Why Do Virtual Heritage?

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Abstract

Virtual Heritage professionals pursue their re-creation goals because we see many benefits of visualizing the past interactively and in 3D. We understand that the past did not happen in 2D nor can it be effectively studied and taught as a series of disconnected images that for the most part represent incomplete remains. To convince the broader historical community, and especially archaeologists, we must show them that it is to their advantage to see the ancient world as the ancients did, rather than as static 2D representations in black and white. I will discuss several of our projects that demonstrate new insight about the ancient world. The archaeologists who collaborate with us learn about their sites in ways otherwise impossible with traditional analytical tools. They have come to realize that only by seeing the ancient world in 3D, and through the eyes of the ancient inhabitants, can new understanding emerge.

1 Introduction

Those of us engaged in the discipline now known as Virtual Heritage pursue our re-creation goals, because we see many benefits in visualizing the past interactively and in three-dimensional (3D) space. We have come to understand that hypotheses about past cultural environments cannot adequately be tested using static two-dimensional (2D) images and lengthy descriptions alone. Our biggest challenge, however, is how do we convince the broader historical community, and especially the archaeologists who should be embracing our technologies, that it is to their advantage to see and study the ancient world as the ancients did, rather than as segmented, 2D representations in black and white? In the 21st century, where video-enabled iPods, GPS-enabled camera cell phones, wireless high-speed home networks, and laptops for almost every schoolchild are commonplace, why is it so difficult for those, whose use of imagery to supplement their textual descriptions is taken for granted, to accept that interactive 3D environments are instructive, not eye candy? Perhaps, we need to phrase this dilemma a bit more forcefully—we could argue that archaeologists are doing a disservice to their discipline and to their colleagues by not using all means available to test their theories about the past, teach their students, and publish their data.

This chapter will begin with a summary of how buildings and sites have traditionally been illustrated and then review some of the ways in which interactive 3D environments in my team's projects (at Learning Sites and the Institute for the Visualization of History) have provided new insights and understanding impossible with traditional analytical and visualization tools.

2 Background

To provide some historical context to the projects described later, we need to look at how archaeological data have traditionally been illustrated, and how those types of visualizations have affected what we know and how we came to know it.

Since the 18th-century beginnings of archaeology, our visualization of finds, reconstructions, and theories have relied mostly on drawings, photographs, charts, and graphs on paper. Long before the advent of the discipline, however, there was stone. For example, when Gudea (prince of Lagash in ancient Sumeria, around 2125 BC) wanted a new temple built, he depicted his vision using a simple plan, carved in stone (see for example, the small headless diorite Gudea statue in the Musée du Louvre, #AO2). He most likely chose the plan form because it symbolized the beginning of the construction process and could be reproduced fairly precisely on the ground. But Gudea was depicting future architecture not past architecture. In similar fashion, when the Egyptians, Assyrians, Greeks, and Romans depicted architecture (as room decoration, to record battles, or show foreign lands) they were usually illustrating their present—for storytelling, education, or enjoyment—not trying to understand a distant past. Yet, over the millennia, the methods chosen to represent the built environment have been relatively consistent: 2D plans and elevations.

A bit more recently, when seeking to document the history of architecture (either for aiding contemporary construction or as a chart of past styles), dating at least as far back as the 13th-century work of French traveler Villard de Honnecourt, the use of elevations and plans continued as the preferred means of representation, now recorded on paper or parchment (for a complete review of the work of this early chronicler of architecture, see the exhaustive research by Carl F. Barnes, Jr., including his comprehensive bibliography about Villard's portfolio and analysis of his life, now online at: http://www.villardman.net [accessed August 16, 2006]; the complete Villard portfolio of drawings is in the Bibliothèque Nationale, Paris, MS. Fr. 19093).

For the most part, archaeologists continue to record architecture using precisely the same methods. They do so, because the development of archaeology as a discipline in the late 18th and early 19th centuries was linked directly to the needs of the architecture profession and the Classical revival styles then popular. Architects needed accurate renditions of ancient Greek and Roman building details in order to construct contemporary edifices, and they needed those delineations in the same formats they used to submit their designs to builders, so archaeologists of the period (many of whom were architects themselves) captured their finds in ways most useful to the architecture profession (see, for example, the drawings of the Tower of the Winds, Athens, published by Stuart and Revett (1762) and compare them to the details of the tower on St. Pancras New Church, London, by William and Henry Inwood, architects (1818); the full connections between the origins of archaeology, the Neoclassical movements of the time, and the design choices of European architects are a bit more complex, as further discussed in Sanders 1988 and 1985).

As this unfolded in the 19th century, a radically new technology emerged. Photography offered archaeologists a more efficient and effective means of recording their work and providing duplicate images for mass distribution (similar to the promised benefits offered by early users of 3D computer models). By the 1840s and 1850s, soon after photography was invented, travelers used the new medium to document their discoveries, including newly found ancient architecture. However, archaeologists resisted accepting photography into their normal fieldwork and reporting process for many of the same reasons that interactive 3D graphics have been slow to become widely adopted today: the equipment is awkward, expensive, and breaks down frequently; the results cannot be trusted; and too few people know how to use the technique adequately (for complaints about photography during its early use by archaeologists, see for example, Dorrell 1994:1-7; Lemagny and Rouillé 1987:54ff; Meyers 1997:vol.4:331-33). Only toward the end of the 19th century, did photography finally become the standard tool for recording excavations and artifacts. Nevertheless, for decades thereafter photography was little more than a way of illustrating monuments, enlivening reports, and providing visual aids for fundraising efforts. It was not until the mid-20th century, when “Mortimer Wheeler and his photographer Maurice B. Cookson insisted that site photographs should reveal every detail of the excavations as they proceeded, that archaeological photography made the transition from mere snapshots to scientific recording” (Meyers 1997:vol.4:331-33; Wheeler 1964:200-206).

Today, interactive 3D computer graphic formats can reproduce the ancient built environment as a precise digital replica of its original spatial and temporal characteristics. Yet, most archaeologists continue to illustrate their publications and teaching materials with few photographs and the same 2D plans, sections, and elevations that have been used to depict architecture for millennia. As was the case with the early use of photographs, computer graphics visuals are included, they are too often added mainly for their eye-catching appeal.

There are increasing numbers of archaeologists who have acknowledged that interactive 3D modeling can help them better understand their data. However, too often their use of the technology is prefaced by the comment, “oh, I have a grad student who can do this for me.” This is an unsatisfactory response. Again there is a parallel in the use of photography for archaeology. Even with easy-to-use digital cameras, archaeologists need professional photographers. Look at the majority of photos published with excavation results; they still, half a century later, do not meet the minimum standards for clarity codified by Wheeler and others 1940s and 1950s. Creating 3D models is great fun and getting easier, but it still takes teams of trained professionals to get the visualizations correct and have the results fit the goals and hypotheses of the dig.

My focus, in the following discussion of case studies, will be on one specific benefit of using interactive 3D modeling in the field of cultural heritage. That advantage is one that does not merely extend the types of visualizations that can be created, but really takes advantage of the digital medium to do what photography, drawings, or carvings on stone cannot, that is, produce new insight into the past, which after all is what archaeology is supposed to be all about. The examples outlined below are presented in no particular order; each will be described with regard to its location and excavation, the goals of using digital visualizations, and the benefits resulting from that approach.

Figure 1. Montage of projects developed over the years by both Learning Sites, Inc., and the Institute for the Visualization of History, Inc., including (clockwise from top right): the Acropolis, Athens, Greece; the temples at Gebel Barkal, Nubia, Sudan; the sanctuary at Nemrud Dagi, Turkey; the mastaba of Ka(i)pura, Saqqara, Egypt; and the settlement of Til Barsib, Syria; images © 1996-2006 Learning Sites, Inc. and the Institute for the Visualization of History, Inc.

3 Examples

3.1 Kyrenia Shipwreck, Cyprus

My first example comes from underwater archaeology; a small Greek ship with all its cargo and contents that sank off the north coast of Cyprus, at Kyrenia, around 300 BC (Figure 2).

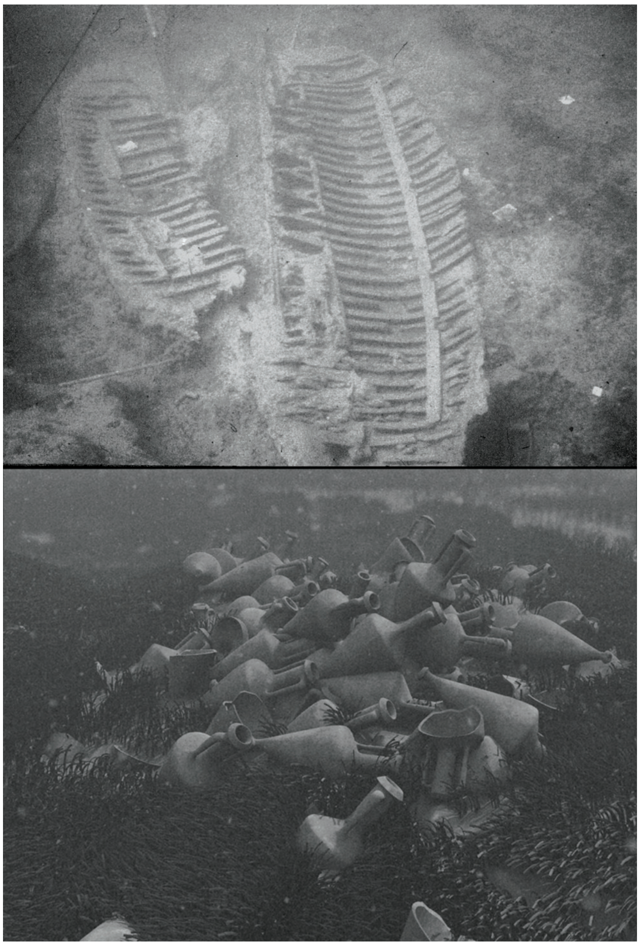

Figure 2. Photograph (top) showing the cleaned excavated Kyrenia shipwreck and rendering (bottom) showing the amphora pile amidst the eelgrass that marked the shipwreck's initial location to divers; photograph © 1969 Susan Katzev; and rendering © 2006 Institute for the Visualization of History, Inc.

Work on the final publication of the Kyrenia wreck began only after decades of analyzing the ship's timbers and cargo (nearly 1000 pieces of pottery, thousands of food items, and 100s of stone, metal, and wooden artifacts). Despite the long time spent studying all the evidence, questions remained. It is unusual in shipwreck archaeology to have such an old ship survive so completely, with so much of its cargo still nicely arrayed along the hull. Could there be clues here to help researchers determine not only the original arrangement of the contents, but also what happened to the ship when it crashed into the seabed, breaking apart and scattering its cargo? Most amphora wrecks (shipwrecks containing mostly scatters of common ancient wine and oil containers) are just that, wreck sites marked by the piles of ancient pottery, but containing little or no evidence of the ship that carried them. Further, the typical transport amphora has a long tapering base so it cannot stand up by itself and had to be somehow secured onboard ship so as not to rattle around and break during transit. No one is quite sure how this was done, yet given the vast number of unbroken surviving amphoras at this and other wreck sites, ancient sailors clearly had solutions. The excavation team realized that these questions could not adequately be answered by traditional archaeological interpretive or visualization methods.

One of our goals was to allow researchers to redive the site and collect data as if they were seeing the wreck as the excavators did, since sites like this are impossible to visit after exposure. We starting by modeling the hull and cargo in their as-discovered state (Figure 3).

We will then clamshell the hull back to form the whole ship before it hit the bottom to see how the objects might arrange themselves. A second and parallel process will be to model a completely as-built digital version of the ship and place objects into the sinking hull testing where we believe they were loaded, then to fast forward the stages of collapse and see where items end up. In this way, we can change the starting positions each time until the objects end up matching their as-found positions

The benefits emerging so far have been our ability to test the accuracy of the amphora pile drawings of and interpretations about the shipwreck. Soon, we will test hypotheses about the arrangement of the cargo, the seaworthiness of the ship, and the ship's last days. Since virtual reality will make the findspots of the objects much easier to understand, hand-drawn site plans will serve simply to identify which catalogued objects are which, rather than how they lay in the wreckage.

So, why then do Virtual Heritage? Because we can test hypotheses about ancient seafaring that cannot be accomplished in other media; test the accuracy of traditional documentation and interpretation methods; and create for future amphora wreck discoveries, methods for understanding the types of ships that sank, how their cargo was arranged, and how ancient wooden ships break apart and decay.

3.2 Monument at Actium, Greece

In 31 BC, Mark Antony and Cleopatra fought Octavian (later Augustus) in what became the crucial naval battle for control of the entire ancient Roman world. The two fleets clashed along the western coast of Greece, where a nearby cape (Actium) gave the battle its name. Two years after the battle, Augustus built a trophy monument, in thanksgiving for his victory, on the heights overlooking the waters where the battle had been waged. The monument has a stone podium, into one side of which his masons cut specially shaped sockets to hold the bronze ramming prows cut off the fronts of Antony and Cleopatra's sunken ships (Figure 4).

Figure 3. Rendering from the virtual reality model of the Kyrenia shipwreck showing the fully loaded hull after excavation and clearing; © 2006 Institute for the Visualization of History, Inc.

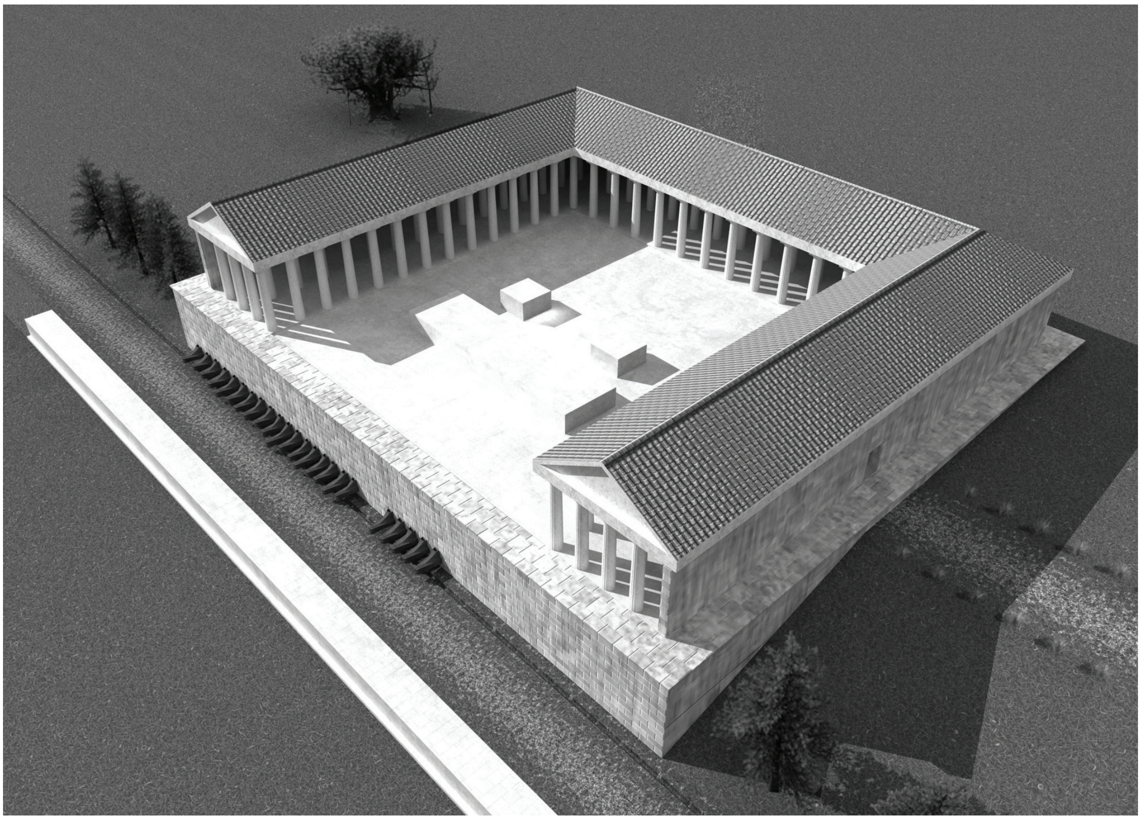

Figure 4. Rendering of the monument at Actium showing a reconstruction of the main features, including the row of bronze rams protruding from the main wall of the complex; © 2003 Institute for the Visualization of History, Inc.

The odd cuttings in the podium wall are large and deep and were discovered to represent the negative shape of the backs of the rams (Figure 5).

Each socket is unique in its size and outline, reflecting the dimensions of the actual rams at the point of contact with the wall. One goal of the project is to develop a virtual reality (VR) model that would give visitors to the site museum an appreciation for the massiveness of the weapons and understanding of the general design of the monument. As we struggled with the details of modeling our first ram and its socket, other interesting goals presented themselves that were directly related to the construction details of the monument and the artifacts we were modeling.

We began modeling the only surviving ancient bronze ram (Figure 5), found off the coast of Athlit, Israel, in 1980. Next, we modeled the monument at Actium, starting with the sockets. We could then take the computer model of the Athlit ram and warp it while keeping the proportions intact until it fit into socket #4, one of the largest preserved sockets (Figure 6). We used depictions of the battle carved on the monument at Orange, France, to refine the shape of the

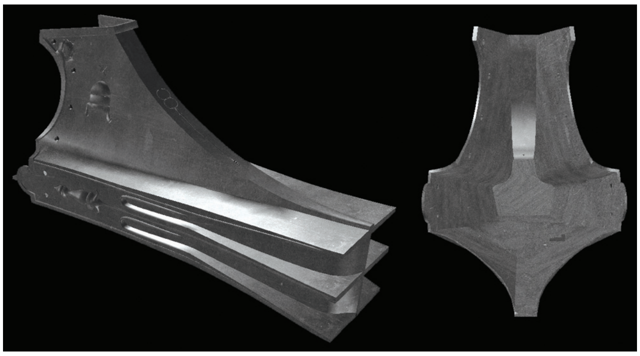

Figure 5. Screen grabs from the virtual reality model of the Athlit ram, showing the ram shape and the rear outline of the ram (which matches the negative shapes cut into the wall at Actium); © 2003 Institute for the Visualization of History, Inc.

Figure 6. Rendering from the virtual reality model of the monument at Actium, showing the socket wall, the original Athlit ram, and the much larger warped Athlit ram scaled up to fit into socket #4; © 2002 Institute for the Visualization of History, Inc.

socket #4 ram. As our process unfolded, we could appreciate the problems that were faced and solved by the builders of the monument in fitting the rams to the sockets. Finally, we were able to calculate from the 3D models that emerged the weight of the original rams; information not previously known.

Information gained from a study such as this allows historians to compare performance capabilities on simulated weapons with ancient historical accounts in order to reconstruct more accurately the battles in which these big ships took part. Historians will also be able, for the first time, to examine the accuracy of claims made by various ancient writers regarding the size and composition of the warring fleets, since here we will have a good representative sample of the weapons and thus the size of the ships actually used

Figure 7a. Plan of the citadel at Nimrud (the Northwest Palace is marked as "A"); drawn and © by 2003 Richard P. Sobolewski.

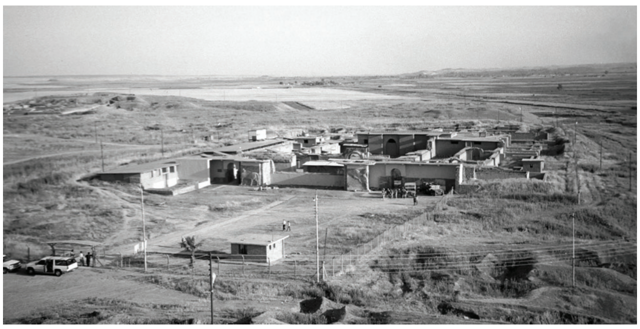

Figure 7b. View south over the Northwest Palace remains; © 2003 Mark Altaweel.

in battle.

So, why then do Virtual Heritage? Because we were able to gain new insight into one of the most famous ancient battles; to allow archaeologists to study the ship-building expertise and naval tactics of the ancient Romans; and to test the veracity of ancient Roman texts describing the battle. In other words, to ask questions and test theories about the archaeological data that could not be attempted otherwise. Here, we have been able to work backward from a single artifact to build a large historical picture and educate archaeologists about the nature of naval warfare.

3.3 Northwest Palace, Nimrud, Assyria (Iraq)

The Northwest Palace at Nimrud is considered the prototypical ancient Assyrian palace, the best preserved, and most elaborately decorated (Figures 7a, 7b). It was built by King Ashur-nasir-pal II during the 9th century BC, in the NW corner of the citadel at Nimrud. The palace has been extensively excavated by a succession of British, Iraqi, and Polish teams since the 1840s. Over the years, the magnificent wall reliefs from the building have become dispersed among more than 80 collections around the world, making scholarly research on and understanding of the original complex as a whole impossible. The palace is also the site of continuing gun battles between gangs of looters and local guards (only occasionally backed up by coalition forces; Figure 8).

The primary goals of the project have been: 1) to reassemble the globally dispersed wall carvings from the palace back into a simulation of their original contexts for detailed study; 2) to test various theories about the function, lighting, and circulation of the building; and 3) to evaluate previous visualizations for accuracy. When creating texture maps for the model, we discovered that the published drawings were not very accurate, not in detail or the shape of figures, nor often in transcription of the inscriptions, which have been relied upon for decades as the basis for research and cultural extrapolations. This offers a cautionary tale for those relying on period source material—always go back to originals as much as possible.

As we walked through the virtual reconstruction of the palace, we immediately gained new insight into Assyrian architecture, use of lighting, the carefully planned locational relationship between the wall reliefs and interior circulation and sightlines, and thus about the iconographic, educational, and propagandistic purposes of reliefs and the functions of spaces.

As our consulting Assyriologist puts it: “So here I had all this data and was asked to hand it over to the computer

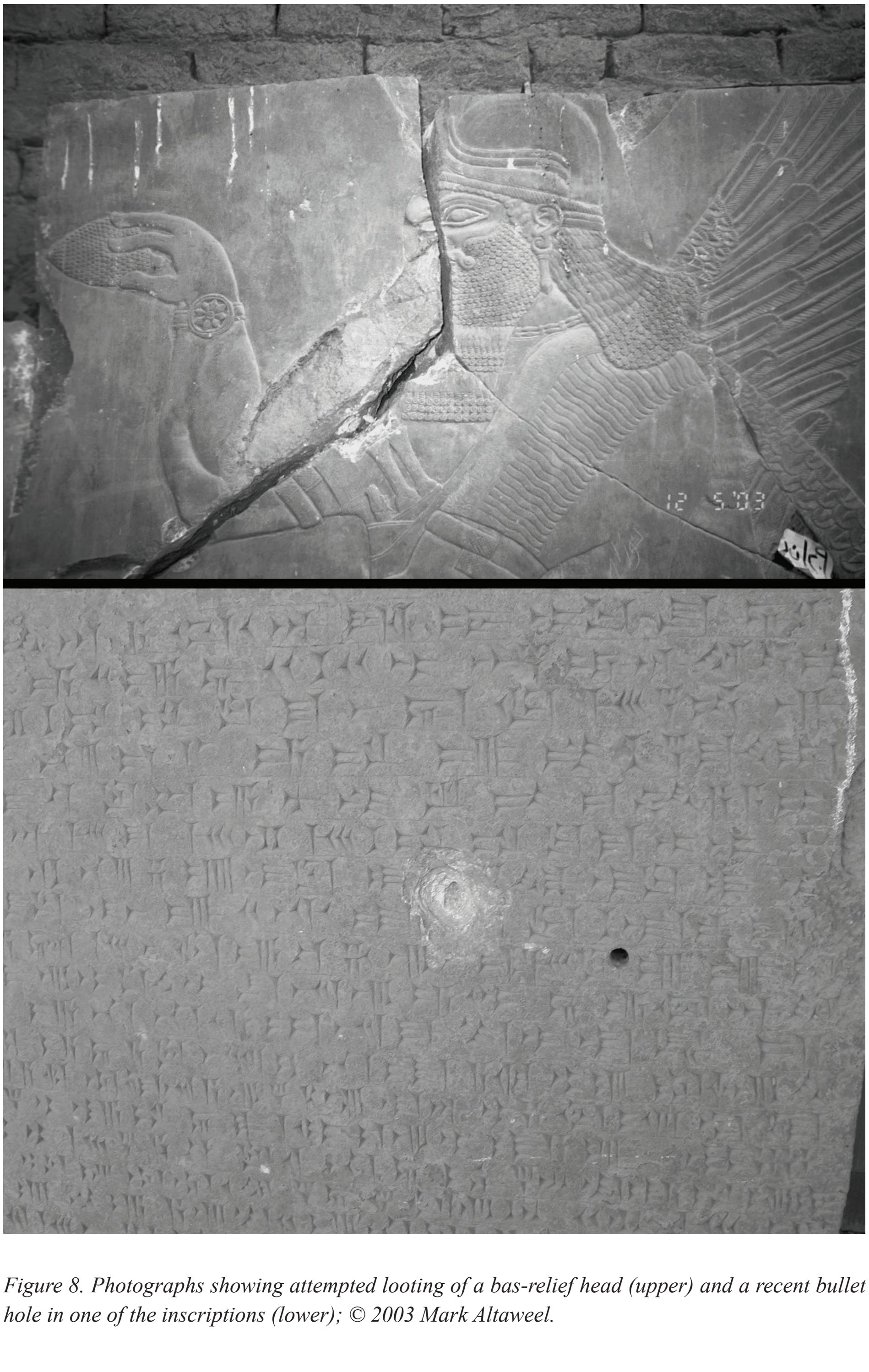

Figure 8. Photographs showing attempted looting of a bas-relief head (upper) and a recent bullet hole in one of the inscriptions (lower); © 2003 Mark Altaweel.

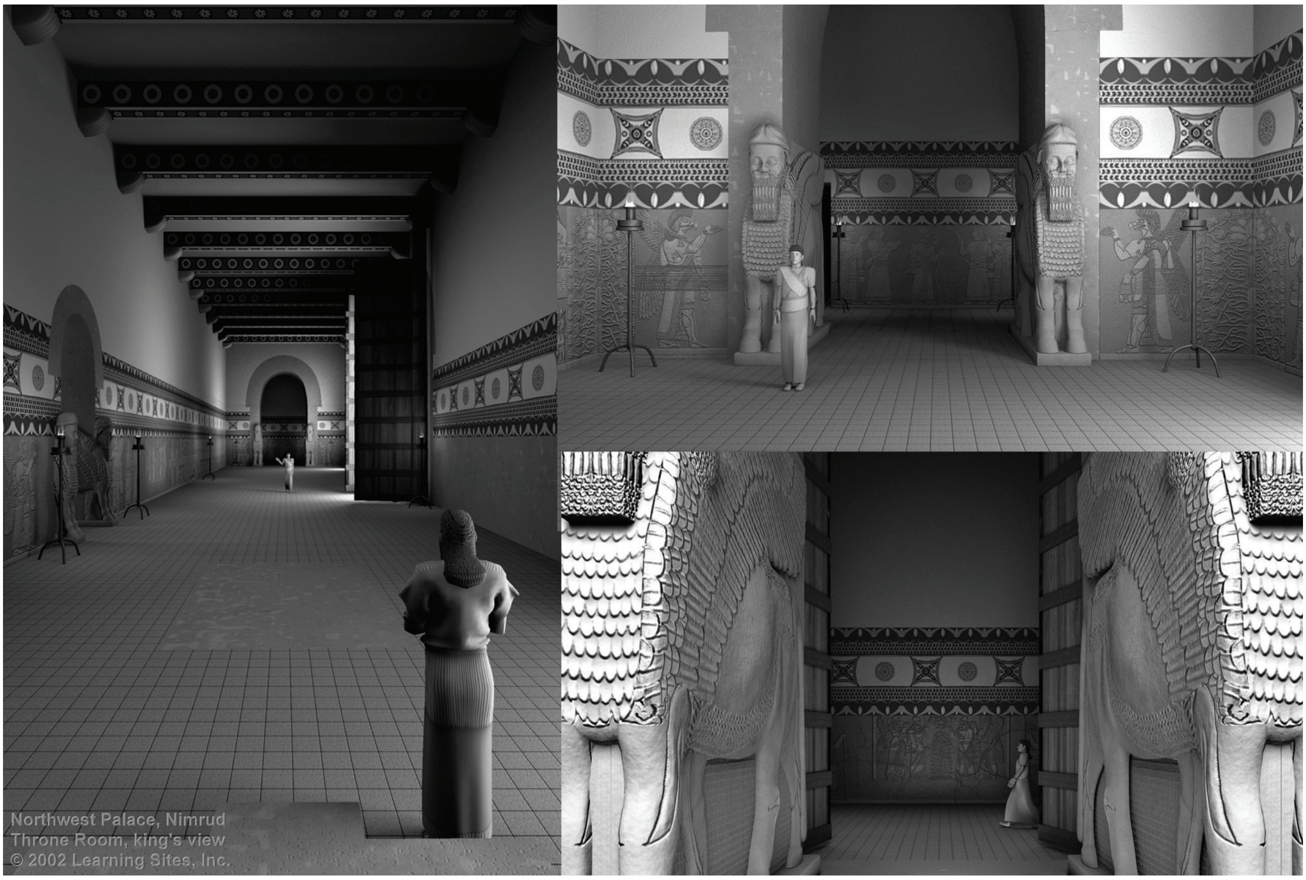

Figure 9. Various views extracted from the virtual reality model of the Northwest Palace, Nimrud, showing facets of the spatial relationships and sculptural program that could not heretofore be appreciated; © 2002 Learning Sites, Inc.

graphics experts. I then realized more than before, that what I had was not complete enough or precise enough for this new technology. Plans were inexact: some of them had been copied over by hand so many times that individual buildings had literally moved across the site. Information on some of the plans (e.g., lack of elevation data) was insufficient for the new digital tasks" (Samuel M. Paley, 2006, personal communication).

Our results proved convincing (Figure 9), he adds: "I am particularly pleased with such virtual reconstructions, because I am able to visit the site and travel through it and see things that I could not see in one image before or even see easily and quickly if I were able to visit the actual ruined site; I could appreciate spatial relationships the way the ancient Assyrians intended" (Samuel M. Paley, 2006, personal communication).

So, why then do Virtual Heritage? Because we are able to assemble for the first time, globally dispersed collections of material so that the original decorative schemes and narrative programs can be fully appreciated in a simulation of their original scale, lighting, color, and 3D spatial complexity. In the process, archaeologists came to realize how much data are missing and how much there is still to learn about the palace despite 150 years of research; and how wrong the long-accepted illustrations of the building have been. Testing data and long-held assumptions in three dimensions is crucial to verifying their validity. The model also acts as a visual repository for documenting the on-going deterioration of the palace.

3.4 Acropolis, Athens, Greece

Over the course of millennia since the Bronze Age, the outcropping of rock that dominates the city of Athens has been re-configured numerous times. The history of the structures and artwork that crowned the Acropolis continues to fascinate students and scholars alike.

Our work on the Acropolis focused on the Archaic temple of Athena Polias (built in the late 6th century BC on the center of the hill, and later flanked by the Parthenon and the Erechtheum; Figure 10). Our partnering archaeologist put our goals this way:

The challenge was to bring about a shift in perspective that would allow us to momentarily escape the tremendous authority and aura of magnificence with which the monument confronts the modern viewer and to consider it instead in terms of a solution to a set of problems in particular situations, and reconstructing a rational relationship between them. This approach called for a detailed account of all the circumstances by which the builders of the Classical monuments did their work and forced our attention to the major problem facing both statesmen and planners of the 5th century: what to do about the ruins of the Old Athena Temple that the Persian sack had left behind. The old hypothesis is that they merely cleared away unsightly rubble to make way for the new buildings. We questioned that prevailing narrative as it seemed odd that the ruins had simply been dismantled and its footprint left vacant everafter. Did the void itself at the center of the Acropolis have the character

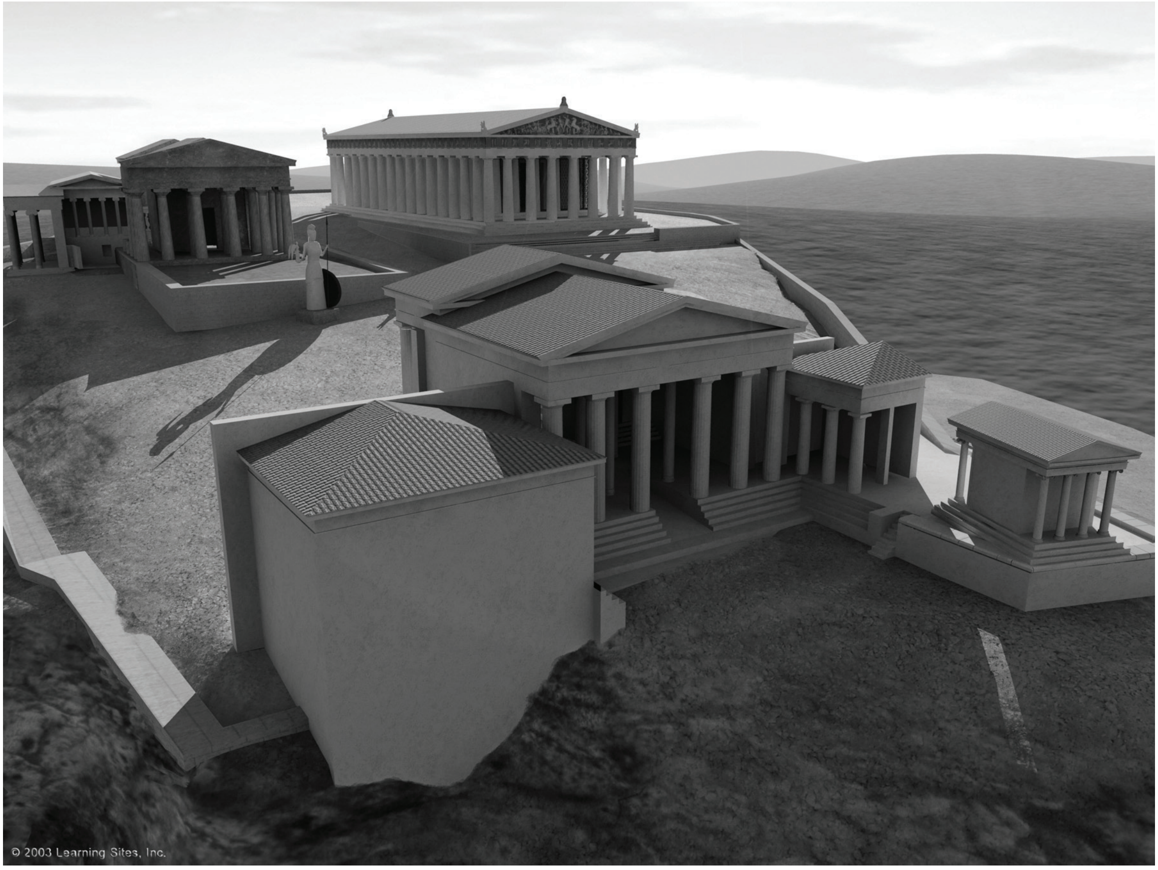

Figure *10. Rendering from the virtual reality massing model of the Acropolis showing a possible reconstruction of the old Athena Temple and how it dramatically changes the general spatial dynamics of the hill; © 2003 Learning Sites, Inc.*

of a war memorial? Or could the Temple, in some state of ruin, have remained? (Gloria F. Pinney, 2006: personal communication).

Nearly two centuries of excavations had created a veritable mountain of evidence about the history of the site, including ancient inscriptions describing the function of the site and the Classical building projects, ancient writers describing the buildings at various periods; 16th- through 19th-centuries travelers' paintings, engravings, and sketches of the Acropolis as they passed by; and 200 years worth of measurements of the buildings and topography. Whilhem Dorpfeld's late 19th-century discovery of the foundations of the Old Athena Temple and his reconstruction provided a starting point.

We learned quickly that no matter how many times the extant remains had been measured or the land surveyed, none of the sets of dimensions or elevations matched another's, leaving the buildings floating in relation to each other. Thus, it was particularly challenging to set the existing Classical triad (the Erechtheum, the Parthenon, and the Propylaea) in 3D space accurately with relation to each other and to the foundations of the Old Athena Temple. Luckily, with the help of old photos in Harvard University's archives, we were able to definitively settle that relationship and to argue that the Old Athena Temple remained in ruins as a war memorial long after the Classical period. In fact, we demonstrated not only how the Classical buildings were built specifically to take the Old Athena Temple's ruins into account, and that the sacred ground was not left empty, but that the ruins remained the focus of the Acropolis, and survived albeit incognito amidst the dense warren of Turkish houses that were summarily swept away in the 1830s without consideration of what might have remained of the holiest Athenian building.

So, why then do Virtual Heritage? Because it forces re-evaluation of orthodoxy and a needed correction in the interpretation of basic bits of evidence (Figure 11). To quote our collaborator:

> We were not to produce an illustration. The model's value resides in the same reasons why modeling is standard practice in schools of architecture: it provides means of checking information and, most of all, of visualizing what one has in mind. It was important to reckon with the visual impact of the Archaic Temple upon the Classical structures surrounding it. Most of all, accurate modeling that took into account all available data revealed existing evidence to refute the traditional argument that the temple could not have stood in that location after the Persian invasion (Gloria F. Pinney, 2006:personal communication).

3.5 Great Temple, Petra, Jordan

Petra lies in a great rift valley in Jordan, about 80 km south of the Dead Sea. As the principal Nabatean city, Petra has a history that can be traced back over 3,000 years. The Great Temple at Petra is one of the major archaeological and architectural features of the city. The Temple precinct

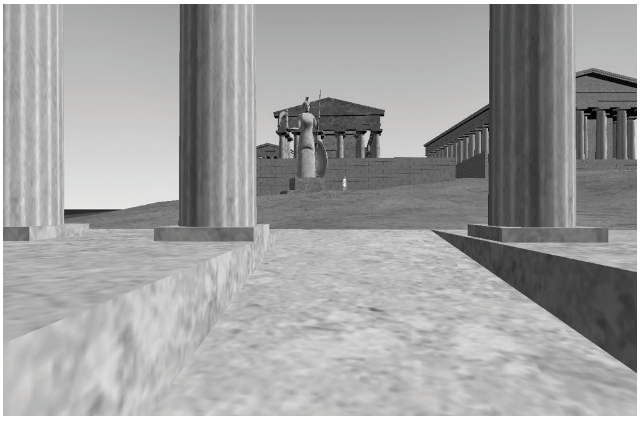

Figure 11. Screen capture from the virtual reality model of the Acropolis showing the visual dominance of the Old Athena Temple and alignment of it to the Propylaea; © 2003 Learning Sites, Inc.

is comprised of a gateway, a lower courtyard (with colonnades on each side), monumental east and west stairways, which lead to the upper sanctuary, and the Great Temple itself. Inside this structure, there is a small amphitheater surrounding a stage area that was installed during one of the last phases of use.

The goals for this project were a bit unusual in that they focused on visualizing human activity to test archeological theories of site function. A key issue was to determine how many people could have been seated in the amphitheater, and how efficiently would they have entered and exited it to and from the main city street.

Our test relied on simple virtual re-constructions of the built and natural environments, as well as ancient texts that were combed for examples of behavior in theatrical settings. Our team included AI experts from Brown University, New York University, and UCLA who developed software with user-specified parameters for sets of autonomous individuals, each with integrative motor, perceptual, behavioral, and cognitive components. When the simulation runs, the programming environment keeps track of the size of the audience, where each member of the audience sits, and how they interact. In a departure from the substantial literature on crowd simulation, we have developed a decentralized, comprehensive model of pedestrians as autonomous individuals capable of a broad variety of activities in large-scale synthetic urban-style spaces.

Our experiments reveal that the amphitheater can hold about 200 people comfortably; it requires about 7–8 minutes for the audience to enter and fill the amphitheater, and approximately 5 minutes to completely empty the space. We confirmed that since the two vaulted stairways leading from underneath the amphitheater to its auditorium are the only avenues for entry and egress, these areas become traffic bottlenecks.

So, then why do Virtual Heritage? Because yet another feature can now be added to the world of virtual ancient environments, that of the inhabitants themselves. With such AI-driven simulations, we are able to fine tune behaviors and situations in ways never before possible for archaeological contexts.

4 Conclusion

In summary, we know that virtual heritage works as eye-candy. There is no better way to engage people to understand and become excited about all those broken stones and dusty artifacts. What is really important, however, is that we need virtual heritage in order to do our best work. Archaeologists must make use of the potential for their research, teaching, excavations, and publications or risk being irresponsible, in not bringing all the means available to the task of collecting, analyzing, interpreting, and disseminating the data about their excavations. Soon, those not using interactive 3D computer graphics will be seen as one now views those who have not published their excavation material—they are depriving the profession of vital information necessary for understanding the past, and may in some cases be culpable of leaving the discipline with misleading and incomplete information.

So, why do virtual heritage?

- because there is no better way to test whether collected archaeological data works in reality;
- because there is no better way to test complex spatial, behavioral, and temporal hypotheses;
- because there is no better way to test the accuracy of past interpretations and evidence;
- because there is no better way to assemble globally dispersed artifacts back into a simulation of their original contexts;
- because there is no better way to visualize intrasite change and development; and
- because there is no better way to absorb complex datasets about the past than visually, interactively, and in 3D, just as we do in real life. Words are good; words and diagrams are better; linked databases and interactive 3D worlds are better yet.

A couple of years ago, historian David Staley (Executive Director of the American Association for History and Computing) wrote that computer visualization when used “to represent simultaneity, multidimensionality, pattern and nonlinearity with…speed and efficiency” can do what “prose cannot capture” (Staley 2002:36-37). In his book Computers, Visualization, and History, Staley argues that the real impact of the computer has been as a graphics tool more than as a processor of words. The importance of 3D imagery lies in its ability to address longstanding concerns of historians who agree with the 19th-century writer, philosopher, and social reformer, Thomas Carlyle’s observation that “Narrative is linear, Action is solid” (Staley 2002:38ff). Thus, the technical potential of computer graphics is that it can present a deeper and more richly rewarding history by giving a 3D solidity to past places and events, and at the same time act as a repository for the images, words, and objects that together define who we are and how we got here. That is why we do virtual heritage.

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