RECONSTRUCTING THE ANCIENT HISTORY OF DIE FORMING

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INTRODUCTION:

Long ago, when dinosaurs roamed the Earth, I was an apprentice at Jewelry Arts Institute. Jewelry Arts is a teaching studio in New York City, founded in 1974 with a mission to rediscover and revive ancient goldsmithing techniques. I fell in love with ancient goldsmithing and resolved to master all the skills I studied. Today, I am a master goldsmith and the Director of Jewelry Arts, working with colleagues including Alexis Menten, a goldsmith and Instructor at Jewelry Arts who also has a degree in Classical and Near Eastern Archaeology, to research ancient goldsmithing and share our knowledge widely.

When I was first starting out, I remember visiting the Metropolitan Museum of Art's Greek Gold exhibition in 1994. The tiny, highly detailed three-dimensional forms – such as the amphora shapes at the bottom of these earrings and the necklace below – blew my tiny, little mind.

Figure 1: Gold earrings with disk and boat-shaped pendants. East Greek, ca. 300 BCE. Courtesy of the Metropolitan Museum of Art.

Figure 2: Gold strap necklace with seed-like pendants. Greek, ca. 330-300 BCE. Courtesy of the Metropolitan Museum of Art.

Figure 3: Gold spiral earrings with lion-griffin terminals. Greek, Cypriot, ca. 400-350 BCE.
Courtesy of the Metropolitan Museum of Art.

One of the other cultures I became particularly obsessed with were the Etruscans, whose jewelry dates from the same approximate timeframe as the above-mentioned Greek jewelry, 700 BCE to 200 BCE. The Etruscans also made extensive use of three-dimensional hollow forms. Note the lions' heads surrounding the center of this disk and the faces in the necklace below, Figure 4.

Figure 4: Gold disk with floral motifs and lions' heads. Etruscan, ca. late 6th century BCE. Courtesy of the Metropolitan Museum of Art. I was fortunate to have photographed this piece myself during a research project with The Met.

Figure 5: Gold and glass pendant necklace from Vulci. Etruscan, early 5th century BCE. Courtesy of the Metropolitan Museum of Art.

Although Jewelry Arts was able to teach me all the other skills, the hollow forms were taught with major design limitations. We only learned to make simple round and oval shapes, not the extremely complex and intricate designs that the ancient goldsmiths produced. This was profoundly unsatisfactory to me and something I knew I would eventually revisit to correct.

To create these hollow forms, the Greek and Etruscan goldsmiths used a technique called die forming. The hollow form is made by pressing a thin sheet of metal into a die, which is a negative depression in the shape of the final form. The metal sheet is pressed into the die by pushing a positive of the same design from the reverse, which can be referred to as a former or a punch. Two halves are made in this way, and then soldered or fused together to create a hollow three-dimensional shape, Figure 6.

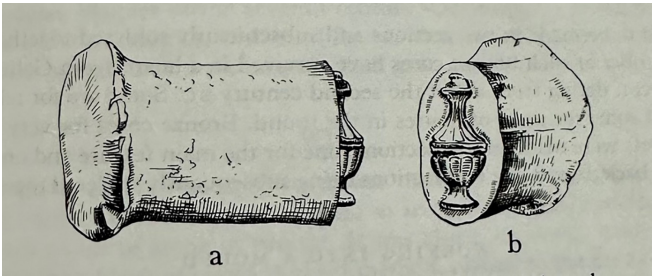

Figure 6: "Bronze stamp for making amphora-shaped pendants for earrings, second-first century BC." (Higgins 1980).

Right before the COVID lockdown in 2019, my colleagues and I started a group project to recreate ancient-style die forming. No amount of theorizing can compare to experimental archaeology, so we started by hand carving a negative die form in wax to be cast into bronze, which was the most likely tool material used in that era (Bronze Age).

I had been searching my entire career for jewelry tools from the Etruscan (or any other) culture to shed light on die forming and other goldsmithing practices, but I found very little. The closest I came was courtesy of Dr. Alessandra Giumlia-Mair, who documented two small chisels from a burnt Iron Age workshop in North-Eastern Italy (Pozzuolo del Friuli) where there was an Etruscan influence. Due to the small size of the chisels, it was possible they had been used for goldsmithing.

Then, a completely chance, eureka moment during August of 2022: One of my colleagues forwarded me an Instagram post from someone who had visited the Glyptothek museum in Munich in 2014, Figure 7. I reached out to William R. Robertson and he was kind enough to share the three pictures he took of a die block and related tools on display, Figures 8, 9, & 10.

Figure 7: Instagram post Courtesy of William R. Robertson

Figure 8: Courtesy of William R. Robertson

Figure 9: Courtesy of William R. Robertson

Figure 10: Courtesy of William R. Robertson

We had long believed that the hollow shapes from the Etruscan and Greek eras were made with dies, due to the following indicators:

- Multiple identical shapes of the same design, detail, size, and/or proportion
- Designs formed by pressing outward from the inside
- Tool marks from the die (negative) or punch (positive)
- Two identical halves (asymmetrical forms can be made from dies as well, they just require more tools)
- Straight seams at the center of the hollow form, running vertically or horizontally
- The widest circumference at the seam, in order to avoid undercutting the metal and making it difficult to remove from the negative die without deforming it

The Glyptothek die block was irrefutable proof, the likes of which

you rarely find when studying ancient jewelry-making techniques, Figure 11. The image and description of the die block below are excerpted and translated from the original German in the book Schmuck der Antike: Ausgewahlte Werke der Staatlichen Antikensammlungen Munchen (Wünsche and Steinhart, 2010):

"The flat bronze cuboid has recessed shapes on five of six sides for the production of gold jewelry. A sheet of gold was pressed into the respective negative mold (die). For example, a tool made of wood was used, or the gold was pressed into the mold with wax, lead or a similarly elastic mass. The bronze cube is cast and then the matrices are cold-worked. The surface of the cube is tin-plated. The shapes are very different and were used to make a wide variety of jewelry: two grooved hoop segments form a basic shape for earrings, two small amphorae and a melon pearl were popular shapes for pendants on necklaces and earrings. Hemispherical depressions of different sizes could also have been used to produce smooth (half) beads that were soldered together. With two mirror-symmetrical halves of a lion's head, finishes for bracelets could be made. Since classical times, so-called Heracles knots have often formed the end or central motif of necklaces and tiaras. Other motifs have a much flatter relief: three different rosettes, a shell and a small mask were used to decorate sheets of gold. The function of the various notches on the narrow sides of the mold remains unclear; perhaps they were used to process the surface of gold foil."

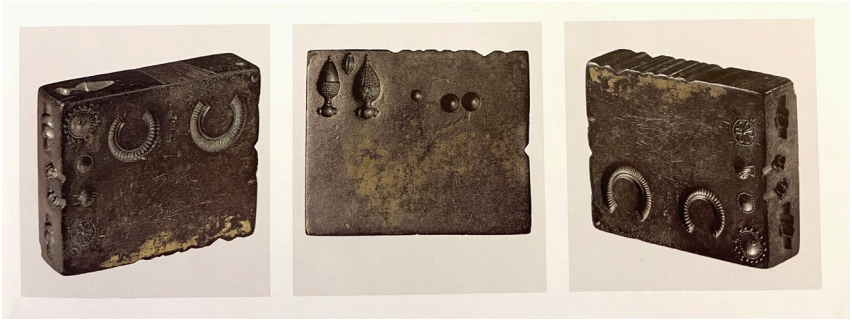

Figure 11: "Blow mold for gold sheets." From Schmuck der Antike (Wünsche and Steinhart 2010).

The notches on the side of the block are what we call a swaging block and are still in in use today in the studio. They are used for bending elements such as bails and ring shanks into a round shape. Translated from German, the term "blow mold" is extremely misleading. We have found that the lack of standard terminology for the die-forming process and related tools makes for difficult research. For example, die blocks are often confused with molds

for casting solid forms. One die block we found in the collection of a major museum was mislabeled as a "gold beater's block." Needless to say, when there is such inconsistency and inaccuracy in the use of terms, it is very difficult to conduct a thorough search of all available images and published research. We immediately reached out to the Glyptothek to request high-resolution detail photos of the die block so we could examine it more closely.

Figure 12: Courtesy of the Glyptothek museum, Munich.

Figure 13: Courtesy of the Glyptothek museum, Munich.

Figure 14: Courtesy of the Glyptothek museum, Munich.

Figure 15: Courtesy of the Glyptothek museum, Munich.

Figure 16: Courtesy of the Glyptothek museum, Munich.

Figure 17: Courtesy of the Glyptothek museum, Munich.

Figure 18: Courtesy of the Glyptothek museum, Munich.

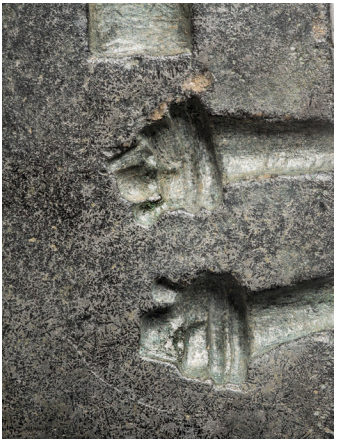

Figure 19: Courtesy of the Glyptothek museum, Munich.

Figure 20: Courtesy of the Glyptothek museum, Munich.

Figure 21: Courtesy of the Glyptothek museum, Munich.

Three main avenues of research opened up from examining this die block, the first of which we begin to explore in this paper, and all of which we will pursue as time allows:

1. Researching when die forming became the standard technique for making hollow three-dimensional shapes
2. Searching for additional die blocks in other museums or private collections. Now that we know some of the misleading terms being used for die blocks, it is possible we will be able to more easily locate others.
3. Identifying extant jewelry from this period with components that match the designs on the Glyptothek die block. It is thrilling to consider – and entirely possible – that there could be jewelry in a museum today that was made with this particular die block!

We started our research into the first topic by studying the earliest examples of gold beads ever found – the gold artifacts from Varna in present-day Bulgaria, excavated from prehistoric graves dating to the Chalcolithic period between 4600-4200 BCE. Although unfortunately we have been unable to find high-resolution photographs of the Varna beads, it is our assumption they were made by burnishing thin gold sheet over a core made of bitumen, resin, wood, or other material. (This core may have been subsequently removed in ancient times or destroyed over the centuries.) Sometimes called gilding, this technique leaves a characteristic wavy or irregular seam that runs lengthwise across the bead where the metal was folded over and smoothed into the other side of the seam. We would need to find high-resolution photographs or study and photograph the Varna beads in person to determine if there is evidence of these types of seams.

However, we also knew from our study of later jewelry from the Classical, Hellenistic, and Greco-Roman periods that burnishing was eventually replaced by die forming, which at some point be-

came the preferred method of creating hollow three-dimensional shapes. As noted above, there are no standard terms to describe die forming. Various terms are used in the literature, such as working into a die[1] stamping, working over a core, and working into a mold[2]; and working sheet with the use of formers, dies, or punches[3].

As Williams and Ogden[4] note, "The term 'die-formed' has been used rather loosely ... since it is not always possible to determine just which type of tool has been used in a particular case." While that is certainly true, we believe that a good deal of information about die forming tools and processes can be derived from extant jewelry. This includes evidence such as the type and placement of the seam, as described above, as well as the quantity and similarity of designs appearing at the same time.

One of the truisms that grounds our understanding of ancient jewelry is that design always follows technology. When we see an explosion of new design, this usually means a leap forward in the development of new techniques. In considering when we see a sudden proliferation of hollow beads, we immediately thought of the Royal Cemetery of Ur in Mesopotamia from 2600-2500 BCE and the grave of Queen Puabi, which contained a cape, headdress, hair ornaments, diadems, necklaces, and belt, Figure 22. The cape alone is made of over 80 strands and tens of thousands of stone and gold beads. Looking at the photographs on the Penn Museum website, we saw several beads from Ur that we thought might have been die formed. We wondered if this could indicate a transitional time period, when jewelers were moving into the use of new technologies such as dies.

Figure 22: Headdress, jewelry, and cape of Queen Puabi. Early Dynastic III, 2650-2450 BCE. Penn Museum. British Museum/University Museum Expedition to Ur, Iraq, 1923.

Over a multi-year journey of designing, testing, and developing dies based on ancient jewelry, we have gained extensive practical experience working with dies and using them to make hollow forms in our studio. This experience is rare among goldsmiths today, who use die forming almost exclusively for the purpose of making hollow domes and spheres (which in modern terminology is called dapping). Through the process of creating and testing our own dies, we identified a set of indicators that can be observed when dies were used.

Our next step was to apply these indicators to the beads excavated from Ur to see if we could find examples of die-formed beads from the Early Bronze Age. After reviewing all the photographed gold beads on the Penn Museum website, we decided to first focus on the fluted beads known as "melon beads." Our assumption was that the more complex shapes (vs. simpler shapes such as smooth round or biconical beads) may have been created using a die. We also selected examples from the Penn Museum collection that were damaged or unstrung beads, so we would be able to view the ends of the beads and not only the parts that are visible once strung, Figure 23. When studying ancient jewelry, we rely on macro photography to show evidence of construction that would be invisible to the human eye. We requested and were granted permission from the Penn Museum to view the beads in person and photograph them at high resolution from multiple angles, so we could study the

photographs for evidence of their fabrication methods.

Figure 23: String of gold and amethyst beads. Penn Museum, Object B15584. British Museum/University Museum Expedition to Ur, Iraq, 1923.

Our first surprise upon viewing the beads we had selected was their size. Although some of the beads we viewed were around 4-6 mm as expected, many more of the melon beads were even smaller – the beads on the strand shown above were approximately 2 mm. We next realized we were not seeing any indication of a straight seam at the equator, and in fact the beads we had selected only showed evidence of vertical seams running from end to end. After careful study of the magnified photographs, we also observed evidence of puckering around both holes of the beads, indicating that the thin metal sheet was gathered and burnished together at the ends of the beads as well as along the seam, Figure 25. Some of the beads had tubes inside that connected the two holes at each end, and many beads were filled with some kind of substance, although we were unable to test and identify the material, Figure 28. We also were unable to determine if the filling material was a part of the original fabrication of the beads, or if it was introduced into the beads over time as the beads were buried underground.

Figure 24: Close-up photos of 2mm melon beads. Penn Museum, Object B15584. August 2023.

Figure 25: Arrows marking areas of puckering or overlapping edges. Penn Museum, Object B15584. August 2023.

Figure 26: Close-up view of burnished, overlapping seam on gold melon bead. Penn Museum. August 2023.

Figure 27: Close-up view of overlapping burnished edges on gold melon bead. Penn Museum. August 2023.

After careful study and analysis of all the Ur melon beads we viewed at the Penn Museum (approximately 100 in total), our understanding is that these beads were created by wrapping a very thin gold sheet around a bitumen (or other, e.g. resin or wood) core. The gold sheet appeared to be wrapped around the core and then crimped and burnished around the holes and along the seam. We assume that the inner tubes were used to provide additional structure and strength to support the hollow beads when strung, although we are not sure if all beads originally had tubes or if they were only applied to certain shapes, sizes, or beads in specific positions on the strand.

Figure 28: Close-up view of inner tube in gold melon bead. Penn Museum. August 2023.

During our visit to the Penn Museum, we were excited to learn that the beads on Queen Puabi's cape were being x-rayed in fall 2023,

while the cape was being re-installed after traveling on loan, Figure 30 and 32. Many of these x-rays are now available on the Penn Museum's website and add new information to our study of the Ur beads. Surprisingly, the x-rays show evidence of potentially three different construction techniques together on the same strands:

1. Solid beads that appear to have been cast, or potentially made out of thicker sheet.
2. Hollow beads that show an uneven lengthwise seam running from end to end, indicating sheet was wrapped around a bitumen core and burnished.
3. Hollow beads with an even straight seam at the widest center point (i.e., the equator), indicating they were created in two halves – potentially with a die – and then soldered or fused together.

Figure 29: String of beads from cape (clothing) – 27 alternating lapis and gold beads, beginning and ending with lapis. All are squat biconical. Early Dynastic III, 2650-2550 BCE. Penn Museum, Object 83-7-1.25. British Museum/University Museum Expedition to Ur, Iraq, 1923.

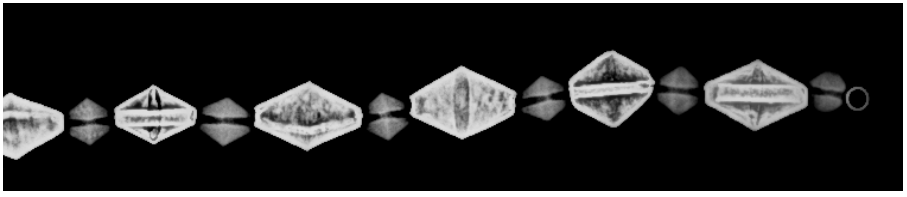

Figure 30: X-ray of Penn Museum Object 83-7-1.25. British Museum/ University Museum Expedition to Ur, Iraq, 1923.

Figure 31: String of beads from cape (clothing) – 33 gold and carnelian beads of various shapes and sizes. 24 carnelian beads. 9 gold beads. Early Dynastic III, 2650-2550 BCE. Penn Museum, Object 83-7-1.7. British Museum/University Museum Expedition to Ur, Iraq, 1923.

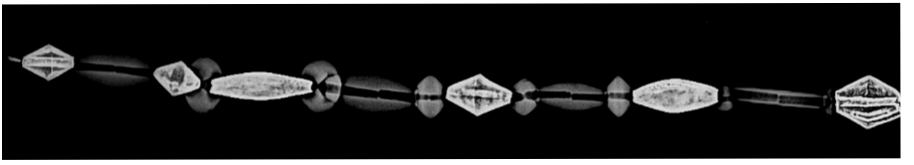

Figure 32: X-ray of Penn Museum Object 83-7-1.7. British Museum/ University Museum Expedition to Ur, Iraq, 1923.

Although the Penn Museum x-rays provide important information, ultimately they are inconclusive. For example, the authors of the recent book Ancient Egyptian Gold[5], theorize that the beads they studied that appear to be solid on x-rays may have been made with thicker sheet or with a different alloy, which could account for their opacity. In addition, although straight seams at the center could indicate that a bead was created with a die, in fact such seams really only indicate that a bead was made in two halves. Each half could have been created by means other than a die (e.g., burnished, as many of the biconical beads appear to be) and then soldered or fused together.

Our next step is to find and document beads showing evidence of each of the three techniques. We also plan to research whether a pattern can be found underlying the distribution of different fabrication methods across different bead shapes. From our study to date, these three techniques seem to be in evidence across many different shapes – beads of one shape do not appear to have been all made the same way, but rather the three different techniques seem to have all been used to make beads of the same shape. The x-rays may also help us determine if there is a pattern as to which beads were made with inner tubes and if so, why and how the inner tubes were added to bead construction.

That at least three different construction techniques may have been

in use concurrently to make the Ur beads surprised us. Goldsmiths typically adopt a new method when a superior technology is developed. However, we know from our own experience that goldsmiths may also hold on to a particular technique because it was how they were first taught, or because it is the one they are most familiar with or comfortable using. Therefore, if it is the case that all three techniques co-existed at the same time, this may indicate that the beads were made by different goldsmiths or in different workshops. It may also suggest that some beads were older than others (and therefore made using earlier techniques), or perhaps different techniques were used to create different shapes or sizes. For example, the large biconical beads appear to be the most prevalent bead shape with x-ray evidence of a straight center seam. However, from study of the photographs on the Penn Museum website, we can see that on some of the beads, both halves have burnished seams and were likely not created with a die.

The next step in our research is to return to the Penn Museum in the summer of 2024 to study and photograph biconical beads. Although we are unable to study the exact same beads that were x-rayed (as they are in Queen Puabi's cape and on display), we are interested to determine if other examples of beads found at Ur will show the same variety of manufacturing methods. Our hope is to identify and photograph die-formed beads in order to learn even more about how die forming was developed and first used in the earliest civilizations.

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