A 3-Dimensional Reconstruction of a Hellenistic Terracotta Plaque

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Abstract. Fragments of a Hellenistic architectural terracotta plaque representing a pair of dolphins confronting a central floral ornament have been excavated from a sanctuary precinct at Monte Pallano (Abruzzo, Italy). This paper describes issues involved in preparing a reconstruction of the original plaque and of the mould from which the individual plaques used to decorate the sanctuary building were made. The initial reconstructions included two-dimensional illustrations and photographic composites. More recently laser scans were combined to produce a three-dimensional reconstruction.

1. Introduction

This paper describes a three-dimensional reconstruction of a Hellenistic terracotta plaque that once decorated a Samnite sanctuary in the Abruzzo region of Italy. The overall project has two main goals:
1 to reconstruct a prototype of plaques' original mould, and
2 to describe quantitatively the variability of the relative sizes of the fragments. Both these goals will help to understand the manufacturing processes by which the tiles were made. Three-dimensional (3-D) scanning has previously been applied to a variety of archaeological reconstruction problems. Examples include generation of pottery in 3-D from single fragments (Mara and Kample 2003; Sablatnig and Menard 1997); 3-D reconstruction of pottery from multiple sherds (Cooper, et. al. 2001; Kampel and Sablatnig 2004); and 3-D reconstruction of a 15th century stone rood-screen from multiple fragments (Laugerotte, et. al. 2003). This paper is the first to reconstruct in 3-D an architectural terracotta tile from multiple fragments.

2. Archaeological Background

For the past five years (1999–2003) the Sangro Valley Project has conducted excavations at Monte Pallano in the middle Sangro River Valley of the Abruzzo region of central Italy. The Project is headed by Susan Kane (Oberlin College, USA) and Edward Bispham (Oxford University, UK) in collaboration with Amalia Faustoferri (Soprintendenza per i Beni Archeologici dell'Abruzzo). The Sangro River begins in the mountainous upland plateau of the Apennines of central Italy (an area that in part corresponds to the territory of ancient Samnium), and flows to the Adriatic coast. Surprisingly, large parts of ancient Samnium remain relatively unknown. Portrayed in the Roman historical record as a culturally isolated area, the region's reputation as the epitome of 'backwoods' Italy has persisted into modern times. New discoveries, such as the terracotta plaques discussed here, are demonstrating that this area was a greater participant in the broader processes that shaped ancient Italy than has been previously thought. The imposing ridge of Monte Pallano rises to a maximum height of over 1000 meters and dominates two river-valley systems, the Sangro to its north and the Osento/Sinello to its south. Long known for its huge megalithic walls, Monte Pallano was an important feature in the ritual and territorial landscape of the ancient Samnites. It was the principal center for a multi-focal nucleated settled environment from the early Iron Age until the High Empire, with possible sporadic activity continuing in the Middle Ages. Over the past decade, the Soprintendenza per i Beni Archeologici dell'Abruzzo has excavated a substantial complex of public buildings in a sheltered saddle on Monte Pallano. During the past five years, the Anglo-American excavations have uncovered evidence for a sanctuary precinct nearby. The latter excavations have revealed a substantial quantity of architectonic debris, largely architectural terracottas that once decorated a sanctuary building of the late-third to mid-second century BC.

3. The Dolphin Plaque

To date over 300 architectural terracottas have been excavated. Many of the fragments are from statuary and high-relief plaques decorated with both figural and floral designs that adorned the sanctuary's building(s). The largest number of terracotta fragments belong to an unusual and highly beautiful type of mouldmade Hellenistic plaque depicting a pair of dolphins confronting a central floral ornament. The imagery of dolphins confronting a floral ornament-an iconography perhaps linking mountain and sea and this world to the next-is a potent cultural symbol, one fitting to the aspirations of the Samnite patrons who commissioned the building.

4. Two-Dimensional Reconstructions

In order to better visualize the complete dolphin plaque, several two-dimension reconstructions have been prepared over the past few years. Swift (2001) drew an illustration, based upon a relatively small number of then-excavated fragments (figure 1). In this illustration, due to the relative paucity of fragments, the tile's left side is simply a reflection of its right side. Subsequently, Carrier (2002) prepared a

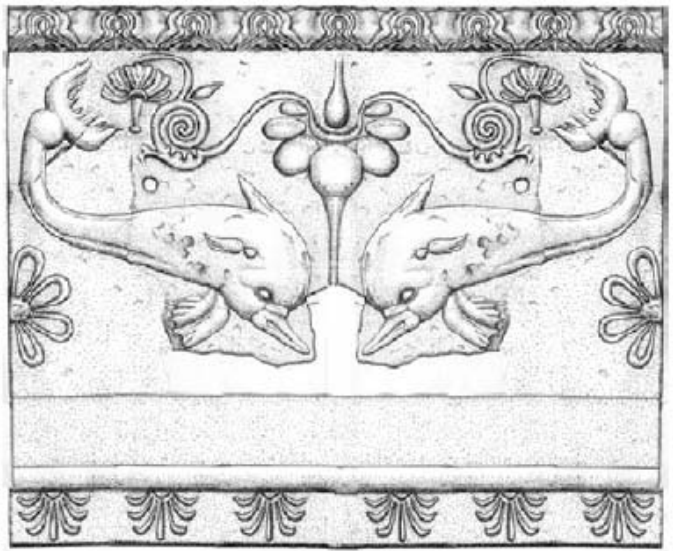

Fig. 1. Pen and ink illustration of dolphin plaque by Swift (2001).

Fig. 2. Photographic reconstruction of dolphin plaque by Carrier (2002).

photographic reconstruction from over 20 pieces (figure 2). During the photographic reconstruction it became apparent that the fragments came from tiles of different sizes, since individual fragments needed to be rescaled as well as moved and rotated in order to overlap appropriately. Two sets of joins establish the overall configuration and the approximate dimensions of the object (figures 3 and 4).

Fig. 3. Joining fragments across vertical dimension.

Fig. 4. Joining fragments across horizontal dimension.

Numerous scholars have discussed range of variability in the size of mould-made terracottas that can be attributed to shrinkage and re-moulding. Nicholls (1952) described the production processes for mould-made terrracottas and examined issues related to the classification of ancient terracottas into types, groups, and series. In the case of architectural terracotta tiles, the producer first sculpts an original plaque (the archetype); from this object a clay mould is taken, which is then fired and used to fabricate a series of individual plaques. Terracotta is pressed in the mould, tamped, and the back surface is smoothed. The plaque is then air-dried and fired. Individual plaques from a single series may be of different sizes due to differential shrinkage during drying and firing. Furthermore, the original mould may subsequently be damaged and the archetype no longer available; thus a second mould is made from one of the plaques to create a production mould for additional plaques (which will be smaller in size than those from the first generation). One study of a series of architectural terracottas (Knoop 1989) considered how variability in the size of architectural terracottas arises during the manufacturing process. Shrinkage can take place during both air-drying and firing, with the latter process probably contributing more than the former. The amount of shrinkage is also dependent upon characteristics of the clay matrix-the amount and nature of the aplastic inclusions, whether occurring naturally or added as tempering. A higher concentration of inclusions is presumed to lead to less shrinkage. Measurements of the width of the half-round that goes across the bottom of the dolphin plaque were made from high-resolution, scaled digital photographs of 28 tiles. These show shrinkage (calculated from the largest width) in the 1–25% range (mean of 10.7%, with a standard deviation of 7.5%). These values compare reasonably well with shrinkage values reported by Knoop (1989) in the 2–15% range (mean of 7.8%, with a standard deviation of 3.8%) for Campanian architectural terracotta antefixes. As a result of excavation we are confronted with an assemblage of terracotta plaque fragments derived from an unknown number of actual plaques (our current estimate is 100–150 plaques, based upon the size of the plaques and typical sanctuary sizes of the

period), each with unknown amount of shrinkage. Some of the excavated fragments are clearly from a single individual tile. This situation arises when:

a the piece was fragmented during antiquity, with the fragments subsequently distributed across the site; or

b the piece was fragmented during excavation. Such fragments may be manually "joined" to restore their original arrangement. More commonly, the fragments are from different tiles of the same series. Here some of the individual pieces may be from the same section of the underlying mould, but the tiles were fractured in different places, and thus forming visually identifiable (based upon features such as a portion of the dolphin body, floral motifs, edges, etc.) segments constituting "overlapping" elements.

5. Three-Dimensional Reconstruction

During the summer of 2003, some 76 plaque fragments were scanned in three dimensions with a Minolta VIVID 900 digital laser-scanner. In this process objects are placed on a computerdriven rotary stage, and scans taken at regular intervals, typically in 60-degree increments. A three-dimensional point-cloud is assembled from the individual scans with commercial software (Raindrop Geomagic's Studio). The composite point-cloud typically requires some manual cleaning-removal of outliers, portions of the rotary stage, and other scanning artifacts. Next a triangular mesh is constructed from the points. Following further editing, a best-fitting NURBUS surface is computed and displayed. The three-dimensional reconstruction of the dolphin plaque proceeded from the 3-D models of individual fragments-the fragments selected for the reconstruction are illustrated in figure 5.

Fig. 5. Mosaic of fragments used in 3-D reconstruction.

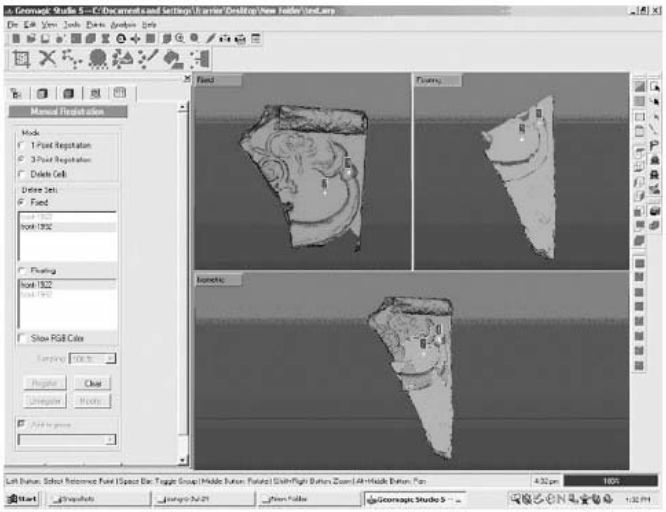

Fig. 6. Screen shot showing registration points on individual fragments (upper section) and the merge.

For the overlapping fragments, registration points are selected on pairs of fragments (figure 6), and the fragments merged in software, based upon the geometry of these points. Progressing from left to right, and top to bottom, additional fragments were then added one-by-one to form a composite of increasing extent.

The software did this fairly well, although registration points must be selected with some care and placed with some precision. Merging the joining fragments proved to be, paradoxically, more difficult. Registration points could not be distributed across the surface of the fragments; they were necessarily restricted to the edges.

Thus, in a first attempt the left side of the plaque was reconstructed from its fragments by manually aligning the top surface of the pieces to a plane drawn in 3-D space and adjusting their position along the z-axis to this alignment plane. This approach proved to be fairly difficult and was abandoned. Rather, other fragments from the left side that did overlap were selected, and these were ultimately used following the procedure for overlapping fragments described above. Finally, the two sections were merged to produce the three-dimensional reconstruction shown in figure 7.

Fig. 7. Screen shot of the 3-D reconstruction.

6. Future Plans

This reconstruction will be used to explore the issue of shrinkage in architectural terracotta plaques. The Raindrop Geomagic software contains routines to compare the fit of a scan of a fragment with a CAD model, displaying visually and quantitatively the deviations. The software also provides 3-D measuring tools, allowing comparisons along all three axes.

Acknowledgments

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