USES OF AN ARCHAEOLOGICAL DATABASE - WITH PARTICULAR REFERENCE TO COMPUTER GRAPHICS AND THE WRITING-UP PROCESS

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Computers are at last beginning to have an impact on the work of field archaeologists. They will finally come of age when archaeological databases are integrated with computer graphics systems, enabling the computer to be used at a basic level to help produce the structural analysis of the site. This paper gives an outline of such a system but concentrates upon those aspects concerned with the production of archaeological phase plans. As it is, the system is designed to be of use to field archaeologists. Basic explanations of computer techniques are given and aspects of archaeological methodology have been included.

The use of computers is justified if they contribute to the reduction of report writing costs and/or an increase in data information retrieval. These aims are best achieved when site records are in a form easily compatible with computing, and where the basic site data are of such a size and/or complexity as to make manual data manipulation very time consuming.

Large urban sites are ideal candidates for computer analysis (Flude 1980). The complex of archaeological deposits, intercut by later intrusions (such as pits and foundations of all periods), produces multiple physically unrelated sequences. The interpretation of such sites depends upon determining sequence correlations by context comparisons based on a consistent recording system which is itself ideal for computer processing.

The system described here was designed to fit the recording methods evolved over several years by the Department of Urban Archaeology, in particular on the 5 year excavation of the G.P.O. site, Newgate Street, London EC1. To date the graphics system is complete and the database set up but considerable work is necessary to complete the whole system. Each context (archaeological recording unit) is individually described and drawn according to the Museum of London's Site Manual recommendations. Over 10,000 contexts for this site were recorded on 31 context sheet files and 26 plan files. Such a system could help in the production of a Frere level III report and materially aid the field archaeologist in site interpretation.

The following sections examine how basic categories of an excavation record can be input to the computer and can be used to interpret a site.

Spatial data

The basic recording unit is the 1:20 plan of each context. Combining these plans into composites can be used to show the relationships existing between contexts and is a fundamental techniques of writing-up. Plans are computerised by the translation of the outlines into a series of discrete points represented by coordinate pairs. This 'digitising' process can be carried out by a number of methods including photographic image analysis, manual creation of coordinate pairs or, most commonly, using the digitising table. The digitiser automatically records onto an appropriate computer readable medium such as paper or magnetic tape, computer file, etc., the coordinates of a point on the table as defined by the sights of the device.

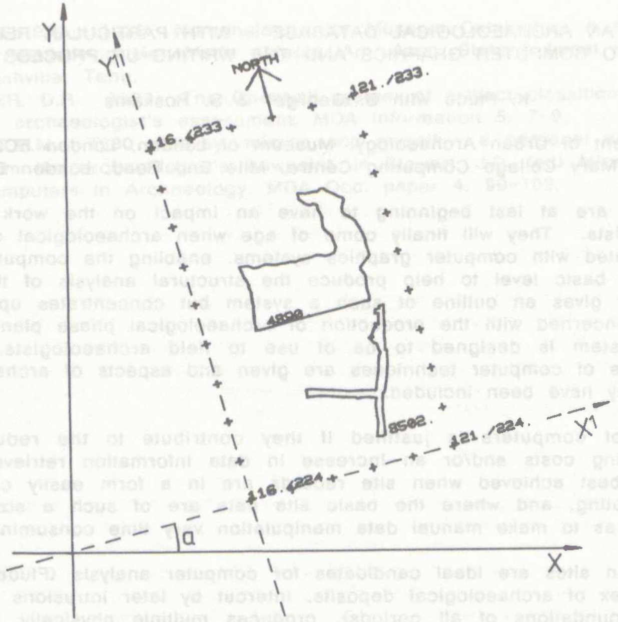


Figure 1: Transformation of digitised coordinates (X ,Y) into site coordinates

Having recorded an outline as a series of points, it is necessary to transform the digitised coordinates into oriented site coordinates, since the digitiser returns coordinates relative not to the site but to the table onto which the plan is unlikely to have been placed squarely. This transformation is achieved by simple trigonometry (Greer & Hancox 1978) using the reference points in lines 3-6 of Table 1 (see Fig. 1) since:

$$\text{angle } A = \text{inverse Tan of } \frac{XSEref - XSWref}{YSEref - YSWref}$$

such that:

$$X' = X \times \text{Cos}A + Y \times \text{Sin}A$$

$$Y' = X \times \text{Sin}A - Y \times \text{Cos}A$$

Similar transformations are used to determine the placement of hachure-heads indicating the direction of slopes. (see Fig. 2).

Figure 2: Illustration of the use of hachureheads.

The next stage in the production of an outline is the drawing itself. Basic GINO (a computer graphics package) drawing routines are used (C.A.D. 1976). For example:

CALL MOVETO2 (50.0, 20.0) - which moves the pen to coordinate point X=50.0, Y=20.0

CALL LINTO2 (60.0, 100.0) - which draws a line from the present position to X=60.0, Y=100.0

If sufficient well-selected points are chosen along an outline it is possible to represent a curved line accurately by a series of straight lines (see Fig. 1). The presence of sharp corners, however, makes the use of smoothed curves problematic.

Table 1: Part of the computer file for an outline plan

0		indicates context number is under 10,000							
4890		context number							
0116	0228	south-west coordinate of plan							
2584	1261	equivalent digitiser coordinates (XSWref, YSWref)							
0121	0228	south-east coordinate of plan							
5084	1293	equivalent digitiser coordinates (XSEref, YSEref)							
0116	0233	north-west coordinate of plan							
-2		tells computer to draw solid line							
3193	1273	3200	1325	3204	1376	3211	1414	3211	1414
3218	1458	3227	1501	3233	1544	3249	1579	3241	1636
3230	1651	digitiser coordintes of outline plan							
-1		tells computer to draw dotted line							
		additional coordinate data							
-7		tells computer to draw hachure							
		additional coordinate data							
-8		end of context data							
		next context							
-9		end of data							

The program for plan production is written in FORTRAN and incorporates a number of options including:

(i) dashed or solid lines (see Table 1)

(ii) output to a graphics screen, paper plotter (up to 1m wide), microfilm plotter, etc.

(iii) a number of additional draughting options such as the position of the North point, Title, etc.

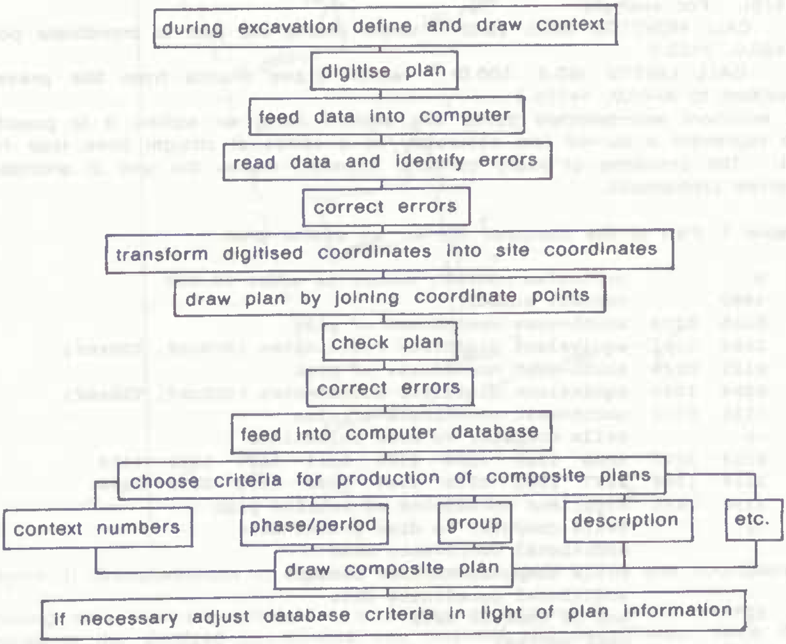
(iv) at present context numbers are positioned by the computer, this occasionally creates legibility problems (see Fig. 5) but optional positioning will be included in future developments.

Combining digitised outlines enables the computer to draw composite plans automatically (see Table 2). These can be used to support archaeological correlations, groupings and phasings, and to document both decisions made and alternative hypotheses. Such a system is most useful when the graphics system is linked to the excavation record database as it is then possible to produce any composite plan almost at the touch of a button simply by choosing variables from the database and plotting the appropriate context plans!

Context descriptions

An underlying principle behind context descriptions is that, other things being equal, contexts with a similar description are more likely to be contemporary than contexts with a dissimilar description. However,

Table 2: Stages in the production of computer-drawn composite plans (adapted from C.A.D. 1976).



descriptions may vary due to a number of factors including:

(i) individual variation in context descriptions
(ii) differing conditions during context description
(iii) variability within a single context

The recording system should minimise such variation since ultimately correlation must be based on these context descriptions.

As context descriptions must be standardised prior to data input use of a computer does make the data more easily comparable and the output of data can be tailored exactly to the user's requirements. It also reduces cross-referencing between files and precludes the examination of contexts without a defined similarity to the description in question. Thus the computer makes the production of all possible comparisons simple and by making any comparative decision explicit helps to make it more objective.

The data from the context descriptions are fed into a CODASYL IDMS database (Integrated Database Management System) written in COBOL. This reflects the heirarchical structure of the data (see Table 3), and is particularly useful for handling large datasets since it reduces the time taken to find a particular record. Thus, for instance, all contexts in a given Building number can be located by simply finding that number among the numerically ordered Building Group records instead of by a sequential search through the whole Context file.

The basic descriptions held in the database are shown in Table 4. Because of the storage space limitation for this test database, it has been necessary to adopt a four letter basic descriptive code for most items but this is easily read. For example:

context-no = 10430 kind of type = CUT interpretation type = PIT

ITEM-DESCRIBED	SHAPE	REGULARITY	LENGTH or GRADIENT	SHARPNESS of CORNERS
TOP	RECT	REGU	04.00:02.00	SHAR
SIDE	CONC	IREG	90.00:00.00	ROUN
WEST	CONV		80.00:00.00	
EAST	UNSP		70.00:00.00	
BOTT	UNDU			etc.

Table 3: Excavation record database structure (arrows originate at OWNER and point to MEMBER record of a set relationship).

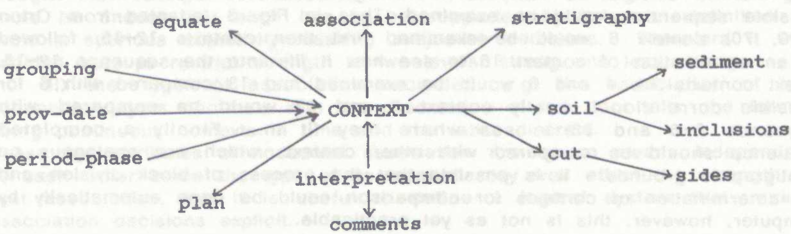
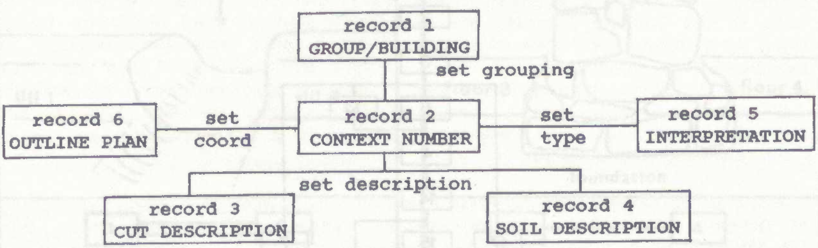


Table 4: Records and sets from the G.P.O. database.



Temporal data

Temporal information can be divided into relative dating provided by stratigraphic relationships and 'absolute' dating provided by finds and scientific dating methods. Because the Department of Urban Archaeology had an extensive backlog to deal with, the test database does not yet comprise a comprehensive finds catalogue but is restricted to recording a provisional date for each find context as determined by finds staff from a provisional analysis of the dating evidence from each context (work is currently in progress on the computer finds catalogue).

Stratigraphic relationships are recorded as they are discovered on site and formed into a site matrix which is then recorded into the database (Harris 1979). If a graphics terminal is available on site it can help to check visually which plans overlap and hence have a direct stratigraphic relationship. This could also be done mathematically but would probably require an excessive amount of computer memory. Computer-based methods of site matrix production for error checking and navigation through the matrix are currently under investigation.

Site Interpretation

Once the final site matrix is produced, barring unsuspected error, the writing-up process can begin. It must be rigorous, consistent and objective.

In making comparisons an examination of the basic descriptions should ignore any preconceived ideas suggested by the use of such words as 'floor sill, destruction debris, etc.' in the interpretative comments attached to the context file.

Context analysis should be determined strictly by position in the matrix. Initially the matrix is divided into groups or BLOCKS. Ideally a block is an arbitrary group of contexts in one sequence bounded by a common context at top and bottom. Where this is not possible, the nearest approximation to this method should be adopted. Having isolated a block, the longest possible sequence should be examined. Thus in Fig. 3 (adapted from Orton 1980, 70) context 8 would be examined first then contexts 12-15, followed by an examination of context 16 to see how it fits into the sequence 12-15. Next contexts 14, 4 and 6 would be examined and 13 compared with 6 for possible correlation. Lastly context 7 and 17 would be compared with sequence 8-6 and 13 to see where they fit in. Finally a completed sequence should be compared with other contexts which are analogous on stratigraphic grounds. It is possible that the process of block division and the determination of contexts for comparison could be done automatically by computer, however, this is not as yet practicable.

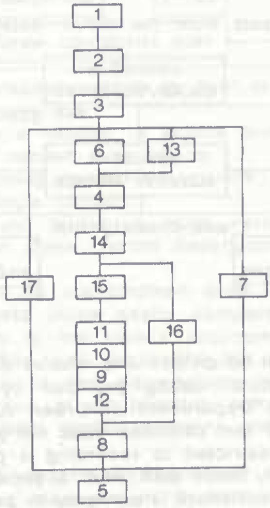


Figure 3: Sequence diagram of a simple site.

The computer can expedite matrix analysis of a large data file such as that from the G.P.O. site. The most appropriate correlations of potentially contemporary context descriptions can be selected by the computer for the user. The validity of a correlation can then be checked by juxtaposing the relevant plans and context descriptions. Since contexts are rarely compared in numerical order the logistics of manually filing and cross-referencing a large data file are daunting and can be done more efficiently by computer.

An additional advantage of the computer database is that decisions made, whether provisional or not, can be added to the database. For example, the grouping, period-phase, equation or association of contexts. This important aspect of database system analysis makes decisions explicit and can, therefore, be used to check their internal logic. If an illogical decision is detected by the system the user must then make an explicit choice between conflicting interpretations.

The basis upon which equation and association of contexts is made must also be made explicit for the computer system. These are shown in Fig. 4 and are input to the computer using a numerical code.

Association between contexts can be analysed from more than one standpoint:

(i) the 'strength' of association. Any number of degrees of strength could be chosen but each has to be supported by its strict definition to avoid a spurious objectivity masking subjective decisions. Therefore it was decided here to restrict strength to two levels: strong and less strong.

(ii) the 'type' of association recorded, e.g. the association of two occupation layers contrasts with the association of two door sills, the former being continuous contexts in time and the latter discrete.

These two attributes of horizontal association are by no means independent of each other since the type of association may well affect the strength of that association, but it is useful to define a logical system that makes association decisions explicit.

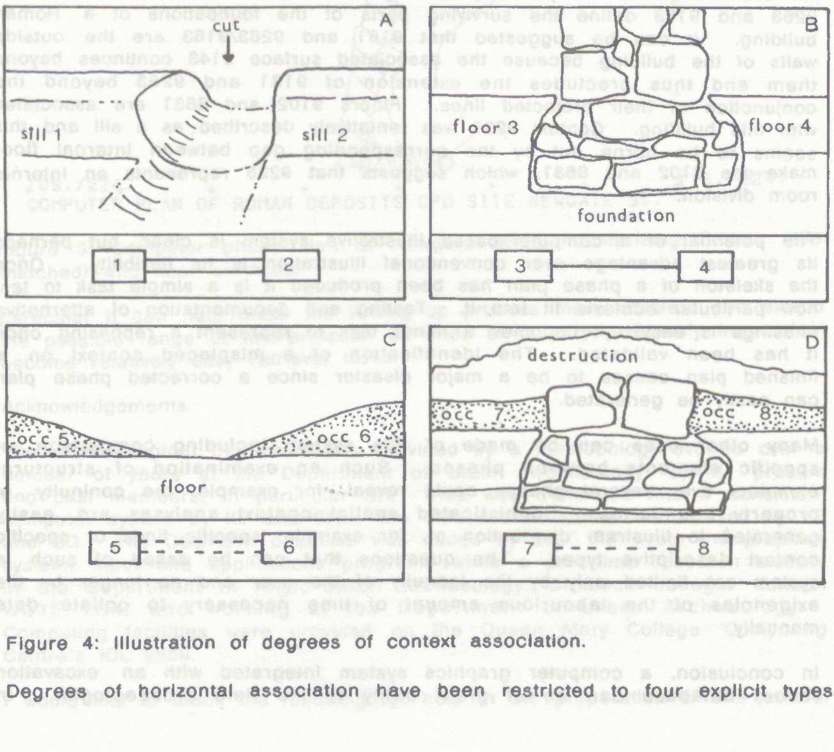


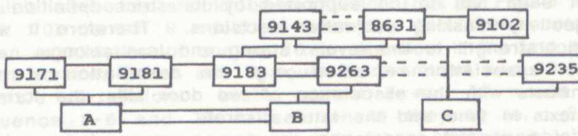
Figure 4: Illustration of degrees of context association.

Degrees of horizontal association have been restricted to four explicit types which are illustrated in Fig. 4. It is implicit that the association between sills 1 and 2 in Fig. 4(a) is stronger than that in Fig. 4(b) between floors 3 and 4 which might belong to two different constructional phases; this association is stronger again than that in Fig. 4(c) between the debris of occupations 5 and 6, while the association between occupation layers 7 and 8 in Fig. 4(d) is weaker. The strength of an association is suggested by the number and solidity of the lines joining the context numbers.

Once these association decisions have been made and checked complete phase plans can be produced. These can be based on a number of criteria such as:

(i) a list of contexts
(ii) all contexts associated or equated together
(iii) contexts from a given phase or group

For example Fig. 5 represents the following context associations:



It is, of course, also possible to reduce a phase plan to its component parts to examine their articulation.

An examination of the phase plan (Fig. 5) reveals that sills 9171, 9181, 9263 and 9183 define the surviving parts of the foundations of a Roman building. It can be suggested that 9181 and 9263/9183 are the outside walls of the building because the associated surface 9143 continues beyond them and thus precludes the extension of 9181 and 9263 beyond the conjunction of their projected lines. Floors 9102 and 8631 are associated with this building. Context 9235 was tentatively described as a sill and this seems to be borne out by the corresponding gap between internal floor make-ups 9102 and 8631, which suggests that 9235 represents an internal room division.

The potential of a computer-based illustrative system is clear, but perhaps its greatest advantage over conventional illustration is its flexibility. Once the skeleton of a phase plan has been produced it is a simple task to test how particular contexts fit into it. Testing and documentation of alternative phasings is easy. It becomes a minor task to represent a rephasing once it has been validated. The identification of a misplaced context on a finished plan ceases to be a major disaster since a corrected phase plan can easily be generated.

Many other uses can be made of this system including comparison of specific elements between phases. Such an examination of structural elements over several phases could reveal, for example, the coninuity of property boundaries. Sophisticated spatial context analyses are easily generated to illustrate distribution of, for example, specific finds or specific context descriptive types. The questions that can be asked of such a system are limited only by the igenuity of the user and no longer by the exigencies of the labourious amount of time necessary to collate data manually.

In conclusion, a computer graphics system integrated with an excavation record database can be of great utility to the field archaeologist. In

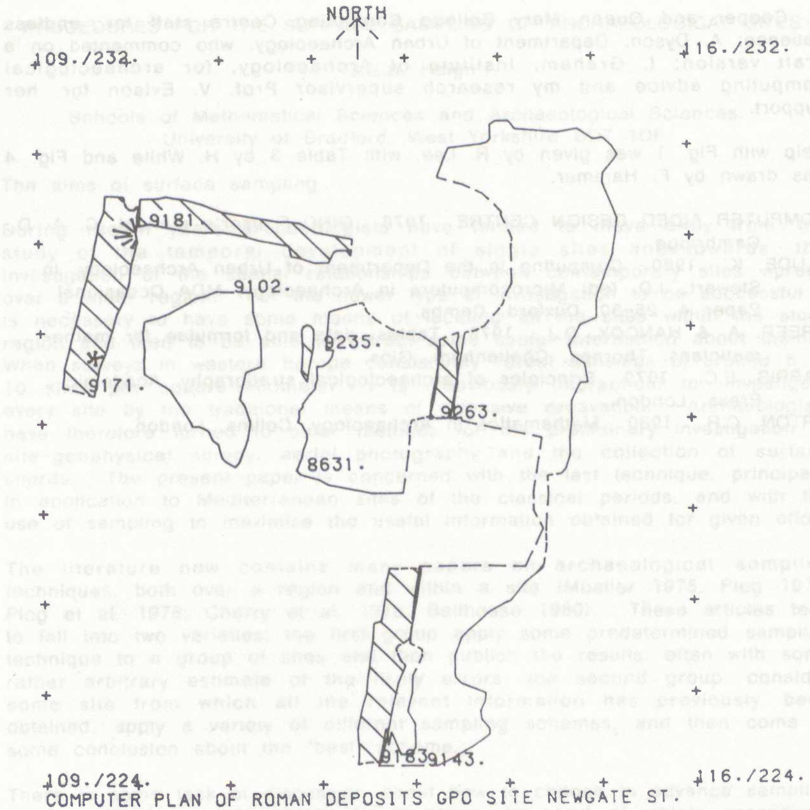


Figure 5: Computer phase plan of Newgate Street, comprising Roman sills (hatched) and floor surfaces.

particular it can help make the writing-up process more efficient and extend the possible range of interpretation as lines of enquiry previously impractical become relatively easy retrieval tasks.

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