

Inside Greek Vases

An Examination of the Skill of Ancient Greek Craftsmen in Producing Complex 3D Shapes

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Abstract

Creating a figural vase was a complex procedure, which included free modeling, the potter's wheel, and clay molds, sometimes all three, but mostly a combination of two of these methods was common. Tracing this manufacturing process without destroying the precious ancient artifacts requires a method of generating an accurate 3D-model of the particular vase. It should provide information about hidden joints of parts separately manufactured and fitted together before firing, as well as information about variations of density in the clay shard itself. Using X-Ray Imaging at the Entwicklungszentrum Röntgentechnik (ERZT), of the Fraunhofer Institut, Projektgruppe Ultrafeinfokus-Röntgentechnologie, at Fürth, data files containing all this information were created, which were processed at the Department of Computer Science 9 (Computer Graphics) of the Erlangen University, transforming them into 3D models.

Keywords: *Non-destructive analysis, CT-Scanning, laser-sintering, rapid-prototyping.*



Fig. 1. I 864 (Pr 1) Erlangen, Antikensammlung. Attic red figured vase from Sotades' workshop.

The Antikensammlung of the Friedrich-Alexander-Universität Erlangen-Nuremberg¹ keeps in its collection six ancient figural vases. Among them is the famous Attic red figured masterpiece from the workshop of the potter Sotades² in the shape of a

¹www.aeria.phil.uni-erlangen.de/.

²I 864 (Pr 1), Erlangen, Antikensammlung. 29,8 cm high; 1951 said to be from Sirolo, Italy. ARV² 766,3. Para 415, 3. Addenda 286. See Wilhelm Grünhagen, *Antike Originalarbeiten der Kunstsammlung des Institutes* (Nürnberg: Verlag Hans Carl, 1948) 90; Martin Boss et al., *Antikensammlung Erlangen, Auswahlkatalog* (Erlangen and Jena: Palm & Enke, 2002) 78f.; 1 189 f. N. 30 (Peter Kranz). www.aeria.phil.uni-erlangen.de/museum_html/vitrinen17-18/vitrine17.html (accessed May 31, 2009).

pigmy dragging a crane, a scene from a mythological battle described by Homer in the *Iliad* (fig. 1)³

Despite their small number, the figural vases in Erlangen provide a representative overview of techniques in manufacturing these vases, which cover a time span of more than six centuries, from the late archaic period to the age of the Roman emperors, as well as and various regions, from southern Italy in the west, the Greek mainland, to Alexandria and the Roman province of Syria in the east. Creating a figural vase was a complex procedure, which included free modeling, the potter's wheel, and clay molds. Sometimes all three were utilized, but mostly a combination of two of these methods was common. However, very similar results could be achieved by ancient craftsmen using completely different techniques.

Tracing this manufacturing process without destroying the precious ancient artifacts requires a method of generating an accurate 3D model of the particular vase. It should provide information about hidden joints of parts separately manufactured and fitted together before firing as well as information about variations of density in the clay sherd itself.

Using X-Ray Imaging at the Entwicklungszentrum Röntgentechnik (ERZT), of the Fraunhofer Institut, Projektgruppe Ultrafeinfokus-Röntgentechnologie, at

³Homer *Il.* 3, 3-7.

Fürth,¹ data files containing all this information in a precision down to 2 μm were created. These were processed at the Department of Computer Science 9 (Computer Graphics) of the Erlangen University, transforming them into 3D models.²

In computer graphics, methods exist for examining scalar volume data as generated by a CT scanner.³ Volume rendering provides an exact method of producing see-through images of the data. Cracks of joints and borders of sherds can be easily analysed. Repairs of the past become visible by the varying density of plaster or other materials compared to the original clay. Furthermore, density variations of the clay sherd itself reveal wheel-made parts as well as the joints of mold-made parts.

As a reference and a starting point, the clay sculpture representing Isis from a private collection, currently in the Antikensammlung at Erlangen, was used (fig. 2).⁴ Dating to the first century B.C. and nearly 30 cm high, this unusually large representation of the goddess was obviously once fabricated from molds. After processing the CT scanner data as 3D volume rendering, the parting line separating the front and back sides can be clearly distinguished; it is a narrow strip of darker gray, indicating an area of lesser density of the clay material at this point. In the same way, restoration work executed in plaster becomes visible as irregular patches between the lighter gray indicating the greater density of the original clay sherds (figs. 3 and 4).

Once a 3D digital model has been made, a physical replica can be made which allows us to retrace the manufacturing steps of an ancient craftsman, since the replica can be disassembled, cut away and finally reassembled. This was done by the Chair of Polymer Technology (LKT) of the University Erlangen-Nuremberg⁵ using selective laser sintering, which is well known as a rapid prototyping technology.⁶ This technology was selected because parts can be directly created out of thermoplastic polymer powder in a free-

form fabrication process. Hence, this model is robust and has no additional support structures that need to be removed. Surfaces for the laser-sintering process can be extracted with standard computer graphics iso-surface extraction.



Figure 2. P3, Erlangen, Antikensammlung, private collection. Clay sculpture of the goddess Isis.



Figure 3. Vectorizing the CT-data of P 3.

Here, a suitable iso-value can be chosen by incorporating an estimate of the average density of the clay, as well as the weight of the object, as a reference surface most similar to the real object. To exaggerate

¹www.iis.fraunhofer.de/bf/xrt/index.jsp (accessed May 31, 2009).

²www9.informatik.uni-erlangen.de/ (accessed May 31, 2009).

³www9.informatik.uni-erlangen.de/research/project/Research.tech.IMMD.IMMD9.volume_5/ (accessed May 31, 2009); www9.informatik.uni-erlangen.de/research/project/Research.tech.IMMD.IMMD9.visual_6/ (accessed May 31, 2009).

⁴P 3, Erlangen, Antikensammlung, private collection. 28, 3 cm high. Klaus Parlasca, *Wechselwirkungen. Beiheft zur Sonderausstellung 2000/2001* (Erlangen, Antikensammlung, 2000) 6, no. 3.

⁵www.lkt.uni-erlangen.de/ (accessed May 31, 2009).

⁶www.lkt.uni-erlangen.de/forschung/bereiche/werkstoffe/additive-fertigung.shtml (accessed May 31, 2009) s.v. selektives Lasersintern.

the cracks, a higher iso-value can be chosen, showing a surface representation of the higher density of the clay.



Figure 4. *The elaborated 3D volume rendering of P 3.*

A second test to determine the informative value of laser sinter copies was run on a figural *rhyton* showing the rather unusual combination of a Dionysos head on top of a large cluster of grapes (fig. 5).¹ Dating from the late Hellenistic period, this Alexandrian terracotta is an example of mass-produced coarse pottery used in burials. As a surprising result, the copy shows not only the separation between the mold-made figural front and the unrefined backs, but also reveals a separation between the fruit itself and Dionysos. Both clay sheets are obviously cast from different molds; the head was extracted from a mold originally showing the front of a entire statuette and then cut off by the Greek craftsman on purpose to be joined above the grapes (fig. 6).



Figure 5. *P 1, Erlangen, Antikensammlung, private collection. Alexandrian figural rhyton.*



Figure 6. *Laser sinter copy of P 1.*

Examining figural vases through time, from the late archaic period onwards, started with a fairly common type: a late Attic black-figured jug representing a human head (fig. 7).² The 3D-volume rendering reveals that the head was cast from two separated molds and fitted together, the same technique used for terracotta sculptures such as the much later Isis shown above. The connection between the front and back is seen on the inside of the vase as triangular protrusion running from ear to ear. A distinguishing feature of the manufacturing process is the featureless balloon-like inside of the head without any correlation to the detailed and elaborated outside (figs. 8 and 9).

¹P 1, Erlangen, Antikensammlung, private collection. 24 cm high. Klaus Parlasca, *Wechselwirkungen. Beiheft zur Sonderausstellung 2000/2001* (Erlangen, Antikensammlung, 2000), 4, no. 1.

²I 390, Erlangen, Antikensammlung. 19.6 cm high. ARV² 1450, 50. Wilhelm Grünhagen, *Antike Originalarbeiten der Kunstsammlung des Institutes* (Nürnberg: Verlag Hans Carl, 1948), 65; Olaf Dräger, *CVA Deutschland 84, Erlangen 2* (München: Verlag C. H. Beck, 2007) 110f. pl. 45, 10. 11 Beilage 9, 11. www.aeria.phil.uni-erlangen.de/museum_html/vitrinen12-14/vitrinen12-14.html.



Figure 7. I 390, Erlangen, Antikensammlung. Attic black-figured figural jug.

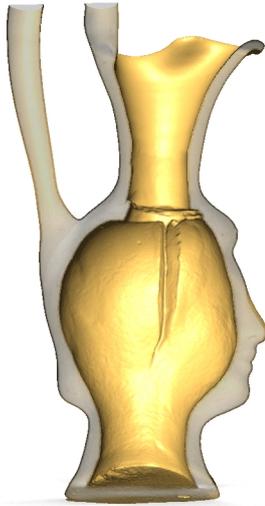


Figure 8. Volume rendering, showing the inside of I 390.

The head itself was made as an independent piece. The upper head was cut out in order to add the wheel-made spout of the jug. It was apparently left to the potter to choose which form of mouth and handle to adjoin in order to create different types of figural vases such as a jug like the piece at Erlangen or a figural *lekythos*.

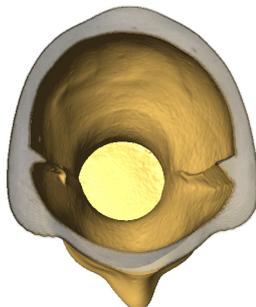


Figure 9. Cross-section showing the bottom part of I 390.

The same feature is shown by the *guttus*, or rather *askos*, representing a dog-like creature, most probably a seal. This unusual vase appears to have been manufactured in one of the Greek cities in southern Italy during the fourth century B.C. (fig. 10).¹ The 3D model shows a separation line between the left and right half of the animal, the direction forced by the elongated shape of the body (fig. 11). Tail and legs were subsequently—after the process of molding and connecting the halves together—hand-made and attached. A narrow hole was pierced between the shoulders of the animal to attach the wheel-made nozzle. The process of pressing the raw clay in the molds as well as the piercing for the outlet is clearly visible in the cutaway laser sinter model (fig. 12).



Figure 10. I 553, Erlangen, Antikensammlung, South Italian figural *askos*.



Figure 11. I 553 seen from behind as a transparent 3D rendering.

¹I 553. 10.3 cm high. Wilhelm Grünhagen, *Antike Originalarbeiten der Kunstsammlung des Institutes* (Nürnberg: Verlag Hans Carl, 1948) 65.



Figure 12. Cutaway laser sinter model of I 553

While these basic procedures concerning the figural parts of the vase—cast in molds just like terracotta figurines and thereafter adjusted by attaching the wheel-made as well as the hand-made parts of the vase—remain more or less the same throughout the centuries, there are some significant variations. A miniature figural jug covered in a thick greenish lead glaze may have been fabricated in Syria during the late Hellenistic or Roman period (fig. 13).¹ It inherited its form and function from works such as the late archaic figural jug I 390 shown above. Both represent human heads, which were cast from two molds forming front and back, but the Roman example has at least the base of the spout incorporated in the mold-made part (fig. 14). Only the outer rim and the handle were formed separately by hand and attached.



Figure 13. P 32, Erlangen, Antikensammlung, private collection. Late Hellenistic green-glazed figural jug.



Figure 14. Cutaway volume rendering of P 32.

A surprise resulted from the examination of a South Italian figural *guttus* in the Antikensammlung at Erlangen (fig. 15).² It was manufactured in ancient Taranto and is roughly contemporary with the figural vase representing a seal mentioned above. Despite clearly being mass-produced, no mold was involved in the procedure of manufacturing. The center of the bird's body is formed by a little wheel-made bowl, afterwards distorted and the rim folded inwards. Traces of tiny horizontal and parallel grooves are nicely preserved on the inside. They were carved in the unfired clay while spinning on the wheel under the fingers of the potter. In the following steps the wheel-made foot and base were attached and all the asymmetrical parts like the tail, wings, and head, as well as the handle and inlet were formed by hand. Then the bird's back was perforated by three holes acting as a kind of strainer (figs. 16 and 17).



Figure 15. I 528, Erlangen, Antikensammlung. South Italian figural *guttus*.

¹P 32, Erlangen, Antikensammlung, private collection. 12 cm high. Klaus Parlasca, *Wechselwirkungen. Beiheft zur Sonderausstellung 2000/2001* (Erlangen, Antikensammlung, 2000) 25, no. 32.

²I 528, Erlangen, Antikensammlung. 12,5 cm high. Wilhelm Grünhagen, *Antike Originalarbeiten der Kunstsammlung des Institutes* (Nürnberg: Verlag Hans Carl, 1948) 65. www.aeria.phil.uni-erlangen.de/museum_html/vitrinen21-24/vitrinen21-24.html (accessed May 31, 2009).

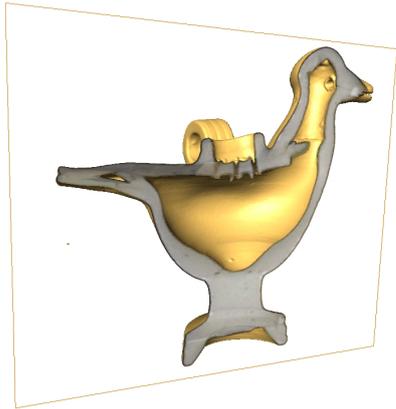


Figure 16. Cutaway volume rendering of I 528.

The procedure chosen by the potter is based on local tradition as well as on his practice and experience. The use of molds does not necessarily indicate standardized mass production, and the lack of such use does not mean the opposite.



Figure 17. Cross-section showing the upper part of I 528.

And how does the masterpiece of Sotades (fig. 1) fit into the big picture? The figural part was mold-made from two separate molds, the separation running from front to back and right through the pigmy's nose. In the laser sinter model (fig. 18), it can be seen as a protrusion on the inside of his forehead (fig. 19). The use of molds underlines the fact that the vase, which today seems outstanding, was by no means singular in antiquity, but was part of a larger sequence of production. Separating the molds into left and right

BIBLIOGRAPHY

- Boss, Martin, Peter Kranz, and Ulla Kreiling. *Antikensammlung Erlangen, Auswahlkatalog*. Erlangen and Jena: Palm & Enke, 2002.
- Dräger, Olaf. *CVA Deutschland 84, Erlangen 2*. München: Verlag C. H. Beck, 2007.
- Grünhagen, Wilhelm. *Antike Originalarbeiten der Kunstsammlung des Institutes*. Nürnberg: Verlag Hans Carl, 1948.
- Parlasca, Klaus. *Wechselwirkungen. Beiheft zur Sonderausstellung 2000/2001*. Erlangen, Antikensammlung, 2000.

halves had to be done in order to avoid undercuttings in the elongated layout of the figural group. It required thorough refining of the outer surface. Variations in density of the clay itself cause tiny artificial patterns on the laser sinter model. These variations are traces of the refining and polishing process, leaving less important parts less densified. This final elaboration distinguishes the work of Sotades, made about 450 B.C.

Thanks to the laser-sintered copies, the Antikensammlung as a museum open to the wider public is now able to show this otherwise hidden technique of ancient craftsmanship.



Figure 18. Laser sinter model of I 864 (Pr 1).

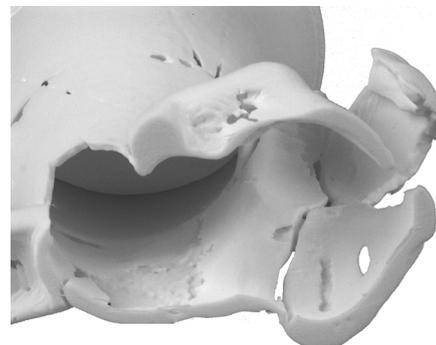


Figure 19. Cross-section of the laser sinter model showing the interior of the pigmy from the chest upward. The inside of the forehead can be seen in the upper right.