From Field Books to Powerbook

Computer Applications and the Promontory Palace of Herod the Great

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Abstract: Since 1976, the Hebrew University of Jerusalem and University of Pennsylvania Museum's joint excavation of over fifty trenches has revealed the promontory palace built by Herod the Great at Caesarea Maritima, Israel. Foremost among the many tasks that now face the excavators is a site-wide analysis of the stratigraphy. During the author's study of the destruction of the palace, the analytical and visualization capabilities available through traditional stratigraphic analysis incorporating Harris Matrices and CAD plans of excavated loci proved limiting because of the size of the data set. To address these limitations, a GIS combining the most desirable quantities from both approaches was created. This has allowed for the creation of an intra-site database, as well as the examination and visualization of stratigraphical relationships in three dimensions. The project is still underway, but this paper discusses the process that brought the excavation team to the present point and the difficulties that were encountered along the way.

Keywords: Caesarea, Promontory Palace, Herod, GIS, intra-site analysis, 3D, Harris Matrix, stratigraphy

Introduction

The accurate recreation of excavated stratigraphy in three dimensions continues to be an important goal for archaeologists. The possibilities for utilizing a GIS to accomplish this goal have been previously discussed by Trevor Harris and Gary Lock (Harris and Lock, 1996). Among the different solutions proposed and attempted by others since then are those incorporating various 3-D modeling programs, such as the project currently being undertaken as part of the Brown University excavations at the Great Temple, Petra, Jordan (Vote, et al., 2001). Recent work on the creation of an analytical tool for the University of Pennsylvania's excavations at Herod the Great's Promontory Palace in Caesarea Maritima has shown that another possible solution is to combine a site-wide Harris Matrix with an intra-site GIS using the 3-D capabilities of ArcView's 3D Analyst extensions.

The promontory palace at Caesarea Maritima, Israel, was built in two stages in the first century BC. The first, the Lower Palace at sea level, was excavated in 1976 by Ehud Netzer and Lee I. Levine of Hebrew University, Jerusalem (Levine and Netzer, 1986). They revealed the remains of a palatial complex surrounding a rock-cut pool (fig. 1). In 1990, Kathryn Gleason and Barbara Burrell of the University of Pennsylvania Museum joined Netzer to resume excavations on the top of the promontory, where they discovered an attached Upper Palace (Gleason and Burrell, 1998) (fig. 2). In 1992, Burrell and Gleason assumed the excavation license and carried out annual excavations until 1996. In 1997, they began a series of annual study seasons that have continued until the present.

By 2000, work done on the promontory palace had produced a very large data set. Analysis of this data set was complicated by the fact that the 1993-1996 excavations had been carried out under "rescue" conditions in advance of the development of major new tourism facilities within this portion of the Caesarea National Park. There were also records that had been made under less than ideal conditions, such as a series of photographs and sectional drawings of the long baulks left standing at the end of the 1994 season just before they were bulldozed for development.

In most respects, however, the excavation continued as it had before the 1993-1996 seasons. For example, one procedure that forms a basis for this study is the "overlay" system, in which each member of the staff recorded in plan view each locus or stratigraphic unit excavated in their trench. In many cases these plan views are complete with elevations. As part of the plans for publication, these drawings, photographs, and overlays needed to be correlated with the trench stratigraphy.

Objectives

One of the main objectives of this project has been an analysis of the relationships both among the individual trenches and between these trenches and the site as a whole using the sources discussed above. The analysis of each of these pieces of data has presented unique challenges requiring specific solutions. The photographs of the long baulks taken at the end of the 1994 season show continuous stratigraphy across the majority of the site. However, no one excavator had dug all of the trenches along a full length of baulk and not all of the baulks had been drawn along any particular transect. To prepare the excavation for publication, the author was asked to develop a site-wide Harris Matrix. Along with defining the exact limits of the different strata found on the site, such as the destruction layers being studied by the author, the Harris Matrix was to provide the excavators with the means to confirm or disprove ideas that had been forming throughout the years concerning the phasing of the architecture. For example, was the destruction of the palace complex was wholesale, or piece by piece?

Process

To produce this Harris Matrix, a windows-based Harris Matrix program, ArchEd, was employed. Unlike many flow-chart design programs, ArchEd allows the user to add as much information as needed for each excavation unit or locus, such as information concerning shape, elevation, contents and date, without necessarily affecting the initial appearance of the rectangle or oval representing that stratum. Instead, by clicking on the appropriate locus, information about elevation, soil type, content, and date can all be added in a separate window that appears on the screen (fig. 3). This feature allowed the incorporation of all relevant data into each particular locus. This data, organized by locus and in its stratigraphic context, could then be shared with all of the other excavators working on the analysis of different aspects of the excavations.

The first step taken was the creation of separate matrices for each of the individual trenches excavated over the six field seasons of the Penn Project (1990-1996). Information from the excavators' field books and locus sheets such as that described above was added to each locus using the inherent capabilities of the ArchEd software. At this scale, the program proved completely adequate.

The next step was to combine these individual matrices with neighboring trenches linking similar loci into continuous strata across the site. This proved especially feasible in the upper strata of the excavated area that were consistent across the whole site. Once all of the neighboring trenches had been combined, the goal was to create one large, site-wide Harris Matrix. This method was at first attempted when all of the loci from the Lower Palace excavations had been entered into the computer. Unfortunately, this was the point at which the software proved somewhat limiting. In order to combine matrices, for example two separate matrices from neighboring trenches sharing the same stratigraphy, first one file and then the next had to be exported from ArchEd to a text-based program such as Notepad. Once this was done, the information from one Harris Matrix in text form could be copied and pasted into that of the other file. The new combined text file was then re-imported into ArchEd where the two matrices appeared side by side. They could then be joined manually at the appropriate loci. Unfortunately, when combining matrices, not all of the information attached to a particular strata or locus concerning date or contents was exported with all of the other information. concerning the placement of that particular locus within the actual Harris Matrix. In addition, exporting and re-importing the files erased any changes made to the dimensions of the shape representing any particular locus. As a result, any data associated with individual loci that the user wanted to have within the larger matrix had to be recopied each time that the matrix was enlarged in this manner.

This problem may prove to be a stumbling block for some projects, but is in no way insurmountable if one has enough patience and manpower to cut and paste the lost information into the new diagram and to double-check the relationships established between these loci. If one is willing to work with a skeleton Harris Matrix, serving only as a visual aid, these issues likewise cause no problems. However, since part of the excavators' intention was to use the Harris Matrix as a repository and source for information about each locus, the information was needed. It is for this same reason that simply re-drawing an increasingly larger Harris Matrix was not a viable option.

Another difficulty encountered was that of the correlation of the loci within the Harris Matrix with their physical location on the site. As more and more loci were entered into the computer, the number of components in the Harris Matrix naturally increased. As the site-wide matrix grew, it became increasingly difficult for users to relate different loci with their actual in-situ location through the Harris Matrix alone. This proved true even though one can include information such as location, soil type, and/or date into the label of the locus to avoid the need for continual clicking back and forth within ArchEd. Still, the team eventually reached the point where we thought it would be really useful to be able to see the location of these loci on-site as we examined the information being provided by the Harris Matrix, especially since there were already so many different loci to account for, and this number would only continue to grow as more loci were added.

To resituate the loci onto the site, the plan views or overlays of the different loci that had been drawn during excavation were added onto the existing AutoCAD site map. To handle the large number of layers within AutoCAD that this process required, the site was divided into a number of areas and each of the plan views was drawn separately onto the appropriate one. Separate files could then be associated with one another to get a view of the stratigraphy over specific areas of the palace. In addition to allowing users to view the loci in their original locations within the site, this regrouping facilitated interpretation of the architecture.

Analysis

Initially, the AutoCAD program proved sufficient to run the sorts of analyses that we were interested in for the lower palace. Once all of the loci for the lower portion of the palace had been entered, the plans could be cross-referenced with the information on the Harris Matrix. The analysis we were most interested in at the time involved the *terminus post quem* for each of the loci covering various walls and therefore indicating the destruction or cessation of different rooms of the Lower Palace complex. To do this, information concerning the dates of individual loci from the Harris Matrix covering the lower palace was used to select which layers to leave on and which to turn off. After all of the loci with the selected date had been turned on and all others turned off, the resulting image could then be exported from CAD and another date could be selected. This was done for loci dating to the 1-2 centuries AD, the 2-3 centuries AD, the 3-4 centuries AD, and so on, based on the pottery readings.

To work with the information stored in the Harris Matrix, it was necessary to print hard copies of the Harris Matrices. One subsidiary issue then became the display of the date of each locus on these hard copies. The dates were indicated in one of two ways: 1) printing out the matrices as they were and hand-writing the dates next to them; or 2) adding the date of each locus to the locus' label and then printing out the matrices.

In the end, all of the CAD images that had been exported were arranged in chronological order in a simple slide-show presentation to show the chronological progression of the strata across the Lower Palace. Viewing the strata in this way allowed the excavators to confirm some of their earlier suspicions. As mentioned, because of the nature of the dig, the excavators had assumed that something interesting was going on here, but until we had performed this analysis, the patterns were somewhat speculative.

At this point, the next difficulty was recognized. Once the other five years worth of excavation data representing the loci covering the Upper Palace (eastern area of the site) was entered, this method of analysis, that is, selectively turning different CAD layers on and off depending on the criteria selected for would become more complicated, not to mention time consuming, considering the thousand or so loci excavated. At the same time, it became clear that by turning these different AutoCAD layers on and off in the way that we had done, we were essentially mocking a GIS analysis. So, we decided to move ahead with a site-based GIS.

The GIS and its Results

To begin, the drawings and the data for the loci covering the lower palace were imported into ArcView. The data from the Harris Matrix for each locus was then added to the appropriate field in a theme table. The result is an intra-site database in which each locus is considered an individual entity with specific identifiable characteristics. Analyses can be performed by querying these characteristics. This type of analysis provides much quicker results than the previously mentioned CAD method. In addition, by utilizing ArcView's 3D Analyst extension, we not only have the option of seeing these results in plan view, but in 3-dimensional space as well. This can be done by creating a 3D-shape file from the 2D-shape file resulting from any particular query, and assigning the elevation of each strata as the attribute from which the z value is selected (figs 4-5). By doing the same to the architectural elements and then extruding them by subtracting their elevation from the maximum z value, we can create solid architectural blocks and see their relationship to the loci in 3-dimensional space (figs 6-7). Should it be desired, the depth of individual loci can also be seen in 3D by entering the depth into the appropriate theme table as the loci's thickness and then extruding the loci by subtracting the thickness from the maximum z value. In cases of complex stratigraphy, relationships can also be exaggerated vertically to create a clearer picture. These results can in turn be compared with specific Harris Matrices to clear up stratigraphical relationships on a site-wide level. This is especially important for our goal of examining architectural phases and determining when walls/rooms were covered and out of use. Once more data is entered, we will be able to recreate the surfaces of the different strata and see how they relate to the architecture across the site.

Conclusions

Although not part of the original research design, an intra-site GIS is proving to be an important analytical tool for stratigraphical analysis at Caesarea Maritima. The results are preliminary, but already suggest a pattern of inhabitation and abandonment in the Lower Palace that is somewhat different from the original interpretation of the excavators (Burrell, Gleason, Netzer 1993). The distribution of loci seen in the GIS images suggests that the northern area of the building had a longer, more complex history than the southern portion. This pattern needs further evaluation before a final interpretation can be made, but clearly the process is giving us the kind of complexity and specificity needed at this stage of the project. GIS has proven to be an exciting and effective tool for intra-site and stratigraphical analysis.

Acknowledgements

The author would like to thank Drs Kathryn L Gleason and Barbara Burrell for permission to work on this material, as well as their advice on this paper; and Dr Bruce Ralston, Joseph D Nigro, and Daniel L Costura for their continued help along the way. This paper was also made possible by generous travel grants from both the Cornell University Graduate School and the Conference Organizers.

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Figures

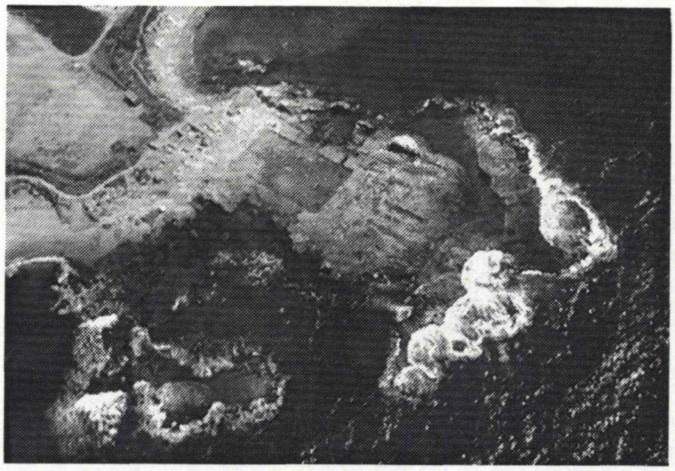

Figure 1. Lower Palace, Caesarea Maritima, Israel

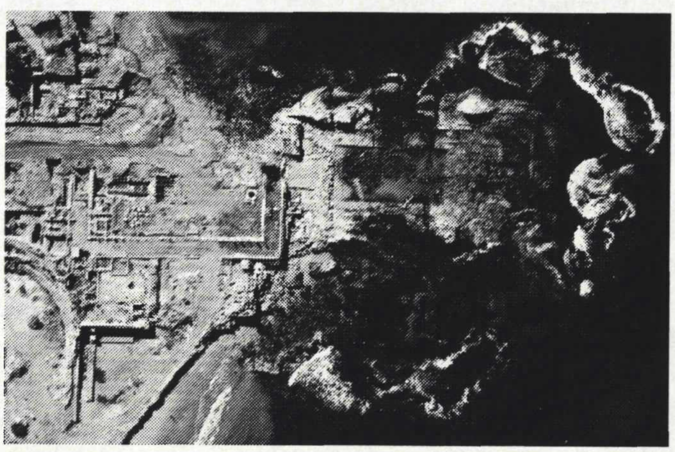

Figure 2. Upper Palace, Caesarea Maritima, Israel

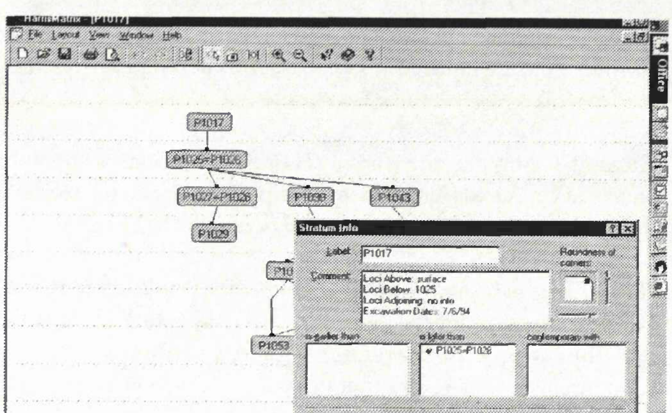

Figure 3. Harris Matrix software

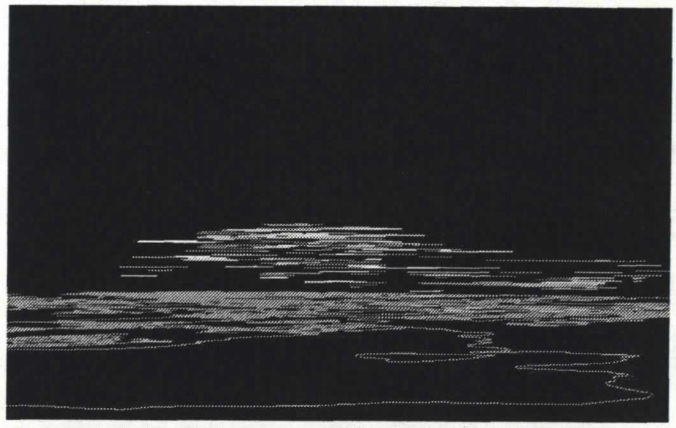

Figure 4. 1990-1992 excavated loci in situ

Figure 5. 1990-1992 excavated loci in situ

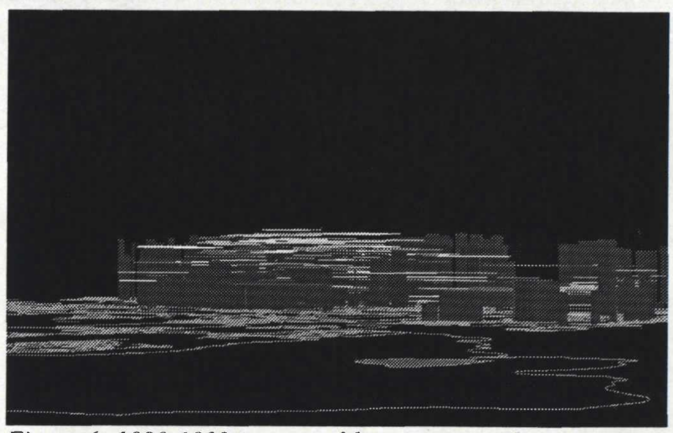

Figure 6. 1990-1992 excavated loci in situ with architecture

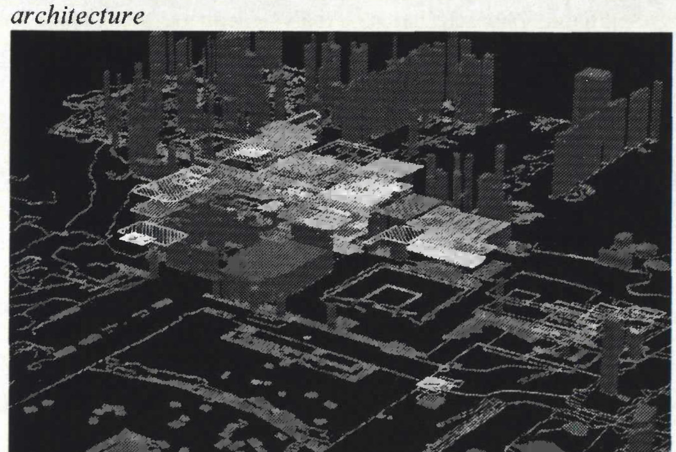

Figure 7. 1990-1992 excavated loci in situ with architecture