



Scythian Gold under the Microscope

Aude Mongiatti

The special exhibition *Scythians: Warriors of Ancient Siberia* recently held at the British Museum prompted the study of eight Scythian-style gold artefacts from the Oxus Treasure in the Department of Scientific Research. Optical microscopy and scanning electron microscopy were used to identify their manufacturing and decorative techniques as well as their gold composition. Such technical examinations combined with the archaeological and historical contexts of the artefacts made it possible to shed some light on the craftsmen who created them.

a.



The latest BP exhibition *Scythians: warriors of ancient Siberia* recently held at the British Museum featured some of the research undertaken by scientists from the Department of Scientific Research of the British Museum. Amongst the displayed objects from the British Museum collections investigated scientifically for their manufacturing technology and gold composition were eight gold artefacts of Scythian style from the Oxus Treasure. This treasure consists of about 180 gold and silver objects from c. 500–300 BC, many of which are of the so-called

Achaemenid Court style (the ruling dynasty in Persia c. 550–330 BC) but a few are associated with the Scythian-style art of western Siberia. They include a pair of bracelets with terminals in the shape of winged beasts with long snouts, a finger ring with a winged lion, a head ornament in the shape of a lion-griffin, a bird's head, possibly used as an attachment on a bow case, and three roundels. The roundels depict a demon's face, a lion's face and boars and ibex heads (Figure 1).

b.



c.



d.



e.



f.



g.



Figure 1. Oxus Treasure, a) bow-case attachment, 3.5x2.5 cm Wgt 10 g, b) bracelets, dmt 8 cm Wgt 140 g each, c) finger ring, bezel dmt 2.5 cm Wgt 10.5 g, d) head ornament, Lgth 6 cm Wgt 44 g, e) roundel, dmt 4 cm Wgt 10 g, f) roundel, dmt 4 cm Wgt 10 g, g) roundel, dmt 4 cm Wgt 23 g

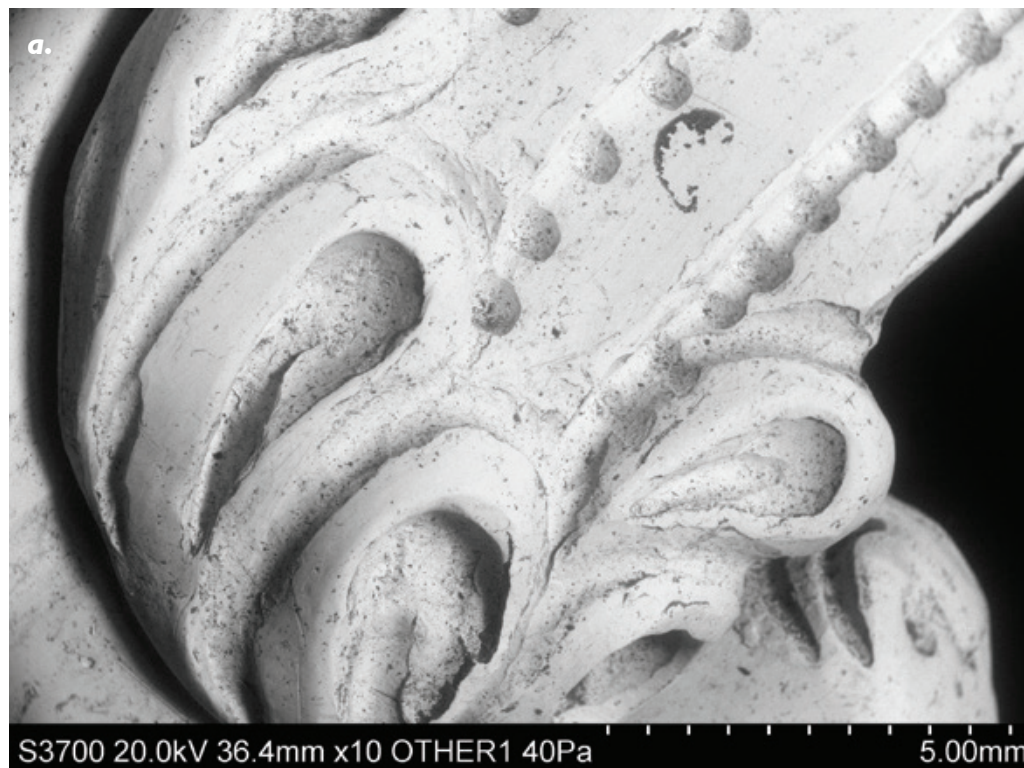


Figure 2. a) High relief on the left wing of the lion-griffin-shaped head ornament, b) Highly three dimensional feline head on the finger ring



SCIENTIFIC CMOS, EMCCD AND CCD CAMERAS

95% QUANTUM EFFICIENCY

PRIME CAMERAS



Maximum Versatility

4.2 Megapixel

6.5 x 6.5 μm Pixel Size



Maximum Sensitivity

1.44 Megapixel

11 x 11 μm Pixel Size

LARGE FIELD OF VIEW

IRIS CAMERAS



IRIS 15™

Light Sheet Optimized

15 Megapixel

4.25 x 4.25 μm Pixel Size

Visit our website
to learn more and
read what customers
are saying about
Photometrics cameras.

www.photometrics.com



Setting the standard in scientific imaging for life science research since 1978.

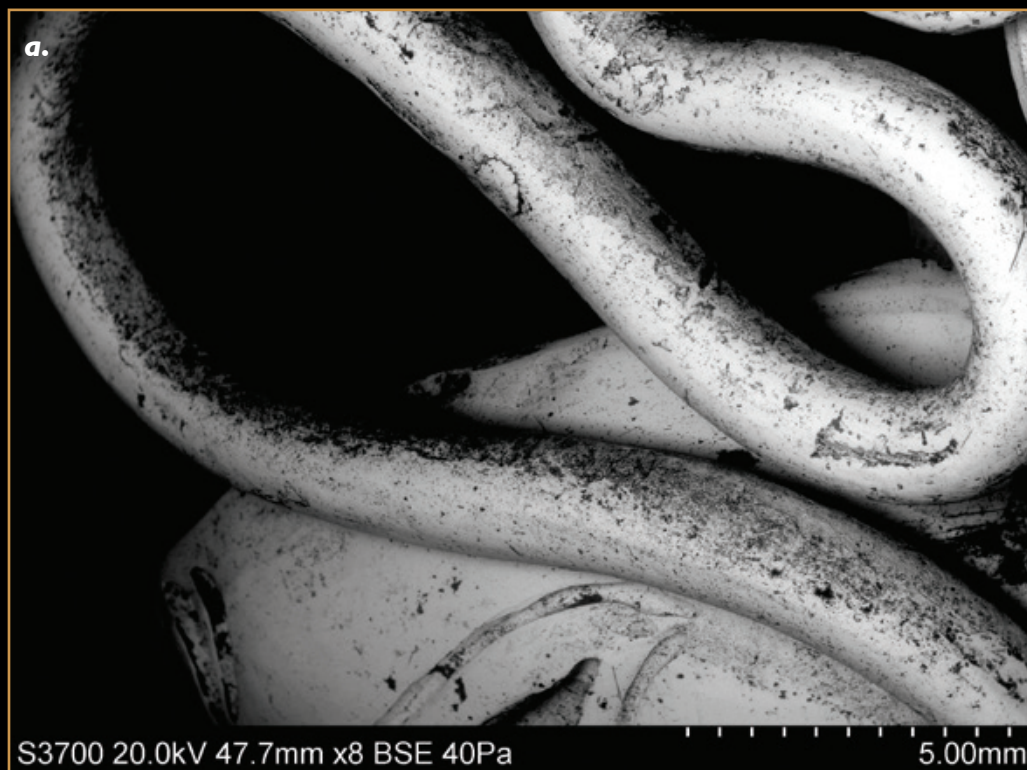


Figure 3. a) Hammered tail wire on head ornament, b) Hammered wire used as attachment at the back of the roundel with a demon's face x6



Figure 4. Tail of the lion-griffin-shaped head ornament x10

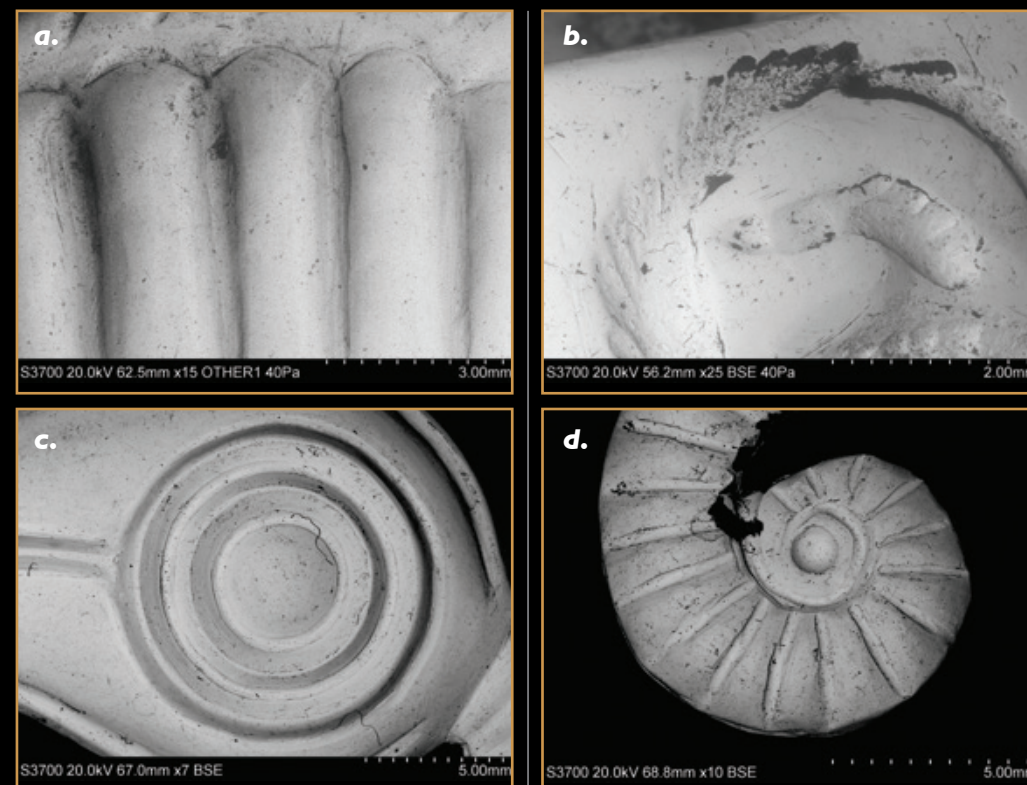


Figure 5. a) Chased lines to create the lion mane on a roundel, b) Close up view of chasing tool marks on the hoop of the finger ring, c) Concentric chased lines creating the bird eye on the bow-case attachment, d) Short chased lines decorating the bird neck on the bow-case attachment



Figure 6. Punched hemispheres on the bezel of the finger ring

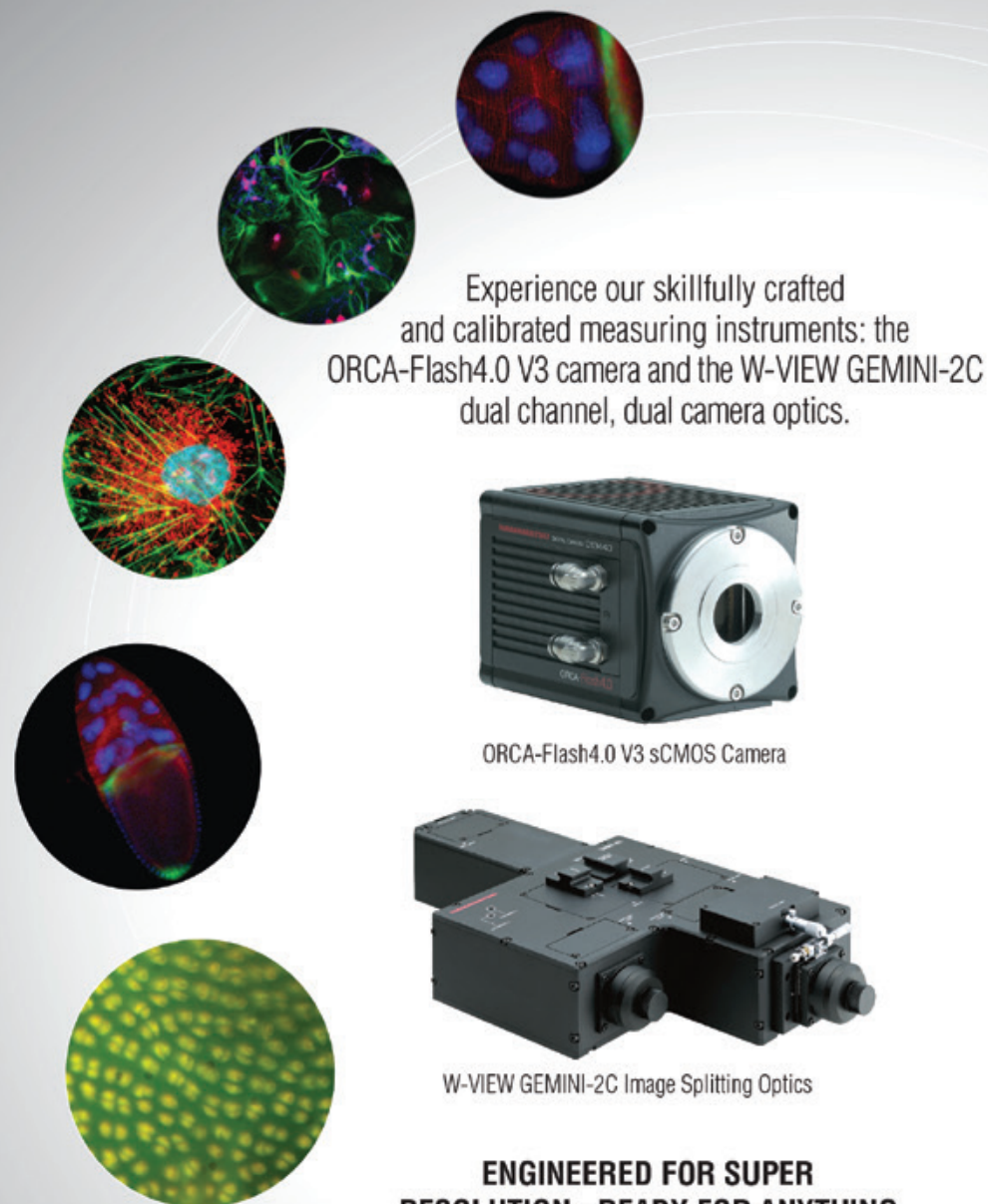
Optical microscopy and scanning electron microscopy (SEM) are some of the analytical techniques routinely used in the Department of Scientific Research of the British Museum for the identification of a variety of materials, such as metals, ceramics and glass, wood and plants, etc., and for the study of manufacturing technology. Variable pressure scanning electron microscopy (VP SEM) is particularly relevant to our work as the relatively large chamber available on our instrument makes it a totally non-invasive analytical technique, which is critical for studying museum artefacts (Meeks *et al.* 2012). It also allows the study of non-conductive materials, such as ceramic or wood, without the need for sampling. The SEM has also a great advantage compared to a traditional binocular microscope when studying gold especially, as it removes the problem of imaging highly reflective metal surfaces. Microscopy is also often combined to other relevant non-invasive techniques such as X-radiography, computed tomography, X-ray fluorescence, etc.

The combination of optical microscopy, including digital, and SEM allows overall observation of the construction methods and decoration of the gold artefacts as well as a more detailed investigation. On gold artefacts, images are generally captured at various magnifications, from 7x to 2000x, to identify and record physical features, tool marks and surface textures, as these are characteristic of the goldsmithing techniques used to manufacture and decorate them. The SEM is also equipped with energy dispersive X-ray spectroscopy, which enables the identification of elemental compositions of alloys.

This short article draws on two contributions recently published: the catalogue of the exhibition mentioned above and a British Museum blog related to this exhibition (Simpson and Pankova 2017: 312-317; Mongiatti 2017). Six of the eight artefacts studied were manufactured by hand-working gold sheets and wires. The sheets were hammered to the desired shapes and thicknesses from small cast ingots. Further work from the front and the back

Made to Measure

Ever wonder about the quantitative nature of imaging data?...we have!



Experience our skillfully crafted and calibrated measuring instruments: the ORCA-Flash4.0 V3 camera and the W-VIEW GEMINI-2C dual channel, dual camera optics.



ORCA-Flash4.0 V3 sCMOS Camera



W-VIEW GEMINI-2C Image Splitting Optics

**ENGINEERED FOR SUPER
RESOLUTION - READY FOR ANYTHING**

HAMAMATSU
PHOTON IS OUR BUSINESS
www.hamamatsucameras.com

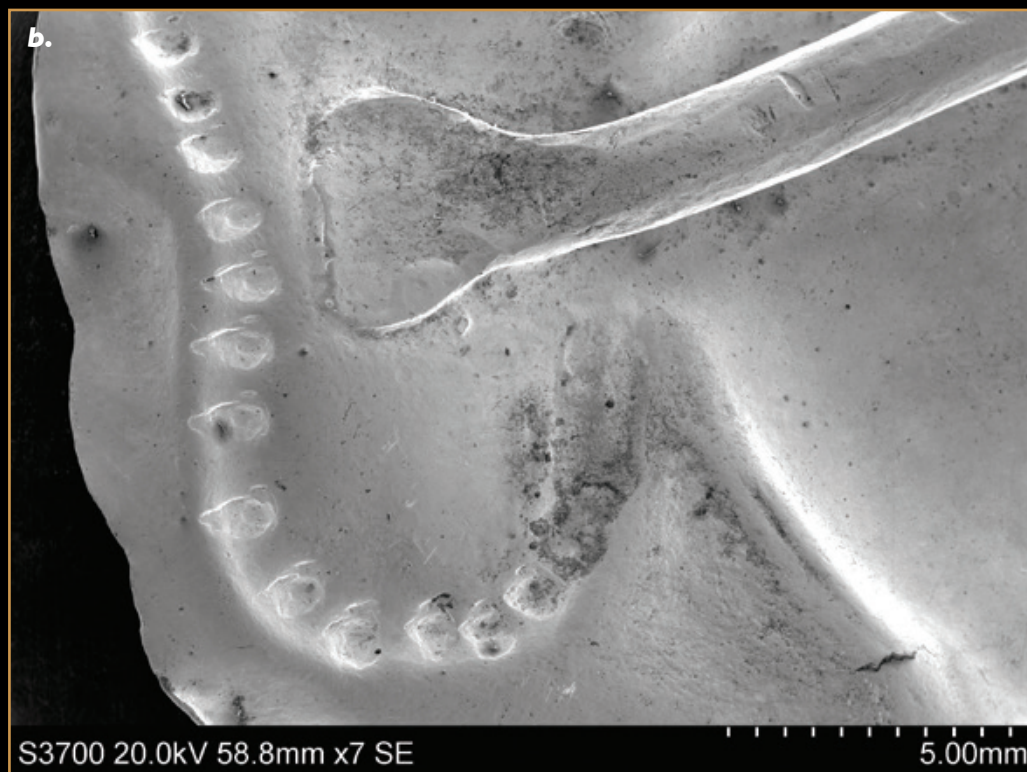
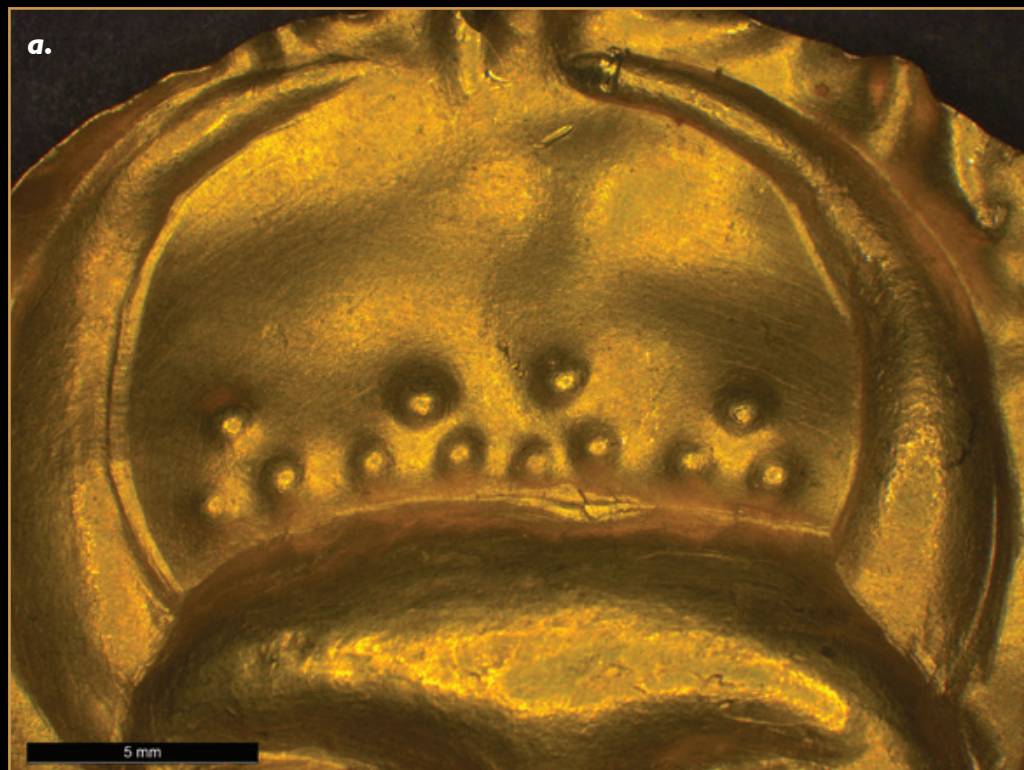


Figure 7. a) Punched decoration made from the back but seen here from the front on the top of the demon's head x6, b) Punched marks from the back outlining the left ear of the demon

created the various three-dimensional designs from the flat sheet (Figure 2). The goldsmiths had to go through cycles of hammering and annealing in order to achieve the desired deformation of the metal. Annealing the metal releases the internal stress produced by hammering: the metal sheet was heated to several hundred degrees in order to soften it and allow further deformation and shaping without cracking. Solid wires, such as the tail of the lion-griffin aigrette and the attachment loops on the roundels (Figure 3), were also hammered, in this case, into a circular section from a small square ingot. The wire tail of the aigrette is a nice example of the choices made by its maker: the leaf-like terminal was shaped from the wire itself rather than as a separate piece attached by soldering (Figure 4).

A variety of techniques and tools could be used to deform the gold sheet by hand: the goldsmith could work it into relief from the back, a technique called *repoussé*, or from the front, a technique called chasing. Both techniques are often combined on one object and most gold objects. Chasing involves gently hammering blunt-edged punches of various shapes along the gold surface, which move and push the metal in order to trace outlines and produce decorative patterns (Untracht 1982: 115-132; Untracht 1985: 93-110; Brepohl 2001: 391-400). Chasing tool marks can be identified using SEM and optical microscopy through the soft edges of the grooves and lines within them left by the tool (Figure 5). To produce the finely modelled decoration seen on these gold objects, most would have been worked both from the front and the back, as shown by the deeply deformed sheets and tool marks on both sides. Chasing is the main decorative technique used but evidence of punching is also frequently seen on these Scythian-style objects, to produce smaller decorative embellishments. Punching is achieved by striking a specially shaped punch directly into the metal, on the front side of the sheet, and produces a single design, which is often repeated. The most recurrent examples of punched motifs are the lines

of dots/hemispheres (Figure 6), as seen on the finger ring and the aigrette.

Although the techniques documented here are the same for all objects, there are several particularities when looking at each object in more detail. For instance, the punching on the gold roundel bearing a demon's face stands out from the main group of objects in that it was achieved from the reverse side (Figure 7). This roundel has further been decorated by engraving grooves on the front to outline facial features, such as the eyes and the tusks, and creating relief using *repoussé*. The gold roundel with the boars and ibex heads also shows tool marks characteristic of engraving. Unlike chasing, which only deforms the metal, engraving entails cutting grooves into the metal with a sharp tool. The latter roundel is also interesting in that it not only has a significantly higher silver content in its alloy – which makes it appear greener – but it is made of a thicker sheet, which has been worked from the front only. The reverse side of this convex roundel lacks the three-dimensionality, (Figure 8) that would be expected if the sheet was shaped from the back. It seems more likely that the sheet was worked from the front to create relief and raise the animal shapes. Backscattered SEM images of both roundels clearly show that the edges of the grooves outlining these shapes in relief are sharply cut showing chisel-cut steps around them, indicating the use of engraving (Figure 9). This may explain why a thicker sheet of electrum, a naturally occurring gold and silver alloy, was used for the manufacture of this object as the extra thickness has allowed for some metal to be cut and removed. The three roundels have attachment loops soldered to their back.

The two remaining artefacts in this group of eight, a pair of gold bracelets, have been manufactured differently: they are made of solid gold and have been cast, most likely by means of the widely used lost wax technique, and then further hand-worked by chasing and punching to further accentuate the outlines and give finer definition to the designs. Lost wax casting involves making a wax model with all the necessary

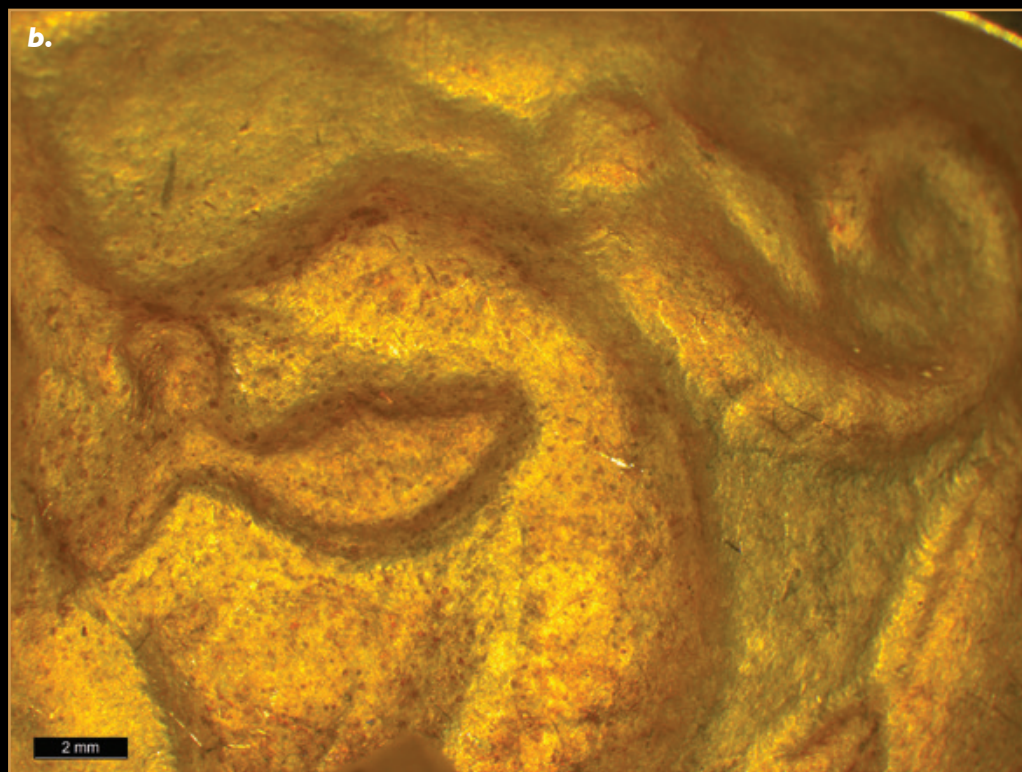
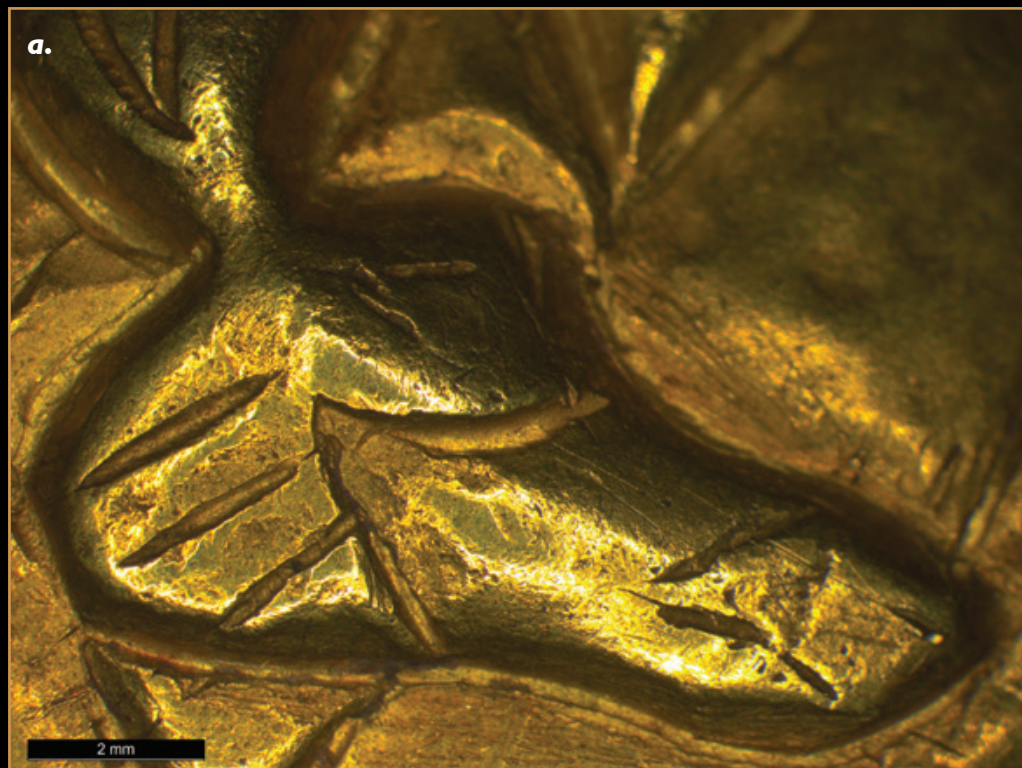


Figure 8. a) Roundel with boars and ibex's heads showing a green-coloured gold due to it being made from a silver-rich gold alloy x12, b) Surface texture and low relief at the back of the roundel showing boars and ibex's head x6

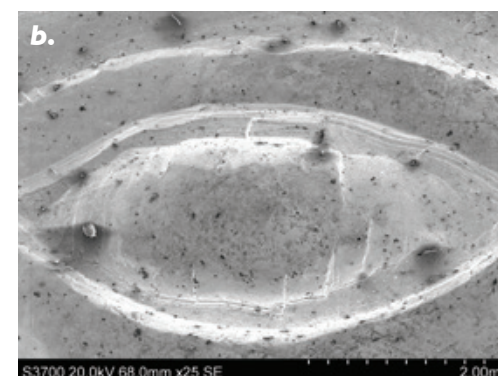
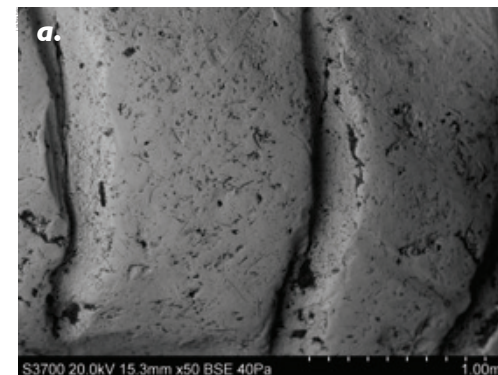


Figure 9. a) Grooves on an ibex horn cut by engraving on the roundel with boars and ibex's heads, b) Left eye of demon made by engraving



Figure 10. a) Terminal of one of the cast bracelets x5, b) Terminal of one of the cast bracelets

details, then encasing this model in clay, thus creating a mould which is the exact negative of the original wax model. The mould is heated in order to harden the clay and allow the wax to melt out, and is then inverted so that the molten gold alloy is poured into it. After the metal has cooled, the mould is broken, revealing the cast object.

It is not possible to distinguish the extent of hand-working which was used to design and shape the original wax model and that which has been applied directly to the cast metal object. It is very likely, however, that the high relief features, such as the eyes, ears and deep grooves and inlay cells (Figure 10) were modelled in the wax and then finished by chasing the metal to outline and give definition to the design. Some decoration such as hemispheres and lighter lines were respectively punched and chased, probably also directly into the metal. The surface texture of these cast bracelets is remarkably

dissimilar to that of hand-worked artefacts (Figure 11).

This group of artefacts shows a wide range of alloy compositions, from high-purity gold to high-silver electrum (79 to 93 wt% gold and 2.5 to 20 wt% silver for six artefacts). The copper content varies between naturally-occurring levels in unrefined gold (0.5 to 2 wt% copper) (Ogden 2000: 162) to being intentionally alloyed with silver-bearing gold (4-6 wt% copper for two artefacts). Copper makes gold harder and stronger and therefore easier to work and shape. Sources of gold exploited from early times are generally gold particles deposited by water movement and found in river beds – this is called alluvial gold. These native gold particles are not pure gold, and usually include a proportion of silver, which is the case for most of the objects analysed here. These alluvial deposits commonly hold copper in concentrations up to 2 wt%. Another feature of

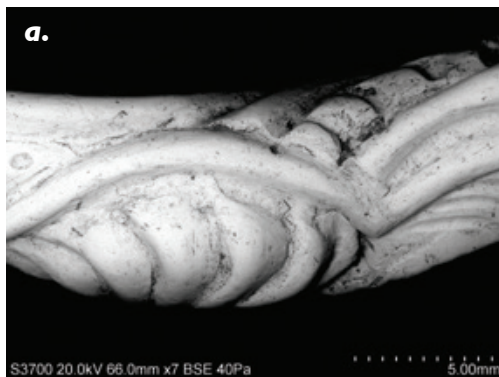


Figure 11. a, b, c) Surface texture and relief on the cast bracelets (b) x5)

native alluvial gold deposits is the presence of tiny, hard Platinum Group Elements (PGE) inclusions (Ogden 1977:53-71; Meeks and Tite 1980: 267-275). Microscopic examination of the surfaces of the artefacts studied detected PGE inclusions on most of them, indicating the use of unrefined alluvial gold (Figure 12).

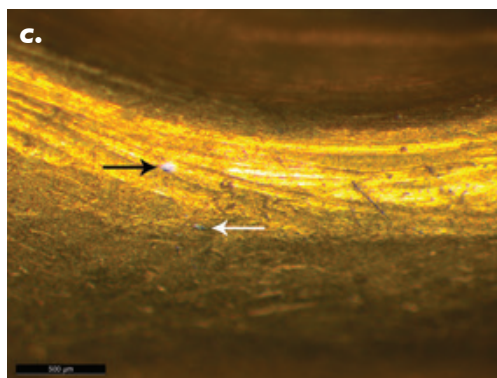
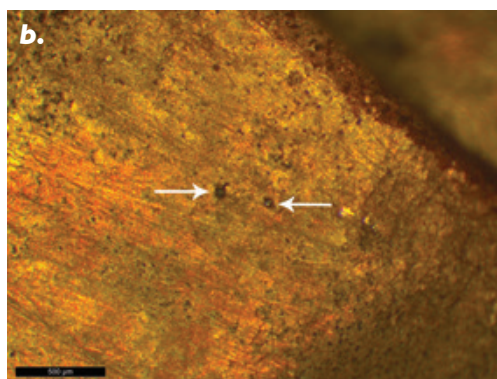
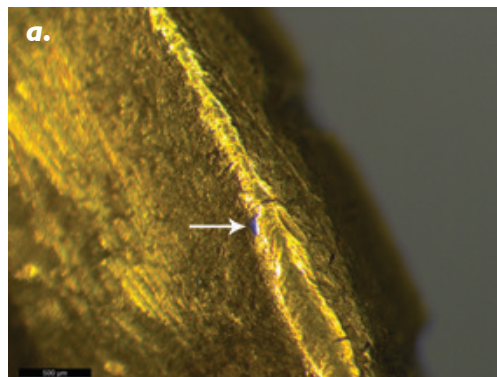


Figure 12. a) PGE inclusion on the left horn of the lion-griffin on the head ornament x50, b) PGE inclusions at the back of the roundel with a demon's face x50, c) PGE inclusions on the bow-case attachment x50

The wide variety of techniques used to manufacture and decorate these objects was commonly in use in the first millennium BC. From earlier scientific research carried out on the Oxus Treasure (e.g. Mongiatti et al. 2010), we know that chasing, punching and repoussé were the main techniques used to produce gold objects of Achaemenid style. It appears from the present study that the type of objects

investigated were manufactured using the same methods, despite being of different style. It raises interesting questions regarding ancient technologies and craftsmen: did Achaemenid goldsmiths create objects in a Scythian style or did Scythian goldsmiths use the same techniques learnt from Achaemenid goldsmiths for similar types of objects? We may never know but it is only by continually asking questions and testing them with scientific research like this that we can better understand the development of ancient crafts.

References

- Brepohl, E. 2001. *The theory and practice of goldsmithing*, Brynmorgen Press, Brunswick, Maine.
- Meeks, N. and Tite, M.S. 1980. 'The analysis of platinum-group element inclusions in gold antiquities', *Journal of Archaeological Science*, 7, 3, 267-275
- Meeks, N., Cartwright, C.R., Meek, A. and Mongiatti, A. (eds.) 2012. *Historical technology, materials and conservation: scanning electron microscopy and microanalysis*, Archetype Publications in association with The British Museum, London.
- Mongiatti, A. 2017. 'Under the microscope: the Oxus Treasure and Scythian gold', British Museum blog published on 20 November 2017.
- Mongiatti, A., Meeks, N., and Simpson, St J. 2010. 'A gold four-horse model chariot from the Oxus Treasure: a fine illustration of Achaemenid goldwork', in *The British Museum Technical Research Bulletin*, 4, 27-38.
- Ogden, J.M. 1977. 'Platinum group metal inclusions in ancient gold artifacts', *Journal of the Historical Metallurgy Society* 11. 53-72.
- Ogden, J. 2000. 'Metals', in *Ancient Egyptian materials and technology*, ed. P.T. Nicholson and I. Shaw, Cambridge University Press, Cambridge, 148-176.
- Simpson, St J. and Pankova, S.V. (eds.) 2017. *Scythians: warriors of Ancient Siberia*, Thames and Hudson, London.
- Untracht, O. 1982. *Jewelry concepts and technology*, Robert Hale, London.
- Untracht, O. 1985. *Metal techniques for craftsmen. A basic manual on the methods of forming and decorating metals*, Robert Hale, London.

All images are © The Trustees of the British Museum with SEM images and photomicrographs taken by the author.

About the author

Aude Mongiatti is a research scientist in the Department of Scientific Research at the British Museum. She specialises in metals and works mostly on non-ferrous metal artefacts and ancient metallurgical technologies with a special interest in archaeological and museum material such as crucible remains associated with metal production. She uses mainly microscopy (optical, digital and SEM), X-ray fluorescence and radiography to identify composition of metals and alloys and the techniques used to produce the objects. She studied chemistry with a specialisation in materials science in France where she obtained her MSc degree from the French Grande Ecole "Ecole Nationale Supérieure de Chimie de Paris" in 2003. She then completed a PhD at UCL Institute of Archaeology in 2009, studying technological processes in the production of precious metals in early modern Austria (assaying and smelting).

The author would like to thank her colleagues in the British Museum, especially St John Simpson (Department of the Middle East), for the opportunity to study these artefacts, and Nigel Meeks, Susan La Niece and Caroline Cartwright (Department of Scientific Research) for insightful discussions and comments.

