover, the succession of phases must form a fully ordered set, and, if that is not the case, the excavator is asked to enforce the ordering of phases without relation. Therefore, it is possible to indicate the phases in the final diagram.

If a diagram has many crossings and consists of a lot of layers, layers which formed a single structure before excavation may become widely distributed over the diagram. This may be overcome via a structure concept. In my definition, a simple structure consists of a connected set of layers. It is even possible to define hierarchies of structures: a composed structure consists of simple structures, composed structures and single layers, with all the layers in this structure forming a connected set. But structures overlapping other structures are too complicated to handle and therefore should not be allowed. It should be noted that the structure concept is a generalization of the phase concept. To keep the layers of a structure in one place during the layout, the simple structures should be laid out first according to the Di Battista and Nardelli algorithm. Afterwards, the program replaces these simple structures by an artificial layer which I would like to term 'metalayer'. It has all the external relations of the structure. The composed structures are laid out treating the metalayers as normal layers of different sizes and are replaced by metalayers too; finally, the full diagram is generated from these metalayers. A method with simple structures only has been discussed in more detail in graph theory, with a different crossing minimization heuristic (Messinger *et al.* 1991).

Practical experience

For demonstration purposes at a meeting, the sections of Billingsgate Buildings as published by Orton (1980) were analysed. It was found that several layers were not numbered at all, that several were duplicated and that other layers which were shown in the Harris Matrix did not occur in the section drawings. After naming the layers without numbers, Fig. 13.10 resulted. The layer relations were entered, as precisely as these could be determined. At the time only an interactive layout of the diagram was supported by the program and a diagram with four crossings was created. Later with automatic layout the number of crossings was further reduced to one (Fig. 13.11). This shows that even with relatively small diagrams an excavator may not be able to find the layout with the minimum number of crossings. Figure 13.11 was plotted on a laser printer with the help of a public domain program that translates the HPGL plotter language to graphic output for a wide variety of printers. Crossings are not shown in the diagram but layers with crossings are marked by a double frame.

The Bonn program was used to reproduce the diagram for the South Gate site as published by Harris (Harris 1975a: fig. 29). This data set consists of 406 strata and 856 earlier or later relations. The diagram in the Harris publication allows only rough guesses

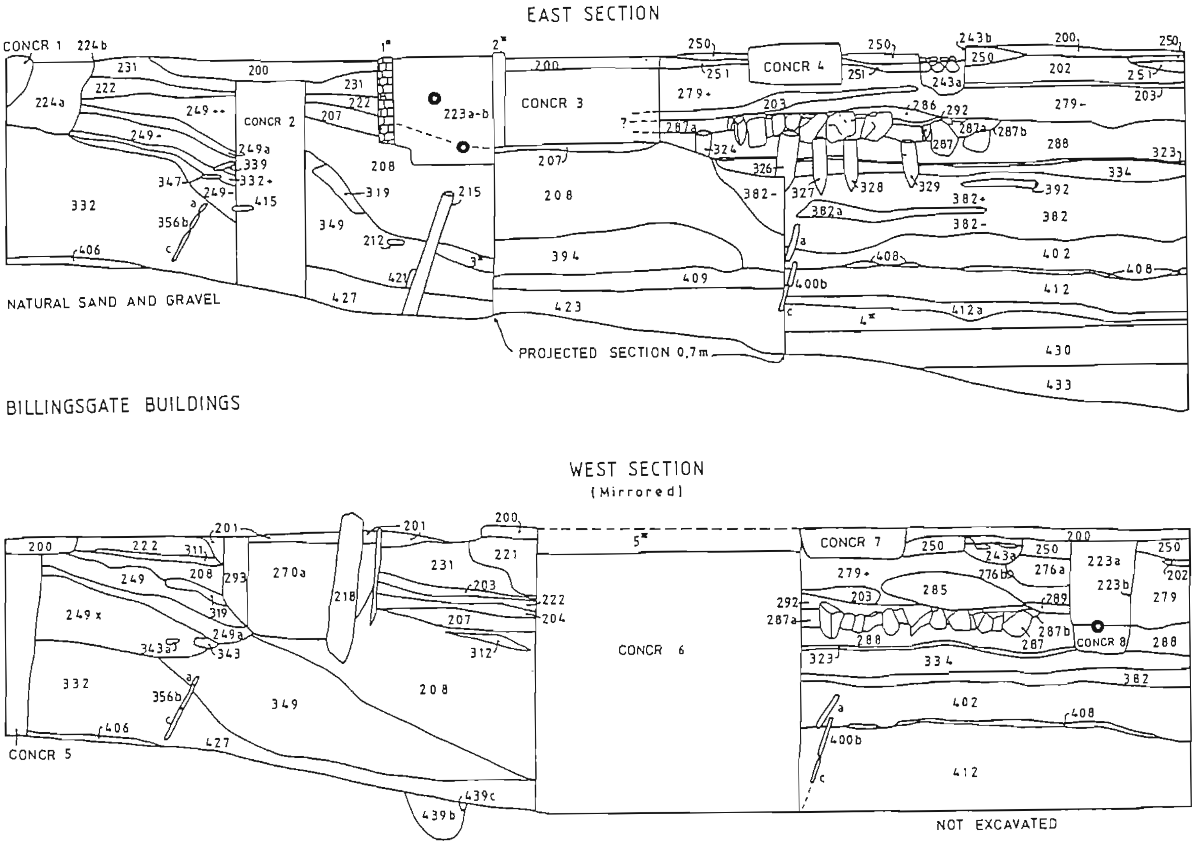


Fig. 13.10 Sections of Billingsgate Buildings as published by Orton (1980), with correct layer identifiers.

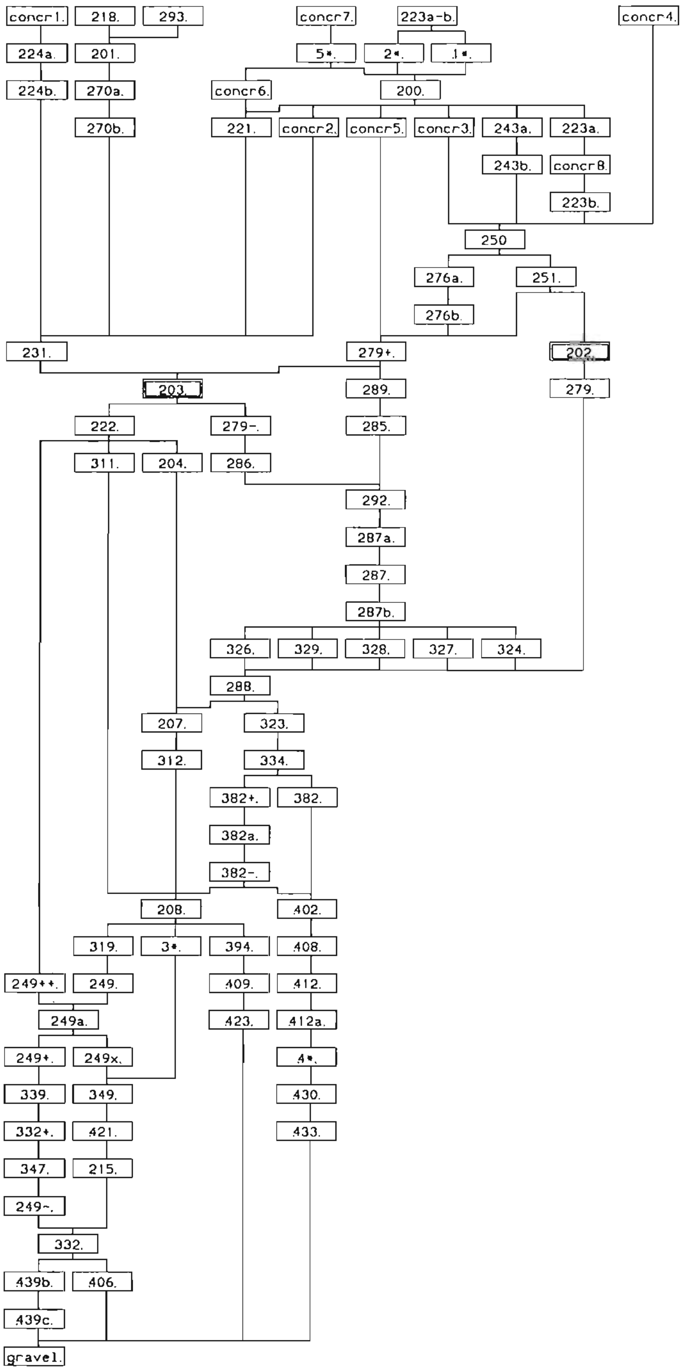


Fig. 13.11 Harris diagram output of the Bonn program for the stratigraphic data set resulting from Fig. 13.10. The layout includes a crossing relation: 202 is later than 203. The two double frames indicate that this crossing relation is not shown in the diagram.

about contemporary relations, therefore these relations were omitted. Layers whose frames are connected with a horizontal double bar were considered equal in the sense of this paper. One error was found (layer 266 occurs twice in the diagram). After correcting this error, no other problems were detected during the data checking phase. The diagram produced by the program is 65 cm long and 25 cm wide.

Additionally, two excavations in the city of Xanten on the lower Rhine were analysed. One of them was a Roman site with about 1000 layers, the other excavation documented medieval buildings with about 800 units of stratification. With the Roman site, 881 redundant relations were erased. Cycles, bad and conflicting relations were detected by the program and led to corrections in the data. Especially with the Roman site, which had undergone several phases of demolition and reconstruction, the number of crossings which could not be reduced automatically any further was considerable.

Acknowledgements. I would like to thank C.J. Bridger for suggesting the problem, for archaeological advice, for his utmost patience while working with unstable test versions and for many useful suggestions. I. Scollar recognized the similarity of directed graphs and the Harris Matrix independent of Ryan, and called my attention to the work of Di Battista, Tamassia *et al.* I also thank them for correcting my English.

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14 Interpreting archaeology with Hindsight: the use of three dimensions in graphic recording and site analysis

BRYAN A.P. ALVEY

Introduction

When archaeologists approach the interpretation of an excavation, there are a number of different sources of information at their disposal: the written information regarding each of the deposits, cuts or interfaces observed on site, photographs, graphic data, specialist reports and the matrix. It is a large body of data, which, when recorded using standard procedures, lends itself to computerization. Amongst the most important aspects of these data are the graphic and matrix information. To understand and impart the importance of a site, the archaeologist must publish plans of the site, and may use graphics to illustrate more clearly, for example, cultural changes or spatial distributions. To ensure that an interpretation may be correct stratigraphically, the analyst should always refer to the sequence of the deposits, as held in the matrix.

In recent years more and more archaeological units in the United Kingdom have adopted the principles of the Harris Matrix, and incorporated the use of single-context[1] planning in their recording systems (see Harris 1979). The reasons for this are outlined in Harris (1979: ch. 8): that each context is drawn in its entirety, enabling stratigraphic relationships to be tested in post-excavation using overlays; that phase plans may be reconstructed *after* the information on the small finds, etc. has been investigated; that phase plans may be constructed from the earliest point in time to the latest – reflecting the development of the site – rather than having to draw phase plans at the time of excavation, from the latest point in time to the earliest.

The adoption of single-context planning therefore has many advantages, but the composite plan is still the vehicle for publication. Compiling site plans from single-context plans manually is a boring, time-consuming and therefore costly business, especially if the archaeological site under investigation is complex and covers a large area. In these circumstances the illustrator is hampered by the fixed scale of the plans drawn on site, and the ever-changing views of the archaeologist who would like to see a number of

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[1] More extensive definitions of a context are given elsewhere in this volume (see Pearson and Williams (Chapter 6), for example). For the purposes of this document, a context is a single event or action that can be recognized by the archaeologist – for example, a layer of soil, a wall, a cut into a surface – and is the minimum unit recognized in archaeology to determine stratigraphy.

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possible permutations before making any decisions or interpretations. If the analyst changes his or her mind as to which deposits form the basis of a group or phase, then the illustrators must peel off a number of plans from the drawing board, add a few more, and then redraw the whole – a fiddly and frustrating business that bears little relationship to their talents.

In recent years in the UK, there have been many developments in the computerization of archaeological data. Most of these have concentrated on the written aspects of an excavation using desktop computer systems running relational database systems such as dBASE III+, dBASE IV, Informix, etc. Relatively few attempts have been made to computerize the matrix (STRATA (Bishop and Wilcock 1976; Wilcock 1982); CONSORT (Rains 1984; see also Haigh 1985), and fewer still (PLANDATA (Alvey and Moffett 1986), and more recently AEGIS, as used by the Scottish Urban Archaeological Trust) to produce a graphics database for archaeological sites.

The visualization of archaeological data is amongst the most important developments: in the bad old days of on-site composite planning, the first thing the archaeologist did before reaching for the site notes was to stretch out the plans on the wall. With the introduction of single-context planning, which records every single context in its entirety, it is now possible to reconstruct every possible sequence of an archaeological site. Since every context is planned using standard recording procedures, this method of recording is most suited to computerization.

What is Hindsight?

The purpose of this paper is to outline the potentials for use of three-dimensional computer graphics to help analyse and interpret archaeological sites, and its application in the graphics system I have been developing for archaeology called 'Hindsight'. Hindsight is essentially an AutoCAD customization that combines the philosophy of the Harris Matrix with single-context plan elements to reconstruct composite plans and three-dimensional models for investigation and analysis.

AutoCAD is a powerful computer-aided design system, and is the market leader in CAD desktop sales. AutoCAD's latest offering, Release 11 (as of October 1989), is a full three-dimensional system, and since Hindsight produces AutoCAD drawing files, all drawings produced by Hindsight can be customized using AutoCAD's extensive editing facilities to produce drawings for publication. Any drawing can be outputted directly to a plotter or PostScript laser printer, or be transferred easily to other graphics systems. Since other programs have been written for AutoCAD for contour surveys, etc., and Ordnance Survey plans can be obtained in AutoCAD's format, Hindsight drawings can be combined with contours or survey plans to relate an archaeological site to its surrounding area.

Whilst the heart of Hindsight is written in AutoCAD's programming language, AutoLISP, a suite of programs written in 'C' can be addressed that allow any aspect of the information from a written database to be displayed in the drawings. This will be discussed in further detail below. The system has been designed to bolt on to existing archaeological databases of written information. Whilst Hindsight has been designed for the single-context planning methodology, it is in fact quite flexible and can be applied to the graphics of any recording system that uses a single number sequence for its contexts.

In Hindsight, a single context can have up to 26 plans, and Hindsight can use up to 99 999 contexts – providing there is enough room on the hard disk.

AutoCAD is a large program and requires a fair amount of computing power. Current Hindsight systems are using 80386-based systems running DOS with extended memory and a math coprocessor, as 80286 systems are found to be slow. Computers such as these work with a digitizing tablet and a plotter.

Although the construction of composite plans is a primary use of this system, I have discussed this elsewhere (Alvey 1989; in press), and this will only be outlined briefly here. The main purpose of this paper is to describe the potential of using three dimensions and colour in the investigation of archaeological sites, and how Hindsight may be used to achieve these aims. Since colour is not available in this publication, the illustrations given here are not direct output from Hindsight: the colour output from Hindsight has been replaced by differences in patterning and shading.

Creating the composite plan

Plans of contexts can be entered into the system at any scale using a digitizer, and can easily be edited. During composite plan reconstruction, single-context plans are inserted from the bottom of the site to the top. Drawing on information held in a stratigraphic database, the analyst is able to create the composite plans in stratigraphic order – from

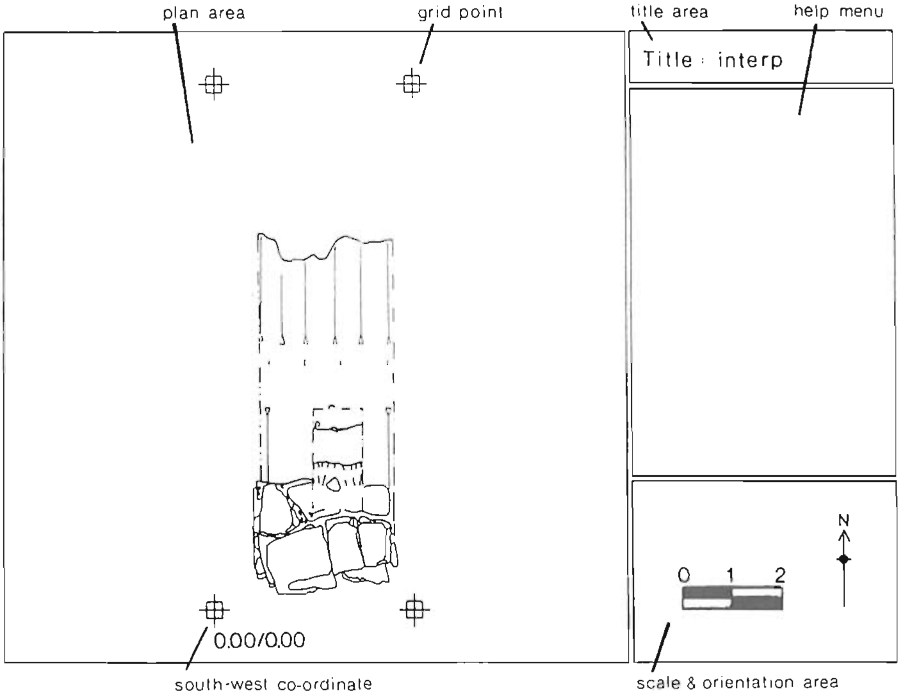

Fig. 14.1 The Hindsight screen, showing test data from part of the Stakis site in York.

the earliest point in time to the latest. As each new context is called from the database, Hindsight tests the stratigraphic position against all others already contained in the composite drawing. If the context is not stratigraphically below any of the existing contexts already contained in the drawing, then it may be added to form part of the composite plan. Thus the same control is held over the reconstruction of composite plans as is kept in the Harris Matrix: any plans inserted 'out of sequence' are rejected by the system. When the analyst decides that the composite plan on the screen represents a significant stage in the development of the site – often called a phase or group – it can be saved as a 'sequence', and can be drawn on a plotter at any scale, or reconstructed at a later date. Hindsight can also address 'files' of information: if, for example, a file has been created of the context numbers of all the pits containing Bronze Age pottery, then this can be submitted to Hindsight, and a distribution plan obtained.

An example of a Hindsight screen is shown in Fig. 14.1. For those familiar with the single-context recording system adopted by London's Department of Urban Archaeology, York Archaeological Trust, Norfolk Archaeological Trust and others, the screen is a close representation of the plan sheet they use on site. In addition to a north point and scale bar as well as a 'help screen' area, Hindsight can display the same planning conventions as used on site: there are special line types for excavation outlines, context outlines, edges of contexts that have been cut from above, plan outlines, uncertain edges, etc., and the archaeologist may add text, levels, hachures, small finds, stones and internal creases to Hindsight as they are drawn on site.

The three-dimensional (3D) Model

Hindsight has a second important function, which forms the main subject of this paper. Hindsight is also able to display the composite plans as a 3D representation of the sequence of deposition on site (Fig. 14.2). The vertical dimension of this model does not represent 'depth', but the chronological sequence, and is essentially a 3D visualization of the Harris Matrix. I have often felt that the past reluctance to adopt the principles of the Harris Matrix from traditional recording methods has been due to a lack of visualization: the reduction of context associations to an array of lines and boxes is often disconcerting to the archaeologists when the Harris Matrix is first viewed.

The 3D Model attempts to overcome this obstacle: rather than reducing each of the contexts to a numbered box, the shape of the contexts is retained, and is therefore much easier to grasp than the traditional matrix diagram. The model also overcomes the problem of 'jumping' seen in more complex matrix diagrams (Fig. 14.3). These 'jumps' – a cause of consternation to computer programmers when trying to display the matrix – occur because the Harris Matrix is a 2D representation of what is essentially a 3D relationship: the archaeologist is dealing with a volume of soil. Hindsight, retaining the third dimension of the relationship, uses vertical lines only (see Fig. 14.4).

The 3D Model is not 'static'. Once created the model can be viewed from a variety of angles and directions; one can zoom into a particular detail of the model that is of particular interest, or even 'move' into it. Any view seen on the screen can be plotted.

The use of the 3D Model as a tool for research is explored in detail below. However, this model is best seen in relation to the possibilities the computer can offer using the colours of the video display unit (VDU).

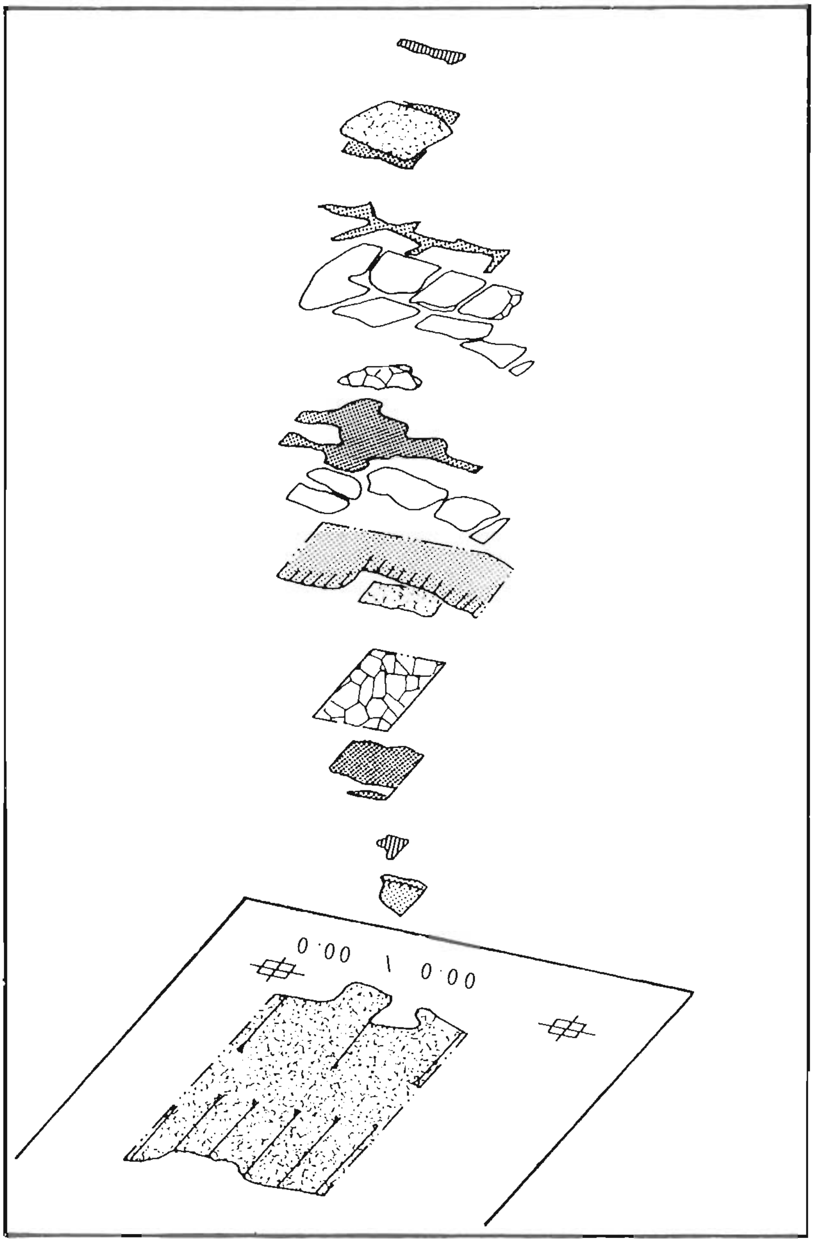

Fig. 14.2 The 3D model of the test data from Fig. 14.1, showing the sequence of deposition (internal details excluded).

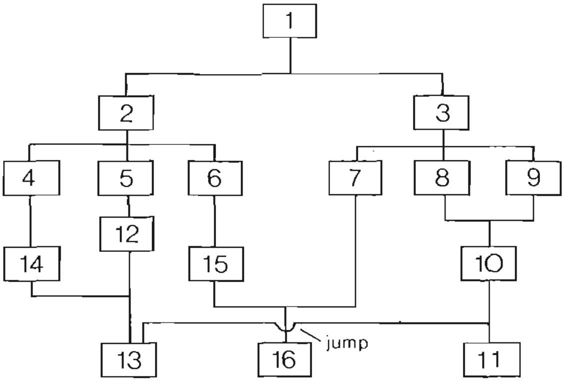

Fig. 14.3 An example of the traditional matrix diagram (test data), showing a 'jump'. These occur as the relationships between contexts are three-dimensional rather than two-dimensional.

The use of colours in Hindsight

When creating or reviewing composite plans and 3D models in Hindsight, the archaeologist can make use of the colours of the VDU to display different characteristics of the context. After each context is called up, Hindsight shades in the context with a colour. To create traditional composite plans, colour is not important, but when using Hindsight as a tool for interpretation, colour can play an essential part in understanding the function of a context.

Colours have been used in manual recording procedures in the past: the Department of Urban Archaeology in London, for example, used coloured pencils to show up differences in soil make-up and stone types (DUA 1980: 16). Colours can of course be used to display any attribute of a context, and since the computer can reduce dramatically the time taken to reconstruct composite plans, the same composite plan can be generated again and again using different criteria each time to shade the contexts.

Hindsight shades in the context in a number of ways. If a specialist has submitted a report on paper rather than on disk, then Hindsight is able to pause after each context is entered to allow the analyst to provide a colour for shading. If the information is present in a database, then Hindsight is able to transform output from the database into 'shadefiles', and use these to colour the contexts of a plan automatically. Thus one can use a number of shadefiles on a single phase plan to produce a number of displays based on different aspects of the site.

Using colours to identify each context with a particular aspect of archaeology has many advantages. At a basic level, when the archaeologist is constructing phases or groupings, one method of testing the validity of a context grouping would be to regenerate an established 'group' or 'phase' into a composite plan using different criteria: a valid group should show a certain uniformity or development of colour with each attribute investigated; perhaps in some cases a change in colour might be expected from the bottom of the sequence to the top (for example, where a particular pottery type went out of use); problems in the interpretation of the group may be reflected in unexpected changes of colour in the model.

Inappropriate changes in colour within a sequence may be due not only to mistakes of interpretation. These colour changes could be due to a number of reasons – perhaps they could be indicators of residuality. Looking at these contexts in both plan and 3D views could also help to identify the possible origins of residuality: colour coding could help to indicate whether or not a particular deposit was exposed much later in the sequence, or was redeposited from elsewhere.

The potentials for interpretation with Hindsight

As everyone knows, the Harris Matrix is a means to an end rather than an end in itself: the archaeologist uses the matrix to arrive at an interpretation of events. In arriving at this interpretation, the archaeologist groups together a sequence of contexts that is considered related to a group or phase from a number of strands of the matrix (for more information on this see Pearson and Williams, Chapter 6 of this volume). A context may or may not be stratigraphically related to other contexts in that group. However, any context associated with one group must not be associated with another; nor should any context of a group be stratigraphically later than any group stratigraphically later than its own, nor be stratigraphically earlier than any group stratigraphically earlier than its own. Once the groups have been established, they interact with each other in much the same way as contexts in a Harris Matrix. Because of this, there is never one fixed interpretation: depending upon the complexity of the sequence, the researcher may be presented with a number of possible explanations for the structural sequence of a site's formation. Some may have more validity than others, but there may be situations in which different interpretations have equal validity. Many interpretations may exist, and indeed, different specialists may interpret the same matrix in very different ways.

Archaeologists are supposed to make their interpretations having assimilated all aspects of information from the specialists – this is one of the prime considerations for the use of single-context planning stated by Harris (1979: 69). In practice, however, this rarely takes place. The archaeologist can wait well over six months for specialist reports to be returned, and the temptation to interpret the site whilst it is still fresh in the mind, coupled with the very real financial pressures to publish quickly, often means that the interpretation of the matrix is usually based on the structural development of the site under investigation, with the specialist reports playing a very secondary role, used as supporting evidence or evidence of use. Obviously this is a generalization, but my point is that each specialist may have a completely different – but equally valid – view of the matrix, related to his or her particular discipline (Fig. 14.4). For example, where an archaeologist may split up a site into ten groups of phases, a fish specialist may only see two – perhaps where the fishing practices changed from on-shore to deep sea. The pottery specialist may, on the other hand, have a very different interpretation of the site: for example, a particular type of pottery may have been introduced during the use of a number of buildings, whilst other types could show a long period of use through a number of structural changes. Equally, burial types or dietary evidence may not necessarily relate to the building sequence of an archaeological excavation, and it would surely benefit the specialist and the archaeologist alike to allow the specialist to interpret the site using the specialist's data.

Present working methods rarely allow the specialist to see the matrix, when the data

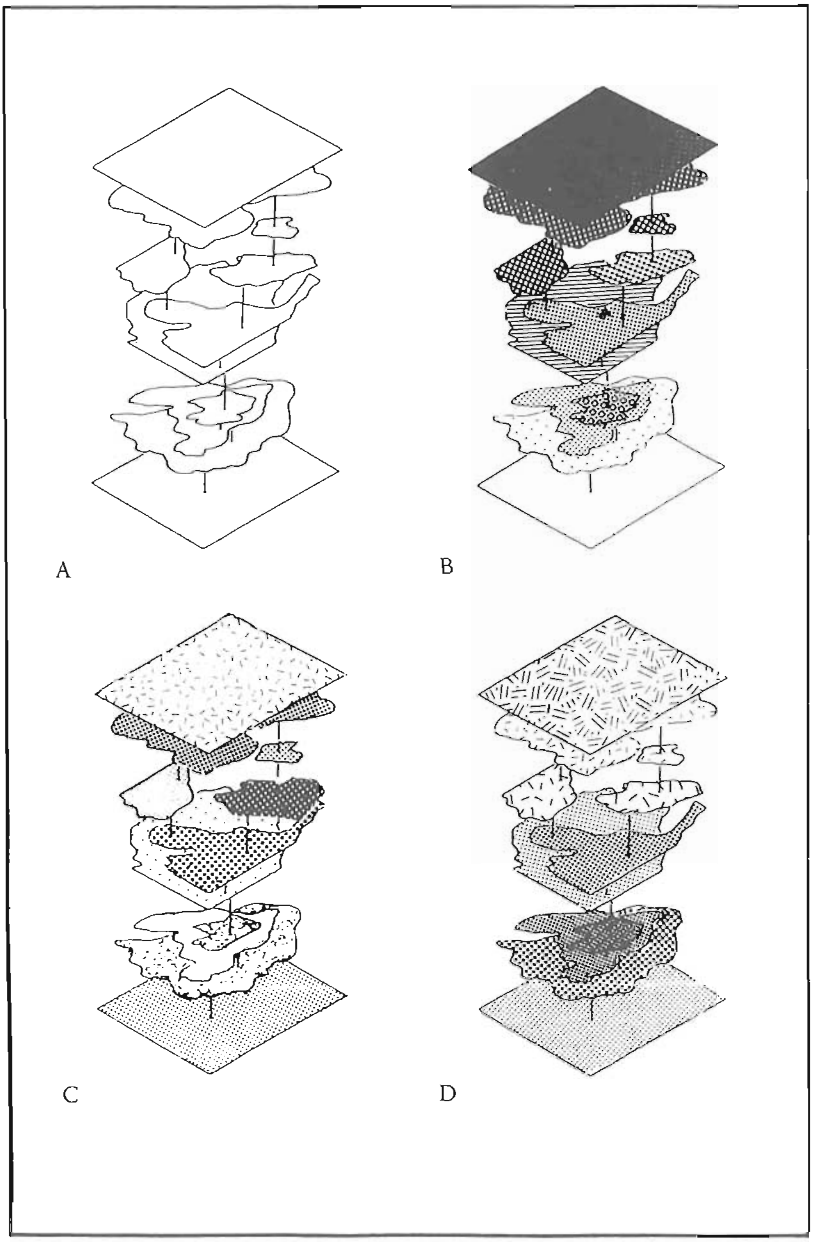

Fig. 14.4 Four 3D model views of a 'phase' or 'period' (test data – internal details excluded, but stratigraphic association lines included). (A) No shading. (B) Shading could refer to changes in pottery. (C) Shading could refer to changes in soil type. (D) Shading could reflect changes in dating evidence.

arrive for analysis. On the rare occasions that a matrix is made available, then it is fairly meaningless without plans, which are even more difficult to get hold of. Should any plans at all be submitted to the specialist, then these are usually presented in the form of composite plans already constructed by the archaeologist. Surely any 'final' composite plans should be constructed *after* the specialist reports have been written. Again, the reasons why this happens is down to money: to reconstruct composite plans relating not to structural development but to the specialism is currently too expensive and time-consuming to accomplish. Yet in order to get the most from our specialists we must bring them closer to the archaeology.

The truth, then, is that whilst in theory it is possible for archaeologists to interpret the site with all aspects of archaeological information available to them using the new methodology, in practice this rarely, if ever, takes place. For the specialists to give the full benefit of their knowledge for any one site, they should be given the opportunity of reconstructing the site from the site plans themselves, allowing their interpretation of events and their conclusions as to grouping and phasing according to their own particular specialism. Currently this is impossible using the manual system of plan reconstruction due to time and financial constraints: as a consequence, the majority of publications derive from an interpretation of the matrix made by the archaeologist *before* all the information is to hand, with the basis of publication given over to a single structural sequence with alternative interpretations and specialist reports sidelined.

The introduction of computer methods may allow a different perspective. Because Hindsight can generate a number of composite plans and 3D models quickly, it is possible for specialists to arrive at their own specific groups and phases using their own data to colour code each of the contexts. Thus each specialist can review the matrix model with contexts coloured to answer the specific questions related to his or her own subject.

The archaeologist too is able to reconstruct a number of alternatives as well: just because the current theories are watertight in relationship to the Harris Matrix does not mean that an alternative approach to the site's interpretation may not gain more credibility in the light of future excavations.

I feel that each excavation could potentially have a number of different interpreted phases (as in Fig. 14.4), each portraying the development of a particular aspect of the cultural or ecological formation of the site: the burials, the pottery, environmental information, structural information, etc. Each model could be used to test the hypotheses put forward by the archaeologist, and would be a valuable contribution to the understanding of cultural continuity and change in the development of a site.

Hindsight as a demonstration tool

The Hindsight model can be used in a number of ways, but in terms of demonstrating the sequence of deposition of a site, it has many advantages over the traditional matrix diagram and the composite plan (see Fig. 14.5). When trying to explain the development of a site to a layman, it is much easier to show graphic representations that embody both the shape of the site and the stratigraphy in the same drawing. When explaining interpretations to other archaeologists, the sequence can be seen at a glance, and the 3D model Hindsight produces, like the Harris Matrix, is a form of 'proof'. The use of

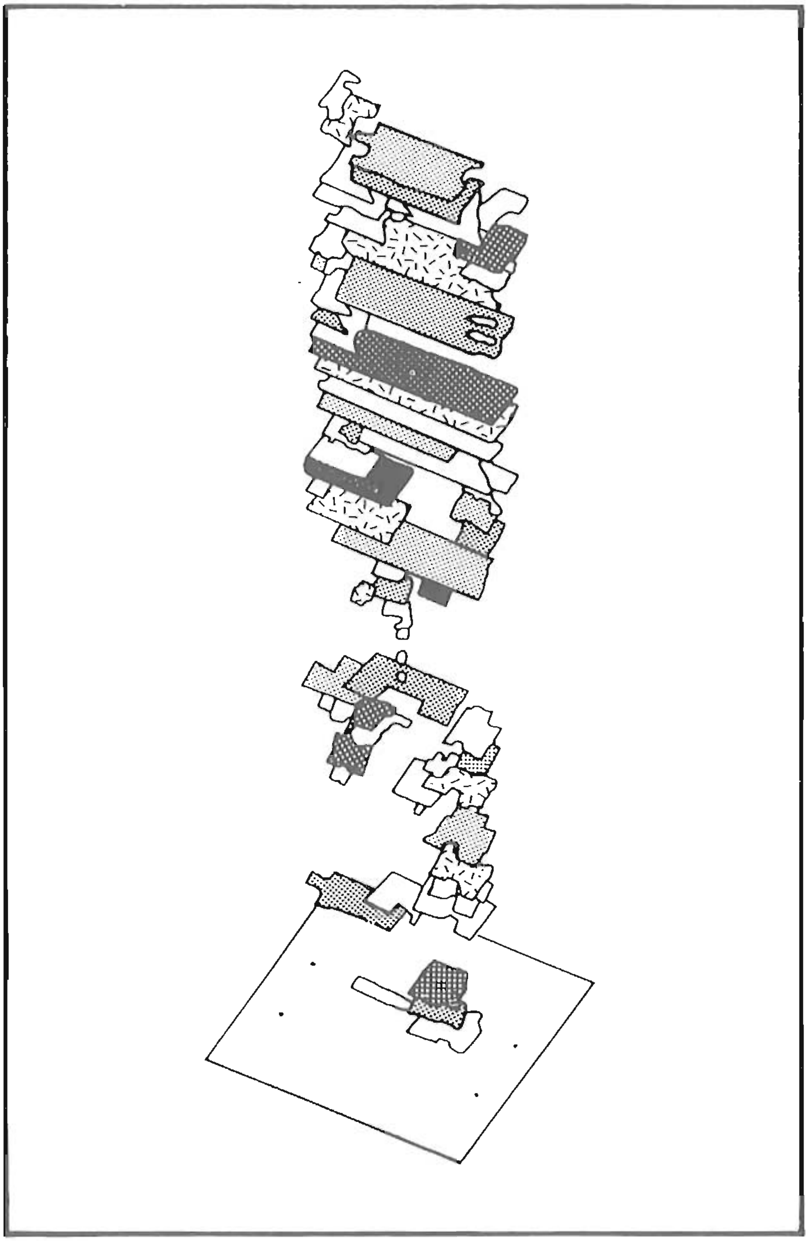

Fig. 14.5 The bottom half of the matrix from part of the Stakis site in York (internal details excluded, arbitrary shading).

colours can further add to the meaning of the site's development, showing how different aspects of the site changed or continued through time.

Conclusions

Hindsight is one of the emerging graphic databases designed specifically to cope with the problems encountered in post-excavation with the reconstruction of composite plans from single context plans. In addition, Hindsight's 3D model of the matrix offers the opportunity for more alternative interpretations to be explored and examined, and may allow the specialists to come closer to the archaeology when compiling their reports. Although the advent of the Harris Matrix has done much to improve and standardize the ways in which sites are recorded, present working methods still have some way to go before all the theories of Harris can be put into practice. I hope that Hindsight, or systems like it, will play a part in future changes.

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15 Beyond crossmends: stratigraphic analysis and the content of historic artefact assemblages on urban sites

RICHARD H. GERRARD

Introduction

This paper reports the results of a statistical and stratigraphic examination of diversity in ceramic assemblages during the 1987–88 excavations at Fort York, Toronto, Canada. These inquiries attempt to arrive at a better understanding of the origins of artefact diversity observed in an archaeologically recovered ceramic collection.

Before one can begin to address any questions concerning the socio-cultural sources of material culture diversity in the archaeological record, one must first come to an understanding of how an excavated assemblage was formed. Typically on urban sites there are many cultural and non-cultural post-depositional alterations to the artefact assemblages. Building and landscaping activities, for example, have the potential to introduce artefacts into, or to remove artefacts from, a deposit, thereby changing the diversity of an assemblage after the artefacts have been deposited in the ground. The most extreme case is the removal of complete deposits (with their associated artefacts) from the stratigraphic sequence of the site.

The quantification of any post-depositional changes to the composition of an assemblage would enhance the ability of archaeologists to interpret their data, by isolating the portion of an assemblage actually in use at the time of the formation of a layer or feature. This will allow us to create more accurate reconstructions of the behaviour patterns associated with the material culture in active use during any given period of a site's occupation. Three analytical techniques are discussed: matrix-based stratigraphic analysis, mean ceramic dates and diversity indices.

Fort York

Fort York is the location of the founding of the Town of York (now the City of Toronto) by John Graves Simcoe, in 1793 (Benn 1984, 1989). The ceramic sample used in this study was recovered from a 6 m^2 test excavation in the present soutwest bastion (Operation 1FY5).

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Historical and cartographic data indicated a high degree of activity occurring in the excavation area throughout the occupation of the site. A series of barracks buildings was constructed in this general area beginning in 1793. These were replaced with gun platforms in the period 1860–1900. The ramparts of the Fort were rebuilt in the 1932–34 restoration and the area landscaped. The intensity and nature of activities in the study area has influenced assemblage formation and subsequent modification of assemblage content. For a full discussion of the excavation methodology and results see Brown (1988).

Assemblage formation and alteration

In this study, three analytical techniques were used to investigate how archaeological assemblage diversity is affected by post-depositional disturbance processes. Two techniques, matrix-based stratigraphic analysis and mean ceramic dating, are well known to historic archaeologists. The third, however, the application of diversity statistics to the analysis of artefacts, is not yet widely applied. The approach towards the application of this statistic for the purposes of this paper is drawn largely from taphonomy and palaeoecology.

These disciplines address concerns about their basic data similar to those faced by an archaeologist discussing the formation of a bone assemblage or fossil recovery site. For example, in order to understand how a specific bone deposit was formed, the taphonomist must attempt to trace and describe all of the changes to the assemblage which have taken place from the time an animal died until its remains were recovered. The process of deposition, transportation and redeposition of the bones are studied to interpret more accurately the composition of a living animal population (Gifford 1981).

It is this understanding of the post-depositional disturbances which allows the taphonomist (or archaeologist) to account for any possible alterations to the original assemblage. In this way, one may begin to identify assemblages or parts of assemblages which have been modified by later depositional events.

There are many post-depositional processes which may alter an artefact on archaeological sites. Schiffer (1976, 1983) separated them into two broad classes of processes, cultural and non-cultural. The major cultural disturbance processes operating in an urban context involve the creation and modification of the urban environment itself: building construction, renovation, demolition, and landscaping operations (Rothschild and Rockman 1982; White and Kardulias 1985). Non-cultural disturbance processes are also in operation in urban areas. Processes such as freeze–thaw, burrowing animals and tree root displacement are all familiar to city dwellers (Wood and Johnson 1978). Both of these classes of events may have a subtle impact on the archaeological record by adding artefacts to a deposit from an earlier or later assemblage, thus altering (or 'contaminating') an artefact assemblage with the addition of non-indigenous artefacts.

Archaeological excavation itself is a special case of a cultural process which may inadvertently alter an assemblage's composition. These changes may be brought about in several ways. First, by imposing arbitrary recovery units (for example, 2 × 2 m squares or arbitrary levels) an archaeologist may divide the artefact content of a single depositional event in several separately recovered artefact samples. This may separate an assemblage of artefacts related to one another by a specific pattern of behaviour into several separately recovered collections. Second, since most excavations only sample the material culture within a limited area of a site, they may not recover all of the artefacts associated with every depositional event encountered. It is possible, therefore, that the relative proportions of each artefact class may become skewed by the recovery process. Third, poor or incomplete data recovery in the field caused by inexperienced excavators, or complex or indistinct stratigraphic boundaries, may result in the incorporation of several assemblages or portions of assemblages from discrete depositional events into a single ('lumped') assemblage.

Given these observations, we may place an artefact recovered with a specific assemblage into one of two groups based on the artefact's relationships to the depositional event itself. Artefacts may be indigenous or non-indigenous to a given event. Indigenous artefacts are those that find their way into the ground at the time of the formation of the deposit (Harris 1989: 121). Often these artefacts relate directly to the activities ongoing at the time of the deposit's formation. As such, this is the group which has the potential for making the best contribution to the interpretation of the activities on-going at the site at the time of the deposit's formation.

Non-indigenous artefacts can be subdivided into two subgroups, residual and infiltrated artefacts. These subgroups are based on their specific stratigraphic relationship to the depositional event in which they were recovered. Residual artefacts are those that originally were laid down in older deposits but have since been incorporated into stratigraphically younger assemblages. This type of assemblage alteration appears to be more common in an urban setting (Harris 1989: 122) because of the nature of urban development. The type of deposit usually associated with residual artefacts is relatively easy to recognize in the field. Trenches, pits, secondary fills and the deposits resulting from grading and landscaping operations all commonly have a residual component (Barker 1977; Harris 1979; Triggs 1986b, and Chapter 16 of this volume).

Infiltrated remains are artefacts that relate to activities which formed later deposits and have subsequently been incorporated into earler strata (Harris 1989: 122). The mechanisms which may cause these younger artefacts to become incorporated into earlier assemblages are less well documented. As a result, unless an artefact type is particularly well documented (such as a coin or military button) it may be more difficult to detect infiltrated materials in all but the earliest deposits on an urban site. However, unconsolidated deposits (Triggs 1986b) and deposits associated with the replacement of or repair to a building's underpinnings (Davies 1987) have been demonstrated as good candidates for the infiltration of younger artefacts into earlier assemblages.

Data management and analysis

Since non-indigenous artefacts are found in earlier or later deposits due to various disturbance processes, they affect the interpretation of both the assemblage in which they were recovered and the assemblage from which they were derived. The movement of artefacts may change within an assemblage the number and type of artefact classes or the frequencies of artefacts within classes already present. It is this fact that allows us to begin a quantitative analysis of frequency data from each artefact assemblage, in order to understand better the depositional history of a given stratigraphic sequence. The hypotheses based on the three techniques used were tested against a background consisting of the available historical data for the site and on observations provided by mathematical models simulating the formation of various disturbed assemblages.

Archaeological Database Management System

An Archaeological Database Management System was developed by the Toronto Historical Board (THB) to manage and assist in the analysis and interpretation of the text excavations at Fort York. It has become the standard format for preliminary artefact inventories from the Fort's archaeological excavations. Between 1988 and 1990 over 110 000 artefacts from 1386 deposits have been input. The system is currently being enhanced to integrate descriptions of strata and stratigraphic relationships with the artefact data base (Gerrard 1991) and integrated into the Toronto Historical Board's collections management information system (Gerrard and Knowles 1989).

There were several reasons for computerizing the data storage and retrieval system. The first is obvious. It allowed the researchers using the collection to make better use of limited analysis time by allowing faster data retrieval and more accurate mathematical manipulations. Second, it forced the standardization of terminology used to describe the artefact through the use of codes for artefact description within the database. This allowed the staff in the field lab to enter information accurately and quickly.

The artefact database was designed to be a preliminary inventory of the excavated material, not a definitive catalogue. The decision was made that it would be better to collect a small amount of descriptive information about each object rather than complete descriptions of a portion of the assemblage. In addition, the database application had to be made globally applicable to the range of materials which would be recovered. These decisions had a significant limiting effect on the data structure. Nine fields were eventually selected: Provenience; Event; Material; Class; Type; Variety; Alteration; Form/Portion; Frequency (Gerrard 1988a, b). The descriptive portion of the inventory (Class, Type, Variety, Alteration and Form/Portion) are arranged hierarchically, based on two criteria: (1) the level of difficulty of accurately deriving information from observation of shards, Class being the easiest to derive and Form/Portion the most difficult; (2) the level of information being recorded, Class being the most general and Form/Portion the most specific.

A Provenience field holds the code describing the location of the recovery unit. The recording system used at Fort York follows the system used by Parks Canada for recording archaeological provenience (Swanneck 1977). The Event field holds the depositional event numbers assigned during stratigraphic analysis. This forms the primary key of the cataloguing system and is the basic unit in stratigraphic and material cultural analyses. The Material field describes the material of which an artefact is composed. The Class field is a subset of the materials field. Each material is divided into several classes based on physical attributes of the piece. The Type and Variety fields are linked descriptive fields and form a subset of the class field. The Alterations field is designed to describe certain types of usewear and post-depositional modification to an artefact. The Form/Portion field is used to describe the type of fragment that an artefact represents. Frequency is a raw shard count. Given the time restrictions, the large numbers of artefacts recovered, and the highly fragmented nature of many of the assemblages, no attempt was made during the inventory to establish minimum vessel counts.

In the case of ceramics, Class has been used to describe the ware type of a shard. The Type–Variety fields have been used for further technological breakdown of classes based on decoration. For example, a shard might be entered as Class – Refined White Earthenware, Type – Underglaze Transfer Print, Variety – Blue. For this paper, the analysis of the ceramic assemblages was conducted using shard counts at the Class level of description, although the techniques could have been applied at a finer level of description. (See Doroszenko and Gerrard (1991) for application using vessel counts and more detailed descriptions.)

Harris Matrix analysis

Harris Matrix analysis (Harris 1975, 1979, 1989) was used to establish the relative stratigraphic position of the depositional events uncovered in the southwest bastion at Fort York. Done prior to the artefact analysis, it allowed the placement of the ceramic assemblages into a relative chronological sequence independent of the artefacts themselves. Control over this relative placement of the assemblages is necessary if one is to look for the movement of artefacts between or among depositional units.

The Harris diagram graphically illustrates the possible pathways along which an artefact might be displaced between depositional events (Fig. 15.1). To show these pathways more effectively a few stratigraphically redundant physical relationships were purposely left in the diagram. In addition, lines joining the 'lumped' lots to the events from which they were assembled were used to include these artificially created assemblages on the matrix.

Combining the Harris Matrix analysis with the archival research to identify known historical periods for generating test hypotheses (through the correlation of features or structural remains to known or potential historical buildings or events) was particularly useful to place known historical dates on the stratigraphic event matrix prior to the examination of the artefacts. This allows the artefacts to be used for independent testing of the preliminary structure/feature identifications. It will also allow us to examine the amount of disturbance in the artefact assemblages by relating the mean ceramic date and diversity index for each depositional event to those with which it shares a physical relationship as illustrated in the matrix diagram.

Mean ceramic date analysis

The mean ceramic dating (MCD) technique has been widely applied since it was first developed by South (1974, 1977). It has been broadly criticized as an absolute or historical dating method because of its inability to estimate precisely occupation dates for deposits. Several alternatives for making the formula provide better date estimates have been proposed. Using modal dates based on the period of maximum popularity of a ceramic class instead of mean dates based on manufacture have been proposed by several researchers (Jouppien 1980; Jacobs 1983; Grange 1977). Kalb *et al.* (1982) suggests that altering the formula itself in order to factor in the variance in the range of dates of manufacture for each class would give a more accurate date. The author chose to reject all of these alternatives and apply the technique as originally described by South (1977: 201–74) using dates of manufacture for the ceramic classes defined in the database. Figure 15.2 shows the Classes used for this study.

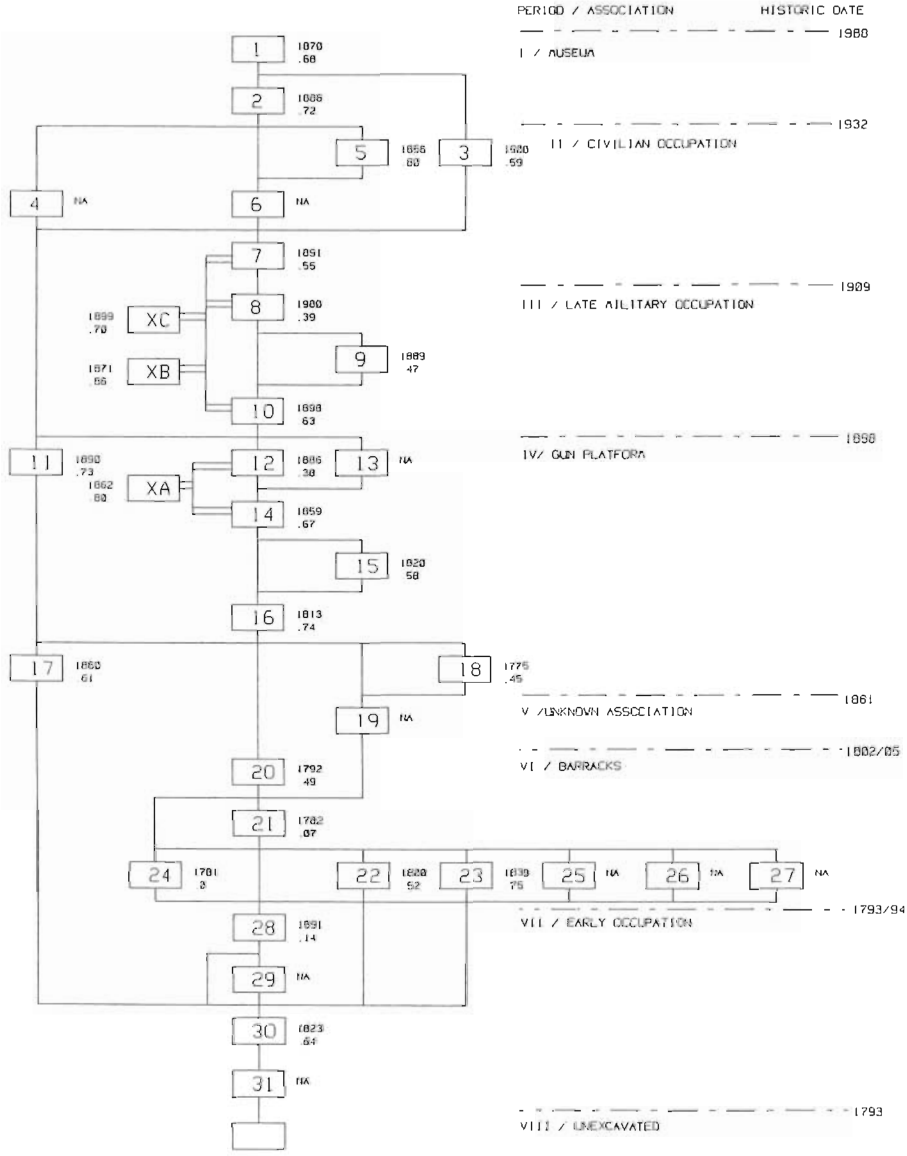
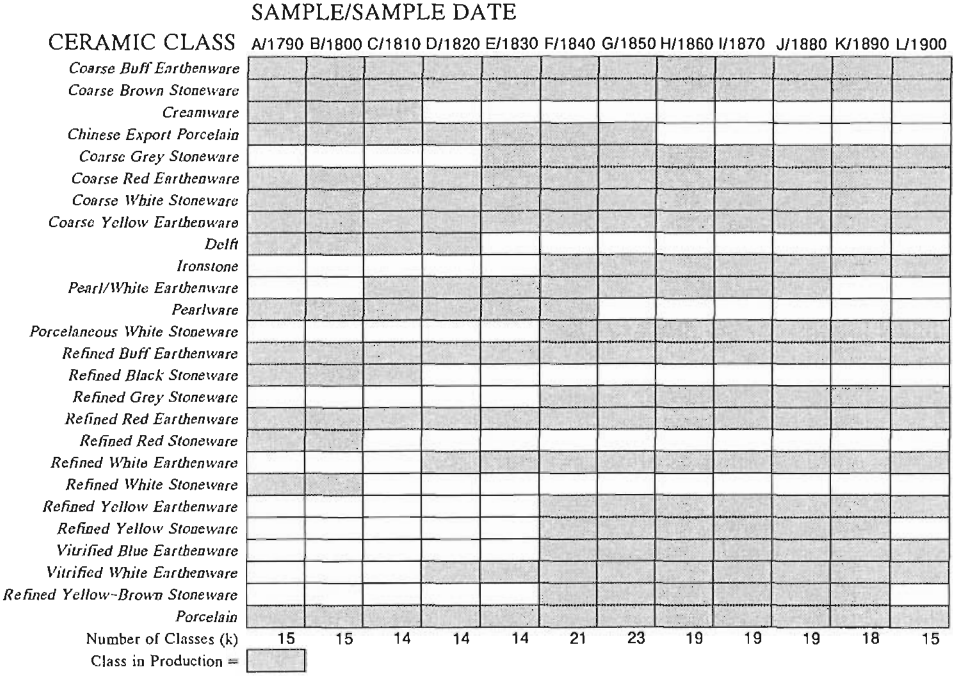


Fig. 15.1 Harris Matrix for Operation 1FY5, Fort York, Toronto, Canada, showing mean ceramic dates and diversity index for each event, plus historical association and dates for each period of use.



SAMPLE/SAMPLE DATE

CERAMIC CLASS	A/1790	B/1800	C/1810	D/1820	E/1830	F/1840	G/1850	H/1860	I/1870	J/1880	K/1890	L/1900
Coarse Buff Earthenware	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Coarse Brown Stoneware	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Creamware	▨	▨	▨									
Chinese Export Porcelain	▨	▨	▨	▨	▨	▨	▨					
Coarse Grey Stoneware					▨	▨	▨	▨	▨	▨	▨	▨
Coarse Red Earthenware	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Coarse White Stoneware	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Coarse Yellow Earthenware	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Delft	▨	▨	▨	▨								
Ironstone						▨	▨	▨	▨	▨	▨	▨
Pearl/White Earthenware			▨	▨	▨	▨	▨	▨	▨	▨		
Pearlware	▨	▨	▨	▨	▨	▨						
Porcelaneous White Stoneware						▨	▨	▨	▨	▨	▨	▨
Refined Buff Earthenware	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Refined Black Stoneware	▨	▨	▨									
Refined Grey Stoneware						▨	▨	▨	▨	▨	▨	▨
Refined Red Earthenware	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Refined Red Stoneware	▨	▨										
Refined White Earthenware				▨	▨	▨	▨	▨	▨	▨	▨	▨
Refined White Stoneware	▨	▨										
Refined Yellow Earthenware						▨	▨	▨	▨	▨	▨	▨
Refined Yellow Stoneware						▨	▨	▨	▨	▨	▨	
Vitrified Blue Earthenware						▨	▨	▨	▨	▨	▨	▨
Vitrified White Earthenware				▨	▨	▨	▨	▨	▨	▨	▨	▨
Refined Yellow-Brown Stoneware						▨	▨	▨	▨	▨	▨	
Porcelain	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Number of Classes (k)	15	15	14	14	14	21	23	19	19	19	18	15

Class in Production = ▨

Fig. 15.2 Ceramic assemblages created at 10-year intervals for use in the mathematical modelling of assemblage disturbance.

The mean ceramic date for each event was calculated using the formula (South 1977: 217)

$$Y_i = \frac{\sum X_i f_i}{n}$$

where

Y_i = mean ceramic date;
x_i = the median date of manufacture for each ceramic class;
f_i = the frequency for each ceramic class;
n = sample size.

In this paper, the application of this technique was *not* used to derive precise historical dates for the depositional events. As discussed earlier, these historical dates had been established during the stratigraphic–historical analysis, independently of the artefact content of the deposits. Instead, the mean ceramic date allowed each ceramic assemblage to be placed into a relative chronological seriation. Turnbaugh and Turnbaugh (1977) note that seemingly erroneous dates could be indicators of discrepancies between the historical documents and the material history of a site. While the presence of some curated objects could affect the dating of a sample, I am proposing that these apparently 'erroneous dates' are indicators of post-depositional disturbances occurring in a ceramic assemblage.

This can be graphically illustrated by placing the mean ceramic dates directly onto the stratigraphic matrix after the phasing has been done based on the available historical data

(Fig. 15.1). Discrepancies from the smooth flow of dates from top to bottom can be easily observed. If the matrix has been correctly constructed based solely on stratigraphic data and principle, this variance in the mean ceramic dates from the expected historic dates can then be explained in terms of cultural or natural post-depositional processes acting upon the assemblage.

Diversity index analysis

There are three subsets of diversity statistics. Richness measures examine the sample's richness in terms of number of classes present, in a given sample. The evenness measures the frequency distribution among those classes. Heterogeneity measures are sensitive to both an assemblage's richness and its evenness. This paper will deal with heterogeneity as a measure of the diversity of an archaeological assemblage. For a full discussion of richness, evenness and heterogeneity statistics see the papers in Jones and Leonard (1989).

In the late 1940s, Claude Shannon began his mathematical work for the development of Information Theory (Shannon 1963). The Shannon Index (H) provided a quantitative measure of the variability of artefact frequencies within a series of defined classes (Odum 1971; Pielou 1969). The Shannon index measures the entropy (or heterogeneity) in a system. Entropy, as defined by Shannon, is the measure of probability of a given message. For the purpose of this paper the 'message' is being equated with a recovered ceramic assemblage. A totally random sample would have a maximally high entropy. This is defined as log (k), where k is the number of classes present in the system.

The formula for calculating the Shannon index for a population is as follows:

$$H = -1 \sum p_i \log p_i$$

where p_i is the probability of the occurrence of class i.

For computing the Shannon index of a sample, the relative proportion of the sample class (n_i/N) is substituted for p_i (Rindos 1989: 16).

Richness, heterogeneity and sample size

Kintigh (1984, 1989) has demonstrated that sample size has an important effect on the interpretation of the diversity measured in an assemblage. This effect has been summarized by McCartney and Glass (1990: 523–4, Figs 1 and 2) in two basic statements. First, as sample size is increased the values for richness (expressed as the number of classes of artefacts recovered) and heterogeneity tend to increase in a decreasing curve until they level off. Second, the range of error at a lower sample size is much greater than at a larger sample size. However, McCartney and Glass noted differences in the behaviour of richness and heterogeneity measures in simulations of samples of various sizes drawn from the same parent population. For their data set, to attain expected values within 5% of the maximum value for heterogeneity, samples had to be greater than 40, while the comparable sample size for richness needed to be in excess of 3000. Although, the range of error for small sample sizes was larger for heterogeneity than for richness (McCartney and Glass 1990: 523).

It was felt that for the purpose of this analysis the lower susceptibility to the sample size effect of heterogeneity measures (Jones *et al.* 1989: 75), and their increased sensitivity to rare classes (Rice 1989: 112), may make them superior to richness or evenness measures. This is especially important since we wished to detect the slight compositional changes caused by residual or infiltrated material has been added to a ceramic assemblage.

Two different approaches for estimating expected values for assemblage diversity have been put forward: the sampling approach (Kintigh 1984) and the regression approach (Jones *et al.* 1983; Grayson 1984). Both approaches originally dealt with diversity as expressed in sample richness, and both have been widely applied (see papers in Jones and Leonard 1989). Rhode in his discussion of the relative utility of these approaches points out the sampling approach requires a highly detailed knowledge of the underlying structure of the population from which the assemblages are drawn, while the regression approach requires that the assemblages meet the statistical assumptions of regression analysis (Rhode 1988: 711–3). Since the underlying structure was not known for the Fort York ceramic population, a regression approach was used to estimate expected values for the heterogeneity.

Some of the earliest applications of the Shannon index were used to examine problems in ecology (Odum 1971; Pielou 1969). The measure has had a long acceptance for interpreting palaeontological assemblage content (Beerbower and Jordan 1969; Hill 1973; Lasker 1976), and it is finding a larger acceptance for among archaeological faunal analysis (Grayson 1978, 1984; Cruz-Uribe 1988). There has also been a growing interest among archaeologists to apply heterogeneity measures to various problems in the analysis of archaeological assemblages (Rothschild and Rockman 1982; Cannon 1983; Jones and Leonard 1989).

In order to evaluate differences between the measured diversity of samples, 'some independent test of the significance of the differences in diversity between two pottery samples must be made. Tests of significance, such as the chi-square (Toll 1981) and *t*-test (Stark and Hepworth 1982), have been used to determine whether the samples represent the same population (statistically speaking) of variability, or represent distinct populations' (Rice 1989: 112). The test for a statistically significant difference between the diversity indices was done with a variant of the two-tailed version of the *t*-distribution. (For a full discussion of a similar variant of the *t*-distribution estimate used in this paper see Wetherill (1967: 160–1).)

The computational formula for the *t*-test is as follows (Triggs 1986a: 203):

$$t(obs.) = \frac{H_1 - H_2}{S_{H_1+H_2}}$$

where

$$S_{H_1+H_2} = \sqrt{S^2_{H_1} + S^2_{H_2}}$$

where

H_1 = diversity index of the first ceramic assemblage;
H_2 = diversity index of the second ceramic assemblage;
$S_{H_1+H_2}$ = standard error of the difference in H's;
$S^2_{H_1}$ = estimate of the variance of H_1;
$S^2_{H_2}$ = estimate of the variance of H_2.

The sample variance of the diversity indices is estimated with the formula

$$S^2 = \frac{(\sum f \log^2 f) - \left(\frac{(\sum f \log f)^2}{n}\right)}{n^2}$$

and the degrees of freedom calculated as

$$\mathrm{df} = \frac{(S^2_{H_1} + S^2_{H_2})^2}{\left(\frac{(S^2_{H_1})^2}{n}\right) + \left(\frac{(S^2_{H_2})^2}{n}\right)}$$

In summary, it is being proposed that the degree of heterogeneity in a ceramic assemblage may be used to infer post-depositional relationships between ceramic assemblages recovered from *stratigraphically related* depositional events. Further, it is proposed that the direction of movement of material across stratigraphic boundaries is indicated by an increase in diversity when comparing two assemblage diversities. In other words, it can indicate whether the majority of a disturbance is the result of artefacts being infiltrated into a deposit or is residual within an assemblage. The diversity index is responding to an increase in the number of ceramic classes in the assemblage as a function of sample size and/or a change in the relative frequency within each ceramic class.

Test hypotheses

It is important to emphasize that the purpose of this study was not to identify which specific shards are infiltrated or residual. Rather, combining these three independent methods has assisted in elucidating general trends in the patterning of infiltrated and residual remains within the ceramic assemblages under study. This comparison offers an expedient and independent measure for the amount of disturbance to an assemblage, and indicates the possible source and direction of the disturbance.

Two test hypotheses are outlined below. These generalize the effect on the mean ceramic date and diversity index when residual or infiltrated materials are added to an assemblage.

Hypothesis 1: residual artefacts

1a: In the case where artefacts are being incorporated into a later assemblage A from an earlier assemblage B the mean ceramic date (MCD) of the later assemblage should be skewed in the direction of the earlier assemblage. The amount of skew will depend upon the frequency of artefacts and the specific artefact classes being incorporated into the later assemblage from the earlier one.

This assumes a fairly constant diversity of classes in production through time, even though the specific classes constituting any production period will change.

1b: In the case where artefacts are being incorporated into a later assemblage A from an earlier assemblage B, the diversity index (*H*) of the assemblage from which the artefacts are derived will be lower than the assemblage into which they are being incorporated. This is because the later assemblage is acquiring non-indigenous classes of artefacts from the earlier assemblage, thus increasing its number of artefact classes and relative frequencies in each class, therefore increasing its diversity.

Hypothesis 2: infiltrated artefacts

2a: In the case of artefacts being infiltrated into an earlier assemblage C from a later assemblage D the mean ceramic date of the earlier assemblage will be skewed in the direction of the later assemblage. The amount of skew will depend upon the frequency of the artefacts and the specific artefact classes being infiltrated into the earlier assemblage from the later one.

2b: In the case where artefacts are being incorporated into an earlier assemblage C from a later assemblage D the diversity index from which the artefacts are derived will be lower than the assemblage into which they are being incorporated. This is because the earlier assemblage is acquiring new artefact classes from the later assemblage, thus increasing overall its number of artefact classes and its diversity.

Modelling disturbed assemblages

In order to test the theoretical implications of these hypotheses, a series of assemblage formation events was mathematically modelled. Using the ceramic manufacture date ranges, hypothetical ceramic assemblages were created for each 10-year period of Fort York's occupation (*c.* 1790–1900). In general, the sample for each decade was derived from incidence data based on the classes in production for the sampling period. Figure 15.2 illustrates the production periods for these ceramic classes. The creation of specific test samples was done by drawing an even number of shards from the available classes at a given time interval up to a fixed sample size. This allowed us to control for the sample size effect, as all samples would be large and of a similar size.

While these assumptions could represent major deviations from the behaviour existing for many real sites, it was felt that since an urban site was being modelled many of the test implications of these assumptions appear to be true for many of the excavated deposits. Construction, demolition, landscaping and long-term occupation with several different land-use patterns tend to blur the behavioural and functional patterning over much of an urban landscape. At Fort York these post-depositional events tend to create fill layers more resembling glacial till than primary occupation strata. For these reasons it was felt that highly simplified models such as these and the results derived from them would have practical application for the preliminary interpretation of urban archaeological assemblages. Although much more work is needed to refine how the initial assemblages are created, the method can be used to develop better urban site assemblage formation models.

Two scenarios based on the hypotheses were modelled. In the first, artefacts were infiltrated into a lower layer. Three trials were made where 10% of the final assemblage

	Test Sample	Constituent Assemblages	
	A/F	A/1790	F/1840
Sample Size	2310	2100	2100
Number of Classes	26	15	21
Mean Ceramic Date	1847	1844	1878
Diversity Index	1.25	1.18	1.32

	Test Sample	Constituent Assemblages	
	F/I	F/1840	I/1870
Sample Size	2310	2100	2100
Number of Classes	21	21	19
Mean Ceramic Date	1879	1878	1888
Diversity Index	1.32	1.32	1.28

	Test Sample	Constituent Assemblages	
	I/L	I/1870	L/1900
Sample Size	2310	2100	2100
Number of Classes	19	19	15
Mean Ceramic Date	1888	1888	1895
Diversity Index	1.28	1.28	1.18

Fig. 15.3 Constituent ceramic assemblages and the resulting disturbed assemblage used in the infiltration experiment.

	Test Sample	Constituent Assemblages		
	A/F/I	A/1790	F/1840	I/1870
Sample Size	1050	210	420	420
Number of Classes	26	15	21	19
Mean Ceramic Date	1875	1844	1878	1888
Diversity Index	1.38	1.18	1.32	1.28

Fig. 15.4 Constituent ceramic assemblages and the resulting disturbed assemblage used in the residual experiment.

consisted of later ceramics infiltrated into the earlier assemblage. The results are given in Fig. 15.3. In only one case (material from 1840 infiltrated into an assemblage from 1790) did the MCD and diversity index change in the manner described in the initial hypothesis. In the other two cases (1870 into 1840 and 1890 into 1870) there was no significant change in either statistic. One explanation for these results is the appreciable increase in the number of classes (15 to 26) in the mixed 1790/1840 assemblage. However, the 1840/70 and 1870/90 assemblages remained at 21 and 19 classes respectively after mixing. Thus the MCD and diversity index for the 1790/1840 assemblage would be greatly affected, while the 1840/70 and 1870/90 assemblages would remain relatively unchanged.

In the second, a residual assemblage was formed by the excavation of an intrusive feature. The intrusive feature assemblage was created from a mixture of ceramics from layers dating to 1790 (20%), 1840 (40%) and 1870 (40%), with artefacts drawn equally from each class for contributing assemblage. The results are given in Fig. 15.4. The MCD and diversity index for the residual assemblage behaved as predicted by the test hypotheses.

Again it was the increase in the number of classes and change in frequency for each class present in the residual assemblage that was responsible for the observed change in mean ceramic date and diversity index. The work of developing this model has only begun. Continuing research will attempt to expand on the foundation discussed above.

Ceramic assemblage from the southwest bastion (Operation 1FY5), Fort York

The results of the analysis of Operation 1FY5 (Southwest Bastion) are presented here to illustrate the application and interpretation of this technique. The data on the ceramic assemblage recovered from the southwest bastion are presented in Fig. 15.5.

Residual assemblages, or 'lumped lots'

Lumped lots (assemblages composed of portions of two or more discrete depositional events) can be viewed as a subset of residual assemblages with the exception that they are formed intentionally or unintentionally during the archaeological recovery process. The three positively identified lumped lots from Fort York were examined and the results are summarized in Fig. 15.6.

Hypothesis 1a predicted that the mean ceramic date of a lumped lot will fall within the range defined by the mean ceramic dates for the depositional events from which it was assembled. The data indicate that this hypothesis was valid in two of three cases. However, placement within the range defined by the related events varies widely. This could be the result of sampling error during the recovery of the individual lots, or due to the random over- or under-representation of specific events within the lumped lot.

Hypothesis 1b predicts that the diversity of a lumped lot will be greater than the diversity of lots/depositional events to which it is related. In all three cases the hypothesis appears to be valid. One possible reason for the lower index for event xc could be sampling error due to its small sample size ($n = 17$). When each lumped lot was tested against its source event for statistically significant difference, in six of the eight cases a significant difference was demonstrated at the 0.05 level.

The results of the t-test indicate a general acceptance of hypothesis 1b. The reason the lumped lot exhibits a higher diversity index than does the events of which it is composed is that each event contributes a different set of classes; the sum of which spans a wider range of wares than is available to each event alone. It should be noted that the lumped lots showed the highest diversity indices for all samples tested (see Fig. 15.7).

Other residual artefacts

The validity of these hypotheses in a wider context was tested through an examination of the relationships among the events at the boundary between Period IV (Gun Platform) and Period VI (Barracks) and the boundary between Period I (Museum) and Period II (Civilian Occupation). Reconstructed vessels and crossmends were used as an independent test of the interpretations drawn from the statistical results.

	EVENT																																	
CERAMIC CLASS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	XA	XB	XC
Coarse Buff Earthenware		1														1																2		
Coarse Brown Stoneware		2														3																		1
Creamware					6							12		48	10	104	36	2		325	344	6	6	1						107		29	7	
Chinese Export Porcelain																1				4			1											
Coarse Grey Stoneware					1						2			2		3	3			2	2	1	1							2		6		
Coarse Red Earthenware	1	2	5		10		1	5	1	6	3	3		9	1	7	14			11								9		6		11	5	1
Coarse White Stoneware												1																						
Coarse Yellow Earthenware		2	2						1							3	2													2		13		
Delft																				3														
Ironstone	1	2	1		4		2	5		4		6																				7	10	7
Pearl/White Earthenware																														9				
Pearlware	4	5			11		1	2	7		1	100		130	20	56	66	1		44	2	5	4							25		75	6	
Porcelaneous White Stoneware			3																															
Refined Buff Earthenware											3					2	1																	
Refined Black Stoneware												3																						
Refined Grey Stoneware								3	2			6		16	2	1					1									1		4		1
Refined Red Earthenware																3	1			1														
Refined Red Stoneware	1																			1												4		
Refined White Earthenware	7	16	21		26		3	87	43	9	11	518		179	5	27	128			1			3					1		30		112	11	2
Refined White Stoneware					19							4		8	2	53	4	1		121	5	2	1										5	
Refined Yellow Earthenware	1		1		4				17	1	3	9		81		3	2						4							26		16	2	4
Refined Yellow Stoneware																																4		
Vitrified Blue Earthenware								1																										
Vitrified White Earthenware								3				10		2						1														
Refined Yellow-Brown Stoneware																	1																	
Porcelain	1	4	3		2		8	4		5	8	5				1	1			10												8	11	1
TOTAL	16	34	36	0	83	0	15	110	71	25	31	677	0	475	40	268	259	4	0	524	354	14	20	1	0	0	0	10	0	208	0	291	57	17
NUMBER OF CLASSES	7	8	7	0	9	0	5	8	6	5	7	12	0	9	6	15	12	3	0	12	5	4	7	1	0	0	0	2	0	9	0	13	8	7

Fig. 15.5 Ceramic sample recovered from 1FY5 ordered by event.

Lumped Lot	*H*	*MCD*	*Source Event*	*H*	*MCD*
XA	0.8	1862	12	0.38	1886
XA	0.8	1862	14	0.67	1859
XB	0.86	1871	7	0.55	1891
XB	0.86	1871	8	0.39	1900
XB	0.86	1871	10	0.63	1898
XC	0.7	1899	7	0.55	1891
XC	0.7	1899	8	0.39	1900
XC	0.7	1899	10	0.63	1898

Fig. 15.6 Comparison of known 'lumped lots' to their source events.

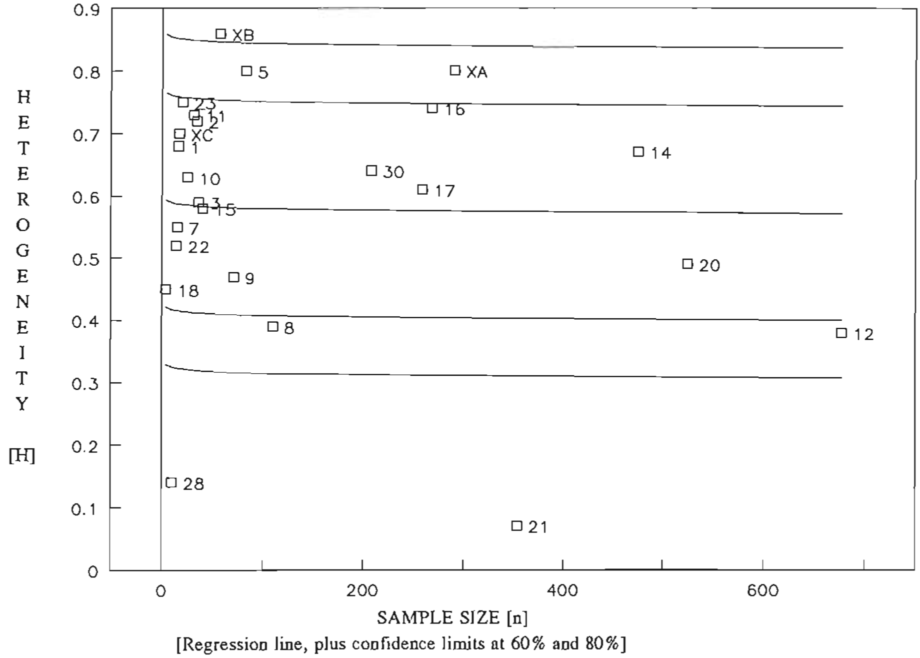


Fig. 15.7 Graph of the ceramic sample from 1FY5 plotted as sample size *v.* diversity index for each event. The graph clearly shows that the known disturbed assemblages have the highest diversity index for their sample size.

The reasons for choosing these as test cases were threefold. First, the depositional relationships were stratigraphically complex. This allowed the Harris Matrix to be used to its full effect. Secondly, they were periods of major structural changes to the test area which would be expected to cause identifiable alterations to the assemblages. Thirdly, these were the boundaries of important cultural periods in the history of Fort York. Therefore, the study can make an interpretive contribution to our understanding of the history of Fort York.

Three specific cases have been chosen to illustrate these effects, events 5, 16, and 23.The mean ceramic dates and diversity indices are shown on the Harris Matrix in Fig. 15.1.

Case 1: Depositional event 5. The event 5 assemblage ($n = 83$) is from a large trench excavated during the civilian occupation of the fort. The mean ceramic date of event 5 (MCD = 1856) was significantly lower than that predicted by the historic date ranges for the period (i.e. 1909–34) and those of its stratigraphically associated events (event 2 [1886], event 3 [1900], and event 7 [1891]). Similarly, the diversity index of event 5 ($H = 0.80$) was significantly higher than those of its associated events (event 2 [0.72], event 3 [0.59], and event 7 [0.55]). While all the ceramic samples from its associated depositional event were small (less than 50) the trends in diversity and mean ceramic dating predicted in hypotheses 2a and 2b can still be observed.

When event 5 was tested for significance in its diversity as compared to events 2, 3 and 7, several interesting effects were observed. The diversity index of event 5 was found to be significantly different than that of event 7 at the 0.01 level and of event 3 at the 0.05 level. However, it was not found to differ significantly from event 2. This has been intepreted as demonstrating a relationship between events 5 and 2, and showing a dissimilarity with events 3 and 7. Event 5's similarity to event 2 is interesting if one considers that event 2 was deposited after the active domestic occupation ended. In other words, event 5 shows a marked similarity in diversity to an assemblage that is predominantly composed of residual materials. This was interpreted as supporting the hypothesis that event 5 contains a greater percentage of residual artefacts than events 3 and 7.

While there were no direct crossmends between event 5 and the other events, these conclusions were supported by the general composition of the ceramic assemblage. The assemblage contains a large percentage (approximately 43%) of late eighteenth–early nineteenth century ceramic classes (e.g. refined white stoneware – salt glazed, creamware, pearlware) which were incorporated from much earlier deposits. Further, these early classes were not found in the assemblage recovered from event 2, again indicating their residual nature, as opposed to being infiltrated from event 2.

Case 2: Depositional event 16. Event 16 was a black soil with yellow mottling and is possibly related to the construction of the gun platform. It overlies a destruction deposit related to the 1793–1802 Barracks. It has a mean ceramic date of 1813, a diversity index of 0.74, and a sample size of 268. There were three stratigraphically associated events with large ceramic samples (event 14, $n = 475$; event 17, $n = 259$; event 20, $n = 524$). The relative positioning of event 16 provided a good test of the use of the diversity index to determine the type and direction of disturbance to a ceramic sample.

The mean ceramic dates for these events showed the expected progression through time. From their position matrix it appeared that either event 17 (MCD = 1860) or event 16 (MCD = 1813) was a disturbed sample, when compared to events 14, 20 and 21 (MCD = 1859, 1792 and 1782, respectively). In order to resolve this question the diversity indices of these samples were examined. It was hypothesized that event 16 ($H = 0.74$), with a diversity index higher than any of the adjoining events, had been disturbed probably with residual materials as predicted by hypothesis 2b. The matrix gave the possible origin of this material as either event 17 or event 20.

Application of the t-test gave the following results. There was a significant difference in the diversity indices of events 16/17, 16/20 and 16/21 at the 0.01 level. Events 16/14 were significantly different at the 0.05 level but not at the 0.01 level. Furthermore, there was no significant difference in the diversity indices between events 14/17 at the 0.01

level. Based on these observations and the relative stratigraphic position of these events, the diversity index was interpreted as indicating the presence of disturbed materials in the event 16 assemblage, predominantly of a residual nature and originating in event 20.

An examination of the crossmends confirmed these observations. It was shown that residual late eighteenth–early nineteenth century ceramic classes (creamware, refined white stoneware – salt glazed, Chinese export porcelain) derived from the event 20 assemblage form a high percentage of the assemblage (up to 58%). The ceramic assemblage from event 16 also contained a small amount of residual material (polychrome sponged pearlware) which was probably derived from event 17 and infiltrated material ('flow-blue' decorated white earthware) probably derived from event 14.

Case 3: Depositional event 23. Event 23 is the remains of a poorly preserved brick feature stratigraphically associated with a stone foundation (event 24) and a small pit feature (event 22) dug during the Barracks period. All three of these events have small sample sizes (n = 21, 1 and 14, respectively) in comparison to the overlying and underlying depositional events. The mean ceramic dates of events 22 (1800) and 24 (1781) are in keeping with hypothetical historical dates for the formation of the deposit (*c.* 1793–1802), and generally agree with the progression of mean ceramic dates for this portion of the matrix. However, the date for event 23 (1831) seems to be an incongruity. Similarly, examination of the diversity index for event 23 (0.75) shows it to be higher than the indices calculated for the other events (event 20 = 0.49; event 21 = 0.07; event 22 = 0.52; event 24 = 0.0) in this period. This has been interpreted as indicating the presence of infiltrated remains in the ceramic assemblage of event 23.

The results of the t-test show a significant difference in the diversity indices between events 23/20, 23/21, 23/24, 24/20, 23/22 and 22/21 at the 0.01 level. There was no statistically signficant difference in the index between events 23/30 and 22/30 at the 0.05 level. These results were interpreted as indicating post-depositional disturbance of the assemblages in events 22 and 23 with material derived from event 30.

An examination of the ceramic samples from events 22 and 23 show that overall they are quite similar, but event 23 has had several classes added to its assemblage. The added classes appear to originate from two sources, events 20 and 30. The material from event 30 is refined white earthenware and refined yellow earthenware, with the Chinese export porcelain and refined red earthenware possibly being derived from event 20. While there are no direct crossmends, close examination of the shards for similarities in paste and glaze composition and decoration (from a technological and stylistic perspective) seems to indicate a relationship between the classes.

Infiltrated artefacts

Hypotheses 2a and 2b attempt to predict the effects of infiltrated artefacts upon the mean ceramic date and diversity indices of a ceramic assemblage. These were tested by examining the relationship among the events of Periods IV, VI and VII (Gun Platform, Barracks and Early Occupation, respectively).

Case 4: Depositional event 30. Event 30 is stratigraphically the earliest ceramic assemblage recovered during the 1987 test excavations in the southwest bastion. The mean ceramic date was calculated as 1823 ($n = 208$), which is significantly later than the 1782 and 1792 mean dates associated with the stratigraphically younger events 21 and 20. One must ask whether the foundation (event 24), stratigraphically placed between these events, is associated with the earlier or later date. The solution was found in an examination of the stratigraphic relationships displayed in the matrix combined with the diversity index data (see Fig. 15.1).

The diversity indices of events 21 and 20 are low (0.07 and 0.49, respectively), while the diversity index of event 30 is much higher (0.64). This was interpreted as indicating that the event 30 assemblage had been disturbed with infiltrated remains, based on the prediction of hypothesis 2b. The superpositional relationship between event 17 and event 30 illustrated in the matrix indicated the probable source for the infiltrated remains.

The results of the *t*-tests show a statistically significant difference in the index between events 30/21 and 30/20, with no significant difference between the index of events 30/17, 30/22 and 30/23. These results indicate a relationship between events 30/17. This has been interpreted as the presence of infiltrated remains in the assemblage of event 30 probably originating from the event 17.

Examining the ceramic assemblages from events 17 and 30 found no crossmends. Nor did the profiles indicate substantial mixing between these units. However, a closer examination of the undecorated refined white earthenware indicated a relationship between these two events. Most (66%) of the refined white earthenware shards (hard, uncrazed grey-white glaze) from event 30 were clearly late nineteenth century in date, and closely resembled shards of refined white earthenware from event 17. Furthermore, the shards from event 30 were small and appeared more fragmented than those from event 17. This supported a disturbance in the direction suggested by the Shannon index. This leads us to conclude that the foundation (event 24) relates to the 1793 construction of the Fort and not to the rebuilding of the barracks after the War of 1812, establishing this as one of the oldest building features recovered at Fort York, relating to Simcoe's original fortifications.

Conclusions

Simulating the content of ceramic assemblages which have undergone known types of disturbance provided results which generally agree with findings from the excavated assemblages at Fort York. While the assumptions necessary for these specific mathematical models are limiting, the basic technique itself could be elaborated into more complex models which would more closely simulate actual site formation processes.

Cases 1 and 3 from Fort York demonstrate the practical advantages of using a stratigraphic matrix analysis combined with the diversity indices and mean ceramic dates as an indicator of assemblage disturbance. The most important of these is the ability to identify quantitatively the presence and possible sources of disturbed material in an assemblage based solely on shard frequencies. This method for detecting disturbance has proved effective even in cases where there are no physical crossmends and minimal evidence for disturbance from field notes, profiles or photographs. In addition, when these results are tested independently using the mean ceramic date, there is general agreement between these two measures as to the source and direction of disturbance.

Cases 2 and 4 illustrate the major difficulties in the application of the method. The diversity index and mean ceramic date will only indicate the major source of a disturbance (i.e., where the majority of the disturbed materials are originating), while minor assemblage constituents contributed from other sources will go undetected. Further, the method will not identify what portion of a ceramic class is infiltrated or residual. However, the author believes that with additional work these problems could be overcome. One possible solution could be an examination of the diversity within each of the ceramic classes based on type–variety criteria. A comparison of the diversity from class to class could indicate which classes are non-indigenous or disturbed.

Ultimately the ability to identify residual and infiltrated portions of an assemblage will assist in developing a better understanding of the activities on-going at the time of the formation of a deposit. From a methodological point of view, calculation of the mean ceramic date on an expunged assemblage produces a better estimate of the actual date of the formation of the depositional event. Similarly, the calculated diversity index will reflect the actual assemblage diversity at the time of the formation of the deposit (or an isolatable portion thereof) once the disturbed portion has been removed.

There is some controversy surrounding the application of different diversity measures to the analysis of archaeological data, thus the interpretation of the results from this quantitative technique are still in need of refinement. However, these preliminary results seem to indicate that the method can be useful in detecting the presence of non-indigenous remains in an artefact sample. When combined with a Harris Matrix (as a taphonomic pathway) and mean ceramic date analysis (as a measure of central tendency) as an independent control, the relationship between the diversity indices is a useful indicator of the direction that the non-indigenous material is moving.

Crossmends will always be necessary as the final confirmation of any quantitative examination of disturbance by providing absolute connections between depositional events. However, locating all the crossmends in a ceramic sample, especially if the sample is large and highly fragmented, is extremely time consuming and often impossible. While the methodology outlined in this report is still imperfect, it allows the archaeologist to identify the probable sources for the disturbed portions of his or her assemblages using simple quantitative analytical procedures based on shard frequency data in only a fraction of the time needed to do crossmends. As an archaeological consultant's time becomes more expensive or a research archaeologist's analysis time more limited, a fast and accurate quantitative predictor of assemblage disturbance will become increasingly more valuable.

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16 The seriation of multilinear stratigraphic sequences

JOHN R. TRIGGS

Introduction

From its inception as a discipline, archaeology has relied upon the principles of stratigraphy as the basis for chronological interpretations (Daniel 1975; Grayson 1983). Presently, stratigraphy is such an integral part of archaeology that it is almost inconceivable for an archaeologist to construct a cultural synthesis which does not incorporate even the most elementary stratigraphic analysis. It is somewhat surprising therefore that a unified approach to archaeological stratigraphy is still forthcoming. Recent statements on the subject suggest that archaeologists are still in need of such an approach (e.g. Harris 1979; Gasche and Tunca 1983; Stein 1987). These authors are in basic agreement concerning the principles upon which stratigraphy is based (Harris 1979: 3–7); however, where a difference of opinion exists, this may be attributable to the way each perceives *archaeological* stratigraphy. This is a distinction which Harris (1979), in particular, emphasizes. The departure stems primarily from the fact that the principles upon which geological stratigraphy is based are sometimes not appropriate in the interpretation of stratigraphy on archaeological sites. This is because humans create and greatly modify the archaeological record.

The human factor means that archaeological sites can include natural layers in addition to man-made layers and 'upstanding' strata or walls (Harris 1979: 37). In geological stratigraphy there is no analogue for upstanding strata and different techniques are required to construct a sequence of deposition on a site where walls are present. Another unique aspect of archaeological stratigraphy is the way in which the contained finds are treated. Although geological stratigraphy includes the notion of 'non-indigenous' remains (remains introduced into a deposit after deposition (ISSC 1976: 47)), these types of remains may be more prevalent in archaeological strata (Harris 1979: 93–4; Barker 1977: 177). Once again, this is largely a function of the human element active in the formation and post-depositional modification of the archaeological deposit, but a host of natural processes also contribute to the problem. The consequence of this is that archaeologists must improve current methods of analysis and interpretation which take into account the unique nature of archaeological stratigraphy.

Nowhere are these problems more apparent than on a site characterized by successive episodes of occupation where standing architecture is in evidence. Under such conditions the notion of superposition is of limited utility for establishing an order of deposition and

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the stratigrapher is frequently confronted with ambiguous stratigraphic relationships. For instance, one can imagine a situation where a single deposit is truncated by a wall. There is clearly no stratigraphic means of establishing an order of deposition, although in this case correlations can easily be made based on the characteristics of the deposits themselves. On the other hand, if the deposits on the interior are of a different nature than those on the exterior, in the absence of any physical stratigraphic links, the relative order of deposition of all deposits must be established using an independent source of data – for example, artefacts. This problem is evident at an elementary level of stratigraphic reconstruction where a single structure is involved, but becomes progressively more difficult as the number of structures increases and correlations are attempted between them.

Phasing a stratigraphic sequence: the Jericho example

Although it is an essential element of post-excavation analysis, phasing remains one of the least understood practices of archaeological stratigraphy (see for example Harris 1989: 105–19). Statements on the subject describe phasing as the amalgamation of stratigraphic units assumed to be contemporary on the basis of stratigraphic and structural evidence or artefact studies (Alexander 1970: 72; Kenyon 1971; 274; Webster 1974: 122). In one of the few systematic descriptions of phasing, Kenyon (1971) points to the importance of initially establishing a sequence of phases based on the relation of strata to structures. To do this, it is necessary to use all available stratigraphic records, i.e., plans, stratigraphic sections and field notes recorded during excavation. The pottery or other finds are then analysed according to the phased sequence. In this way a pottery chronology is built up according to stratigraphic evidence which can then be used for making inter- and intra-site correlations.

In a more recent explication, Harris (1979: 89) has suggested that phasing must include two steps: the construction of the stratigraphic sequence and the division of the sequence into phases and periods. Although the stratigraphic sequence is considered immutable, because it is constructed on the basis of the superpositional relationships of layers and interfaces, the process of dividing the sequence into phases and periods may take many forms depending on the criteria chosen for this pupose. According to Harris (1979: 91), this stage of the archaeological process can begin while in the field using the available stratigraphic evidence, but the division of the stratigraphic sequence cannot be considered final until all materials have been analysed.

The essential difference between both methods is the manner in which the artefacts are treated. For Kenyon, the artefacts are analysed within a chronological framework established on stratigraphic grounds alone. In this sense, the artefacts do not alter the sequence already established. For Harris, the artefacts must be used in conjunction with the stratigraphic evidence to establish a cultural sequence. This sequence may be initially constructed on the basis of stratigraphic relationships and inferences, but it may be adjusted in light of artefact studies if the adjustments do not break stratigraphic relationships determined according to *superpositional relationships*.

This divergence of viewpoint may stem from a fundamental difference in the way both Harris and Kenyon approach stratigraphic analysis. Phasing based on stratigraphic grounds alone carries with it the implication that only one sequence is possible. Yet, when one reads Kenyon's own description of the phases for Jericho (Kenyon 1981), it is quite apparent that constructing a sequence of phases is rarely an unequivocal exercise. Kenyon (1981) frequently alludes to the uncertainty involved in assigning deposits to phases when she describes particular deposits as possibly or probably belonging to a given phase. This is not intended to undermine Kenyon's final phasing scheme, but merely to point out that phasing can often be little better than guesswork when only stratigraphic information is used. It is particularly difficult when the physical separation of deposits is such that there are no stratigraphic links. A final ordering under these circumstances can represent only one of a number of plausible alternatives. In actual fact, if the stratigraphic sequence is represented on a Harris Matrix and a single deposit is held constant and other deposits are moved in relation to it, the permutations of the sequence of phases can be on an exponential scale for even a small site (see for example Dalland 1984).

In order to assess both methods, two Harris Matrices have been prepared for Trench III, Site N at Jericho (Kenyon 1981). This was done by redrawing Kenyon's section for this excavation area (Fig. 16.1) in such a way that only the interfaces are indicated (Fig. 16.2). The superpositional relationship between layers, features and interfaces were then used to place contexts in position on the Harris stratigraphic matrix. Figure 16.3 shows a segment of this matrix for the Jericho stratigraphy, derived from the west section of Trench III, Site N. (In view of the fact that this matrix is used for illustrative purposes, it represents only some of the deposits and phases in this area. Additional deposits and phases are in evidence from the east section and in plan and a complete matrix of the Trench III, Site N stratigraphy would incorporate these as well.) Next, deposits were grouped according to Kenyon's phases, defined in the absence of actual stratigraphic links by similarity of building material and architectural style as well as evidence from plans. Finally, a phase matrix was constructed by determining superpositional relationships as indicated on the stratigraphic matrix. A section of this phase matrix is shown in Fig. 16.4.

It is on the phase matrix that the stratigraphic relationships between Kenyon's phases are clarified. Potential problems with the phasing scheme are suggested where horizontal lines are crossed over by vertical lines. Orton (1980: 71) has stated that a correctly phased stratigraphic sequence should not exhibit such crossovers. The fact that these are present when the site is phased according to Kenyon's interpretation of the site stratigraphy suggests that an alternative phasing is necessary. It should be noted that crossovers are not present on the stratigraphic matrix (see Fig. 16.3), since this matrix is an objective representation of the stratification based on superposition alone.

Stratigraphic ambiguities are apparent on both types of matrices. As walls destroy original stratigraphic relationships and create new basins of deposition, the matrix takes on a multilinear form. Stratigraphic ambiguities are manifested on the matrix by deposits on separate linear sequences. This makes determining the relative position of deposits on separate linear sequences impossible. As stated above, the number of permutations of orders between units increases as the matrix increases in size (Dalland 1984). The problem is alleviated somewhat on a phase matrix where the stratigraphic units are grouped together. In the present example, the stratigraphic matrix, consisting of 525 units, has been reduced to a total of 90 units on the phase matrix. Although the number of ambiguous relationships is considerably reduced at this stage, it is still only possible to achieve a sequential ordering between units where deposits are located on the same linear sequence since these relationships are based on simple superposition.

A practical solution to reducing the number of possible permutations may include the

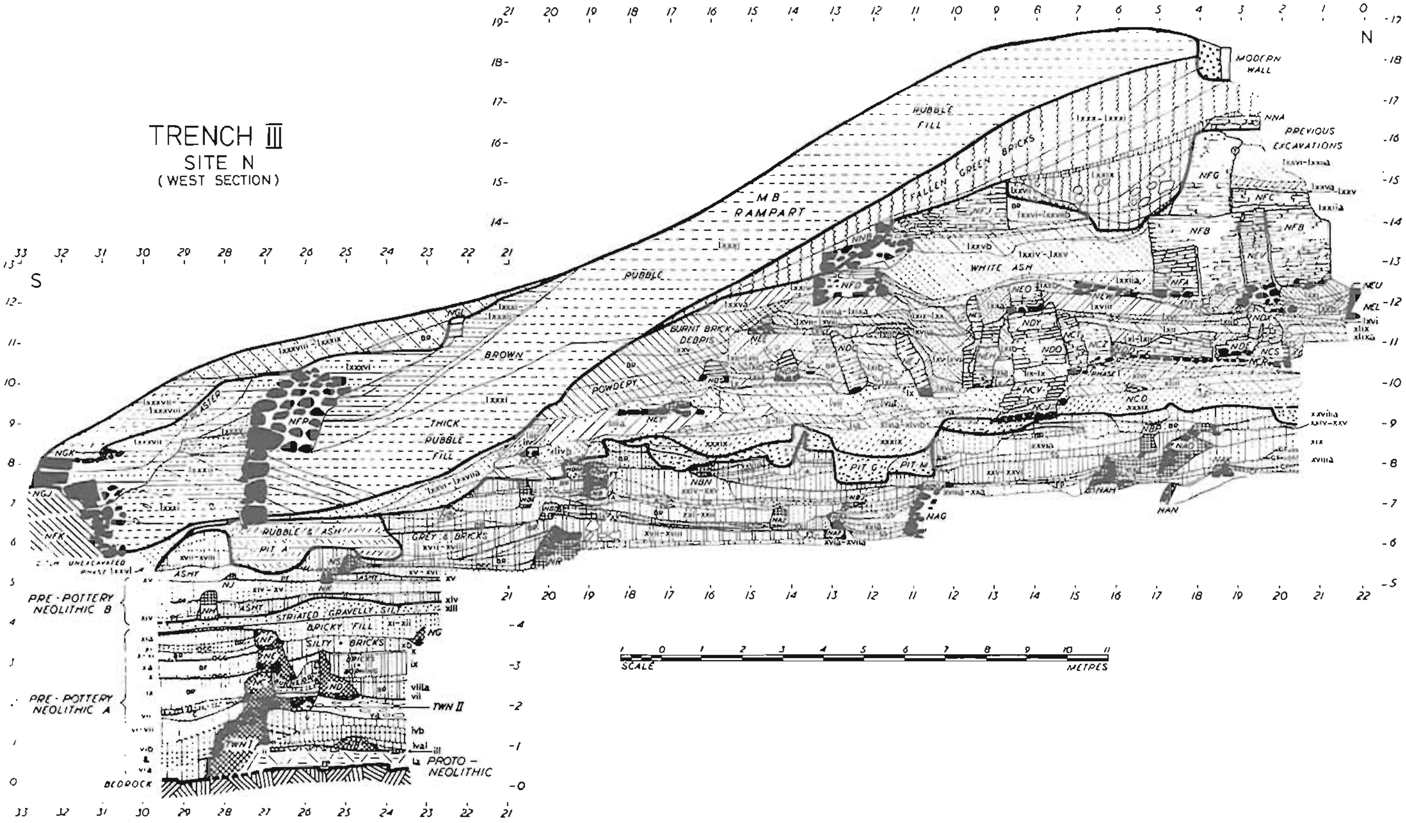

Fig. 16.1 West Section, Trench III, Site N, at Jericho (Kenyon 1981: plate 273). (Courtesy of the University of London, Institute of Archaeology.)

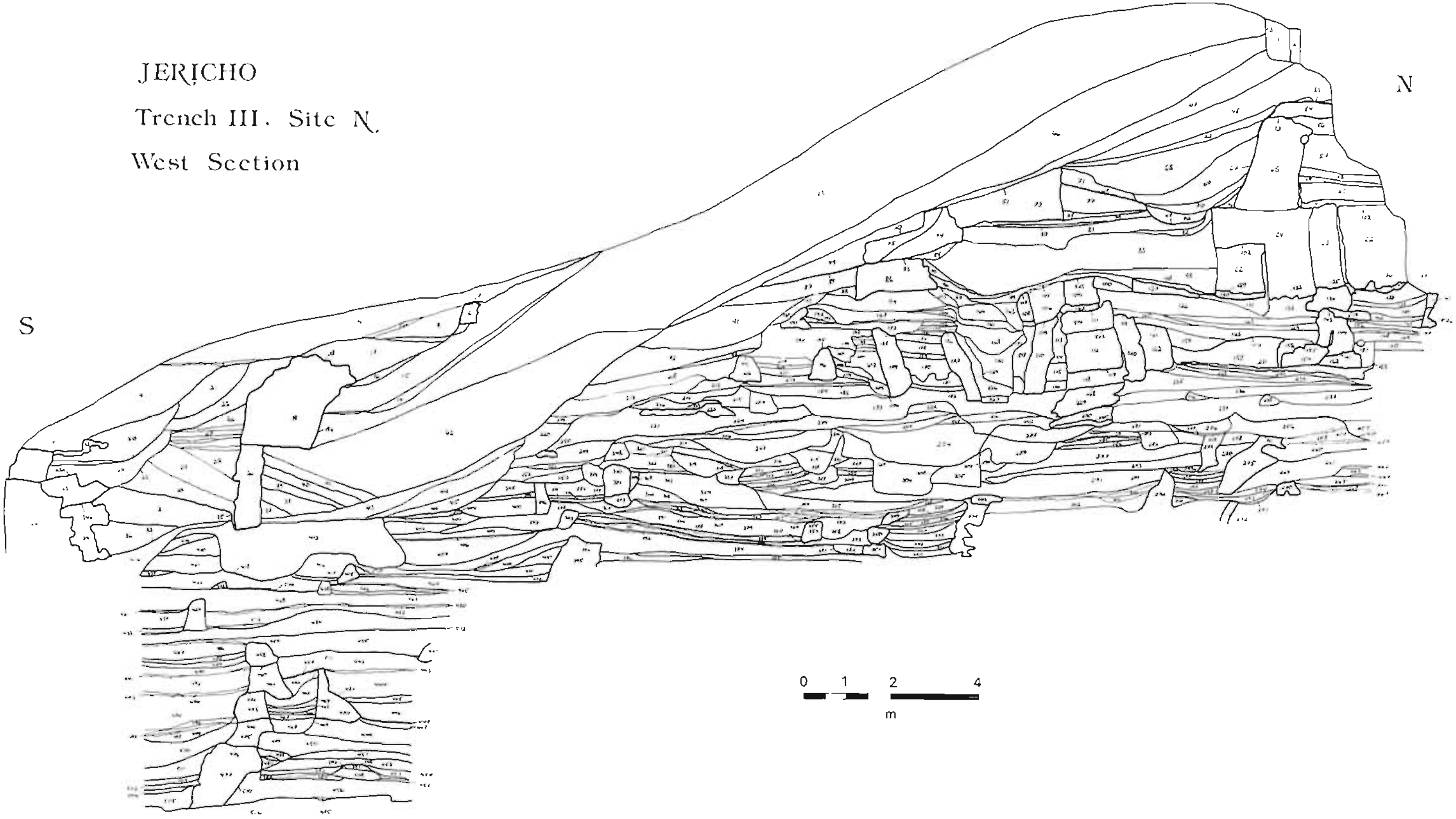

Fig. 16.2 Based on the original drawing of the West Section, Trench III, Site N, at Jericho (Kenyon 1981: plate 273), this representation shows only the interfacial boundaries of the stratigraphic units.

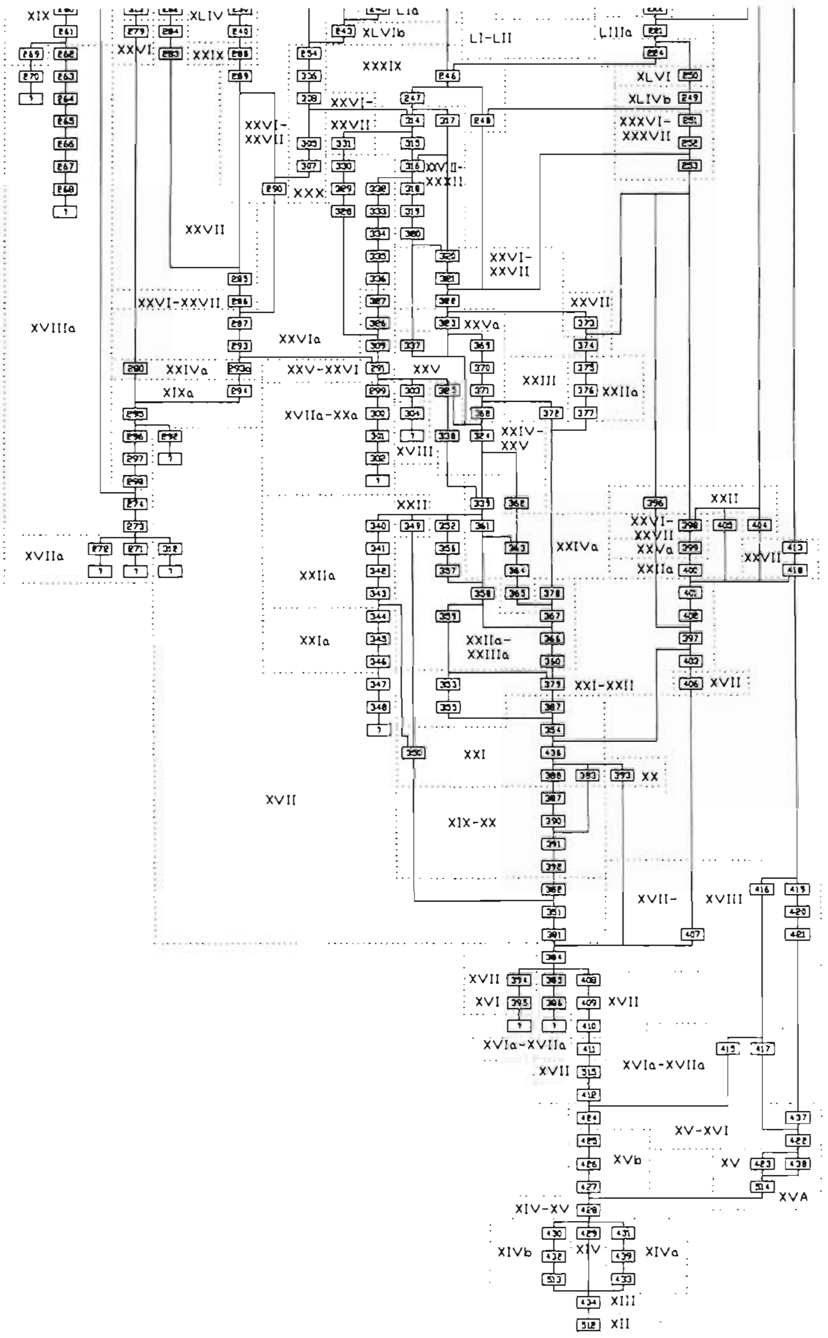

Fig. 16.3 A segment of the stratigraphic matrix for the West Section, Trench III, Site N, at Jericho (Kenyon 1981; plate 273). This has been constructed from the superpositional relationships indicated in Fig. 16.2. Individual deposits are indicated in the matrix boxes; Kenyon's phases are indicated by upper case Roman numerals. (Questions marks indicate an arbitrary excavation termination.)

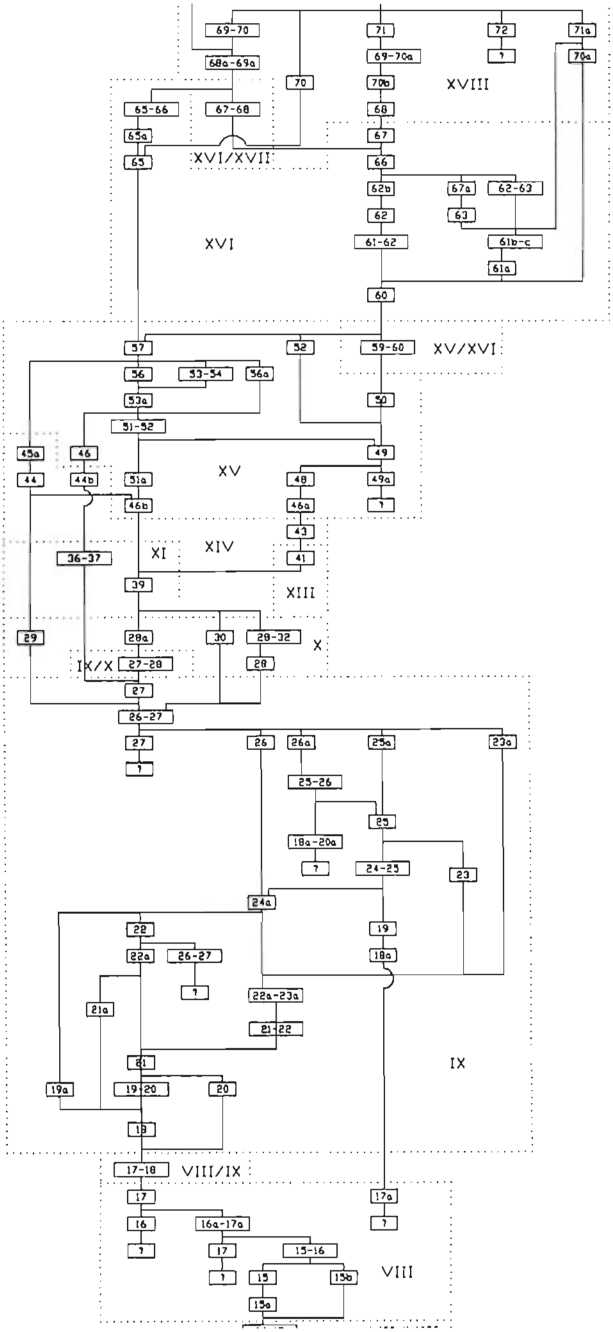

Fig. 16.4 This section of the phase matrix is derived from the stratigraphic matrix in Fig. 16.3. Phases are defined according to Kenyon (1981). Phases indicated on Fig. 16.3 are represented here in the matrix boxes by Arabic numbers; Kenyon's stages are indicated by Roman numerals. Problems with Kenyon's phasing are indicated where crossovers are present and where phases have been necessarily duplicated to correspond to Kenyon's scheme. (Question marks indicate where an arbitrary excavation termination has made it impossible to determine lower phase relationships.)

analysis of single-layer plans. This is very much a part of the phasing process as both Harris (1979: 65–90) and Kenyon (1971: 274) stress. Work along these lines includes an automated approach which offers an efficient means of studying plan data (Alvey and Moffett 1986). However, even after a thorough examination of the plans, one can still be left with ambiguous orderings. It is for this reason that an independent means of establishing the sequences of phases is necessary.

Seriation: the analysis of incidence and abundance data

Seriation is a method well suited to the problem of phasing a sequence where ambiguous stratigraphic relationships are present. Essentially a descriptive analytic technique, the aim of seriation is to arrange comparable units along a single dimension. It is usually regarded as a dating technique, but note that the order represents the time dimension only if the ordering criteria are chronologically sensitive. In order for data to be seriated, these must be arranged in either an abundance or an incidence matrix of rows and columns. In its most familiar form, elements in an abundance matrix represent the proportion of a certain characteristic for each unit being seriated. Thus, for each row (representing the analytical unit) the percentages of each characteristic must sum to 100%. A basic assumption of the technique is that each type has an incipience, floresence and a decline. (The reader is undoubtedly reminded of the battleship shaped curves represented by Ford's (1962) graphic technique.) In matrix form, a correct chronological ordering would appear as a series of columns where the elements either (a) increase to a maximum and then decrease, (b) increase or (c) decrease. A variation on the technique is where the percentages are converted into between-unit similarity coefficients (Robinson 1951). In this form the matrix is arranged such that the high values cluster around the principal diagonal and then, to use Robinson's own words, 'fall off as one goes away from the diagonal either vertically or horizontally' (1951: 295).

Another means of sorting archaeological data is through manipulation of an incidence matrix. With this method the presence of an item is usually indicated by a '1' and absence is denoted with a '0'. The best ordering of the matrix is achieved when there is an uninterrupted sequence of 1's in every column. In such a situation the matrix is said to be a *P*-matrix (Kendall 1971: 220). In actual archaeological situations, however, as the number of units to be seriated increases, the *P*-matrix is rarely achieved and the seriation can only be regarded as an estimate. A considerable body of literature has been generated on the subject of computerized seriation (see Ryan (1988) for a bibliographic review) and there are now available several techniques capable of efficiently sorting hundreds of types and units.[1] Goldmann (1971, 1972) presented an early computerized algorithm for ordering an incidence matrix of considerable size: 790 units by 404 types. Although, at the time, this represented a great advance in seriation studies, there are problems with the subjective

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[1] In spite of continuing research there is still no recognized 'best' seriation technique (Hodson and Tyers 1988: 33) and the interested person has numerous computerized packages from which to choose. Several personal computer packages have become available since this analysis was conducted. Two of these are available through the Institute of Archaeology, London. The programs IAGRAVES aud IASTATS are designed for the seriation of incidence and abundance data respectively (Duncan *et al.* 1990). The Bonn Seriation and Archaeological Statistics Package Version 4.1 (Scollar 1990) also performs incidence seriation and, in addition, includes a routine for the generation of Harris Matrices.

methodology (Marquardt 1978: 274). For this reason Wilkinson (1974: 31) considers the technique as an inefficient means of seriating large matrices. Other early computerized applications are given by Bordaz and Bordaz (1970) and Cowgill (1972). These techniques have been shown to be efficient, but each incorporates a built-in bias. For the former, differential weighting is given to the archaeological units and proveniences are sorted in relation to 'typical members' defined using a clustering technique. Cowgill's program involves differential weighting of the artefacts and, although it is capable of sorting hundreds of archaeological units, this is only possible if the number of types is not large.

Another technique developed by Wilkinson (1974) treats both artefacts and units equally and is theoretically capable of sorting very large matrices. The program, AXIS, alternately orders the rows and columns of the matrix by calculating the mean position of the 1's. The algorithm is as follows (Wilkinson 1974: 31–32, in Marquardt 1978: 274):

(1) calculate the mean position of the 1's in the columns;
(2) order the columns according to these means;
(3) calculate the mean position of the 1's for the rows;
(4) order the rows according to these means;
(5) repeat steps 1–4 until no further improvement is noted.

The 'best' order is achieved when the score of the matrix, *R*, is minimized. *R* is calculated by summing, for every column, the difference between the last and first non-zero elements (Laporte and Taillfer 1987: 285). Wilkinson (1974) also offers another program, POLISH, which refines the sequence established initially by AXIS and calculates a stress variable which has been shown to be a good measure of success in ordering the data (Graham *et al.* 1976: 16).

Several mathematically sophisticated seriation techniques are also available for analysing abundance matrices. These employ various multidimensional scaling programs, e.g. MDSCAL (Kruskal 1964a, b; Shepard 1962a, b); LOCSCAL (Wilkinson 1974); and factor analysis (Marquardt 1978: 287–91). Although these were demonstrated to be efficient, a comparison of incidence and abundance seriation techniques by Graham *et al.* (1976) yielded some interesting results. They generated four sets of simulated cemetery data with graves that varied in terms of number and diversity of grave goods. Each data set was seriated using the AXIS, POLISH, MDSCAL and LOCSCAL programs. Among their conclusions was the observation that incidence matrices sorted by AXIS and POLISH scored consistently high correlations with the 'true' order. On the other hand, MDSCAL and LOCSCAL exhibited erratic results and were on average more poorly correlated with the true ordering than were AXIS and POLISH (Graham *et al.* 1976: 14, table 2). An incidence matrix seriation may provide a better sorted sequence as noted by Laporte (1976), who demonstrated that a better order is achieved by minimizing the score for an incidence matrix (*R*) rather than an abundance matrix (*F*).

Seriation of stratified assemblages: the problem of residual, infiltrated and indigenous remains

It appears, therefore, that the incidence seriation program AXIS offers a potential solution to the problem of phasing on a site where ambiguous stratigraphic relationships are present. Before this can be done, however, consideration must be given to some of the problems involved with seriating assemblages on a stratified site. Although it is not traditional archaeological practice to seriate assemblages on a site where stratification is clearly visible, in a provocative article Rowe took exception to the traditional approach, and suggested that in view of the shortcomings of both stratigraphic analysis and seriation, such an exercise would provide a check on each technique (1970: 68). While Rowe was not concerned with the unique aspects of stratigraphy on sites with architecture, the idea that both stratigraphic analysis and seriation should be applied in concert represented a departure from the prevailing attitude that stratigraphic excavation alone could solve all chronological questions (1970: 68). This attitude was fostered presumably because it was assumed that the principle of superposition had no exceptions. In Rowe's own words 'it is this fact which gives stratigraphy its high reputation for credibility in present-day archaeology' (1970: 68). Thus, in the traditional sense, to combine stratigraphy and seriation would be superfluous: it had the appearance of trying to establish an order for units that were already ordered.

As we have seen though, there is a need for an independent method of sequencing those contexts where ambiguous stratigraphic relationships are present. However, despite Rowe's recommendation made over two decades ago, such an approach is still considered unorthodox. As will be shown the seriation of assemblages from stratified sites requires a re-evaluation of one of the basic assumptions on which seriation is based: namely, that the assemblages to be seriated contain finds which are indigenous to the deposit in which they are recovered. Since seriation problems traditionally have been concerned with graves (see for example Doran 1971; Hodson 1988) where anachronistic items are usually identifiable, this has not presented a serious problem. A stratified site presents an entirely different set of problems, however. This is because of the many sources of disturbance which can introduce artefacts to deposits after deposition, thereby altering the original assemblage content (see Rowlett and Robbins 1982).

Harris (1979: 93) provides a concise description of the three types of cultural remains found in archaeological contexts:

> *Indigenous remains.* These objects were made at about the time of the formation of the layer in which they were found. The layer and the objects are thus considered to be contemporary.
>
> *Residual remains.* These objects were made at a much earlier time than that of the formation of the layer in which they were found. They may have been residing in earlier deposits subsequently dug up to provide soil for the newer layer, or they may have remained in circulation for a long period of time, as may happen with heirlooms.
>
> *Infiltrated remains.* These objects were made at a later time than the formation of the deposit in which they were found and were introduced into that layer by various means which can no longer be detected in the soil.

Although Harris's terms are precisely defined they have not witnessed wholesale adoption into the archaeological lexicon. As a result, confusion may arise if the process of *infiltration* and the type of artefact identified as *infiltrated* are not kept distinct. In the literature when one encounters the term infiltration this usually is in reference to a post-depositional process which can take many forms. In general terms it is the process of infiltration which is responsible for the introduction of material into a deposit following deposition regardless of the object's age. In this sense one can expect infiltration of 'indigenous', 'infiltrated' and 'residual' material into deposits following deposition. In the latter situation, residual material may infiltrate a later deposit through, for example, digging activity (Harris 1979: 94; Barker 1977: 177), or through the natural sedimentary processes of erosion, transportation and redeposition. Human disturbance can be quite pervasive on urban sites in particular, especially where building activity results in earlier artefacts becoming incorporated into later deposits. Likewise, infiltrated objects may also become introduced into a deposit following deposition through a variety of processes including trampling (Flenniken and Hagarty 1979; Gifford-Gonzalez *et al.* 1985; Hughes and Lampert 1977; Keeley 1980: 35; Knudsen 1979; Mobley 1982: 84; Pyszczyk 1984; Stockton 1973); faunalturbation (Bocek 1986; Erlandson 1984; Schiffer 1987: 208; Stein 1983); cryoturbation or freeze–thaw action (Wood and Johnson 1978: 343); and argilliturbation or the shrinking and swelling of clays (Schiffer 1987: 216). On some sites the degree of vertical displacement can be quite substantial. Villa and Courtin (1983: 271) have used conjoinability of artefacts to demonstrate that vertical separation of pieces on the order of 25–30 cm is not uncommon. Finally, objects from one deposit may become incorporated into another contemporary deposit through any one of the above infiltrative disturbances. In this type of situation it would be very difficult indeed to identify the intrusive materials since they would appear to be indigenous based on whatever chronological indicators one chose to examine.

This points out one of the major difficulties involved when analysing assemblages in this way. Quite often it is not possible to identify confidently whether an artefact is infiltrated, indigenous or residual in the absence of an independent source of dating information such as documentary sources. Even when this type of data is available, problems are still evident in that there may be no way to distinguish between those finds that may have originated from another site entirely as could occur with a fill that has been brought to the site from another location. In spite of these problems, to consider an assemblage as comprising indigenous and non-indigenous materials is a first step towards the development of archaeological methods capable of dealing with what is potentially a widespread phenomenon.

Although research into the various processes that are responsible for disturbance to archaeological sites is ongoing, as indicated by numerous experimental, simulated and laboratory studies, the techniques for identifying specific processes from a study of the artefacts are not yet well developed (Schiffer 1987: 267). Consequently, while it may be possible in some instances to identify the precise type of disturbance to a deposit through a study of the sediment, in most situations it is not possible to determine the effect of such a disturbance on the contained assemblage. To phrase this in terms of the present discussion, until the relationship between the controlling factors of artefact morphology, soil matrix and mechanism of displacement are understood, one can only make inferences as to the proportion of non-indigenous remains (infiltrated and residual) which may actually be contained in a specific deposit.

The implication of this as regards the seriation of artefact assemblages from stratified sites is that a proportionately large number of these finds in an archaeological assemblage will influence the final ordering of units. The extent to which this will have an affect on the 'true' order will depend on the degree of post-depositional disturbance on the site. Far from rendering the technique of little use, however, it will be demonstrated how the seriation of stratified assemblages, when shown on a Harris Matrix, can (1) provide a solution to the phasing problem, and (2) provide insight into site formation processes by identifying those assemblages with disproportionate amounts of either infiltrated or residual remains.

Fort Frontenac: a case study in the seriation of a stratified site

Fort Frontenac is an historic period (1673–1870) site located in Kingston, Ontario, Canada. Excavations were conducted on the site from 1982 to 1984 by the Cataraqui Archaeological Research Foundation and have been reported on by Stewart (1982, 1983) and Triggs (1985). Collections from two excavation areas, referred to as the West Curtain Area and the Barrack Master's House Area, are to form the basis for a doctoral dissertation by the author. To date, a total of approximately 8000 ceramic sherds, covering a period of over three centuries (1673–present), have been examined. Stratigraphic data from the two excavation areas that have been analysed and the stratigraphic sequences are represented by a combined total of 250 stratigraphic units (layers, features and interfaces). These were excavated and recorded according to the Harris (1979) method and a stratigraphic matrix has been constructed for each area. The stratigraphic matrix for the West Curtain Area (Fig. 16.5) is presented.

The following discussion will focus primarily on the West Curtain Area for the following reasons:

(1) This area is characterized by successive episodes of building activity. Here the ubiquitous masonry foundation walls have complicated the stratigraphic sequence such that the stratigraphic matrix has a multilinear appearance. Consequently, the site provides a good test case for the applicability of ordering units by incidence seriation.

(2) There has been a fair amount of occupational disturbance to this area of the site and several deposits probably contain infiltrated and residual remains. In this respect the area serves as an instructive case of how such assemblages can be dealt with using the Harris Matrix and incidence seriation.

(3) Of 80 stratigraphic units (layers, features and interfaces) represented on the matrix, 42 are artefact bearing deposits.

The stratigraphic sequence from the West Curtain Area has been phased using documentary sources. Dates of construction, demolition and accumulation episodes associated with the various structures have been determined using maps, historical sketches, journal notes, tax asssessment roles, census records, newspapers and photographs. In this way, a 'true' sequence, determined by stratigraphic and documentary information has been compiled without the aid of the artefacts (Table 16.1). This has the advantage of offering a means of assessing the accuracy of artefact-based dating techniques. In this regard, the Fort Frontenac material is ideally suited to the current problem: the evaluation of incidence seriation as a means of ordering units on the Harris Matrix.

The ceramic assemblages from the 42 deposits have been used as the basis for performing an incidence matrix seriation since it is this class of artefact which is the best chronological indicator. Although a generally accepted classification scheme for late eighteenth and nineteenth century refined earthenwares has yet to be established, the taxonomy developed for this analysis assigns sherds to discrete categories on the basis of ware type and decoration. A total of 97 types have been defined for the West Curtain Area. The taxonomy

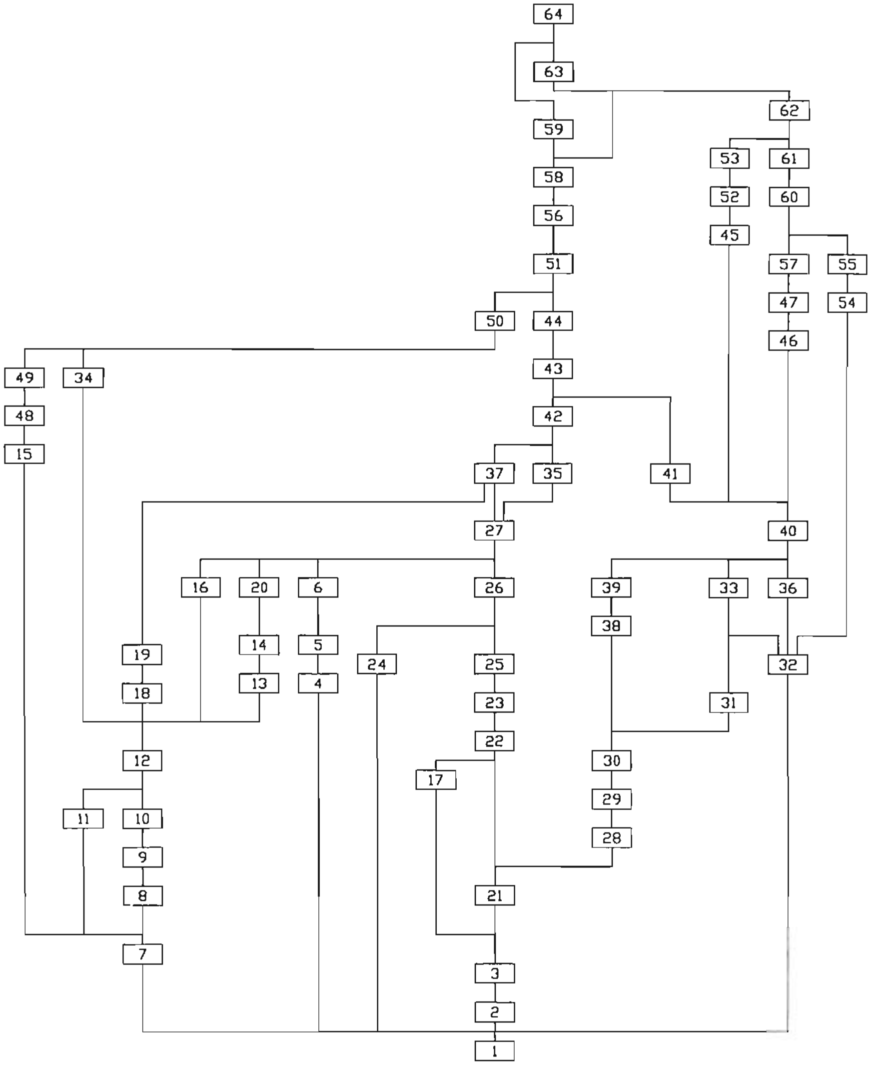

Fig. 16.5 The stratigraphic matrix from the West Curtain Area of Fort Frontenac. All stratigraphic units are ordered according to the principle of superposition. In such situations, where phasing has not been attempted the matrix takes on a squat appearance.

attempts to overcome some of the difficulties encountered when analysing refined earthenwares that span the nineteenth century. These problems involve internal inconsistencies associated with defining groups on the basis of waretype exclusively (see for example Miller 1980; Majewski and O'Brien 1987: 129–38). Date ranges for each type have been derived from a number of sources (Collard 1984; Hughes and Hughes 1968; Jouppien 1980; Kenyon 1985a–c; Majewski and O'Brien 1987; Miller 1980, 1987; Sussman 1978) and indicate dates of manufacture and, whenever possible, dates of popularity for the Ontario context (Table 16.2).

Table 16.1 'True' sequence of deposition as determined through historical documentation

Period	Stratigraphic unit*	Historical date
XVIII	63a, b, 64	1976–Present
XVII	60, 61, 62a, b, c, d	1956–76
XVI	54, 55, 56a, b, 57, 58, 59	1924–56
XV	50, 51a, b, 52, 53	1913–24
XIV	48, 49	1890–1913
XIII	43, 44, 45, 46, 47	1884–90
XII	37, 38, 39, 40a, b, 41, 42	1858–84
XI	31, 32, 33a, b, c, d, 34, 35, 36	1828–43
X	27a, b, c, d, e, 28, 29a, b, 30	1820–28
IX	24, 25, 26	1783–1820
VIII	20, 21, 22a, b, 23	1783
VII	18, 19	1758–83
VI	17	1758
V	13, 14a, b, 15, 16	1756–58
IV	7, 8, 9, 10, 11, 12	1726–56
III	4, 5, 6	1720–26
II	3	1675
I	1, 2	1673–1675

* Stratigraphic units are numbered in relative chronological order; e.g. 56 is later than 55.

These data were arranged in an incidence matrix format (42 rows by 96 columns) and sorted according to the AXIS algorithm (Wilkinson 1974). (Wilkinson's (1974) supplementary program, POLISH, was not used in this preliminary analysis, however, this will be done at a later date.) Next, the sequence of deposits as determined by AXIS was incorporated with the stratigraphic matrix (Fig. 16.6). On this diagram, the relative position of units as determined by AXIS is indicated in parentheses. Thus, Fig. 16.6 shows the relative vertical position of various deposits on separate linear sequences. The AXIS-ordered proveniences can be thought of as being 'frozen' to a specific vertical position which, in some cases, serves to limit the range of possible positions of other units. For example, the 'freezing' of |5|, |22b| and |15| into positions (1), (2) and (3) respectively, limits the vertical movement of all those units located below them (e.g. |7|, |4|, |21|, |17|, |3|, |2|, |1|). As can be seen on Fig. 16.5, where the matrix has been constructed only on the basis of superpositional relationships, the range of possible permutations between these units alone is considerable. Here the units are 'free' to move vertically to any position on their linear sequence and are constrained only by the horizontal lines. It is only through an independent source of data, such as that offered by seriation, that the elements on the matrix can be locked into positions on these vertical lines. In doing so, the matrix becomes elongated as individual deposits are assigned to a specific row.

A further advantage offered by this method is the insight provided into site formation processes. Referring to Fig. 16.6, where numbers in parentheses are accompanied by an asterisk, this indicates a position that is stratigraphically 'out of sequence'. For example, unit |29b| is assigned position (16) by the incidence seriation. Since this unit is located stratigraphically below position (9) (unit |33d|), the seriated order is in violation of the

Table 16.2

			Date range	Mid-date
Cream-coloured earthenware				
1.	Transfer printed	Black	1769–1820	1795
2.	Handpainted	Red edge-lined	1769–1820	1795
3.		Early palette	1769–1820	1795
4.		Brown edge-lined, regimental insignia	1769–1820	1795
5.	Annular banded	Brown	1790–1820	1805
6.	Undecorated	Plates	1769–1820	1795
7.	Undecorated	Chamber pots, kitchen bowls	1820–1900	1860
Pearlware				
8.	Transfer printed	Brown	1828–40	1834
9.		Blue willow pattern	1780–1830	1805
10.		Blue floral/abstract motif	1780–1840	1810
11.		Blue teaware	1810–30	1820
12.		Blue dinnerware	1825–30	1828
13.		Blue romantic motif	1820–40	1830
14.	Handpainted	Blue edge-lined	1810–30	1820
15.		Blue	1810–30	1820
16.		Blue 'chinoiserie' motif	1775–1820	1798
17.		Late palette	1840–50	1845
18.		Blue, wavy line motif	1819–30	1820
19.		Early palette	1810–30	1820
20.	Spongeware	Blue	1830–40	1835
21.	Edge painted	Green shell edge, stylized, shallow incised	1780–1830	1805
22.		Blue shell edge, stylized	1780–1830	1805
23.		Green shell edge, deeply incised	1780–1830	1805
24.		Blue shell edge, no relief	1780–1830	1805
25.		Green shell edge, shallow incised	1780–1830	1805
26.		Blue shell edge, stylized, parallel to border	1830–40	1835
27.		Blue shell edge, deeply incised	1780–1830	1805
28.		Blue shell edge, stylized, deeply incised	1780–1830	1805
29.		Blue shell edge, shallow incised	1780–1830	1805
30.		Blue shell edge, shallow incised, sharp edge	1780–1830	1805
31.	Annular banded	Blue	1790–1830	1810
32.		Brown	1790–1830	1810
33.		Swirl pattern	1790–1830	1810
34.		Undecorated	1775–1830	1803
Refined white earthenware				
35.	Transfer printed	Coral motif	1830–50	1840
36.		Green	1835–70	1853
37.		Cobalt blue floral/abstract motif	1830–40	1835
38.		Cobalt blue	1830–40	1835
39.		Blue floral/abstract motif	1830–50	1840
40.		Purple	1835–70	1853
41.		Green, floral/abstract motif	1840–85	1863
42.		Blue	1830–50	1840
43.		Flow blue	1844–1900	1877
44.		Lilac	1835–70	1853
45.		Cobalt blue willow pattern	1830–40	1835
46.		Brown	1835–70	1853
47.		Blue romantic motif	1830–50	1840

Table 16.2 *continued*

			Date range	Mid-date
Refined white earthenware				
48.		Blue willow pattern	1830–1900	1865
49.		Brown, floral abstract/abstract motif	1835–70	1853
50.		Multicoloured	1852–1900	1876
51.	Handpainted	Late palette	1840–72	1856
52.		Early palette	1840–60	1850
53.		Green sprig	1840–60	1850
54.		Blue	1830–50	1840
55.	Spongeware	Blue, teaware	1843–75	1859
56.		Blue, bowls	1843–85	1864
57.	Edge painted	Elaborate decorative motif	1830–40	1835
58.		Blue shell edge, shallow incised, sharp edge	1830–73	1852
59.		Blue shell edge, parallel to border, deeply incised	1840–73	1857
60.		Blue shell edge, shallow incised	1830–60	1845
61.	Annular banded	Mocha design	1830–1900	1865
62.		Swirl pattern	1830–1900	1865
63.		Edge-lined brown, regimental insignia	1830–1900	1865
64.		Blue	1830–1900	1865
65.		Undecorated	1830–1900	1865
Blue-bodied ironstone				
66.	Non-painted relief	Delicate floral/abstract motif	1880–90	1885
67.		Naturalistic motif	1850–70	1860
68.		'Wheat' motif	1850–85	1868
69.		Abstract motif	1860–80	1870
70.		Undecorated	1840–85	1863
White-bodied ironstone				
71.	Transfer printed	Green, abstract motif	1845–85	1865
72.		Green	1845–85	1865
73.		Blue floral/abstract motif	1845–85	1865
74.	Annular banded	Red 'earthworm' pattern	1845–85	1865
75.		Blue	1845–85	1865
76.		Undecorated	1845–85	1865
Porcelaneous stoneware				
77.	Handpainted	Gilded design	1885–1925	1905
78.		Undecorated	1885–1925	1905
Bone china				
79.	Transfer printed	Blue	1790–1820	1805
80.	Handpainted	Gilded design	1855–1900	1878
81.		Red overglaze	1790–1900	1855
82.		Overglaze	1790–1900	1855
83.		Blue 'chinoiserie' motif	1790–1820	1805
84.		Purple, gilded	1855–1900	1878
85.		Lustre technique	1820–80	1850
86.		Undecorated	1790–1900	1855
Hard paste porcelain				
87.	Handpainted	Overglaze	1880–1900	1890
Yelloware				
88.		Undecorated	1830–1920	1875

Table 16.2 *continued*

		Date range	Mid-date
Coarse red earthenware			
89. Undecorated	Jackfield	1780–1830	1805
90.	Green glaze	1670–1780	1725
Tin glazed earthenware			
91. Undecorated	Yellow fabric, blue glaze	1670–1780	1725
92.	Blue glaze	1670–1780	1725
93.	White glaze	1670–1780	1725
94.	Brown glaze	1670–1780	1725
95.	Salmon-coloured fabric, blue glaze	1670–1780	1725
96.	Salmon-coloured fabric, blue and brown glaze	1670–1780	1725
97.	Blue glaze	1670–1780	1725

Table 16.3 A comparison of ceramic types from 29b and 33d

Type	Description	Sherd frequency	Minimum vessels
Unit 33d	(seriated rank = 9; date of deposition = 1828)		
2.	Cream-coloured, red edge-lined	1	1
6.	Cream-coloured, undecorated	7	2
9.	Pearlware, blue willow	5	1
12.	Pearlware, plate	2	1
23.	Pearlware, green shell edge, deep	1	1
24.	Pearlware, blue shell edge, no relief	1	1
29.	Pearlware, blue shell edge, shallow	1	1
34.	Pearlware, undecorated	10	2
		28	10
Unit 29b	(seriated rank = 16; date of deposition *c.* 1820)		
6.	Cream-coloured, undecorated	1	1
41.	Refined white, green floral/abstract*	1	1
45.	Refined white, cobalt blue willow	1	1
65.	Refined white, undecorated	1	1
68.	Blue bodied ironstone, wheat*	2	1
70.	Blue bodied ironstone, undecorated*	19	3
77.	Porcelaneous stoneware, gilded*	1	1
		26	9

* Probable infiltrated types.

stratigraphic relationships indicated on the matrix. Although the seriated order is clearly not correct, its position is due to the fact that the unit contains an artefact assemblage that would, in the absence of stratigraphic data, place it in a much higher position (see Table 16.3). Such a situation would occur in the case where an assemblage had a sufficiently large number of infiltrated types to rank it high in the seriated sequence. In the reverse situation, where a deposit has a large proportion of residual types, it will also appear

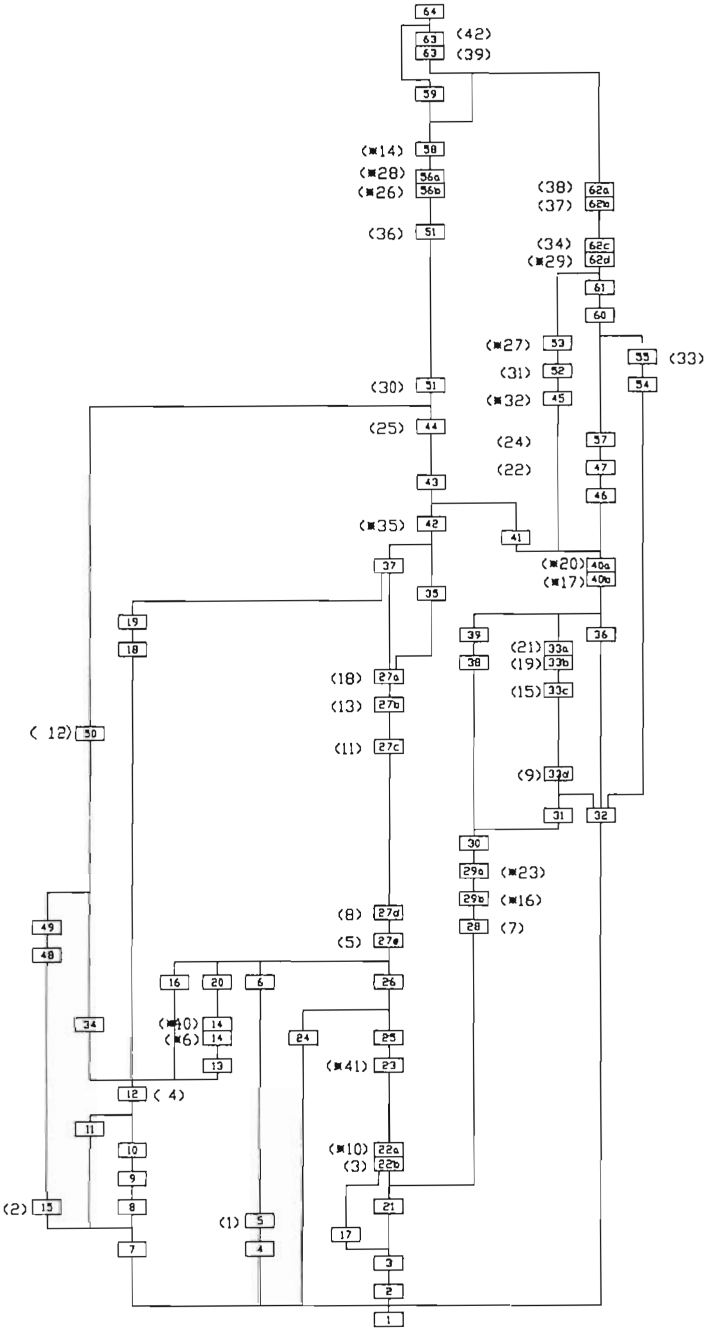

Fig. 16.6 The same stratigraphic matrix as represented in Fig. 16.5. Here, some stratigraphic units have been ordered according to AXIS and the matrix has been elongated. Numbers in parentheses indicate the AXIS rank. Deposits with infiltrated and reisudal remains are indicated by asterisks.

stratigraphically 'out of order'. This is indicated on the matrix where the seriated position is below that of the stratigraphic position. To move the unit to the seriated position would be 'anti-stratigraphic'. Thus, units |40a| and |40b| are ranked lower in the seriation (20 and 17 respectively), but it is not possible to move them without destroying stratigraphic relationships established by superposition.

Examination of the stratigraphic matrix (Fig. 16.6) indicates that 15 of the 42 deposits have both residual and infiltrated remains. Although further analysis is required, two generalizations can be made at this stage: (1) It is apparent that those deposits containing infiltrated remains tend to occur towards the bottom of the stratigraphic sequence. (2) Those deposits with residual remains are more likely to be found at the top of the sequence.

In the latter case, this is largely a function of the digging activity on the site where earlier remains have been incorporated into later deposits. In all but one case where residual remains are present, the deposits are trench fills of various sorts. In a single instance, the deposit was a fill deposit presumably used for grading. The occurrence of residual remains here indicates the type of activity common on intensively occupied sites where earlier deposits are dug up to provide material for construction purposes.

In the case of infiltrated remains, all deposits were loosely compacted sediments consisting of sand, pebbles, mortar and rubble. The effect of trampling as a process responsible for the vertical displacement of artefacts was noted earlier. This is the likely source of infiltrated remains in these deposits given the history of land use in the area. This particular district of Kingston saw not only intensive foot traffic, but also a fair degree of vehicle (wagons and carts) and animal traffic as well. Throughout the different periods of occupation the area was located variously on the exterior periphery of the fort, along a major road connecting Kingston with nearby towns, in the vicinity of the hay market and weigh scales, and adjacent to the first rail line through the city.

Here it is worth noting that sediment compaction by itself is not a reliable indicator that infiltrated remains will be present. In the Barrack Master's Area, a midden deposit with a sand matrix was seriated into a position consistent with the stratigraphic position indicated by the matrix. In this area foot and vehicle traffic could be expected to have been low since the deposit was located in a shallow depression some distance away from a macadamized road which was surfaced with a compact clay layer. In this instance at least, intensity of trampling, rather than sedimentary matrix alone, appears to be the important variable.

Another question worth considering is the relative effectiveness of incidence seriation on a stratified site as compared to those contexts where post-depositional disturbance is at a minimum – e.g. graves. In the study by Graham *et al.* (1976), correlations between the AXIS ordering and the 'true' ordering of the simulated data were found to be quite high: the range of r was from 0.80 to 0.93. For the West Curtain Area a Spearman rank correlation coefficient of $r = 0.72$ was calculated between the AXIS ordering the 'true' order based on documentary evidence. Although the observed r value is lower than that reported by Graham *et al.* (1976) this is attributable to the occurrence of non-indigenous remains as a result of occupational disturbance on stratified sites. A better correlation was achieved for the Barrack Master's Area, $r = 0.89$, where occupational disturbance was historically less intensive.

The Mean Ceramic Dating formula

At this point, it seem appropriate to briefly discuss the Mean Ceramic Dating (MCD) formula (South 1972, 1977) since it has become a commonly used dating technique on historic sites. This is given by

$$Y = \frac{\sum x_i f_i}{n}$$

where

x = the mean manufacture date for each ceramic type;
f_i = the frequency of each ceramic type;
n = the number of ceramic types in the sample.

Although the technique is generally not regarded as such, in actual fact South's formula is a form of seriation (e.g. Marquardt 1978: 277; Lofstrom *et al.* 1982: 3–4). As with seriation, the proportion of types forms the basis for the subsequent chronological ordering. The formula incorporates known manufacture date ranges of artefact types and uses the median of the ranges to calculate an historical date. The 'date' purportedly reflects the median date of occupation of the site (South 1972: 84). The formula is not restricted to a site level of analysis, however, and South suggests that in certain cases it could be applied on a feature by feature basis for a single site (1972: 82). One difference between the MCD formula and conventional seriation is that for the former, the variability of the assemblage is reduced to a single 'date', whereas for the latter, it is precisely the variability which forms the basis of the ordering.

South never intended the formula to be used as a blind dating technique, but rather as a way to examine the variation in culture processes operative in the past (1972: 97). In fact, several studies can be cited where discrepancies between the MCD and the documented median historic date have been used as a basis for these very types of interpretations (e.g., Deetz 1977; Miller and Hurry 1983; Salwen and Bridges 1977; Turnbaugh *et al.* 1979; Wheaton *et al.* 1983). While these and other studies are concerned with factors such as differential use-life of vessels, recycling, vessel repair, transportation networks and ethnicity, another way such discrepancies are described is through manufacture-deposition lag (e.g. Adams and Gaw 1977; Hill 1982; Worthy 1982). The underlying rationale here is that a proportionately large number of older types (residual remains) in an assemblage will result in a much earlier MCD than the true median date of occupation. These may occur as a result of various depositional and cultural processes. Other concerns have been raised regarding the use of sherds as opposed to vessel counts in the formula (e.g. Lofstrom *et al.* 1982: 4). It is thought by these authors that vessel counts will yield a more reliable date since these are more representative of past behaviour than are sherds.

Because South advocated the formula date as an improvement over simple presence–absence analysis (1972: 83, 96), it was considered a relevant exercise to compare results achieved using this technique with those attained through incidence seriation. In order to assess the applicability of South's technique as a means of ordering deposits or phases on a stratified site, MCDs were calculated for both the Barrack Master's Area and the West Curtain Area and compared to the true order of deposition based on documentary evidence. Table 4 shows that for the West Curtain Area, the dates are correlated extremely

Table 16.4 Spearman rank correlation coefficients: true order *vs*. MCD and incidence seriation

Excavation area	MCD (sherds)	MCD (vessels)	Incidence seriation
West Curtain	0.35	0.40	0.72
Barrack Master's	0.73	0.76	0.89

poorly with the true order based on documentary data. An improvement is evident when vessels are used, but the chronological orderings are not as accurate as those achieved using incidence seriation. Because there are so many potential sources of error when the MCD formula is used (cultural, depositional, computational) it is difficult to isolate the reasons for the poor correlations with the documented sequence. It is clear that post-depositional disturbance is responsible for the poor correlations in the West Curtain Area, but the overall poor results for both excavation areas, in comparison to the correlations achieved with the incidence seriation technique, indicate that other variables, such as those presented above, are involved.

Conclusions

The fact that archaeological stratigraphy represents a unique set of problems which principles of geological stratigraphy are unable to deal with has only recently begun to be addressed by archaeologists. Ambiguous stratigraphic relationships created by standing architecture and the problem of post-depositional assemblage alteration are common occurrences on intensively occupied sites and require methods of analysis and interpretation grounded in archaeological theory. The development of the Harris Matrix (Harris 1979) as an approach to stratigraphic analysis, represents a significant step in this direction. As a schematic representation of the entire site stratigraphy, the matrix clarifies the full range of possible stratigraphic relationships where walls create multilinear sequences.

This paper has suggested the computerized incidence seriation program AXIS (Wilkinson 1974) presents a method of ordering units on separate linear sequences. These units can be either deposits as plotted on a stratigraphic matrix or phases on the phase matrix. In so doing, it is also possible to identify those deposits where infiltrated and residual remains occur in disproportionate amounts sufficient to skew the relative temporal order. Where identified, some insight may be gained into site formation processes operative on the site. Also, comparison of incidence seriation with another form of seriation commonly used for historic artefact assemblages, the MCD formula (South 1972, 1977), indicates that the latter is a much less effective method of ordering deposits on a stratified site.

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SECTION VI
Future developments

The foregoing chapters have given some indication of the range and diversity of new stratigraphic studies which have arisen in archaeology following the invention of the Harris Matrix in 1973. They of necessity can only represent a small sample of this new work and that sample was itself dependent upon the willingness of authors to produce papers for this book. We are well aware that considerable new stratigraphic work is being carried out, for example, in the Near East on what are generally called Classical sites. Other work has been attempted on prehistoric sites, especially shell middens.

These principles of stratigraphic study are also being applied to the management of archaeological collections. At Fort Louisbourg in Canada, for example, archaeologists have taken to storing objects according to their stratigraphic provenience as established through phasing based on the Harris Matrix. This stratigraphic approach is apparently a boon to finds specialists and of course continues to reinforce the concept of the stratigraphic sequence as the testing pattern for all post-excavation analyses of archaeological sites.

The papers included in this volume do touch, however, on nearly all the important aspects of the science of archaeological stratigraphy – which we believe is only now in its infancy, having taken over a century to free it from the inadequate maxims of geological stratigraphy. The single recommendation on the use of arbitrary excavation aside, it must now be axiomatic that archaeologists excavate by the stratigraphic method and by that method alone. The matter of stratigraphic analysis by interfacial definition is paramount to the overall advance of the discipline.

The use of single-context planning again must be seen as axiomatic in site recording: indeed, as Clark (Chapter 17) notes in the final paper of this book, 'I have yet to discover a cogent, logical rationale for using composite planning for site recording: it is difficult to imagine a reason which would outweigh the difficulties the system creates in post-excavation analyses'. The single-context plan is the primary building block for all later stratigraphic, topographical, site-wide and country-wide analyses of the physical development of archaeological sites and the historical landscape of a nation.

The devising of stratigraphic sequence diagrams should be from now on an integral part of the process of archaeological excavation. The phasing and periodization of such sequences has already brought new methods and answers to archaeology and will continue to do so in the future. The application of all of these notions to standing historic buildings, which are our largest category of 'artefact', is a long overdue and very significant development, which again bodes well for future archaeological research above the ground. Finally, the application of the computer to all of the studies passed on by the papers is present fact which archaeologists will ignore at their peril, aside from the loss of many new and exciting research possibilities.

It is always easy to look back with hindsight (especially in this instance with Alvey's program) at the mistakes of earlier generations. In the case of archaeology, however, we have often been blinded by the flow of artefacts and the grandeur of superior ancient monuments, to the detriment of commonplace stratification. We hope this book will perhaps suggest through the work of our colleagues how the inequalities of past stratigraphic methods can be rectified for the good of all.

It is for this reason that we have left for last the important paper by Peter Clark, who looks back with a pun at 'Sites without *Principles*: Post-Excavation Analysis of "Pre-Matrix" Sites'. This article is at once a damning criticism of past practices, but at the same time a fine study of how we may, on occasion, as written by an American archaeologist, 'salvage the salvage', which was so much past archaeological excavation.

17 Sites without *Principles*; post-excavation analysis of 'pre-matrix' sites

PETER R. CLARK

The Scottish Urban Archaeological Trust uses a standardized recording system on all of its excavations (SUAT 1988a, 1989a, b, d), largely based on the work of Harris put forward in his *Principles of Archaeological Stratigraphy* (1979), and its practical applications as discussed by Boddington (1978) and the Museum of London (Schofield 1980). The use of such a system, with major emphasis on the recording of stratigraphic relationships and comprehensive planning of all stratigraphic units, has proved invaluable in the excavation and subsequent analysis of archaeological strata.

However, like many archaeological institutions in the United Kingdom, the Trust has inherited a large backlog of un-analysed excavation records which were compiled without the benefits of a standardized methodology or a full awareness of the principles of archaeological stratigraphy outlined by Harris in his book. Thus they may be described as 'sites without *Principles*'.

The problem

Although I have referred to these sites as 'pre-matrix', their archive records are distinguished by several features apart from the absence of a 'Harris Matrix'. First, the stratification has been recorded using 'composite' or 'multicontext' plans. The problems in using such plans as a primary recording technique have been described by Harris (1979: 65). I have yet to discover a cogent, logical rationale for using composite planning for site recording; it is difficult to imagine a reason which would outweigh the difficulties the system creates in post-excavation analyses. In extreme cases, some archives have as little as 40% of the recorded stratigraphic units (or 'contexts') appearing on plan. Many of those that do appear are not shown to their full extent, as they run underneath other contexts on the same plan. Furthermore, a single context may appear on several different plans, with a different spatial extent on each. Secondly, few archives place a great importance on the accurate recording of stratigraphic relationships. Not only is there rarely a site matrix, but the relationships recorded on Context Recording Sheets, site notebooks, etc., are often incomplete or demonstrably incorrect.

Thirdly, the lack of a standardized system may mean that information about the stratification is scattered through a host of different recording media — from context sheets,

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site notebooks and annotated plans to scraps of paper and notes on finds bags. Thus it can prove difficult to review all of the information recorded about a single context.

These problems are not peculiar to Scottish urban archaeology. They are common features of many site archives throughout Britain. To aid their comprehension it is worth considering briefly the philosophy behind their compilation. First, the site records do not appear to be viewed by the excavators as an 'archive' as such; they seem rather to have the status of an *aide memoire* to the site director. This of course implies that the analysis will be carried out by the excavators, which whilst desirable, is not always possible. Secondly, the selectiveness of the recording seems to stem from the principle that 'the best time to interpret the site is in the field'. This principle is often quoted at conferences as a self-evident truth, but is in fact highly questionable.

The excavator is required to interpret the stratification before the full range of information is available, such as artefact and environmental studies, and to make interpretive decisions without the ability to assess the influence of earlier, underlying strata. Thus the excavator is continually assigning subjective *significance values* to each unit of stratification. Comprehensive planning is unnecessary as all 'significant' contexts will be planned, and presumably the significant parts of contexts, as their full extent is not planned. There is no need for a complete, accurate record of the stratigraphic sequence, as the excavator will 'remember' relationships in post-excavation. This is often assisted by references to 'Fred's pit' and 'Hilary's wall' with no other identification.

Lastly, there is no need for a standardized recording system, as the excavator will remember (for example) that a note on a scrap of paper in box 4 relates to a plan in box 7.

This is not the place to dissect the failings of such archives, nor to note the exceptions to some fairly bald criticisms. Harris (1979) has discussed in depth some of the methodological problems contained within them, whilst all those involved in their post-excavation analysis will be depressingly familiar with the pragmatic difficulties they present.

Two general observations may be made about such archives; the first is that such a selective, interpretive method of primary recording compromises the principle of *preservation by record,* often quoted as a justification for 'rescue' archaeology. As the primary record represents the excavators' on-site interpretation, it is often very difficult to assess the validity of, or alternatives to, this interpretation. Obviously this is a question of degree; the identification of contexts always involves some interpretation, if one is to avoid the compilation of the site record 'untouched by the human mind'. However, this should not prevent the site records being open to alternative interpretations.

Secondly, the personal nature of these archives compromises what has become known as the 'Bus Principle'. Simply stated, this is the principle that if the site director is run over by a bus, the site records should be easily comprehensible to another archaeologist with no first-hand experience of the excavation. Most backlogs are caused by staff moving on to new appointments rather than any mishaps with public transport, but the effect is just the same.

In this short paper I would like to outline some practical guidelines for analysing such site archives. They have proved successful in dealing with a wide variety of sites of different periods from all over Scotland, excavated by different people, each with their own idiosyncratic style of recording archaeological strata.

It is worth saying at the outset that my approach has always been to analyse the *archive* rather than the *site*. If one is fortunate enough to have access to a member of the excavation team, then their reminiscences should be written down and included in the site records. Attempting to pull too much information from an inadequate archive, or bemoaning 'what-might-have-been' is usually a fruitless and frustrating task.

Overview

The first task when approaching the analysis of a site archive is to organize the various recording media so that all information regarding the stratification is cross-referenced and easily accessible. Although this may be a time-consuming task, experience has shown that avoiding or skimping on this will invariably create problems at a later stage in the analysis.

Secondly, the entire stratigraphic sequence must be compiled and verified as far as is possible, and presented in the form of a Harris Matrix. The matrix is the fundamental tool of stratigraphic analysis, and any problems or ambiguities should be clearly identified.

Thirdly, with all the data accessible and the stratigraphic sequence established, the contexts may be grouped together, moving through a hierarchy of groupings based on their *levels of association* (discussed below).

Fourthly, as the post-excavation analysis is a process which will subsequently form part of the site archive, the structure and procedure of that analysis should be documented in a *project diary*. This will help satisfy the Bus Principle during the course of post-excavation analysis.

These tasks may be summarized as four principles in preparing and analysing a site archive:

1. *Accessibility* of information;
2. *Integrity* of stratigraphic information;
3. *Structure* of interpretation and inference;
4. *Documentation* of post-excavation procedure.

The identification of discrete stages in post-excavation procedure has important benefits. As each stage of analysis should be completed before moving onto the next, so effort may be focused at the appropriate point, problems identified and hopefully resolved. Thus the 'history' of higher-level interpretative decisions may be traced back through the post-excavation procedure. This can be a boon both to other users of the archive and to the stratigraphic analyst, through organizing effort and clearly identifying ambiguous or problematic areas in the archive.

Accessibility

There are two aspects to organizing the site records to ensure accessibility: compiling a *master index list,* cross-referencing all information concerning each stratigraphic unit, and the physical organization of the records to allow easy consultation of that information. A master index list should always be prepared, listing the relevant types of recording media with entries for each context number. The record types will, of course, be dictated by the nature of the site archive. An example of a master index list is presented as Fig. 17.1.

CONTEXT NUMBER	PLAN NUMBER	CONTEXT TYPE	SECTION NUMBER	DESCRIPTION / NOTES	Notebook Pages	PHOTOGRAPHS	
						B+W	COLOUR
1832	85,87,91	Deposit	13	Sandy Silt	39, 52	6/ 17-19	12/ 15-17
1833	———	Cut	———	0.45m diameter 0.30m deep	40, 41	———	———
1834	87	Fill of 1833	———	Sandy Clay	40	———	———
1835	88,89,90,91, 107	Wall	15,16,17	Sandstone Rubble	37,39, 40	6/20-24 7/1-10	12/18-23 13/8-18
1836	———	Deposit	13	Silty Clay	———	———	———
1837	89,90	Deposit	———	Organic Silt	42	7/11-12	13/19-20
1838	107,109	Timber	17	1.5m long, squared timber,0.25m x 0.25m thick	41,42	7/18-24 8/9-15	13/24-30 14/1-7
1839	———	Unspecified	———	Described only as "Feature". Did produce finds, and appears on matrix	———	———	———
1840	93,94	Cut	18	Large pit, 0.8m diam. 0.7m deep. Fill renumbered as 2011.	43	8/16-18	14/8-10
1841	93,94	Deposit	———	Clay Silt	43	———	———

Fig. 17.1 Example of master index list.

An index list of this type will allow the stratigraphic analyst to see 'at a glance' the range of information available for an individual context, and a guide to its location.

'Context Type' has proved a useful *aide memoire* when dealing with large numbers of contexts. The range of context types should not be allowed to proliferate, as this would defeat the object of this category. An example list is given below.

Context Types

Deposit	Timber	Fill (of XXXX)
Wall	Cut	Unspecified

It is important to keep interpretation to a minimum at this stage. Contexts should not be classified by interpretive criteria, such as a 'drain', 'make-up', 'cess pit', etc. It is important to assess all the evidence unfettered by simplistic interpretive tags, even if they were assigned in the field. Equally, description should be kept very simple; it is enough to describe a deposit as a 'silt', 'sand', 'organic silt', etc. The index list is intended as a guide to full information, not as its replacement.

Occasionally one may encounter site archives where several contexts have been conflated under a single context number, for example, a group of stakeholes, a cut and its fills, or groups of cuts. Ideally, these should be split up and assigned new context numbers. Such newly created numbers would be clearly differentiated from the site numbering system. However, this can be time consuming, so an assessment of the benefits to be gained by this process should be made. It is usually worthwhile if each element has been described separately, or if contradictory stratigraphic positions are suspected for each element. It is imperative that these changes are clearly documented on the new context sheets and in the project diary. If a computer is available, the master index list may be usefully stored on a simple database file, which can provide the source of later 'phasing lists', etc.

Having prepared the index for the various types of records, the next step is to prepare the data so that any information about an individual context may be quickly and easily examined. An important aspect of this data preparation is that examining one piece of information does not disrupt the rest of the records; this information will be continually referred to throughout the analytical process. Good data preparation will mean that a minimal amount of time will be spent re-ordering and sorting out the data as work progresses.

Context sheets are best kept in numerical order in ring binders. Arranging in stratigraphic order will cause problems if there is a need to consult between context sheets. For the same reason, context sheets should not be removed when they have been 'dealt with', but should be kept together as a coherent whole. If a single number sequence has been assigned to blocks of strata from discrete areas, then they should be organized in numerical order by area in separate files. Card dividers may be used to separate the context sheets into manageable blocks.

If the *plan records* are comprehensive (i.e. a 'single-context planning' system was employed), and the plans are on sheets of A3 or A4 permatrace, they may be easily stored in numerical order in ring binders. Card dividers may be used to separate the plans into manageable blocks.

If a multicontext planning system was employed, it is more difficult to organize the plan records to allow easy access. Often the 'site plans', covering most or all of the excavation area are on very large sheets of permatrace, often A1 or even A0 on large sites. They are often accompanied by several much smaller sheets, dealing with one or two contexts, usually cut on an *ad hoc* basis. This creates difficulties in practical storage, and it is best to sort plans into small/medium and large size groups. Alternatively, organizing the plans in a hanging-file store is an effective storage solution. A major problem with this kind of plan is that, as several contexts are represented on each large plan, they will be referred to time and time again. It is very difficult to keep the storage system in order, and the plans quickly become disorganized, thus compromising the principle of *accessibility*. Also the large size of the plans means that it is clumsy and frustrating to overlay plans to check relationships, and the psychological effect of this is that shortcuts are taken and the stratigraphic relationships are not comprehensively checked. This compromises the principle of *integrity of stratigraphic information*.

Composite plans are best broken down into individual plans showing a single context. Not all contexts will have a plan, and a special line symbol will probably be needed to indicate where a context underlay another; it is at this point that any problems in the composite plans should be identified and resolved. Any stratigraphic notes on the plans should be copied into a separate notebook, for use when compiling the matrix. Such 'single-context' plans may be copied manually onto sheets of permatrace (which may be expensive), or photocopied onto standard-sized sheets of paper. These single-context plans may then be stored in ring binders in numerical (i.e. context number) order.

An alternative to this method is to use a computer graphics system to store the plans. I have used two purpose-built graphics programs: Hindsight, developed by Bryan Alvey (Alvey and Moffett 1986; Alvey 1989, and Chapter 14 of this volume), and AEGIS, developed by Mike Rains (Rains, forthcoming). Both offer the facility to store plans, automatically overlay them on screen (referring to a computer-stored matrix), and to construct and store multicontext plans. The power of such systems to manipulate and interrogate the plan record cannot be overestimated; they have proved of inestimable value in post-excavation analysis. An examples of an AEGIS screen display is presented as Fig. 17.2.

Sections pose fewer problems than plans in that they rarely have to be directly compared to each other, and have an internal logic as the stratigraphic relationships between contexts are graphically displayed. Because of this quality, section drawings may be continually referred to, and it is useful to display copies of relevant section drawings on the wall when analysing the stratification. Occasionally, a site archive will contain section drawings on which the context numbers have not been recorded. Unless the stratification is very simple, either site-wide or in a particular cut, do not attempt to cross correlate such a section with the context record on the basis of soil descriptions. Section drawings are notoriously misleading when dealing with complex stratification (Harris 1975: 110), and unless this correlation is carried out in the field, it can be a time-consuming and frustrating exercise to attempt this in post-excavation analysis.

The nature of *photographic records* varies enormously between site archives. Although many excavation teams place a great importance on the technical quality of the photographic record, the usefulness of the record in analysing the site does not always correspond. If the photographic record is to contribute significantly to detailed analysis, it must be closely linked to the rest of the site archive. General shots of the site are of little use, though as a greater knowledge of the archive is achieved, and if context sheets, plans and photographs are dated, they may be useful at a later stage of the analysis. Primarily, the photographs must be linked with individual contexts. This information will have been prepared on the master index list.

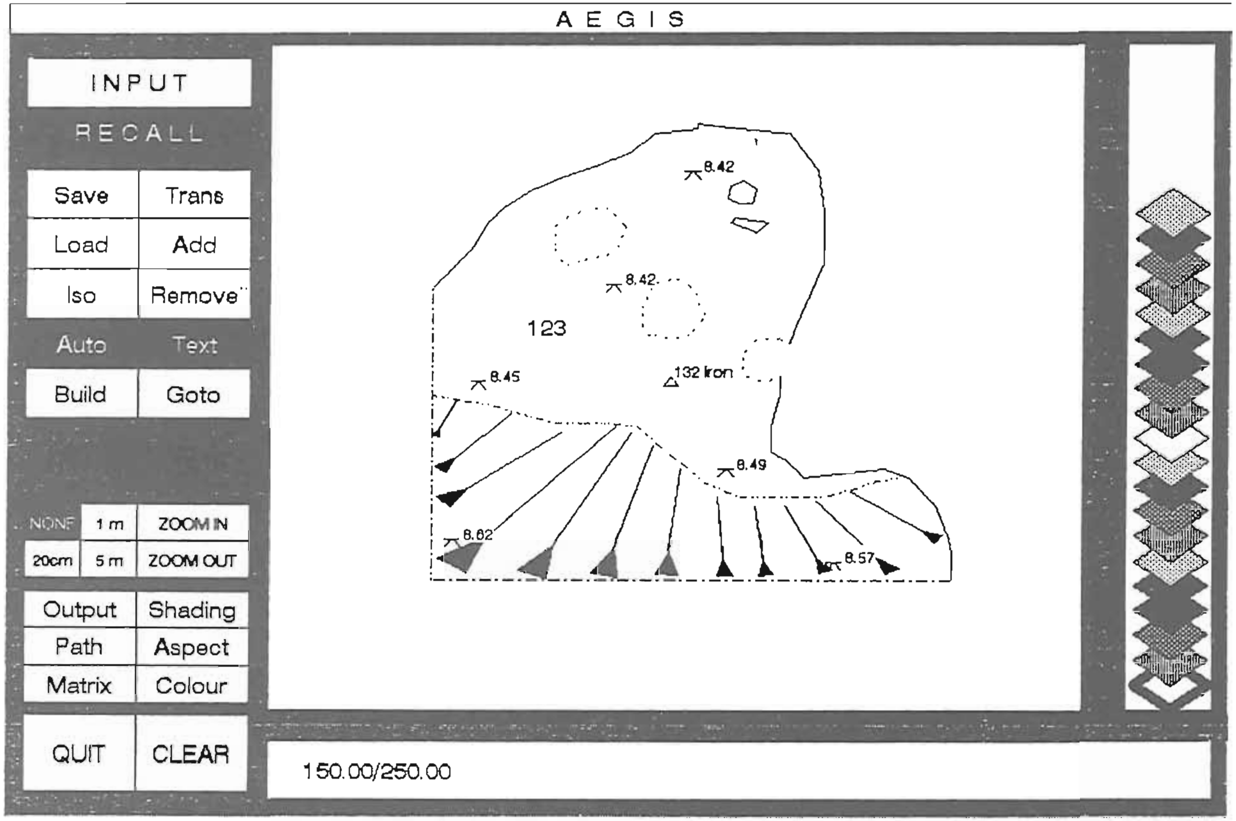

Fig. 17.2 Example of AEGIS context plan.

The monochrome photographic record is usually present as a series of contact prints which are of little use as they stand. Preparing enlargements may be expensive, so unless there are monochrome shots for which there are no duplicate slides, it is recommended that only the colour slides are referred to. At this stage, only those slides which can be directly related to individual contexts should be considered. These should be extracted, numbered with the appropriate context number and filing information, and stored in slide magazines. A concordance should be prepared listing the context number, slide number and slide location. Thus the photograph of a particular context may be examined without disturbing the storage system. The use of a desk-top slide viewer, particularly if it accepts magazines, is recommended.

If the *site notebooks* contain information about specific contexts, and they are referred to by number, it is useful to paginate the notebooks and create an index for the context numbers. Thus one may refer directly to the appropriate part of the notebook when considering a particular context. If a computer is available, this may easily be done using standard word-processing facilities.

All other types of information should be linked as far as possible to the context record, and filed in such a way as to ensure easy access without disturbing the filing system excessively. Information that cannot be linked to the context numbering system should be structured and organized so that it may be examined and assessed at the appropriate stage of the analysis. A list of the rest of the archive data, indicating what they are and how they relate to other information is a valuable and useful tool.

When this stage of the data preparation is complete, the stratigraphic analyst should be able to assess the complete range of information about a particular context, and quickly and easily gain access to that information. All other types of information should be structured in such a way that they may be examined when appropriate.

Integrity of stratigraphic information

With the data organized, one may now consider the record of stratigraphic relationships. The stratigraphic sequence of any excavation is of primary importance in its analysis, and it is recommended that no further work is carried out until the stratigraphic analyst is assured of the integrity of this information.

It is a remarkable fact that, in spite of the primary importance of this information, it is one of the most neglected and badly recorded aspects of many excavation archives. An excavation where a running matrix has been maintained, with rigorous monitoring of stratigraphic recording on site, will quickly become apparent when studying the site archive. Ensuring the integrity of a site archive's stratigraphic information may involve any or all of the following processes;

1. *Checking* the site matrix.
2. *Correlating* stratigraphic information on the context sheets.
3. *Merging* together partial matrices.
4. *Compiling* a site matrix from other types of stratigraphic records.
5. *Constructing* a site matrix in the absence of a stratigraphic record.

Checking the site matrix. If a site matrix has been prepared, then it should be checked for consistency and accuracy. Starting from the bottom of the matrix (i.e. the earliest stratigraphic units), the plan of each context should be overlain by that of the next context in the stratigraphic sequence. In this fashion, the sequence recorded on the matrix may be checked for errors or omissions.

This is a straightforward task if comprehensive single-context plans have been compiled on a transparent medium such as permatrace. If multicontext plans have been prepared, this task is made much more difficult. If they have been broken down into single-context plans drawn on a transparent medium, then a similar process to that used for a single-context planning system may be used. If the plans have been photocopied, trace the lowest stratigraphic context onto a sheet of tracing paper, and use this as a basis for comparing overlays. These plans are intended only as a tool for checking the site matrix; they are temporary and may be discarded after the matrix has been checked. Each strand of the matrix should be checked by overlaying the tracing paper sheet onto the photocopy of the context it is supposed to relate to. The new context may then be traced off and numbered on the tracing paper sheet, and the next context checked. If a long strand is being checked, the temporary plan may become cluttered and confusing. In this case it is best to start a new sheet, checking back if necessary to the previous sheet. A new sheet should always be started when more than one strand comes together under a single context. In this fashion the immediate above and below relationships may be checked, and any problems identified. If using a computer graphics system, plans may be recalled in sequence to check the relationships on screen.

Correlating stratigraphic information. Once the matrix has been checked, it is important that the stratigraphic information recorded on the context sheets is correlated. In other words, the 'above' and 'below' relationships are checked and consistently filled in for each context. This will make life easier when addressing individual contexts.

Merging partial matrices. This can be a very difficult and frustrating task. As the term implies, partial matrices represent only a portion of the total stratigraphic sequence. This may mean that the entire sequence was recorded in a series of blocks, or that only certain parts of the sequence are matrixed. Occasionally, partial matrices are not internally consistent or complete, being dependent on other partial matrices or parts of the unmatrixed sequence to be completed. Initially, it is important that the partial matrices are fully checked and their integrity ensured. If they are interdependent, i.e., they cannot be checked in isolation, then it is best to compile the site matrix from scratch, using the partial matrices as a guide.

If they can be checked, and exist as separate entities, then they should be merged into a single site matrix. Again it is important to utilize the plan database. Copy the uppermost and lowermost contexts of the partial matrix onto separate transparent sheets (either tracing paper or permatrace). Label each context on this temporary multicontext plan, and then overlay the uppermost plan on one partial matrix with the lowermost plan of the next matrix in stratigraphic order. If there is no record of the stratigraphic relationships between these partial matrices, go by numerical sequence or the dates recorded on the plans or context sheets. It should then be possible to link the contexts within each partial matrix stratigraphically. If this is not the case, copy the next context plan (i.e. the next context going up the stratigraphic sequence) onto the multicontext plan sheet until all the contexts are stratigraphically tied in.

Compiling a matrix. If there is no matrix as such, but there are stratigraphic relationships recorded, either on the context sheets, the site notebooks, or on the plans, then a proper Harris Matrix should be prepared. The value of such a graphic display of the stratigraphic sequence is inestimable when analysing and structuring the interpretation of the stratification.

The important thing here is to compile as accurately as possible a site matrix which may be checked using the procedures outlined above. There really is no substitute for the plan records in this task, which again stresses the value of a comprehensive plan record.

If possible, one should start from the bottom of the stratigraphic sequence, usually (though not always) meaning the highest context number. Moving through the sequence, the above and below relationships should be translated into a Harris Matrix format. This process may be continued until the matrix is complete. However, it is unlikely that the stratigraphic relationships will be totally consistent without a site matrix having been prepared by the excavation team. Omissions and contradictory relationships will probably be common. It will not always be possible to resolve these, though notes, sketches and the dates on context sheets may be useful when sorting out the stratigraphic sequence. Otherwise they should be left as problem areas, and resolved in the checking stage. It is a good idea to enter all contexts on the matrix, even if they have no recorded stratigraphic relationships, otherwise they are easily overlooked. It is often the case that large areas of the matrix cannot be compiled from existing stratigraphic records. These areas will need to be constructed, following the procedures outlined below.

Constructing a site matrix. If there is no site matrix, or any reliable stratigraphic record, then the site matrix will need to be constructed from whatever information is available. This is obviously an appalling situation, and is one of the most difficult tasks in archive analysis.

Once again, the plan record is of paramount importance. *The success of constructing a site matrix is directly proportional to the quality of the plan record.* First, as one is primarily concerned with sequence, one must search for sequence in the site records. This is contained in the numbering sequence of the contexts, and in the dates on which the contexts were recorded. The numerical sequence of the plans also contains important information. The belief is, as long as the site was *excavated* in stratigraphic sequence, then this sequence will be reflected in the numbering sequence and in the chronological sequence of excavation. This sequence may then be used as the basis for overlaying plans to create the *stratigraphic sequence.*

Thus initially the contexts are arranged in numerical order, the highest number being presumed to be the earliest stratigraphic unit. This may be checked through the plan database, as clearly this logic is only applicable to unilinear strands of the matrix. Anomalies may be identified and corrected by using the dates on which a context was recorded; a context recorded the day before another presumably cannot be stratigraphically earlier. Similarly, the numbering sequence of the plan record may contain valuable stratigraphic information; a context on plan 66 which has a spatial relationship with a context on plan 70 may be presumed to be stratigraphically later.

Information may be recorded on plans directly relating to the stratigraphic sequence; however, great care must be employed when using levels to establish sequence. Although some care is usually taken on sites when recording levels, it is rare that the *position* of spot levels is recorded with the same degree of accuracy. Undulating and sloping deposits make comparisons between contexts dubious unless there is a significant difference in recorded levels. A rough rule would be that unless there was a difference of at least 0.10 m in levels between contexts, then this information should not be relied upon for establishing stratigraphic relationships.

These guidelines may help towards constructing a site matrix; if the plan record is lacking, then one must often fall back on intuitive, interpretive decisions to construct the matrix. These must be documented and clearly identified in subsequent analyses.

In some instances, the lack of a stratigraphic record is compounded by the fact that the site was excavated out of stratigraphic sequence. If the plan record is not comprehensive, it is almost impossible to reconstruct the sequence. It is best not to attempt this with such an archive, as this will lend a spurious accuracy to any report prepared. Admit defeat, and simply describe the recorded stratification without attempting to impose a sequence upon it (although one may be suggested from other information, e.g. pottery dating).

With the data easily accessible, and the site matrix compiled and checked, it should now be possible to commence analysing and structuring the interpretation of the stratification.

Structure of interpretation and inference

The preparation of the site records for analysis is often the most time-consuming aspect of post-excavation work. Excavations which have been conducted using a standardized recording system, comprehensive planning and accurate recording of the stratigraphic sequence require far less time for post-excavation analysis.

The stratigraphic analysis of excavation archives entails the assessment of the entire range of information pertaining to each context and the identification of groups of contexts based on their *levels of association*. In this fashion a hierarchy of groups may be established, allowing a range of interpretive statements to be made. The level of association between two or more contexts is inversely proportional to the level of interpretation required to link them together. Thus a pit and its primary fill would have a high level of association and a low level of interpretation, whilst the grouping together of a series of discrete cuts in different excavation areas, interpreted as a building, would have a lower level of association and a higher level of interpretation.

A hierarchy of groups may be established using this relationship. There are no explicit rules for these groupings; they will depend upon the nature of the stratification, the site records, and the personal perceptions of the stratigraphic analyst.

Three types of groups are used by SUAT: the Context Set; the Context Group; and the Inter-Group Discussion.

The context set

This is the lowest level of context grouping, identifying contexts with a high level of association. A Context Set consists of one or more contexts with a high degree of stratigraphic cohesion, representing a single ‘activity’ or process. In practical terms, Context Sets form the basic building blocks for higher level groups, and the fundamental organization of the stratification for use by other specialist analyses, for example, artefact and environmental studies. Ideally, the stratigraphic reasons for forming a Context Set should be so strong that it would be highly unlikely that it would need to be split up subsequently due to the results of other types of analysis. All contexts should belong to a Context Set; it is common that a Context Set contains a single context. Examples of a Context Set might be a cut and its primary fills, a closely related sequence of make-up deposits, or the interface of a major truncation of the stratification.

The context group

Once the Context Sets have been established, they may be brought together into Context Groups. The contexts contained within a Group may have a lower level of association and thus a higher level of interpretation. However, a Group may consist of only one Context Set, and thus only one context. The Group differs from the Context Set in two ways; first, it is at the Group level that the final stratigraphic report will be structured, each Group forming a discrete discussion point in the text. The identification of Context Sets is part of the logical procedure which leads to the establishment of Groups. Secondly, because Groups may consist of contexts with a low level of association, they may be susceptible to redefinition due to the results of other types of analysis. Context Sets should not be susceptible to such redefinition except in extreme circumstances.

The nature of particular Groups will be dictated by the nature of the site, the site records and the perceptions of the stratigraphic analyst. Thus in one instance a Group may represent the construction, use and destruction of a building; in another these activities may each be represented by one or more Groups.

The inter-group discussion

It will often be appropriate, apart from a general discussion of the site, to discuss the interpretive relationships between Groups. Although the Inter-Group Discussion has been identified as part of the grouping hierarchy, it is not an entity in the same way as the Context Set or Group. Alternative interpretations may involve different configurations of Groups, and thus a Group may be discussed in more than one Inter-Group Discussion. Such discussions may involve high-level interpretive statements, and thus a low level of association between the contexts referred to. There may also be a hierarchical relationship between Inter-Group Discussions; the discussion of a series of Groups relating to the structural history of a building may be referred to in another discussion of the relationships between a group of structures. At this level other types of studies, such as artefactual and environmental analyses, become of increasing importance; it is the synthesis of all types of evidence that forms the basis of the published report.

The series of logical steps implied by this grouping hierarchy has the important benefit of structuring and targetting interpretive decisions at an appropriate stage. Thus the rationale for forming a Context Set would be clearly documented at the Set level, with a discussion of the way in which any problems of ambiguities in the site records were resolved. These particular issues would not be addressed at the Group level; only problems and interpretations pertaining directly to the Group would be discussed. Thus as the stratigraphic analyst moves up the grouping hierarchy, each stage is built upon the comprehensive and explicit rationale of the previous stage. This chain of argument is unidirectional; the rationale for forming a Context Set should not be based on its relevance to a Context Group.

Also, the structuring of the post-excavation procedure in this way allows more accurate estimates to be made, with important benefits for project timetabling, resource allocation and project management.

Procedure

The establishment of the interpretive groupings stems initially from the stratigraphic sequence represented by the site matrix. The first step is to identify the 'longest strand' or 'primary route' through the matrix. This is the longest sequence of individual contexts without regard to their type, character or interpretation. This is then drawn as a vital sequence, upon which all other strands of the matrix may be added. Organizing the matrix in this way allows the recognition of patterns in a multilinear sequence, and the extent to which unilinear strands 'float' in relationship to each other.

Large complex matrices may be divided up into more manageable blocks by the identification of nodal points (Williams 1987: 96). A nodal point is a single context on the matrix which all of the stratification either pre- or post-dates. This will make primary analysis easier, although ultimately the entire sequence should be considered as one.

After restructuring the matrix the context numbers should be annotated with their basic composition and type. The easiest and most useful method is to colour-code the matrix using colour pencils. The detail of this coding will be dictated by the standard of site recording; if a standardized recording system was employed, and the excavation team was experienced and consistent, a detailed coding system may be used. Such a system has been outlined by Hammer (1987: 79). With most archives, a simpler system will suffice.

A group of descriptive categories should be established, and particular colour codes assigned to them. These colour codes should be documented in the project diary. The context numbers on the matrix may then be circled or underlined using coloured pencils. This is the first stage at which the context descriptions need to be referred to. It will usually suffice to identify the major constituent of a deposit, e.g. a sandy silt would be categorized as a silt. If necessary, two or more colours may be used. When annotating a cut number, it is useful to make this as a U shape, the sides of the U containing the fill(s) of the cut.

When this process is complete, it will be possible to see crude patterns of context composition and type in the stratigraphic sequence. The colour coding of the site matrix may be used as the basis for establishing Context Sets. On each strand of the matrix, short sequences of contexts with the same coding exist. These sequences may then be examined to establish Context Sets.

It must be emphasized that the code groupings do not represent Context Sets by themselves; at this stage, although using the colour codes as a guide to the establishment of Context Sets, it is imperative to assess the nature of each context and its intepretive relationships to other contexts within the Context Set. For example, a cut and its fills, normally representing a Context Set, may represent a robbing cut (sometimes representing two activities), or the fills of a cut plus slumping of overlying deposits, etc.

Text sections for each Context Set may then be prepared; each Set should be given an individual number, its constituent contexts listed and described, and a discussion written where appropriate. This should document the rationale for forming the Set, any problems encountered and the manner in which they were resolved, and any interpretation based on the information presented in the Set. It is important that any interpretation should be based solely on the evidence presented in the Set description, without reference to other parts of the stratification. These Set descriptions may then be brought together to form the basis of the Context Group descriptions. It is at this stage that one may consider the preparation of the final stratigraphic report.

The final report

The structure of the stratigraphic report will be largely dictated by the group hierarchy. Thus the bulk of the report will consist of the description and discussion of each Context Group, with additional discussion contained within the Inter-Group Discussions.

It is important to keep in mind that as this is a stratigraphic report, arguments of interpretation and inference should be based on stratigraphic criteria, rather than also employing artefactual data. The analysis of artefacts employs a different set of assumptions and interpretive methodologies to stratigraphic analysis, and at this stage the two should be kept separate. Failure to do this may result in problems such as 'circular' interpretive statements, e.g.: 'this pottery is ninth century because it came from Group IX'; 'Group IX is ninth century because of the pottery dating'.

Comparing and contrasting the results of different types of analyses will result in a final synthesis of the evidence which will ultimately form the published report.

The stratigraphic report should consist of a summary of the interpretation of the site, the site matrix, a Group matrix, and an introduction describing both the circumstances of the excavation and a general review of the site archive and the procedure employed for its analysis.

The Context Groups should be presented in stratigraphic order, starting from the earliest Group and moving to the latest. If the Group matrix is multilinear (Harris 1984), then each unilinear strand should be described in turn.

The Group descriptions should follow the following format: the Group number; a list of constituent contexts in numerical order; any illustration numbers; the matrix for the Group, linked through to other Groups; the Group description; and the Group discussion.

The description of the Group would be quite distinct from the Group discussions. Each context should be fully described, and the text should be written in a narrative style, using relational verbs to link the individual context descriptions. A simple list of detailed context descriptions is difficult to read, and usually hard to understand without a descriptive narrative linking them together. If context descriptions have been uniformly recorded, it may be appropriate to separate the detailed descriptions from the narrative text; this approach has been adopted by the Museum of London (e.g. Steedman 1985). However, experience has shown that context descriptions in many archives vary so much in nature that this approach is often not suitable.

Although Context Sets are not explicitly recognized in the stratigraphic report, it is advisable to divide the descriptive text into subsections based on the Sets.

A composite plan should be prepared for each Group; for more complex Groups more than one may be needed. These plans may be supplemented by elevations and sections where appropriate. The close association of plans and text remove the need for exhaustive spatial information in the text, although the depth of cuts and deposits should be noted. If standard information is lacking (such as context descriptions or depth of cuts), then this should be clearly stated to remove any ambiguities from the reader's mind.

The discussion and interpretation of the Group should be based solely on the preceding description; no new information should be introduced in discussion, and references to other Groups kept to a minimum. The relationships between Groups should be discussed in the Inter-Group Discussion. These do not involve the presentation of new information, and so may be simply preceded by a list of the Groups referred to. Accompanying plans may aid comprehension of the discussion.

The report should finish with a general discussion of the site, and relevant acknowledgements. A context index should be prepared allowing easy access to the description and interpretation of any individual stratigraphic unit.

Towards publication – integrated post-excavation analysis

The manner in which archaeological excavations should be published, especially large and complex sites, is still a matter of debate in British Archaeology, which has not yet been adequately resolved. However, there is clearly a logical need to assimilate and synthesize the results of stratigraphic, artefactual, documentary and environmental analyses into an integrated report.

As has been observed in this paper, the different theoretical and methodological approaches to different kinds of data has meant that their respective analyses, in general, have been kept separate. Once these analyses have been completed, their results are compared and contrasted, ultimately resulting in a synthesis of the whole range of information from a site. However, there clearly must be some information exchange between specialists before their work can be completed; artefact analysts need information on 'phasing' at the very least, whilst environmental specialists need information on the nature and status of specific deposits. As archaeologists are becoming increasingly aware of the importance of deposit formation processes (Schiffer 1987; Clark 1988b; Janaway 1987), the need for an inter-disciplinary approach to archaeological analysis has become recognized. This can place a strain on the methodological and procedural aspects of post-excavation analysis.

Financial constraints on post-excavation projects also mean that the results of different analyses are often not *synthesized in depth* (i.e. at the context level); synthesis may take place only at the broadest level of interpretation. On small or medium-sized sites, the project logistics may allow on-going synthesis in depth, but this is usually on an *ad hoc* basis, with no clear understanding of the theoretical or methodological basis of such a procedure. On large sites the problem becomes more apparent; attempts have been made to integrate different kinds of evidence to allow synthesis in depth, with varying degrees of success (e.g. Carver 1980), but integrated post-excavation analysis remains a problem at both the conceptual and procedural level.

The series of procedural steps in stratigraphic analysis outlined above have been documented more fully for SUAT post-excavation projects (Clark 1988a). The recording and analysis of other types of data has also been broken down into a series of logical procedural steps (SUAT 1988b, 1989c).

The identification of discrete stages in each type of analysis allows information to be exchanged between specialists at particular points in their respective studies. Although this process and its schedule is not yet formalized, it is expected that this will allow synthesis in depth to take place during the course of post-excavation analysis. To help cope with any logistic problems this approach may cause, an *Integrated Archaeological Database* is being developed on a networked computer system to allow easy access to all types of data (Stead 1988).

Whilst it is expected that this holistic approach will greatly improve our comprehension of archaeological phenomena, the reservation remains that the different methodologies and assumptions implicit in different types of analysis should be kept separate. Thus, while information derived from pottery analysis may highlight problematic areas in the stratigraphic analysis, or even suggest the resolution of ambiguities in the stratigraphic records, any conflict of results should be presented as such, and discussed at the appropriate point.

This approach does widen the responsibilities of all the specialists involved in the analysis of archaeological stratification; artefact analysts should be aware of the complexities of the stratigraphic sequence (if only as represented by the Group matrix), rather than relying on rigid, site-wide 'phases' or 'periods', as is often the case. Equally, stratigraphic analysts should be aware of the implications of artefact studies in understanding the formation processes of the strata they are studying. It is a difficult problem, but some steps are being made to address this aspect of post-excavation analysis.

Stratigraphic analysis has been a much neglected aspect of archaeological endeavour in the literature; whilst excavation techniques have been discussed at some length (e.g. Barker 1977; Jeffries 1977; McIntosh 1986), post-excavation methodologies have received little attention (but note Bishop 1976; Carver 1979; Dalland 1984).

The separation of excavation from post-excavation work is an unfortunate one, as the two processes are clearly intimately related. Involvement in post-excavation analysis is of inestimable value in the training of field excavators; all too often site records are compiled with little understanding of the purpose or 'analytical destiny' (Carver 1985: 50) of the information being recorded.

It is encouraging to witness the increasing concern with the methodologies of post-excavation analysis, and the beginnings of discussion and debate in the literature (e.g. Schofield 1987). Through this debate, it is hoped that the problems encountered in backlog archives will not appear in future site records.

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Index