Using 3-D Prototyping as an Intermediary in the Reconstruction of Ancient Pottery
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This project explored the use of 3-D prototypes to aid in the reconstruction of ancient ceramic vessels through the treatment of two fragmentary objects in the collection of Greek and Roman Art at Emory University's Michael C. Carlos Museum in Atlanta, GA. A black-figure plate depicting the Judgment of Paris is attributed to Lydos (ca 560-550 BCE). About one half of the plate survives, and all but one of the fragments join together. The second object is a red-figure kylix with an offering scene in the interior tondo and lovers in women’s quarters on the exterior that is signed by the potter Euphronios and attributed to the painter Onesimos (ca. 500-490 BCE). Approximately one dozen fragments, some assembled from smaller fragments, represent less than one third of the kylix, and these pieces do not join directly. These important examples require reconstruction to join the fragments, making the objects stable and the forms more legible for teaching and exhibition.

Three-dimensional prototypes of the original vessels were created to serve as intermediaries in the reconstruction process, facilitating molding and filling while minimizing direct handling of the ancient fragments. 3-D prototyping is widely used in industry to model examples prior to initiating costly production. It is also used to reproduce handmade forms, as for jewelry, and has been used by sculpture artists. For this conservation application, a replica of each object was produced from 3-D digital renderings, based upon measurements taken off the objects themselves using ruler, compass, and calipers to draft the profiles. The digital renderings were produced using imaging software including Lightwave, 3-D Studio Max, and Rhino. Of these software options, Lightwave was found to be the most accessible and easily learned.

The digital files were then “built” as three-dimensional volumes in either wax or resin. The ThermoJet® 88 wax forms were built on equipment that operates much like an ink-jet printer. 3-D printing with a thermoplastic, compound such as ThermoJet 88", is the faster and less expensive process. The thermoplastic compound handles much like the wax-resin fill often used for translucent stone and can be refined with scalpels and hot tools. Alternatively,
stereolithography uses a laser, guided by the digital rendering file, to produce forms from the light-cured epoxy/ acrylate ester resin such as RenShape® SL 7150. These plastic forms are stronger and can be made with more precise edges. The plastic can be refined with sandpaper and can be painted. Prototypes should be built from high resolution image files to minimize faceting and all surfaces will require refining to remove ridges and struts that result from the build process. The size of the prototype will be limited by the build chamber whether a platen for 3-D printing or a vat for stereolithography. Prototype sections can be hot-melted, pinned, or glued together.

Rubber molds were then made from the prototypes, avoiding the need to mold directly off the ancient fragments. SmoothSil® series platinum silicone (930 and 940 were used) by SmoothON, Inc was used because it results in negligible shrinkage. Ease Release® 200 by Mann Release Technologies and petroleum jelly were used as release agents during moldmaking. When a single sizable section was missing, as on the plate and the foot of the kylix, the ancient fragments were placed into the rubber molds, and the missing portions were cast-on by injecting pigmented plaster into voids in the molds. Pottery Plaster® by US Gypsum Inc. was pre-toned through the addition of ground earth pigments from Kremer Pigments. Hydrocal® by US Gypsum was also tested but found to set more quickly, often with more surface bubbles. Edges of the ancient ceramic were sealed with Acryloid B-72 (approximately 10% wt./ vol. in acetone) before plaster was applied.

Very little overflow of the plaster onto the ancient ceramic occurred, demonstrating the successful fit of the molds. Floating fragments were, however, difficult to secure tightly and precisely in the molds, risking more plaster overflow onto ceramic surfaces and misalignment of small floating fragments. For this reason, small fragments like those of the kylix must be attached with fills before larger areas of plaster could be cast-on using the molds produced from the prototype. In the treatment of the bowl of the kylix, the rubber molds made off the prototype served as cradle and dome to support the fragments during filling, applying the plaster with a spatula. All plaster fills were refined and integrated through limited compensation of the images and patterns, continuing repetitive or geometric forms and referencing other examples attributed to the same hand.

Despite the inherent impossibility of correlating hand-made variations with machine-made precision, prototypes can be successfully employed to aid the process of reconstructing ancient ceramic vessels. A prototype intermediary can minimize the direct handling of the object itself, whether for moldmaking or refining of fills. In the case of exceptional objects, the expense and time to produce the prototype may be justified, and depending on the skills available, could even be more expedient than the trial and error of hand-made jigs or replicas. With adequate experience in generating the digital renderings, the creation of a prototype can be efficiently accomplished through the services of a commercial lab. If enough fragments survive to provide a
complete profile, an accurate rendering can be produced. If the fragments join and the losses are essentially large expanses, fills can be directly cast onto the ancient fragments using a mold made off the prototype.

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