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Complex Beauty: the Manufacture of Hellenistic Wreaths

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Abstract: During rescue work in the north cemetery of ancient Demetrias in Volos, fragments from several gilded wreaths were revealed. These wreaths were made using a number of different materials, including wood, bone, ceramic, organic fibers, various pigments and different metals. A number of fragments of these wreaths were studied in order to understand their manufacturing techniques as well as the composition of the metals used (Cu, Au, Pb), and the gilding practices. The wreaths are dated from the mid 4th up to 2nd centuries BC.

The investigation has shown that the wreaths from Demetrias were complex items, produced from highly skilled craftspeople using high-quality materials. The leaves and wires were made from un-alloyed pure copper metal which was easy to hammer into thin sheet and then to cut into shape using chisels or scissors. Similarly, pure lead possibly originating by Laurion was used to manufacture the metal strips of the trephines. Despite the bad preservation of the items, traces of gilding are preserved in most of them. The gilding was probably done using two slightly different techniques. All together the wreaths were made to appear like myrtle plant, probably related to the cult of Demeter. The berries of this plant were simulated using ceramic beads, which were gilded, typically again with a gesso layer underneath the gold leaf. The red flowers were made from ceramic coloured with pigments. We identified the use of both iron oxide and cinnabar.

Περιληψη: Κατά τη διάρκεια σωστικής ανασκαφής στο βόρειο τμήμα του νεκροταφείου της αρχαίας Δημητριάδας στον Βόλο Μαγνησίας, ανακαλύφθηκαν τμήματα αρκετών επίχρυσων στεφανιών τα οποία ήταν κατασκευασμένα από συνδυασμό υλικών, όπως ξύλο, κόκαλο, πηλό, οργανικές ίνες, διάφορες χρωστικές και διαφορετικά μέταλλα.

Ένα μέρος του συνόλου αυτού μελετήθηκε προκειμένου να γίνει κατανοητή η μέθοδος κατασκευής τους, η σύνθεση των μετάλλων που χρησιμοποιήθηκαν (Cu, Au, Pb), και οι τεχνικές επιχρύσωσης. Τα στεφάνια χρονολογούνται από τα μέσα του 4ου αι. π.Χ έως τον 2ο αι. π.Χ.

Η έρευνα αποκάλυψε ότι τα στεφάνια της Δημητριάδας είναι κατασκευασμένα από επιδέξιους τεχνίτες οι οποίοι χρησιμοποίησαν υψηλής ποιότητας υλικά. Τα φύλλα και τα σύρματα ήταν κατασκευασμένα από καθαρό χαλκό ο οποίος ήταν εύκολο να σφυρηλατηθεί και να κοπεί στο επιθυμητό σχήμα με ψαλίδι ή κοπίδι. Σχεδόν καθαρός, ελεύθερος από άργυρο μόλυβδος, προερχόμενος από τα μεταλλεία του Λαυρίου, χρησιμοποιήθηκε για την κατασκευή των χοινικίδων. Παρόλο που τα αντικείμενα βρέθηκαν σε πολύ κακή κατάσταση διατήρησης, ίχνη επιχρύσωσης σώθηκαν σε πολλά από αυτά. Η επιχρύσωση έχει γίνει με δύο διαφορετικές τεχνικές.

Όλα τα στεφάνια αποδίδουν το φυτό μυρτιά, ίσως σχετισμένο με τη λατρεία της θεάς Δήμητρας. Οι καρποί και τα λουλούδια του φυτού αποδίδονται με πηλό επιχρυσωμένο. Σε ορισμένες περιπτώσεις δε τα λουλούδια είναι βαμμένα με κόκκινη χρωστική.

Introduction

Few studies in the past have focused on fragile composite items such as funerary gilded wreaths from burial sites, mostly because of their typically bad state of preservation. So far, attention has been concentrated on a few exceptional, high status examples, typically made of solid gold and decorated with various other precious materials.

During rescue work by the 13th EPCA in 1995-96, at the cemetery of ancient Demetrias in Magnesia, a number of fragments from gilded Hellenistic wreaths were recovered (Fig. 1). The necessary conservation work gave us an opportunity to investigate the manufacture of these important finds in some detail. The nature of these wreaths, composed of a mixture of materials, some of them quite heavy, others rather delicate and fragile, makes it unlikely that they were used in daily life; they were rather made specifically for funerary purposes (Tsigarida 1993 Higgins 1961).

Although gilded wreaths are relatively common in Hellenistic graves, especially in Macedonia (Orlandos 1960; Makaronas 1965; Despini 1980; Andronikos 1984: 209, Lilimpaki-Akamati 1989: 79, Grammenos 1990, Vokotopoulou 1990, Tsigarida 1993), only about one percent of the tombs found in the cemetery of Demetrias preserved such kind of material (Nikolaou 2000). Is their rarity due to the fragile nature of their material, was it a matter of social desegregation and only a few people could afford them, or were they a Macedonian custom and belonged to people who brought them from their particular homes (as Demetrias was a Macedonian colony at that period)?

Material and methods

The tombs date from the late 4th to the early 1st centuries BC. Fragments of wreaths are spanning all these centuries, giving us information about the materials used and the way of their manufacture over time.

During investigative conservation (Asderaki-Tzoumerkioti 2000, 2001), it was found that all the wreaths of Demetrias are modeled on the myrtle plant, related either to Demeter, Aphrodite or Persephone, all goddesses of fertility and vegetation (Tsigarida 1993, Despini 1996, Nikolaou 2000). The wreaths consist of a trephine made of either lead or wood that holds together the various decorative items. Attached to the trephine, about two centimeters in distance from each other, were tufts comprising imitation leaves and fruits or flowers, fixed through holes in the trephines. Each tuft consisted of a bunch of copper wires, which at their end had either globular ceramic beads in two sizes, or flowers in two different types, or lancet-shaped copper leaves. A thin thread of organic fibre was wound around them holding the wires together (Fig. 2). The majority of the items of the wreaths were gilded, while others showed evidence for yellow paint on the copper leaves, probably in imitation of gilding. A few of the ceramic fruits were colored with a red pigment.

Figure 1: Gilded wreath found in tomb 386; note the fragmentary condition of preservation.

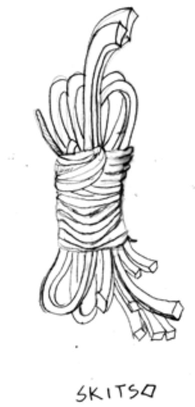


Figure 2: Drawing of a tuft coming from tomb 393. The thread of organic fibre is well preserved, still holding the wires together (drawing G. Kiassas , 13th EPCA).

The main analytical methods which we used for this study were:

a. Optical microscopy (low powered microscopy and metallography),
b. Secondary Electron Microscopy with attached Energy Dispersive Spectrometry (SEM-EDS) for chemical analysis of corrosion products, gesso layers and the gold,
c. Electron probe microanalysis (EPMA) to determine the elemental composition of the metal sheet where it was preserved,
d. X-ray diffraction to verify the nature of the corrosion products both in copper and lead,
e. Inductively Coupled Plasma – Atomic Emission Spectrometry (ICP-AES) to determine the elemental composition of the lead of the trephines and
f. Multicollector Inductively-Coupled Plasma Mass Spectrometry (MC-ICP-MS or PIMMS) for lead isotope analysis to discuss the provenance of the lead.

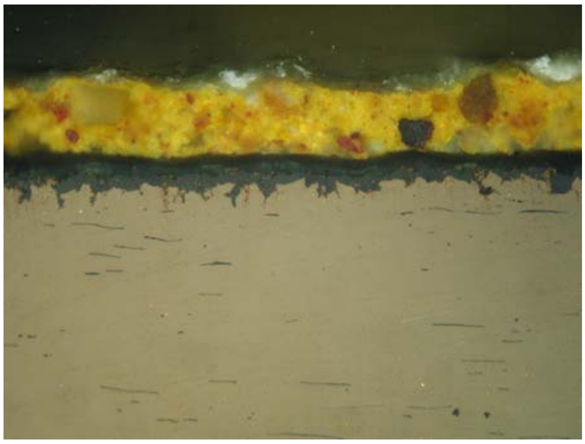


Figure 3: Copper sulphide inclusions are clearly visible throughout the body of the metal. Optical microscope, magnification 500X plm. Copper leaf from tomb 206.

The samples were selected based on the ethical considerations necessary in any conservation and restoration work; thus, only tiny fragments were used which could not have been used in the restoration of the wreaths. The aim was to cover several tombs from both the early and the late period of the cemetery, to gain an understanding of material and technological homogeneity and / or diversity within the entire sample.

Results

The copper

All copper wires and leaves were found to be made of the same type of technically pure metal with a fair amount of copper sulphide inclusions throughout the body of the metal (Fig. 3). In the majority of the samples, the metal was almost totally corroded to form copper chloride, copper phosphate, copper oxide and malachite as identified by SEM-EDS and XRD analyses. In addition to these secondary corrosion products, we often identified inclusions of copper sulphides; these were always elongated parallel to the outer surfaces of the leaves, reflecting the mechanical deformation of the metal. Where the metal was preserved, it showed upon etching with alcoholic ferric

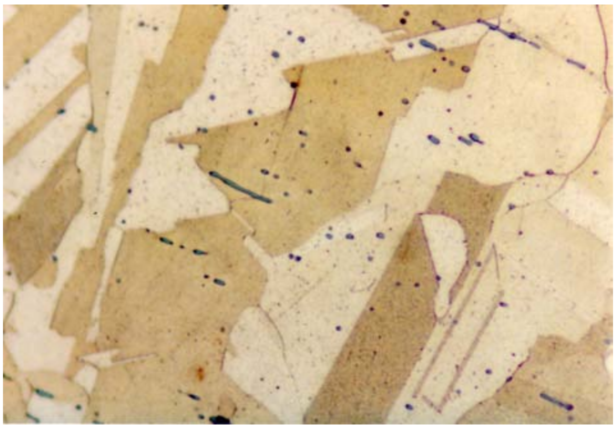
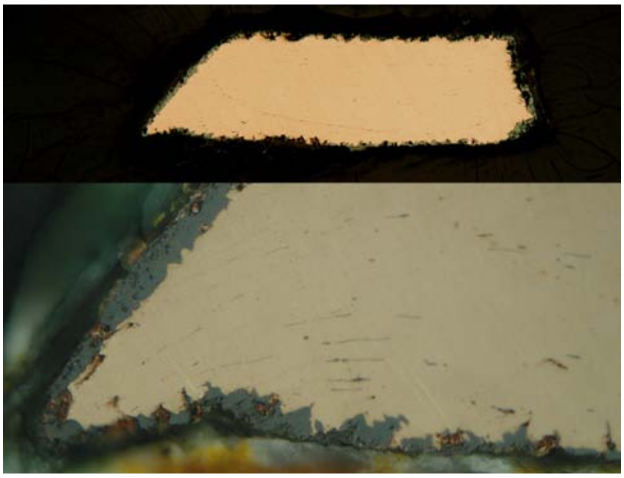


Figure 4: Copper metal etched with alcoholic ferric chloride. The annealed, recrystallized texture of equiaxed grains is visible. Optical microscope, magnification 500X.



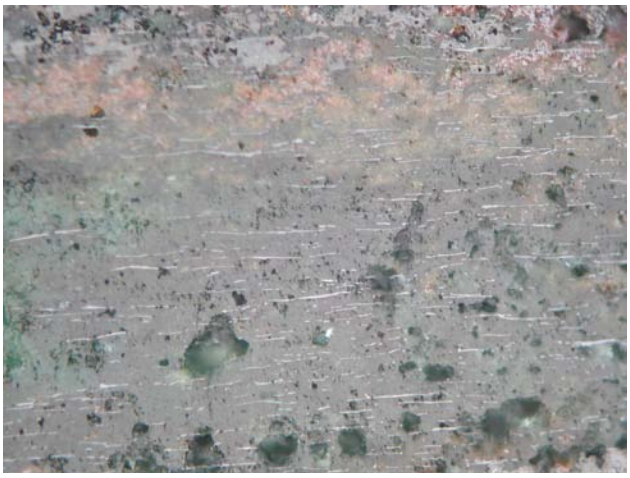


Figure 5: a) Trapezoid cross section of the metal and a deformation pattern showing the flow of the metal at the very edge made by the chisel. Copper leaf from tomb 206. Optical microscope, magnification 100x (top) and 500 (bottom). b) The elongated shape of the sulphide inclusions is clearly visible, especially in the body of the leaves (here fully corroded). Copper leaf from tomb 23. Optical microscope, magnification 500X.

chloride solution ($FeCl_3$) (Scott 1991, 2002) an annealed, recrystallized texture of equiaxed copper grains with no preferential orientation (Fig. 4). Microprobe analyses are given in Table 1.

A number of features immediately emerge from these analyses. The composition is very homogenous across almost all objects; there is no difference between leaves and wires, and no change in composition over time. The main components other than copper are arsenic, which is consistently present at around one fifth of a percent, and iron, which varies more widely around a similar value. Exceptions from this pattern include T140A and B (two samples from the same leaf fragment) which have much less arsenic, and O18091, which has about half a percent of iron. The general level of arsenic is too low to be interpreted as intentionally added, but clearly represents some impurity in the primary ore, as does the iron. Tin and antimony appear to be present at the limit of detection for the microprobe used; not much can be said here. Lead was always found to be below the detection limit. Clearly, the metal is clean, unalloyed, copper and not recycled bronze scrap. The presence of sulphur, already indicated by optical microscopy, further indicates that this metal was freshly smelted from a sulfidic ore body; at present, however, we cannot say more about its origin. In some samples, the average level of iron exceeds that of arsenic; this is mostly due to individual areas having rather high levels of iron, which are on the level of individual analyses strongly correlated with increased sulphur levels. This reflects both the discrete nature of these copper sulphide inclusions which are more abundant in some areas than in others, and their composition which often includes a significant iron component. At this stage however, no attempt was made to study the chemical or mineralogical composition of these inclusions in any more detail.

The copper leaves have been cut from sheet metal into shape by chisels or scissors, and were then hammered further to give the desired shape. The typical trapezoid cross section of the metal, particularly well visible at the stems of the leaves, and a deformation pattern showing the flow of metal at the very edge where it was deformed, are clearly visible (Fig. 5a). The elongated shape of the sulfide inclusions, especially at the body of the leaves (Fig. 5b), indicates a fair amount of hammering of the initially cast metal sheet to thin it further, finished by an annealing step as evident from the recrystallization of the copper grains.

The stems of the leaves are somewhat thicker than the leaves and relatively long; they are typically bound together with the wires, which carry the beads and flowers (see below) in the tufts running through the trephines. In one case the stem creates a loop in its end (Fig. 6).

The wires were apparently hammered into a thin sheet and cut into strips, which then were often or typically hammered into a “G” shaped (Oddy 1987) or even into a spiral cross section (Fig. 7a, 7b). The copper wires were best preserved near the holes of the lead trephines where they were bunched together to tufts; apparently their tight wrapping together with the presence of lead metal seems to have slowed down the corrosion of the fine copper wires.

Tomb Nr	Date BC	Cu	Sn	Fe	S	Sb	Ni	As
T454	mid 4th	98.8	<0.03	0.14	0.02	0.02	0.03	0.27
T455leaf.c	end 4th	98.9	0.05	0.16	0.08	0.04	0.04	0.15
T455stem.c	end 4th	99.4	<0.03	0.15	0.09	<0.02	0.04	0.16
T140A	3rd-2nd	98.7	<0.03	0.13	0.03	<0.02	0.03	0.05
T140B	3rd-2nd	98.5	<0.03	0.11	0.02	<0.02	0.02	0.05
T810A	2nd	98.6	0.03	0.18	0.06	0.03	0.04	0.20
T810B	2nd	98.6	0.03	0.20	0.15	0.03	0.04	0.20
T206A	-	98.5	<0.03	0.26	0.16	<0.02	0.03	0.17
T206B	-	98.8	<0.03	0.24	0.02	<0.02	0.02	0.17
T445	-	98.8	<0.03	0.34	0.07	0.04	0.03	0.16
O148stem.l	-	100.5	<0.03	0.06	0.09	<0.02	0.04	0.20
O148stem.c	-	100.2	<0.03	0.03	0.07	<0.02	0.04	0.20
O18091	-	98.0	0.04	0.53	0.04	0.03	0.04	0.23

Table 1. EMPA analyses of selected copper leaves and wires from Hellenistic wreaths from Demetrias. Lead was found in all samples to be below the detection limit (<0.05 wt%). Zinc was found consistently at about 0.06 wt%, but for instrumental reasons this value needs re-evaluation and is therefore not included in the above table. The data given are averages of five to eight analyses covering an area of c. 20 by 25 micrometers each. All analyses by K. Reeves, Wolfson Archaeological Science Laboratories, Institute of Archaeology UCL.

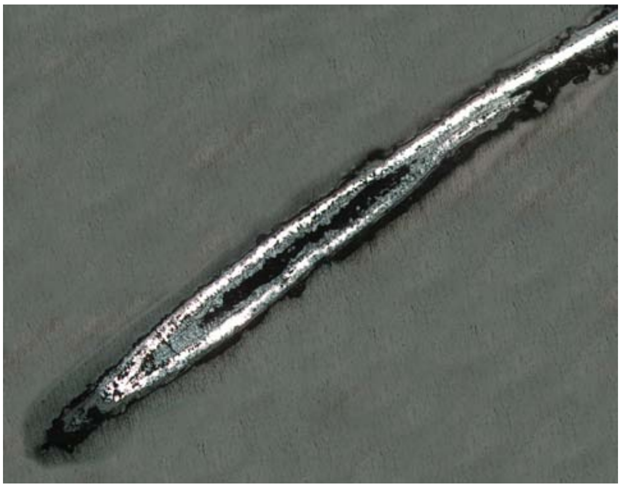
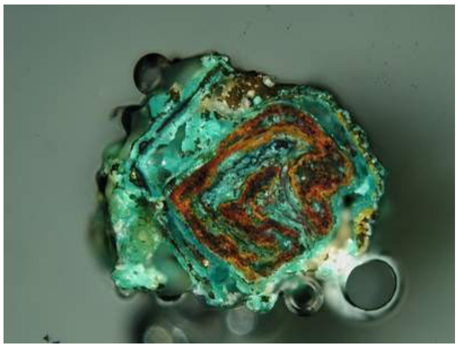


Figure 6: Stem from a leaf of tomb 454 creating a loop in its end. Optical microscope, magnification 50X.

a.



b.

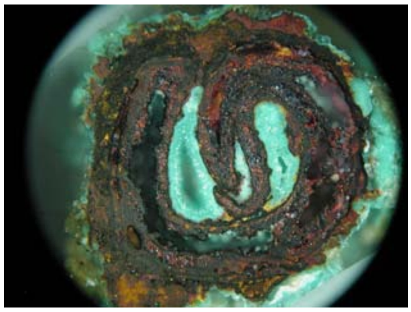


Figure 7: a) Cross section through gilded wire; the "G" hammered shape is clearly obvious. Copper wire from tomb 924. Optical microscope, magnification 200X. B) Cross section through gilded wire of tomb 397; the spiral shape is clearly obvious. Optical microscope, magnification 200X.

The corrosion products of the two metals often preserved a central thread of organic fibre among each group of 3-4 wires, which apparently was both running parallel to the wires along their length, and then was wound round the lower ends of them, securing them probably by a knot (Fig. 11); see also below.

The gilding

Many samples showed remains of gilding, typically buried underneath the severe corrosion crust. In most of the cases the gilding was applied on top of a layer of fine-grained plaster-like material covering the metal core (Oddy *et al*. 1979) (Fig. 8). This *gesso* layer was identified by SEM-EDS analysis to consist either of pure kaolinite, or calcium carbonate, or calcareous clay. In some cases the gold leaf was applied straight to the metal surface, either by burnishing (Oddy 1981, 1991, 1993, La Niece 1993) or possibly using an organic glue to keep the gold adhered to the metal substrate as indicated in figure 9 (Lucas & Harris 1962, Oddy *et al*. 1979, Kingery *et al*. 1988, Oddy 1993). In other cases a yellow pigment, ochre, was identified instead of gilding (Fig. 10); in these cases there was never an intermediate gesso layer between the copper and the pigment. This yellow pigment was not used as a substrate to the gold leaf, as it is the case for the Hellenistic ceramic hydriae from Rhodes (Giannikouri *et al*. this volume). In

Figure 8: Gesso layer applied between the copper body and the gold leaf. Copper leaf from tomb 924. Optical microscope, magnification 100X.

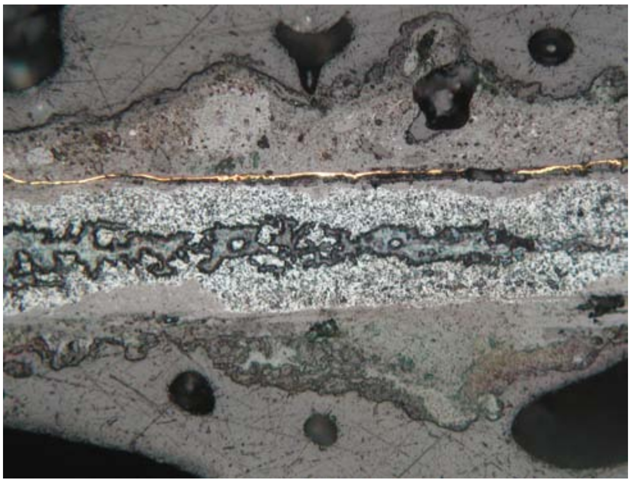


Figure 9: Gold leaf applied straight to the copper surface. Copper leaf from tomb 23. Optical microscope, magnification 200X.

Figure 10: Yellow pigment applied on the copper surface. Copper leaf from tomb 140. Optical microscope, magnification 200X.

our samples, no traces of gold were found on any of the fragments containing ochre. This is an indication that the craftsmen chose ochre as an alternative to gilding, possibly for economic reasons.

In all samples from the stems studied so far, the gold leaf or the ochre was applied straight to the metal surface, without any gesso layer. However, most of the wires were gilded in the same way as the leaves, with the gilding applied on top of a gesso layer covering the metal, and some others are painted with the same yellow pigment (ochre) as the leaves.

The gold leaf was always found to be about 1 μm thick (Oddy 2000) and to consist of technically pure gold, with less than 0.5 % copper and silver in the metal matrix. It is known that ancient craftsmen knew how to separate copper from gold since 2000 BC (Forbes 1971, Oddy 1981), and since the mid-first millennium BC how to part silver from gold (Craddock *et al*. 1998, Craddock 2000, Ramage & Craddock 2000). The use of such pure gold is no surprise; refined gold is preferred for most gilding work as it can be much better hammered into thin leaves and foils than impure gold or gold alloys.

The lead

The fragments of lead trephines are about 2 mm thick and 1.6 cm wide and are preserved in various lengths. They were made from lead metal, hammered into thin sheets and cut into strips. Holes were then punched in at regular intervals of about 2 cm, where the tufts or bunches of copper wires and leaves were attached. In one sample traces of gilding are preserved, in others it may have disappeared due to the initial cleaning of the finds. From optical microscopic observation we can assume that the gold leaf was applied straight to the metal surface either by burnishing it or by using a kind of organic glue; no evidence for the use of gesso was found here.

Even though extensively corroded to cerussite, hydrocerussite and litharge (Turgoose 1985) as found by XRD analysis, the lead trephines preserve enough metal in their core for metallographic and chemical analysis. According to ICP-AES analyses, they have been made of almost pure lead. The main trace elements found were copper at just below 0.1 wt% and iron with about 0.02 wt% (Table 2). The copper is about twice that of other published values from ancient lead finds, while the elevated iron content may indicate a certain degree of corrosion of the lead metal (Rehren & Prange 1998). Significantly, the tin level is very low, indicating that no recycled lead was used (Wyttenbach & Schubiger 1973), and the silver level is relatively low at around 50 ppm. This is even less than the level typically found in LBA and Roman period desilvered lead (Rehren & Prange 1998).

The lead isotope ratios for the three samples were determined by MC-ICP-MS at the Dept of Earth Sciences, University of Bristol (Table 3). All three samples seem to have rather similar ratios, which fall within the range of ratios published for ores from Laurion (Stos-Gale *et al*.

1996: 384-5), while none of the other Aegean ore 'fields' presented in that data list has a matching composition.

Organic materials

The specific conditions within the tombs led to the preservation of very little solely organic remains; as part of the wreaths we could identify a wooden trephine fragment and mineralised fibre remains preserved within the corroded metal.

The single example of a wooden trephine stems from tomb 386, dated to the 3rd to 2nd cent. BC, and is preserved to a length of 19 cm; it is 1.5 cm wide. No systematic work was done for the identification of the wood. However, Dr Jon Hather, from the Institute of Archaeology, UCL, after a preliminary assessment of only a minute piece of it under the microscope identified it as a softwood, possibly cypress or pine. No gilding or other surface decoration was preserved on its surface.

Figure 11: Organic fibres, linen, preserved by copper salts in copper leaves of tomb 393. Optical microscope, magnification 200X.

Figure 12: Linen fibre under the light microscope.

The fibres which were preserved among the copper wires where they went through the lead trephines were mounted in glycerol for examination under the light microscope (Fig. 12). They showed a central lumen with pits in the cell wall. Their ends are elongated and pointed; the pits are parallel to the fibre walls, a view typical of linen (Catling & Grayson 1982). Based on these characteristics, these fibres were identified as linen (E. Pye & S. Bond, pers. comm. 2001).

Ceramics

The occurrence of ceramic materials within the wreaths is restricted to beads and flowers mounted on copper wires and positioned among the leaves. The beads occur in two different sizes, with diameters of 5 and 8 mm respectively. The flowers are conical, and measure about 6 to 10 mm in length. They all have a small hole at their lower end to fix them to the copper wires, which in turn are bound into the tufts which are then fastened in the trephines.

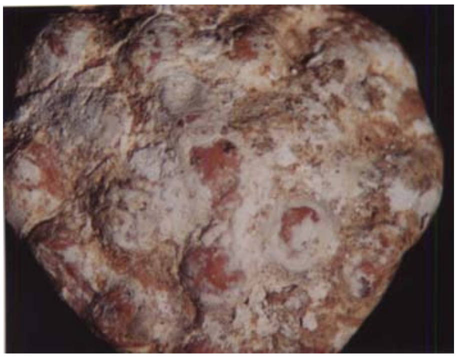


Figure 13: Ceramic bead from tomb 393. The gesso layer and some gilding are visible.

All of the beads and most of the flowers were gilded. For this, they are covered with a white layer of gesso which was identified by SEM-EDS as kaolinite; on top of it the gold leaf was applied (Fig. 13). Only a few flowers are coated with a red pigment (Fig. 14), which was in one case identified by SEM-EDS as cinnabar, and probably iron oxide in most others.

The main ceramic core, of both the beads and the flowers, was found to consist of a ferrogenious ceramic; at this time, no further study of the composition and possible source of this clay was undertaken.

Figure 14: Ceramic bead from tomb 924. Note the red pigment near the top.

Conclusion

The investigation so far of only a small number of

Tomb Nr	Date BC	Bi ppm	Cu ppm	Sb ppm	Sn ppm	Ag ppm	Fe ppm	Zn ppm	As ppm
455	end 4th	40	800	285	11	30	190	4	22
924	4th- 3rd	45	895	10	14	30	190	1	3
140	3rd-2nd	40	835	45	7	40	275	1	3

Table 2. ICP-AES analyses of selected lead trephines from Hellenistic wreaths from Demetrias. The matrix is lead. Selenium and tellurium were analysed for but not found. All analyses Dr Chung Choi, Dept of Earth Sciences, University of Bristol.

Tomb Nr	Date BC	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{206}Pb/^{204}Pb$
455	end 4th	2.0562	0.83104	18.828
924	4th- 3rd	2.0548	0.83064	18.810
140	3rd-2nd	2.0587	0.83162	18.832

Table 3. MC-ICP-MS analyses of selected lead trephines from Hellenistic wreaths from Demetrias. All analyses Dr Tim Elliott, Dept of Earth Sciences, University of Bristol.

fragments has shown that the wreaths from Demetrias were complex items, produced from highly skilled craftspeople using high-quality materials. The leaves and wires were always made from pure copper, which is easy to hammer into thin sheet and then to cut into shape using chisels or scissors. This metal appears to be coming straight from a primary copper smelting source, rather than being recycled copper/bronze. Similarly, the lead was found to be of consistent quality, possibly originating from Laurion. However, not all aspects of the manufacture of the wreaths were kept constant. Within the examples studied, several technological choices were identified. The trephine, for instance, could be made either from lead, or wood. Some of the leaves were gilded with the gold leaf either applied straight to the metal surface, or using a range of gesso materials to support the gold layer. In some cases the gold leaf is applied only to one side of the leaf, likely the front one. Other leaves, however, were coloured yellow using ochre, with the pigment layer being applied directly to the metal. The wires are hammered in a 'G' or spiral shape and in most cases they were gilded too, while there are a few examples that preserve yellow pigment on their surface. It is interesting that in some cases wreaths from the same tomb have both gilded leaves and leaves painted with ochre. Is it possible that the gilded items have been used in the front part of the wreath, while the painted ones were in the back where no one could see them? Unfortunately, the wreaths were too poorly preserved to locate individual pieces within the overall layout of the objects; hence, this question has to remain unanswered for the time being.

The ceramic beads were all gilded, with the gold leaf consistently applied on a white layer of kaolinite gesso, while the ceramic flowers are either gilded in the same way as the beads or painted red with either cinnabar or iron oxide.

Thus, we see a range of different techniques and materials being used all to produce in effect the same final product, but probably reflecting the different economic means of the customers. The consistent level of craftsmanship and selection of raw materials of good and constant quality, however, indicates that a specialist workshop with skilled artisans produced these items.

How much of the technological and material difference that we have observed among the wreaths may relate to changes over this period of several hundred years? At present, we can not see a correlation of specific technological choices with time, i.e. all the various methods and materials were used both in the early and the late tombs. Hence, the differences visible in the archaeological record are not due to technological changes or changes in the availability or supply of raw materials, but seem to reflect differences within the population of the cemetery. Further analyses of more material from this type of wreaths found in Hellenistic graves in Greece are necessary before any firm conclusions can be reached.

Further questions arising from this study relate to the relatively small number of tombs at Demetrias yielding such wreaths. Does this reflect a general social or economic stratification within an otherwise homogenous cemetery population, or do we see here cultural preference of a small ethnic Macedonian population within a larger local people, or even the adoption of Macedonian customs by some parts of the local population following the emergence of Macedonian rule over the region in this period?

These questions, and many others, can only be addressed in close co-operation between the archaeologists, conservators and archaeometrists, using all the appropriate techniques available, and combining their results.

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