GOLD AND IRON FINGER RING FROM A MIDDLE BRONZE AGE GRAVE IN SIDON

1 A gold and iron finger ring from a Middle Bronze Age grave of a female (burial 102) on College site in Sidon. This view is from an elevated angle near to the axis of the ring. It shows the plano-convex section of the iron band, now incomplete and apparently completely corroded. This figure also shows the gold sheet holding the ends of the sheet together to form a ring (fig. 4). The inner lining of the ring and the fine row of granulation along the upper edge of the ring, and the fine row of granules. The upper edge of the ring shows the gold band beneath the gold sheet comprising the inner lining of the ring is seen across the upper part of the image. A row of granules is seen in the centre. Across the lower part of the image (slightly out of focus because it is further away from the camera) is the outer edge of the wire that runs around the periphery of the main gold band beneath the row of granules. The field of view is approximately 3.5 mm from side to side.

Description and discussion of the manufacture of the ring

The finger ring comprises a broad gold band with two narrow bands of granulation (tiny gold spheres) that border both edges of the ring. Between the two bands of granulation is a broad band of iron with a plano-convex section. Although the iron band is now incomplete and appears to be entirely corroded, it is likely that in use it would have been a complete metallic iron band and have been silver grey in colour, standing out in handsome contrast against the peripheral bands of gold granulation.

In the Sidon ring it seems as though iron is being treated as a "jewel" and the gold is used as a setting, albeit a very elegant setting, for the iron. Based on the number of known excavated gold alloy objects from the period, gold appears to have been much more common than iron. It is of course the case that the marked difference in susceptibility to corrosion between gold and iron will have distorted the picture by differential survival. Nevertheless, it seems likely that iron (whether meteoric or smelted) was very rare in this period. This view is further supported by records of iron being included in tribute to Egyptian pharaohs in the time of Amenhotep III and Amenhotep IV (see below).

The ring measures approximately 0.7 cm between what would have been its proximal and distal edges when it was worn. (In other words, the height between the upper and lower edges when the ring is rest-
Maryon reports that the techniques and skills of soldering fine spherical granules (granulation) and wires (filigree) of gold and silver to make the finest decoration appear to have been lost at various times in the past. Many attempts were made in the nineteenth century to copy the finest ancient filigree and granulation. Eventually a Mr. Littledale devised a method of fixing the granules or wires in place with small amounts of a mixture of copper carbonate and glue. When heated, the glue turns to carbon which then reduces the copper salt (which may previously decompose to copper oxide) to copper. The copper diffuses into the gold to form a fine film of solder just where needed by reducing the melting point of the alloy into which the copper has diffused.

Ogden believes that this type of technique was probably used for much granulation work in ancient times. He notes, however, that in some cases (such as a gold cylinder pendant from Harageh in Egypt now in the Petrie Museum at University College London (UC6482) a silver-based solder may have been used to fix the granulation. Investigations into the granulation-decorated gold jewellery found in Troy by Schliemann confirm the use of reaction solders for granulation in the Early Bronze Age.

In some areas on the Sidon ring, the relatively thin main band of gold looks as though it may have been partly folded over the top of the granules. This might reflect a slight error in the positioning of the soldered wire bands with respect to the edge of the main band, leaving the row of granules slightly beneath the edge of the main band. On the other hand, the apparent slight folding of the main band over part of the granules is only seen in some parts of the periphery and seems more likely to be the result of wear during use (fig. 6). It is clear that the ring was worn for quite some time in life as a good number of the granules show clear signs of wear.

Scratches on the wire under the granules (fig. 5 and fig. 6) may also have arisen during use. In terms of inferring the manufacturing process used in making the ring, it may be noted that the forging of the plano-convex section of the iron band would have required considerable heat during hot working and would have required heavy beating. This could hardly have been conducted with the soft and delicate gold and solder components already in place. Some of the working of the iron might have been done cold but a metallographic section of uncorroded metal would be required to distinguish hot working from cold working. Due to corrosion, it is not possible to determine whether the two ends of the iron band were welded together into a ring.

Heat would also have been required to solder the main part of the gold ring, to fix the peripheral wires and to fix the granulation, but not so much heat as to damage the gold components themselves, nor the iron. (The essence of a solder is that it is an alloy which melts below the melting temperatures of the adjacent alloys). Granulation was done under reducing conditions to allow reduction and minimize oxidation.

An alternative possibility for manufacture might be that the gold ring was made first and a slightly open iron ring then beaten closed around the gold ring by cold working. This would be feasible but less elegant than the iron ring was made first as this would allow it to be hot worked and possibly have the ends welded together (at around 700-10000 degrees centigrade) to form a continuous ring. The completed ring of harder iron could then readily be fitted with an inner gold band cut to length and soldered to match the inner circumference of the iron ring.

There are a number of early instances of iron being used with gold. Gold was used to inlay decoration on iron objects. Clay tablets from the Amarna Period refer, to the presentation by Tusratta, King of Mitanni, of two “hand-rings of iron, overlaid with gold” to Amenhotep III (around 1350 BC) and “ten rings of iron, overlaid with gold” to Amenhotep IV. Although the above examples attest to the use of gold and iron in rings, they may simply refer to the overlaying of gold foil on baser materials. This was a common technique, the use of which is attested, for example, in the cylindrical gold pendant found in the very same grave as the Sidon gold and iron ring. To the best of the authors’ knowledge, however, the design of the Sidon ring remains...
The origin of iron in early archaeological artefacts

There is much archaeological and archaeometallurgical interest in whether iron used in early periods was obtained by smelting iron ores or obtained from iron meteorites. Analyses of metallic meteorites show that they contain substantial amounts of nickel. Analyses of several hundred iron meteorites by Buchwald showed that none contained less than 5 wt% nickel. Although some contained up to about 35 wt% nickel, the great majority contained 5-15 wt% nickel.

Early metallic artefacts are sometimes analysed in an attempt to determine whether they are made of smelted iron or meteoric iron. Interpreting the analytical results is not, however, an entirely simple exercise as, depending on the nature of the ore, nickel can also be present in some smelted iron. Nevertheless, for artefacts in good condition, the nickel content remains a clue as no meteorites contain less than 5 wt% nickel and smelted alloys with more than a few percent nickel are rare. Whether an alloy with more than 5 wt% might be the result of smelting is still not clearly established.

As an example of analysis of an ancient artefact conducted in an attempt to investigate this question, an iron dagger from the tomb of Tutankhamun (dated to around 1355 BC) was analysed by non-destructive X-ray fluorescence spectroscopy of the surface and was found to contain about 2.8 wt% nickel. The surface of the dagger blade appeared to be in good condition so it was concluded that the dagger was not made from meteoric iron.

A complication in assessing whether an ancient iron artefact is made of smelted iron or meteoric iron is that the processes of corrosion can alter the proportions of iron and nickel remaining in the artefact. Ogden states that "long buried meteoric iron artefacts can have much, if not most, of the nickel leached from them." Because of this complication, it is sometimes assumed that very early iron artefacts are probably reworked meteoric iron, even if the nickel content in corroded areas is found to be below 5 wt%.

A relevant example in the present context is the analysis of corroded iron beads found in Predynastic graves at Gerzeh, 70 km south of Cairo and now in the Petrie Museum, University College London. Polished sections through the corrosion products were analysed by electron probe microanalysis using X-ray spectroscopy. These analyses were reported as finding 51-59 wt% iron, 0-0.2 wt% nickel and 0.03-0.5 wt% copper depending on the location analysed. The other components reported are probably contaminants from soil trapped in the corrosion. It was concluded that while the analytical results did not completely rule out a meteoric origin, the low nickel concentrations did not particularly support the argument previously made in favour of a meteoric origin.

Analytical results

Returning to the present case, the iron band around the Sidon ring now appears to be entirely corroded. A small speck of corrosion from the iron was loose in the sample container. This was subjected to non-destructive energy dispersive X-ray spectroscopy in a scanning electron microscope, primarily with the purpose of investigating its nickel content and the possible origin of the iron. These analyses were non-destructive analyses conducted directly on the fragment, not on a polished section as in the example above. Because of surface irregularities and large differences in porosity between the areas analysed, the results needed to be normalized to facilitate comparison. Out of 18 areas analysed, nickel was detected in only half of them. (If nickel was present in the areas where it was not detected, the level must have been below about 0.1 wt%). Elements attributable to soil contamination were found in all areas analysed. With normalized results including all elements detected (that is including those that are likely to have originated from soil contamination), the highest level of nickel found was 1.2 wt%. If the above concentrations were normalized on the basis of iron and nickel alone (in other words excluding the soil contamination elements and assuming the band was originally simply an iron-nickel alloy) and ignoring possible distortion of the ratio by corrosion, the nickel content in the band could have been around 3.5 wt%. This was the highest proportion of nickel to iron found in the very small flake of corrosion after 18 analyses of different areas: in half the areas analysed no nickel at all was detected. Only if severe depletion of nickel content due to corrosion can be assumed would such analyses be consistent with a possible meteoric origin of the iron on the Sidon gold and iron ring. The possibility of drawing more definitive conclusions must await a better understanding of the corrosion of meteoric iron and changes in nickel concentrations.

Conclusions

As regards the origin of the iron band on the Sidon ring, present understanding would allow the possibility that it was originally meteoric iron if much of the original nickel had been lost during corrosion processes. With the current state of knowledge, however, the conclusion has to be that it is not known whether the iron band on the Sidon ring came from a meteorite or from a smelted ore.

Whatever the origin of the iron, however, it remains the case that the
gold and iron finger ring found in the Middle Bronze Age grave at Sidon displays masterful craftsmanship in its manufacture. To the best of the authors’ knowledge, the ring is of a design hitherto unparalleled, furthermore a design that prior to corrosion would have had considerable aesthetic appeal.

The Sidon ring may be seen as displaying iron as a “jewel” in a setting of gold. Contrasting the values of today with those suggested by the Middle Bronze Age Sidon ring provides an interesting example of how the relative values accorded to different materials depend heavily on the cultural context, on the technological context and on availability.

To judge by the wear on the granulation, this gold and iron ring was a jewel worn for quite some time during the life of the owner. Whatever its significance to the wearer, it may be inferred that the ring held significance during the wearer’s life and not only in death. The significance of this remarkable ring as perceived in the culture in which it was worn is not known at present. Nevertheless, at least a little insight into the culture and society of an elite female in Middle Bronze Age Sidon may be gained by observing that the ring was much worn in life. Furthermore, it was deemed by those who buried the woman that it may be gained by observing that the ring was much worn in life. Nevertheless, at least a little insight into the culture and society of an elite female in Middle Bronze Age Sidon may be gained by observing that the ring was much worn in life.

1  H. Maryon, 1971, p. 53-54.
3  J. Ogden, 2000, p. 165.
6  A. Lucas and J. R. Harris, 1962, p. 940.
13 E. S. El Gayar, 1995, p. 11-12.

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1 Pendant from burial 102 made of gold alloy foil wrapped around a copper core. The copper core has corroded badly and shows as green corrosion products beneath the decorated gold foil covering which has been split open by the corrosion. The upper end of the pendant is on the right hand side of the photograph. It may be seen that the upper end cap has split open, showing that it encapsulates the upper part of the decorated gold foil wrapping.

A CYLINDRICAL GOLD PENDANT FROM A MIDDLE BRONZE AGE GRAVE IN SIDON

Description and discussion

A cylindrical rod-shaped gold pendant was found in the Middle Bronze Age grave of a female (burial 102) on College site. This grave also contained a gold and iron ring (see C. Doumet-Serhal & K. Kopetzky, p. 39 and D. Griffiths, p. 53).

The pendant is about 4.7 cm long and about 0.6 cm in diameter. It is formed of decorated gold foil wrapped around a copper (or possibly bronze) core (fig. 1 and 2). As can be seen in these figures, the green copper corrosion products occupy more volume than the original copper core and the corrosion has split the decorated foil that encased it. Each end of the pendant bears a plain gold foil cap. One of the caps has part of the end missing (fig. 3). This is interpreted as the upper end of the pendant where a fixing (now absent) might have allowed the pendant to be suspended. Beneath the gold is missing from the top part of the upper cap, there is what appears to be a small, central piece of green corroded metal, possibly the stump of a copper strip that might once have formed a loop for suspension. The narrow central piece of metal below the level of the top of the upper cap is surrounded by an off-white filler around which the upper gold cap was fitted. The filler is needed to fill the space between the thin central stump of metal and the gold foil cap. Given the extent of the corrosion that can be seen on the core, it is quite likely that the thin
Moving now to the lower end cap, the bottom end of this cap appears to have a slightly greater diameter than its upper rim (see left-hand end of fig. 1 and 2). The lower end cap thus appears to form the base of a truncated gradually tapering cone rather than the base of a cylinder. This form of end cap widening slightly towards the end is also seen on a cylindrical pendant from Haregeh in Egypt, now kept in the Petrie Museum at University College London (UC 6482).

Figures 5 and 6 show the lower end cap. As can be seen from the green corrosion under the tear in the lower cap (fig. 2, 5 and 6), the copper rod extends to the end of the lower cap and there is no need for filler. This difference in the upper and lower end of the core, with the upper end being thinned into a narrow strip, gives further support to the idea that the object was a pendant. The appearance of the join between the circular end piece of the lower cap and the side of the cap might suggest that the circular end of the cap was soldered onto the foil cylinder that constitutes the side of the cap (see fig. 5 and 6). The appearance of the corresponding join on the upper end cap (fig. 3 and 4) also suggests that it also may have been soldered. The sides of the caps were probably made from strips of foil bent into cylinders. The join between the ends of the strips running down the sides of the caps were probably also soldered although the evidence for this is less clear. There is a more or less linear split along the side of the upper end cap that might correspond to the original join (see the right hand end of fig. 1). Further examination might clarify whether the side joins were soldered.

Scratches on the surface and signs of wear at the peripheries of the caps suggest that the pendant was worn in life rather than it being an object made purely for funerary adornment (fig. 3-6). The foil wrapped around the length of the pendant bears linear motifs running the length of the pendant. The motifs resemble garlands of leaves with the leaves hanging downwards towards the bottom of the pendant. This decoration was probably pressed into what is now the inner or
being derived from the edge of one of the end caps. The flap torn upwards to reveal the inner surface of the upper cap (fig. 4) may have an edge that is folded under. The folded straight edge of the fragment showed no signs of soldering. The end caps have very straight open ends and appear not to be soldered to the decorated sheet (see fig. 1, 2, 4 and 6). It thus seems it is quite possible that the fragment comes from the open rim of one of the end caps. Further work might serve to place these hypotheses on a firmer basis.

Analytical results

The above fragment of foil was subjected to non-destructive elemental analysis using scanning electron microscopy with energy dispersive X-ray spectroscopy. The shiny surface of the fragment of foil, taken to have been the outer surface, gave normalized compositions from different analysed areas ranging from 61-88 weight % gold, 11-36 wt% silver and 2-3 wt% copper. In modern jewellery terminology this corresponds approximately to 15-21 carat gold.

It should be noted, however, that the analytical results given above were surface analyses taken on an unclean surface, not analyses taken from a polished cross-section of the foil. It is possible that the surface may have been subject to contamination and to variable degrees of preferential corrosion during burial. These processes might make the surface composition a little different from the original bulk composition of the gold foil. It should also be noted that the composition of the alloy used to form the end caps may be different to the composition of the alloy used to form the decorated foil.

As may be seen beneath the split in the upper (right-hand) end cap in fig. 1, and again beneath the torn flap of the upper end cap in fig. 2 and 4, the end cap overlaps the decorated foil that sheathes the copper core. This overlap is also apparent at the open end of the lower cap (fig. 1, 2, 5 and 6). The end caps thus help to keep the decorated foil in place. The decorated foil does not, however, extend beneath the caps as far as their closed ends. The fact that the decorated foil extends only a little way under the end caps is apparent in fig. 1 in the split along the side of the upper cap and (in fig. 2 and 6) from the green corrosion visible under the tear in the lower end cap.

A tiny fragment of the foil had become detached and was loose in the sample container. Examination with scanning electron microscopy of the duller side of the fragment of foil (taken to be the inner side) showed that one edge of the foil had been folded under to make a straight edge to the fragment. (This is similar in principle to folding over the ragged cut edge of a piece of material to make a hem and a neat edge). The fold gave a far neater straight edge than the somewhat ragged cut edge of the foil still seen on the inner margin of the fold. This is very fine work as the strip folded under is only about 0.03 mm wide (fig. 7). This evidence would be consistent with the fragment being derived from the edge of one of the end caps. The flap torn upwards to reveal the inner surface of the upper cap (fig. 4) may have an edge that is folded under. The folded straight edge of the fragment showed no signs of soldering. The end caps have very straight open ends and appear not to be soldered to the decorated sheet (see fig. 1, 2, 4 and 6). It thus seems it is quite possible that the fragment comes from the open rim of one of the end caps. Further work might serve to place these hypotheses on a firmer basis.
found on the outer surface. Analyses of different cleaner areas of the inside of the foil (when normalized for a gold-silver-copper alloy) gave results ranging from 47-55 wt% gold, 41-47 wt% silver and 4-6 wt% copper.

As the analyses have been conducted on unclean surfaces, it is difficult to draw any firm conclusions from differences between the results obtained from the inner and outer surfaces of the foil fragment. Some of the copper found in the analyses of both the inner and the outer surfaces of the fragment of foil may have been contamination from the clearly visible corrosion of the core of the pendant.

The apparently higher gold lower silver content of the outer surface may have been due to loss of silver from the surface during burial but it might have been due to deliberate surface treatment during manufacture. The variability of the analytical results from different areas of the outer surface should be a warning against overinterpretation. The wide range of results from different areas of the surface may suggest that postdepositional processes (which might vary on a microscopic scale) might account for the differences in composition between different but closely positioned locations: the fragment is after all very small.

Despite the above cautions, the analytical results from the fragment are broadly consistent with what might be expected from native gold. In the Middle Bronze Age gold would probably have been available from the Eastern Desert of Egypt, from Nubia and from Anatolia. Natural gold deposits often contain appreciable amounts of silver (5-45 wt%), most commonly 8-15 wt% and a little copper. Ogden states that for Egyptian gold alloys, a gold content of 70-85 wt% is most typical. Copper may be present at up to 10 wt% but some of this may be deliberately added. Bachmann lists analyses of about 160 natural, native binary and ternary gold alloys ranging in composition from 49-98 wt% gold, 2-42 wt% silver and 0-4 wt% copper. These figures exclude examples where associated copper or other minerals were suspected to have been present. Bachmann considers that gold artefacts with copper contents above about 2 wt% may have had copper deliberately added to the alloy, although the unintentional inclusion of copper minerals in the analysed sample may distort the analytical results.

No tin was detected in any of the analyses which may suggest that the core of the pendant was copper rather than bronze. It must be noted, however, that the green corrosion products have not been analysed directly so the possibility of the core being bronze remains.

Conclusions

Given the non-destructive nature of the elemental analyses, which were conducted on contaminated surfaces rather than on polished cross-sections, caution is necessary in drawing conclusions from the analytical results. It would be reasonable to infer, however, that it is likely that the fragment of foil was made from naturally occurring gold alloy. Deliberate addition of a small amount of copper is a possibility but the copper levels detected seem quite likely to arise from the openly visible corrosion products originating from the core. It should be noted that only one tiny fragment of foil has been analysed: the decorated foil may have an alloy composition different to that of the end caps.

No tin was found in any of the analyses so it may be that the core was made of copper, rather than bronze. This is not yet certain, however, as the core material itself has yet to be analysed.

The decorated foil covering most of the length of the core had its design worked from what was to be the inner side before the foil was applied to the core. The ends of the decorated foil were protected against damage and partly held in place against the core by the enclosing end caps which were probably held in place by adhesive.

The end caps appear to have been formed by soldering a disc of gold foil (a perforated disc in the case of the upper cap) to the edges of the foil cylinders which formed the sides of the caps. Each cylinder was probably formed by bending a strip of foil. The ends of the strips may have been soldered together to make the sides of the caps, though firm evidence for this requires further work.

Comparing the circular ends of the two end caps, it would seem that while one was complete, the other was perforated, perhaps to allow the passing through one end cap of the thin metal strip whose stump is seen at the centre of one end surrounded by whitish filler (fig. 2). The fact that the core extends to the end of the cap at one end and at the other is reduced to a narrow strip surrounded by filler is also consistent with one end being designed to allow suspension. This interpretation of the surviving material remains would be consistent with the object having been a cylindrical, gold-sheathed pendant.

We do not know the true significance of the pendant but signs of wear on the end caps suggest that it was worn in life and was not made purely as an object for burial. Those who buried the occupant of burial 102 believed that it was appropriate for the pendant to remain with the body in the grave after death.
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