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Review

Goldwork in Ancient Egypt: workshop practices at Qurneh in the 2nd Intermediate Period

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ABSTRACT

Described by Petrie as '*the largest group of goldwork that had left Egypt*', the jewellery from the intact burial of an adult and child discovered at Qurneh in 1908 is the most important group of gold objects excavated in Egypt dating from the 2nd Intermediate Period (c. 1800–1550 BC). This unique collection has been studied using several non-invasive analytical techniques (μPIXE, PIGE, XRF, and SEM-EDS), while calculation of the effective penetration depth values allowed the degree of surface enrichment to be assessed. The most recent results in respect of gold-working techniques are discussed and related to published work on the techniques used in Egypt in the same era and the subsequent era. The data showed, the coexistence, in a single grave, of jewellery with different levels of wear and colours of gold. The extensive use of hard soldering by the addition of copper to the gold-based alloys was also revealed. All the objects presented PGE inclusions implying the use of alluvial gold and/or recycling of ancient alloys made with this type of gold.

1. Introduction

The most important group of gold jewellery attributed to the 2nd Intermediate Period (c. 1800–1550 BC) forms part of the burial discovered intact by Sir William Flinders Petrie in 1908 at Qurneh,[1] near Thebes (Petrie, 1909). The burial, which is dated to the 16th Century BC on stylistic grounds as well as by radiocarbon dating (Eremin et al., 2000), was centred on a large anthropoid *rishi*-coffin (Miniaci, 2011), painted dark blue and gilded and containing the mummified remains of a young adult female surrounded by a wide range of grave goods, including a large group of gold jewellery items, see Fig. 1 (Petrie, 1909; Eremin et al., 2000; Tate et al., 2009). Above the foot of the woman's coffin was a simple chest-shaped coffin containing the remains of a young child also buried with several jewellery items (Petrie, 1909; Eremin et al., 2000). The richness of the burial was so exceptional that Petrie, when it was brought back to Britain, described it as '*the largest group of goldwork that had left Egypt*' (Petrie, 1932). The burial is today part of the extensive National Museums' Scotland (NMS) Ancient Egyptian collection and several aspects of the mummies and coffins have been investigated in recent years (Eremin et al., 2000; Manley et al., 2002; Tate et al., 2009; Troalen et al., 2009).

The detailed description of the Qurneh jewellery items can be found in Petrie's excavation report (Petrie, 1909) and also in several subsequent publications (Eremin et al., 2000; Roehrig, 2007; Tate et al., 2009; Troalen et al., 2009). The adult individual wore a necklace made of 1699 gold rings[2] (4.5 mm external diameter) strung together to form four decorative strands,[3] two penannular gold earrings or hair-rings, four gold bangles, an electrum girdle consisting of 26 semi-circular so-called 'wallet beads' (10 mm diameter) spaced by two threads of 6 barrel beads (4 mm length)[4] and an electrum button (the latter today missing). The child wore

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[1] Other possible spellings include Qurna, or Gourna.

[2] Petrie measured and weighed the rings of the 4 strands of the necklace and counted a total of 1653 rings (394; 416; 422; 421) (Petrie, 1909). When the necklace was disassembled for conservation at NMS in 2006 the number counted was 1699 (397, 410, 415, 477) (Tate et al., 2009).

[3] The Qurneh necklace has often been described as the earliest example of *shebiu*-type collar, although this is could be an erroneous description. *Shebiu*-type necklaces are made of large, thick lentoid-beads, tied around the neck (Roehrig, 2007 p. 19).

[4] Petrie noted in his description of the girdle that: '*… the spaces between these ('wallet beads') had two threads of six beads each, and in one case a space of seven beads*' (Petrie, 1909). There is a total of 316 barrel beads, of which 5 have fallen inside two 'wallet beads' and are now only visible by X-Radiography (Troalen et al., 2009).

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Fig. 1. The Qurneh adult jewellery set, © National Museums Scotland.

two ivory bangles, several strings of faience beads around the waist and both ankles, a necklace made of 215 small gold rings (<1.5 mm external diameter) strung together, and two asymmetric rings made of three-and-a-half gold rings soldered together, which have been interpreted as earrings from their location in the burial.

From visual examination the workshop practices seem to be the same for all the objects, with the use of sheets or strips of gold which were then hammered, stamped-died or rolled, sometimes chased, with the different parts joined together. However the jewellery items showed variable levels of wear, indicating different amount of usage. The gold items belonging to the young adult female can be separated into three groups according to their level of wear: the necklace and the two penannular earrings are virtually un-used; the four bangles are slightly used; while the girdle shows very intensive wear. The jewellery items belonging to the child also show marks of wear; these are extensive for the necklace beads and less so for the two earrings.

In the jewellery of the adult the wear-marks indicate that the bangles were certainly worn, presumably during the life-time of the woman, in contrast to the girdle, which seems to be a much older piece. Interestingly, on the girdle beads the wear-marks show that the present construction is the original one, as we observed some deformation of the holes in the wallet beads where they sit against the barrel beads (S.I. 1). In the case of the child, the earrings do not show much signs of wear prior to deposit, but these can hardly have belonged to the young child,[5] while the necklace is clearly a re-use of gold beads from different gold items. It is interesting to note that several of the beads exhibit a slight border, suggesting that their form was adjusted slightly to match an adjacent round stone or paste/glass bead, such as a spacer (S.I. 1). Petrie's report only records numerous faience beads around the ankles and waist of the child rather than at the neck (Petrie, 1909), but the adjustments might relate to an earlier use of the beads.

This paper presents a comprehensive study of all the gold jewellery items and the coffin gilding from the Qurneh burial and discusses the diversity in the apparent colours of the gold items, the possible origin of the gold and the joining techniques. The results obtained are discussed in respect of gold-working techniques used in Egypt, and compared to the few published jewellery items that can be attributed to the 2nd Intermediate Period (Miniaci et al., 2013) and the subsequent era (Gale and Stos-Gale, 1981; Schorsch, 2001; Lilyquist, 2003). As part of the study the limitation of the non-invasive analysis of ancient gold is discussed, following calculation of the effective penetration depth values of the different techniques; this confirms the feasibility of comparing the analysis of objects from other collections by using different non-invasive X-ray based techniques.

[5] Closer examination revealed that the child's earrings do not match as a pair. Both earrings were found to fasten together, as would be expected from a clasp for a necklace. It could be that this clasp was recycled as earrings, and deposited next to the ears of the child.

2. Analytical techniques

Several non-invasive techniques were used in order to gain information on the morphology of the objects and their elemental composition with no surface cleaning or polishing. These techniques allowed high spatial resolution with elemental mapping for the study of the areas around the joints, and were undertaken in air allowing the analysis of the larger and more complex-shaped objects. Measurements were also made using portable equipment to analyse the original gilding on the *rishi* coffin.

The objects were examined visually under an Olympus SZX12 stereo-microscope equipped with an Olympus DP70 digital camera and by X-radiography using a 320 kV Pantak system at NMS. Elemental composition of the alloys was determined using: (1) an Oxford Instruments ED 2000 air-path X-ray fluorescence spectrometer (XRF), with Rh target X-ray tube collimated to a point of about 2 × 1.5 mm, coupled to a Si(Li) detector; (2) μPIXE (Particle Induced X-ray Emission) and PIGE (Particle Induced γ-ray Emission) with a proton beam of 3 MeV, with an analytical spot of 50 μm, Si(Li) and Ge(Li) detectors at the AGLAE accelerator of the C2RMF; (3) a Niton XL3t portable XRF system with a 'GOLDD' detector, set to "Precious Metals" mode; (4) CamScan 2500 SEM with a Noran Vantage Energy Dispersive X-ray analysis (EDS) system, at the analytical working distance of 35.0 mm, 300 s measurement at electron beam energies of 20 and 25 kV. A range of Au/Ag/Cu standards were used for calibration in all experiments and the inter-instrument compatibility can be found in a previous publication (Troalen et al., 2009).

2.1. Surface analysis of ancient gold

The main issue with non-invasive surface analysis of ancient gold is the phenomenon of surface enrichment, due to the depletion of copper and silver through either deliberate surface treatment or from corrosion during burial (Scott, 1983; Rapson, 1996). It is accepted however that for a binary gold–silver alloy above 64.6 wt% gold/35.4 wt% silver, corrosion is limited (Scott, 1983). Usually this corrosion layer is in the range of a few μm and some studies have shown that chemical-induced surface depletion is usually less than 10 μm (Grimwade, 1999). Such surface enrichment can particularly affect the composition determined by analytical methods based on X-ray fluorescence spectra, and in some cases the difference between surface and sub-surface composition can reach 8–10 wt% gold by SEM-EDS analysis (Mongiatti et al., 2010).

Depth profiles of gold (Au), silver (Ag) and copper (Cu) depend on the energy and type of the ionising source, the composition of the alloys being analysed, and the spectral lines used for analysis. In order to compare the measurements obtained by PIGE, μPIXE, XRF and EDS analysis, we calculated the density ρ (g cm^{-3}) and mass absorption coefficients μ expressed in cm^2 g^{-1} for four Au/Ag/Cu alloys close in composition to those of the Qurneh items (Table 1). The effective penetration depth values, corresponding to the thickness in μm from which 95% of the detected X-rays are produced, were calculated for Au, Ag and Cu at these experimental conditions (Table 1). The penetration for PIGE depends on the energy of the incident protons (28 μm for 3 MeV), and since the emitted gamma-rays are hardly attenuated by the matrix the