McDONALD INSTITUTE MONOGRAPHS

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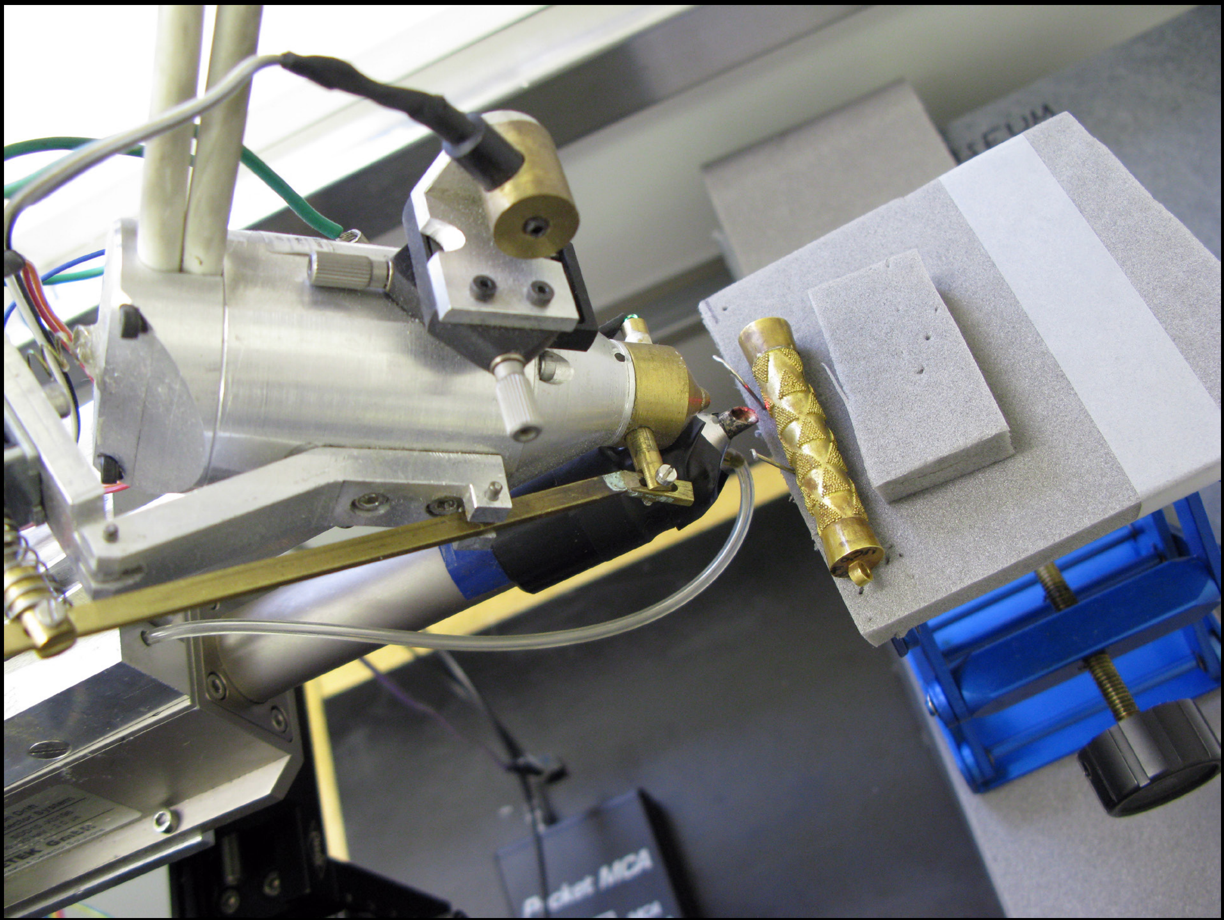
Archaeology and science in jewellery (3500–1000 BC)

Edited by Maria F. Guerra, Marcos Martinón-Torres & Stephen Quirke



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with contributions from
Wolfram Grajetzki, Maria F. Guerra, Marei Hacke, Mona Hess, Susan La Niece, Quentin Lemasson, Lindsay MacDonald, Margaret Maitland, Marcos Martinón-Torres, Nigel Meeks, Gianluca Miniaci, Brice Moignard, Jack Ogden, Claire Pacheco, Sandrine Pagès-Camagna, Laurent Pichon, Matthew Ponting, Campbell Price, Stephen Quirke, Martin Radtke, Uwe Reinholz, Ian Shaw, Jim Tate, Isabel Tissot & Lore Troalen

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On the front cover: *Analysis of the gold cylindrical amulet from Haraga at The Petrie Museum of Egyptian Archaeology (UC6482) using a portable XRF spectrometer*.
On the back cover: *Details under the SEM of the triangular designs of granulation on the tube of the cylindrical amulet from Haraga*.

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Editorial foreword

This volume aims to present a wide range of perspectives on early Egyptian goldwork, integrating the complementary yet distinct approaches of archaeology, materials science, jewellery and Egyptology. On one level, our primary task has been to present new analytical data on the manufacturing technology and elemental composition of dozens of artefacts preserved at six European museums. At the same time, we have sought to anchor and contextualize this new information based on current research from three perspectives: an introduction to the fundamental geochemistry and material properties of gold, a reanalysis of historical sources and of goldwork manufacturing-techniques, and a guide to the key analytical techniques employed. In this way, we wish to ensure that the volume is accessible to specialists and students from different backgrounds. We anticipate that this body of material will provide a rich source of information for further interrogation and discussion in the future, and our concluding chapter offers a first synthesis of some key points emerging from this new research. There we focus particularly on the findings that seem to us most significant, alongside open questions and suggestions for future work. In so doing, we explicitly highlight some of the many strands beyond the scope of the work presented here, hoping that they may provide pointers for others. We emphasize that the volume is addressed not only to those interested in the archaeology of Egypt in the timespan covered, but equally to scholars researching past technologies and archaeological goldwork elsewhere, who may find technical observations of broader scope that could prompt cross-cultural comparisons.

In spite of the substantial amount of data compiled here for the first time, it is important to remind ourselves of some potential biases that are inherent to this work and may thus skew our interpretations. The most important of these concerns the selection of objects. This project starts and, in many ways, remains throughout its course with the exceptional group of gold jewellery buried in Qurna, on the west bank of Thebes in Upper Egypt, with a woman and child whose names are unknown to us, at some point in the 17th or 16th century BC. Today the Qurna group is the most important Egyptian assemblage in the National Museum of Scotland, Edinburgh. In 2008, curator Bill Manley with materials scientists Jim Tate, Lore Troalen and Maria Filomena Guerra launched a programme of new analyses of the goldwork from the group. Already in this first investigation, the scope extended to comparison with jewellery from the preceding and following centuries (Tate et al. 2009; Troalen et al. 2009). With funding obtained from the CNRS, Guerra could then expand the range of collections involved in collaboration with Thilo Rehren at UCL, to include the UCL Petrie Museum of Egyptian Archaeology and the UCL Institute of Archaeology with its laboratory facilities, as well as the National Museums of Scotland and the British Museum as project partners (CNRS project PICS 5995 EBAJ-Au). On the initiative of Jim Tate, contact had been established already with colleagues Matthew Ponting and Ian Shaw at the University of Liverpool. As a result, the Garstang Museum is also participant in the wider project, together with the Manchester Museum, through the support of curator Campbell Price, and the Louvre Museum, through the support of curator Hélène Guichard and the late Sandrine Pagès-Camagna, material scientist at C2RMF (Centre de Recherche et de Restauration des Musées de France). We wish to emphasize here the fundamental role of Sandrine Pagès-Camagna in crucial stages of the project; without her participation the project could not have achieved a significant part of its aims – notably comparison between the Qurna group and the nearest securely dated examples of royal goldwork from the reigns of kings Kamose and Ahmose.

Other institutions participated with the provision of access to particularly specialized equipment: AGLAE facilities at C2RMF, Bundesanstalt für Materialforschung und –prüfung, and LIBPhys at NOVA University of Lisbon

With this new support, the research agenda was able to grow organically, adapting to fresh questions emerging from preliminary results, while contingent on the artefacts present in museums that were accessible to the project. Indeed, the history of the collections has been a significant factor, both enabling and constraining our research. The Louvre collections contain a range of jewellery from early excavations in Thebes, including representative material from the late second millennium BC settlement Deir al-Madina, and major works from 16th century royal burials uncovered during fieldwork directed by Auguste Mariette. The British Museum and the other participating museums in England and Scotland also preserve a mixture of material from documented excavations and earlier undocumented collecting practice. Here colonial history frames the kinds of material available. During and after the full British military occupation of Egypt (1882–1922), the Antiquities Service of Egypt under French Directors permitted officially recognized institutions to excavate in Egypt and, in return for the enrichment of the Egyptian Museum Cairo, to take a share of finds from excavations. Following division of finds in Egypt, excavation funding bodies based at Liverpool (since 1903) and London (since 1882) distributed finds to dozens of sponsoring museums (Stevenson 2019). The university museums in Liverpool and London were among the major recipients of these finds, and also hold substantial excavation archives. The Qurna group itself and several other sets of jewellery analysed during the project are unusual examples of this pattern of dispersal, where the vast majority of items distributed belonged to the types of objects found in large numbers in fieldwork. The project was therefore able to investigate objects from a wide social spectrum, from palace production (Qurna group, Haraga fish and cylinder, items of kings Ahmose and Kamose from Thebes) to finds in cemeteries of regional rural towns and villages (Qau, Badari, Matmar). At the same time, in expanding the chronological scope of analyses forwards to the New Kingdom and back to the late prehistory of Egypt, the participating museums could not cover every social group for every period. Most notably, and perhaps surprisingly for those outside the museum circle, these collections hold none of the major goldwork from the age of the great pyramids, the mid-third millennium BC. At that period, the concentration of power at Memphis around kingship separates the royal court from the regions, and this is reflected in the tombs of the period and in the distribution of finds. Gold and gilt ornaments are more prominent in burials at the Memphite cemeteries: Giza and Saqqara. The single outstanding assemblage of Egyptian goldwork from the mid-third millennium BC is the unparalleled burial of material related to Hetepheres, mother of king Khufu; the finds are on display in the Egyptian Museum Cairo. Egyptologists from Cairo, Vienna, Boston, Hildesheim and Leipzig directed excavations at Giza; their museums received a share in finds (Manuelian 1999). The museums in our project, from Paris to Edinburgh,

Table 0.1. *Numbers of artefacts (museum inventory numbers) analysed by site and period.*

	Dyn 1-2	**First IP**	**Middle Kingdom**	**Second IP(-Dyn18)**	**New Kingdom**	**?**	**Total**
Memphis					2		**2**
Riqqa			4		7		**11**
Haraga			13 + 1?				**14**
Lahun			5				**5**
Ghurab					1		**1**
Sidmant			1		1		**2**
Amarna					8		**8**
Qau area		15		5			**20**
Abydos	4		2 + 2?	2		3	**13**
Naqada			2				**2**
Thebes			2	2 + 7?	4		**15**
*Qurna				12			**12**
Buhen			1				**1**
?		1	5	2	22		**30**
TOTAL	**4**	**16**	**36**	**30**	**45**	**3**	**136**

are not on that distribution map. With this and other lesser gaps, our sample, however extensive, cannot and does not claim to be random or representative of an underlying population of 'Egyptian goldwork'. On our chronological range from fourth to second millennia BC, there are peaks and troughs in the frequency of artefacts, and we encourage the reader to keep these in mind graphically, in order to assess our interpretations in context and to develop their own further research agendas (see Table 0.1).

Another delimiting factor in the selection of objects derives from our focus on technique, directing our attention predominantly to jewellery, rather than other gold elements such as the prominent use of sheets for gilding larger substrates of wood or plaster. Gold foils were included for comparative purposes, particularly in the investigation of composition, but to a lesser extent. Furthermore, within the rich repertoire of Egyptian gold jewellery, we took a particular interest in select assemblages, starting with the Qurna group itself, and within these certain specific features, such as the small beads found in the child's coffin and the adult's girdle. While these are fascinating manifestations of both technology and consumption, they are not necessarily representative of a broader corpus. We would also emphasize that we sought primarily artefacts with well-recorded archaeological contexts, as these evidently allow for more robust inferences, and provide the most secure foundations on which to build further research. Where the museums could provide access to material not from documented excavations, but acquired before 1970, we have included certain items if they helped to complete gaps in understanding, as a secondary circle of supplementary information. In each such case we have done our utmost to investigate their authenticity and source, but undeniably any interpretation based on an unprovenanced object will have to remain tentative. Indeed, one of our analytical investigations demonstrated the risks in building historical conclusions on material without documented excavation context; a gold shell inscribed with the name of king Taa, who reigned close in time to the Qurna group, presents disconcerting features more consistent with modern rather than with ancient manufacture.

A final and equally important constraint concerns the background and expertise of the editors and contributors to this volume. While together we span interdisciplinary breadth, and have found synergies in our research, inevitably there remain areas beyond our interests and access, and indeed beyond the time scope of the project. For example, our data may be used as a starting point to address issues of provenance, but targeted consideration of the extraction methods and possible geological sources of gold is not addressed in detail in this volume. Instead, much more emphasis has been placed on issues of technology, and the application of the results to a concluding interpretation of the Qurna group. We look forward to seeing how others may take up such topics, and feel sure that the woman and child of Qurna will continue to pose new questions.

Finally, for the opportunity to share our discussions and findings with a wider research audience, we would like to express our gratitude to the McDonald Institute for Archaeological Research for including this volume in its series.

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Chapter 10

New Kingdom jewellery

Maria F. Guerra, Susan La Niece, Marcos Martinón-Torres,
Nigel Meeks, Stephen Quirke & Lore Troalen

The technological study of a small number of objects produced mainly in the 18th Dynasty provides new data that can be related, typologically or geographically, to earlier studied objects. The analysis of the jewellery assemblage from tomb 296 at Riqqa, and of earrings from different sites, provides information on the production of ribbed penannular earrings in Egypt, comparable to those worn by the woman buried at Qurna. The study of typical New Kingdom gold objects, such as finger-rings of different types, provides further insight into the jewellery made when peace was re-established in Egypt.

Chapter 10.1

Jewellery in the New Kingdom

Maria F. Guerra

The best known group of New Kingdom gold jewellery is that found in the tomb of one of the last pharaohs of the 18th Dynasty, king Tutankhamun, excavated in the Valley of the Kings by Howard Carter in 1922 (Carter & Mace 1923). The diversity of objects and the variety of materials employed are remarkable even for this period of wealth. As with the grave goods from previous periods, gilding and plating are frequently used, but several objects are in solid gold (Andrews 1990) and others are richly and skilfully enhanced with stones and glassy materials to produce colourful motifs that increase the perception of wealth.

Two major technological changes characterize this period. The first is the pronounced use of granulation. Timidly employed in the Middle Kingdom for simple decorative patterns, granulation attains a high level of virtuosity in Tutankhamun's jewellery. Granules are here also employed to form gold beads and minute patterns of decoration using the traditional hard soldering processes, which need meticulousness and a great temperature control. Examples include the necklaces with the three-scarab pectoral (Carter & Mace 1923, pl. 84c; Hawass 2008, 142) and with the Ra pectoral in gold and blue faience (Edwards 1976a, 26). Gold wires are also commonly used,[1] demonstrating the growing ability of the Egyptian goldsmith to produce tiny and complex decoration patterns.

It is interesting to consider the ear ornaments with gold and lapis lazuli beads. The gold beads are finely decorated with geometrical patterns in granulation and filigree, but the gold is reddish pink instead of yellow (Carter 269a(2); James & de Luca 2000, 240). The second major technological difference of this period is the presence of many objects in 'pink' gold. Identified in several objects found in Tutankhamun's grave, such as the buckles (Carter & Mace 1923, pl. 67), the earrings with ducks (Carter 1972, 144), the shoes (Ogden 2011), etc., 'pink' gold remains so far unexplained. This 'new colour' of gold is said to produce a brilliant scarlet shade (Lucas 1927, 1922–39), and is thought to be based on the application of a surface film (James 1972), translucent and containing iron (Lucas 1927; Wood 1934).

Although the high quality of the employed materials and the artisans' skills are evident from simple observation of the New Kingdom jewellery, this can hardly compete in delicacy and lightness with the jewellery produced during the Middle Kingdom. The New Kingdom items seem to be the result of well-established workshop practices, applied by skilled artisans, who had access to a large quantity of raw materials expertly combined to obtain well-defined subtle effects, which were emphasized by the colour nuances of the materials. It is not however the aim of this chapter to discuss in full the many known examples of New Kingdom jewellery, nor the great diversity of technologies and materials that were employed during this period, as those aspects are fully covered in other publications (Aldred 1971; Andrews 1990; Wilkinson 1971; Ogden 1990). Instead, we present the analytical results obtained for a small number of objects produced mainly in the 18th Dynasty.

Some of them were selected based on the find location. This is the case of the group of jewellery found in two coffins discovered in tomb 296 excavated at Riqqa (Engelbach et al. 1915, 15–16, frontispiece), one of them containing the body of a man with a gold necklace including a plaque inscribed with the names of king Thutmes III and 'the scribe Beri'. Others were selected by their typology, such as the penannular earrings made from hollow tubes either round or triangular in section. Representing typical New Kingdom productions (Hayes 1959, 185; Müller & Thiem 1999, 166), they allow a technological comparison with those from the burial at Qurna (discussed in

Chapter 9.2), which are among the earliest examples of earrings in Egypt.

A small selection of swivel and signet finger-rings of different types, with coiled wires around the shank, were also analysed. Made in gold and sometimes containing components in other materials, such as carnelian, their study provided information on their steps of construction. The selected finger-rings include two similar ones, in the collections of the British Museum and National Museums Scotland, containing a gold frog encircled with two ropes of granules, which provided important information on the art of granulation in Egypt. The one in the collection of National Museums Scotland belongs to the group of jewellery supposedly from the Royal Tomb at Amarna. Another finger-ring and other objects in the same collection, contained in the group of jewellery from the same tomb and dated to the New Kingdom, were also included in this section.

Finally, a few other pieces of jewellery, such as strings and components of necklaces, were also selected for analytical study. They contain gold components typical of the New Kingdom production and some of them also contain traditional components of Egyptian jewellery, namely the common tiny gold beads used as spacers.

Notes

1. One example is the bracelet adorned with a pale green stone (Carter & Mace 1923, pl. 86; Hawass 2008, 149), which can be seen as a 'precursor' of the very delicate Ramses II's hinged bracelet with ducks in gold and lapis lazuli, found at Tell Basta (69 in Vilímková 1969).

References

For references see pp.445–8 at the end of this chapter.

Chapter 10.2

Jewellery from tomb 296 at Riqqa

Lore Troalen & Maria F. Guerra

Excavated by Reginald Engelbach, the site of Riqqa consisted of a series of graves, ranging from the Predynastic to the Late Period, distributed in seven cemeteries, labelled by the letters A to G. The graves in cemeteries A and C produced some of the most exquisite gold items. Tomb 124 in cemetery A, dated to the second half of the 12th Dynasty, provided the jewellery discussed in Chapter 8.3, while tomb 296 in cemetery C provided gold items dated to the New Kingdom (Engelbach et al. 1915). The burial from tomb 296 housed two coffins, one containing a male body and the other a female body. Flinders Petrie attributed these burials to the 18th Dynasty, and the male coffin as belonging to a scribe named Beri, of the reign of Thutmes III (Petrie 1914).

Engelbach recorded the grave goods from the tomb of Scribe Beri (Engelbach et al. 1915, 16, pl. 11). The group of jewellery included one gold necklace, shown in Figure 10.1. This necklace, found behind the male body, contains two gold-encased scaraboids, a gold-encased lapis lazuli cowroid and a small gold pendant. On one side the pendant has an incised inscription '*sesh Beri*' [Scribe Beri], and on the other side is inscribed '*Men-kheper-re tit-Amun*', which corresponds to the praenomen of Thutmes III. The remainder jewellery was found in the female's coffin. Among the items, four gold ribbed penannular earrings described by the finder as gold rings used for fastening the hair. One of them is shown in Figure 10.2. With the exception of one penannular earring currently missing, the group of gold jewellery from tomb 296 is now in the collection of NMS (A.1913.388-391).

The group of jewellery

The necklace found with the male body contains 94 spherical beads alternating with 72 flat lenticular beads, with a central section of 20 small ball beads of different sizes, and a flat incised square gold pendant. Unlike the pendant, which is a solid cast, the gold beads are hollow, as shown in the X radiography of Figure 10.3. The lenticular and the large spherical beads were obtained by joining two embossed halves made from sheet gold. Observation under the SEM of some specimens (Fig. 10.4) reveals the joining seams at the edge. The small spherical beads are made by bending and soldering a gold sheet. All the beads and the chased pendant show marks of use-wear.

At the ends of the necklace can be found two gold-encased scarabs and one gold-encased cowroid bead. One of the necklace's terminal is a small gold biconical bead and the other a gold ring bead. The two scarabs, one in steatite and the other in lapis lazuli, are set in gold frames made from gold sheet bearing one undecorated gold collar at each side, as shown in Figure 10.5. The small scarab's tray is a mounting of two gold sheets. The cowroid bead in lapis lazuli is set in a gold tray made from a corrugated sheet of gold to which two undecorated gold collars were added.

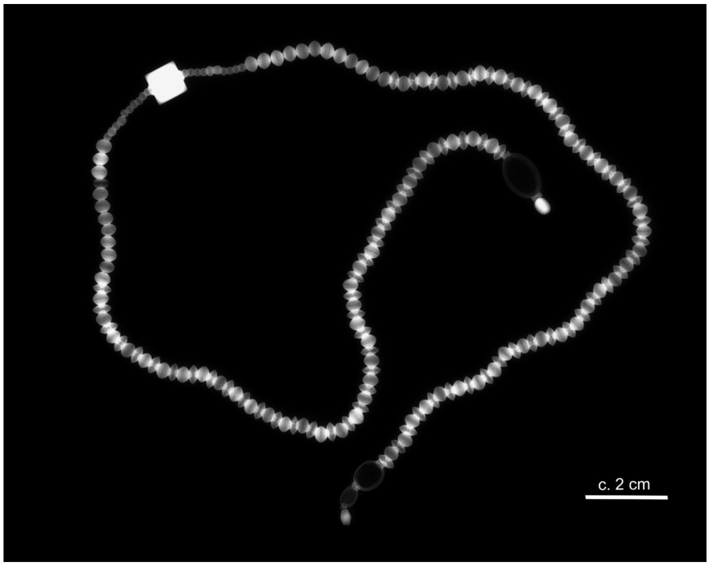
The ribbed penannular earrings consist of four hollow hoops of triangular section joined at their bases. The hoops were obtained by bending or embossing a gold sheet that is soldered at the base, as shown in Figure 10.6 (left). The hard solder used in the joining process is still visible between the hoops, as shown in Figure 10.6 (right). The tubes may have originally been closed with gold sheets, similarly to other examples of penannular earrings (see Chapter 10.3), however these are all missing in the earrings from tomb 296.

The gold alloys and the soldering process

The data obtained for all the gold alloys of the jewellery from tomb 296 are summarized in Table 10.1 and plotted in Figure 10.7. The diagram shows that different gold alloys were used to manufacture the items.

Figure 10.1. *The gold necklace NMS A.1913.388 with a detail of the small pendant bearing the cartouche of Thutmes III.*

Figure 10.2.
One of the three ribbed penannular earrings from tomb 296 at Riqqa (NMS A.1913.389-91).



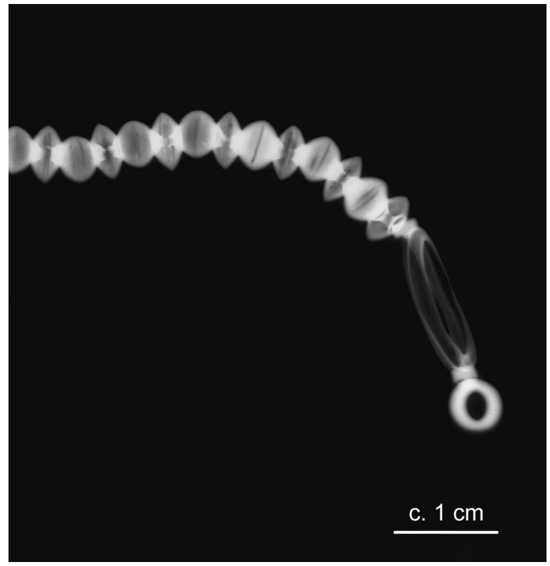
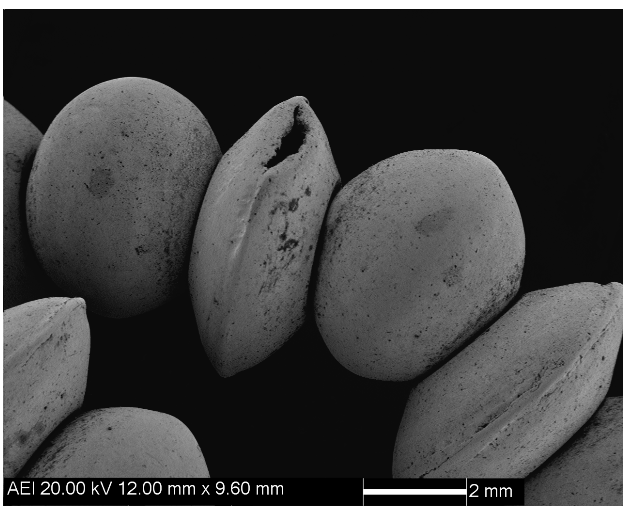


Figure 10.3. *X-radiograph of necklace NMS A.1913.388 and detail of the joining of the beads (NMS plate 20091009-9: 4 mA, 260 kV, 3 min, lead screen, 3.3 mm Cu filter, Structurix D7).*



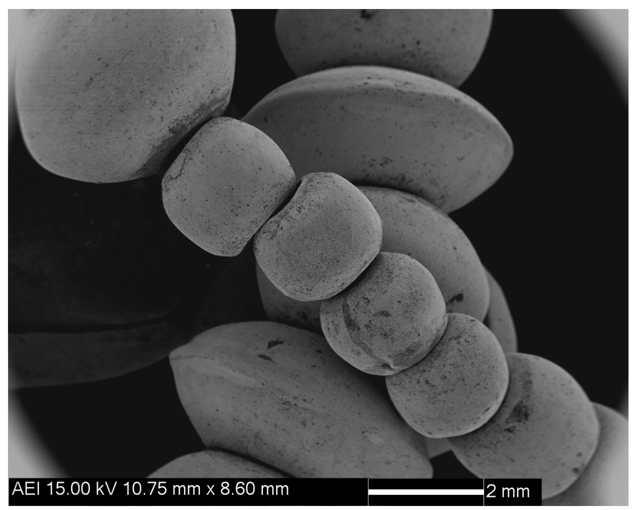


Figure 10.4. *SEM-AEI micrographs of (left) the lenticular and large ball beads and of (right) the small ball beads contained in the necklace NMS A.1913.388.*

Figure 10.5. *Details of the scarabs and scaraboid bead in the necklace NMS A.1913.388.*

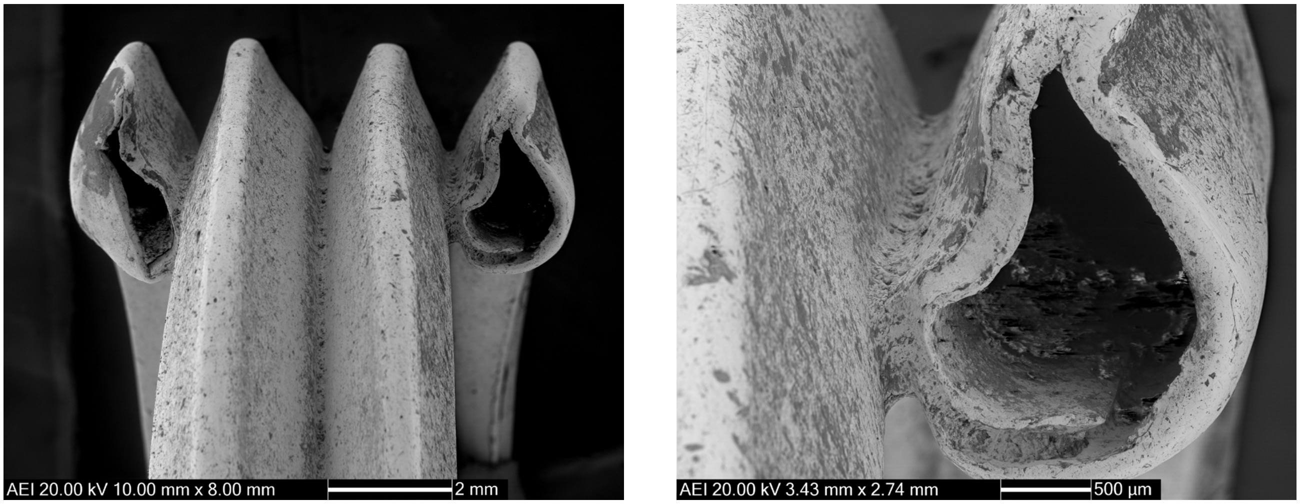


Figure 10.6. *SEM-AEI micrographs of one of the ribbed penannular earrings from tomb 296 (NMS.A.1913.390) showing (left) the mounting of the four triangular hoops and (right) a detail where the gold foil overlaps inside one of the triangular hoop and the remains of solder between two hoops.*

The three ribbed penannular earrings are made of similar alloys with silver levels of *c*. 9–10 wt% and copper contents below 1.5 wt%. Each hoop of the earrings is made from a slightly different alloy, which is necessary when joining by hard solder. By comparison, the beads and pendant that make up the necklace are made from several alloys with silver contents ranging between 13 and 31 wt%, with a level of copper reaching 3 wt% for some of the beads. Each type of bead, however, exhibits a single composition that is clustered in the diagram of Figure 10.7, suggesting that each bead type could correspond to a single alloy batch. The variation in silver content between the types of beads could correspond either to the search for a polychrome effect

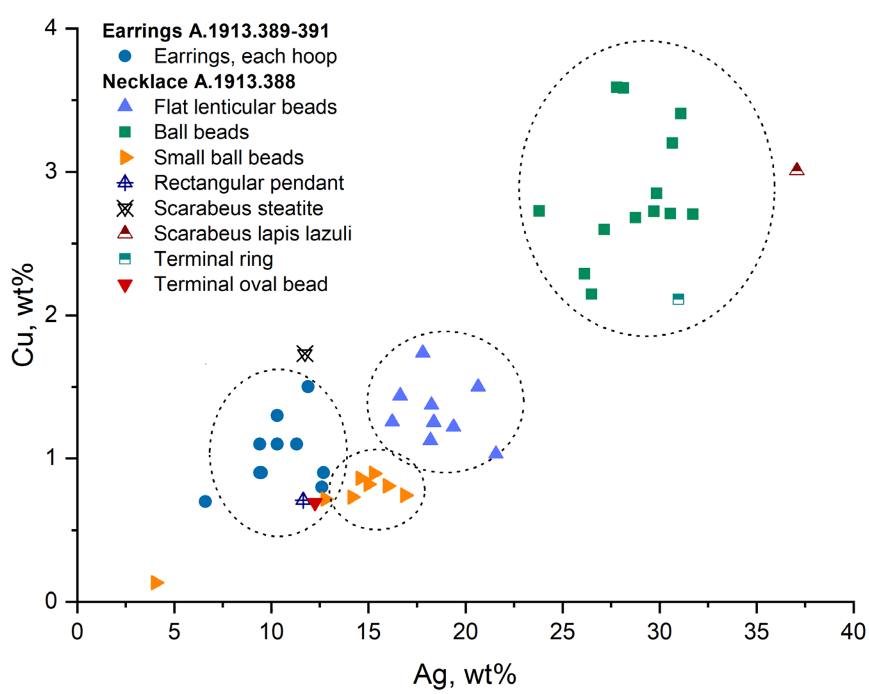


Figure 10.7. *Silver versus copper contents obtained by PIXE and XRF for the gold items from tomb 296. The dashed lines highlight the alloys used to produce the earrings and those used to produce each type of bead in the necklace.*

Table 10.1. *Results obtained by µPIXE, XRF and SEM-EDS for the base alloys, and by µPIXE and SEM-EDS for the solder alloys for the jewellery from tomb 296 at Riqqa and for one published earring (*Lilyquist 2003). For the necklace, the average composition of each type of bead is given.*

		Alloy wt%			Solder wt%		
Acc. No.	**Method**	**Au**	**Ag**	**Cu**	**Au**	**Ag**	**Cu**
A.1913.389							
Hoop 1	XRF	89.2	9.5	0.9			
Hoop 2	XRF	89.3	9.4	0.9			
Hoop 3	XRF	87.1	11.3	1.1			
Hoop 4	XRF	88	10.3	1.1			
A.1913.390							
Hoop 1	XRF	86.3	12.7	0.9			
Hoop 4	XRF	86.3	12.6	0.8			
A.1913.391							
Hoop 1	PIXE	92.8	6;6	0.7			
Hoop 2	PIXE	89.5	9.4	1.1			
Hoop 3	PIXE	88.3	10.3	1.3			
Hoop 4	PIXE	86.5	11.9	1.5			
A.1913.388							
Flat lenticular beads	PIXE	80.1	18.6	1.3	70	26	4
Ball beads	PIXE	68.4	28.7	2.9	61-68	28-36	3_4
Small ball beads	PIXE	85.9	13.4	0.7			
Rectangular pendant	PIXE	87.7	11.6	0.7			
Scarabeus steatite	PIXE	86.5	11.7	1.7			
Scarabeus lapis lazuli	PIXE	59.9	37.1	3			
Terminal ring	PIXE	66.9	31	2.1			
Terminal small oval bead	PIXE	87.1	12.2	0.7			
MMA 26.8.94b*							
Tube	EDS	69	26.3	4.7			
Disk attachment	EDS	69.3	26.3	4.4			
Coupon on back of disk	EDS	69.7	24.4	5.9			

or to separate manufacturing events at different times or by different goldsmiths. The twenty small spherical beads yielded a more diverse range of compositions, with one group being made of high purity gold alloy. It is also these beads that exhibit a larger variety of sizes. This could be the result of a manufacture by different goldsmiths or perhaps the reuse of spacer-beads from different items, similar to what has been observed for the child's necklace from Qurna (see Troalen et al. 2014 and Chapter 9.2). The other components of Scribe Beri's necklace are scattered in the diagram of Figure 10.7. Two are made from high silver electrum, one very close in composition to the lenticular beads, while the pendant and the other terminal beads all show silver contents lower than 13 wt%, compositionally closer to the ribbed penannular earrings.

None of the analysed ribbed earrings exhibits the same purity as those from the Qurna burial. In the group analysed, only one small spherical bead from the necklace contains 95.8 wt% Au, 4.0 wt% Ag and 0.1 wt% Cu. In comparison to the earrings from tomb 296, one ribbed penannular earring from the so-called tomb of three foreign wives of Thutmes III (Wadi Qurud, Thebes) in the Metropolitan Museum of Art analysed by EDS (Lilyquist 2003) shows the use of electrum alloys with silver contents around 26 wt%.

As mentioned, when the small cast pendant is excluded, all the objects investigated in this group were made of sheets of gold with the different parts joined using the hard soldering technique. While the mounting of the earrings is clearly visible and the joins are easy to identify (Fig. 10.6), in the case of the gold beads from the necklace, the joins are almost invisible even under the SEM. Even though, the morphology of the gold surfaces suggests the use of heating (Fig. 10.4). The geometry of the beads, together with the very

Table 10.2. *Results obtained by SEM-EDS for the PGE inclusions in the jewellery from tomb 296 at Riqqa.*

	Composition wt%		
Acc. No.	**Ru**	**Os**	**Ir**
A.1913.390	4	38	57
A.1913.391	16	50	34
A.1913.388			
Rectangular pendant	19	44	37
	17	44	39
	20	43	38
	22	48	31
Terminal ring	40	35	25
	24	43	33
	5	37	58
	33	39	29
	9	53	38

thin joins, meant that it was only possible to evaluate the composition of the joins for a few items by mapping with EDS or PIXE. An increased level of copper, reaching 4 wt%, was observed for the different joining areas analysed. Furthermore, the Ag/Au ratio in the join was found to be similar or close to that in the base alloy, suggesting the use of solder alloys prepared by adding copper to lower the melting point. Evidence for a similar technology has been presented in other jewellery discussed in this volume, pointing to a well established traditional practice in Egypt.

The silver content in the jewellery from tomb 296 at Riqqa, together with the observation of platinum-group elements (PGE) inclusions in the gold and electrum items, suggest that the objects were made from alluvial gold. It must also be emphasized that in the electrum items analysed, the copper content of 3-4 wt% was higher than expected for alluvial gold deposits in Egypt, suggesting the addition of this metal to the base electrum alloy. Such addition of copper to silver-rich electrum seems to have been a continuous practice in Ancient Egypt since the Predynastic and Old Kingdom periods. Published data show that silver-rich electrum objects from the Ashmolean Museum exhibit a copper content ranging from 0.2 to 26 wt% (Gale & Stos Gale 1981). Similar additions of copper were observed in items from the Middle Kingdom (Troalen et al. 2015; Lucas & Harris 1962), the Second Intermediate Period (Troalen et al. 2014), and in several 18th Dynasty jewellery items from the tomb of three foreign wives of Thutmes III (Lilyquist 2003). Some authors have suggested that these enhanced levels of copper result instead from the mixing of metals during recycling (Philip & Rehren 1996). The origin of silver-rich electrum in Egypt remains to be explained: aurian silver might have occurred naturally in primary gold and primary silver deposits (Gale & Stos Gale 1981), but a non-local origin cannot be ruled out (Stos-Gale & Gale 1981).

Table 10.2 summarizes the data on the PGE inclusions that were analysed in the jewellery from Riqqa. Most of the inclusions were found to be rutheniridosmine, as would be expected in Egyptian jewellery. However, their composition was found to be quite variable, sometimes within the same item, especially in the terminal ring of the necklace where numerous inclusions were found. The level of ruthenium was mostly found to be below 25 wt%, which has been suggested to correspond to the gold sources in the Nile Valley Region north of the 18th parallel (Meeks & Tite 1980; Ogden 1976).

References

For references see pp.445–8 at the end of this chapter.

Chapter 10.3

Making pennanular ear ornaments in Egypt

Maria F. Guerra

The regular production in Egypt of ear ornaments has been dated to the end of the Second Intermediate Period – early 18th Dynasty[1] (Andrews 1990; Wilkinson 1971). These ornaments that became popular in the 18th Dynasty were suggested by Wilkinson (1971, 121) to result from imports. This suggestion was corroborated by Edwards (1976b, 140), who stated that they were 'probably a legacy of the Hyksos invaders who brought them from Western Asia, where they had been in vogue for many centuries'.

Egyptian ear ornaments occur in many different styles. Wilkinson (1971, 121–2) separates those made from the early 18th Dynasty onwards in seven categories: open hoops of different widths, open hoops with rings to hung decorative components, ribbed hoops, boat-shaped hoops, wire hoops with pendants, spiral tube round or triangular in section, and tube with bosses at each end.

Since the 18th Dynasty, women are represented wearing quite large ear ornaments of many different types (Arnold 1996). Queen Tiye, for example, is represented wearing several sorts,[2] among which, perhaps the best known, are the discoid ones in gold and lapis lazuli in the collection of the Egyptian Museum in Berlin (ÄM 21834). When discovered at Madinat al-Ghurab, the bust of the queen only exhibited one of the pair (Borchardt 1911, 8), but the X-radiography of the bust, carried out in the 1930s, revealed the presence of the invisible earring (Schäfer 1932). The Computed Tomography (CT) image of the queen's head obtained in the 1990s has added new information on the queen's ornamentation, by revealing the silver headdress and the gold broad band preserved under the wig (Arnold 1996, 30–3).

Women are also represented wearing ear ornaments of different dimensions. In one scene from the tomb of Nebamun at Thebes in the British Museum (EA37981 and EA37984) representing a banquet, the dancers seem to wear smaller specimens than the guests and the musicians. In this scene, visibly only women wear ear ornaments, but in other scenes, such as those in the tomb of Sennefer at Deir el-Medina (Bruyère 1928), both Sennefer and his wife Meryt wear earrings (Virey 1898; Maggio 2013; Eggebrecht 1988), perhaps of distinct types. Sennefer seems to wear one-hoop penannular earrings and Meryt another type, perhaps ribbed specimens (with several hoops). Interestingly, the same situation is observed for Kha and his wife Meryt. The mummies that were found in 1906 in an undisturbed tomb at Deir el-Medina by E. Schiaparelli are in the collection of the Egyptian Museum of Turin. The X-radiography carried out in the 1960s by Curto & Mancini (1968) revealed the jewellery items that ornamented the bodies, showing that both Kha and Meryt wear penannular earrings. However, while he wears one-hoop specimens, she wears ribbed penannular earrings. Recent CT examination and X-ray imaging using mobile equipment (Bianucci et al. 2015) provided new high-resolution images of the jewellery. They confirm the suggested earring types. Apparently, the ribbed penannular earrings contain six triangular hoops.

Although jewellery is said to be 'unisex' in the New Kingdom (Kozloff 2001), Egyptian men and boys are only occasionally represented wearing earrings, despite often showing pierced earlobes[3] where these ornaments could hang. Edwards (1976a) indicates that the first king whose mummy shows pierced earlobes is Thutmes IV. In contrast, Nubians are commonly represented wearing earrings,[4] typically penannular ones. Examples include the Nubians represented in Tutankhamun's gilded walking stick and gold plated wooden chariot (Allen & Burton 2006; Hawass 2008).

Wilkinson (1971, 121–3) suggests that ear ornaments were in fashion for all women before being in fashion for men, and perhaps were worn by young males until they reached adulthood. This is also suggested by Aldred (1971, 230), but according to Edwards (1976b, 140) not in the Amarna period. It is at this point interesting to consider the grave goods from the burial of Tutankhamun. Several personages, such as the gilded statues of the Egyptian guardians, have pierced earlobes; the same applies to several representation of the king (for example, the small squatting figure in solid gold, the canopic coffins and the miniature effigy on a bier) and the king's gold mask. The king's mummy had no earrings, but as reported by Carter (card 256) the pierced ears were 'covered over with gold foil'. The gold disks over the earlobe's holes of his mask are mentioned by Edwards (1976b, 134), and Wilkinson (1971, 123) suggested that they were perhaps intended to disguise the fact that he had perforations. However, it is interesting to consider the pair of ear ornaments with a falcon with spread wings and the portrait of the king visible through the glass covering each button of the earstud clasps (as described by Edwards 1976b, 140). In fact, as recalled by Wilkinson (1971, 124), Carter (card 269) reports: 'the earrings show evidence of wear and tear'. This attests that the king (or at least someone) wore these ear ornaments during his lifetime.

Among the earliest types of gold earrings produced in Egypt are the penannular ones (Wilkinson 1971), commonly consisting of one or more hollow hoops[5] in a more or less complex mounting that can also be the base of more complex ear ornaments by addition of components in gold and in other materials. One of the simplest examples made of several components was found in tomb KV56 (Aldred 1971, 139, fig. 131) among the jewellery containing the cartouches of Seti II and Tausret. It consists of one round hollow hoop with small rings attached to the lower edge (Daressy 1910, 41–2) where were suspended different rows of beads (52399 in Vernier 1907–27, 139, pl. 20).[6] It is also interesting to mention a stela excavated at El-Amarna in the collection of the Cairo Museum (JE 44865) where Akhenaten can be seen giving an earring of this type to Princess Meretaten, his eldest daughter (Arnold 1996, 101–2, fig. 94).

One of the earliest examples of earrings in Egypt are those found in the burial excavated by Petrie (1909) at Qurna, technologically studied in Chapter 9.2 of this volume. They are ribbed penannular specimens made by assembling beaded hollow tubes, a type that is not among those traditionally produced in Egypt. In addition to being an unusual type in Egypt, the Qurna ribbed penannular earrings were made from fairly pure gold alloys, containing higher amounts of gold than the alloys commonly employed in Egyptian workshops in the production of jewellery. For this reason, we decided to carry out analytical research on the earrings produced in Egypt during the New Kingdom. Only a small number was submitted to analytical study, but all of them are penannular. The majority of the studied earrings are ribbed penannular specimens, which are typologically close to the pair worn by the adult woman buried at Qurna.

The ribbed penannular earrings

Different types of penannular earrings were found in tombs, made using round or triangular hoops. Vernier (1907–27, 14–17) reports fourteen penannular earrings in queen Ahhotep's group of jewellery including several specimens with round and triangular hoops. Six of them are ribbed earrings,[7] among which noticeable four specimens (nos. 52378-81), each with four triangular tubes, that are analogous to other four earrings from a burial excavated at Tell Basta (nos. 52382-5). In the burial of a male and a female in tomb 296 at Riqqa, discussed in Chapter 10.2 of this volume, were also found four earrings of the same type. The four specimens found by Bruyère (1937, 161) in tomb 1371 at Deir el-Medina (Grandet 2002), containing a female burial, are also ribbed penannular earrings.

The earrings found in tomb 296 at Riqqa consist of four hollow triangular tubes joined at their bases using the hard soldering process (see Chapter 10.2). In many cases, the solder is still visible between the earring hoops. Based on Vernier's description of Ahhotep's earrings, the four cited specimens found in the queen's tomb were made using the same technique as well as the four specimens found in tomb 1371 at Deir el-Medina, one of which is shown in Figure 10.8. As suggested by Vernier (1907–27, 132–3), each triangular hoop is made from embossed gold sheet. The two central tubes are longer allowing inserting the earring through the pierced earlobe. The tubes were originally closed with gold sheets. For the various specimens known, the sheet of gold was either triangular to be joined by hoop end or larger to cover several hoop ends, sometimes perforated (Fig. 10.9a,b). In Figure 10.9c the profile view of one of a ribbed penannular earrings evidences the closing large gold sheet protruding from the back of the aligned hoops.

However, four ribbed penannular earrings excavated at Riqqa, which could come from one of the robbed tombs in cemetery C excavated by Engelbach during the 1914 season (Engelbach et al. 1915, 31–2, pl. 51.3), demonstrate the use of another mounting technique. Two earrings from Riqqa in the collections of the Petrie Museum (UC31416) and the Manchester Museum (MM6146), studied in this work, seem to be two of them. In this case, the triangular forms are

Figure 10.8. *One of the ribbed penannular earrings from tomb 1371 excavated at Deir el-Medina, in the collection of the Louvre Museum with details of the triangular tube ends.*

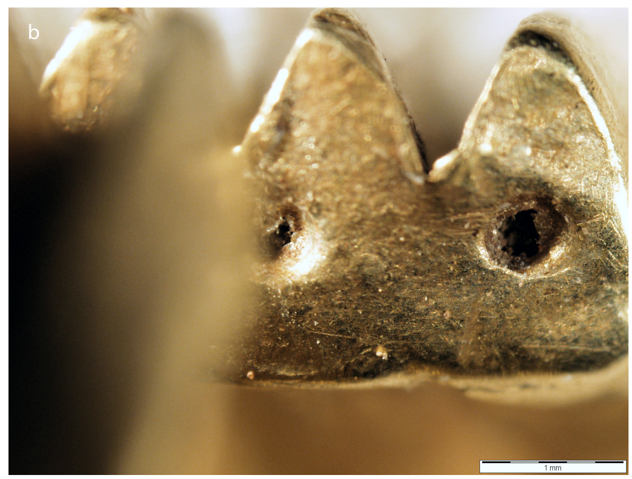


Figure 10.9. *Closing tube sheets in several ribbed penannular earrings. (a) One triangular sheet that covers one of the tubes of earring E 14435C from tomb 1371 at Deir el-Medina. (b) The small holes of the sheet closing all hoops of earring NMS A.1937.691. (c) The unique closing gold sheet protruding from the back of the aligned four hoops of earring NMS A.1928.160.*

obtained by joining V-shaped gold sheets onto a back gold sheet, as shown in Figure 10.10. The back gold sheet is risen to cover the holes, closing the triangular tubes. Considering the description offered by Vernier (1907–27, 134) on the four ribbed penannular earrings found at Tell Basta, which have 'inside a plain plate that forms the ring', they are made using the same technique as those supposedly found in cemetery C at Riqqa. This technology was also employed to produce three earrings in the collection of the Metropolitan Museum of Art (MMA 26.7.1321-3), found inside tomb CC 37, burial 83, excavated by Carter in Asasif, Thebes.

Figure 10.10. *Details of the ribbed penannular earrings from Riqqa in the collections of the Manchester Museum (6146) and Petrie Museum (UC 31416), made by joining four V-shaped gold sheets onto a back gold sheet that is raised to close the hoops.*

Therefore, two technologies (co?)existed at Riqqa, Tell Basta and Asasif. One ribbed penannular earring with five tubes made using V-shaped gold sheets soldered onto a back gold sheet was more recently found in the tomb of Djehuty at Dra Abu al-Naga (shown in Galán 2013) together with two pairs made by soldering at the base six hollow tubes, reinforcing the suggestion of 'regular' use of two technologies. Clearly, one technique might be 'exceptional', resulting from an import or from the work of a precise workshop. Another possibility is a chronological difference. A pair of ribbed bracelets from the Middle Kingdom tomb of Hor excavated at Abydos is made from V-shaped gold sheet (University of Pennsylvania Museum E9190A-B; Wegner 2014). This type of object could have 'inspired' the earliest ribbed penannular earrings.

In order to get a larger picture of the ribbed penannular earrings with triangular hoops made in Egypt, we reported in the Appendix below one hundred and one specimens in several collections. They are made from several tubes. It is noticeable that both technologies (co?)existed in several sites, not only at Riqqa, Asasif and Tell Basta, as mentioned, but also at Dra Abu al-Naga and Gabbanat el-Qurud, because earrings made using the two technologies were found in the tombs of Djehuty and of the three foreign wives of Thutmes III. Although it is impossible to exclude the possibility that this might result from a production of one of the types in one specific region or by specific workshops, it is also possible to say that a chronological replacement of one of the techniques by the other would involve the simultaneous use of new and old pairs by different owners.

We must still note that in the tombs of the three foreign wives of Thutmes III[8] and of Ahhotep as well as in tomb 296 at Riqqa and tomb 1371 at Deir el-Medina, these earrings are always present in groups of four. The ribbed penannular earrings from one of the robbed tombs in cemetery C at Riqqa are also four. In the case of the woman buried at Deir el-Medina, Bruyère (1937) indicates that she was wearing one pair at each ear. The recent CT examination and X-ray imaging of Kha and Meryt jewellery (Bianucci et al. 2015) shows that Meryt is wearing at each ear one pair of ribbed penannular earrings (apparently 6 tubes). To our knowledge this is not represented in tomb scenes, therefore, hanging one pair of ribbed penannular earrings per ear could correspond to a funerary practice in the case of female burials.

Based on the ribbed earrings reported in the Appendix below, we can suggest that the most widespread types have hollow tubes soldered at their bases, and that the use of four and six tubes could have been equally popular. However, a few specimens have an odd number of tubes and a few others more than six tubes. Several of those with more than four tubes are decorated either with gold inlaid components surmounting the hoops to stand against the lobe when wearing the earrings or with gold wires twisted into a braid placed between the middle hollow tubes. Among the compiled ribbed earrings, only two unprovenanced and one excavated at Tell Basta[9] have the ends of the external tubes decorated with incised parallel lines, decoration often observed in those with round tubes.[10] A few specimens have in addition crossed lines. This is the case of four earrings in the collection of the Metropolitan Museum of Art (MMA 16.10.467-470) found on the body contained in burial E4, pit 3, courtyard CC 41 at Thebes[11] (Davies 1917). None of them attains however, the quality of the elaborate specimens in the same collection excavated at Dra Abu al-Naga by Howard Carter in 1914 (MMA 26.7.1355-58). They were found near the head of the female body buried in tomb 74 at Mandara, a tomb that also contained scarabs dated to the early 18th Dynasty (Lilyquist 2020). Decorated with parallel lines and containing three ropes of small beads in lapis lazuli strung in gold wires to simulate the tubes (see Chapter 11 for more details), they are an astonishing example of the remarkable art of goldsmithing in Egypt at the beginning of the New Kingdom.

Earrings with tubes round in section are technologically equivalent to those with triangular hoops. They are sometimes decorated with parallel lines. Specimens were found in several contexts.[12] We can mention, for example, those excavated by Petrie at Abydos, today in the collection of the Museum of Fine Arts Boston (MFA 02.836). Figure 10.11 shows manufacturing details of one earring of this type (N2084 in the collection of the

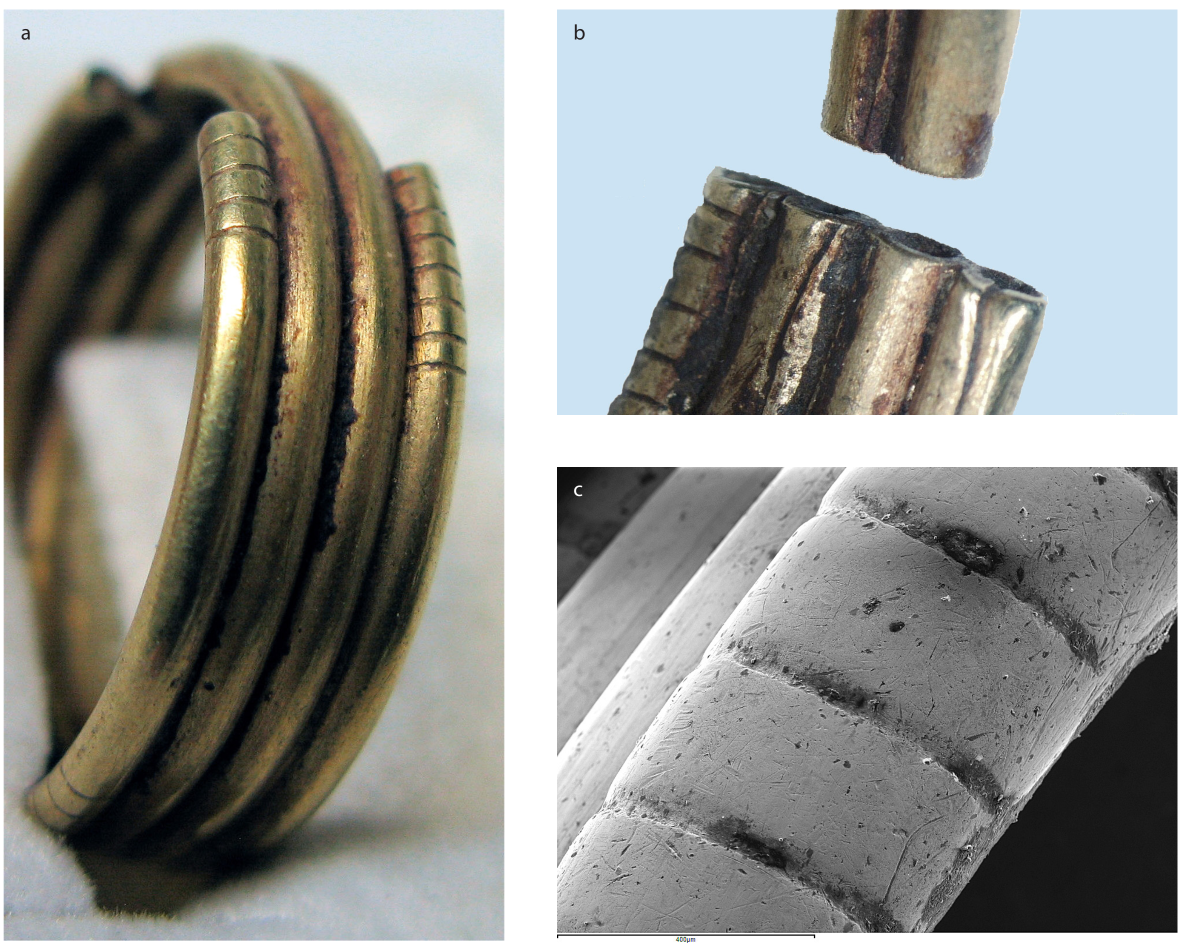


Figure 10.11. *Details of the ribbed penannular earring with hollow round tubes in the collection of the Louvre Museum (N2084) showing: (a) the asymmetrical decoration, b) the joint of the rolled gold sheet in the inner side of the hoops, and (c) the chased decorative lines.*

Louvre Museum, included in the group of selected items for analytical study in this volume), consisting of four hollow hoops joined at their bases using the hard solder process. The two central hoops are longer perhaps to insert the earring through the pierced earlobe. The tubes are made by rolling and soldering a gold sheet; the joining seam is visible on the internal side of the tube (Fig. 10.11b). Originally, the tubes were closed with gold sheets.[13] One of these sheets is still present. The eight groups pf decorative parallel lines, obtained by chasing (Fig. 10.11c), form an asymmetrical motif (for example at the ends of the tubes, Fig. 10.11a).

Penannular earrings with one tube

Penannular earrings with a single hollow tube of different widths (Schäfer 1910; Müller & Thiem 1999, 166)[14] might be triangular, such as those from Mit-Rahineh (University of Pennsylvania Museum 29-70-18) and from the tomb of Ahhotep (52423 in Vernier 1907–27), but the majority seems to be made from a round tube. Figure 10.12 shows one small specimen (LM AF 2444) made from a whitish alloy and a larger one, yellowish, found at Riqqa (MM6146b) during the 1914 season of excavations (Engelbach et al. 1915, 31–2, pl. 51.2). The

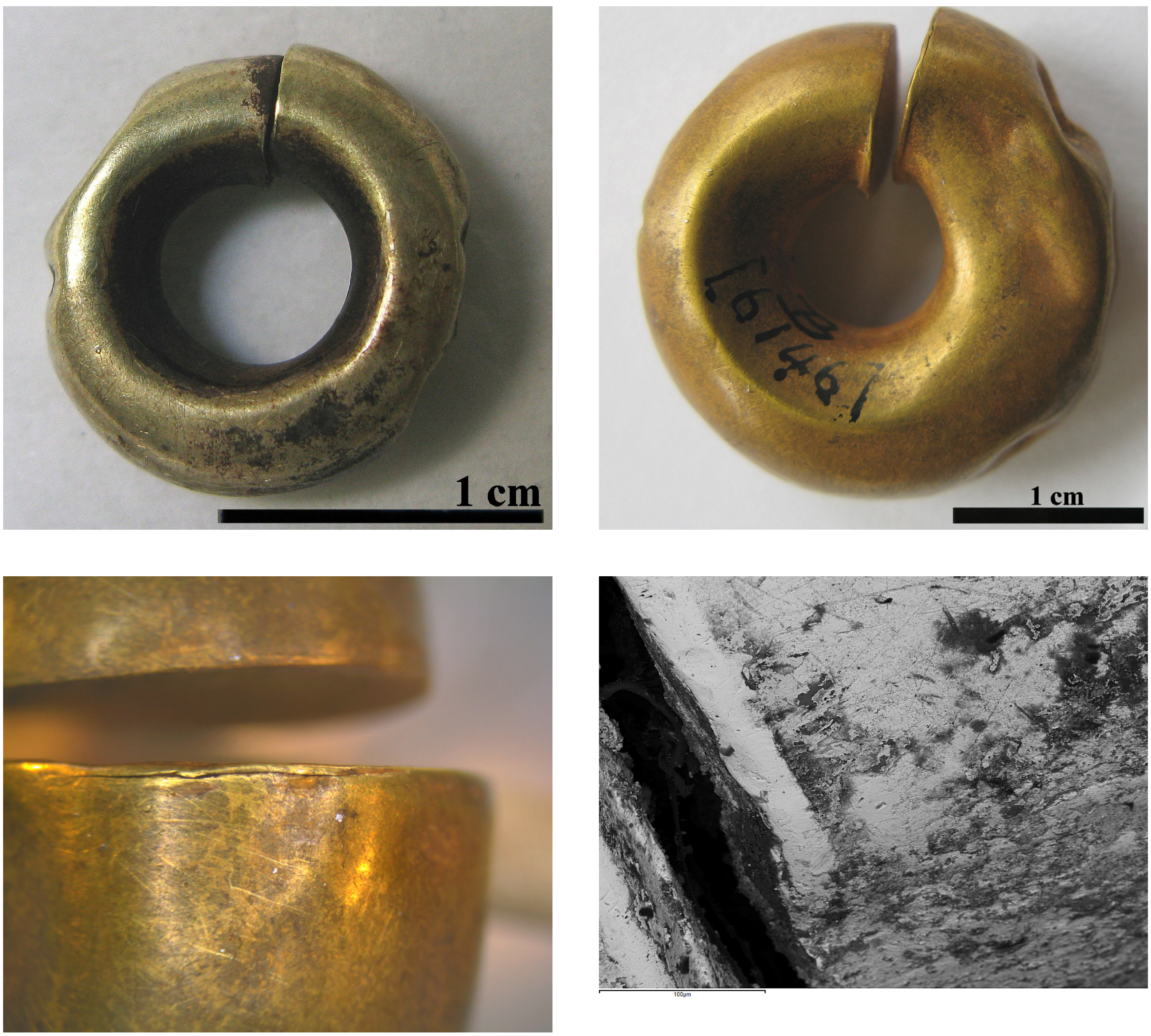
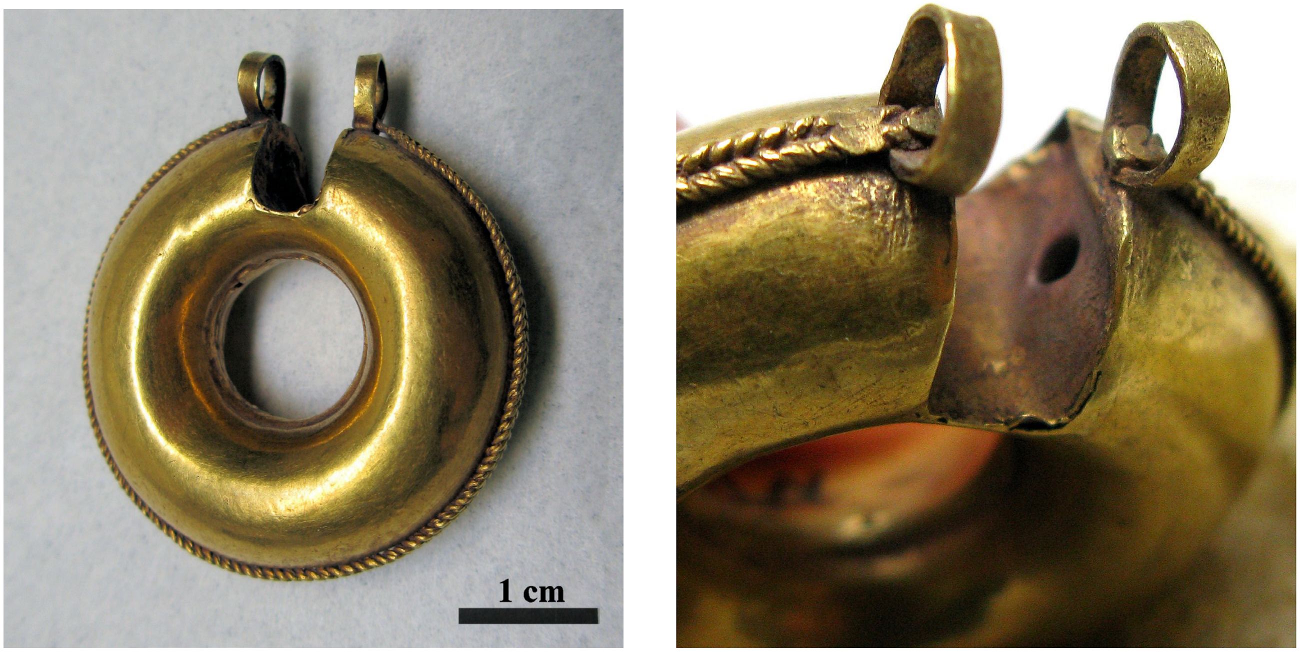


Figure 10.12. *Gold hollow penannular earrings with one round tube. The small whitish earring is in the collection of the Louvre Museum (AF 2444) and the big yellowish earring is in the collection of the Manchester Museum (6146b, from Riqqa). Some PGE inclusions are visible near the discs closing the hoops.*



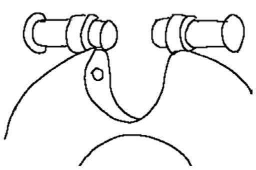


Figure 10.13. *Penannular earring in the collection of the Louvre Museum (N1855B) with one hollow tube, a pierced gold closing sheet and a gold braid covering the outer side joining. The suspension system is incomplete. A complete suspension system is shown on the left (drawing M. F. Guerra after Vernier 1907–27, 126).*

hollow hoop is made from two soldered halves closed with gold discs (Fig. 10.12).

A similar type of penannular earring contains a gold braid made from twisted gold wires (Seipel 2001, 91) that covers the joining seam of the hollow tube, on the external edge, the internal junction remaining apparent. One earring of this type is shown in Figure 10.13. The earring is incomplete. Indeed, many specimens, such as those excavated at Saqqara and Zawiyet al-Aryan (Vernier 1907–27, 126–8), have a hanging system. Vernier (1907–27, 126) describes the original mounting as follows: two small tubes held by the suspension rings fitted into each other through the lobe to maintain the earring hanged. Details of the hanging systems are shown in Figures 10.13. The two suspension rings that surmount the tube at both ends remained in the earring shown in Figure 10.13 as well as in a similar earring in the collection of the British Museum (EA14346). The radiography shown in Figure 10.14 shows the mounting of the components of the latter.

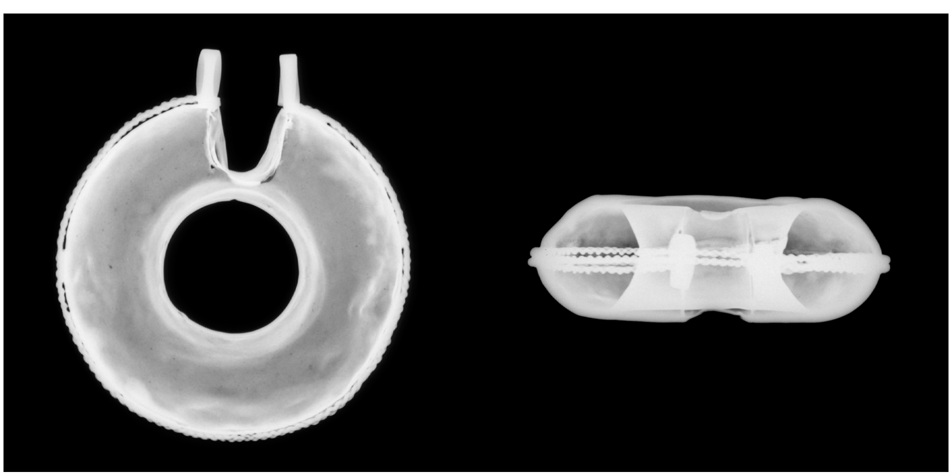


Figure 10.14. *X-radiography of gold penannular earring EA14346 in the collection of the British Museum, consisting of a hollow tube surmounted by a gold braid. Radiography S. La Niece (BM X-ray plate 6900/1, 10 mA, 100 kV, 2min, lead screen, Structurix film D4).*

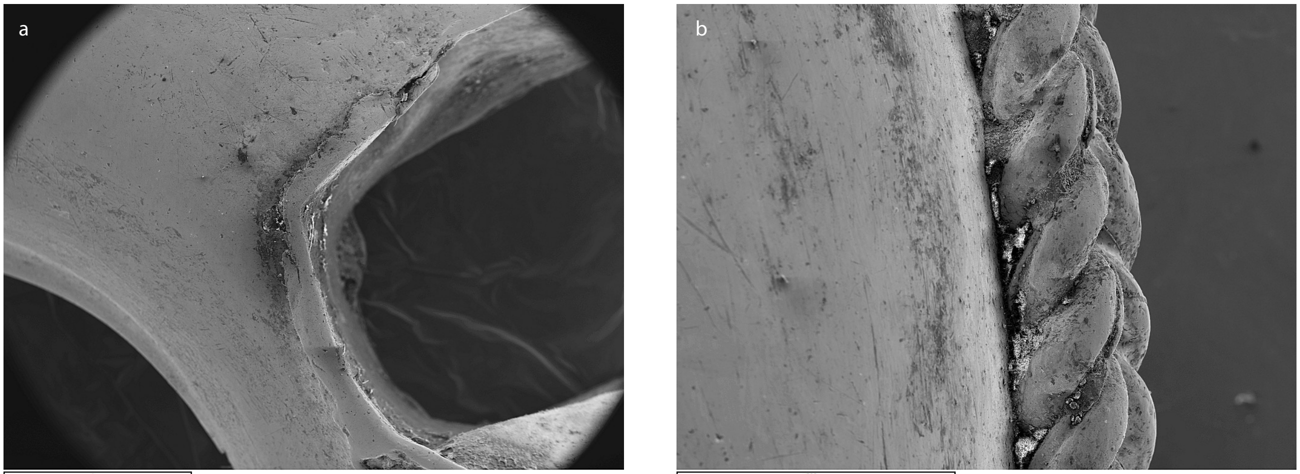


Figure 10.15. *Details of penannular earring N1855B under the SEM showing the gold closing sheet folded over the hoop and the gold braid obtained by twisting gold wires made in this case possibly by strip-twisting.*

The hollow hoop top of these earrings is cut to the shape of the earlobe. The tubes are closed with a curved gold sheet, which is folded over the hoop, as shown in Figure 10.15a for the earring shown in Figure 10.13. The gold braid that decorates this earring is shown in Figure 10.15b. The braid is obtained by twisting gold wires, which are apparently hollow, made perhaps by strip-twisting. They surmount the base of the suspension rings.

It is interesting to consider again the images obtained by X-radiography examination of the sarcophagi of Kha and Meryt (Bianucci et al. 2015). They clearly show that Kha is wearing one pair of penannular earrings with one hoop surmounted by the hanging mechanism shown in Figure 10.13. Considering that, as mentioned above, Sennefer also wears penannular earrings with one hoop in the scenes represented in the tomb of Sennefer and his wife Meryt, we can envisage that this type of ear ornament was worn (only?) by men.

It should however be noted that the same suspension mechanism is employed in quite complex pendant ear ornaments (Schäfer 1910; Aldred 1971; Andrews 1990; Vernier 1907–27). Very complex specimens were found in the tomb of king Tutankhamun (Aldred 1971, 133), such as those with a duck with spread wings (56 in Vilímková 1969).

The gold alloys

A few penannular earrings were analysed for the composition of their alloys. The ribbed ones selected for study are three from tomb 1371 excavated at Deir el-Medina East cemetery (Bruyère 1937, 161) in the collection of the Louvre Museum (E14435A-D), two excavated at Riqqa in the collections of the Petrie Museum (UC 31416) and of the Manchester Museum (6146), and three others in the collection of NMS (A.1928.160, A.1937.691, A.1965.368). One earring with four round hollow hoops in the collection of the Louvre Museum (N2084) was also analysed. The five single tube earrings selected for study are in the collections of the Louvre Museum (AF 2444 and N1855B), of the British Museum (EA14346), and of the Manchester Museum (6146b, from Riqqa).

The results obtained are summarized in Table 10.3, where we also include for comparison the published earring with six hollow triangular hoops from the tomb of the three foreign wives of Thutmes III (analysed by SEM-EDS by M. Wypyski, Lilyquist 2003, 342). We furthered considered for comparison the ribbed penannular earrings from tomb 296 at Riqqa (composition given in Chapter 10.2) and the pair from the Qurna burial (composition given in Chapter 9.2).

Data obtained for the hoops were plotted in the diagram of Figure 10.16, showing that none of the analysed specimens reaches the high gold contents observed for the Qurna earrings. The copper contents observed for the earrings are all under 5 wt%, with the majority of them showing less than 3 wt%. The majority of the ribbed earrings is made from alloys containing 10–20 wt% Ag. The earrings with V-shaped tubes from Riqqa are however made from silver-rich alloys, containing 45–48 wt% Ag. The analyses show the use of the same alloys for both the hoops and the back plates. The unique analysed ribbed earring with round tubes is also made from silver-rich alloys, containing *c*. 40 wt% Ag. The earrings from tomb 296 at Riqqa cluster together compositionally. One of the three analysed

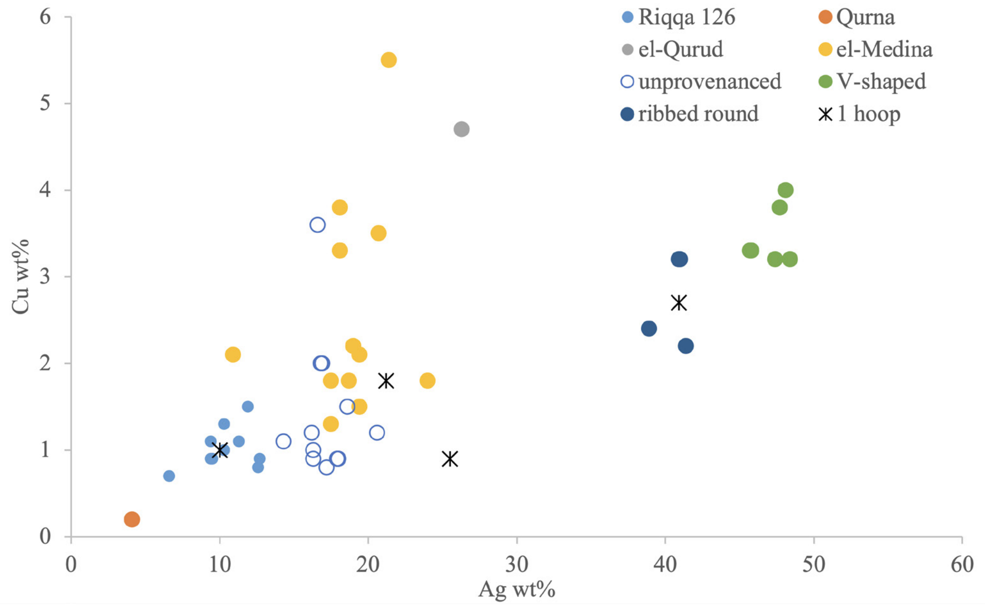


Figure 10.16. *Silver versus copper contents obtained by µPIXE, XRF and SEM-EDS for the gold penannular earrings analysed.*

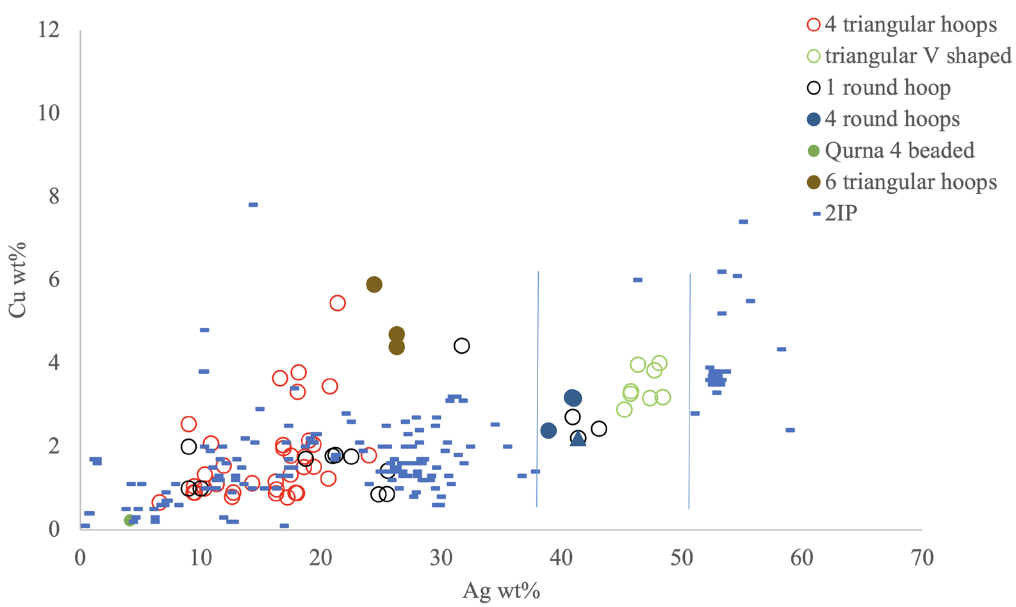


Figure 10.17. *Silver versus copper contents obtained by µPIXE, XRF and SEM-EDS for the gold penannular earrings analysed compared to Second Intermediate Period objects considered in Chapters 8.6 and 9, and published by Gale & Stos-Gale (1981, Oxalid) and Klemm & Klemm (2013).*

earrings from Deir el-Medina is compositionally different. Earring E14435B contains higher amounts of copper than the other two. Despite the few closing tube sheets present in the analysed ribbed earrings, one in A.1928.160 shows the use of a different alloy compared to the hoops.

The penannular earrings made from one large hollow hoop, with variable silver contents, are contained in the two chemical groups in the diagram of Figure 10.16. The gold sheet applied on a one hoop penannular earring in plated silver analysed by J. E. Whitfield (in Williams 1924, 118) contains 71 wt% Au

Table 10.3. *Results obtained by XRF, µPIXE and SEM-EDS for the studied penannular earrings. Were added to the table those from tomb 296 at Riqqa (discussed in Chapter 10.2) and from the Qurna burial (discussed in Chapter 9.2), as well as (*) one from the tomb of the three foreigner wives of Thutmes III (Lilyquist 2003).*

Acc No.	Collection	Provenance	Section	Hoops	Region of analysis	Method	Au wt%	Ag wt%	Cu wt%
A.1928.160	NMS	unprovenanced	triangular	4	hoop 1	XRF	81.2	16.9	2
					hoop 2		79.8	16.6	3.6
					hoop 3		81.1	16.8	2
					hoop 4		79.9	18.6	1.5
					closing sheet		88.5	9	2.5
					solder terminal		80	10.4	9.7
					solder hoops 3-4		78.8	15.3	5.9
A.1937.691	NMS	unprovenanced	triangular	4	hoop 1	XRF	78.2	20.6	1.2
					hoop 2		81.1	18	0.9
					hoop 3		82	17.2	0.8
					hoop 4		81.2	17.9	0.9
A.1965.368	NMS	unprovenanced	triangular	4	hoop 1	XRF	82.7	16.3	1
					hoop 2		82.9	16.3	0.9
					hoop 3		82.6	16.2	1.2
					hoop 4		84.6	14.3	1.1
					solder hoops 1-2		81.4	15.2	3.4
					solder hoops 2-3		85	12.5	2.5
MM 6146	MM	Riqqa	triangular	4 V-shaped	hoop 1	XRF	47.9	48.1	4
					hoop 2		51	45.7	3.3
					hoop 3		50.9	45.8	3.3
					hoop 4		48.4	47.7	3.8
					back plate		51.9	45.2	2.9
MM 6146b	MM	Riqqa	round	1	hoop side 1	XRF	77	21.2	1.8
					hoop side 2		77.2	21	1.8
UC 31416	PM	Riqqa	triangular	4 V-shaped	hoop 1	XRF	48.4	48.4	3.2
					hoop 4		49.5	47.4	3.2
					back plate		49.7	46.3	4
E 14435B	ML	Deir el-Medina	triangular	4	hoop 1	PIXE	73.2	21.4	5.5
					hoop 2		78.1	18.1	3.8
					hoop 3		75.8	20.7	3.5
					hoop 4		78.6	18.1	3.3
					solder hoops 1-2		71.8	24.4	3.2
					solder hoops 2-3		71.3	24.6	3.4
E 14435C	ML	Deir el-Medina	triangular	4	hoop 1	PIXE	78.8	19	2.2
					hoop 2		78.6	19.4	2.1
					hoop 3		79.6	18.7	1.8
					hoop 4		80.7	17.5	1.8
					solder hoops 1-2		71.2	24.9	3.9
					solder hoops 2-3		78	17.7	4.4
					solder hoops 3-4		81.1	15.8	3.2
E 14435D	ML	Deir el-Medina	triangular	4	hoop 1	PIXE	74.2	24	1.8
					hoop 2		79.1	19.4	1.5
					hoop 3		81.2	17.5	1.3
					hoop 4		87.1	10.9	2.1

Table 10.3 *(cont.)*.

Acc No.	Collection	Provenance	Section	Hoops	Region of analysis	Method	Au wt%	Ag wt%	Cu wt%
N 2084	ML	unprovenanced	round	4	hoop 1	PIXE	55.8	41	3.2
					hoop 2		58.7	38.9	2.4
					hoop 3		56.4	41.4	2.2
					hoop 4		55.9	40.9	3.2
					solder hoops 2-3		62.8	33.5	3.7
AF 2444	ML	unprovenanced	round	1	hoop side 1	PIXE	56.4	40.9	2.7
					hoop side 2		56.5	41.1	2.4
					closing disk		63.8	31.7	4.4
					solder hoop-disk		54.7	38.7	6.3
N 1855 B	ML	unprovenanced	round	1	hoop side 1	PIXE	73.5	25.5	0.9
					hoop side 2		74.2	24.8	0.9
					suspension ring 1		73	25.5	1.4
					suspension ring 2		75.5	22.7	1.7
					wire		75.5	22.5	1.8
					solder hoop	EDS	74.1	24.2	1.5
					solder wire		76.5	20.3	3.3
					solder suspension ring 2		75.8	19.3	5
EA14346	BM	unprovenanced	round	1	hoop	XRF	89	10	1
					suspension loop		90	9	1
					twisted wire		88	9	3
					closing sheet	EDS	91	8	1
					wire		89	9	2
26.8.94b	MMA (*)	Gabbanat el-Qurud	triangular	6	tube	EDS	69	26.3	4.7
					disk attachment		69.3	26.3	4.4
					back of disk		69.7	24.4	5.9

and 29 wt% Ag, a silver content in-between our two groups in Figure 10.16. The analyses reported in Table 10.3 of some of the small parts contained in those earrings show the use of similar alloys to produce all the components. Only the closing disk of AF 2444 shows a silver content close to 30 wt%.

The composition of the solders was determined for a few joins with SEM-EDS and μPIXE. We could observe for the majority of the analysed regions an increase of the amounts of copper to lower the melting point of the alloy, but in a few joins, such as in earring E14435B, a small increase of the silver content was also observed.

The majority of the penannular earrings analysed contain visible inclusions of platinum-group elements (PGE), testifying the use of alluvial gold. Table 10.4 summarizes the data obtained for the inclusions that were analysed and includes the two results obtained for the earrings from tomb 296 at Riqqa. As expect, the majority of the inclusions analysed were found to be rutheniridosmine. However, in two earrings from Deir el-Medina (E14335B and D) the inclusions also contain platinum. PGE inclusions containing this element were so far observed in this volume for the jewellery dated to the Second Intermediate Period-early 18th Dynasty bearing the names of Ahhotep and of Ahmose (Guerra & Pagès Camagna 2019), as discussed in Chapter 9.4.

It is also important to mention that the earrings from Deir el-Medina contain a large number of visible PGE inclusions. Nineteen of them, present at the surface of earring E14335B, were analysed by SEM-EDS and μPIXE, showing the wide variability of their composition. The majority of platinum-group minerals (PGM) found in placer deposits are Ru–Ir–Os–Pt and Pt–Fe alloys (Brenan 2008), but it is difficult to propose further discussion on the data obtained for the earrings. Recycling of gold and gold objects from different provenances (including not local), and from previous periods, has to be considered, as well as exploitation of new sources of gold, perhaps in Ethiopa, where PGMs of many different compositions could be identified (Cabri et al. 1981)

Table 10.4. *Results obtained by µPIXE and SEM-EDS for the PGE inclusions in the studied earrings.*

Acc. No.	Method	Ru wt%	Os wt%	Ir wt%	Pt wt%
A.1965.368	EDS	19.7	41.8	38.5	—
E 14335B	PIXE	9.8	1.2	77.1	11.9
		4.9	32.9	53.6	8.7
		29.6	33.7	26.1	10.6
		23.6	40.2	30.5	5.7
		25.6	37.6	32.0	4.9
		29.9	34.0	31.6	4.5
		24.1	39.4	32.3	4.2
		18.6	40.8	37.4	3.2
		47.0	31.1	18.6	3.2
		22.5	39.2	38.3	<0.2
		19.9	41.9	38.2	<0.2
		19.6	41.7	38.6	<0.2
	EDS	12.8	—	76.4	10.8
		12.4	—	77.9	7.6
		11.5	—	80.4	8.1
		43.7	31.6	24.7	—
		20.5	38.8	40.8	—
		20.7	36.8	42.5	—
		22.6	35.5	41.9	—
E 14335D	PIXE	13.6	41.8	42.2	2.4
N 2084	PIXE	4.0	54.6	41.6	—
		5.7	50.8	43.8	—
		5.1	51.1	44.1	—
		6.3	48.9	45.2	—
	EDS	5.0	56.6	38.4	<0.2
		5.3	53.1	41.6	<0.2
A.1913.390	EDS	4.3	38.4	57.3	—
A.1913.391	EDS	16.0	50.3	33.7	—
A.1965.368	EDS	19.7	41.8	38.5	—

Concluding remarks

Despite the small number of pennanular earrings analysed and their typological variety, we could show that the alloys employed in their production split into two groups (Fig. 10.16) according to the amounts of silver present in the gold alloys. The Qurna adult's earrings, made from soldered beaded hollow tubes, and different from all the other penannular earrings analysed, are made with distinct alloys.

In Figure 10.17, the analysed earrings were plotted by type and technology, showing that the ribbed pennanular ones made by soldering four hollow triangular tubes at their bases match quite well. They also match the one with six tubes made using the same technology. As the production of ear ornaments has been dated to the end of the Second Intermediate Period – early 18th Dynasty, we plotted in the diagram of Figure 10.17 gold objects dated to the Second Intermediate Period. In addition to the objects analysed in Chapter 9, were also plotted in the diagram the string of beads E.2380 in the Garstang Museum of Liverpool, from tomb 492 at Abydos (Chapter 8.6), six objects in the collection of the Ashmolean Museum analysed by Gale & Stos-Gale (1981, Oxalid) and the data obtained by A. Murr for the mask of Satdjehuty (Klemm & Klemm 2013, 46, fig. 4.3).

The analysed earrings containing the highest silver contents are situated in the chemical area of the diagram where the distribution of the Second Intermediate Period gold alloys presents a 'gap' (considering the data available to make the plot). This 'gap', roughly situated between 38 and 50 wt% Ag, might correspond to the highest silver contents that could be found in native gold alloys accessible to Egypt during this period. In fact, it is noticeable that the objects dated to the Second Intermediate Period that are made with the alloys containing the highest silver contents were employed to make the Qurna adult's girdle. The girdle shows signs of intense use-wear and could therefore be an earlier production (end of Middle Kingdom - beginning of Second Intermediate Period?). The other objects containing high silver amounts include one of the beads in string E.2380 from Abydos that is also quite worn, and the tiny gold spacers in string UC26275 from Qau with marks of wear, and which could have been reused from earlier objects.

Interestingly, it is in the mentioned gap in the diagram of Figure 10.17 that the two studied ribbed penannular earrings made by soldering V-shaped sheets to a back sheet are contained. As previously suggested, this technique evokes the pair of ribbed bracelets from the Middle Kingdom tomb of Hor excavated at Abydos, made from V-shaped gold sheets (University of Pennsylvania Museum E9190A-B). Objects of this type could have 'inspired' the earliest ribbed earrings. No valid argument serves however, as support to such assumption. We can only say that among the contextualized Middle Kingdom objects analysed in Chapter 8 (from Haraga, Riqqa, Lahun, Naqada, Buhen and Abydos) and those from the same period compiled by Lucas & Harris (1965, 490–2) and published by Berthelot (1906, 20–3, 62–5), Schorsch (1995, 132) and Gale & Stos-Gale (1981, Oxalid), a few are contained in the 'gap' of Figure 10.17.

Indeed, some Middle Kingdom objects excavated at Haraga analysed in Chapter 8 are made from alloys containing quite high silver contents. For example, the whitish parts of the polychrome fish pendant from tomb 72 contain amounts of silver close to those determined for the Qurna adult's girdle. At this stage, it is impossible to suggest whether the whitish gold alloys were aesthetically more interesting or 'in fashion' during the Middle Kingdom than in the Second Intermediate Period and use this argument to support a chronological hypothesis for the two technologies observed for the New Kingdom ribbed penannular earrings.

Results published by several authors indicate the use in the New Kingdom of gold alloys containing low silver contents. The data considered was compiled by Lucas & Harris (1965, 490–2) and was published by Bosse-Grifith (2001) for the tomb of queen Tyie, by Hatchfield & Newman (1991) for items in the collection of the Museum of Fine Arts Boston and by Adrabou et al. (2020) and Riffai & El Hadidi (2010) for objects from the tomb of Tutankhamun.[15] The results obtained in Chapter 10.2 for the group of jewellery from tomb 296 at Riqqa shows however the use of alloys containing more than 30 wt% Ag. In addition, among the jewellery from the tomb of the three foreign wives of Thutmes III analysed by M. Wypisky (Lilyquist 2003, 342–3) is one small shell pendant that contains 65 wt% Ag and one uraeus pendant that contains 51 wt% Ag. It is also interesting to consider three objects in the collection of the Louvre Museum related to the burial of Khamwaset excavated in the Serapeum of Saqqara by A. Mariette. Two of them (ram-headed falcon amulet E80, and pectoral vulture with outstretched wings E2988) are made from a quite pure gold alloy (*c*. 99.5 wt%) whilst the third (pectoral with the cartouche of Ramses II E79) is made from a gold alloy containing 62 wt% Ag and 2 wt% Cu (Bouquillon 1995).

Appendix: Ribbed penannular earrings with triangular tubes

Eight ribbed penannular earrings made by soldering four hollow triangular tubes at their bases excavated at Riqqa (tomb 296) and at Deir el-Medina (tomb 1371) were studied in this project. Earrings of the same type were excavated in many sites, such as at Zawiyet al-Aryan, tomb Z95, Tell el-Yahudiya (Petrie 1906, pl. 13) and at Abydos, tomb 102 (Randall-MacIver & Mace 1902, 101, pls. 46, 53) and tomb group 941–949 (NML 1977.108.7). Vernier (1909–27) reports six from the tomb of Ahhotep excavated at Qurna (52378-81 are similar and pair 52390-1 is of smaller width), one with decorative lines excavated at Tell Basta (52382) and nine unprovenanced (52386, 52387, 52388-89 and 52392 to 96). Several unprovenanced are part of collections (National Museums Scotland, British Museum, Cleveland Museum of Art, Egyptian Museum in Berlin, etc.). As mentioned, two ribbed penannular earrings with four triangular tubes from Riqqa (Petrie Museum UC31416 and Manchester Museum 6146) are made by soldering V-shaped sheets to a back sheet. Vernier (1909–27) reports three earrings of the same type excavated at Tell Basta (52383-85). Three additional earrings from tomb CC 37, burial 83, in Asasif, western Thebes (Carnavon & Carter 1912, 86) are in the collection of the Metropolitan Museum of Art (26.7.1321-1322-1323) and one unprovenanced is in the collection of the Fitzwilliam Museum (E.61.1955).

Several ribbed penannular earrings have more than four tubes. In the collection of the National Museum Liverpool are two pairs excavated at Abydos[16] made by soldering hollow triangular tubes at their bases. One pair, already mentioned, has four tubes (NML 1977.108.7), but the other pair has six tubes (NML 1977.108.6). One pair acquired in Memphis (by Henry Salt before 1827) in the same collection (NML M11440) also consists of six tubes. Vernier (1909–27) mentions four earrings with six triangular tubes excavated at Saqqara (52742-45), and other contextualized specimens are in the collections of the Egyptian Museum in Berlin[17] and of the University of Pennsylvania Museum, such as one from Meydum. Four pairs were found in the tomb of the three foreign wives of Thutmes III (Lilyquist 2003, 224); others in the collection of the Metropolitan Museum of Art are reported as possibly from the same tombs (Lilyquist 2003, 248). Recent excavations in the second shaft of the tomb of Djehuty at Dra Abu al-Naga yielded two pairs (Galán 2013) and recent X radiographs of the sarcophagi of Kha and Meryt showed that Meryt wears two pairs of apparently 6 tubes earrings that Curto & Mancini (1968, 79) say are made with triangular tubes. Finally, some unprovenanced earrings are in the collections of the National Museum of Antiquities in Leiden (Bulsink 2015, 67–8) and Pelizaeus Museum in Hildsheim (Seipel 2001, 91).

When made with more than four tubes, the ribbed earrings are frequently adorned with components of decoration in gold and other materials surmounting the hoops to stand against the lobe when the earrings are worn. Others exhibit gold wires twisted into a braid between the middle hollow tubes. Unprovenanced examples are in the collection of the British Museum (EA54315-6 and EA54317-8) and some, purchased in Luxor in 1919 (Lilyquist 2003) and presumed to be from the tomb of the three foreign wives of Thutmes III, are in the collection of the Metropolitan Museum of Art (26.8.92 a, b).

However, earrings with an odd number of tubes or more than six tubes seem to be exceptional. One with five tubes from the tomb of Djehuty at Dra Abu al-Naga (Galán 2013) is made with V-shaped gold

Table 10.5. *Technology, number of tubes, provenance, collection, and account number of the ribbed penannular earrings with triangular hoops mentioned in the text. (BM- British Museum; NMS- National Museums Scotland; MM- Manchester Museum; ML- Louvre Museum; PM- Petrie Museum of Egyptian Archaeology; MET- Metropolitan Museum of Art; NMAL- National Museum of Antiquities in Leiden; NML- National Museums Liverpool; PMH- Pelizaeus Museum in Hildsheim, MFA- Museum of Fine Art in Boston, AEMB- Egyptian Museum in Berlin, PENN- University of Pennsylvania Museum, EMC- Egyptian Museum in Cairo, FM- Fitzwilliam Museum, CMA- Cleveland Museum of Art, BRM- Brooklyn Museum).*

Collection	Acc. No.	Provenance	Hollow hoops	V-shaped hoops	Comment
NMS	A.1913.388	Riqqa	4		
NMS	A.1913.389	Riqqa	4		
NMS	A.1913.390	Riqqa	4		
NMS	A.1913.391	Riqqa	4		
NMS	A.1928.160	unprovenanced	4		
NMS	A.1937.691	unprovenanced	4		
NMS	A.1965.368	unprovenanced	4		
MM	MM6146	Riqqa		4	
PM	UC 31416	Riqqa		4	
undefined	?	Riqqa		4	Engelbach et al. 1915
undefined	?	Riqqa		4	
ML	E 14435A	Deir el-Medina	4		
ML	E 14435B	Deir el-Medina	4		
ML	E 14435C	Deir el-Medina	4		
ML	E 14435D	Deir el-Medina	4		
EMC	CG52378	Qurna	4		
EMC	CG52379	Qurna	4		
EMC	CG52380	Qurna	4		
EMC	CG52381	Qurna	4		
EMC	CG52390	Qurna	4		
EMC	CG52391	Qurna	4		
EMC	CG52386	unprovenanced	4		
EMC	CG52387	unprovenanced	4		
EMC	CG52388	unprovenanced	4		
EMC	CG52389	unprovenanced	4		
EMC	CG52392	unprovenanced	4		
EMC	CG52393	unprovenanced	4		
EMC	CG52394	unprovenanced	4		
EMC	CG52395	unprovenanced	4		
EMC	CG52396	unprovenanced	4		
EMC	CG52382	Tell Basta	4		decorated with lines
EMC	CG52383	Tell Basta		4	
EMC	CG52384	Tell Basta		4	
EMC	CG52385	Tell Basta		4	
MFA	MFA 11.2677	Zawiyet el-Aryan	4		
undefined	tomb 102	Abydos	4		Randall-MacIver & Mace 1902
undefined	tomb 102	Abydos	4		Randall-MacIver & Mace 1902
BM	EA54320	unprovenanced	4		
BM	EA54321	unprovenanced	4		
CMA	1916.129	unprovenanced	4		
CMA	1916.129	unprovenanced	4		
AEMB	VÄGM 1984/071	unprovenanced	4		
AEMB	VÄGM 1984/071	unprovenanced	4		
AEMB	ÄM 8404	unprovenanced	4		decorated with lines
AEMB	ÄM 8404	unprovenanced	4		decorated with lines
MMA	26.7.1321	Asasif		4	
MMA	26.7.1322	Asasif		4	
MMA	26.7.1323	Asasif		4	
MMA	06.971a	Tell el-Yahudiya	4		

Table 10.5 *(cont.)*.

Collection	Acc. No.	Provenance	Hollow hoops	V-shaped hoops	Comment
MMA	06.971b	Tell el-Yahudiya	4		
FM	E.61.1955	unprovenanced		4	
NML	1977.108.7A	Abydos	4		
NML	1977.108.7B	Abydos	4		
NML	1977.108.6A	Abydos	6		
NML	1977.108.6B	Abydos	6		
NML	M11440A	Memphis	6		
NML	M11440B	Memphis	6		
EMC	CG52742	Saqqara	6		
EMC	CG52743	Saqqara	6		
EMC	CG52744	Saqqara	6		
EMC	CG52745	Saqqara	6		
PENN	31-27-214	Meydun	6		
PENN	31-27-216	Meydun	6		
PENN	32-42-433	Meydun	6		
AEMB	1826/7	Memphis	6		
MMA	26.8.93a	Gabbanat el-Qurud	6		decorated
MMA	26.8.93b	Gabbanat el-Qurud	6		decorated
MMA	26.8.94a	Gabbanat el-Qurud	6		decorated
MMA	26.8.94b	Gabbanat el-Qurud	6		decorated
MMA	26.8.95a	Gabbanat el-Qurud	6		decorated
MMA	26.8.95b	Gabbanat el-Qurud	6		decorated
MMA	26.8.96a	Gabbanat el-Qurud	6		decorated
MMA	26.8.96b	Gabbanat el-Qurud	6		decorated
MMA	58.153.5	Gabbanat el-Qurud?	6		
MMA	63.15.2	Gabbanat el-Qurud?	6		
MMA	63.15.3	Gabbanat el-Qurud?	6		
MMA	58.153.6	Gabbanat el-Qurud?	6		
MMA	26.8.92a	Thebes		8	decorated
MMA	26.8.92b	Thebes		8	decorated
Cairo-Djehuty	?	Thebes	5		decorated, Galán 2013
Cairo-Djehuty	?	Thebes	6		Galán 2013
Cairo-Djehuty	?	Thebes	6		Galán 2013
Cairo-Djehuty	?	Thebes	6		Galán 2013
Cairo-Djehuty	?	Thebes	6		Galán 2013
EMT	S. 08470	Deir el-Medina	6?		X-image, Bianucci et al. 2015
EMT	S. 08470	Deir el-Medina	6?		X-image, Bianucci et al. 2015
EMT	S. 08470	Deir el-Medina	6?		X-image, Bianucci et al. 2015
EMT	S. 08470	Deir el-Medina	6?		X-image, Bianucci et al. 2015
NMAL	AO.2c-1	unprovenanced	6		
NMAL	AO.2c-2	unprovenanced	6		
NMAL	AO.2d-1	unprovenanced	6		
NMAL	AO.2d-2	unprovenanced	6		
NMAL	AO.2f	unprovenanced	6		
PMH	5471a	unprovenanced	6		
PMH	5471a	unprovenanced	6		
BM	EA54320	unprovenanced	5		decorated
BM	EA54321	unprovenanced	5		decorated
BM	EA54315	unprovenanced	6		decorated
BM	EA54316	unprovenanced	6		decorated
BRM	72.123a	unprovenanced	7		
BRM	72.123b	unprovenanced	7		

sheets soldered onto a back gold sheet.[18] This earring was found with two pairs made from six hollow tubes soldered at their bases. The Brooklyn Museum has in its collection one earring with seven tubes (72.123a-b).

Table 10.5 summarizes the number of hoops and the technology of construction employed for one hundered and one ribbed penannular earrings with triangular tubes. In addition to those studied in this volume, we considered the published ones (with a description or with an image) and those for which a photograph was available in the online museum catalogues. From the data summarized in the table, the following profile emerges (Meryt's four earrings were considered as hollow triangular with six tubes, but the technology employed is not visible in the published X- radiographic images):

- 42 earrings are made from 4 hollow tubes (~ 42% of the corpus);
- 41 earrings are made from 6 hollow tubes (~ 41% of the corpus);
- 3 earrings are made from 5 hollow tubes (~ 3% of the corpus);
- 2 earrings are made from 7 hollow tubes (~ 2% of the corpus);
- 11 earrings are made from V-shaped sheets forming 4 hoops (~ 11% of the corpus);
- 2 earrings are made from V-shaped sheet forming 8 hoops (~ 2% of the corpus).

We cannot be confident that our corpus is fully representative of the effective production of ribbed penannular earrings with triangular tubes in Egypt. However, if we consider them as 'statistically representative' of the New Kingdom production, we can suggest that:

- those with four and six tubes were the most popular (83% of the corpus);
- those with four and six tubes were roughly equally popular (42% and 41% of the corpus, respectively);
- the most widespread technique uses hollow tubes soldered at their bases (87% against 13% of the corpus);
- those with more than six hoops seem quite uncommon (4 only), perhaps because they were seen as too big, too heavy, unsightly, or too expensive, rather than owing to any factors related to production.

While the interpretation of these results is rather tentative, it appears that both technologies to make hollow tubes were present in several sites. These technologies might have coexisted, but, based on our corpus, the use of V-shaped sheets seems limited. This could be the result of a chronological difference, explained by the ongoing replacement of one of the techniques by the other. If so, the old pairs, when broken, for example, were replaced by new pairs, while some owners were still wearing old earrings. We cannot rule out the possibility that this coexistence can also result from an import (within Egypt), if one technique was in use in one specific region (or in specific workshops?) that we are unable to identify.

Notes

1. Only a small number are attributed to earlier periods. Wilkinson (1971, 121) indicates that at Hu, in addition to a skull with 'earrings still in the ears' (shown in Petrie 1901, pl. 25), probably dated to 13th–18th Dynasty, there was found in tomb W72 one ivory figurine (Petrie 1901, 44, pl. 26) that has silver wire loop earrings. This figurine, in the collection of the Fitzwilliam Museum (E.16.1899), was found in a burial containing late Middle Kingdom finds, as mentioned by J. Bourriau (1988, 124, cat.no.117) who also indicates that a parallel was excavated by Petrie at Dendera. Petrie (1900, 22) reports that this 'peculiar burial' contained the body of a young woman wearing a 'spiral of silver and two beads at left ear'. In addition to these two examples, we can mention one item found at Dahshur by de Morgan in 1891–5 described by Vernier (1907–27, no.52834) as a small earring consisting of a hollow ring of irregular shape and a small pendant made from a wire where a garnet hangs.
2. Floral ear pins in one of the panels of a great outer coffin-shrine found in Valley of the Kings tomb 55 (Davis 1910, 14, pl. 33); penannular earrings in a sard plaque from Thebes in the collection of the Metropolitan Museum of Art (26.7.1342, bearing the praenomen of Amenhotep III); discoid earrings in a bust in the collection of the Egyptian Museum in Berlin (AM 21834; Borchardt 1911).
3. For example, king Akhenaten is often represented with big earlobe holes (Aldred 1973, 1988), such as in the bas-reliefs in the collections of the Egyptian Museum of Berlin (AM 14512) and of the National Museums Scotland (A.1969.377).
4. For instance, the scenes of the presentation of the annual Nubian tribute to the king in the tombs of Huy (Davies & Gardiner 1926, pl. 27) and Sobekhotep (British Museum EA922).
5. Gold platted hoops in copper or copper-base alloys were also employed in Egypt, but they were not considered in this study.
6. They were certainly quite popular in the New Kingdom. N.G. Davies (1927, 43, pl. 25) provides a description of this type of ear ornament, as illustrated in one wall painting from the tomb of the sculptor Ipuy at Thebes: 'The earrings of the ladies are wheel-shaped, with white rim and blue radii, from which depend three little strings of blue beads ending in blue tassels.'

7. Sixteen penannular earrings of different types and widths can be seen in the group exhibited in the Museum of Egyptian Antiquities opened at Boulaq with Ahhotep's jewellery (Mariette 1872, pls. 29 & 31). Based on the description of the earrings exhibited in 1883 in showcase H (Maspero 1883, 77, pls 29 to 31) and on the entries of the Cairo Museum catalogue (Vernier 1907–27), it seems that those from Ahhotep's burial are pair 52372-73 decorated with a braid, pairs 52355 to 52358, and the small specimens 52357–58.
8. The two groups of four specimens are shown in Müller & Thiem (1999, 166).
9. The two unprovenanced are in the collection of the Egyptian Museum in Berlin and might form a pair (ÄM 8404-5); the one excavated at Tell Basta is no. 52382 in Vernier (1907–27).
10. They could result from the evolution of spiral rings. In courtyard CC 41 at Thebes there was found on the body contained in burial B2, tomb R8, one pair of silver spirals that has the external hoop ends finely decorated with parallel lines (Metropolitan Museum of Art 16.10.337-8).
11. Others excavated by Lord Carnarvon and Howard Carter between 1907 and 1911 at Thebes in the collection of the Metropolitan Museum of Art (MMA 26.7.1334 to 1337), are made using the same technology, the same number of tubes and the same decoration. Some of their tubes still exhibit at their ends the small and large closing gold sheets.
12. Several undecorated specimens were excavated in Buhen, Nubia, but they are made from four gold plated copper hoops (E10372 to 75). However, one ribbed earring made with six gold tubes perhaps round in section was found with two skulls and some fragments of bones in individual shaft tomb J 42 (10354 in Randall-MacIver & Woolley 1911, 177, pl. 60).
13. One specimen decorated with parallel and crossed lines in the collection of the Fitzwilliam Museum (E.267.1932) has all the closing sheets.
14. The KV56 group of jewellery contains two pairs of different widths (Davis 1908, pl. 'ornaments of Queen Tauosrit'). Those from the tomb of queen Ahhotep excavated at Qurna are made by gold plating a copper rod (52409 to 13 in Vernier 1907–27). Other examples are in the collections of the National Museum of Antiquities in Leiden (Bulsink 2015, 69–70) and the Metropolitan Museum of Art (for example, 16.10.473 and 474).
15. The diagram in Bertsch et al. (2017) shows the use of gold sheet of variable composition in the tomb of Tutankhamun, but these analyses are unspecified.
16. Found in an undisturbed vaulted-chamber tomb containing eight burials, chamber 941 in tomb group 941–949 A'09, dated to the mid-18th Dynasty (Snape 2011, 134).
17. Interestingly, one pair (1826/7, Schäfer 1910, 26, pl. 5) is said by Passalacqua (1826, 35, entry 601), the previous owner, to have '6 rows' and be similar to 'striated bracelets'. The earrings were found among the grave goods of a female burial excavated in Memphis (Passalacqua 1826, 157–61).
18. It has the same decoration as one earring in the collection of the Metropolitan Museum of Art (26.8.92).

References

For references see pp.445–8 at the end of this chapter.

Chapter 10.4

Finger-rings

Maria F. Guerra, Susan La Niece, Nigel Meeks,
Stephen Quirke & Lore Troalen

10.4.1 Rings for the fingers in Egypt

Maria F. Guerra

Finger-rings may have developed from seals, formerly hung on a rope or chain (Newberry 1908), perhaps mounted on a gold setting to 'be slung from a string or chain' (Hall 1913, xiv) and suspended around the neck or tied round the wrist (Hall 1913, 19–20). Scarabs tied with linen threads were found in some tombs, for example Passalacqua (1826, 159) describes a woman buried in a tomb excavated at Memphis who had her left hand adorned with a very small scarab in a gold tray set on the index finger by a braided cord in the shape of a ring. The blue-glazed steatite scarab found in the wrappings over Wah's crossed wrists (Winlock 1940; Becker & Schorsch 2010), in the collection of the Metropolitan Museum of Art (MMA 40.3.11), and one carnelian bead also found in his tomb (MMA 40.3.1) were tied with a linen thread.[1]

Finger-rings started to be placed in burials from the 12th Dynasty onwards. Among the earliest finger-rings, are those with a swivelling bezel consisting of a perforated scarab and a metal shank, sometimes just a simple wire. This is the case for the uninscribed scarab ring of Sathathoriunet (MMA 16.1.24) consisting of a gold beetle inlaid with semi-precious stones mounted on a gold tray pierced to let a thin gold wire pass through to create the shank by wrapping the ends in a tight coil. Several other scarab rings from Middle Kingdom burials excavated at Dahshur by de Morgan (1895) have the same type of shank (Vernier 1909–27, 90–5, pls. 20 and 22).

Often found in New Kingdom burials, unlike other personal adornments finger-rings are seldom represented in wall scenes. Signet rings are however clearly visible in a wall scene in the tomb of Ay (Davies 1908, pl. 29) representing Ay with his wife Tyi receiving from king Akhenaten the 'gold of honour' (Binder 2008). Davies (1908, 21) enumerated the gifts of the king as follows: '18 double necklaces of gold beads, two at least of them fitted with pectorals; 2 plain necklaces; 5 collars, no doubt of threaded faience trinkets; 6 fillets, probably of the same sort; 4 golden (?) cups, two with a foot, two without; 2 metal (?) vases; 5 signet rings; 1 pair of gloves, 12 pairs of plain armlets'.

In addition to signet rings, such as those received by Ay, many other types were produced in Egypt. Finger-rings made during the Middle Kingdom remained popular during the New Kingdom (Wilkinson 1971). Quite simple forms were popular in the New Kingdom, such as the swivel scarab rings of steatite, lapis lazuli and gold from the tomb of the three foreign wives of Thutmes III (Lilyquist 2003, 181–3). Recent X-radiographs obtained *in situ* at the Egyptian Museum of Turin for the mummies of Kha and his wife Meryt (Bianucci et al. 2015, figs. 3 and 7b) revealed the presence of these types of rings placed on the bodies. Nevertheless, types that are more elaborate come into fashion during the New Kingdom. The group of finger-rings found in Tutankhamun's burial (Wilkinson 1971; Carter & Mace 1927, pls. 85–6; Vilímková 1969, pls. 60–3), in gold, lapis lazuli, chalcedony, turquoise, etc. (Carter & Mace 1927, 266, pl. 85), is quite representative of New Kingdom production. In addition to gold signet rings and swivelling scarab rings, can be found in the group quite elaborate finger-rings, made by joining several parts in different materials. One example is one of the finger-rings contained in the group of five found beside the right wrist of the king, included in the wrappings (Carter & Mace 1927, 127–8, 266, pl. 85), with a triple shank and the barque with the sun's disc.

It is also interesting to consider the metals used to make finger-rings in the New Kingdom. For example, five signet rings, mainly from the Amarna period, in several collections shown by Aldred (1971, pls. 69–70) have quite different colours: they are whitish, yellowish and reddish. Two of them, the yellowish ones, are made of gold. One of them, bearing the name of Nerfertiti (A.1883.49.1 in the NMS collection), was analysed in this project (see Chapter 10.5) and showed to contain *c*. 90 wt% Au. Two other finger-rings shown by Aldred are made of silver, thus whitish. The fifth, also in the collection of NMS (A.L.190.1), is made from a reddish gold alloy. This ring bears the cartouche of Akhenaten, contains *c*. 50 wt% Cu and several PGE inclusions. Two other reddish signet rings from the reign of Akhenaten are analogous to this one. One (shown in Hayes 1959, fig. 180), today in the collection of the Metropolitan Museum of Art (MMA 26.7.767),[2] was found by Flinders Petrie in 1891–2 during the excavations of Amarna (Petrie 1894, pl. 14.31). The other example, which bears the name of Akhenaten, formerly in the Goodison collection, was analysed by J. Ogden who indicates a copper content of *c*. 20 wt% in the alloy (Ogden 1992).

In addition to signet rings, among the most common types of New Kingdom finger-rings are those with a gold shank, a swivelling bezel, and a gold wire coiled around the shank on both sides of the bezel. Despite general similarities between the mountings of swivelling rings with coiled wires, various differences were identified.

Vernier (1907–27, 79–84; 1907, 81–4) suggested different techniques for the application of the coiled wire around the shank. The simplest form – where the gold wires, formed by extending the ends of the shank, entered the pierced scarab from each side and were twisted around the opposite end of the shank – closely corresponds to the technique suggested by H.R. Hall (1913, xiv) for Middle Kingdom scarab finger-rings. This technique is illustrated in Figure 10.18 as described by Vernier (1907–27, 79–80, figs. 38–40), who affirms that the Egyptian goldsmiths 'approached as much as possible the final shape by hammering and then finished the work using stones of various grains'. This mounting is visible to the naked eye for example in the two small rings, said to be a child's rings (CG52690-1), from the tomb of king Siptah in the Valley of the Kings (Davis 1908). The two finger-rings, which are described by Daressy (in Davis 1908, 42, pl. 'Amulets and rings') and by Vernier (1907–27, 230, pl. 54 E–F), lost their scarabs leaving visible in one the shank and in the other the shank and the gold setting.

Because signet rings, rings with swivelling scarabs and with coiled wires around the shank seem to be quite popular specimens in the New Kingdom, several examples in the collections of the British Museum, the Petrie Museum, the National Museums Scotland and the Louvre Museum were selected for analysis in order to understand their manufacturing technologies. Among the selected finger-rings are two, typologically equivalent and with swivelling mechanisms, containing a gold bezel surmounted by a frog encircled by two rows of granules. Their study allows tackling the production of granulation in the New Kingdom. Finally, one whitish gold finger-ring in open-work in the collection of the Petrie Museum was also considered in this study to gather more information on the production of wires and on the composition of whitish gold alloys.

The data obtained for the finger-rings analysed in this project is reported in the sections below.

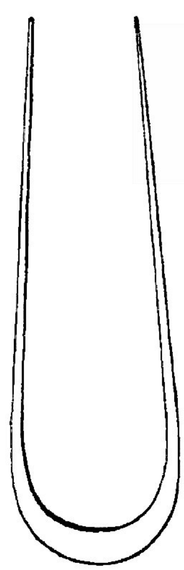


Fig. 38.

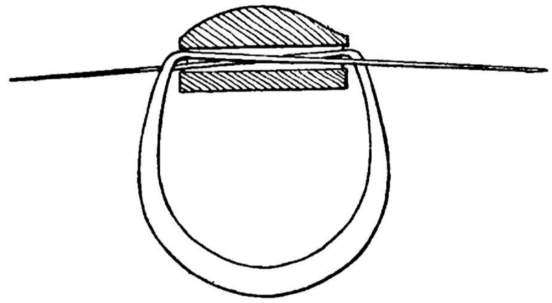


Fig. 39.

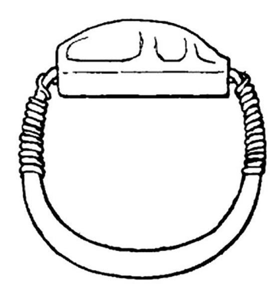


Fig. 40.

Figure 10.18. *Mounting suggested by Vernier (1907–27, 79–80, figs. 38–40) of finger-ring no. 52204 in the collection of the Cairo Museum: the gold wires, formed by extending the ends of the shank, enter the pierced scarab from each side and are twisted around the opposite end of the shank.*

Figure 10.19. *(a) Middle Kingdom finger-ring from tomb G62 at Abydos, EA37308, in the collection of the British Museum, with details of the mounting: (b,c) the thinned ends of the shank wire and (d) the gold tray of the obsidian scarab. Note the worn, thin shank wire and thin gold sheet mount for the obsidian scarab.*

10.4.2 Swivelling finger-rings and signet rings in the collection of the British Museum

Nigel Meeks & Susan La Niece

One Middle Kingdom obsidian scarab ring in the collection of the British Museum represents well the simplest form of swivelling rings with coiled wires as shown in Figure 10.19. Ring EA37308 was found in the burial of tomb G62 excavated by Flinders Petrie in 1902 at Abydos (Miniaci 2020).

EA37308, shown in Figure 10.19a, has a wire shank 1.3 mm in diameter at its widest, tapering to 0.35 mm at the point where it enters the bezel. There are facets where the shank wire thins towards the bezel, which is typical of thinning by hammering on a flat anvil.[3] The wires and shank are much worn through use. The wires that pass through the bezel are the hammered, extended and thinned ends of the shank wire threaded through from both sides of the pierced scarab and coiled around the opposite shank (Fig. 10.19b,c). The obsidian scarab is set in a gold mount with side walls made from a single thin sheet (Fig. 10.19d). The most likely construction is that of finger-ring EA54547, discussed in Chapter 10.4.3

and shown in Figure 10.29, comprising a gold shank and a swivelling carnelian bezel in the form of a cat on a plinth.

Three rings in the collection of the British Museum – EA49717, EA2922 and EA4159 – have more complex assemblies between the shank and the bezel. Swivel ring EA49717, shown in Figure 10.20a, which entered the British Museum collection in 1911, has a 3 mm diameter thick wire shank, slightly tapered at the ends and has a turquoise green glazed scarab inscribed with the name of queen Hatshepsut flanked by 'the Good Goddess Maatkare, may she live' (Andrews 1990; Hall 1913). Unlike the previous ring mounts with simple wires on which the bezels swivel, this ring has more complex soldered mounting arrangements at the ends of the shank which act as bearing surfaces between shank and bezel. The shank ends have an independent single coiled wire and pierced hollow cups through which this pivot wire passes and which are all soldered together forming fixed bearings or spacers between the bezel and shank (Fig. 10.20b). The sheet gold bezel mount has semi-circular extensions at the ends of the stone scarab to protect the stone from direct wear from the shank (Fig. 10.20c). The soldering would have been completed before the bezel stone was inserted into the frame mount.

The lapis lazuli swivel ring EA2922 is shown in Figure 10.21 and some details of construction are illustrated in Figure 10.22. This unprovenanced ring was found, or acquired, in Egypt, it was registered in the British Museum collection in 1837 and described 'with a massive solid-cast shank and lapis lazuli cylindrical bezel'.

Ring EA2922 consists of a large cylindrical bezel of lapis lazuli with a thick gold cap at each end acting as a close fitting retainer and swivel bearing for the stone. This is held within the 'massive' solid cast gold tapering shank which has hemispherical ends with flat inner bearing surfaces soldered to each end of the shank, and also soldered to ends of the coiled wires. The wires are 0.7 mm diameter and coiled twenty-seven times round each side of the shank. The bearing surfaces support the large, plain, pivoted lapis lazuli cylinder held within gold caps on each end (Fig. 10.22). A gold ring soldered centrally onto each hollow sheet gold cap (Fig. 10.22) rotates against the hemispherical bearing surfaces on the shank ends.

It is not possible to see whether the long coiled wire from the shank passes right through the lapis lazuli bead as a pivot. This may not be the case because the wires are soldered to each side of the shank and bearing regions, which would not be possible with the lapis lazuli stone fully assembled with

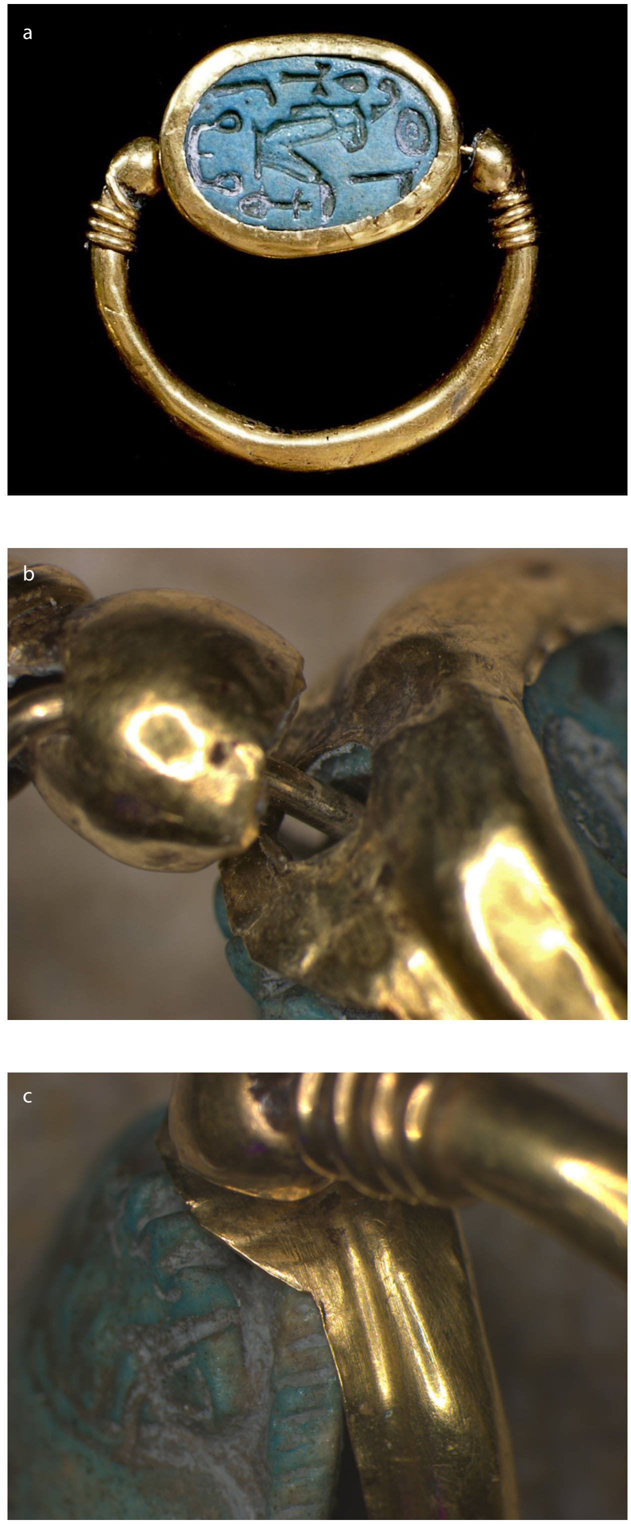


Figure 10.20. *Finger-ring EA49717, in the collection of the British Museum, with details under the stereomicroscope showing that the gold wire on which the bezel pivots first passes through the half sphere then enters the bezel. Its ends are wound around the shank.*

Figure 10.21. *Finger-ring EA2922, in the collection of the British Museum.*

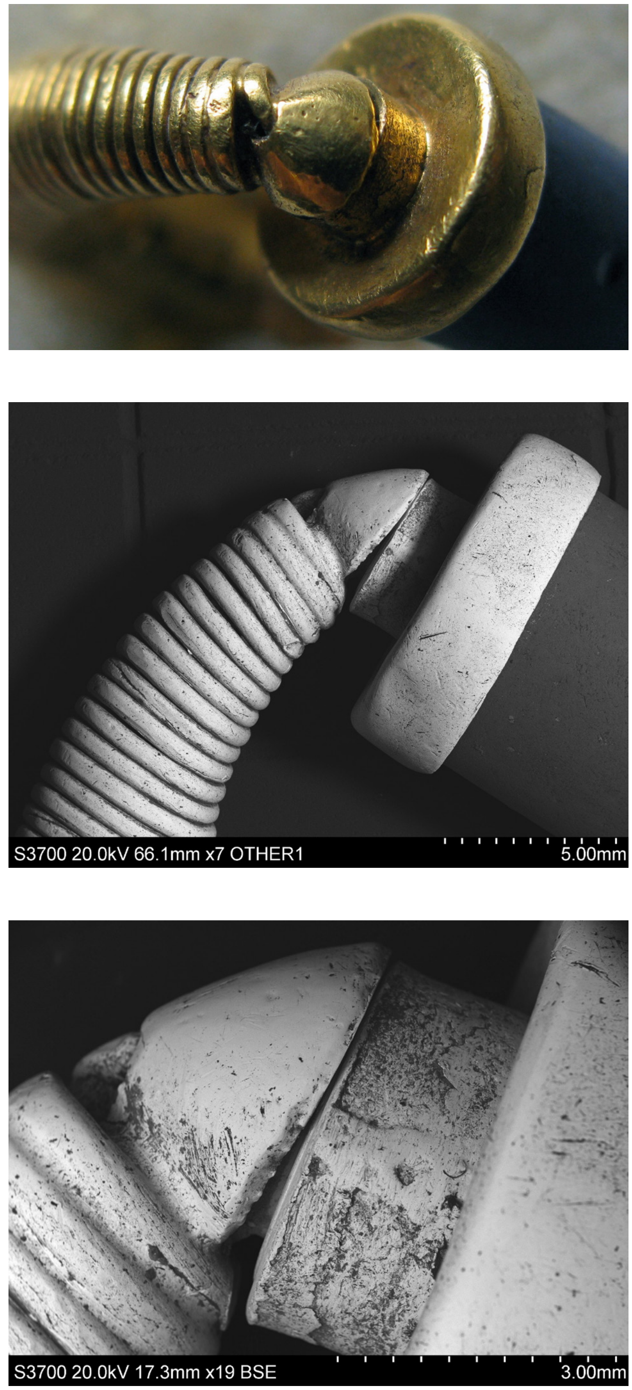


Figure 10.22. *Details of finger-ring EA2922 showing the well-engineered swivelling mechanism and the long wires wound around the shank and soldered.*

the wire running through it. Heat from soldering would destroy the stone bead. Therefore, it has to be assumed that the wire ends are most likely short and only pass into the end caps through the hemispherical bearings. The shank, wires and hemispherical bearings would have been completed and soldered, then the shank sprung open sufficiently to allow the lapis lazuli cylinder with its gold cap bearings to be put in place.

The workmanship is finely executed and is a miniature engineering solution to the problem of making a substantial, heavy swivel ring for extended use, as evidenced by the heavy wear on the surfaces of the coiled gold wire. The mount and bearing surfaces of this ring have some similarities to those of the solid gold ring EA71492 discussed below (Fig. 10.25).

Gold swivel finger-ring EA4159 (Fig. 10.23), with a turquoise green glazed scarab bearing the name of queen Hatshepsut, has a different mounting. This ring was purchased by the British Museum in 1840 from Dr Edward Hogg (Andrews 1990). However, the British Museum catalogue description states that the 'hoop of the ring is modern, but it quite accurately reflects the ancient mounting...'. The rectangular bezel is of ancient blue glazed faience inscribed in hieroglyphs – 'perfection for the son of Amun'.

The chipped edge of the bezel in Figure 10.23 shows the typical faience blue glaze on a white core.

The gold shank ends are flattened into discs about 1 mm thick and pierced to allow the pivot wires to pass through. The two pivot wires pass through the bezel in opposite directions, each finished by coiling around the shank. The globular features emerging from

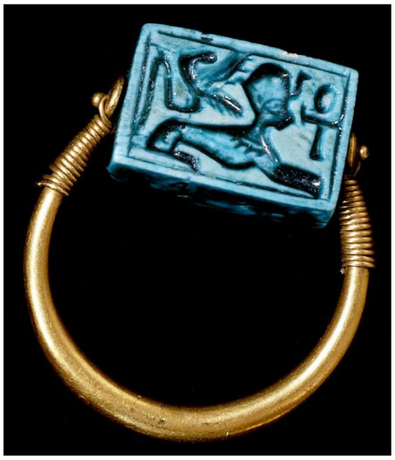


Figure 10.23. *Finger-ring EA4159, in the collection of the British Museum, with a detail of the chipped edge of the bezel, which is typical faience blue glaze on a white core.*

the holes in the shank ends are the ends of the pivot wires (Fig. 10.24). This unusual feature was created by flash-melting the wire ends and prevents them slipping through the perforation in the bezel. The ends of the two wires would have been melted first and then each threaded through the bezel from opposite sides, through the pierced shank disc and then coiled around the shank ends. It is not possible to melt the wire ends once the ring is assembled as the faience bezel would most likely shatter in the heat from wire melting. This wire mounting is not like the other Egyptian rings examined here and supports the suggestion that the wires, at least, are a modern repair or reconstruction and their unusual composition with very high copper is evidence of this too.

Finally, one gold swivelling finger-ring in the collection of the British Museum was also selected for analytical study. The heavy gold signet ring with a swivelling solid gold bezel is the so-called Ashburnham finger-ring (Andrews 1990). Finger-ring EA71492 (Fig. 10.25) is said to have come from the burial assemblage of Djehuty, a military official of Thutmes III, whose tomb was discovered in the early 1820s at Saqqara. Its name derives from its first purchaser, Earl of Ashburnham, who acquired the finger-ring in 1825 (Reeves 1993). After passing through several purchasers' hands, including Jonathan Harris and Rev. Bickersteth, the ring was bought in 1989 by the British Museum.

This signet ring consists of a thick gold shank of *c.* 3.0 mm diameter and has a solid cast gold

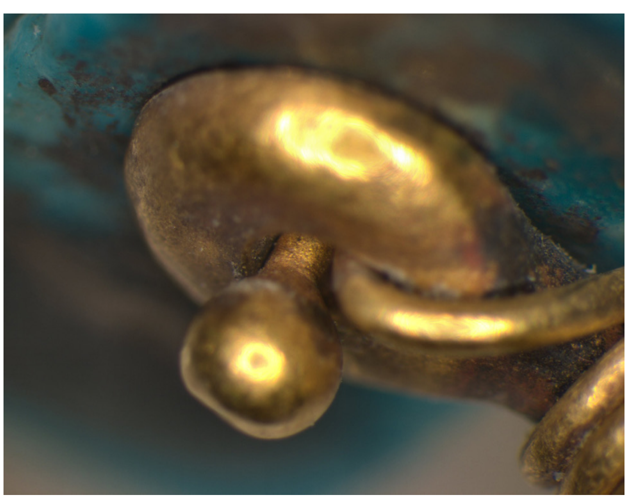
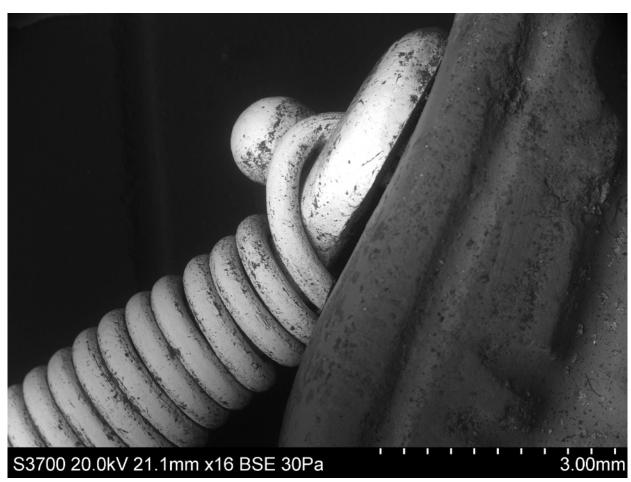



Figure 10.24. *Details of the swivelling mechanism of finger-ring EA4159 showing the 'modern hoop' and the unusual melted wire end globule. Bezel length 1.75 cm. The wires are a modern repair or reconstruction.*

Figure 10.25. *(a,b) The Ashburnham finger-ring EA71492, in the collection of the British Museum. The stereomicroscope details show (c) the hemispherical terminal of the shank with its internal ring fitting into the gold collar on the side of the bezel and (d) the wire passing through the shank terminal.*

rectangular swivelling bezel (length 1.85 cm, 4 mm thick) with plain gold collars acting as bearing surfaces around the perforation in the bezel. It is inscribed on one face with the praenomen of Thutmes III and epithets 'Menkheperra beloved of Ptah beautiful-of-face', and on the other face the two Ladies name of the king 'Great of Terror in All Lands'. The inscriptions, cut in the wax model, were enhanced after casting by engraving to remove metal, as evidenced by the sharp tool marks and striations left in the grooves and hieroglyphic figures (Fig. 10.26). There is some red pigment containing cinnabar (mercury sulphide) trapped in a few places in the inscription. This is most likely to be from use of the ring, post-excavation, to imprint the cartouche in a cinnabar-coloured sealing wax.

The shank terminals are formed into hemispheres with flat inner surfaces. Onto each of these is soldered a gold ring that fits into the gold collar on the bezel and swivels inside it (Fig. 10.25c). The coiled gold wire that is wound around the shank ends of the signet ring enters the swivel mechanism and appears to pass through a hole through the centre of the bezel. The main bearing surfaces of the swivelling bezel engage with the shank terminals and the wire ensures they do not come apart (Fig. 10.25c,d).

Table 10.6 summarizes the data obtained by using XRF and SEM-EDS for the surface composition of the alloys of the studied finger-rings.

The shank/wire of finger-ring EA37308 found in Middle Kingdom tomb G62 at Abydos contains 32–34 wt% Ag and 1.5 wt% Cu, similarly to several objects from excavations at Haraga dated to the same period, discussed in Chapter 8. The gold components of the other analysed finger-rings are made with alloys containing lower silver contents and copper contents under 3 wt%. Therefore, the silver contents observed are contained in the values expected for Egyptian productions and can be accounted for the use of alluvial gold. In Egypt and Nubia, native gold contains high silver contents, which may attain 30 wt% in the case of the Eastern Desert mines (Klemm & Klemm 2013). Some of the finger-rings contain visible PGE inclusions, testifying the use of alluvial gold.

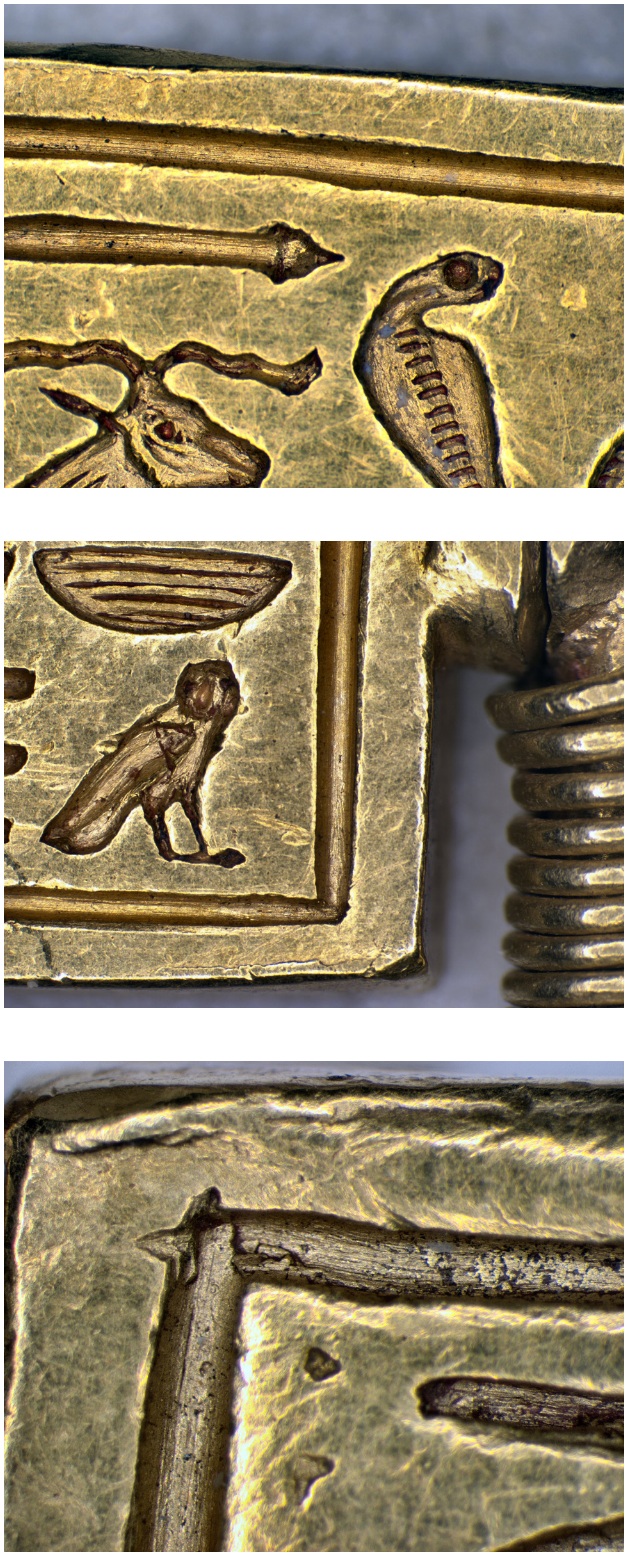


Figure 10.26. *The Ashburnham finger-ring EA71492: tool marks left by sharp engraving/chasing tools to enhance the cast-in decoration. Note the red cinnabar wax in the eye of the cobra and deer.*

Table 10.6. *Results obtained by XRF and SEM-EDS for the finger-rings in the collection of the British Museum.*

Acc. No.	Method	Region of analysis	Au wt%	Ag wt%	Cu wt%
EA71492	EDS	shank	97.3	2.8	0.0
		bezel	98.2	1.6	0.2
		wire	97.1	2.1	0.8
EA2922	XRF	shank	96	3	1
		cylinder cap	93	5	2
		wire	96	3	1
	EDS	wire	97	2	1
		shank cup	95	4	1
		cylinder collar	96	2	2
		cylinder cap	97	2	1
		solder collar/cup	91	6	3
		solder wires	93	4	3
		solder cup/wire	86	8	6
EA49717	EDS	tray	82	15	3
		shank	81	16	3
EA37308	EDS	bezel plate	93.3	6.5	0.2
		shank	64.3	34.2	1.5
		coiled wire	66.7	32.0	1.3

Similarly to what was observed for the majority of the jewellery studied in this volume, the solders used in finger-ring EA2922 were analysed showing that it was assembled using hard soldering processes, using added copper in the solder alloys to reduce the melting point relative to the pieces being joined.

10.4.3 Finger-rings supposedly from the Royal Tomb at Amarna and comparators

Lore Troalen, Nigel Meeks, Susan La Niece & Maria F. Guerra

This section discusses the construction of finger-rings with swivelling mechanism and granulation from the collections of National Museums Scotland (NMS) and the British Museum (BM). Two finger-rings in the collection of NMS (A.1883.49.2 and A.1883.49.8) are supposedly from the Royal Tomb at El-ʻAmarna, on the basis of stylistic grounds and inscriptions. The finger-rings were acquired by the Royal Scottish Museum (now NMS) in 1883 as part of a group of 19 objects purchased from W. T. Ready, a private collector and dealer in London.[4] Other items from this group of objects can be dated to the late 18th Dynasty and are discussed in Chapter 10.5.[5]

The finger-ring A.1883.49.8 consists of a thin gold shank with a swivelling carnelian bezel in form of a *wedjat*-eye (Fig. 10.27). The shank is made from a single

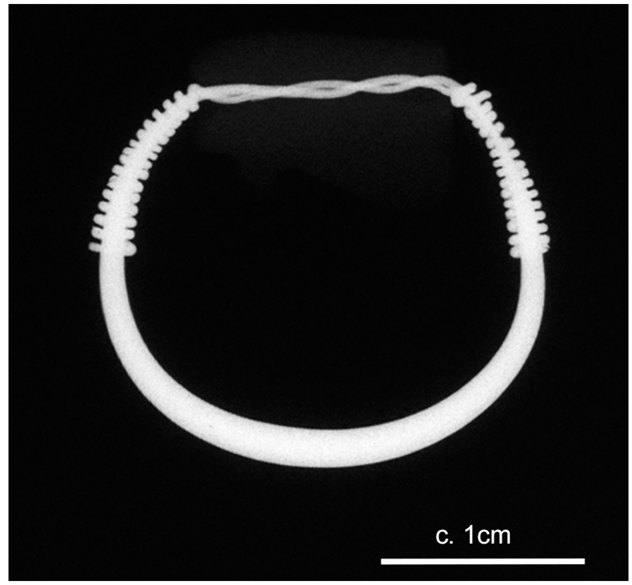
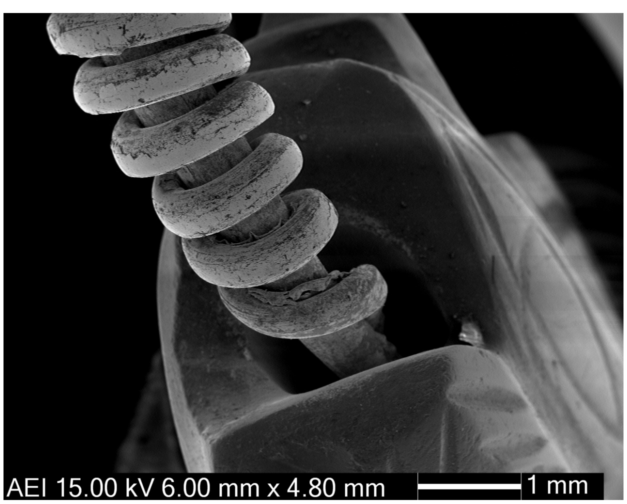


Figure 10.27. *(left) Finger-ring with carnelian in the form of a wedjat-eye, A.1883.49.8, in the collection of NMS; (right) X-radiograph of this finger-ring revealing the twisted wire within the carnelian. Note that the carnelian is transparent to the X-rays and is unseen in the image (NMS X-ray plate 260209-4, 3.5 mA, 300 kV, 1 min, lead screen, 2 mm Cu filter, Structurix film D7).*

thick gold wire, tapering to a thinner wire; the two ends are threaded from opposing sides of the perforation through the drilled carnelian bezel, twisted internally and then coiled around the shank at each side of the bezel. The X-radiograph of the ring provided in Figure 10.27 shows the twisted thin gold wire shank inside the bezel. The observation of the gold wire under the SEM (Fig. 10.28) shows the use of hammering, which has left smeared overlapping creases and there are faint longitudinal striations suggesting that finishing of the shank wires may also have been made by linear abrasion.

Finger-rings consisting of a gold shank with a bezel of carnelian representing different forms are quite common.[6] The finger-ring EA54547, shown in Figure 10.29, comprises a gold shank and a swivelling carnelian bezel in the form of a cat on a plinth. The technology employed in the manufacture is similar



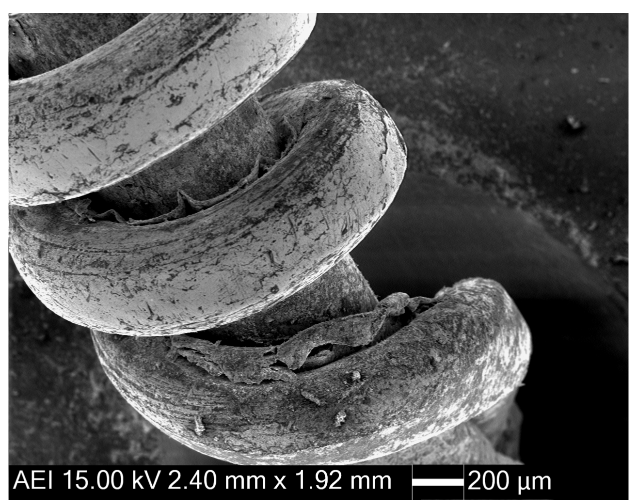
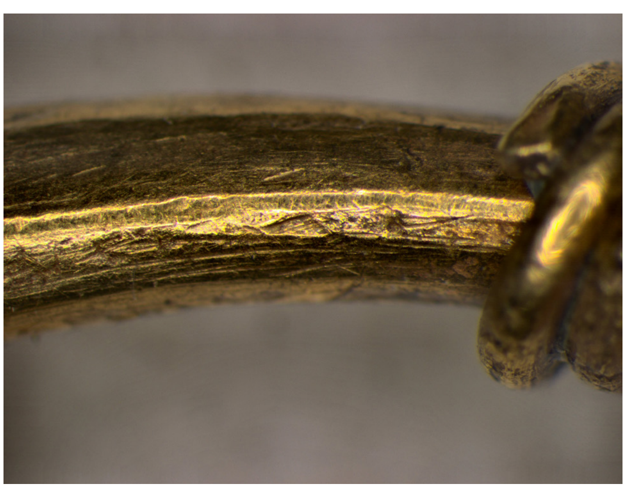


Figure 10.28. *SEM-BSE details of finger-ring A.1883.49.8 showing (left) the mounting of the wire entering the carnelian, and (right) details of the wire with morphologies showing overlapped hammering and possible linear abrasion.*

Figure 10.29. *(left) Finger-ring with a carnelian bezel in the form of a cat on a plinth, EA54547, in the collection of the British Museum, and (right) X-radiograph revealing the twisted wire within the carnelian (BM X-ray plate 6900/1, 10 mA, 100 kV, 2 min, lead screen, Structurix film D4).*

to finger-ring A.1883.49.8. In this case, the hammered linear flats on the ends of the shank where it was being thinned to form the extended wire for the pivot show even more clearly and the twisted wire around the shank shows linear hammered folds (Fig. 10.30).

The second finger-ring, supposedly from the Royal Tomb at El-'Amarna (NMS A.1883.49.8), is shown in Figure 10.31. This swivelling ring consists of a massive shank and a gold bezel surmounted by a frog encircled by two rows of granules. Finger-rings with a



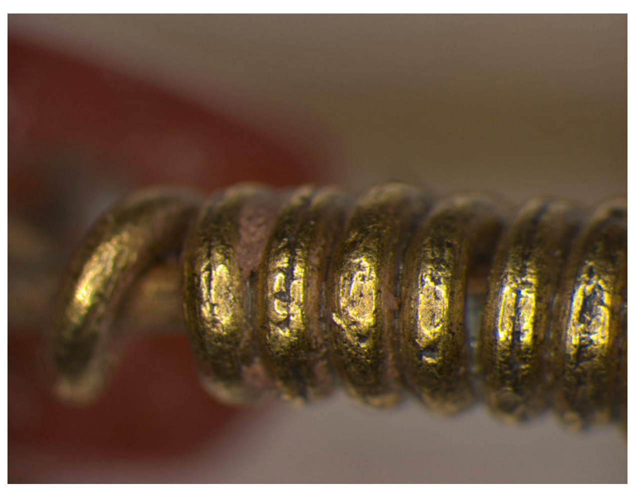


Figure 10.30. *Details of finger-ring EA54547 showing (left) flat linear hammer marks on shank and (right) linear hammer folds along the spiral wire.*

Figure 10.31. *(a) Finger-ring with frog and granulation A.1883.49.2, in the collection of NMS and (b) the reverse of the bezel inscribed in hieroglyphs 'Mut, Lady of the Sky'. (c,d) X-ray images showing the hollow plinth and the two twisted wires inside. The arrows indicate the location of two ancient breaks in the swivelling mechanism (NMS X-ray plate 260209-3, 3.5 mA, 300 kV, 1 min, lead screen, 2 mm Cu filter, Structurix film D7).*

figure of a frog encircled by two rows of granules are rare, nevertheless, to our knowledge two equivalent finger-rings can be found (Figs. 10.35 and 10.36 below). One, in the collection of the British Museum (EA 2923), was examined in detail and is discussed below, and the second, in the collection of the Cleveland Museum of Art (1916-658), is considered on the basis of the published images.

Visual observation of the finger-ring A.1883.49.2 suggests the use of the same technique to construct the swivelling mechanism as the two carnelian rings. Although the hoop is much thicker, it has also been worked into thinner section wires, which pass through opposite sides of the hollow bezel and are twisted within. The emerging wires are coiled around the shank at each side of the bezel. This is confirmed under X-ray observation (Fig. 10.31c,d). The finger-ring exhibits extensive use-wear and the coiled part of the shank/wire is now broken in two places: one break is inside the bezel, while the second one is at the exit of the bezel, just below the collar (Fig. 10.32). From these new observations, it is therefore possible to confirm that the wire and the shank were originally made of a single piece of gold.[7] Originally, two undecorated gold collars were positioned on each side of the gold bezel, but only one remains today (Fig. 10.32). As in the case of finger-ring A.1883.49.8, the observation of the gold wire under the stereomicroscope and the SEM shows the use of hammering to thin the shank, creating deep folds and overlaps (Fig. 10.32).

The bezel of this finger-ring shows a complex construction. It consists of a cast gold frog that surmounts, and is soldered to, a hollow gold plinth encircled with two rows of granules. It is made of many components

Figure 10.32. *Details of finger-ring A.1883.49.2: (left) the shank worked into a thinner section exhibiting two ancient breaks, the undecorated collar, and (right) detail showing the hammered overlapping seam morphology of the wire.*

soldered together. The sheet on the reverse of the ring is punched and chased with a hieroglyph of Mut and is soldered to a gold frame, which also supports the lower row of granules. The majority of the granules are flattened by intense use-wear, as are the frog's body and head, where the eyes are obliterated by wear. Only the granules protected by the shank are still spherical. The hollow gold plinth consists of several components: (1) a sheet of gold is folded around and soldered to the bezel to create a rim; (2) below this a rectangular section strip was folded round to create a wider tier to support the upper row of granules (Fig. 10.33); (3) the rim of the frame to the reverse sheet was used to support the whole structure, with the lower row of granules soldered onto this tier of the construction. The hollow plinth is open on both sides and traversed by the swivelling mechanism.

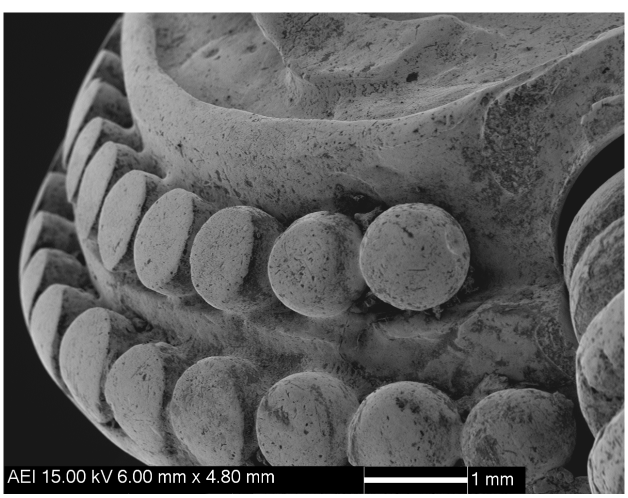
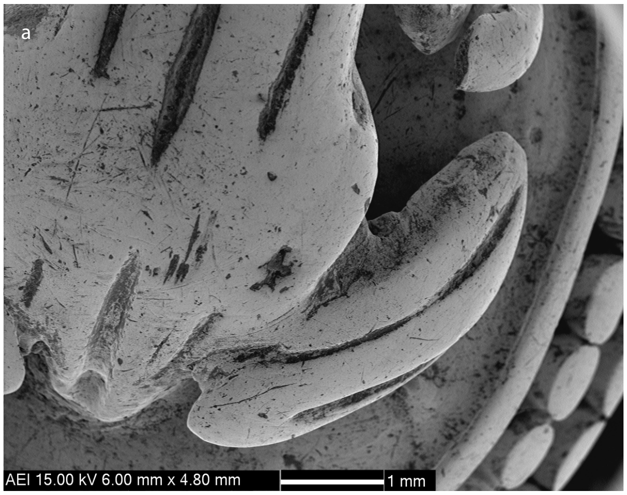


Figure 10.33. *SEM-BSE detail of finger-ring A.1883.49.2 showing the components used to form the plinth and support the granules: a gold sheet that forms the rim around the frog; a strip of gold used to support the granules; the rim of the frame of the inscribed reverse that supports the tiered structure.*

Some early restorations to repair the frog are visible on the object (Fig. 10.34b). Unfortunately, we cannot accurately date these repairs, but we can note that the object was already in this condition in a photograph from the 1960s taken at the Royal Scottish Museum for Martin's catalogue (Martin 1974, pl. 50); there are no museum records of the restoration so they may predate the acquisition in 1883, or could perhaps have taken place during a period of sustained restoration work in the 1950s before recording became common.

The soldering of the frog's pelvis to the plinth is now broken (Fig. 10.34a), and the front legs of the frog are also broken. The frog's upper front legs have been re-soldered to the frog's shoulders, although the lower legs are still broken. Several spots of solder are visible on the front and rear legs of the frog, but also on some of the lower granules and the wire. These spots are silvery-dark in colour and were identified by SEM-EDS analysis as mainly based on silver. Unfortunately, we cannot accurately date these repairs, but we can note that the object was already in this condition in a photograph from the 1960s taken at the Royal Scottish Museum for the Martin's catalogue (Martin 1974, pl. 50) and there are no museum records of restoration so they may predate the acquisition in 1883. It could perhaps have taken place during a period of sustained restoration work in the 1950s before recording became common.



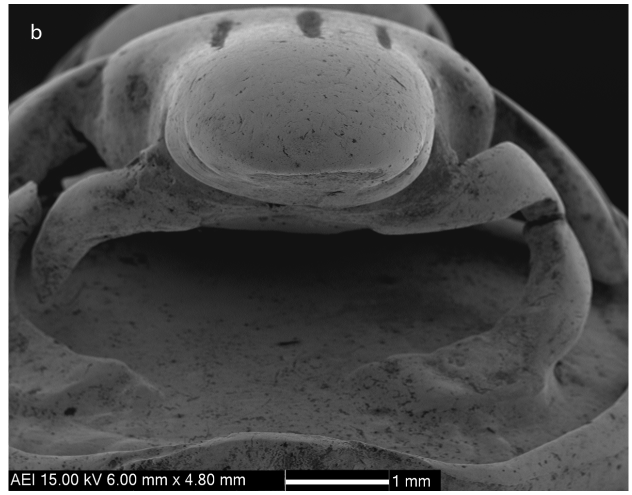


Figure 10.34. *SEM-AEI details of finger-ring A.1883.49.2, showing: (a) the chased decoration, with a detail from a sharp tool and the restoration to attempt to re-solder the frog's pelvis to the supporting plinth; and (b) the now broken front legs and their re-soldering to the frog's shoulders, and the worn head with obliterated eyes.*

Two further gold finger-rings each with a swivelling figure of a frog encircled by two rows of granules can be found in the collections of the British Museum (EA 2923) and of the Cleveland Museum of Art (1916-658). The ring in the collection of the Cleveland Museum of Art is not precisely dated. Commonly attributed to the reign of Akhenaten, the finger-ring was donated in 1916 to the museum by J. H. Wade, one of the founders of the museum, who served as president of the board of trustees from 1920 until his death in 1926. No scientific images of this ring are available. We show in Figure 10.35 the images available online at the site of the Cleveland Museum of Art.

The British Museum acquired finger-ring EA 2923 in 1839 (Fig. 10.36); previously it formed part of Giovanni Anastasi's collection. The ring cannot be dated with greater precision than the 14th century BC and the find-spot in Egypt is unknown. However, the finger-ring does appear in several catalogues of Ancient Egyptian objects as associated to the Amarna period (e.g. Andrews 1990; Tait 2006) and therefore likely to be also dated from the 18th Dynasty.

The construction of the three finger-rings with swivelling frogs appears quite similar. All of them have a massive shank surrounded with a wire coiled on both sides of the bezel and an oval shaped inscribed bezel with a gold frog encircled by two rows of granules. Some


Figure 10.35. *Gold finger-ring with a frog 1916-658, in the collection of the Cleveland Museum of Art (2.3 cm diameter, 1.3 cm overall),* c. *1353–1337* BC. *Gift of Mr. and Mrs. J. H. Wade. (https://www.clevelandart.org/art/1916.658).*

Figure 10.36. *Finger-ring with a swivelling frog EA 2923, in the collection of the British Museum, bearing a scorpion on the reverse.*

differences can, however, be pointed out. The form of their shanks is different. Finger-rings A.1883.49.2 and 1916-658 have a thick stirrup-shaped shank, while the shank of EA 2923 is thinner and rounder.[8] Finger-ring EA 2923 has limited use-wear, while finger-ring A.1883.49.2 has marks of intense use-wear, also discernible in the images provided online by the Cleveland Museum of ring 1916-658. These wear marks are visible on the two rows of granules of both of the latter rings and particularly on one side of the coiled wire of finger-ring 1916-658, which could indicate it had been worn with an adjacent ring in contact with it. The frogs were cast, but the front legs of frog EA 2923 are each made from a piece of round wire soldered to the frog's body and to the top gold sheet of the bezel. In the case of ring 1916-658 the top sheet is enhanced by the addition of a corrugated gold strip that imitates a beaded wire border. The granules are also mounted in two different ways. In finger-ring EA 2923, and apparently in finger-ring 1916-658, the granules are placed one row above the other. In the case of EA 2923, the top row of granules are touching and neatly sitting in the dips between the lower granules on the rim (Fig. 10.37), whilst in A.1883.49.2 they are, as mentioned above, soldered in a separate layer to a podium-shaped mount (Fig. 10.33).

The ends of the shank of finger-ring EA 2923 have been formed into a cup-shape with a perforation through which a wire passes.[9] This is a different construction to the previous ring with its hammered, extended shank, which is continuous with the wire pivot. Ring EA 2923 shank ends in perforated cups, and not wires. A separate wire is used for the coils and pivot. This wire coils around the shank, passes through the centre of the perforated cup and through the length of the bezel, acting as the pivot, and emerges to coil around the other side of the shank. On one side of the bezel (frog nose side, Fig. 10.38) the pivot assembly is complete with the tubular collar of the bezel resting against the shank cup (Fig. 10.38b). On the other side, the collar is missing and a smaller inner tubular collar or ring is exposed and appears to be soldered to the cup. This inner collar acts as a bearing against which the larger outer collar, now missing, would swivel (Fig. 10.38a). The coiled wire on the shank shows clear hammered wire with longitudinal creases smeared over (Fig. 10.38c).

The analysis of the finger-rings in the collections of National Museums Scotland and British Museum was carried out at three different laboratories using

Figure 10.37. *SEM-BSE image showing details of the granulation on the bezel of the finger-ring EA 2923. Note the difference in the mounting of the granules between this ring and ring A.1883.49.2 in Figure 10.46, and also the small solder meniscus which joins the granules on the left of the image.*

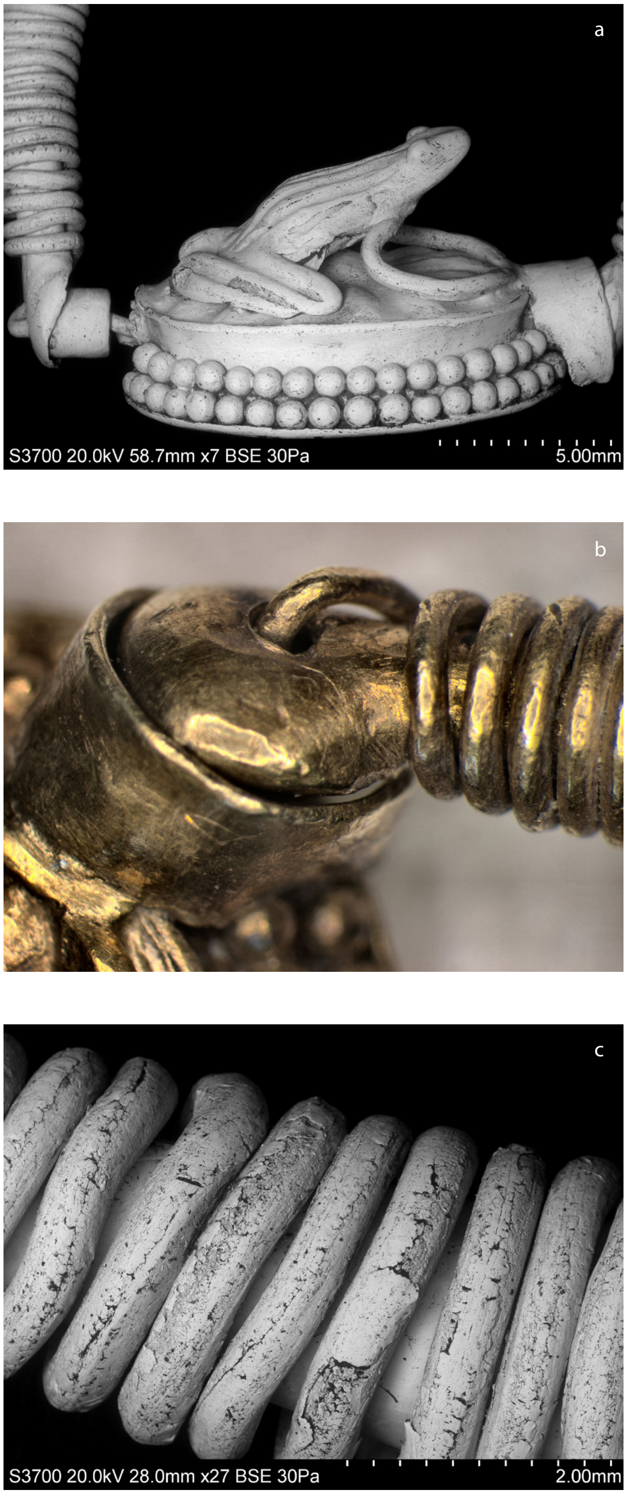


Figure 10.38. *(a) SEM-BSE image of the bezel and end shanks of finger-ring EA 2923, (b) a detail under the stereomicroscope of the coiled single wire entering into the bezel through the gold cup, and (c) SEM-BSE image of the hammered wire showing longitudinal creases smeared over.*

SEM-EDS, XRF and µPIXE. The rings of the British Museum were analysed at the Department of Scientific Research by SEM-EDS and XRF and those of National Museums Scotland by XRF at NMS and by µPIXE using the AGLAE facilities of the C2RMF in Paris. Analyses were carried out on unprepared surfaces as the objects could not be sampled. The complex geometry and small size of the objects meant that not all the parts could be investigated.

Concerning the rings in the collections of National Museums Scotland, while the analytical composition of the shank and average values for the bezel could be obtained by XRF analysis with its wide beam, it was possible by µPIXE, using a 3 MeV proton beam of only 50 µm diameter, to analyse some smaller components of the bezel of finger-ring A.1883.49.2 (Fig. 10.39). Analytical data obtained for the rings are summarized in Table 10.7.

The analysis of the hoop and the coiled wire of finger-ring A.1883.49.2 shows that they are the same composition and therefore supports the explanation of the mounting technique suggested above of hammering

Figure 10.39. *Areas analysed by µPIXE on finger-ring A.1883.49.2. Several granules on the lower row and upper row were analysed, as were join areas between some granules, together with key elements of the bezel.*

Table 10.7. *Results obtained (average) by XRF, μPIXE and SEM-EDS for the finger-rings in the collections of NMS and the British Museum.*

<table>
<tr><th>Collection</th><th>Acc. No.</th><th>Method</th><th colspan="2">Region of analysis</th><th>Au wt%</th><th>Ag wt%</th><th>Cu wt%</th></tr>
<tr><td>BM</td><td>EA 2923</td><td>XRF</td><td colspan="2">Shank (hoop)</td><td>83</td><td>16</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Coiled wire</td><td>81</td><td>18</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Bezel reverse</td><td>82</td><td>17</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Frog</td><td>83</td><td>16</td><td>1</td></tr>
<tr><td></td><td></td><td>EDS</td><td colspan="2">Average composition of lower row granules</td><td>83</td><td>16</td><td>1</td></tr>
<tr><td>BM</td><td>EA 54547</td><td>XRF</td><td colspan="2">Shank (hoop), mean of two analyses</td><td>94</td><td>7</td><td>1</td></tr>
<tr><td>NMS</td><td>A.1883.49.2</td><td>XRF</td><td colspan="2">Shank (hoop)</td><td>98.3</td><td>1.6</td><td>0.1</td></tr>
<tr><td></td><td></td><td>PIXE</td><td colspan="2">Shank (hoop)</td><td>98.5</td><td>1.4</td><td>0.1</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Coiled wire</td><td>98.5</td><td>1.3</td><td>0.2</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Frog</td><td>77.0</td><td>20.4</td><td>2.6</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Rim, around bezel (folded area)</td><td>71.6</td><td>26.3</td><td>2.1</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Rim, behind upper row of granules</td><td>73.0</td><td>25.2</td><td>1.8</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Strip forming the podium for the granules</td><td>85.0</td><td>13.0</td><td>2.0</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Sheet, reverse</td><td>72.1</td><td>25.6</td><td>2.3</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Rim, reverse</td><td>73.0</td><td>25.2</td><td>1.8</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Granules upper row (mean, 4 measures)</td><td>76.5</td><td>21.1</td><td>2.4</td></tr>
<tr><td></td><td></td><td></td><td colspan="2">Granules lower row (mean, 9 measures)</td><td>78.0</td><td>18.7</td><td>3.3</td></tr>
<tr><td></td><td></td><td></td><td rowspan="2">Solder (estimate)</td><td>Solder between granules, lower row</td><td>78</td><td>12</td><td>9</td></tr>
<tr><td></td><td></td><td></td><td>Solder between granules, lower row</td><td>84</td><td>11</td><td>5</td></tr>
<tr><td>NMS</td><td>A1883.49.8</td><td>XRF</td><td colspan="2">Shank (hoop)</td><td>81.1</td><td>18.1</td><td>0.8</td></tr>
</table>

the shank ends into thinner wire. The composition is of a very pure alloy containing 98.5 wt% Au, with less than 2 wt% Ag and traces of copper. The same composition was obtained for the hoop using both μPIXE and XRF techniques, which rules out a surface enrichment. Such composition is unusual (Ogden 2000). This probably indicates that Ancient Egyptians had access to gold of exceptional purity, either from alluvial deposits, or by importing from abroad (James 1972), as the use of the cementation method to refine gold was not practised there before the 1st millennium BC (as discussed by Craddock 2000; Meeks et al. 1996; Craddock et al. 2005). A fascinating account of Egyptian gold mining and refining from around the latter part of the second century BC given by the Greek historian Diodorus Siculus writing in about 60 BC is presented in the article by Notton (1974). Overall, the composition of the hollow plinth components is consistent with a gold alloy containing 23–25 wt% Ag and *c*. 2 wt% Cu. The most noticeable difference is the cast frog composition, which contains 20 wt% Ag and *c*. 3 wt% Cu, and the strip used to hold the granules, which has a lower silver content, around 13 wt% and *c*. 2 wt% Cu. The frog was cast separately and then soldered to the supporting plinth, while the strip of gold used to create the podium for the placement of the granules is also an added element. Several flattened granules from the upper and lower levels were analysed, bearing in mind the difficult analytical geometry, it appears that they are slightly variable in composition. The mean values obtained for the lower and upper rows show that they contain respectively 18 wt% Ag and *c*. 2 wt% Cu and 21 wt% Ag and *c*. 3 wt% Cu.

In the case of finger-ring EA2923, the hoop, coiled wire and bezel are all close in composition with around 16–18 wt% Ag and 1 wt% Cu. A similar silver content was found in the shank of the other finger-ring A.1883.49.8, while finger-ring EA54547 is made of a much higher purity gold alloy with only about 6 wt% Ag, and therefore is an intermediate composition between the very silver-rich rings and the highest purity gold ring shank of A.1883.49.2.

Visual observation of finger-rings EA2923 and A.1883.49.2 suggests in both cases the use of the hard soldering technique from the appearance of the shape of the meniscus joints, formed by surface tension of the molten solder before solidification, between the individual granules and the supporting sheet. These joins are very subtle, particularly on EA2923 (Fig. 10.37) showing the very delicate use of minimal amounts of solder. It was difficult to analyse soldered areas due to the small regions involved and the geometry of solder visible between the granules, but by using μPIXE targeting these areas of finger-ring A.1883.49.2 we found a significant increase in copper, consistent with the use

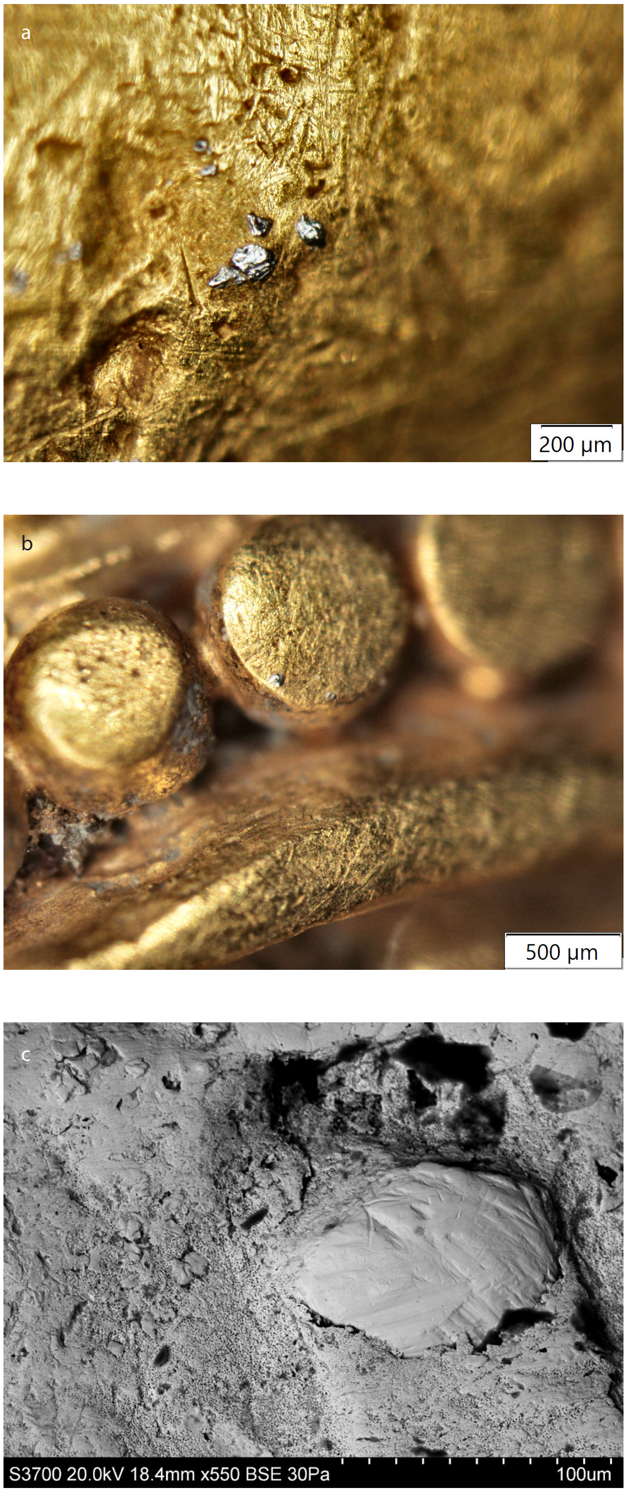


Figure 10.40. *(a, b) PGE tiny silvery coloured inclusions observed under the stereomicroscope at the surface of finger-ring A.1883.49.2, and (c) SEM-BSE image of a PGE inclusion greatly magnified in finger-ring EA2923 (this inclusion,* c. *100 µm wide, stands proud of the worn soft gold surface due to its hardness compared to gold).*

of a lower melting-point solder (Table 10.7), which is a common tradition of ancient metalsmithing.

The use of gold from alluvial deposits is confirmed for all the studied items through the presence of platinum-group elements (PGE) inclusions (Ogden 1976). In the case of finger-ring A.1883.49.2, these inclusions are numerous at the surface of the shank and several granules, as shown in Figure 10.40. The PGE inclusions were found to be rutheniridosmine (Table 10.8), as expected in Egyptian jewellery (Meeks & Tite 1980; Troalen et al. 2009, 2014; Miniaci et al. 2013; Troalen & Guerra 2016). These inclusions are of quite variable composition and cover a similar range of compositions reported for other New Kingdom Egyptian objects discussed in Chapter 10 of this volume. However, the presence of PGE inclusions does not preclude the possibility that artificial alloys were produced by mixing gold from different sources.

It is difficult to conclude whether the gold alloys are natural or were expertly mixed to produce the desired metallurgical properties. The use of high purity gold alloy for the hoop and coiled wire of finger-ring A.1883.49.2 might be explained by the need for a soft alloy, as significant hammering must have been necessary to create the thinner wires for the swivelling mechanism. Such composition is unusual, but not unreported in Egyptian gold objects. High purity gold alloys can be found as early as the Predynastic Period in Egypt. Gold alloys containing above 95 wt% Au were detected in some ring beads from the Predynastic diadem at Abydos (tomb 1730, see Chapter 7.3), a string of beads found at Badari (tomb 4915, see Chapter 7.4.), a Middle Kingdom fish-pendant at Haraga (tomb 72, see Chapter 8.2), and the earrings from the Qurna burial from the Second Intermediate Period (see Chapter 9.1).

Table 10.8. *Results obtained by SEM-EDS for the PGE inclusions in the NMS finger-rings showing a wide range of compositions.*

Collection	Acc. No.	Region of analysis	Ru wt%	Os wt%	Ir wt%
NMS	A.1883.49.2	PGE inclusion 1	19	41	40
		PGE inclusion 2	22	39	38
		PGE inclusion 3	42	36	22
		PGE inclusion 4	2	38	60
		PGE inclusion 5	23	40	37
		PGE inclusion 6	3	38	59
		PGE inclusion 7	37	38	25
NMS	A.1883.49.8	PGE inclusion 1a	20	41	39
		PGE inclusion 1b	22	40	39
		PGE inclusion 2	18	43	39
		PGE inclusion 3	16	44	40
NMS	A.1883.49.1	PGE inclusion	17	48	36

The study of these objects demonstrates that such native alloys were available at least during the mentioned periods. The use of gold alloys of quite variable purity is in fact observed for Middle Kingdom (see Chapter 8) and Second Intermediate Period (see Chapter 9) jewellery studied in this volume and was also previously reported in the analysis of Middle Kingdom objects in the collection of the Ashmolean Museum (Gale & Stos-Gale 1981, Oxalid). The majority of the observed compositions also match the published composition of gold grains from the Eastern Desert mines (Guerra & Pagès-Camagna 2019). However, it is expected that before the New Kingdom, Egyptians had the ability and knowledge to control alloys and produce them according to their use.

10.4.4 New Kingdom finger-rings with wires
Maria F. Guerra, Stephen Quirke & Lore Troalen

In order to investigate further the type of alloys used during the New Kingdom for the production of finger-rings, seven rings from the collections of the Louvre Museum, the Petrie Museum and the National Museums Scotland were selected for scientific investigation. Most of these finger-rings have swivelling mechanisms and contain decorative wires coiled around the shank. Some of them are signet rings and others are scarab rings. One pale gold finger-ring in openwork wire in the collection of the Petrie Museum was also considered for analysis.

Finger-rings with swivelling scarabs
Four selected finger-rings are swivelling scarabs with coiled wires around the gold shank.

Finger-ring AF2462, in the collection of the Louvre Museum, is shown in Figure 10.41. It consists of a quite thin faceted shank obtained by hammering and a pierced scarab in steatite decorated with volutes. It is made using one of the simplest swivelling mechanisms observed for this type of rings, similarly to finger-rings EA37308 found in Middle Kingdom tomb G62 at Abydos (see Chapter 10.2.2) and A.1883.49.8 dated to the 18th Dynasty (see Chapter 10.4.3). The technique employed, described by Vernier (1907–27, 79–80), is illustrated in Figure 10.18. To make the scarab swivel, the shank ends were narrowed to pass directly through the pierced holes of the unmounted scarab (Fig. 10.41). The resulting wires were then coiled around the shank at the opposite ends. Under the SEM and the steromicroscope, the thinned wire terminals (Fig. 10.42) and the many folds from hammering and rolling are visible (Fig. 10.43).

Finger-ring A.212.12 in the collection of National Museums Scotland is a restored swivelling ring that comprises a bezel in the form of a green glazed steatite scarab with the base incised with hieroglyphs reading 'Men-Kheper-re'. Apparently mounted similarly to AF2462, it is in fact one modern drawn wire. The marks of wire drawing are visible under the SEM and some residues of resin and/or glue are visible on the surface to hold the ring components together and create an ancient aspect. To let the scarab swivel, the pivot wire was coiled around one side of the shank to pass through the scarab in order to be coiled around the other side of the shank. The X-radiograph, shown in Figure 6.6, reveals that the shank ends were cleanly cut and pass only about one quarter of the way into the bezel. Therefore, this finger-ring could be a restored piece with addition of a modern wire or a complete modern assemblage.

The two other finger-rings with swivelling scarabs and wires coiled around the shank selected for analysis are in the collection of the Petrie Museum. Finger-ring UC12689, shown in Figure 10.44, contains a carnelian scarab set in a gold mount inscribed with the throne name of Ramses II (Usermaatra) and the epithet 'chosen by Ra'. The faceted shank is obtained by hammering,

Figure 10.41. *Finger-ring AF2462 in the collection of the Louvre Museum with a detail showing the thinned shank entering the bezel to emerge and be coiled around the shank on the opposite side.*

but this ring has a different bezel mounting to the others: the scarab is set in an open gold frame that allows the cartouche on the underside of the scarab to be seen. Originally, at each side of the bezel was placed one gold collar, from which only one remains, consisting of a ribbed ring soldered to the gold frame. As in the case of the ring AF2462, the narrowed ends of the gold shank pass through the scarab to be coiled around the opposite shank's ends.

The second finger-ring (UC12683), shown in Figure 10.45, was acquired by Petrie during his season of excavations at Qift (ancient Gebtyu, Coptos). It comprises a carnelian scarab set in a gold frame inscribed with the throne name of Ramses II (Usermaatra) and the epithets 'chosen by Ra' and 'beloved of Thoth' (no. 19.3.37 in Petrie 1917, pl. 41). In his Journals (the circular letters he wrote to family and supporters in England), he records purchasing items from dealers based at Qena, and it seems likely that this is the ring

Figure 10.42. *Detail under the SEM of the shank of finger-ring AF2462, showing the thinned terminal laying on the shank.*

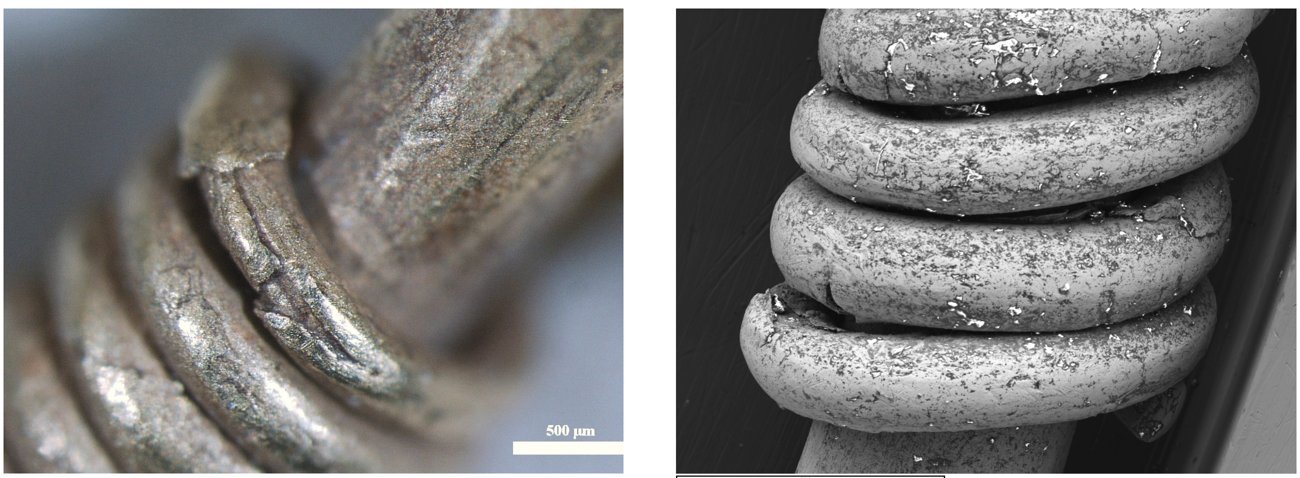


Figure 10.43. *Creases from hammering and rolling visible at the surface of the coiled shank of finger-ring AF2462.*

Figure 10.44. *Finger-ring UC12689 in the collection of the Petrie Museum showing the open frame mount of the bezel, the ribbed gold collar and the coiled thinned shank.*

Figure 10.45. *Finger-ring UC12683 in the collection of the Petrie Museum with details of the gold pivot wire wound around the shank, which passes through the cup and the pierced gold disc before entering the bezel.*

with the 'Coptos' provenance now in UCL (as described by Adams 2002, 5–22).

Despite apparently being mounted as UC12689, the swivel mechanism of finger-ring UC12683 is different from the others, as it was made using a more elaborate assemblage of the shank and the bezel. Its swivel mechanism is similar to the mechanism of finger-ring EA49717, described in Chapter 10.4.2. In this case, hollow cups, pierced to let a pivot wire pass through, are placed on the shank terminals (Fig. 10.45). The pivot wire is coiled on one side of the shank and, after passing through the cups and the scarab, is coiled on the other side of the shank in order to hold the components of the ring and let the scarab swivel. A small pierced disc of gold is soldered to the gold frame, between the open end of the cup and the bezel, appearing to act as a thin spacing washer to prevent rotation wear.

Signet rings

Two gold signet rings, one in the collection of the Louvre Museum (N747) and another in the collection of National Museums Scotland (A.1965.362), were selected for analytical study.

Finger-ring A.1965.362, a gift from Dr. Charles Taylor Trechmann to the National Museums Scotland collection in 1965, is a signet ring cast in one piece that reads 'Anubis in the sacred place' (*ỉnpw m st ḏsr*(*t*)). The deep inscriptions were cut into the wax model before casting and finished by removing the metal after casting. Tool marks are visible at the hieroglyphs bottoms (Fig. 10.46) and several PGE inclusions could be easily identified at the surface of the finger-ring (Fig. 10.46). Another gold signet ring in the collection of NMS (A.1883.49.1), bearing the name of queen Nefernefruaten-Nefertiti and reportedly from the Royal Tomb at El'Amarna, is described in Chapter 10.5 (Fig. 10.53).

Finger-ring N747 (Fig. 10.47), bequeathed to the Louvre Museum by the Count of Clarac in 1835, who had bought it from E. Gastard in 1834 (Monnot 2015, 22), has a very thick, rectangular cuboid gold bezel with all four faces decorated. One of the main faces bears the cartouche of Horemheb, shown in Figure 10.47, the last king of the 18th Dynasty, and the other a lion, symbol of royal power, and hieroglyphs 'neb khepesh', 'lord of valour' (Etienne 2000). The two smaller faces

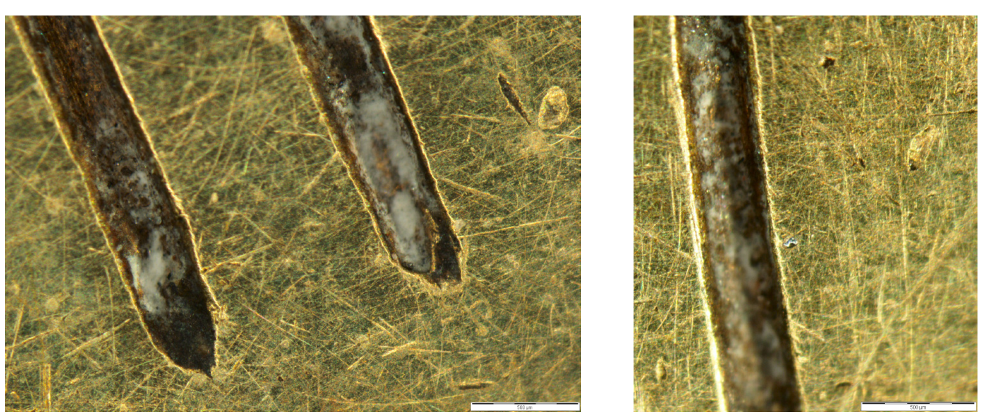


Figure 10.46. *Details of signet ring NMS A.1965.362 showing the tool marks of the inscription and on the right one of the PGE inclusions visible at the surface of the ring.*

Figure 10.47. *Gold signet ring bearing the cartouche of Horemheb, in the collection of the Louvre Museum (N747). On the left the massive shank with the remaining spindle and on the right the bezel side where the cartouche of Horemheb was inscribed.*

are also decorated, one of them with a scorpion and the other with a crocodile. Some red residues visible inside Horemheb's cartouche are from the wax used to imprint it in the museum.

This finger-ring is made by lost wax casting. The deeply inscribed hieroglyphs and animal figures of the bezel were cut in the wax model. Some of them show evidence of the dendritic as-cast structure. Figure 10.48 shows some of the toolmarks visible at the bottom of the inscribed motifs. After casting, many finer details were enhanced by removing metal and, perhaps, also by chasing. The presence of organic residues from making a mould to cast replicas makes SEM examination of the ring difficult.

Today the bezel and the shank are separated, showing the swivelling mechanism of this finger-ring. The few visible remains of a modern tin-lead solder one side of the bezel result from a restoration to hold the bezel and the shank together. In fact, the swivelling mechanism of this finger-ring uses small spindles and one of them is missing. The spindles are short pins soldered onto the massive cup terminals of the shank. To make the bezel swivel, the short spindles enter into the hole of the cast hollow bezel. A detail of the remaining spindle is shown in Figure 10.49; the missing one might have been the last component included in the mount. In this case, the coiled wire has only a decorative purpose, as it was soldered to the shank. One of the wire-ends at the base of the terminal cups can be seen in Figure 10.50. The wire shows marks of use-wear and overlapped seams from hammering and rolling.

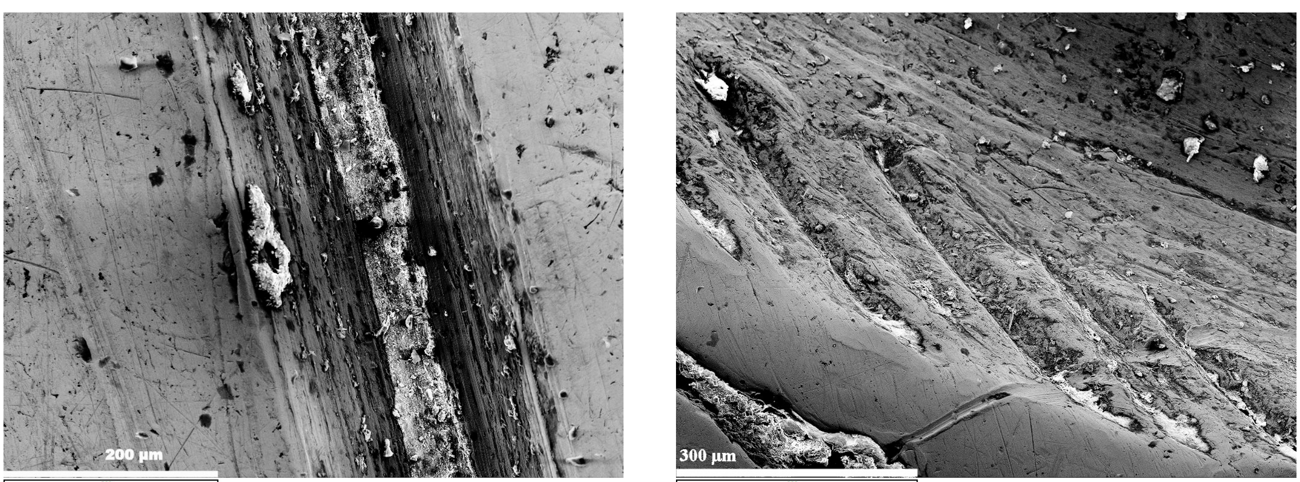


Figure 10.48. *The sharp linear tool marks from enhancing the line encircling one of the motifs of the inscribed bezel of finger-ring N747 and the as-cast structure visible at the bottom of the tool marks, on the right in the case of the motif representing a lion.*

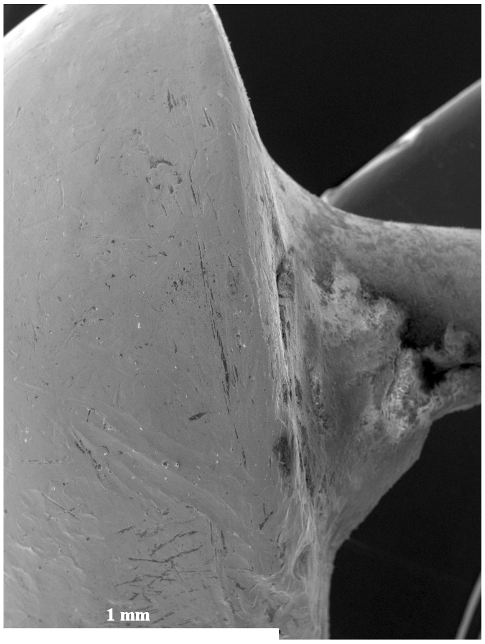


Figure 10.49. *The small spindle soldered to the cup terminal of the shank of gold signet ring N747. Remains of a modern solder used to assemble the two parts (shank and bezel) are also visible.*

The swivelling mechanism of signet ring N747 is very different from those used in the other finger-rings reported in Chapter 10, but the same technique was used in the production of other Egyptian swivelling rings. For example, Vernier (1907–27, 79, fig. 37; no. 52203) reports one finger-ring in the collection of the Cairo Museum containing a carnelian bezel that swivels using small spindles applied on the shank.

Finger-ring in openwork wire

Finally, one finger-ring in openwork wire construction in the collection of the Petrie Museum was also analysed. Finger-ring UC58121 is made by two gold round wires forming a hoop that terminate into a gold wire construction representing the eye with falcon face markings, associated with Horus and Ra, and evoking *wedjat*, 'bodily wholeness, well-being for the wearer'. As shown in Figure 10.51, the ring was obtained by soldering round and rectangular sectioned wires made by hammering; the ends of some of the wires were cut at an oblique angle. The solder is visible in the joining areas, between wires, as shown in Figure 10.51 for the two round wires that form the hoop.

Gold alloys

Table 10.9 summarizes the data obtained by using XRF, SEM-EDS and μPIXE for the composition of the alloys used to make the components of all the analysed finger-rings, excluding the modern wire of A212.12.

As expected by visual colour assessment, the highest silver contents were observed for finger-ring in openwork wire UC58121, which is made from an alloy containing 52.6 wt% Ag and 4.6 wt% Cu. Despite their uncertain origin (see Chapters 5 and 7), gold alloys containing more than 50 wt% Ag have been observed in Egyptian jewellery produced in all the periods considered in this project and also in objects from other collections. Examples include one gold foil dated to the Naqada period (Payne 2000, 255; Stos-Gale & Gale 1981) made from an alloy containing 62 wt% Ag and several items found in burials dated to the Middle Kingdom and to the Second Intermediate Period that contain more than 55 wt% Ag (see Chapters 8.4 and 9.2; Gale & Stos-Gale 1981).

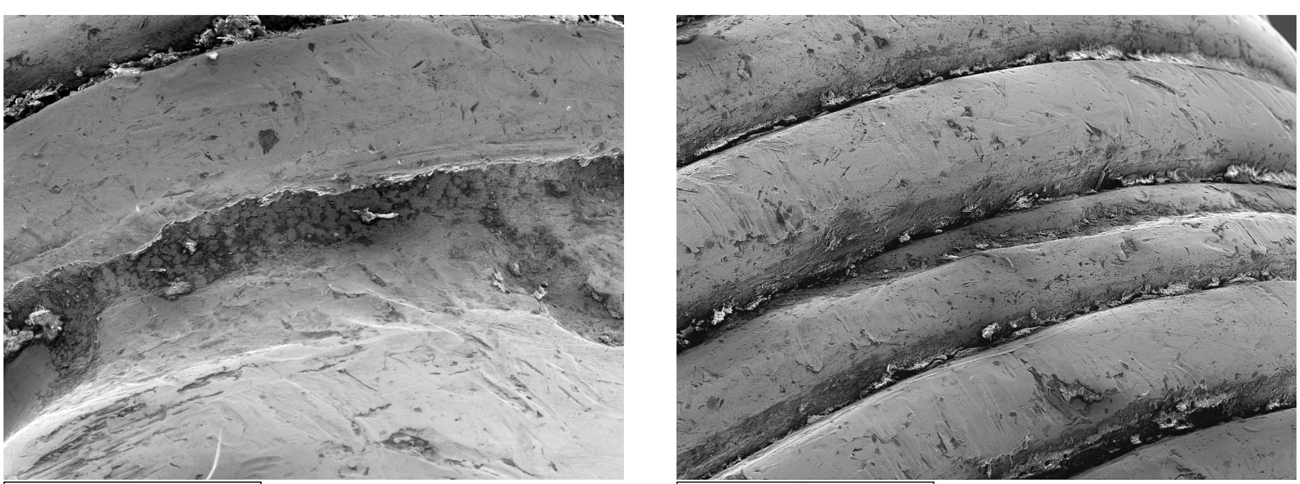


Figure 10.50. *The coiled gold wire that decorate the shank of gold signet ring N747 is soldered to the shank. The wire smoothing from use-wear and an overlapping seam are also visible.*



Figure 10.51. *Finger-ring in openwork wire UC58121, in the collection of the Petrie Museum, showing the solder between the two rounded wires that form the hoop and the cut ends of the solid wires that form the bezel.*

A few objects dated to the New Kingdom are also made from silver-rich alloys. We can mention two pendants from the tomb of the three foreign wives of Thutmes III (Lilyquist 2003, 342). One is a bivalve shell pendant (MMA 26.8.71) containing 65 wt% Ag and 3 wt% Cu and the other one is an uraeus pendant (MMA 26.8.81) containing 51 wt% Ag and 3 wt% Cu. In addition to these objects, two beads from tombs E269 at Abydos and 19B at Ehnasya analysed by Stos-Gale & Gale (1981) were found to contain *c*. 50 wt% Ag. These objects testify of the use of silver rich gold alloys during the New Kingdom, and of compositions similar to the one observed for finger-ring UC58121

Two other analysed finger-rings (A.212.12 and A.1965.362) contain *c*. 30 wt% Ag, a type of alloy commonly observed in New Kingdom items, such as those from the tomb of the three foreign wives of Thutmes III. One example is the gazelle diadem (MMA 26.8.99) that contains 36–38 wt% Ag and *c*. 3 wt% Cu (Lilyquist 2003, 342). In fact, Nubian and Egyptian mined gold contains quite high silver contents that attain regularly 20–30 wt% Ag, particularly for the Eastern Desert gold deposits (Klemm & Klemm 2013, 42, fig. 4.1).

In the diagram of Figure 10.52, we plotted the values obtained for the shank and bezel of all the New Kingdom finger-rings analysed in this project in order to illustrate the diversity of the alloys employed in their production. We added to the diagram the finger-ring and the bezel bearing the name of Ahhotep in the collection of the Louvre Museum (see Chapter 9.4), which match the composition of the finger-rings studied in this chapter.

Among the New Kingdom objects analysed in this project, a quite large number corresponds to penannular earrings, which are discussed in Chapter 10.3. It seems therefore useful to compare their composition to the group the finger-rings considered in this chapter.

Table 10.9. *Results obtained by XRF, µPIXE and SEM-EDS for the finger-rings in the collections of the Louvre Museum, the Petrie Museum and the NMS.*

	Acc. No.	Method	Region of analysis	Au wt%	Ag wt%	Cu wt%
Petrie Museum	UC12383	XRF	shank	89.5	6	4.4
			wire	89.2	6.2	4.6
			bezel	88.6	5.6	5.8
	UC12689	XRF	bezel	81.6	14.2	4.2
			wire	79.3	16.9	3.8
			shank	83.9	13	3.1
	UC58121	XRF	average	42.9	52.6	4.6
Louvre Museum	AF2462	PIXE	shank	75.5	22.4	0.8
			wire	75.7	22	1
	N747	PIXE	bezel	91.9	7.1	1
			shank	91.4	7.7	0.8
			wire	91.2	7.5	1.1
		EDS	solder	90.7	7.2	2.2
			shank	92.7	6.8	0.5
			wire	92.7	6.3	1.1
			spindle	91.3	8	0.8
NMS	A.212.12	XRF	shank	65.1	31.9	3
	A.1965.362	XRF	average shank and bezel	68.6	29.4	2

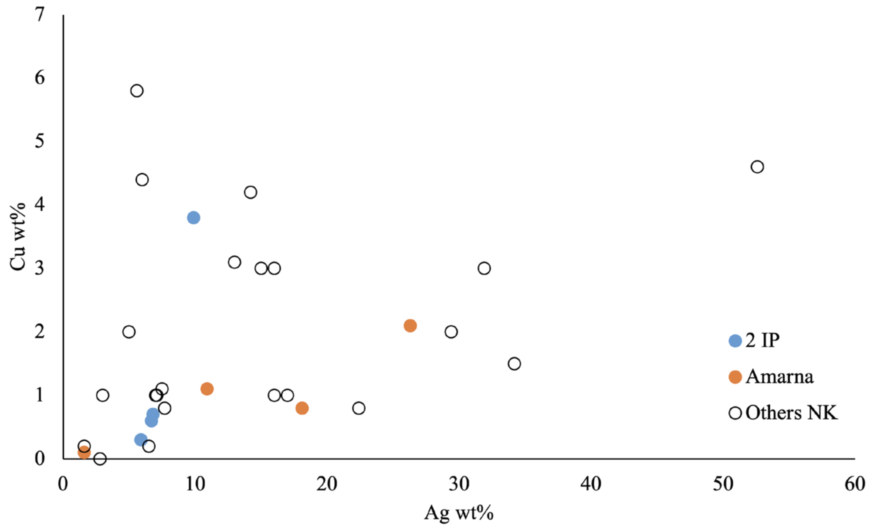


Figure 10.52. *Silver versus copper contents obtained by μPIXE, XRF and SEM-EDS (mean values are provided for the bezel and the shank) for all the New Kingdom finger-rings analysed in this volume. The two finger-rings bearing the name of Ahhotep (Chapter 9.4) were also added to the diagram for comparison.*

By comparing the data plotted in the diagrams of Figures 10.52 and 10.16, we can observe that for both groups of objects the concentration of silver in the alloys ranges from *c*. 1 to 50 wt% and that the copper contents observed are under 6 wt%. All the possible values of silver contents between 1 and 50 wt% are filled in the diagram, even those corresponding to a 'gap' revealed for the Second Intermediate Period productions, which roughly ranges between 38 and 50 wt% Ag (see Chapter 10.3).

The wide exploitation of gold mining regions during the New Kingdom certainly contributed to an increase of the quantity of gold available to produce jewellery and to the diversity of the native alloys accessible during this period. In fact, Klemm & Klemm (2013, 606–9) indicate that at the beginning of the New Kingdom the gold mining regions expanded into more Eastern Precambrian basement zones and southern areas (around Wadi Allaqi and throughout Nubia), extending to the Red Sea. Despite the expected use of mined gold, the presence in some finger-rings of PGE inclusions testify that alluvial gold was still widely exploited (and perhaps also recycled) in this period to produce jewellery.

Finally, the use of hard soldering processes to join the several components of finger-ring N747 was revealed. In contrast to what has been regularly observed for the items studied in the previous chapters of this volume as well as for the objects from the tomb of the three foreign wives of Thutmes III (Lilyquist 2003), in the joins of N747 both silver and copper increase when compared to the composition of the joined parts.

Notes

1. Another example is one scarab in glazed steatite (MMA 31.3.97) found tied with a linen thread to the left hand of an unknown woman who was buried on the hillside below the tomb of Senenmut (leading official of Hatshepsut) at Abd el-Qurna.
2. Finger-ring MMA 26.7.767 is inscribed with two seated figures, probably Akhenaten and Nefertiti as the deities Shu and Tefnut, and with hieroglyphs representing the earth and the sun disk flanked by two ureaus.
3. This is seen in other studied rings and discussed in Chapter 10.4.4.
4. The exact circumstances of the discovery of these jewellery pieces are unknown, as W. T. Ready had purchased them from the British clergyman W. J. Loftie, who had himself purchased the objects in Egypt in 1882 from the villagers of Hagg Qandil, following the discovery of the Royal Tomb at El-'Amarna (Martin 1974; Aldred 1988).
5. The group of objects includes a massive gold signet ring, one pair of gold ear-studs, one string containing components in gold, one gold sequin and one gold foil.
6. For example, a finger-ring in the collection of the Walters Art Museum at Baltimore (57.1536) has a small carnelian frog, which serves as a swivelling bezel.
7. And not by the addition of a coiled wire as originally suggested (Troalen et al. 2009), before X-ray observation.
8. The form of the shank is close to that of one finger-ring in silver found at Abydos in tomb 70 in cemetery G. It consists of a silver shank set with a blue glass frog, which was found with two silver scarab rings and one gold signet ring in a very rich burial of a woman whose coffin was resting inside a shaft on early 18th Dynasty limestone blocks (Ayrton et al. 1904, 50, pl. 17.2–5).
9. Similar mounting seems to have been used for finger-ring 1916-658 from Cleveland Museum. This is based on visual observations of the photographs available. This is also very similar to the shank and swivel construction of signet ring BM EA 71492, discussed in Chapter 10.4.2 though the alloy of their shanks is very different.

References

For references see pp.445–8 at the end of this chapter.

Chapter 10.5

Jewellery reportedly from the Royal Tomb at Amarna

Lore Troalen, Maria F. Guerra & Margaret Maitland

Among the group of nineteen objects described in Chapter 10.4.3, acquired by National Museums Scotland (NMS; formerly the Royal Scottish Museum) from the dealer W. T. Ready in 1883[1] are a few other objects that reportedly came from the Royal Tomb at El-'Amarna (Aldred 1971; Martin 1974). According to the archaeologist W. M. Flinders Petrie, the Royal Tomb was initially discovered by locals and even when this news spread and official excavations began in 1891/2, these were irregular and without supervision; Petrie believed that some of the finds were sold (Petrie 1896, 220; Blackman 1917).

The group of objects acquired by NMS consists in fact of jewellery items from distinct periods. As mentioned, several items can be associated on the basis of stylistic grounds and inscriptions with the Royal Tomb at El-'Amarna and dated to the late 18th Dynasty, while others appear to be late Romano-Coptic and Ptolemaïc in date (Martin 1974). It is believed that the latter could be from an intrusive burial or burials in the vicinity of the Royal Tomb rather than objects added by the locals for sale (Aldred 1971). It is therefore assumed that the group of objects was sold intact and then purchased by the Royal Scottish Museum. Only two gold signet rings with representations of god Bes (as described by Blackman 1917, 44–5) were separated from the hoard and purchased by Sir H. R. Haggard. These objects are today part of the collection of National Museums Liverpool.

The objects reportedly from the Royal Tomb acquired by NMS include a gold signet ring (A.1883.49.1), a gold sequin (A.1883.49.6), two floral[2] ear-studs in gold (A.1883.49.9/10), two finger-rings with swiveling mechanisms (A.188.49.2 and A.1883.49.8),[3] a string of gold components and green glass round beads (A.1883.49.13) and a fragment of gold foil probably from a coffin or a piece of furniture (A.1883.49.15). The analytical study of these objects is reported below.

A.1883.49.1 is a substantial gold signet ring bearing the second name form of queen Nefertiti, Nefernefruaten-Nefertiti (Fig. 10.53). It was cast in a single piece and tool marks are visible at the bottom of some of the hieroglyphs showing that the inscriptions were cut into the wax before casting and finished by removing the metal after casting and by chasing

The gold sequin is made of a round foil embossed to create a rosette design and has two round suspensions holes pierced back to front (Fig. 10.54). Similar rosette-shaped gold sequins were found in the tomb of Tutankhamun (Carter & Mace 1923, 167, pl. 35),[4] dating to shortly after the burials in the Royal Tomb at El-'Amarna (Cairo JE 62654). The fragment of gold sheet (A.1883.49.15), probably from a coffin or a furniture decoration, presents a surface structure typical of a forming process by hammering (Fig. 10.55) with some decorative lines. The string of die-stamped gold foil beads (A.1883.49.13), probably originally from a broad collar, take the form of a mandrake fruit (similar to C12A and C56 in Boyce 1995) and lotus flower petals (similar to C6-C9 in Boyce 1995), interspersed with minute pendants probably representing poppy heads, or cornflowers (similar to C13B in Boyce 1995). Similar minute poppy head pendants can be seen, for example, in the elaborate ear ornaments of king Tutankhamun with granulated beads (Cairo JE 61972, visible in Aldred 1971, pl. 122).

Two ear-studs of similar form (A.1883.49.9/10) are made from several gold sheets; both have a floral-patterned dome ornamented with the petals of a rosette and A.1883.49.9 has a hollow shank, while A.1883.49.10 is missing this element, likely due to ancient damage (Fig. 10.56). Similar rosette ear-studs in faience have been excavated at the palace at Malqata and at Amarna (e.g. Metropolitan Museum of Art 11.215.444; British Museum EA59306; National Museum Liverpool 1978.291.297ff; Auckland 1932.34; Andrews 1990, fig. 96; Freed et al.

Figure 10.53. *Signet finger-ring A.1883.49.1 with the name of queen Neferneferuaten-Nefertiti.*

Figure 10.55. *Gold foil fragment NMS A.1883.49.15.*

Figure 10.54. *(a) Gold sequin NMS A.1883.49.6 and (b) detail of embossed design with piercing back to front.*

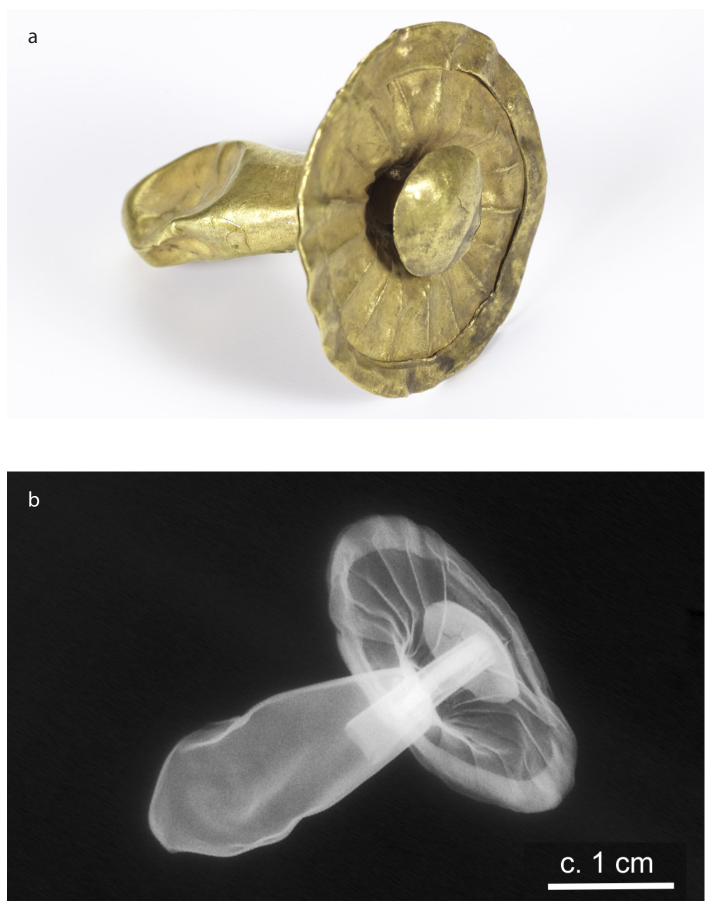


Figure 10.56. *(a) One of the ear-studs (NMS A.1883.49.9) and (b) its construction under X-ray (NMS X-ray plate 20091009-6, 4 mA, 260 kV, 5 min, 3.3 mm Cu filter, Structurix film D7).*

Figure 10.57. *Details under the SEM and stereomicroscope of one of the ear-studs (NMS A.1883.49.9) showing (a) the ribbed gold sheet (SEM-AEI), (b) the reverse chased sheet with the construction of the stud and (c) the guideline for the cutting process.*

1999, 261, pl. 198), but these are the only known examples in gold. However, floral studs in gold form part of the ear ornaments with poppy or cornflower-shaped pendants from tomb KV56, the Gold Tomb, which contained grave goods bearing the cartouches of Seti II and Tausret.[5] The flowers are similar to those in the gold diadem from the same tomb.[6] The opposite side of the ear ornaments (behind the earlobe when worn) features a convex stud decorated with wires and a flat knob.[7]

The floral patterned dome of ear-stud A.1883.49.9 was obtained with two circular gold sheets decorated to simulate the rosette petals. The front sheet is ribbed and the flat bordering sheet was obtained by folding a gold band around the edge of the rosette (Fig. 10.57a,b). Remains of an incised guideline near the folded sheet-edge show that the intended shape was drawn before cutting. The cutting process was quite imprecise, at least in some areas (Fig. 10.57c).[8] The chased gold sheet of the reverse is slightly bent to form a kind of flattened truncated V-cup that enters into the shank. The shank is made from two soldered embossed halves. One gold rivet passes through the dome, the hole and the shank in order to hold all the components together (Fig. 10.57b).

A.1883.49.13 consists of a group of gold components of different sizes and shapes, green glass beads and a green gemstone, currently strung in two rows in a modern re-stringing/mounting (Fig. 10.58). They would originally have formed part of a floral-style broad collar, a style popular in the late 18th Dynasty imitating floral wreaths, worn at banquets and in burials (Andrews 1990, 122–3, fig. 105). The gold components are a central mandrake fruit-shaped pendant, nine lotus flower petal-shaped pendants, and numerous small flower-shaped pendants, one large, representing poppy heads or cornflowers. SEM-EDS investigation of the small green beads revealed a soda-type glass with high aluminium (Koleini et al. 2019) and the presence of copper, while the larger bead is a gemstone that contains mainly aluminium and silicate with traces of iron and chromium. These could correspond to later additions, possibly by the dealer as they were all noted in the register when accessioned at NMS. The green gemstone bead might possibly be a beryl and could perhaps derive from the later Ptolemaic items acquired from Amarna at the same time, as beryl does not appear to have been mined in Egypt before that period (Aston et al. 2000, 25).

Both the gold mandrake-shaped pendant and the lotus flower petal-shaped pendants (Fig. 10.59) are made using an embossing technique that is observed on *nefer*-shaped pendants discussed in the next section of this chapter. Each pendant has a suspension ring at either end, made using two different techniques. A rolled gold band is soldered to each side of the

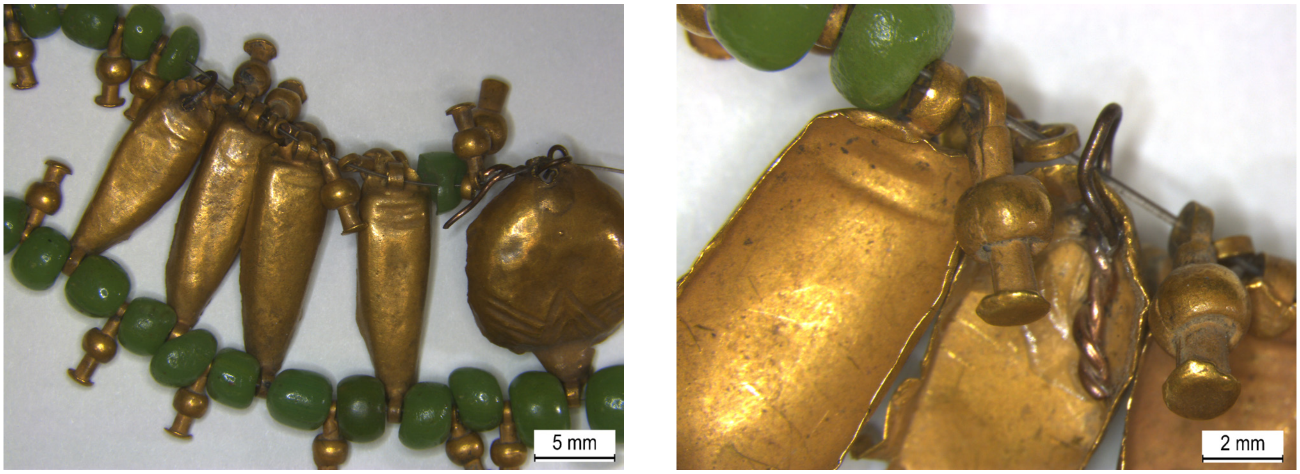


Figure 10.58. *Details of the beads in string NMS A.1883.49.13, showing the mounting of the central mandrake fruit-shaped pendant, lotus flower petal-shaped pendants, and green glass beads that alternate with the small poppy or cornflower-shaped pendants, in a modern mounting.*

Table 10.10. *Results obtained by XRF for the New Kingdom objects associated with the Royal Tomb at El-'Amarna. The key elements detected by SEM-EDS analysis in the green beads of necklace A.1883.49.13 are also reported.*

Acc. No.	Area analysed	Method	Au wt%	Ag wt%	Cu wt%
A.1883.49.1	Finger-ring (shank)	XRF	88.0	10.9	1.1
A.1883.49.2	Finger-ring (shank)	XRF	98.3	1.6	0.1
	Bezel (average of the various parts, excluding granules)	PIXE	75.3	22.6	2.1
A.1883.49.6	Sequin	XRF	77.8	20.1	2.1
A.1883.49.8	Finger-ring (shank)	XRF	81.1	18.1	0.8
A.1883.49.9	Flower	XRF	68.3	30.2	1.5
	Dome	XRF	72.8	26.0	1.2
	Shank	XRF	67.2	31.1	1.7
A.1883.49.15	Gold foil	XRF	88.3	10.5	1.2
A.1883.49.13	Mandrake fruit	XRF	71.8	26.0	2.2
	Large poppy	XRF	85.2	13.3	1.5
	Petal foil - 1	XRF	74.4	24.0	1.5
	Petal foil - 2	XRF	72.2	26.2	1.6
	Petal foil - 3	XRF	70.4	27.5	2.1
	Petal foil - 4	XRF	72.3	25.5	2.3
	Petal foil - 5	XRF	73.4	23.8	2.8
	Petal foil - 6	XRF	72.8	23.9	3.3
	Petal foil - 7	XRF	72.2	26.3	1.5
	Petal foil - 8	XRF	94.6	4.7	0.7
	Petal foil - 9	XRF	66.0	33.0	1.0
	Poppy 1 (removed)				
	Average composition	XRF	72.4	25.8	1.8
	Poppy 2 (removed)				
	Average composition	XRF	84.6	13.7	1.8
	Large green bead	EDS	Key elements detected	Al, Si, traces Fe, Cr	
	Small green beads	EDS		Na, Al, Si, Fe, K, Ca, Cu	

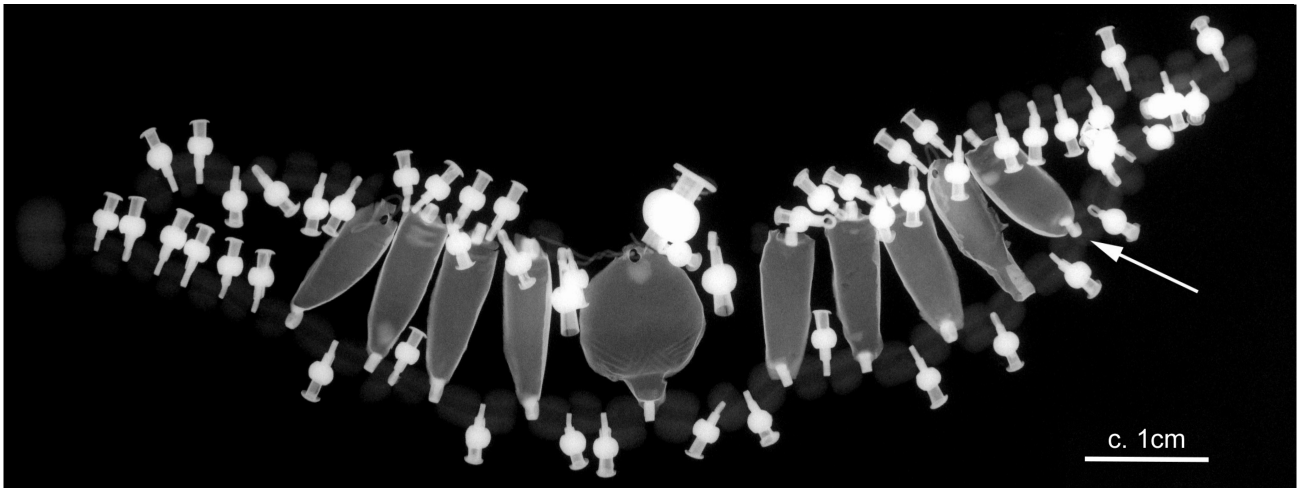
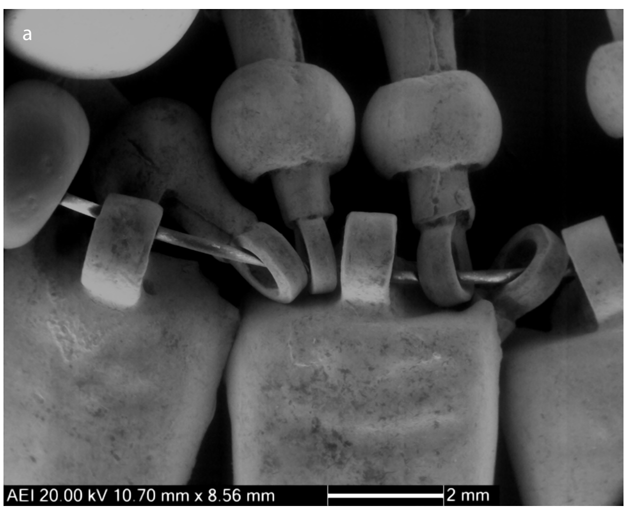
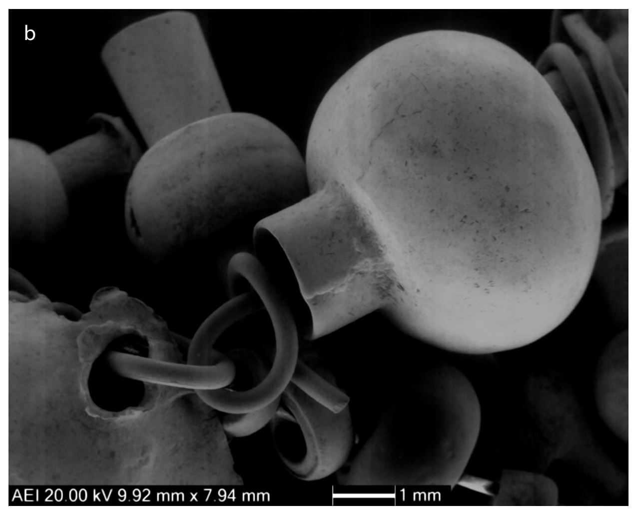


Figure 10.59. *X-radiograph of the bead composition NMS A.1883.49.13 (NMS X-Ray plate 20091009-12, 4 mA, 180 kV, 4 min, lead screen, 2.7 mm Cu filter, Structurix film D7). The arrow indicates the lotus flower petal-shaped pendant exhibiting a different construction and composition.*





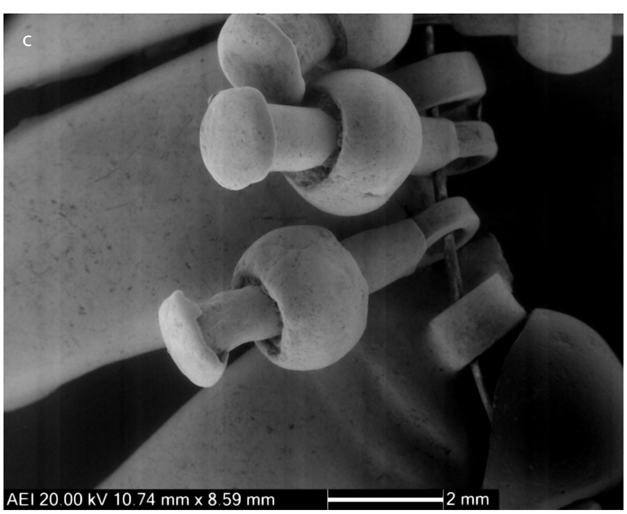


Figure 10.60. *SEM-AEI details of string of beads NMS A.1883.49.13 showing: (a) the suspension rings of the lotus flower petal pendants and poppy or cornflower pendants; (b) the large poppy shaped pendant with soldering of the body to the tube, held to the mandrake fruit pendant by a (modern?) piercing for a modern wire; and (c) mounting of the small poppy pendants with the spherical body, the tube and the rivet. The morphology at the joins confirms that the various parts of the poppy pendants are hard soldered.*

gold sheet, but in one of them (petal-shaped pendant 8 in Table 10.10), the second from the right in the X-radiograph of Figure 10.59, visibly different from the others and not decorated, the embossed gold sheet is cut and rolled to form one of the rings.[9] The other side of the pendant is pierced; one gold wire is used to hold the pendant to the string, which could be a modern mounting.

The poppy-shaped pendants were obtained by joining several components made from gold sheet, as shown by X-radiography in Figure 10.59. These are sometimes incomplete, but their construction is uniform: one gold strip is rolled and soldered forming a spherical ring; a gold tube made by rolling and soldering a gold sheet is inserted into the ring (Fig. 10.60). Finally, a gold rivet passes through the tube to hold all the components together. The rivet forms on one side the pendant base (Fig. 10.60c) and on the other side the suspension ring (Fig. 10.60a). The flattened end of the rivet appears to be missing on several pendants.

The poppy- or cornflower-shaped pendants are more complex, requiring soldering of different small gold components. However, surface analysis was unable to show clear compositional difference, despite a small increase of the silver content, probably due to use-wear of the surface and modern surface cleaning during restoration.[10]

The data obtained for the gold alloys of all the group of jewellery reportedly from the Royal Tomb at El-'Amarna (including the two swivelling finger-rings A.1883.49.2 and A.1883.49.8 discussed in Chapter 10.4.3) are summarized in Table 10.10 and plotted in Figure 10.61. The ear-studs and the majority of the analysed gold components of string A.1883.49.13 are made of electrum alloys with 25–30 wt% Ag and less than 2 wt% Cu, while the fragment of gold foil A.1883.49.15 is made of an alloy containing higher gold content. This foil is close in composition to the signet finger-ring A.1883.49.1, that is made of an alloy containing 11 wt% Ag and 1 wt% Cu. In comparison, the two other finger-rings studied in the previous section of this chapter (10.4.3), display distinct composition. The shank of the finger-ring A.1883.49.2 is made of an alloy containing less than 2 wt% Ag and almost no copper, while the various parts of its bezel is made of an alloy averaging 22.6 wt% Ag and *c.* 2 wt% Cu. The finger-ring with the cornelian wadjet-eye is made of an alloy containing 18 wt% Ag and *c.* 1 wt% Cu. The composition of the latter is close to that of the sequin (A.1883.49.6). Some components of string A.1883.49.13 display a lower silver content in the diagram Figure 10.61. These components are the large poppy-shaped pendant, one of the two analysed small poppy-pendants and one of the lotus petal-shaped pendants, confirming the difference of type mentioned above for these pendants. It is possible that the small poppy-shaped pendants originate from different objects, explaining the different compositions observed for the two analysed specimens, but it also

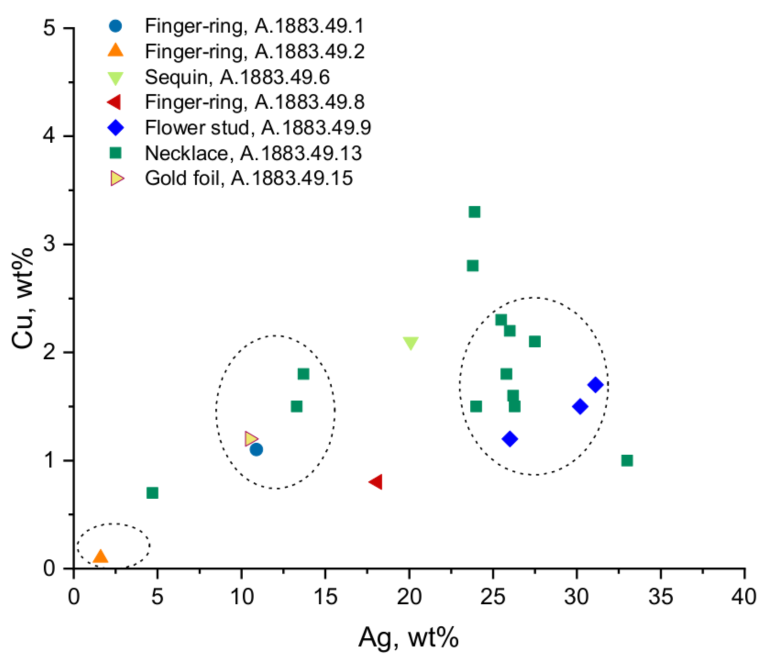


Figure 10.61. *Silver versus copper contents obtained for the New Kingdom gold objects possibly associated with the Royal Tomb at El-'Amarna determined by XRF analysis.*

seems likely that they were simply sourced from different goldsmiths/workshops.

Given the uncertainty over when the objects were deposited and their range of typology, it is not surprising that this group exhibits a very scattered range of composition, even within the same string of beads and pendants. However, it is worth observing that the range of composition observed in the Amarna objects is similar to what is observed in other groups of jewellery in Egypt discussed in this volume.

The presence of PGE inclusions observed in several objects suggests the use of alluvial gold, as for other Egyptian jewellery items. Despite the difficulties in taking the discussion of this group of objects further, we can note that in addition to their close elemental composition, the poppy pendants of string A.1883.49.13 and the ear-stud A.1883.49.9 are made using similar technologies. In these objects, one gold rivet holds the components together and the round pin type terminal is part of the floral element. It is difficult to find technological evidence relating these items to the work of the same goldsmith, or to the work of one single workshop. However, the manufacture of the string and ear studs seems to be inscribed in a certain workshop tradition, suggesting that both were produced in the same period.

Notes

1. W.T. Ready had himself purchased the objects from Rev. W. J. Loftie.
2. Some scholars describe these ear-studs as 'mushroom'-shaped or 'papyrus column'-shaped (El-Saady 1996; Bulsink 2015; Kalloniatis 2019).
3. These two finger-rings are discussed in Chapter 10.4.3.
4. They are described in Carter's note 046gg and shown in H. Burton's photograph p0431, available online at the Griffith Institute, University of Oxford.
5. The elaborate ear ornaments from tomb KV56 (Davis 1908, pl. 'Ceremonial wig ornaments of Queen Taousrit'), which bear the two cartouches of Seti II, have a concave front stud consisting of an eight-petalled flower with a round-headed knob suggesting the pistil (Andrews 1990, 112–13; 52.397 in Vernier 1907–27, pl. 28).
6. They consist of a corolla of ten petals and a round-headed knob (Davis 1908, 35–6; 52.644 in Vernier 1907–27; visible in Aldred 1971, pl. 131). The opposite side of the ear ornaments (behind the earlobe when worn) features a convex stud decorated with wires and a flat knob very similar to one pair of ear-studs in several materials from Tutankhamun's tomb (Cairo JE 61969, no. 9 in Edwards 1976).
7. On the back of the convex and concave studs, two gold tubes fit together through the perforated earlobes to hang the ornaments. The convex pieces are very similar to one pair of ear-studs in several materials (Cairo JE 61973, Carter 620(94)) from Tutankhamun's tomb. Examples of pairs in gold are in the collection of the Cairo Museum (52478-9 in Vernier 1907–27) and of the National Museum of Antiquities of Leiden (Leiden AO 1e-1-4, no. 17 in Bulsink 2015).
8. Only A.1883.49.9 could be analysed in the laboratory. From visual examination, the border sheet on A.1883.49.10 is slightly wider than the other and has a small tear. It is also smooth, while the border sheet on A.1883.49.9 is rippled to match the ribs of the rosette. It is possible that the border sheet on A.1883.49.10 may have been repaired due to the ancient damage the earring suffered.
9. This technique is the same observed for pendants UC38580 supposedly from tomb 406 at Sidmant (Petrie & Brunton 1924, pl. 57), which are discussed in Chapter 10.7.
10. Data obtained by EDS on a few parts of the objects show surfaces significantly richer in gold as compared to composition obtained by XRF analysis, which could result from modern processes of chemical surface cleaning.

References

For references see pp.445–8 at the end of this chapter.

Chapter 10.6

New Kingdom strings in the collection of the British Museum

Nigel Meeks, Susan La Niece & Maria F. Guerra

Two strings of beads dated to the New Kingdom in the collection of the British Museum were selected for analytical and metalworking studies of the gold components. The current stringing of the pieces is not necessarily how they were originally composed, although they are thought to be representative reconstructions.

These strings contain some of the commonest components described in the previous chapters focusing on jewellery from earlier periods. Among them, the small ring beads thought to have been relatively widely produced and, as suggested in the previous chapters, to be (at least sometimes) reused as beads.

The main aim of the study was to obtain information on the gold alloys used during the period and to consolidate suggestions on the goldsmithing practices and technologies of making jewellery in Egypt. The presence of PGE inclusions at the surface of the gold items was also investigated in order to assess the use of alluvial gold, a practice that was regularly observed from the earlier periods.

String EA14696

Besides being common components of New Kingdom girdles, so-called wallet beads are also found in the one worn by the woman buried at Qurna (see Chapter 9.2). Contextualized New Kingdom jewellery productions also contain this type of bead, for example two girdles found in the burial of the three foreign wives of Thutmes III (shown reconstructed in Lilyquist 2003, nos. 135 and 187). For this reason, the string of gold wallet and duck beads in the collection of the British Museum (EA14696) was selected for study (Fig. 10.62a).

Acquired from Alessandro Castellani in 1872, EA14696 is 15.5 cm long in its re-strung configuration and consists of hollow gold beads of two types: five are wallet-shaped beads alternating between eight duck-shaped beads with heads twisted over their backs; both types are 1.1 cm long. At each end of the string are now hollow gold terminals, one in the form of a snake's head and the other is a pair of lotus-flowers. Both the wallet and the duck beads were made by joining two embossed halves. The joining seam is clearly visible around the edge of many of the beads and X-radiography shows this to be the method of construction of all of them (Fig. 10.62b).

All the beads have two holes at each end (Fig. 10.63) for stringing them on a double cord. The neatly pierced holes were made after the bead halves were soldered together. The holes show signs of use-wear. The purpose of having two strings is simply to hold the beads in one orientation while being worn and prevent them from spinning round. The elegance of this arrangement can be seen in Figure 10.62a, where the ducks are all upright with their heads at the top and the wallets hang with the heavier curved side down.

The wallet beads are all similar in size, design and decoration. The undecorated halves of the wallet beads were formed by repoussé of sheet gold, probably in one undecorated blank mould, as both sides of the wallet are symmetrical (Fig. 10.64). This method achieves uniformity of all of the wallet halves, which have to match exactly for soldering. The wallet bead decoration consists of a curved chased line along the border and two rows of short parallel lines perpendicular to, and one each side of, the border line. The decorative marks on the wallet beads in this string show that different tools were used on different beads and in one case even on a single bead (Fig. 10.65).

The duck-shaped beads are more complex in form. The beads are thicker at the wings than the sides of the body and the neck and head are curved over their backs. The preliminary shaping of the halves would have been by repoussé of sheet gold in two

Figure 10.62. *(a) Wallet bead string EA14696 in the collection of the British Museum. (b) X-radiographic view along the narrow edge of some of the hollow beads showing the joining seams (BM X-ray plate 6901, 10 mA, 100 kV, 2 min, lead screen, Structurix film D4).*

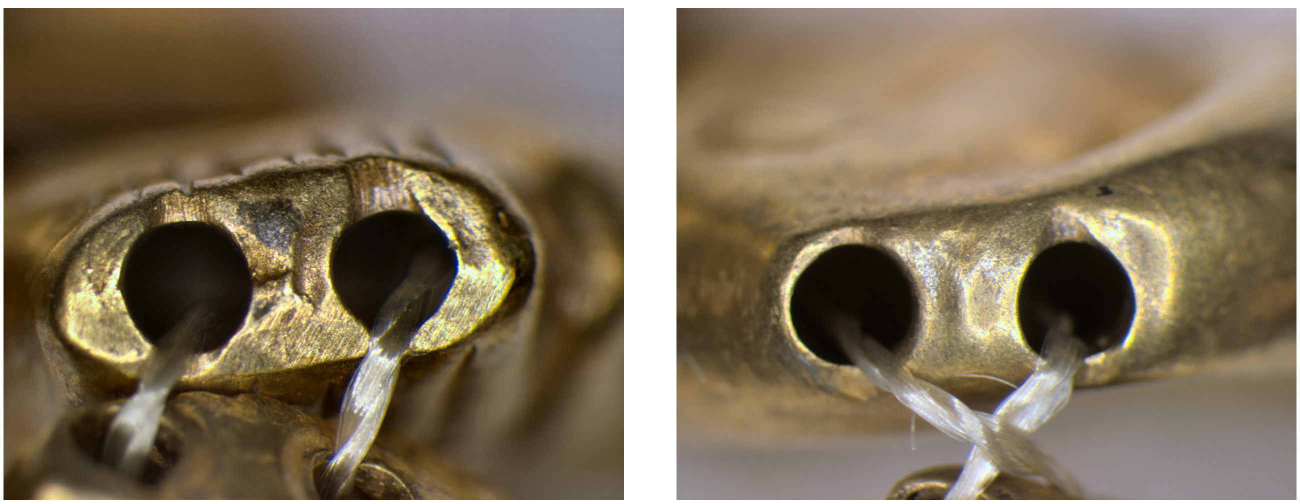


Figure 10.63. *Detail under the stereomicroscope of the pairs of holes for cords in two of the beads in string EA14696. Note the neatly pierced holes made after the bead halves were soldered together (the cord is modern).*

Figure 10.64. *String EA14696: (a) one wallet and one duck bead (mm scale) and (b) one large PGE inclusion on the edge of a wallet bead.*

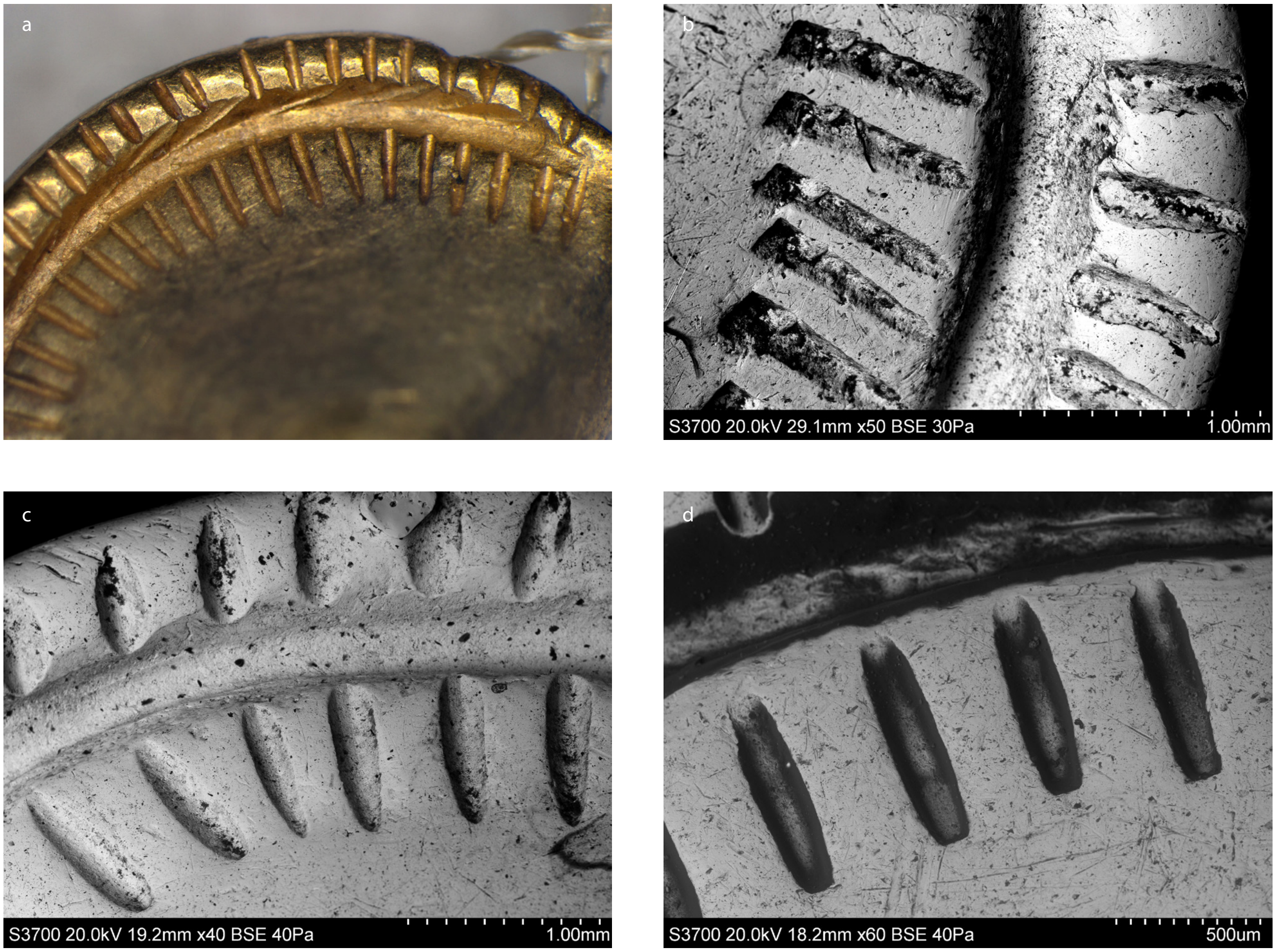
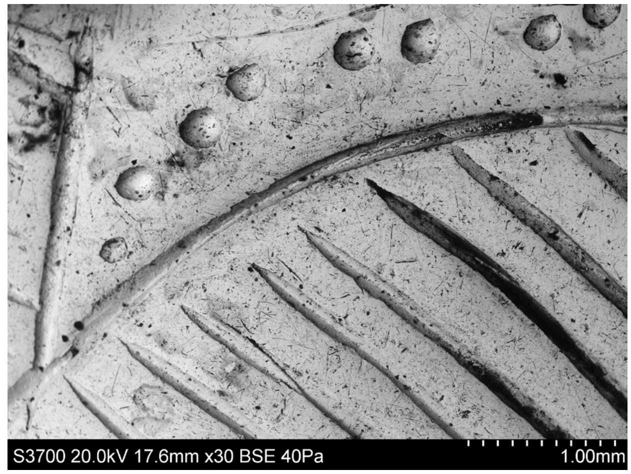


Figure 10.65. *String EA14696: (a) sharp engraved lines seen under the stereomicroscope on the edge of the curved line and (b–d) details under the SEM of the different shapes of individual punches on the punched edge decoration of the wallet beads.*

negative mould blanks for the front and back of each duck, in the same manner as the wallet bead halves. This produced curved edges, which aligned accurately with their opposite halves for soldering. The details of punched dots on the duck's body – chased ring for the eye and sharply engraved lines for wing and tail feathers (Fig. 10.66) – were added prior to soldering while the sheet gold was on a temporary support.

The duck-shaped beads can be separated into two types by their decorative motif. Three of the ducks have small hatched wings whilst the other five have larger hatched wings and a dot-punched body. The X-radiography and macro photograph of the two types in Figure 10.67 evidences the different details. Furthermore, careful observation of the five beads with large hatched wings and dot-punched body reveals a few more differences. It is noticeable that the regularity of the engraved feathers differs, in particular on the tail, and of the eye tracing, illustrated in Figure 10.68 for three beads. This is evidence of individually crafted decoration

Observation under the SEM of the sharply engraved lines depicting the wing feathers of the duck-shaped beads reveals an unusual texture in some, as shown in Figure 10.69. The structures in the bottom of the engraved lines are not impressions of any tool or matrix. They appear to be dendrites, which is not expected for sheet worked gold. Therefore, the microstructure can only occur as a function of a high temperature localized melting event that, in this case, occurred after the lines were engraved in the gold. The most likely heating event would be soldering the bead halves together after the individual sheet halves had been shaped, engraved/chased/decorated and prepared for joining. This would make a lot of sense as the thin sheet halves would need supporting from



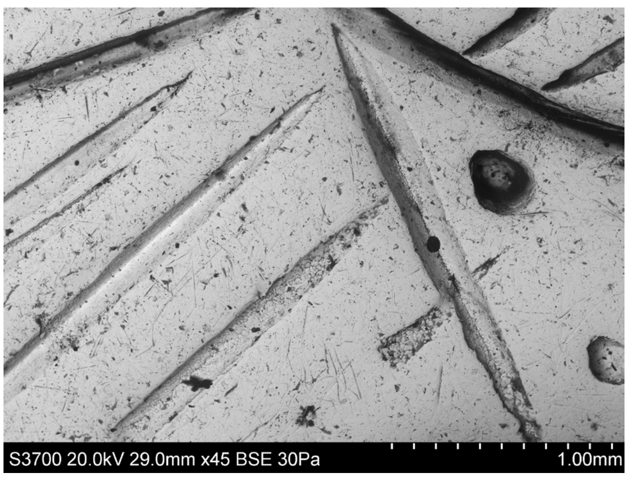


Figure 10.66. *String EA14696: details of the sharply engraved parallel lines depicting the duck bead wing feathers.*

the back in order to enable punching, engraving and/or chasing of the decoration without deformation of the blanks. The soldering of the halves together could have caused the dendritic structures, either by overheating and local flash surface melting or by excessive solder flow from the joints. The flat surfaces of the beads must then have been polished as they are smooth, whereas the deep grooves are unpolished and still retain the dendritic structures.

The snake's head bead that serves as a terminal for the string is composed of two deeply embossed halves soldered together along the sides of the head and decorated by dot punching and chasing (Fig. 10.70a). The second terminal is a hollow tubular component in the form of a double lotus flower joined at the stems and is a more complex assemblage (Fig. 10.70b). It comprises several small components made from sheet gold and wire, revealed under X-radiography in Figure 10.71a. At the joined end is a round-section ring soldered to the double 'Y' shaped tubular 'stems'. The other ends of the hollow stems are soldered to thin hemispherical (slightly dented) sheet components that widen to meet, and are soldered to, the two wide tubular (lotus-shaped) cups

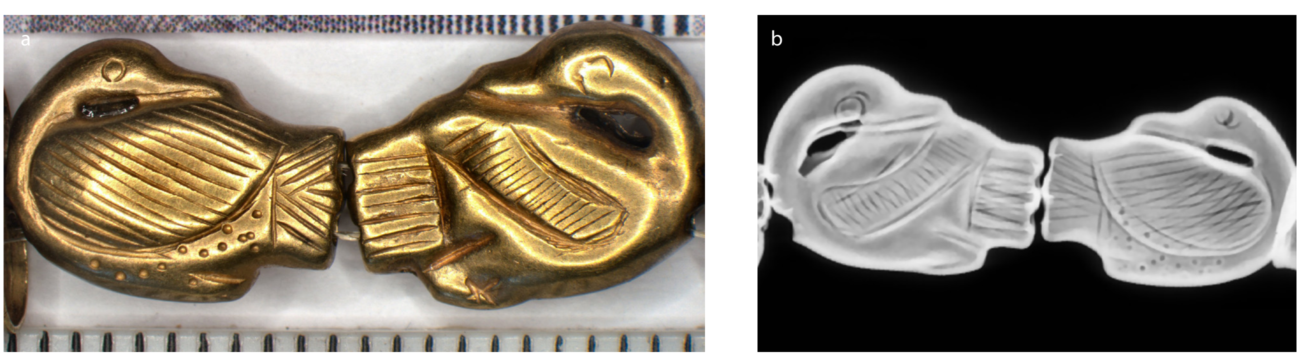


Figure 10.67. *String EA14696: (a) the two types of duck-shaped beads, note the different wing forms; (b) X-radiographic image (BM X-ray plate 6900, 10 mA, 100 kV, 2 min, lead screen, Structurix film D4).*

Figure 10.68. *String EA14696: three of the five duck-shaped beads with large hatched wings and dot-punched decoration showing small design and tool mark differences.*

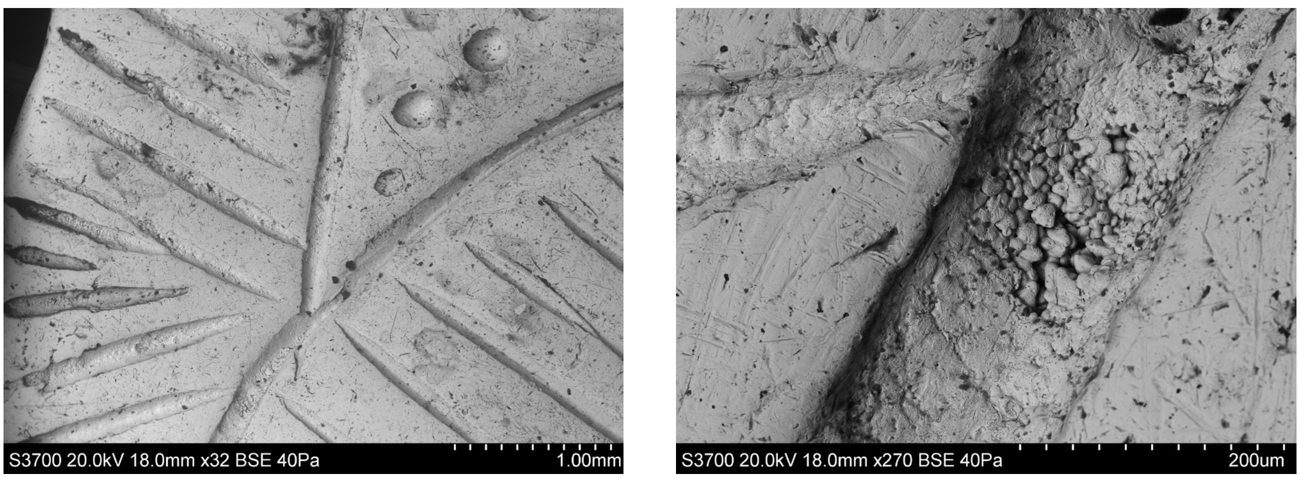


Figure 10.69. *Duck bead in string EA14696: SEM images of the dendritic microstructures in the bottom of the original engraved lines of the feathers, indicative of heating the metal.*

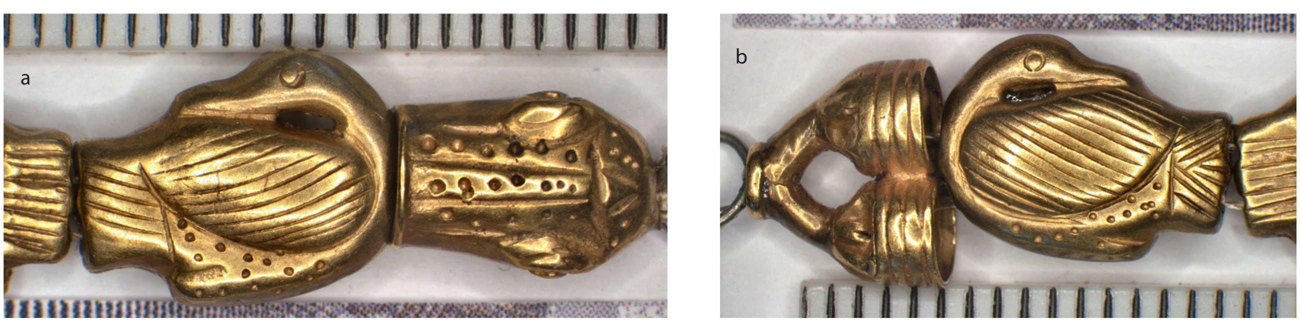


Figure 10.70. *String EA14696: (a) the snake's head terminal and (b) the lotus terminal.*

(Fig. 10.71b,c). X-radiography indicates that the cups are each made of four wire rings or loops stacked and soldered together, rather than being made of chased sheet. The radiograph density shows evidence of wire rings (dense) separated by thin regions of solder, and one ring loop shows internally at the opening. Some of the wire rings also show butt joints. The cups show some marks of use-wear.

There are many PGE inclusions on various gold beads in this necklace, such as on the side of the lotus and the group of large inclusions on the edge of one wallet bead (Fig. 10.72 and Fig. 10.64b).

Figure 10.71. *The lotus terminal of string EA14696: (a) X-radiographic image revealing the different soldered components, including the individual wire loops (BM X-ray plate 6900/1, 10 mA, 100 kV, 2 min, lead screen, Structurix film D4) and (b,c) details of the lotus stems under the stereomicroscope showing the soldered joins of components.*

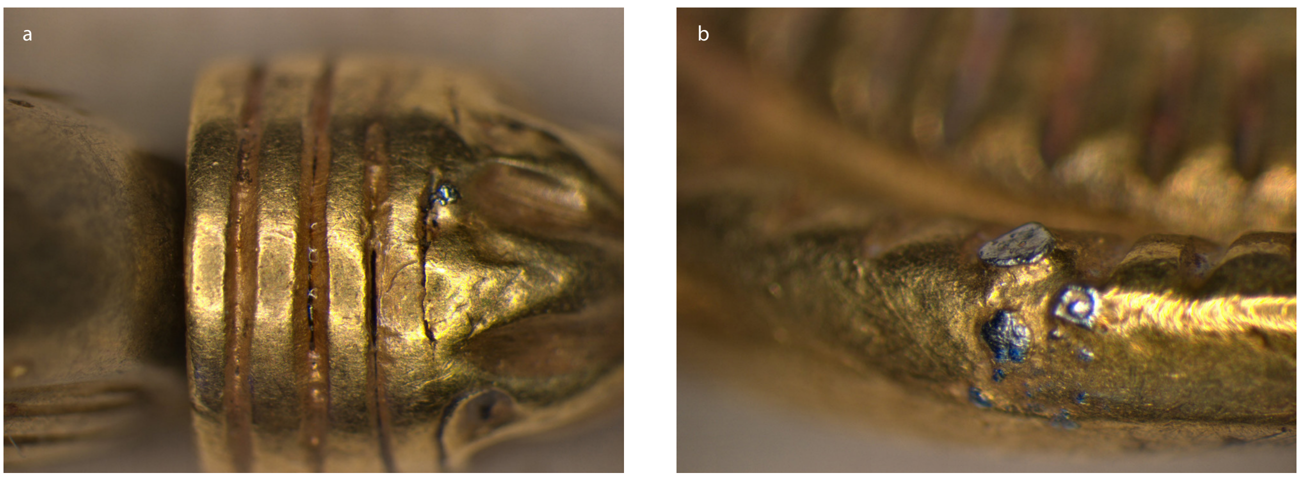


Figure 10.72. *String EA14696: (a) a small PGE inclusion in the lotus terminal and (b) a group of large inclusions on one wallet bead.*

String EA66827

Among the Egyptian bead objects in the collection of the British Museum, is EA66827, now strung as a necklace (Fig. 10.73). It was purchased from Captain Edward G. Spencer-Churchill in 1966 and is a reconstruction of the collection of beads found in the burial of the three foreign wives of Thutmes III, excavated at Qubbanat el-Qirud. It contains ten gold and gold inlaid *nefer*-shaped pendants, one gold inlaid drop-shaped pendant, and various beads in jasper, carnelian, lapis lazuli, feldspar, gold and glass. Some other bead strings found in the same burial, today in the collection of the Metropolitan Museum of Art (Lilyquist 2003, nos. 129–132), contain the same types of beads and pendants. One string in the collection of the University of Pennsylvania Museum (E15789) found by Flinders Petrie in intact pit tomb 254 excavated at Sidmant and dated to the time of Thutmes III, also contains *nefer*-shaped pendants in gold (Silverman 1997, 190). It is notable that among the gold components in all these strings are small ring beads, which are common components of more ancient jewellery.

Necklace EA66827 has two rows of polychrome beads of mixed materials. Those in the outer row are tiny gold, carnelian, lapis lazuli and blue glass beads of similar size and shape. They are grouped to form short alternating colour bands around the entire row (Figs. 10.73 and 10.74) The beads in the inner row of larger beads comprise hollow spherical and hollow fluted gold nasturtium seed forms and other large round beads of lapis lazuli nasturtium shapes and smooth pale blue glass beads of similar size. In addition, there are biconvex cylindrical carnelian beads that form spacers each side of the *nefer*-shaped gold pendants (Figs. 10.73 and 10.74). Small gold beads separate all of these inner

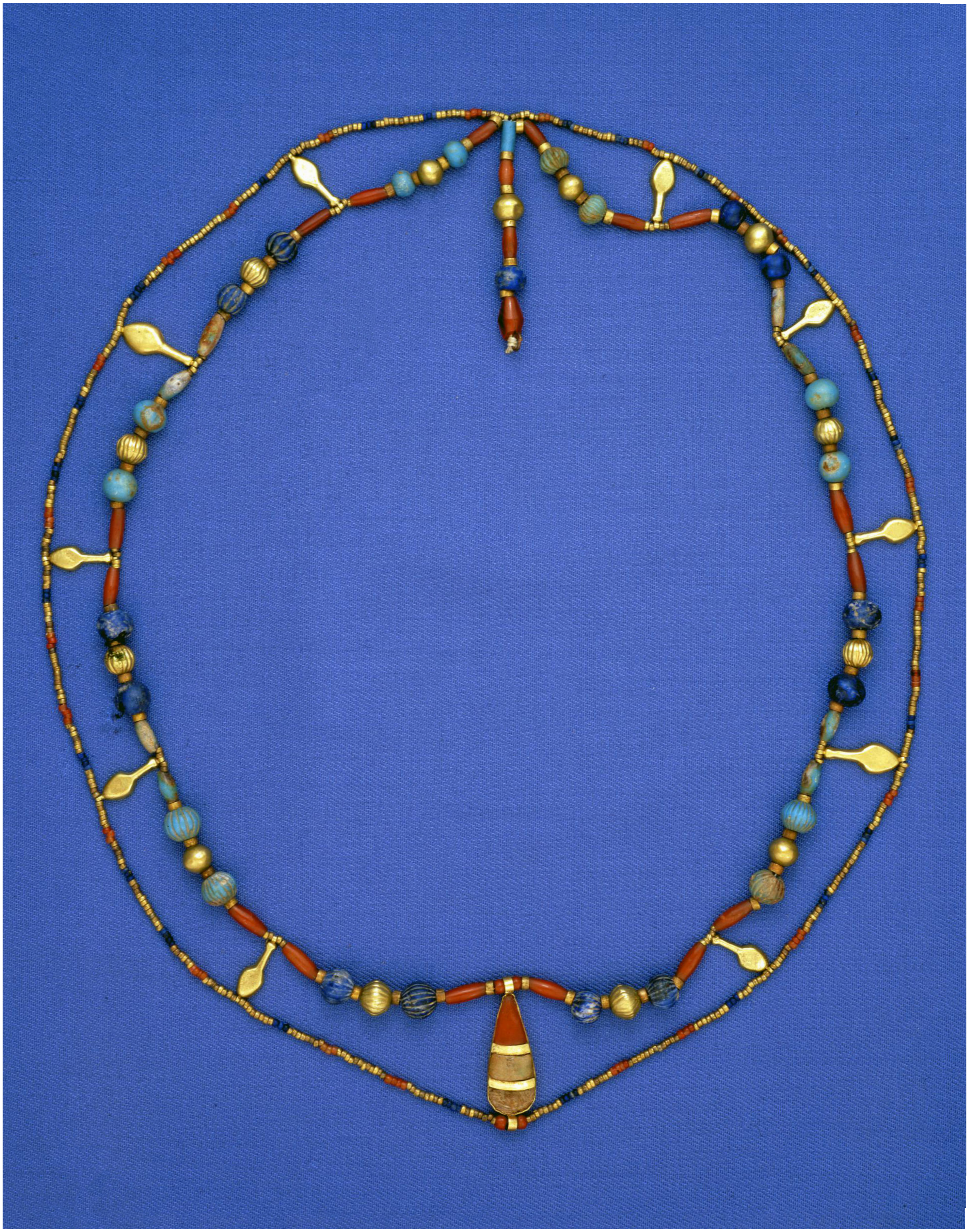


Figure 10.73. *Reconstructed bead and pendant necklace EA66827 in the collection of the British Museum.*

Figure 10.74. *British Museum necklace EA66827. Details of necklace components; the small gold, carnelian and lapis lazuli/blue glass beads are 1.6 to 2.0 mm diameter. Note the intermediate size strip gold beads separating the inner large beads. The X-radiography shows butt joints in the gold beads (BM X-ray plate 6900/1, 10 mA, 100 kV, 2 min, lead screen, Structurix film D4).*

row large beads. The gold *nefer*-shaped pendants act as spacers between the two rows, and an inlaid drop-shaped pendant occupies the central position at the bottom of the necklace between the two rows of beads (Fig. 10.73). This drop-shaped pendant consists of a gold tray to which were soldered two gold bands that separate the inlays of carnelian, green glazed steatite (Fig. 10.75a) and decayed green or blue glass. Suspension rings, made by rolling a gold strip, are soldered to each end of the pendant (Fig. 10.75c, d).

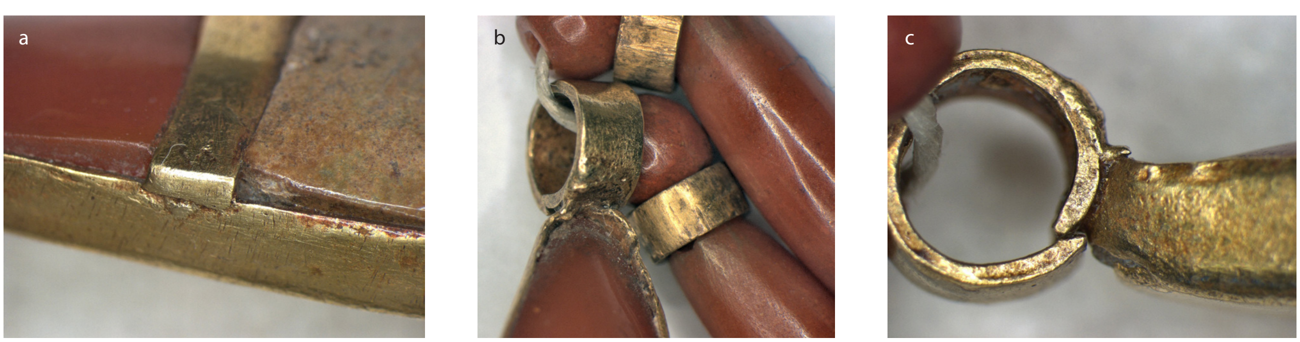


Figure 10.75. *Details of the drop-shaped pendant of necklace EA66827: (a) the gold tray with one of the gold bands separating the inlaid minerals and (b,c) the strip of gold forming the suspension ring of the pendant from the inner row of carnelian (shown here) and mixed beads.*

Figure 10.76. *Details of one of the inlaid* nefer*-shaped pendants of necklace EA66827 showing: (a,b) the seamless back and side of a once inlaid pendant with its suspension ring and (c) the residual decayed calcitic inlaid material (SEM image). (d) Residual traces of blue-coloured material in another pendant (glass?).*

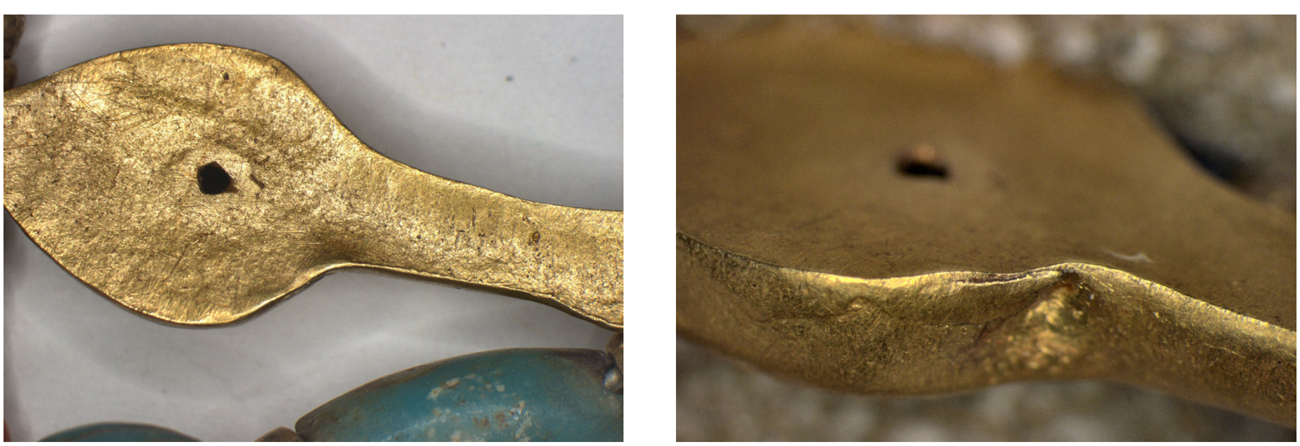


Figure 10.77. *Details of one of the* nefer*-shaped pendants of necklace EA66827 assembled like a closed box showing the side/back joint and the perforation in the back.*

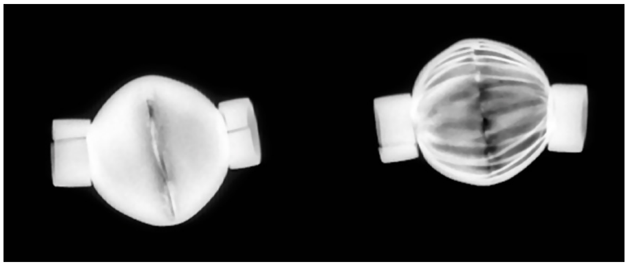


Figure 10.78. *X-radiographs of a spherical bead and a nasturtium seed bead from string EA66827 showing that they are hollow and made by soldering two halves of a sphere around the circumference. The solder seam appears paler in the X-radiograph where it is thicker than the wall of the bead. The darker points are where there are gaps in the join, allowing more X-rays to pass through. (BM X-ray plate 6900/1, 10 mA, 100 kV, 2 min, lead screen, Structurix film D4). A ring bead is strung on each side of these hollow beads. Note the butt join of the strip forming the ring bead.*

The ten *nefer*-shaped pendants are of two types. Seven are inlaid open top gold trays made from a single piece of gold shaped by chasing or repoussé with a suspension ring made from gold strip soldered at the top and bottom of each pendant (Fig. 10.76a,b, d). The inlaid materials have decayed over time and are now largely missing (Fig. 10.76b,d). Analysis shows high concentrations of calcium in the residual deposit, suggesting a calcitic mineral or stone was once present. The other three gold pendants are assembled like a closed box, by soldering a flat gold sheet back to a gold tray with raised sides (Fig. 10.77). There is a hole in the back to allow air to escape during the soldering process. The suspension rings at each end of the box are made by extending the flat sheet of the back of the pendant and bending it into a loop, rather than soldering on separate suspension loops.

The other gold beads in EA66827 are of three forms: spherical, nasturtium seed and ring beads. The five spherical and the seven nasturtium seed beads are hollow and are all made by joining two embossed hemispherical halves around the equatorial circumference of their spheres, as revealed by the X radiography shown in Figure 10.78. They are not identical in size and all are strung between two ring beads, which were made by shaping a gold strip.

There are 420 small gold ring beads in the outer row of the current stringing of necklace EA66827. They are in groups interspersed with smaller groups of both red carnelian beads and blue lapis lazuli or glass beads of the same size. The small gold ring beads are generally slightly variable in width (Fig. 10.74). This seems to corroborate the variety observed in earlier periods within one string.[1] There are some small gold beads on the inner bead string adjacent to the *nefer*-shaped pendants and larger gold ring beads separating the main gold and stone beads on this string (Fig. 10.74).

The small gold ring beads are similar in form but of slightly variable dimensions ranging between 1.6 and 2.0 mm diameter and 0.8–1.13 mm wide for the nine shown in Figure 10.79a, and with different surface textures including filing to chamfer the profile and rounding of the edges by polishing. These tiny beads are each made from a single rectangular strip of gold, rolled into a ring with the ends butting together. No signs of solder were found at these joins.

These tiny gold beads are a key feature of some Egyptian goldwork. As in the necklace EA66827, the gold beads of diadem EA37532, from undisturbed grave 1730 at Abydos and dated to Naqada II (see Chapter 7.3.1), are even smaller, being only 1.0–1.3 mm in diameter (widths and diameters of several beads are provided in the table of Fig. 7.2). Their small size means that they have not had the finer smoothing and shaping of the beads edges compared to slightly larger beads of EA66827.

The small ring beads of all these strings were most likely made, several at a time, from a strip of gold sheet twisted around a thin rod of appropriate diameter, thus forming a long spiral. A single cut along the length of the gold spiral separates it into individual beads of the same diameter. This technique is illustrated in Figure 7.4 (Chapter 7.3.1). The cut ends are angled a little by this method, as is seen in Figure 10.79. Goldsmiths use this technique today to make large numbers of small 'jump' rings of wire. The fact that the Egyptian necklaces show a small range of bead widths in an object is simply accounted for by the production of these beads from slightly different sized hand-cut strips. In a workshop context, the various production batches from an individual or several individual craftpersons would become mixed.

While the attention of the study is focused mainly on the small gold beads, of equal importance are the tiny carnelian, lapis lazuli and glass beads of the same dimensions as the gold beads. The necklace EA66827 has eighty small carnelian beads and similar numbers of blue glass/lapis lazuli beads in the outer row arranged with the small gold beads into a polychrome design. The semi-precious stone beads including the larger nasturtium seed beads and longer bi-convex carnelian beads in the necklace (Figs. 10.73 and 10.74), are each individually crafted from hard materials by cutting, grinding, drilling the central holes and polishing. In particular, note in Figure 10.79b the rounded

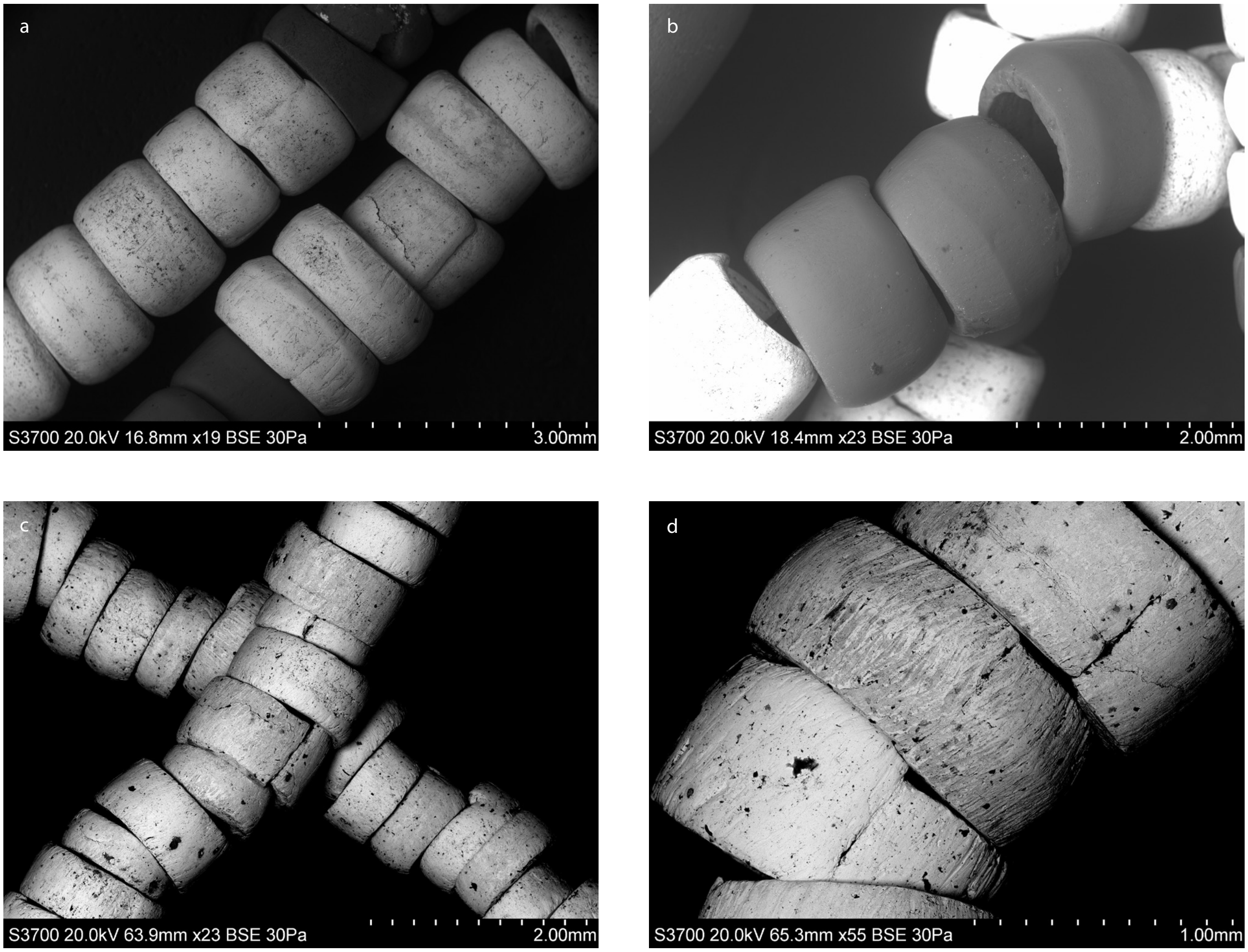


Figure 10.79. *SEM images of small ring beads (a) in gold and (b) other materials in necklace EA66827 and (c–d, for comparison) in gold in diadem EA37532, showing the variety of dimensions and surface textures from finishing processes (see Table 10.11 for EA66827 analyses and Chapter 7.3.1 for EA37532). No signs of solder could be observed in the butt joins. Note the chamfered and polished carnelian beads (b) and the range of diameters and widths of the beads and the small offset angle of the join cut on the central bead of EA37532 (c).*

chamfered edges to the carnelian beads that mimic very closely those of the gold beads in Figure 10.79a. The edges have been ground to the profiles and then polished to a smooth finish. Note also the large drilled hole seen in one bead, which is remarkable because the bead is only 1.9 mm diameter while the hole is 1.2 mm diameter. Illustrations of drilling are seen on Egyptian wall paintings, such as a scene in the painted tomb chapel of Vizier Rekhmira, *c.* 1504–1425 BC, excavated at Thebes, where a craftsman is drilling stone beads using a bow (Davies 1943, 49, pl. 54 row 1). This is a highly skilled and specialized craft for producing semi-precious stone and glass beads in large numbers and of high quality (Gwinnett & Gorelick 1993; Boonstra 2019, 84–5).

The gold alloys

The different components of the objects described above were analysed by using XRF and SEM-EDS. Data obtained were summarized in Tables 10.11 and 10.12, where can be seen that the gold components of strings EA66827 and EA14696 are made with gold alloys containing silver contents ranging from 11 to 30 wt% and 1–4 wt% Cu.

The compositions of the wallet-shaped and duck-shaped beads in string EA14696, made from alloys containing 11–15 wt% Ag and 1–2 wt% Cu, are quite similar, which would imply that they were all made from a fairly homogeneous gold batch and are indeed of one manufacture in time and place.

Table 10.11. *Results obtained by XRF and SEM-EDS for the two strings in the collection of the British Museum with the exception of the small ring beads in EA66827, which are provided in Table 10.12.*

Acc. No.	Method	Au wt%	Ag wt%	Cu wt%
EA66827				
nefer pendant 1	XRF	80	18	2
nefer pendant 2	XRF	80	19	1
nefer pendant 3	XRF	78	20	2
nefer pendant 4	XRF	79	20	2
drop pendant	XRF	74	24	2
nasturtium bead 1	XRF	75	23	2
nasturtium bead 2	XRF	82	16	2
ring bead 1	XRF	66	30	4
ring bead 2	XRF	67	29	4
ring bead 3	XRF	66	30	4
EA14696				
snake's head terminal	XRF	86	11	3
duck bead	XRF	85	14	2
wallet bead	XRF	85	14	1
lotus-flower terminal	XRF	86	12	2
solder on lotus-flower	SEM-EDS	79	12	10
duck bead 1	SEM-EDS	84	15	1
duck bead 2	SEM-EDS	84	15	2

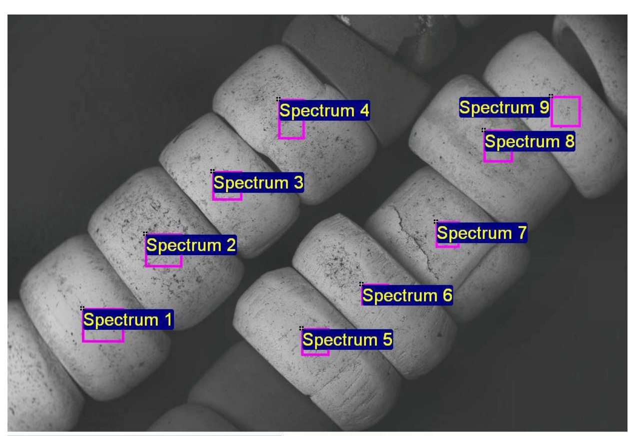
Necklace EA66827, a restrung necklace of beads found in the burial of the three foreign wives of Thutmes III, shows the use of different alloys, containing 16–30 wt% Ag and 1–4 wt% Cu, and thus of mixed batch manufacture. The *nefer*-shaped pendants appear to be a closer analytical group than the other components of the string. The compositions observed for all the components are within the range of alloys regularly employed in Egypt. In fact, the use in Egypt of alloys containing quite high silver contents has been observed for the objects dated to the different periods considered in this volume. In the case of New Kingdom productions, it is interesting to consider the group of jewellery from tomb 296 at Riqqa, discussed in Chapter 10.2, a burial containing a female body and the body of a scribe named Beri attributed by Petrie (1914) to the reign of Thutmes III. A quite wide range of silver amounts was observed in the gold alloys. The ribbed penannular earrings contain 7–12 wt% Ag and *c*. 1 wt% Cu and the necklace components are made using alloys containing 12–37 wt% Ag and 1–3 wt% Cu. The objects from Riqqa show equivalent ranges of composition to those discussed in this section.

It is also interesting to consider the objects analysed by M. Wypyski (Lilyquist 2003, 342) from the tomb of the three foreign wives of Thutmes III, which show the presence of quite high silver contents. The objects reported as ancient contain 20–65 wt% Ag and 1–6 wt% Cu. Data obtained for EA66827 match well the compositions observed for a large part of these objects. The unique drop pendant analysed contains 69.4 wt% Au, 28.8 wt% Ag and 1.8 wt% Cu, values that are very close to those observed for the drop-shaped pendant of necklace EA66827.

Gold alloys containing quite high silver contents were also used in the production of New Kingdom gold leaf. For example, analyses carried out by W. Pollard (in Quibell 1908, 77–9) on samples from the tomb of Yuaa and Thuiu at Thebes show the use of gold alloys containing 2–20 wt% Ag. The production of gold leaf used for gilding normally has very low silver. This is a practical choice by goldsmiths because high purity gold is soft, being the most malleable of metals, and has a unique characteristic and being able to withstand hammering processes without any form of annealing that allows it to be stretched and thinned

Table 10.12. *Results obtained by SEM-EDS for the small ring beads in necklace EA66827, shown in the image below.*

Acc. no.	Au wt%	Ag wt%	Cu wt%
EA66827			
small ring bead 1	74.2	22	3.8
small ring bead 2	72.7	24.6	2.7
small ring bead 3	85.5	13	1.5
small ring bead 4	75.1	23.1	1.8
small ring bead 5	86.9	10.5	2.6
small ring bead 6	90.5	8.1	1.4
small ring bead 7	69.8	28	2.2
small ring bead 8	71.7	24.5	3.8
small ring bead 9	90.8	7.6	1.6



into very thin foils and beyond down to gold leaf of less than 0.5 microns thick.

The results obtained by SEM-EDS for 9 adjacent small gold ring beads in necklace EA66827 of similar form, with well-rounded edges and slight variation in size, are shown in Table 10.12. The analysed areas are identified in the image. Arguably, they could be divided into two groupings that correspond generally to 7.6–13 wt% and 22–28 wt% Ag. These small ring beads should have been made in large quantities by different craftsmen and were perhaps reused to make other strings, as discussed in Chapter 7.

Similarly to what was observed for the majority of the jewellery studied in this volume, the use of alluvial gold was confirmed by the presence of PGE inclusions. These inclusions were observed under the stereomicroscope for several components of the strings, in particular at the surface of the small ring beads in necklace EA66827 and the wallet-shaped beads in string EA14696.

The joining processes employed to mount the objects were also investigated by SEM-EDS. Data obtained for the lotus-flower terminal in string EA 14696, included in Table 10.11, shows that this component is soldered with an alloy obtained by addition of 10% Cu, which is significantly more than in the lotus flower body. This technique, which was shown by Roberts (1973) to be used in Egypt during the New Kingdom by analysis of one gold sequin in the collection of the British Museum, has been regularly observed for the items studied in this volume. This is also the technique observed for the objects from the tomb of the three foreign wives of Thutmes III (Lilyquist 2003, 342).

Notes

1. One example is diadem EA37532 from tomb 1730 at Abydos dated to Naqada II, discussed in Chapter 7.3.1. Several strings containing tiny beads, dated to the First Intermediated Period and excavated at Qau and Badari, are discussed in Chapter 7.3.2.

References

For references see pp.445–8 at the end of this chapter.

Chapter 10.7

On beads, pendants, scarabs and chains dated to the New Kingdom

Maria F. Guerra & Stephen Quirke

In order to obtain more information on the gold alloys and on the technologies of making jewellery used in the New Kingdom, scarabs, pendants, chains and strings of beads dated to this period in the collections of the Petrie Museum and the Louvre Museum were selected for analytical study of the gold components. Wherever possible, these objects are contextualized and typologically related to objects and components of objects discussed elsewhere in this volume.

Therefore, we selected from the collection of the Petrie Museum one string containing two scarabs set in gold mounts, one hollow metal scarab and one gold scorpion-shaped pendant from excavations at Madinat al-Ghurab (UC45602) and four *nefer*-shaped pendants (UC38580) from tomb 406 excavated at Sidmant. Another contextualized object studied in this chapter is one chain in the collection of the Louvre Museum that was found in the burial of Khamwaset at Saqqara (E2990A). From the same collection we selected one unprovenanced string of beads in lapis lazuli and gold (E22658) containing among other components tiny gold beads. Lastly, also from the collection of the Petrie Museum we studied one gold cartouche (UC12323) inscribed with the throne-name of Amenhotep III (Nebmaatra).

Technological study

Chain E2990A

One group of jewellery found by Auguste Mariette during the excavations of the Serapeum at Saqqara (Mariette 1857, 15–16), shown in Figure 10.80 (Mariette 1857, pl. 20), entered the collection of the Louvre Museum in 1852 (Monnot 2015). It was thought to have been found with the body of the grand priest Khamwaset, buried apparently at the catacomb among the sacred Apis bulls, the incarnation of Ptah. This group of jewellery includes one gold inlaid pendant, one gold inlaid pectoral with a vulture with outstretched wings (E2988), made from a quite pure gold alloy containing *c.* 99.5 wt% Au (Bouquillon 1995), and two gold chains found around Khamwaset's neck, one of them containing three amulets. It is the latter that was selected for study, the inner one in Figure 10.80. The amulets were removed before study.

E2990A is a simple loop-in-loop chain made with gold links. This simple technique is one of the earliest methods of chain manufacture (Ogden 1982, 57–8) and was early in use in Egypt. Petrie (1910, 86, fig. 94) reports the find of one of these chains in one burial at Mahasna dated to the 6th Dynasty.

One detail of the gold links is shown in Figure 10.81. The links were produced individually: gold wire was cut into equal length pieces, each length was bent into a ring and the ends soldered to complete a link. The manufacture process (Ogden 1992b) can be seen step-by-step for instance, in Stark & Smith (1997, 23–7). After soldering, the links were compressed to an oval or figure-of-eight shape. The first link was folded in half and the next threaded through its loops and folded, thus building up the required length of chain. Figure 10.81 shows the thick joints revealing the use of hard soldering processes and shows the helicoidal (or spiral, Ogden 1991) seams on the gold wires that seem those typical of the use of strip-twisting.

Nefer-shaped pendants UC38580

The hollow gold *nefer*-shaped pendants UC38580 in the collection of the Petrie Museum are recorded in the museum register as being four of the six found inside tomb 406 excavated at Sidmant (Petrie & Brunton 1924, pl. 57). The tomb (shaft with chamber) was not intact, so it is not certain how many burials it originally contained, but the excavators found a plain wood coffin (form not specified), the lid missing, and reeds over a mummified body (identified as that of a woman) with

Figure 10.80. *The group of jewellery found by Auguste Mariette with the body of the high priest Khamwaset in the Serapeum of Saqqara (from Mariette 1857, pl. 20). Chain E2990A in the collection of the Louvre Museum is the one with the two pendant amulets.*

jewellery specified as found (a) under head: broken bronze ring with steatite (?) scarab; (b) at neck: blue glass Hathor head pendant, gold *nefer* pendants, and lotus beads; (c) at wrists: red, blue, white, green beads (from the colours, presumably faïence), and the seal-amulets (10 scarabs, 6 plaques, jasper and carnelian cowroids) including ones with the names of Thutmes IV and Amenhotep III. The other finds were baskets, dom-palm fruits, pottery including an amphora with an inscription (no longer legible) that Petrie read as Horemheb, and a cosmetic jar in the form of the head of the god Bes, wood cosmetic shell and kohl stick, calcite kohl pot, broken ivory comb, fragmented mat, wood ear-plug and ivory ear-plug.

Based on the seal-amulets with the names of Thutmes IV and Amenhotep III, tomb 406 was initially dated to the 18th Dynasty (Petrie & Brunton 1924, 25), but the group was recently re-assessed by H. Franzenmeier (2017, 1188–98) who concluded on a slightly wider date-range for the finds as late 18th Dynasty to early 19th Dynasty, possibly a burial containing earlier material.

The small *nefer*-shaped pendants UC38580, *c*. 1.2 cm long, are quite similar to three pendants of the same form contained in necklace EA66827, which were discussed in Chapter 10.6. All the four pendants are made using the same technique. They are assembled like a box, by soldering a flat gold back sheet to an embossed gold tray. The edge of the flat back sheet folded over the embossed gold sheet is shown in Figure 10.82. One hole in the back of the pendants allows air to escape during the soldering process. The suspension rings at each end of the box are made by cutting and shaping an extension of the back sheet then bending this into a loop. The back of one of the suspension rings is shown in Figure 10.82. Under the

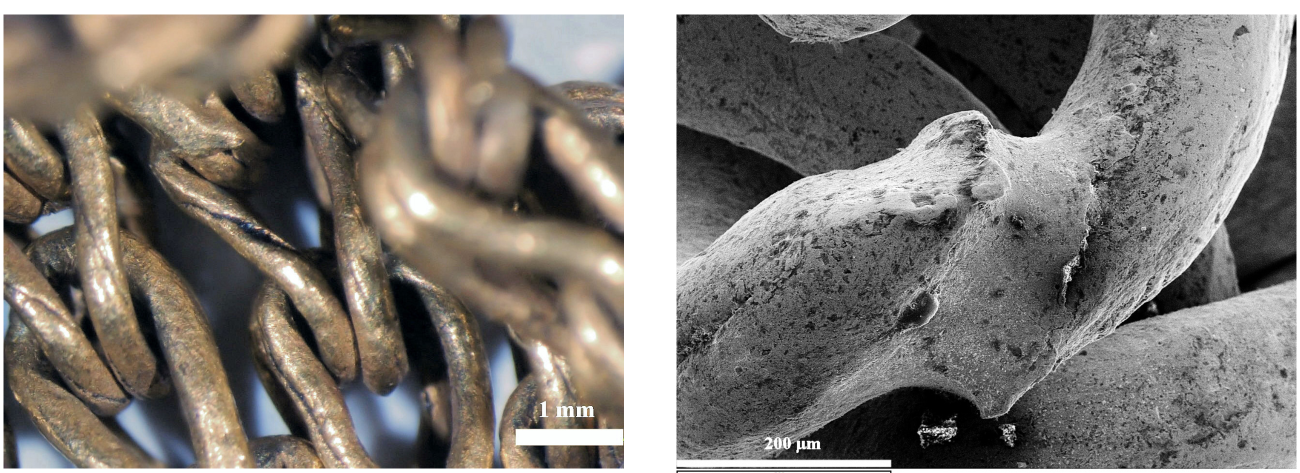


Figure 10.81. *Details of the loop-in-loop chain E2990A showing the longitudinal seams typical of the use of strip twisting and the thick soldered joint of the links.*

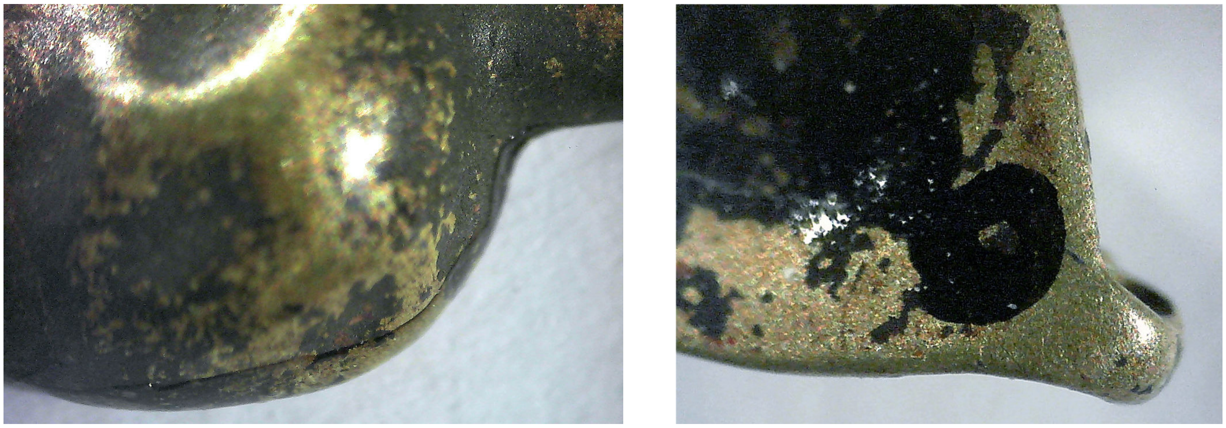


Figure 10.82. *Details of one of the* nefer*-shaped pendants in the collection of the Petrie Museum (UC38580) from excavations at Sidmant showing the overlapping joining of the front and back sheets and the back of the suspension ring made by rolling the cut gold sheet.*

stereomicroscope, no signs of soldering could be found between the ring and the gold sheet.

The pendants are partially covered with (undetermined organic) compounds remnant from the burial process, explaining the blackish areas on the objects surface and perhaps the fact that no PGE inclusion could be identified. Some (brownish and blackish) corrosion products might also have formed on the pendants surfaces, because the gold alloys contain relatively high silver contents (see Table 10.13 and discussion below).

String UC45602

String UC45602 in the collection of the Petrie Museum is a restrung series of New Kingdom components in diverse materials from excavations at Madinat al-Ghurab, but the find place within the site is not documented.

Among the strung components, shown in Figure 10.83, are contained four in gold: two scarabs set in gold mounts, one hollow metal scarab, and one gold scorpion-shaped pendant.

The scorpion-shaped pendant is a hollow construction made by joining two gold sheets. The back sheet is flat and the front sheet is embossed with the animal's details. The scorpion motif is finished by chasing. The edges of the flat back sheet are folded over the sides of the embossed gold sheet forming the join (Fig. 10.84). A gold strip bent into a loop was soldered to the animal's head to serve as suspension ring. The embossed gold sheet is cracked in several areas where it is thinner (around a chased line, for example, as shown in Fig. 10.84), showing the presence of an unidentified filler inside the box.

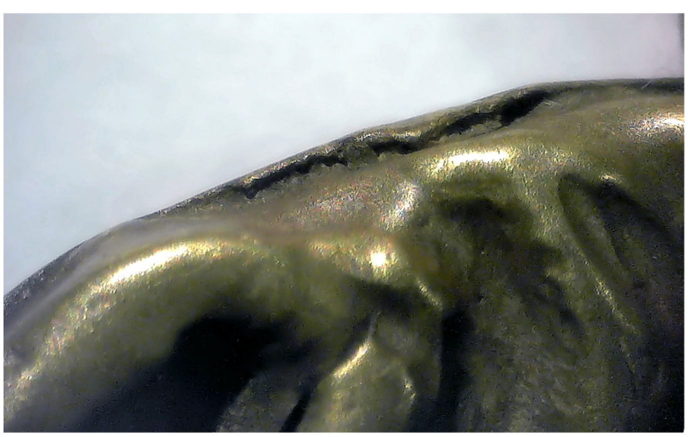
The two glazed steatite scarab seal-amulets set in gold mounts are different (Fig. 10.83 nos. 1 and 2). The largest (no.1) is a finely carved scarab set in a mount that consists of a gold band retaining the scarab inside the gold frame (Fig. 10.85). At both ends of the gold frame was soldered an undecorated round collar showing signs of use-wear. These are quite common mounts in Egypt for swivelling rings with scarabs (see Chapter 10.4).

Similarly to the instance in Chapter 9.4 with a blue scarab in a gold mount showing signs of intense use-wear and bearing the name of Ahhotep (E3297), we can suggest that the big scarab (no. 1) in string UC45602 might have originally been the bezel of a swivelling ring. Incomplete swivelling scarab rings are reported (Williams 1924, 86–7, pls. 8–22) and lone scarabs set in gold mounts might result from corrosion during burial of the shank made from less noble metals. Two glazed steatite scarab rings in the collection of the Metropolitan Museum of Art found in the New Kingdom burial of Neferkhawet, excavated at Thebes, illustrate this possibility. One of these rings (MMA 35.3.104) consists of a scarab set in a gold frame with undecorated gold collars mounted on a highly damaged silver shank. The other (MMA 35.3.105), because it is set in a silver frame and mounted on a silver shank is in several damaged parts.

The second glazed steatite seal-amulet set in a gold mount (no. 2 in Fig. 10.83) is a more schematic scaraboid. This smaller seal-amulet is set in a gold open frame mount that consists of a gold sheet roughly cut on the back to which is soldered a gold side wall decorated with raised punched dots imitating half-granules, which are not well aligned (Fig. 10.86). At each end of the corroded tray is soldered a cylindrical undecorated collar. The metallic parts are of much less skilled work when compared to the largest scarab in the same string (no. 1), perhaps indicating repair for a funerary function.

Figure 10.83. *String UC45602 in the collection of the Petrie Museum, including several New Kingdom components from excavations at Madinat al-Ghurab, among which two scarabs set in gold mounts (nos. 1 and 2), one hollow metal scarab (no. 3), and one gold scorpion-shaped pendant.*

Finally, the third scarab in string UC45602 (Fig. 10.83 no. 3) consists of two metal sheets, one forming the animal's body and the other a tray with a wave-shaped cut border. Damaged and discoloured by corrosion, this hollow metal scarab lost part of the front sheet and many decorative details (Fig. 10.87). At each end of the tray was soldered an undecorated cylindrical collar. The back sheet is inscribed with a motif of a frontal figure with flexed legs, the iconography of the god Bes, protector at childbirth.



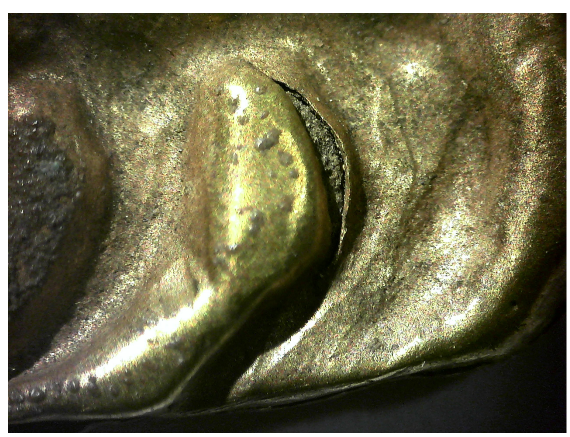


Figure 10.84. *Details of the scorpion-shaped pendant in string UC45602 showing the joining of the front and back sheets and the cracks in the scorpion's tail where the presence of an internal filler is visible.*

Figure 10.85 *(right). The biggest scarab in string UC45602 (Fig. 10.83, no. 1) is set in a gold open frame mount with collar. Details of the mounting are shown.*

Figure 10.86 *(above and right). The smallest scarab in string UC45602 (Fig. 10.83 no. 2) is set in a gold open mount inaccurately cut and with a decoration consisting of a raw of embossed half granules.*

Figure 10.87 *(left). The heavily corroded hollow metal scarab in string UC45602 (Fig. 10.83, no. 3).*

Cartouche UC12323

Cartouche UC12323, in the collection of the Petrie Museum, is a thin gold sheet inscribed with the throne-name of Amenhotep III (Nebmaatra). As shown in Figure 10.88, the ripped sheet has several perforations. Petrie (1917, no. 18.9.69, pl. 33) suggested that the holes were made for attaching the gold sheet to a garment. Textiles found in the tomb of Tutankhamun, for example, are decorated with gold, by sewing holed rosettes and sequins onto the cloths (Vogelsang-Eastwood 2000). However, cartouche UC12323 appears to be cut, or perhaps torn, from a larger gold sheet and could have originally been part of another type of object. One possibility is a gold sheet from a wood piece attached to the support by small gold or silver nails long enough to pierce both the sheet and the wood core. This technique is described by Killen (2017, 7, pl.1) for a bedframe (EA 21574) in the collection of the British Museum said to be from the tomb of Ramses IX (Dreyfus 2005). As for other gold sheets studied in this volume, we could not identify the presence of PGE inclusions on the surface of the gold cartouche.

Figure 10.88. *Gold sheet with the cartouche of Amenhotep III (Nebmaatra) in the collection of the Petrie Museum (UC12323).*

String E22658

Lastly, we studied one string in the collection of the Louvre Museum containing, among other components, tiny gold beads of different widths, diameters and colours.

Atherton Louise and Ingeborg Curtis donated unprovenanced string E22658 to the Louvre Museum in 1938. Details of the string can be seen in Figure 10.89. It contains twenty-five lapis lazuli barrel beads of different sizes and one triangular pendant, also in lapis lazuli, that is placed between one half of a gold spherical bead and one half of a gold lenticular bead, as shown in Figure 10.90. In this figure can also be seen four small cylindrical beads of different dimensions. The tiny gold beads are strung by groups, in general by four, between two lapis lazuli beads. The other gold components of string E22658 are three halves of spherical beads, four lenticular beads made by soldering two embossed halves, and one granulated disc bead made by joining six granules (Fig. 10.90).

Figure 10.89. *Some of the gold components of string E22658, in the collection of the Louvre Museum.*

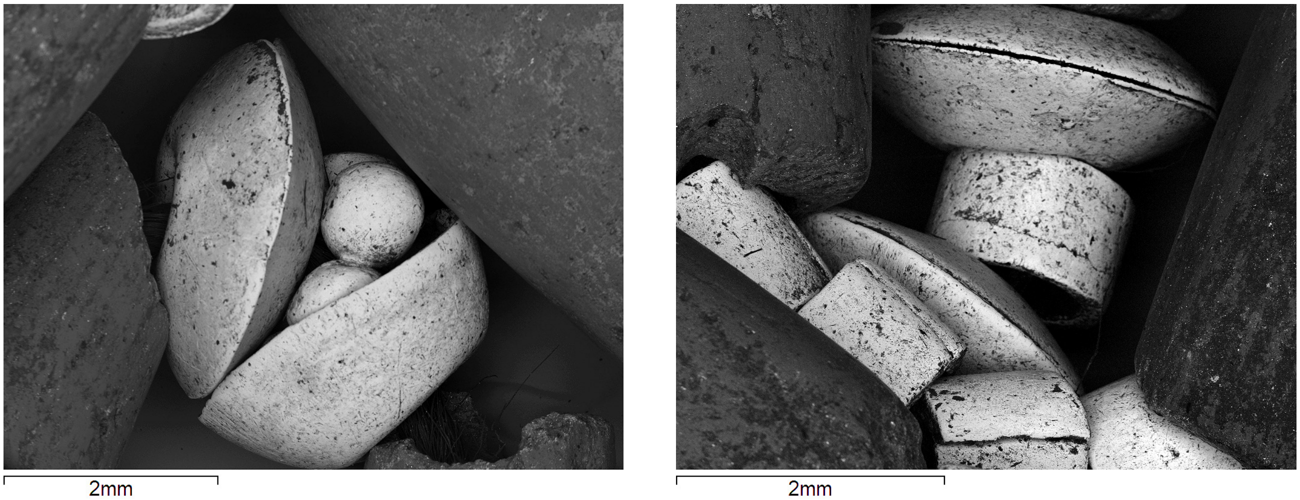


Figure 10.90. *Details of string E22658 showing one half of a spherical bead, lenticular beads, small cylindrical beads and the granulated bead made by soldering six granules.*

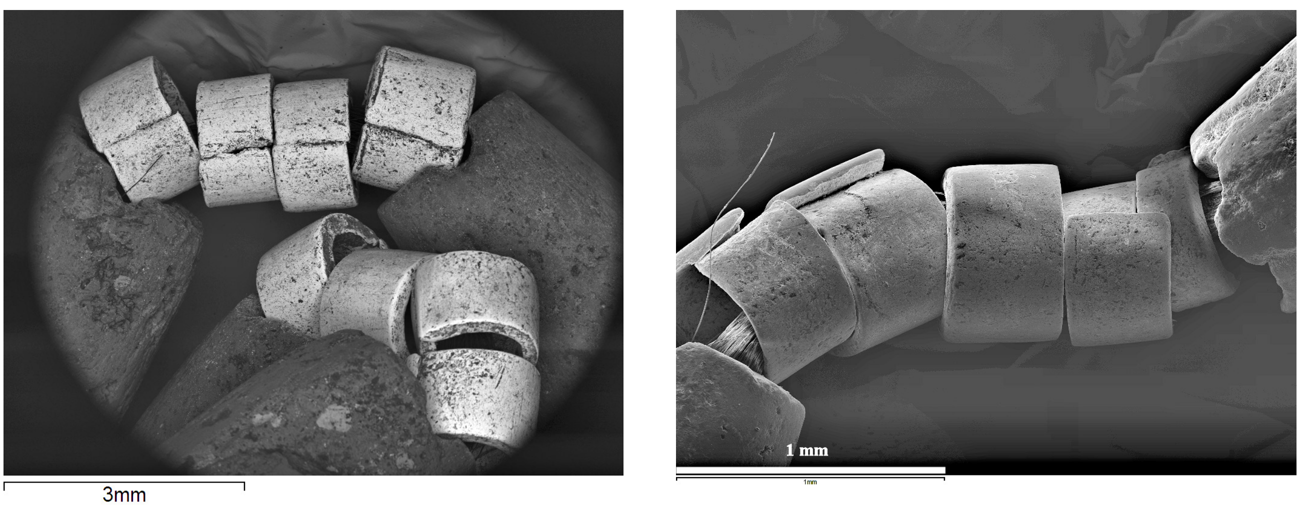


Figure 10.91. *The variety of forms and dimensions of the tiny gold beads in string E22658.*

Several small ring beads are shown in Figure 10.91. Their small dimensions, only 1.0–1.5 mm in diameter, can be appreciated under the SEM. The majority of the tiny beads in string E22658 are cylindrical, but a few are ring beads. Figure 10.91 shows one of them. This observation is consistent with the variety observed within strings studied in this volume, dated either to the New Kingdom or to earlier periods. However, in this case the variety might originate from a restringing of various components.

In addition to different dimensions, the tiny beads in string E22658 also show different colours. Some of them show in addition marks of wear. As with the tiny beads of string EA66827 discussed in Chapter 10.6, those in string E22658 were made from strips of gold wrapped around a rod former and then cutting longitudinally to release the individual beads (see also Chapter 7.3). No signs of solder were found at the joins.

The gold alloys

The different components in gold of the objects described above were analysed by using XRF, μPIXE and SEM-EDS. The technique employed depended on the equipment available for analytical study for each collection and on the required spatial resolution for individual parts of the jewellery. The data obtained, summarized in Tables 10.13 and 10.14, represent well

Table 10.13. *Results obtained by XRF, PIXE and SEM-EDS for the New Kingdom objects in the collections of the Louvre Museum and the Petrie Museum. Data obtained for string E22658 can be seen in Table 10.14.*

Acc. No.	Method	Au wt%	Ag wt%	Cu wt%
E2990A				
chain link 1	PIXE	97.1	2	0.9
chain link 2	PIXE	96.5	2.4	1.1
chain link 3	PIXE	95.8	3.4	0.8
chain link 4	PIXE	97.5	1.3	1.2
chain link 5	EDS	97.6	2.4	0
solder on link 5	EDS	73	25	3
chain link 6	EDS	95	3.9	1
solder on link 6	EDS	84	13	3
UC12323	XRF	80.6	17.9	1.6
UC45602				
scorpion front	XRF	43.7	52.8	3.5
scorpion back	XRF	42.9	53.9	3.2
big scarab frame (no 1)	XRF	85.5	13	1.5
small scarab frame (no 2)	XRF	44.5	51.1	4.5
metal scarab (no 3)	XRF	36.8	57.2	6
UC38580				
nefer pendant 1 back	XRF	74.3	23.8	1.9
nefer pendant 1 front	XRF	74.8	23.4	1.8
nefer pendant 2 back	XRF	70.1	28.6	1.3
nefer pendant 2 front	XRF	72.8	25.3	1.9
nefer pendant 3 back	XRF	66.9	31.3	1.8
nefer pendant 3 front	XRF	66.5	31.7	1.9
nefer pendant 4 back	XRF	69.1	29	1.9
nefer pendant 4 front	XRF	68.9	29.5	1.6

Table 10.14. *Results obtained by SEM-EDS for the different components of string E22658.*

E22658	Au wt%	Ag wt%	Cu wt%
lenticular beads			
bead 1	46	52.4	1.6
bead 2	49.4	48.2	2.4
bead 3	46.2	53.8	0
solder 1	35.3	61.6	3.1
solder 2	34.7	61.6	3.7
solder 3	39.7	56.5	3.9
half lenticular bead			
bead 1	31.8	64	4.1
bead 2	31.2	65.1	3.6
half spherical bead			
bead 1	63	35	2
bead 2	62.4	35.3	2.3
granulated bead			
granule 1	74.6	24.4	1
granule 2	76	22.2	1.8
granule 3	75.5	22.6	1.9
solder 1	72.6	25.5	1.9
solder 2	67.1	31	1.9
ring beads			
bead 1	98.2	1.8	0
bead 2	97.9	2.1	0
bead 3	97.6	2.5	0
bead 4	97.2	1.5	1.3
bead 5	97.1	2.4	0.6
bead 6	97	2	1
bead 7	96.8	2.7	0.5
bead 8	96.4	2.9	0.7
bead 9	96.3	2.7	1
bead 10	96.3	3.4	0.4
bead 11	96	3.4	0.7
bead 12	95.7	3.2	1.1
bead 13	95.6	3.8	0.7
bead 14	95.4	3.1	1.5
bead 15	94.6	4.1	1.3
bead 16	94.2	4.7	1.1
bead 17	94.1	3.4	2.6
bead 18	93.8	5.4	0.8
bead 19	93.1	6.3	0.6
bead 20	92.9	6.5	0.7
bead 21	92.7	6.3	1.1
bead 22	92.4	6.1	1.5
bead 23	91.7	7.3	1
bead 24	91.6	7.9	0.5
bead 25	90.8	9.2	0
bead 26	90.6	7.5	1.9
bead 27	88.6	9.6	1.8
bead 28	81.8	17.5	0.7
bead 29	80.8	18.4	0.8
bead 30	79.6	18.6	1.8
bead 31	79.3	14.2	6.6
bead 32	77.3	21.8	0.9
bead 33	67.2	31.3	1.6
bead 34	68.0	29.3	2.8

the variety of alloys employed in Egypt. While the loop-in-loop chain contains only 2–3 wt% Ag and almost no copper, the components of strings UC45602 and E22658 are made from alloys containing more than 50 wt% Ag.

The use in jewellery of alloys containing very low silver contents does not seem very common in Egypt. However, two other objects in the collection of the Louvre Museum excavated in the Serapeum at Saqqara are made with very pure gold alloy containing *c*. 99.5 wt% Au (Bouquillon 1995). One is a ram-headed falcon amulet (E80) and the other is Khamwaset's gold inlaid pectoral with a vulture with outstretched wings (E2988). A few more objects containing 95–98 wt% Au can be cited, for example the mask of king Tutankhamun (Uda et al. 2014), the earrings of the adult's mummy buried at Qurna (Chapter 9.2), the Naqada diadem EA37532 from Abydos (Chapter 7.3), and one Heh amulet from First Intermediate Period grave 1981 at Hammamiya (Gale & Stos-Gale 1981).

Therefore, loop-in-loop chain E2990A, containing 96–97 wt% Au is in agreement with the composition of the cited contextualized objects. In addition, the use of this soft gold alloy in the production of the chain might also be associated to the technology employed in the wire making. The longitudinal seams on the gold wires indicate the use of strip-twisting, using a thin gold sheet. In fact, high purity gold alloys were regularly used in the production of New Kingdom gold leaf, as shown by analyses carried out by Hatchfield & Newman (1991) at the Museum of Fine Arts Boston and data obtained for the gilded coffin and wooden stick of king Tutankhamun by Abdrabou et al. (2019) and Rifai & El Hadidi (2010).

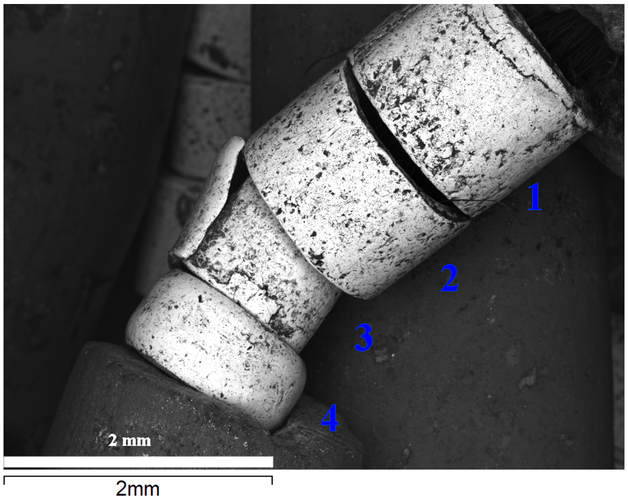
Three components of string UC45602 (the scorpion-shaped pendant, the small scarab and the hollow metal scarab) contain 51–57 wt% Ag and 3–6 wt% Cu and the lenticular beads of string E22658 contain 49–65 wt% Ag and 1–4 wt% Cu. Objects made from alloys containing more than 50 wt% Ag seem to have been regularly produced in Egypt. Several examples from Middle Kingdom and Second Intermediate Period contexts can be found in Chapters 8 and 9.[1] A few New Kingdom examples can also be cited, for example, two ribbed penannular earrings from Riqqa (see Chapter 10.3) and two objects from the tomb of the three foreign wives of Thutmes III (Lilyquist 2003).[2] It is also interesting to consider the pectoral with the cartouche of Ramses II in the collection of the Louvre Museum (E79), excavated in the Serapeum at Saqqara. This pectoral is made from a silver-rich gold alloy, containing 62 wt% Ag and 2 wt% Cu (Bouquillon 1995). Finally, it is interesting to evoke the pale yellow and whitish New Kingdom objects in the collection of the Ashmolean Museum analysed by Gale & Stos-Gale (1981, table 2), because they contain 49–82 wt% Ag and 1–11 wt% Cu.

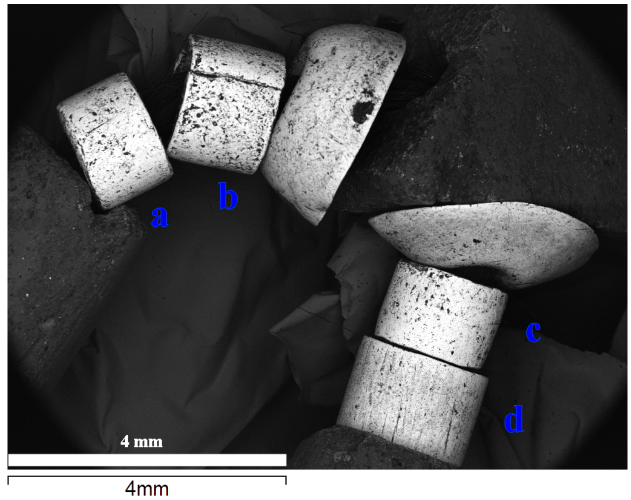
Cartouche UC12323, the largest scarab contained in string UC45602, the spherical and granulated beads in string E22658 and the four *nefer*-shaped pendants UC38580 from Sidmant are made from alloys containing moderately high silver contents, falling well within the range of amounts expected for native gold alloys from Egyptian deposits and quite often employed in Egyptian jewellery making.

The four *nefer*-shaped pendants UC38580 contain 24–31 wt% Ag and *c*. 2 wt% Cu, a composition fairly similar to the one observed for the *nefer*-shaped pendants and other components of necklace EA66827, discussed in Chapter 10.6, and to one drop-shaped pendant from the tomb of the three foreign wives of Thutmes III (Lilyquist 2003).[3] Three of them have very similar front and back sheet compositions. The fourth (no. 2 in Table 10.13) shows slightly different front and back compositions. However, each pendant is made from an alloy containing the same copper content, but a different silver amount. The relatively small variation of the silver contents observed for the four analysed pendants does not significantly change the nuances of their pale yellow colour. However, if they were originally six in the burial and if all of them were in the same string and made using alloys with different silver contents, the group might have originally been made to create a polychrome effect.

Finally, it is interesting to consider the composition of the tiny beads in string E22658. As mentioned, these beads are mostly cylindrical but have different dimensions. It can be observed in Table 10.14 that they also have different compositions. The silver contents range between 1.5 and *c*. 30 wt% and the copper contents are in general under 2 wt% (only 3 of the 34 analysed beads contain higher amounts). Despite the differences observed for the compositions of four adjacent beads, shown in Figure 10.92, three cylindrical (nos. 1–3) and one ring shaped (no. 4), the variety of compositions observed in the whole string does not result from the presence of different types of tiny beads. One, contained in a group of cylindrical beads, shown in Figure 10.92 (named d), has a different composition from all the others.

We plotted in Figure 10.93 the copper and silver contents obtained for all the analysed tiny beads with the values obtained for the other analysed items. We can see that the tiny beads can be separated into two groups. The first group, containing the highest number of beads is characterized by low silver contents, under 10 wt%. The other group includes the beads containing 9–30 wt% Ag, matching the composition of the





Bead no.	Au wt%	Ag wt%	Cu wt%
1	90.8	9.2	0.0
2	96.3	3.4	0.4
3	91.6	7.9	0.5
4	79.6	18.6	1.8

Bead no.	Au wt%	Ag wt%	Cu wt%
a	95.4	3.1	1.5
b	96.0	3.4	0.7
c	97.9	2.1	0.0
d	80.8	18.4	0.8

Figure 10.92. *Groups of tiny beads in string E22658 of different types, dimensions and compositions. The ring bead (4) has a different composition from the three adjacent cylindrical beads (1–3) and three other beads (a–c) in another group of cylindrical beads, but the biggest one (d) has the same composition.*

nefer-shaped pendants and two of the half spherical beads in string E22658.

In Figure 10.94 we plotted with our objects those considered ancient from the tomb of the three foreign wives of Thutmes III in the collection of the Metropolitan Museum of Art (average compositions) and the necklace EA66827 discussed in Chapter 10.6, because it contains *nefer*-shaped pendants and tiny beads. We can see that they are all contained in the range of alloys observed for our objects, but those in the Metropolitan Museum of Art contain higher silver contents, similarly to three of the four components of string UC45602 and the lenticular beads of string E22658.

In contrast to what has been regularly observed for the objects studied in this volume, many of the items studied in this chapter did not reveal under the stereomicroscope the presence of PGE inclusions. Their absence in New Kingdom jewellery can be explained by the expansion since the beginning of the New Kingdom of the gold mining regions in Egypt (Klemm & Klemm 2013, 606–9). The workshops supplies in gold might have contained an increasing quantity of mined gold resulting in the 'dilution' of gold from alluvial deposits (perhaps in increasingly lower quantity) in the 'workable gold mass' accessible for jewellery making.

It is also noticeable that the joining process employed to mount the links of loop-in-loop chain E2990A and the lenticular and granulated beads of string E22658 is the same that has regularly been observed for the objects studied in this volume and for published New Kingdom items,[4] but based on solder alloys of different composition. The hard soldered links of chain E2990A have quite thick joins. Under the SEM we could observe a small increase of the copper contents in the joins, but, when compared to the wire composition, it is the silver contents that significantly increase in the analysed areas. This soldering process was already observed for finger-ring N747, bearing Horemheb's cartouche, reported in Chapter 10.4.4. The same process is observed for the lenticular beads and the granulated bead in unprovenanced string E22658. In contrast to the chain links, these beads show very thin joins.

An equivalent process was employed in the decoration of 12th Dynasty cylinder amulet from tomb 211 at Haraga (UC6482). As discussed in Chapter 8.5, the granulation pattern was applied on the gold tube of this amulet by using a solder containing high silver amounts (13–22 wt%, see Table 8.12), which was suggested to be an imported Near Eastern technology,[5]

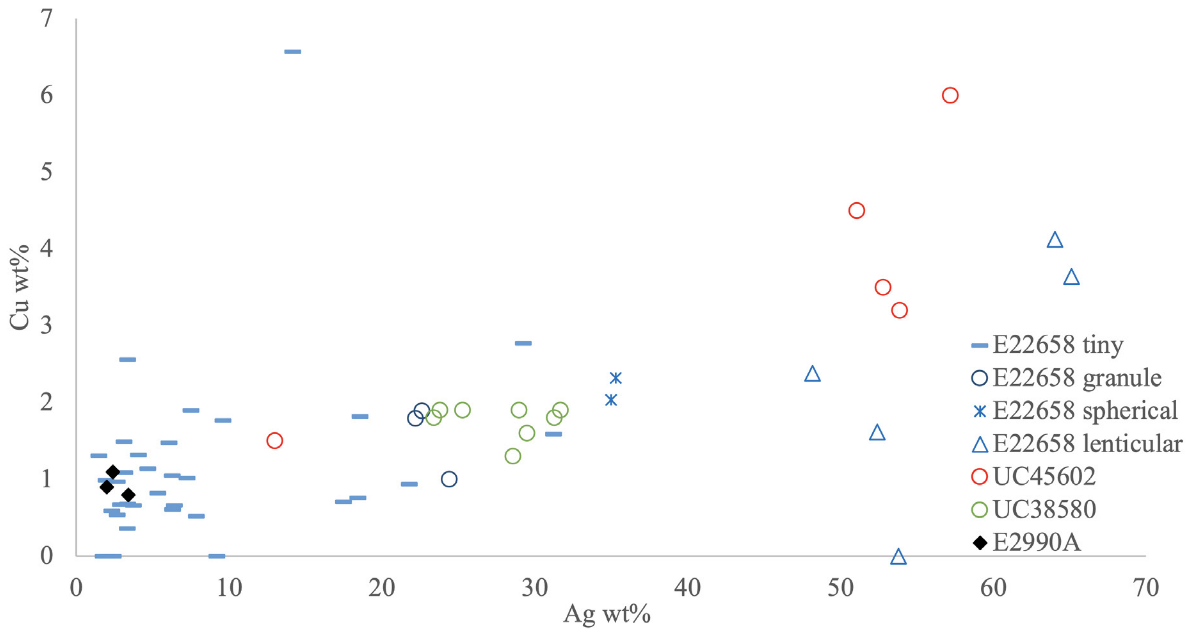


Figure 10.93. *Silver versus copper contents obtained by μPIXE, XRF and SEM-EDS for the New Kingdom strings, chain, sheet and pendants in the collection of the Louvre Museum and the Petrie Museum.*

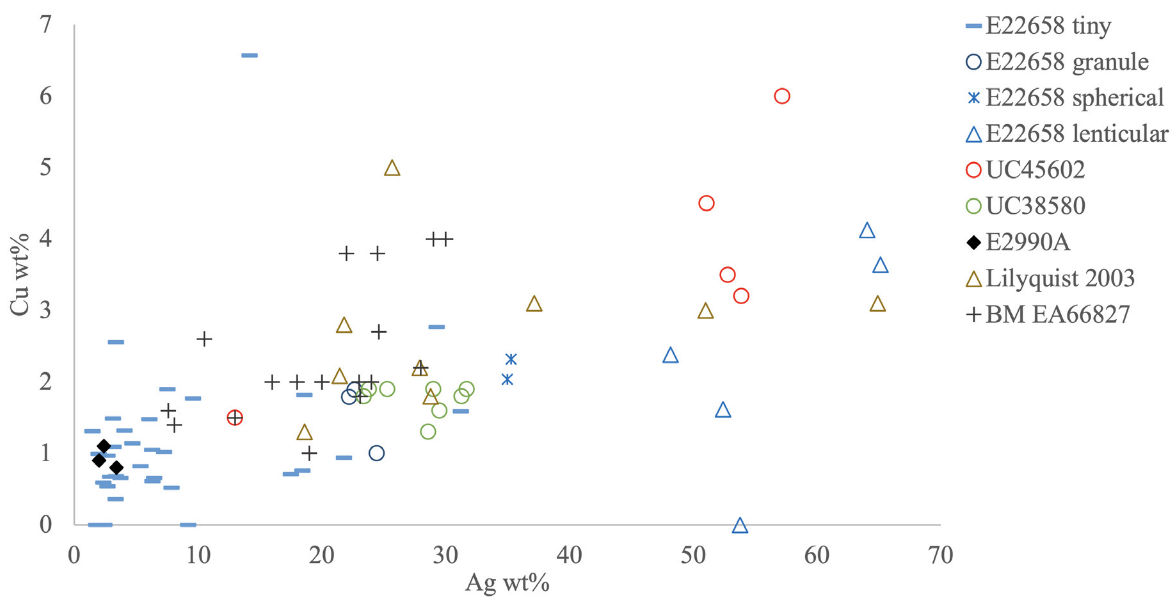


Figure 10.94. *Silver versus copper contents for the objects plotted in Figure 10.93, those (average) considered ancient from the tomb of the three foreign wives of Thutmes III (Lilyquist 2003) and necklace EA66827 in the collection of the British Museum discussed in Chapter 10.6.*

despite the few data available on solder alloys. In fact, E. A. Smith (1930) suggested the use of solders containing high silver contents in objects excavated at Ur and the Late Uruk gold dog-shaped pendant from Susa is soldered with a gold alloy containing higher silver and copper contents than the animal's body (Duval et al. 1987; Eluère 1998).[6]

It is not surprising to find the use in the New Kingdom of a large variety of alloys and techniques in the production of jewellery. A broad trade in the

Eastern Mediterranean area during this period is well documented by, for example, the cargo of the Uluburun shipwreck (Pulak 1998) that also includes items in gold. Among the latter, is a small scarab bearing the name of Nefertiti (Pulak 2008). This circulation of raw materials and objects should go together with the circulation of skilled workers, who certainly brought new expertise to many Egyptian workshops.

Notes

1. The compositions match closely those observed for the whitish parts of the polychrome fish pendant from tomb 72 at Haraga (Chapter 8.4) and the components of the Qurna adult's girdle (Chapter 9.2).
2. The ribbed penannular earrings contain 47–48 wt% Ag and 3–5 wt% Cu and the objects reported as ancient from the tomb of the three foreign wives of Thutmes III contain 20–65 wt% Ag and 1–6 wt% Cu.
3. The drop pendant (MMA 1988.17) contains 69.4 wt% Au, 28.8 wt% Ag and 1.8 wt% Cu) and one segment of armlet from the same group of jewellery (MMA 26.8.124d) contains 69.8 wt% Au, 27.9 wt% Ag and 2.2 wt% Cu.
4. Those from the tomb of the three foreigner wives of Thutmes III (Lilyquist 2003) and one gold sequin in the collection of the British Museum (Roberts 1973).
5. Knowing that granulation appears in Egypt in the 12th Dynasty, as discussed in Chapter 8.
6. The gold dog-shaped pendant from Susa contains 9 wt% Ag and 1 wt% Cu and the solder used to add a suspension ring contains 15–20 wt% Ag and 5–6 wt% Cu (Duval et al. 1987; Eluère 1998).

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This book aims to provide a new level of synthesis in the study of gold jewellery made in Egypt between 3500 BC and 1000 BC, integrating the distinct approaches of archaeology, materials science and Egyptology. Following accessible introductions to the art and use of gold in Ancient Egypt, and to current advances in technical analyses, the volume presents detailed results on the manufacturing technology and elemental composition of some 136 objects in the collections of six European museums, with discussion of the findings in historical and cultural contexts. The questions generated by the jewellery buried with a woman and a child at Qurna (Thebes) led to investigation of assemblages and individual artefacts from later and earlier periods in varied social contexts, from the rural environment of Qau and Badari, to sites connected with urban or royal centres, such as Riqqa, Haraga and Lahun. A final discussion of the Qurna group provides an agenda for future research.

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