3D Model of the Shrine at Vronda, Crete in Auto Cad

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Appendix E - UNIVERSITY HONORS PROGRAM
SENIOR PROJECT - APPROVAL

Name: MICHAEL RYAN DECKER

College: ARTS & SCIENCES Department: CLASSICS

Faculty Mentor: DR. GERALDINE GESELL

PROJECT TITLE: 3D MODEL OF THE SHRINE AT VRONDA, CRETE

IN AUTOCAD

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed: ____________________________ Faculty Mentor

Date: ____________________________

General Assessment - please provide a short paragraph that highlights the most significant features of the project.

Comments (Optional):
In order to make this autocade drawing, Michael Decker had to go through all the excavation notebooks for the shrine area to find all the points taken during four years of excavation of the area, collate them, find the significant ones for his purpose in reconstructing the architecture, and plot them on the autocade. He needed to read all the preliminary publications of the shrine. No such drawing of the shrine had been made previously. His drawing required knowledge of the site excavation techniques, and an understanding of the LM IIIC period in Crete. To do this particular project was his own idea and it is his own original work. I am pleased with it and impressed by it.
A Reconstruction of the Shrine at Vronda in AutoCAD

Michael R. Decker
Advisor: Dr. Geraldine Gesell

May 8, 2001
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The purpose of this project is to create a three-dimensional computer reconstruction of the LMIIIC shrine at Vronda, on eastern Crete. This paper will give a brief introduction to Minoan Crete and the Kavousi excavations, of which Vronda is one of two sites. In addition, I shall also outline the steps involved in reconstructing the shrine in AutoCAD as well as instructions on accessing and manipulating the model.

Background: Minoan Crete

Crete, the largest island in the Aegean Sea, was the home of a flourishing civilization during the Bronze Age (ca 3000-1100 BCE). This civilization, the first great civilization of Europe, was characterized by such things as its palace economy, distinctive pottery, and Linear A, its still undeciphered language. Minoan Crete both influenced and was influenced by surrounding cultures, especially the great civilizations in the Near East, notably Egypt, the Levant, and the emerging civilizations in the Aegean, which included the cultures of the Cycladic islands and the Helladic (later Mycenaean) civilization on mainland Greece. The great centers of Mycenaean Greece would later be recalled in Western literature though Homeric epic. Based on pottery typology, Aegean civilization can be divided into three periods: Early, Middle, and Late (see fig. 1).

The Early Minoan period, abbreviated EM, immediately followed the Neolithic period Crete. This period, from roughly 3000-2100 BCE, is contemporary with the period of pyramid building in Egypt in the Fourth through Fifth Dynasties, although the Early Minoan period

Figure 1: Chronology of Prehistoric Aegean Civilization. S. Hood, The Arts in Prehistoric Greece, The Pelican History of Art, N. Pevsner, ed. (New Haven 1978) 15.
extends as far as the Tenth Dynasty and the First Intermediary Period.\footnote{The Egyptian chronology is used to give absolute dates to relative chronology established by ceramic evidence. The Egyptians kept excellent records of celestial occurrences, and using such evidence, their pottery can be absolutely dated. Thus Egyptian pottery on Crete gives a \textit{terminus ante quem} for the context in which it was found. Other chronologies exist; however I shall use the Egyptian chronology because it is more widely accepted.}

During the Middle Minoan period (roughly 2100-1600 BCE), the first palatial centers were built. The palaces were the religious and administrative centers of the islands and were hubs of large redistributive economies. They featured shrines, private quarters, large storage areas, and central courtyards, their most distinctive feature. The largest of these palaces was that at Knossos, the home of the legendary eponymous king Minos. The island’s other palaces were located at Zakros, Phaestos, and Mallia, although there may have been others (see fig. 2). There were also smaller palaces located in regional centers, such as that of Gournia. However, at the end of MMII (around 1700 BCE) there was a major destruction. Beginning with MMIII, a second palace period was inaugurated, in which the major palaces were rebuilt on an even grander scale (see figs. 3-5).

The Late Minoan period (roughly 1600-1100 BCE) began during the prosperity which marked the second palace period on Crete. However at the end of the LMIA period, around 1450, the Minoan colony of Akrotiri on the volcanic island of Santorini was destroyed by the eruption of Thera, leaving immaculately preserved ruins and a breathtaking caldera in its wake. This eruption may or may not have crippled nearby Crete; however shortly thereafter the warlike Mycenaean Greeks overran the island, destroying the palaces, with the exception of Knossos, which was retained as an administrative center, and establishing Linear B, an early written form of Greek, in place of Linear A. What follows are several years of Mycenaean occupation and cultural and political disintegration. Several portions of the palace at Knossos are burned by 1400
MAP OF CRETE showing the main sites.

Figure 2: Map of Crete. S. Marinatos, *Crete and Mycenae* (London 1960) 114.
Figure 4 (above): Areal View of Knossos. U of TN Dept. of Classics Slide Collection

Figure 5 (below): View of Phaestos. Theatral Area in Foreground with Central Court behind. U of TN Dept. of Classics Slide Collection
BCE (LMIII) and the arts deteriorate in quality. Towards the end of the Bronze Age, in the period from 1200-1100 BCE (LMIIIIC) Minoan civilization had been reduced to small, isolated, easily-defensible, settlements in the mountains. Crete, with the rest of the Aegean, had plunged into several hundred years of darkness, and would not emerge until the eighth century BCE, when Greek culture emerged once again with Homer and the first Olympiad (776 BCE).

**Building G at Vronda-An LMIIIIC Shrine**

Vronda, part of the University of Tennessee excavations at Kavousi, dates to the final years of Bronze Age civilization on Crete. The settlement at Vronda includes several domestic and public buildings, including the shrine (Building G). Although it contains several early iron age burials, the site was primarily occupied during the LMIIIIC period (see fig. 6)

The shrine itself lies in the southern section of the site. While the exact use of the shrine is unknown, it contained several pieces of ritual equipment, such as snake tubes (cylindrical tubes with serpentine handles), kalathoi (ritual bowls), scuttles, and wheel made clay goddess sculptures (see fig. 7)

The architecture, which I attempted to reconstruct, is imperfectly preserved. Only portions of the exterior walls and a small section of one interior wall remains (fig. 8). Along the east side of the structure is a small hill, with which the eastern wall is built upon. The terrain then

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Figure 6: Vronda. Plan of Settlement (1990). G.C. Gesell, et. al., Excavations at Kavousi, Crete, 1989 and 1990," *Hesperia* 64 (1995) 69 Fig. 1.
Figure 7: Shrine Equipment from Vronda: Top, from left: Plaque 1, Goddess 5, Goddess 1, Plaque 2; Bottom, from left: Snake Tube 4 with Kalathos 5, Snake Tube 2 with Kalathos 7. Unpublished Photograph.
Figure 8: State plan of the shrine at Vronda. Unpublished
gently slopes from east to west. The interior of the shrine consists of two rooms, Room 1 and Room 2. Room 1, the larger room has benches or platforms along the north and east walls. In it were found the remains of a goddess and a Geometric (early Iron Age) interment. Room 2 is the smaller of the two rooms. Its features include benches along the north, south, and east sides and a small hearth in the middle. Along the eastern bench, several snake tubes were found in situ.

**Computer Modeling**

In recent years, computers have played an increasingly greater role in archaeology. Databases have been used to record and manipulate data. Also, with increased graphical capabilities, they are now being used to supplement standard paper drawings and to aid in reconstruction. A computer model has several advantages and drawbacks when compared with more traditional drafting techniques. One of the greatest advantages to computer modeling is the fact that a computer model can be manipulated. A three-dimensional reconstruction allows a user to view a structure or site from several different angles and to easily make cross-sections. Although such manipulations can be performed with a few simple keystrokes in a computer model, they would require entirely new drawings to be made if reconstructing the building using pen and paper. Another advantage to computer modeling is that it can be modified when presented with new information, whereas a paper drawing would have to be redrawn. Also a computer allows one to work in three dimensions rather than the two, which permits one to take advantage of newer three-dimensional data collecting instruments, such as Electronic Distance Meters and GIS systems and import them directly into programs such as AutoCAD. However, despite these advantages, there are also several drawbacks, the most prominent of which is its difficulty. Computer modeling requires specialized knowledge in computer aided drafting and related
applications. Also, it requires more work to enter in the data and create the necessary lines, solids, etc., than to simply draw them on paper, which often renders computer modeling impractical. Another drawback is that it is extremely difficult to recreate the detail which is possible with paper based drawings. Therefore, while computers open up exciting possibilities, their current limitations prevent them from supplanting more traditional methods.

Despite their limitations, several projects have used computer aided drafting techniques in digitizing field data and reconstructing archaeological remains. The Corinth Computer Project, run by David Romano at the University of Pennsylvania, uses AutoCAD to digitize and analyze maps and field notes to create a large, comprehensive map of the site and its environs. Similarly, the University of Virginia's Pompeii Forum Project uses computers to digitize and analyze existing field data as well as data gathered through on-site computerized instrumentation. On eastern Crete, the Vrokastro Survey project imports field data into AutoCAD from an Electronic Distance Meter (EDM) Total Station to create a large, two-dimensional map of the survey area.

The use of computer aided drafting has also enabled archaeologists to reconstruct architectural remains. The University of Chicago, as part of its excavation at Isthmia, has created computer generated reconstructions of the various building phases of the Sanctuary of Poseidon,
using AutoCAD for architectural design, Quicksurf for creating realistic topography, and AccuRender for realistic materials rendering. Such rendered images are both beautiful to look at and show the potential of computer aided design in archaeological research.

The Model of the Shrine at Vronda

In creating my model, I sought to follow in the footsteps of work done at Isthmia. However, I was faced with several limitations, not the least of which is that they are simply better at what they do than I am. Other limitations of this project involved software. I lacked topographical software such as Quicksurfer with which to create realistic topography, and a materials rendering program such as AccuRender or 3D StudioMax. While the heart of any such computer based reconstruction, the CAD design, was able to be created with some deal of accuracy, my lack of such related applications to some extent detracted from the overall realism of the project.

Other problems encountered in the reconstruction were purely archaeological. Due to poor preservation, no doors or windows remain. However, it has been determined that there was probably an entrance along the south side and in the wall separating Rooms 1 from 2. Also, while it is possible that there may have been an entrance along the north side leading into Room 2, there is no way to confirm that. Therefore, in my reconstruction, I have chosen not to include it.

Regarding windows, the height of the preserved walls leaves no trace of whether there were windows on the building or not, and if so, where they were located. Therefore, rather than assume something which I had no basis to do, I decided to leave these out of my model.

Another problem in reconstructing the building arose when determining the height. The

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7The rendered images from the Sanctuary of Poseidon at Isthmia are published on the Internet at http://humanities.uchicago.edu/isthmia/isthmia.html.

trench master excavating trench 9900 in 1989 had noticed the presence of stones and artifactual remains above the level of the collapsed roofing clay and that above the roofing clay but below the building stones was a layer of topsoil. He went on to propose in his trench report that the building was two stories, and that the roof and second floor collapsed prior to the walls and that the space between them was filled in by topsoil until finally the unsupported walls collapsed over these. However, another explanation for this phenomenon is that the building was in fact a single story and that after the roof collapsed, the building continued to be used and artifacts continued to be deposited until the final collapse of the building.

Construction of the Model: The Coordinate System

In reconstructing the building, it was first necessary to establish a coordinate system in which to work. AutoCAD uses a standard x,y,z coordinate system. In order to import the field data into AutoCAD, first I adapted the existing trench grid to AutoCAD’s coordinate system on the xy plane. Each trench measures five by five meters. I used a scale of one actual meter equals one unit in AutoCAD. Because the trenches are aligned with the cardinal directions, I decided to align north with the y axis. I then set an arbitrary origin at the intersection of four trenches (8400, 8900, 000, 100) and set up a grid in which each trench has dimensions of five units (see fig. 9). The next step was to establish coordinates on the z axis, which defines the third dimension. Because the lowest point of topography in the area of the shrine was at 421 meters above sea level, I set the value of z at the origin to 420 meters above sea level, allowing me to work fairly close to the origin. See fig. 10 for a diagram of the origin, AutoCAD coordinates, and the corresponding trenches and elevations.

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10G. Gesell, Personal Communication 4/10/01.
Figure 9: State Plan of Building G (the Shrine) with AutoCAD xy coordinate overlay.
Figure 10: The Origin (intersection of Trenches 000,8400,8900,500 at 420 meters above sea level) showing the x, y, and z axis.
Construction of the Model: Importing the State Plan

With the coordinate system established, it was necessary to scan in an image from which to digitize the model. The most recent state plan (an areal drawing which shows the structure as preserved) was drawn by the site architect, Nancy Klein (see fig. 8, above). In order to calibrate and scale this plan with the grid I set up, I had to cut up the image in Photoshop into separate trenches and then stretch the image of each trench into the space allotted for each trench in my coordinate system. An earlier attempt to import and calibrate the entire drawing had failed because the drawing I was using was a photocopy (all the original documents are stored in Crete) which was slightly out of proportion. Fortunately, the copy was no so extremely out of proportion as to cause the walls not to line up after being cut up and put back together on my second attempt. This plan, lying on the plane where \( z=0 \), became my “0,” or background, layer, and it is hidden from view on the final renderings.

Construction of the Model: The Topographic Mesh

Once the coordinate system was set up using the existing trench grid and elevations and the state plan imported into AutoCAD, I was able to create the topography in three dimensions. Topographic software and some GIS programs, z. B. Quicksurf, are able to use scattered points of topography to create contours and to import these contours into AutoCAD into form of a 3D mesh of individuals' faces. However, I performed this task manually. I used the bottom elevations from the Architect's Notebooks and Vronda Trench Reports (unpublished), which were gathered by means of a transit (a mechanical sighting device which enables the user to use trigonometry to determine elevations and distances) and by means of an EDM (see above; this device uses a laser and built-in computer to automate the tasks which are normally performed by a transit). This data, along with site photography, revealed that the ground in the area of the shrine sloped
upwards gently from west (roughly 421 meters above sea level) to east (roughly 421.5 meters), before rising sharply behind the eastern wall of the shrine, in which the slope was embedded (see fig. 11). Rather than create an actual 3D mesh, I created several separate 3D faces, determining the coordinates of each corner beforehand, using the various “snap to” functions of AutoCAD to ensure that each face joined properly with the adjacent faces. All topographic surfaces are stored in a layer entitled “Ground. (fig. 12)” Once this portion of the model was complete, in another layer entitled “Dirt,” the topography surface was skirted with 3D surfaces perpendicular to the xy plane, and this was covered on the bottom (i.e. the xy plane where z=0) with another surface, creating an apparent solid and hiding the “foundations” of the building. Also included in this layer is the hearth from Room 2, which I digitized into this layer using the methodology for creating walls discussed below (fig. 13, n.b. this image is rendered, i.e. AutoCAD, using colors assigned to layers and objects, “renders” light, shadows, and shading).

Construction of the Model: The Walls and Platforms

When building the walls, I determined that it was easiest to digitize the walls and platforms on the xy plane where z=0 and to extrude the polygons created by digitizing the plan upwards. First, I traced the outline of the walls in a layer entitled “Reconstop,” varying from the state plan in places where stretches of walls were not preserved, especially in between the east and west walls, where the location of doors was to a large extent hypothetical. Once the desired outline was drawn using a polygonal line (“pline”), I extruded the walls (as far as the top of the entrance) to a height of four meters from the xy plane where z=0, taking into account that the ground level was between 1 and 1.5 meters above this plane, and that therefore the visible height of the walls above the ground would be between 2.5 and 3 meters. Because extruded polygons can not be directly

\[11\text{N. Klein, “Report on Activities, 1997 Study Season” (unpublished).}\]
Figure 11: The east wall of Trench 9900 with the slope behind it. U of TN Dept. of Classics Slide Collection.
Figure 12 (above): Topography as modeled, from SSW.
Figure 13 (below): Topography as modeled, from SSW, with dirt skirting. Rendered view.
edited, I found it helpful to “explode” (i.e., to break up solids into their respective polygonal faces) these walls prior to modifying or revising them. The section of wall above the level of the door was created in a manner similar to that of the wall beneath it. Using the “snap to endpoint” command, I was able to ensure that the top of the wall as flush with the section beneath it, with the exception that the wall was closed over the doors. This caused a problem in that this section of wall, rather than being one extrudable polygon, was actually three, one exterior polygon and two interior polygons. AutoCAD, in extruding the exterior polygon was unable to recognize the interior polygons and extrude only the space between them. Therefore, I created several separate adjacent closed polygons and extruded them. The extruded height of this section of wall was 0.5 meters, giving the wall a total visible height of 3-3.5 meters (figs. 14-15).

The platforms and benches, which line portions of the interior of both rooms and run along the exterior of the west wall, were created in a layer called “Reconstruction” using the same method as the walls, although these were extruded to a lower height than the walls. Also included in this layer is a small bedrock outcrop which sits in front of the exterior bench on the west side. The purpose of this outcrop is unknown.\(^{12}\) (See figs. 16-17). The final step, the roof, consists of a single extruded polygon flush with the exterior face of the wall. It is in a layer entitled “Roof” and is colored consistent with the clay roofing material used in construction. (see fig. 18)

**Final Comments**

Although the goal of this project was the creation of the model of the shrine, another purpose in doing so was to establish an efficient methodology to create other models. This model was largely the result of trial and error; however using the methodology worked out in this model, models of other buildings at the site can be created in a fraction of the time, while at the same

Figure 14 (above): Walls, as modeled. Southwest isometric view.
Figure 15 (below): Walls, as modeled. Rendered view from SSW.
Figure 16: Benches, platforms, and limestone outcrop from WSW. Rendered view.
Figure 17: Walls, benches, platforms, and limestone outcrop form SSW. Rendered view.
Figure 18: View of the roof from above. Rendered view.
time refining the existing methods. Another, albeit indirect, result of this project involves the trench reports. My preliminary research into these notes prompted me to reorganize them to facilitate location of desired field notes, especially notes relating the shrine (Building G), which I moved and reorganized into two volumes.

Using the Model

To use the model, first open the file in AutoCAD. At this point, you have several options in selecting from which angle to view the building. Under the “View” menu, you may select, under “3D Viewpoints,” from many, including four preset isometric viewpoints. Additionally, under the “View” menu, I have named three custom viewpoints. Click on “Named Views” and select either “Entrance,” “Interior.” When using views “Room1” or “Room2,” which are interior views of their respective rooms, one should turn off the “Roof” layer, under the pull down menu at the top of the screen. (Turning a layer off may be accomplished by clicking on the lightbulb icon next to each layer). Another viewing option found under the “View” menu is the realtime “3D Dynamic View;” however this option requires some prior experience with AutoCAD or the ability to figure things out quickly. To switch from wire-frame to a rendered view, in the text entry box at the bottom window, type “Render.” This will bring up a dialogue box with rendering options. Ensure that the “Destination” section is set to “Viewport” and click “OK.” To switch back from rendered to wire-frame views, type “Regen” in the text entry box at the bottom of the window. Several different views of the model are included here in figs. 19-23.
Figure 19: Final model of Building G (shrine). Rendered southwest isometric view.
Figure 20: Final model of Building G (shrine). Rendered northeast isometric view.
Figure 21 (above): Final model of Building G (shrine). View from SSW.
Figure 22 (below): Final model of Building G (shrine). Rendered view from SSW.
Figure 23: Rendered view of interior.