Precision, Accuracy, and the Fate of the Data: Experiments in Site Recording at Chersonesos, Ukraine

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Abstract

Advances in technology allow ever-increasing amounts of information collected during excavation to be recorded, stored, and displayed. We still do not entirely understand, however, how technology drives our archaeological agendas. Fundamental questions remain: should we collect infinitely detailed data simply because we can? What are the advantages of changes in archaeological documentation for excavators and future researchers? This paper discusses a GIS-based digital recording system developed during excavations at Chersonesos in Ukraine. In its development and use, we have attempted to assess its strengths and weaknesses, both in the field and for future use by others. Here we outline the results of that assessment and the practical and theoretical advantages and disadvantages of our methodology, focusing on the tension between precision and accuracy created by the combination of high-precision measurements and scalable spatial representation. We further address the relation between methodological choices and assumptions about the future presentation and use of the data.

1 Introduction

Over the last ten years, the application of relational databases and geographic information systems (GIS) to archaeological projects has become routine. Few archaeologists now see this sort of computer technology as a startling (and perhaps suspect) innovation, and many would consider database theory and GIS to be fundamental to current archaeological research. Discussions of theoretical problems associated with the digitization of excavation appear less and less frequently, with the exception of those focused on the longevity and accessibility of digital data. Tools that allow us to organize the massive quantities of information produced in the course of an excavation or a survey and—even better—help us to display those data in attractive and easy-to-use formats are generally taken as an unequivocal good.

There are, however, fundamental questions about archaeological knowledge that any active project must answer: what information do we choose to collect? How do our decisions affect the way we manipulate and interpret those data? What will we do with the data when we stop digging, and how might they be useful to others in the future? These questions become even more important as increasingly powerful digital tools become available and as documentation procedures change more and more rapidly in response to technological advances. When new technology makes it possible to record information in new or different ways, the temptation arises to collect extra data simply because we can, without any particular plan for their future use or clear thought about their utility. In some cases, we are even led to abandon tried and tested approaches to documentation in favor of new technology, without attention to the long-term implications of these changes. At the same time, it is undeniable that advances in our ability to collect and manipulate archaeological information make it easier to recreate archaeological contexts, both with respect to space and with respect to the association of finds. These archaeological contexts are both the primary building-blocks of interpretation and the part of the archaeological record that excavation always and irrevocably destroys. One could argue that any addition to the documentation of context can therefore only be for the better.

Here we discuss our experiences struggling with some of these questions in the field, in the course of an open-area archaeological excavation in the Greek, Roman, and Byzantine city of Chersonesos in Crimea, Ukraine (Figure 1). The project, a collaboration between the Institute of Classical Archaeology (ICA) of the University of Texas at Austin and the National Preserve of Tauric Chersonesos (the Preserve), has been fortunate enough to receive generous funding from the Packard Humanities Institute, which has made it possible for us to apply current digital technology to an extremely rich archaeological record. Our present research focuses on a residential block of the Late Byzantine city, a block that was violently destroyed and subsequently abandoned around the end of the 13th century AD (Figure 2).

Much of the material that occupied the rooms of the houses in this block was left where it lay, and the fire that destroyed part of the block also preserved unusual quantities of organic material. Below these Late Byzantine remains lies a continuous record of occupation stretching back almost 2,000 years. The importance and complexity of contextual relationships in this long-lived urban site, then, cannot be overstated, and we have attempted to use digital tools to capture these relationships in all their subtlety. Specifically, we have used a combination of GIS and a relational database to integrate various sorts of graphic and textual data through

Figure 1. Map showing the location of Crimean Chersonesos.

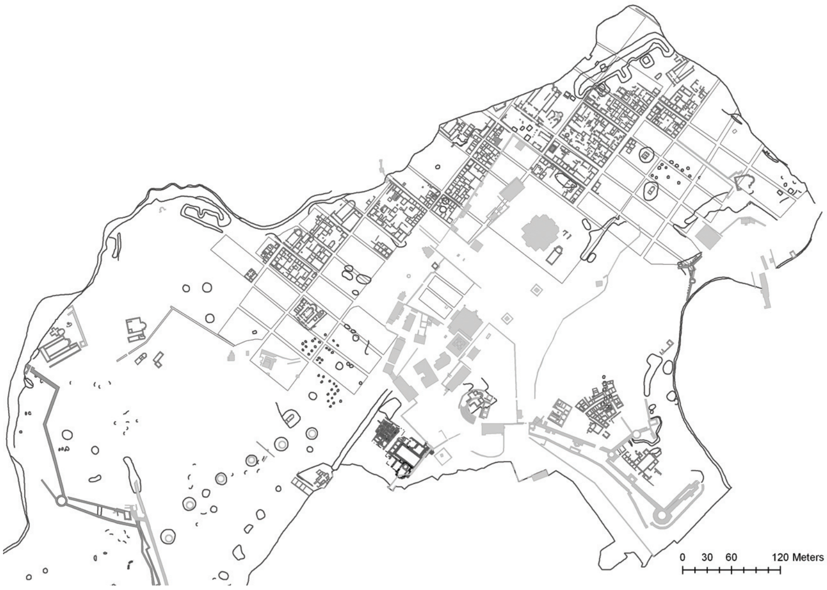

Figure 2. The ancient city of Chersonesos.

the archaeological context or "stratigraphic unit" with which they were associated during excavation, and we have further applied landscape-scale GIS methodologies on an intra-site level. Our use of technology has been broad in approach, but it has relied on well-established and accessible tools and applications. We have deliberately tried to develop a system that could be replicated and sustained locally in Ukraine if desired, without constant financial or technical support from foreign sources. Our surveying equipment currently consists of a pair of Sokkia total stations with separate Carlson data collectors, and we use ESRI's ArcGIS to process survey data. The relational database we use has been custom-built to fit our needs, but it too is now based on a conventional MSSQL database server (using the freely downloadable MSDE version) with a Microsoft Access front-end interface. Our basic documentation is collected on paper according to a single-context recording system widely employed in European archaeology, but such methodologies are well-developed and need no further treatment here (e.g., Spence 1993:23-46). Instead, the following discussion focuses on our attempts to add information and streamline excavation in the field through the collection of additional spatial data and their manipulation in ArcGIS. In our case, this means the incorporation of georeferenced photo mosaics and micro-topographical information for individual layers.[1] In addition to the practical implications of these practices, we will discuss some of the tensions they create on a theoretical level between precision, accuracy, and the potential future uses of the data involved.

2 History of the Site and the Joint ICA-Preserve Project

Chersonesos is located at the southwestern tip of the Crimean peninsula, near the modern city of Sevastopol in what is now Ukraine (Figure 1). It was founded by Greek colonists from the south coast of the Black Sea in the 6^{th} or the 5^{th} century BC and occupied continuously until the 14^{th} century AD. The site has several unique features, chief among which are a vast agricultural territory that preserves its Hellenistic lot and field divisions and the remains of the ancient and Byzantine city, a 42-hectare urban center that was destroyed suddenly and violently in the late 13^{th} century and partially abandoned. The urban area has been the object of continuous archaeological research since 1827, in part as a result of its prominent place in religious tradition—it is held to be the site of the baptism of Volodymyr of Kyiv in the late 10^{th} century, and hence the birthplace of Russian Orthodoxy. In the 19^{th} and early 20^{th} centuries, excavation was relatively unsystematic and focused on ecclesiastical remains. In the Soviet period, however, interest turned to the life and material culture of the ordinary residents of the city and chora, and since then excavators at the National Preserve of Tauric Chersonesos have accumulated an extraordinarily rich body of evidence for life in the Greek, Roman, and Byzantine city and chora (Iakobson 1950; Strzheletskii 1961; Saprykin 1994; Nikolaenko 1999; Carter et al. 2000; Carter and Mack 2003; Romanchuk and Heine 2005; Zubar' 2005).

Excavation practices at Chersonesos have traditionally paid a fair amount of attention to spatial context, at least with respect to individual built spaces and "culture layers." Reports, however, tend to be highly synthetic, and it is the interpretive and comparative material that excavators normally present in publications of their work. Open-area excavation and single-context recording systems were not practiced in the Soviet period, and such methods were applied at Chersonesos only after the beginning of what is now a 12-year collaboration between the NPTC and ICA. The fall of the Soviet Union and Ukrainian independence brought significant shortages of funds for even the most basic aspects of the Preserve's work, and consequently it also fell to the joint project to introduce the total station and archaeological computing. The system that the joint project in the city currently employs, therefore, represents a major change in archaeological practice at the Preserve, and was initially met with a certain amount of diffidence and suspicion. Its usefulness has since been recognized, and the joint project is now generating the first thoroughly contextual documentation of an excavation in the urban area of Chersonesos.

The current joint excavation project in the city began in 2001, with a collaboration between ICA, the Preserve, and an Italian team from the University of Lecce under the direction of Prof. Paul Arthur. It focuses on a residential block in the relatively unexplored South Region of the Byzantine city, near a monumental cistern dating to the 2nd or 3rd century AD (Figure 3). The cistern had been excavated in the 1980s by Dr. Larissa Sedikova, the project's co-director, and had produced a rich deposit of Dark Age pottery. The joint project focused on the block across the street from this cistern, with the idea that it would produce important information about the diachronic development of the city. The first seasons, however, concentrated on the occupation and destruction levels of the 13th century, which included several residential, industrial, and commercial complexes centered on an open court. The Italian team brought to the project a sophisticated relational database constructed in Microsoft Access by Giuseppe Gravili, then a student at the University of Lecce. This database had been designed in Italian to match the context-sheet recording system used by the Italian team, but during the second season it began to be translated into English to match the linguistic profile of other concurrent projects. Massimo Limoncelli, the excavation draftsperson at this stage, made extensive use of AutoCAD for the digitization of drawings he did by hand; these digitized plans, as well as point data collected with a total station, were also manipulated with ESRI's ArcView 3.2.

In addition to the residential complexes, a small chapel, in and around which were a series of collective graves, was investigated during the first and second seasons. The first of these graves, with their complex layers of disarticulated bones, provided the impetus for the project's initial attempts to derive plan data from spatially-referenced photographs in a GIS framework. These photographs allowed work in the field to continue while very detailed digitized plans of the

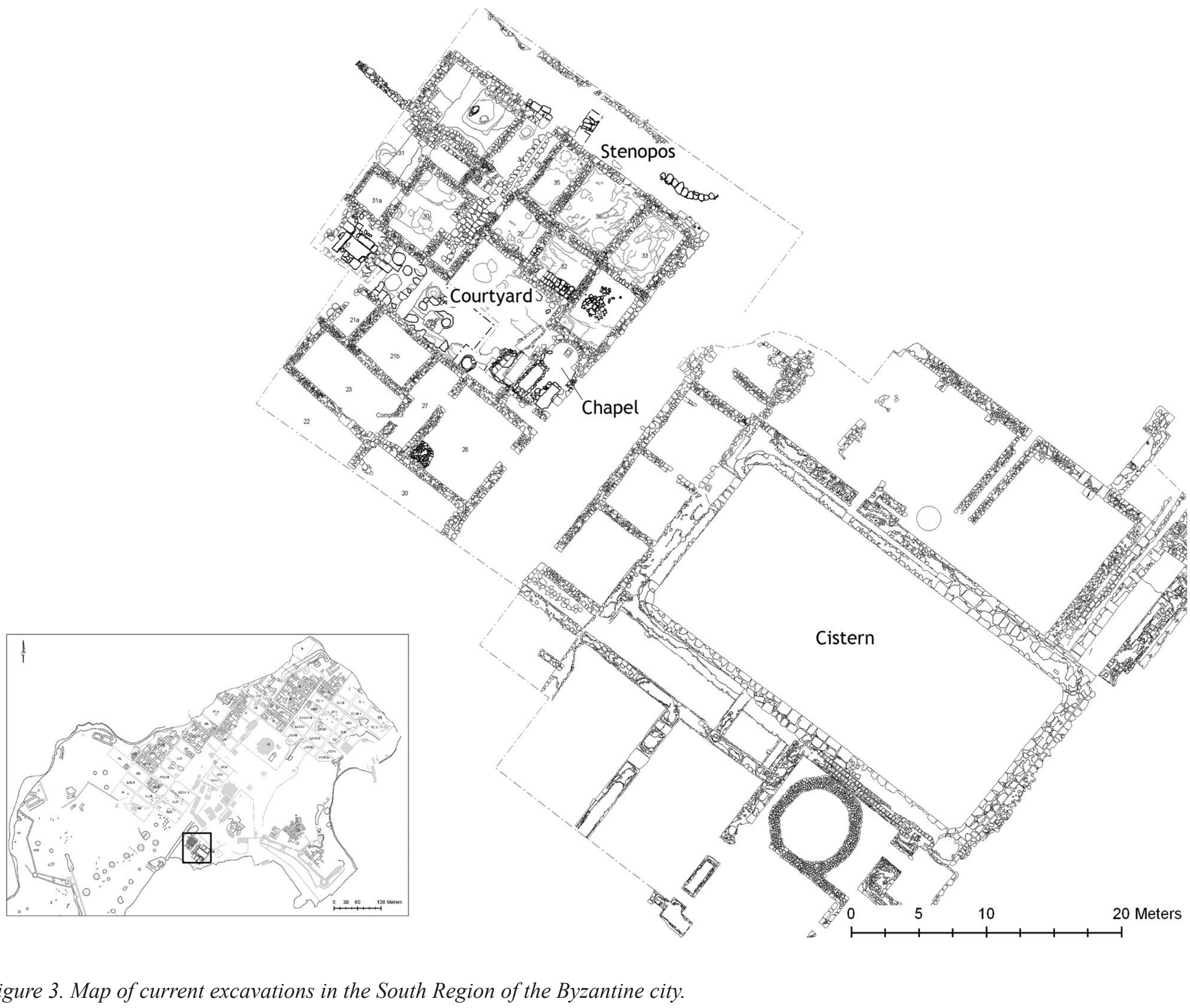

Figure 3. Map of current excavations in the South Region of the Byzantine city.

skeletons were created in the lab, avoiding the delays caused by detailed, large-scale hand-drawing of the remains. The second year of excavation also brought attempts to create detailed microtopographical maps of individual contexts, including a series of rubble and destruction deposits. Both these experiments were eventually abandoned, since the limited capacities of the version of ArcView involved made the efforts too complex and time-consuming to sustain. During these first two years, software difficulties involving limited ODBC communication also prevented the integration of the Access database and the GIS to any significant extent.

3 The Evolution of the Digital Documentation System

Major changes in the composition of the joint project interrupted the excavation in 2003. Excavations resumed in 2004 as a direct collaboration between ICA and the Preserve. At the same time, we began to use ArcGIS as our GIS platform and a new relational database, built by Stuart Eve, which was similar to the Italian original but based on an open-source database server (MySQL) and more directly related to the circumstances on the ground at Chersonesos. To implement these changes, a large quantity of information had to be imported from a variety of prior formats, bringing the usual glitches and difficulties. A portable server was acquired at this point, to enable all of the data to be housed in one place during the excavation season. This choice also allowed us to bring the data back to Texas, where they could be served to collaborators over an internet connection during the year. In 2005, we migrated again, this time to the MSSQL database server, in order to meet the specifications of the server administrators of the University of Texas. The difficulties presented by these constant data migrations have been presented in more detail elsewhere (Trelogan and Eve 2006).

In the end, however, the old and new systems had enough in common to make the transition without loss of data, and when the transition was complete, we were in a position to integrate the GIS and database much more completely. Our current documentation strategy brings together in the GIS and database all the categories of evidence collected in the course of excavation. In addition to the information we record for stratigraphic contexts and small finds, we have now developed tabular formats for the results of the analysis of faunal material and of paleobotanical and metallurgical samples, and we are nearing completion on a simple tabular format for ceramic material. New data—such as those produced during a recent program of mortar analysis—can also be integrated easily, provided that they were collected by context and can be summarized in tabular form. The information in the database can be linked to the spatial information contained and displayed in the GIS, allowing us to create complicated queries that involve both spatial and descriptive criteria (Figure 4).

Other participants in this conference discussed similar or more sophisticated recording systems, and the integration of digital data in databases and GIS is becoming increasingly common. Our basic methodology reflects standard practice for the digital documentation of primary archaeological data, and we will therefore describe our workflow only briefly by following a small find through the process. The three-dimensional (3D) coordinates of the findspot are taken with the total station, and the unique number, material, and type of the small find are recorded with the data logger in the field. The same information entered into the data logger is recorded in a paper register, and the number and type of the find are noted on the paper recording sheet. The find is then bagged and taken to the conservation lab, where it is described on paper by the registrar, who enters the same information into the finds section of the database; there, the find record is linked to the context record by context number. Digital photographs of the small find are taken before, during, and after conservation. These photographs are then linked to the small find record by the small find number. Thus, the GIS and database are linked by the unique alphanumeric codes assigned to both context and find, enabling complex queries and allowing detailed small find records (and photographs) to be brought up with one click (Figure 5). The same principles apply to other types of information we collect, including faunal

Figure 4. Density map, by weight, of the microscopic metallic by-products of ironworking found in soil samples from a specific stratigraphic context in room 33.

remains and samples for scientific analysis.

These practices, again, are not exceptional. A happy coincidence between the development of the project and improvements in ArcGIS, however, encouraged us to resume earlier experiments with less standard techniques, in particular the use of georeferenced photographs for planning and the creation of detailed topographical surfaces of individual stratigraphic layers. Previous experiments with both methods relied on expensive additional software, as the capabilities were not available in ArcView 3.2. We were using ENVI to georeference photographs and Surfer to create continuous topographical surfaces. Although ICA was already using both Surfer and ENVI for other, landscape-level mapping projects, we abandoned their use for the excavation GIS because we deemed the extra expense (in license maintenance and training) to be unsustainable at Chersonesos in the long term. When ArcGIS began to offer the same functionality, however, we returned to our earlier ideas and carried out a series of experiments in 2004 and 2005 designed to test the accuracy, efficiency, and usefulness of these practices. The georeferenced photos, we thought, would allow us to preserve a more accurate photographic record of the contexts we excavated, and at the same time would speed work in the field by permitting us to create digitized plans directly from the photos at our convenience. We also felt that the construction of topographical surfaces for individual layers, as an amplification of the traditional practice of indicating levels on plans, would provide useful additional information and perhaps allow us to calculate the volume of stratigraphic deposits. The topographical surfaces were the easier of the two. Using the total station to survey an irregular grid of points on the surface of a deposit, with denser spacing to define the shape of specific features of interest, we experimented with various point spacing and interpolation methods to achieve the closest possible match to the surface of the deposit surveyed. With the improved interpolation methods available in the Spatial Analyst extension of ArcGIS 9.1, we were able to significantly streamline the process without using an additional piece of expensive software. In recognition of the interpretive nature of this process, we also collected metadata related to the creation of each topographical surface. Although the final product cannot be as high-resolution as a surface using points collected by, for example, a laser scanner, we were confident that enough points were taken in each case to make these topographical surfaces a reasonable representation of the original state of the layers involved (Figure 6). The main problem with the extra work required to create these surfaces was the heavy demand it placed on the total station in the field, often creating a backlog in the mapping of finds and samples and thus holding up the excavation. In 2005, we used two total stations when the demand was high, substantially alleviating the bottleneck in the field.

The georeferenced photographs created more difficulties, since they had to be taken from an angle that reduced distortion as much as possible. Although some of this distortion could be removed by orthorectifying each photograph, we determined that this would require too much additional processing time (and additional software) to make it worthwhile. In 2004, we attempted to take vertical photos by standing on the better-preserved walls of relatively small rooms. Although the results looked acceptable to the naked eye, we worried about their accuracy and therefore carried out a preliminary test in which we compared a georeferenced photo of a stone paving, a georeferenced plan of the same paving drawn at 1:50, and survey control points taken on a series of recognizable features in that paving (Figure 7). With the survey points as a control, we found that the georeferenced photographs were generally off by 2-4 cm, while the 1:50 drawing was generally off by 4-8 cm. This seemed

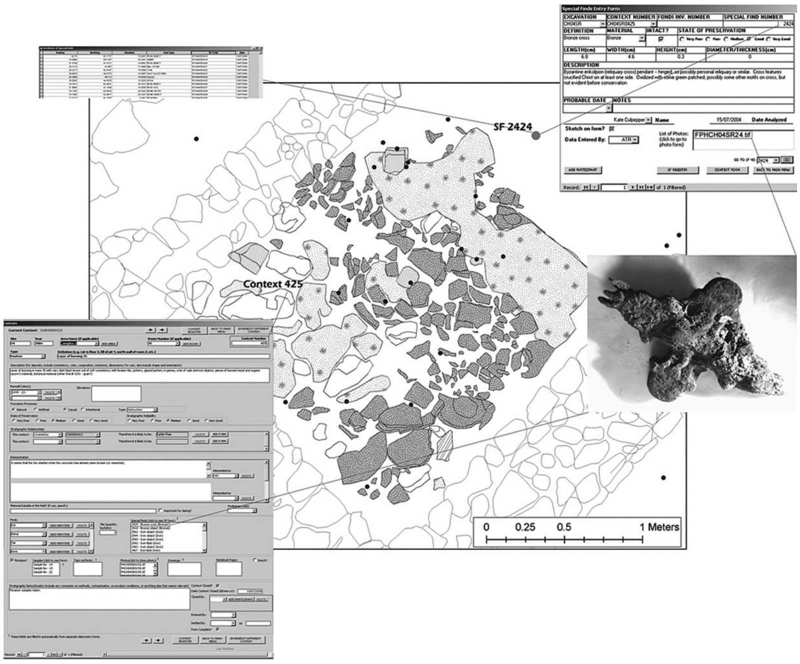

Figure 5. The interaction of a find, its spatial location, contextual associations, and text data.

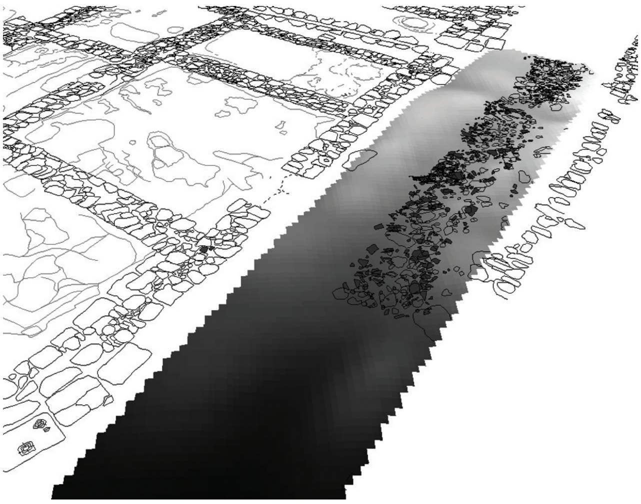

Figure 6. Three-dimensional model of the surface of the stenopos, created using total station points.

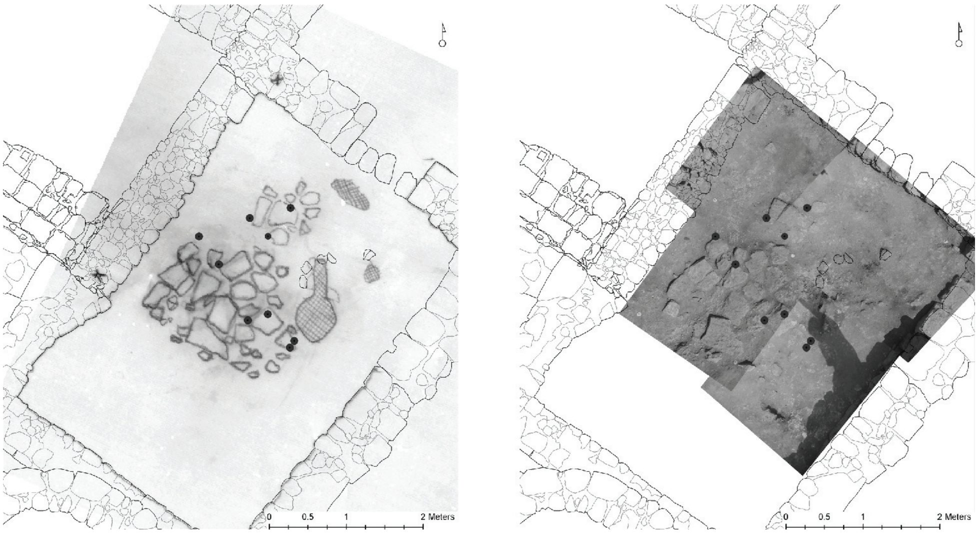

Figure 7. 1:50 scale drawing (left) and digitized plan of the same area from a set of georeferenced photographs. Black dots indicate the location of the control points.

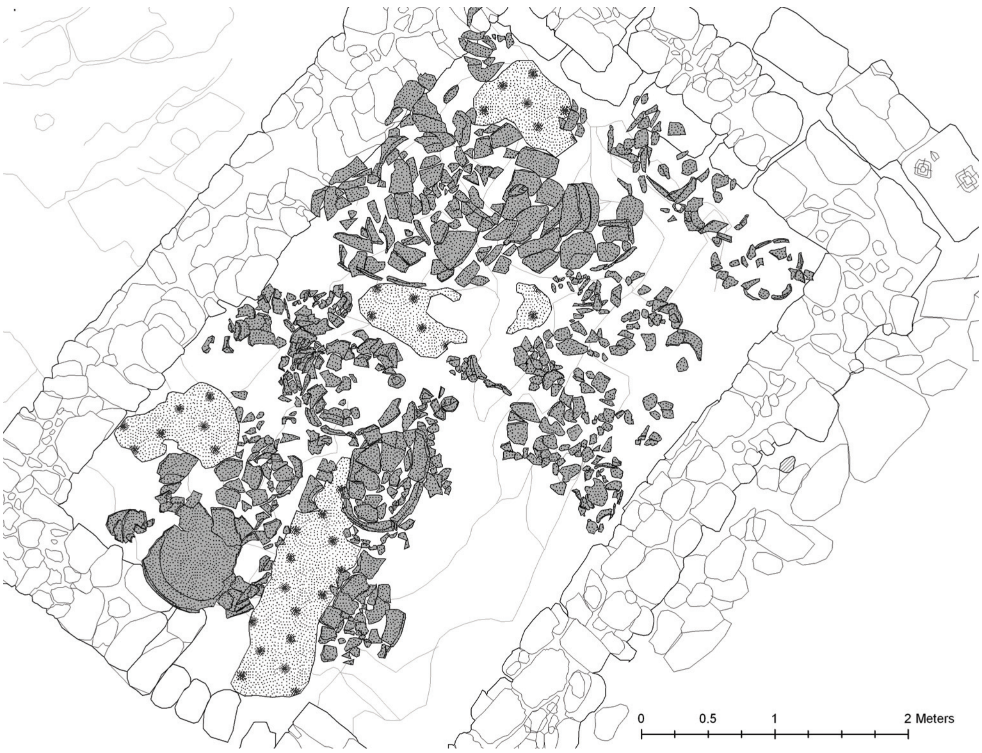

Figure 8. Plan digitized from georeferenced photograph.

an acceptable degree of accuracy for the representation of deposits that would normally be documented only by standard photographs or quick scale plans and rarely published. This could be further improved, if necessary, by orthorectifying the photographs using the elevation data from the topographical surfaces, but our main concern was keeping the data collection and processing as rapid and efficient as possible. The georeferenced photographs provided substantial gains in precision, since the digitizer could zoom in to ensure that the digitized plan followed every irregularity in the outline of every stone or tile fragment, in a way that would be impossible in a 1:50, a 1:20, or even a 1:10 plan drawn by hand. With our doubts about accuracy and precision assuaged, we assumed that this practice would save us time in the field without any loss in documentation. During this season, however, we did not test this assumption by recording the amounts of person-hours each approach required.

By the end of the season, we had also experimented with the integration of georeferenced photos and topographical surfaces, using ArcScene's 3D capacity to create more informative displays of stratigraphic data. Although we had created digital plans of only a few layers directly from the photos at this point, those few plans had turned out very well and allowed us to associate specific attributes with different elements of these two-dimensional representations (Figure 8).[2] We therefore resolved to use this method more consistently during the following season, and in 2005 we went into the field with two total stations, which we operated at the same time to handle the increased spatial workload. Apart from the doubled surveying equipment, however, we deliberately attempted to use simple procedures and out-of-the-box equipment and software within the financial and technical reach of most excavations.

During the 2005 season, we also standardized our georeferencing procedures: they involved a basic 7-megapixel Olympus camera with the equivalent of a 28-135mm focal length, a faceted line level, and a wall or a ladder (Figure 9). The photographer set the focal length roughly a third of the way up the zoom slider bar in the display to approximate a 50 mm lens and reduce distortion, stood on the ladder or a wall, held the camera at arm's length with the lens facing down, and leveled it in the horizontal plane with the line level set across its upper side. The view panel was then used to frame four yellow surveying disks placed in a rectangular alignment about 1.75 x 1.25 m. The area of the photo was shaded when possible, in an attempt to avoid strong, direct light. The disks were then surveyed with the total station, and the resulting coordinates

Figure 9. Gordana Karovic uses a roughly-leveled camera to take photographs of the rubble layer covering the stenopos for georeferencing.

were associated with a unique number assigned to the photograph. The series of photos collected for any given layer had a significant degree of overlap, to minimize the distortion at the edges of the frame. At the end of the day, all these photos were downloaded to be georeferenced and digitized in the computer lab the next day.

4 Practical and Theoretical Issues Encountered in this System

We began to use georeferenced photographs because they seemed to us to speed work in the field and enrich the description of stratigraphic deposits, and we decided to collect topographical surfaces because they seemed to us to offer substantial additional data at the cost of very little extra time. Both methods, we felt, gave us the chance to preserve more information about the contexts we were removing. In some ways, this was true. Georeferenced photographs turned out to be a fairly accurate and precise way to record visual and spatial information that is difficult to extract from oblique photographs, and they lent themselves to visualization and study in the GIS. The topographical surfaces could be examined in conjunction with other spatial and graphic data, and were very useful in visualizing and analyzing the position and distribution of finds within a layer. An example of the use of these tools in analysis can be drawn from our actual experiences with the study of our data. In 2005, we excavated the beaten-earth floor of an earlier building under one of the rooms of the 12th-13th century residential complex. The date of construction of this floor was particularly important since we assumed the earlier building to have been constructed well before the later complex. Several coins were recovered during the excavation of this early floor, and we found to our surprise that the latest datable coin belonged to the end of the 11th or to the 12th century, although the rest belonged to the 10th or early 11th century. If we had relied only on traditional documentation techniques, we would probably have taken the late coin as a *terminus post quem* for the formation of the early floor, and then revised our phasing to reflect a much shorter building sequence. When we looked at the distribution of coins through the layer in three dimensions and in conjunction with the topographical surface we had created for this floor, however, we discovered that the latest coin was just below the floor surface, while the earlier coins were scattered throughout the layer from its deepest points (Figure 10).

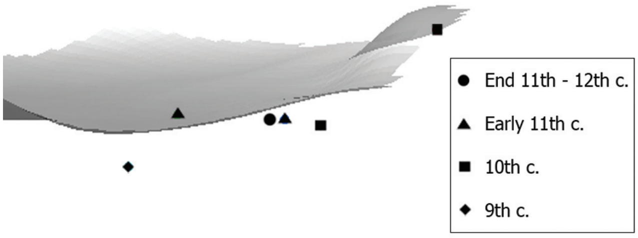

Figure 10. Topographic surface of early beaten-earth floor with 3D distribution of coins found in it.

This suggests that the floor was constructed in the 10th or early 11th century and then occupied through the late 11th or 12th, and that the late coin was trampled into the floor during the later years of its use. Documentation strategies that allow us to read the evidence in its full spatial context thus allow us to produce much more nuanced and fine-grained interpretations. Together, the georeferenced photos and topographic surfaces also help us to make attractive presentation material without any extra software or deep programming expertise. Such presentation material is particularly important in helping an audience understand and evaluate the spatial evidence that supports interpretations like the one above.

Pretty pictures and attractive hypotheses, however, are not an adequate justification for major changes to documentation practices, and we are only now coming to understand the practical drawbacks and epistemological problems these methods bring with them. On a practical level, georeferenced photographs can only be used effectively where areas of investigation are relatively small and well-defined, and where the photographer can work from an elevated position. In general, they are a good substitute for drawn plans only if the area contains complex details that would be very time consuming to draw at a reasonable scale. They worked for this particular site, which has many flat spaces and small rooms with walls preserved up to one or two meters; elsewhere they might be less appropriate. The quality of the results is extremely variable and depends in part on circumstantial factors like the height and steadiness of hand of the photographer. Even with two total stations, gridlock and confusion were frequent occurrences on a site where thousands of nails and small finds need to be shot in every season. On a more psychological level, we found it easy to get caught up in the exhaustive documentation of deposits that would normally be sketched, photographed, and removed in an hour or less. At the same time, the creation of plans by a digitizer looking at photos, rather than by an excavator looking at the remains, seriously impoverished the interpretive value of those plans. This was all the more problematic when, as was the case in both seasons, there was a significant backlog of digitization that was done months after excavation had ceased. Some less important deposits are still waiting for digitization two years after they were excavated.

These two interlocking issues—time and efficiency in the creation of documentation, and the psychological or epistemological issues related to our perceptions of scale, accuracy, and precision—are perhaps best illustrated by the second set of tests we applied to the georeferenced photograph method in 2005. As in the initial test carried out in 2004, we compared 1:50 hand-drawn plans of complex deposits to digitized plans of the same deposits created from georeferenced photographs. This time, however, we were also careful to note the time in person-hours that each approach took in the field and the overall time required, including downloading and digitization. Several interesting patterns emerged from these tests, some in the context of the factors we set out to measure and others from entirely unexpected directions.

One of these patterns became apparent during the photography stage of the first test we undertook in 2005: the photographer, worried about accuracy, took a very large number of highly overlapping photographs for georeferencing—just under 60 for an area approximately 25 m^2 (Figure 11). When the time required for two people to survey the reference points was taken into account, this took three or four times the number of person-hours it took an experienced draftsperson to draw the collapse. We therefore had to repeat the test with a more reasonable number of photographs (15, in this case, for a room that was approximately 5 m x 7 m). In the second test, the overall number of person-hours required came out about even, with the georeferencing method making possible substantial time savings in the field (all the photos were shot and points taken in well under an hour, in contrast to the more than three hours that it took to produce a drawing of the same area). In this case, however, we noticed that there were substantial differences between the digitized plans produced from the georeferenced photos and the hand-drawn plan. In particular, we noted that the plans produced from photographs lacked the interpretive quality of the hand-drawn version. We had already observed this phenomenon in other cases, where, for example, the digitizer failed to notice subtle distinctions between a tile and a large pithos fragment. It was more pronounced, however, in the plans of the collapse involved in this test, in which there were differences not only in the identification of material but even in the selection of stones to be included in the plan.

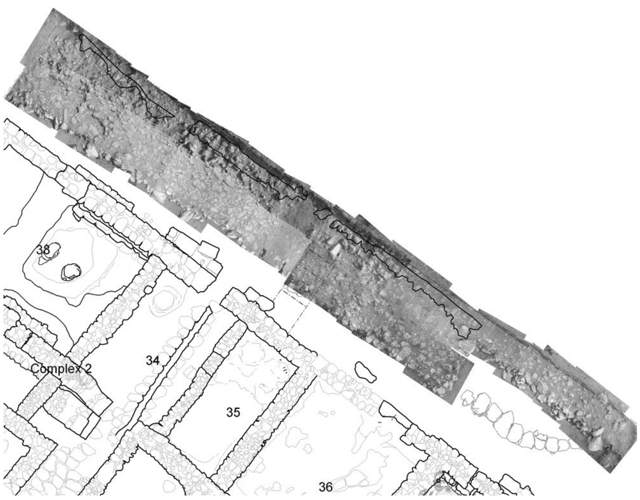

Figure 11. Mosaic of photographs (with approx. 80% overlap) of the stenopos.

Other elements that are standard features of drawn plans, like the borders of layers, were left off the digitized version, presumably because the photograph on which the plan was based seemed to make such information self-evident.

Further work with georeferenced photos produced more convincing plans, but a second tendency became evident: to produce plans like this, the digitizers tended to zoom in on the photographs in order to draw very precise outlines of tile fragments and pebbles that were often no more than a few centimeters across. This trend was encouraged by the error calculations built into ArcMap's georeferencing function: as the software indicated that the georeferenced photographs were approaching millimeter *accuracy*, the digitizers grew more and more concerned with *precision* in the representation of the remains. The ability to visualize both accuracy and precision in the GIS also led to an increasing conviction on the part of the people generating the plans that the combination of total station and GIS recorded more *reality* than any graphic documentation produced by human hands. On several occasions, in fact, the apparent precision offered by the total station led our architect to question her own more accurate hand drawings. This drive to make documentation more representative of physical reality obscured, to a certain extent, the original goal of these methodological changes, which had been to save time while generating plans in which more useful information was included. The more precise the digitization became, the longer it took; and the larger the scale on which it operated—in some cases 1:1—the less practically useful the information included became. Some of the objects over which our digitizers lingered were not as thick as the pencil line in a 1:50 plan, even for deposits of wall collapse that had limited value for site interpretation to begin with.

Something very interesting had happened to our graphic documentation during our experiments with georeferenced photographs. On the one hand, the accuracy of our georeferencing procedure had increased, often showing root mean square errors of less than a centimeter during rectification. On the other, an increased attention to precision led to more time-consuming plans with less interpretive value. It was only in retrospect that we began to understand that these developments had sprung from the erosion of the boundary between reporting and interpretation. We had seen an opportunity to represent more completely and more accurately the physical reality of our excavation, but the appearance of greater truth offered by spatially-referenced photographs caused us to forget the significance of the interpretive moment in archaeological documentation. The same blurring of the line between interpretation and reality accompanied the introduction of photographic methods into archaeology in the late 19th century, and has long inspired criticism (Shanks 1997; Lyons et al. 2005). The danger of losing the distinction is perhaps greater in the sphere of GIS, however, where the quantitative elements of measurement and mathematical accuracy are even more compelling to both excavators and their audiences.

Archaeologists generally understand photographs and plans to provide different sorts of information. A photograph, at least in principle, is uninterpreted—it simply represents what can be seen through the lens of a camera in a certain position. A plan, on the other hand, is more easily understood as an interpretive representation of reality. It presents spatial information that we can assume was collected by a person who was looking at the wall or deposit in question as the plan was created. Furthermore, scale, drawing conventions, and a symbol key explicitly indicate the way in which its creator has interpreted and filtered what was visible on the ground. That interpretive moment is fundamental to archaeological planning: as an archaeological audience, we assume and accept that such plans are not a strict record of physical reality, but a reasonable representation, in a simplified and conventionalized format, of elements and relationships that the excavator or planner deemed important. In using photographs to generate plans digitally within the GIS software, we undermined the interpretive process, which is best situated in the field and carried out by—or at least in conjunction with—the excavator. In our system, the burden of interpretation was placed on the digitizer, who had often not seen the layer during excavation and could not always distinguish subtle changes in slope or color from the photographs. At the same time, however, we nearly convinced ourselves (and perhaps would also have convinced our eventual audience) that the plans produced in this way held more objective knowledge than versions drawn by hand without photographs.

5 Solutions to an Epistemological Crisis

In thinking of plans as simple representations of photographic truth, we lost much of the very information we hoped to convey. Similarly, the scalability of GIS data beguiled us with a vision of absolute accuracy and precision in those plans, leading us to turn a time-saving strategy into one that was more time-consuming and more prone to errors than the hand-drawing it replaced. These issues obviously had practical ramifications for our project, but they also raise larger theoretical questions. The problem seems to lie in the way archaeologists—or perhaps people in general—deal with scale and think about reality. Our tendency seems to be, when given the opportunity, to think of reality at the largest, most granular scale possible, and we seem to forget our tolerance for reasonably accurate imprecision when we feel that we can achieve both perfect accuracy and total precision. We have attempted to resolve some of these problems by going back to the beginning and thinking more carefully about what the various forms of archaeological documentation are meant to accomplish. Plans, we decided, are still best done by hand in the field by the excavator or by a skilled draftsperson in communication with the excavator. These documents do not claim to represent physical reality; instead, they offer themselves explicitly as interpretations, just as textual interpretations are recorded as such on paper and in the database. We do not plan to abandon digital plans, since the additional information they include and the opportunity to query that information represent a significant step forward. These plans, however, will be digitized from hand-drawn versions, not from photographs. This choice also provides an extra level of security for these data in the future: plans on paper can be viewed and understood without the aid of GIS software or a computer system, while digital plans derived from digital photographs exist only in the digital sphere. Even if the digital versions are lost or become impossible to access, the hard copies will still be available for study in the future.

At the same time, we will continue to collect digital photographic documentation that can be spatially referenced in the GIS. Such documentation does provide much additional information that cannot be presented in a standard oblique photograph, and when employed in an interactive GIS setting, georeferenced photographs allow a researcher to "re-excavate" the site in much greater detail. But we intend in the future to allow the photographs to stand alone, without forcing them to perform both as an "objective" record of reality and as the source of plans that present not reality but interpretation. This choice could be criticized from very different standpoints: some current archaeological theorists might object that photographs are hardly free from interpretation, while their more traditional counterparts would argue that a good plan *should be* as accurate and precise a representation of reality as possible. Given our experiences in the field, however, and given the standard expectations of the audience for whom archaeological reports are intended, it seems reasonable to treat plans as the interpretive vision of an individual human and photographs as the record of light passing through a lens, and to keep the two distinct. Of course, it is crucial that such decisions be explicitly documented in the publication of our interpretations and especially of our raw data.

This last point raises the question of the future use of the documentation we are generating. After this extended discussion of the problems we encountered, one is compelled to ask whether such attempts to broaden archaeological documentation offer sufficient practical advantages to be worth adopting. At least in terms of the interpretation of the site by the excavators, we feel strongly that the answer is yes, provided that the limitations of the system are always taken into account. An example of the use of the system was provided above, and we encountered innumerable other cases where georeferenced photos or topographical surfaces or both informed our understanding of the historical and archaeological record. This conclusion has in fact been subject to external review: a series of specialists who were not present during earlier seasons found in 2005 that they could easily reconstruct contexts for the material they were studying, and one even exclaimed that using the system was like having been there for the excavation.

The documentation strategies we have employed, however, are meant not only to facilitate our own interpretations, but also to give future researchers the information they will need to ask questions we have not anticipated. In this case, the question of practical benefit is harder to answer. In essence, it depends on the way the data we have collected are preserved and presented. If methodological innovations are combined with a long-term plan for the accessibility and use of the data in the future, the answer is yes. If they are performed for their own sake, because we can, the answer is no—and it is worth saying that without plans for preservation and accessibility, such methods will leave to posterity substantially less archaeological information than traditional systems. We have included in our methodological discussions plans both to find a safe home and stable format for the data and to make all of this information available on the World Wide Web in an interactive, queryable format

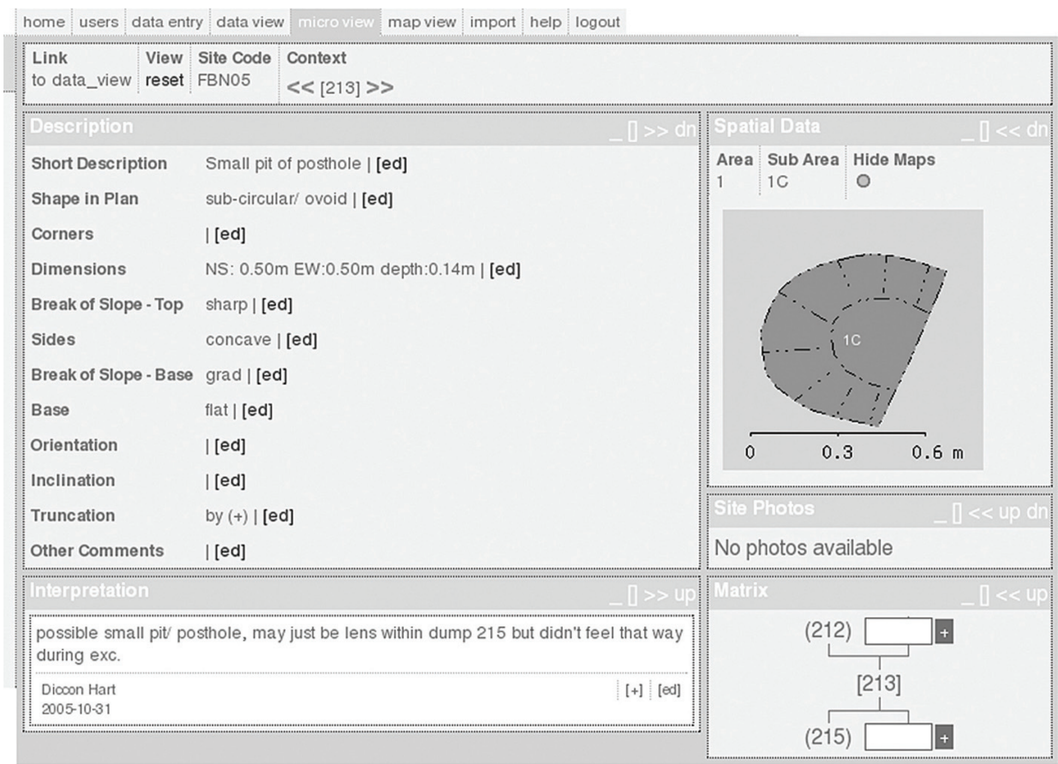

Figure 12. Screen shot of a prototype for web-based viewing and querying of stratigraphic units and associated finds.

that allows both researchers and lay audiences to answer questions of their own (Figure 12). If these plans are successful, we feel that there are tangible benefits to this methodology, especially as new tools develop. The topographical surfaces, for example, could be used to calculate the volume of individual deposits, which would have a substantial advantage over the use of area alone in the normalization of specialists' findings across deposits. Preliminary work on a custom GIS tool for volume calculation was, in fact, presented at the 2006 CAA conference (Tschauner 2006). Similarly, although we have no specific plans to study nail distributions by type, this system makes it possible for another researcher to do so with relative ease.

Access and preservation will be the two major issues affecting the increasing use of digital technology in archaeology over the next decades. If we can address these issues, we will have enriched the information that traditional documentation methods already attempt to recover. None of the layers we have documented in this way now exist outside these photographs and surfaces. A few years ago, they would have existed only in some oblique photographs in a binder and a few hasty plans with one or two level notations on scraps of mylar. If we are successful in our plans for both the preservation and the dissemination of our data, we will have created instead an integrated, functional, and accessible archive that will unfold before a broad audience the entire rich tapestry of evidence for the daily lives of the inhabitants of this part of Chersonesos across sixteen centuries. Only then will the scholars who use these resources to ask their own questions and come to their own conclusions be able to judge the benefit of our digital efforts.

6 Epilogue

Between the CAA conference in 2006 and the submission of this paper for publication, we carried out another season of excavation at Chersonesos. We would like to provide a brief report on our methodology during the summer of 2006, for two reasons: first, we put into practice the ideas we lay out at the end of this paper, and had a chance to evaluate the results; and second, our methodology was significantly influenced by our participation in the CAA conference itself. We drew particular inspiration from the same paper that proposed software for the calculation of volume in GIS projects (Tschauner 2006). In this paper, the author also described the application of the photogrammetry software PhotoModeler Pro to the generation of 3D models of stratigraphic surfaces, and the importation of the results into ArcGIS-based documentation systems. Early in the history of our project, some experiments with photogrammetry software were conducted, but they were abandoned when the results could not be integrated with ArcView. Tschauner's paper led us to return to PhotoModeler Pro, and in the course of the 2006 field season we replaced both georeferenced photographs and microtopographical surfaces with 3D models generated in PhotoModeler. We developed a slightly different methodology from that presented by Tschauner, however. He had employed a set of reflective targets that PhotoModeler automatically recognizes as tie-points between photographs, using them to orient the camera locations and to generate 3D locations that can be interpolated into a continuous 3D surface. We determined that, for our site, the distribution (and collection) of enough targets to model the complex topography of typical deposits created a major gridlock in the field. We devised, instead, a method using a set of strings, marked at regular intervals with high-contrast tape, that could be draped easily in a grid pattern over the surface of interest. Although these strings did not have the added benefit of automated target recognition by the software (i.e., we had to mark the tie-points manually), the time saved in the field was significant and models could be created at our leisure with as much detail as we desired for a given stratum. The PhotoModeler model can then export to ArcGIS not only a three-dimensional topographic surface, but also an orthorectified planimetric photograph (Figures 13 and 14).

This approach worked very well with our choice to separate interpretive documentation from photographic records. Our architect spent a great deal of time in the field producing layer plans on mylar in consultation with trench supervisors, while members of the survey team took turns constructing photomodels. Once the string system had been worked out, the capture of the information necessary to create these models was somewhat faster than the collection of georeferenced photographs alone, and substantially faster than the collection of both georeferencing and topographical data. The models themselves could easily be integrated into our GIS structure, where they performed as well as our previous system in the display and investigation of the archaeological remains in three and two dimensions.

A final unanticipated benefit of this system emerged in

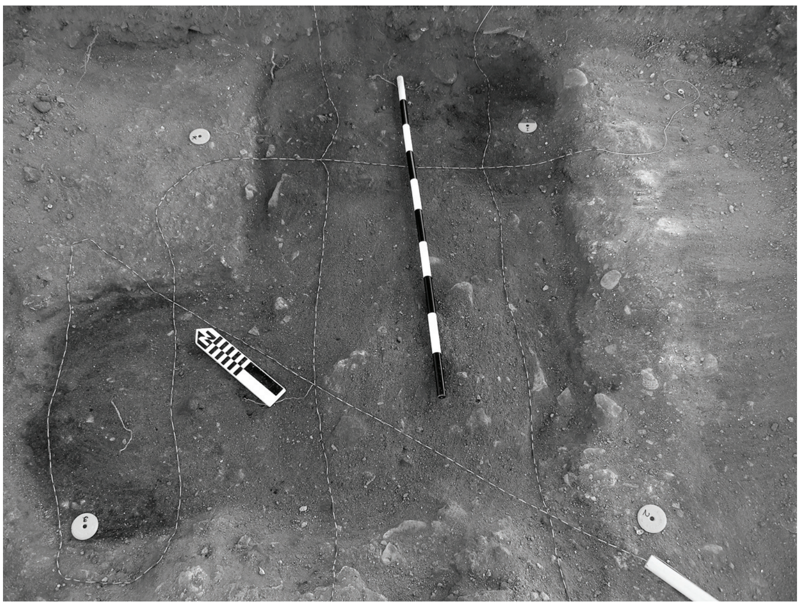

Figure 13. Strings draped over area to be photographed and modeled.

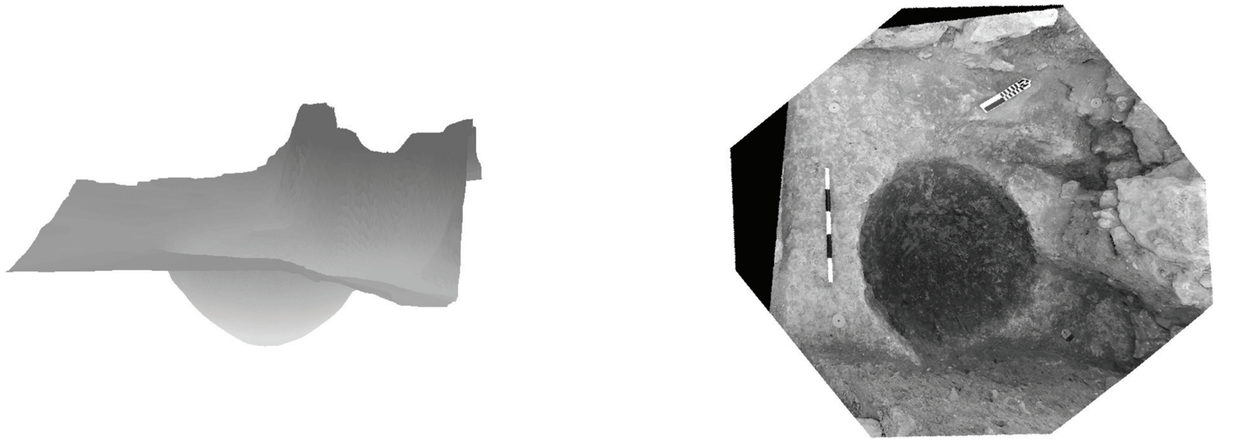

Figure 14. 3D model and associated orthorectified photograph of a pit in the courtyard of the Byzantine block.

the summer of 2006, further clouding the murky relationship between interpretation and reality. After our site had been backfilled, we realized that, in the confusion of the end of the final season before publication, drawings had not been made of a few features that had now been reburied. The photomodels, however, preserved two- and three-dimensional spatial information that was accurate enough, and could be displayed easily enough, to allow us to make acceptable drawings directly from the digital records. This brings us full circle, from experiments with digitized photographs as a better representation of reality to the use of photomodels for interpretation even after the excavation is closed.

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Endnotes

[1] Georeferencing is the process of defining the location of a dataset using map coordinates so that it can be viewed and analyzed in conjunction with other spatial data. Orthorectification removes distortion due to camera angle and terrain variation, but does not associate a photograph with specific spatial coordinates.

[2] That is, the vector polygons that described the closed forms of rocks, tiles, broken vessels, etc. visible on a normal top plan could be furnished with extra information: the notation that a particular polygon should be represented with the symbology convention for tile, for example, or the addition of an individual vessel number to the polygons that represented its articulated sherds. This was particularly useful for the employment of consistent graphic conventions and for filtering and querying the graphic information (to make plans on the fly to show, for example, only pithos 5, or only ash deposits, or only pieces of carbonized wood).

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