Summary

A collection of twentieth-century Omani silver jewellery was acquired in 2009 by the Department of the Middle East at the British Museum from a private British collector, who bought these pieces in various markets in Oman in the 1980s. This assemblage of over 240 handcrafted silver objects of adornment represents a well-established tradition of jewellery-making that can be traced back to at least the mid-nineteenth century. This tradition continued into the mid-twentieth century, but has now largely gone out of fashion due to contemporary tastes for gold jewellery throughout the region. The assemblage attests to a wide variety of silversmithing techniques and a high level of craftsmanship that is not extensively documented and is in danger of vanishing in present-day Oman.

Scientific investigation of this collection has helped characterize and better understand its manufacturing techniques and materials. A combination of complementary techniques has allowed the fabrication methods to be described comprehensively, the compositions of the silver, solder and gilding to be determined and the tool marks, joins and rattling materials inside hollow bracelets and anklets to be identified. All the objects appear to have been made from hand-worked sheets and wires of high-purity silver, with the parts assembled by brazing with a zinc- and copper-rich hard silver solder. Various finishes were created by gilding, chasing and punching, so that each piece of jewellery is the product of complex and skilful craftsmanship.

Traditional Omani Silver Jewellery

The Sultanate of Oman is a country with a history that stretches back to the third millennium BC. Often referred to as 'the land of frankincense', this seafaring nation of traders has, throughout its history, linked the Middle East with Europe, Africa, Iran, India and China. Oman is the third largest country of the Arabian Peninsula and is divided into four governorates and five regions, with its capital city at Muscat. Each region of Oman has maintained distinctive traditions of jewellery-making and local dress styles. Silver jewellery and ceremonial weaponry have always been considered hallmarks of Omani craftsmanship. Oman's highly skilled silversmiths employ a variety of techniques to create intricate designs passed down through generations, traditionally from father to son.

Traditional Omani silver has maintained a remarkable continuity of style over the ages. This is evident from the jewellery once owned by the Omani princess Sayyida Salme bint Said (1844–1924), the daughter of one of the most powerful rulers of Oman and Zanzibar, sultan Sayyid Said bin Sultan (1791–1856). A selection of her personal belongings dating to the 1860s is now housed at the National Museum of Oman in Muscat, Figure 1. Several of her silver pieces correspond directly in style to those from the 1950s in the British Museum collection of Omani jewellery.

Despite this unbroken tradition of silversmithing that dates back to at least the mid-nineteenth century, but probably earlier, the demand for the silversmith's craft has declined in recent years due to shifting tastes in fashion, greater prosperity and the contemporary preference for gold jewellery throughout the region. The addition of small elements of gilded decoration on Omani silver jewellery gained popularity from the 1960s onwards, during a time when earnings increased and vast quantities of gold were readily available from Saudi Arabia and Dubai [1; pp. 44–45]. Over time, however, Omani women's fondness for small gilded embellishments developed into a demand for pieces made entirely of gold. Indian goldsmiths have largely met this demand, having established a thriving trade in Oman and neighbouring Dubai and, interestingly, traditional designs of Omani silver are sometimes reworked as entire gold pieces or smaller, lighter versions in gold. Nevertheless, the British Museum's collection of 1950s Omani silver attests to a wide variety of silversmithing techniques.
and a high level of craftsmanship that is not extensively documented and is in danger of vanishing in present-day Oman.

The majority of Omani silversmiths who are skilled in traditional techniques of jewellery manufacture are of an advanced age and the future sustainability of this time-honoured craft remains uncertain. One such craftsman, Salim bin Nasser bin Salim al-Shareqi, a 70-year-old practising silversmith from Nizwa, was interviewed for the purpose of this study and a selection of his tools comprising two handmade punches, a drawplate and two small melting crucibles was acquired for the Museum’s collection (2010,6019.1–14). Salim al-Shareqi shared some of his silversmithing techniques with the authors and provided samples of worked silver at various stages of completion including twisted wire, embossed silver sheets and two chased and embossed end toes made for ceremonial daggers. He also gave the authors: samples of the borax that he uses as a flux; small fragments of copper wire that he customarily includes in hollow anklets and bracelets to make them rattle; and foreign coins (a Maria Theresa thaler, two Saudi riyals and an English half crown) that he uses either as jewellery pendants or to provide metal to alloy with the silver that he now acquires as one kilogramme bars from the Emirates.

**Function and significance of Omani silver jewellery**

On special occasions, Omani women traditionally adorn themselves from head to toe; they wear elaborate headdresses, forehead pendants, earrings, necklaces, bracelets, finger rings, anklets and toe rings, Figure 2. Individual pieces are imbued with religious significance as well as beauty and function. A woman’s jewellery indicates her financial and marital status, often represents her tribal or regional identity and protects her from the ‘evil eye’. This notion of the ‘evil eye’, or ‘eye of envy’, is widespread across world cultures, including Middle Eastern societies. In Muslim belief, the idea that a person can inflict harm upon someone they envy is rooted in the Holy Qur’an and against such a threat the best recourse is divine protection. Sometimes the evil eye is inflicted unintentionally, for example by someone who innocently expresses admiration of a child or animal, or by a person when surprised. In Oman, envy against children is a serious concern and silver jewellery, which is customarily presented to children on special occasions, is thought to distract malevolent spirits (*jinns*), leaving the child unharmed [1; pp. 91 and 128].

For a similar protective purpose, verses from the Qur’an feature prominently in Omani jewellery, either as engraved inscriptions or as a rolled-up page sealed inside a decorated
Qur’an case (hirz). Qur’an case necklaces are worn in combination with silver pendants set with natural materials such as coral, carnelian, fox and wolf teeth or the tips of gazelle horn [1; p. 106]. These are also thought to protect the wearer from evil influences and to bring happiness and good health. According to a saying of the Prophet Muhammad, carnelian (‘aqiq) is believed to banish poverty whereas coral (marjan), mentioned in the Qur’an as a symbol of God’s mercy and bounty, is thought to possess curative powers. Red and orange beads, pendants and charms made from more affordable substitutes such as ceramic, glass and resin are still thought to possess the beneficial properties of coral and carnelian by virtue of their colour. The British Museum collection also includes a necklace (2011,6004.1) with a pendant made from a red plastic bicycle reflector, which is referred to as a hirz al-atfal (an amulet for children) and is illustrated on the cover of this Bulletin.

Jewellery as portable wealth

Jewellery represents an Omani woman’s financial security and personal assets. Omani silversmiths from the nineteenth to the mid-twentieth century melted down coins and old jewellery to make new artefacts. Maria Theresa thalers were particularly highly valued for their purity and the consistency of their silver content, at least 84 weight % (wt%) [1; pp. 33 and 42, 2; p. 165], and were readily available in vast quantities as they circulated as a trade currency throughout the Levant, Red Sea, Arabia, Horn of Africa, Americas and China before the advent of local currencies in these regions [3; pp. 44–45]. Maria Theresa thalers were first minted in Austria in 1741 and continued to be struck and circulated in the Hapsburg empress’s name even after her death in 1780. Other foreign coins, such as Indian rupees and Spanish reales, also circulated as trade coins until the new Omani rial was introduced in the 1970s and these foreign coins were officially withdrawn [3; pp. 8–9 and 69]. As well as being melted down, these imported coins were also fashioned into pendants for Omani necklaces, Figure 3.

THE BRITISH MUSEUM’S COLLECTION OF OMANI JEWELLERY

In 2009 the Middle East Department at the British Museum acquired a substantial collection of 1950s silver jewellery from Oman (2009,6023.1–246). The objects were purchased from two British private collectors, Alan and Denise Costley, who bought them in Oman between 1987 and 1995 when Alan Costley was working as an oil engineer there. Their collection of over 240 silver items handcrafted in Oman was acquired mainly in the markets of Nizwa, Mutrah and Rustaq and a small number of pieces came from Sur, Wadi Bani Ouf, Bahla, Ibra and Ibrī. The assemblage comprises a large number of women’s objects of adornment, including head-dresses and hair ornaments, earrings, necklaces, bracelets, anklets and kohl pots. It also includes several silver artefacts for children such as forehead pendants, buckles, necklaces, bracelets and anklets. Finally, silver objects for men are represented in the form of kohl containers, sets of tweezers and picks and a gunpowder horn. The vast majority of the pieces originate from the northern, north eastern, interior and central regions of Oman with about 30 pieces from the Governorate of Dhofar in the south, Figures 4a and 4b.

The intricate decoration on many of the objects displays a wealth of traditional silversmithing techniques and all the objects appear to have been made from hand-worked sheets and wires of high purity silver. Many of the hollow elbow bracelets, anklets and hair ornaments contain fragments that rattled inside when worn. Some of the necklaces, bracelets and hair ornaments also incorporate semi-precious stones, mammals’ teeth or horn, coral, carnelian and colourful ceramic or glass beads. The chased and punched designs are mostly floral and geometric patterns accentuated with silver granulation and applied motifs, but a few objects include Arabic inscriptions and magic numbers or symbols. Many of the necklaces incorporate Maria Theresa thalers, Saudi riyals or Indian rupees as coin pendants.

The precise dating of individual pieces in this collection is extremely difficult, as Omani silversmiths have never followed a tradition of stamping hallmarks or signatures.
on their jewellery [1; p. 54], while dating pieces based on their coin pendants is also highly problematic, Figure 3. An important aspect of the tradition of Omani silver jewellery is that pieces are purchased and worn by an individual and rarely passed down from one generation to the next; bridal jewellery in particular is always new and produced by melting down old pieces [1; pp. 164–165 and 434, 2; p. 33, 4; p. 31]. It is very difficult, therefore, to find Omani jewellery that is more than a generation old, even though styles and designs are sustained over generations. Exceptions include the mid-nineteenth-century jewellery once owned by Princess Salme, already mentioned above.

The acquisition of this collection has transformed the British Museum’s holdings of Omani silver jewellery. Prior to this purchase, the Museum had only five examples, three of which were acquired in Zanzibar, a former territory of Oman and part of present-day Tanzania. Although acquired in Zanzibar, a pair of hinged silver anklets (Af 1948.05.1.a–b) and a Qur’an case necklace (Af 1974.01.1) fit nicely within the corpus of the Costley collection and raise further questions regarding the movement of Omani silversmiths and their products during the early- to mid-twentieth century.

The scientific investigation of a selection of artefacts from this collection was initially undertaken upon its acquisition in order to characterize fully and better understand their manufacturing technologies and raw materials. The decision to exhibit this material in a temporary exhibition,
Adornment and Identity: Jewellery and Costume from Oman (21 January–11 September 2011), supported by BP in association with the Ministry of Tourism of the Sultanate of Oman, provided further impetus to conduct a major study of the collection. As a result of this collaboration, preliminary research was carried out in Oman at markets and at a silversmith’s workshop. In addition, the Ministry of Tourism supplemented the British Museum’s collection of Omani silver by generously donating a group of ceremonial weapons and a few key pieces of jewellery to help fill in the gaps in the Museum’s collection, as well as over 50 items of traditional Omani male, female and children’s costume to allow the silver ornaments to be displayed within the broader context of personal adornment.

This contribution outlines the results of the first scientific investigation ever carried out on Omani silver jewellery, which builds on previous ethnographic research and will hopefully inspire further scholarly studies of the subject. The results attest to the importance of precise identification of materials as a means of revealing the differences between accepted knowledge and reality. The study also highlights the variety of local or regional practices in silver technology and offers insights into the complexities of the manufacture of individual pieces; this was further enriched by the exceptional opportunity of sharing Salim al-Shareqi’s silversmithing experience, Figure 5. Due to the decline in local demand for silver jewellery, many silversmiths in Oman have adopted the role of antique dealers and the vast majority of traditional Omani silver today resides in private collections. The British Museum’s collection is now the largest public collection of Omani silver in Europe and it is hoped that these holdings will revitalize interest in a craft that is in danger of vanishing within the next few decades.

METHODOLOGY

A combination of complementary scientific techniques allowed the comprehensive chemical characterization of the silver, solder, gilding and non-metallic materials added as ornaments, as well as the identification of physical features such as tool marks and joins. X-radiography helped with the physical characterization of the materials that create the rattling noise inside hollow bracelets and anklets. Semi-quantitative X-ray fluorescence (XRF) analysis on the uncleaned surfaces of objects was used to determine the elemental compositions of the silver, solder and gilding. Secondary electron (SE) and backscattered electron (BSE) images were recorded by scanning electron microscopy (SEM) to look more closely at tool marks and surface textures. The SE images yield information about the topography, while the contrast provided by the BSE images reveals the differences in mean atomic weights of the elements present; the denser the element, the paler it appears in the BSE image. Energy dispersive X-ray analysis within the SEM (SEM-EDX) was also applied to the brazed and gilded areas to provide elemental analysis; full details are given in the experimental appendix.

SILVERSMITHING TECHNIQUES

Hammering, rolling and forming

All the objects, except one pair of c-shaped bracelets discussed below, have been created by the following process. First, silver sheets and drawn wires were made and hand worked. The rod or bar of silver bought commercially or cast from melted coins and/or scrap jewellery would have been hammered and annealed to the desired thickness, possibly with the initial use of a hand-turned rolling press, Figure 5 [1; p. 35, 2; p. 167]. The various components were next assembled by brazing (i.e. hard soldering with a silver alloy) and then finished by mechanical deformation of the metal to create the decorative motifs; typical examples of bracelets and necklaces from the collection are shown in Figure 6. The mechanical deformation used to finish the objects is a so-called plastic deformation and is an irreversible change, as the forces that are applied cause a rearrangement of the atoms in the metal crystal lattice [5; p. 115, 6; pp. 104–106]. Deformation hardens the metal and limits the amount of mechanical work that can subsequently be applied before it becomes necessary to anneal the metal to allow it to be worked further. Annealing consists of heating the metal above its recrystallization temperature of several hundred degrees centigrade and letting it cool afterwards. This serves to release the internal stress produced by hammering and to soften the metal, which results in increased ductility and so allows further deformation and shaping of the metal sheet without the risk of structural failure [5; p. 30, 6; pp. 176–193, 7; pp. 49–50].

Chasing and punching

Plastic deformation can also be achieved by chasing and punching. Chasing involves creating patterns by gently deforming the metal sheet from the front side by hammering punches of various shapes across the surface to produce decorative patterns [5; p. 119, 7; pp. 105 and 482]. Punching entails the impression of a single design, usually repeated more than once, using a punch struck with a hammer [5; p. 122, 7; p. 85]. Various punches were used to create the different three-dimensional decorative patterns, such as circles, short grooves, three-dimensional hemispheres and cross-hatching. Several long grooves were produced by chasing [1; pp. 37–38], a technique for which the silversmiths of various regions in Oman are famous [2; p. 168].
Open crescent bracelets, anklets and necklaces were studied at low magnification in the variable pressure SEM to examine the tool marks, brazed areas, gilding and surface texture. They illustrate the combination of decorative techniques used on most artefacts to enhance the three-dimensional effects of the patterns. One bracelet shows the use of punches for circles, inferred from the identical marks left by each unique punching tool, Figures 7a and 7b. The same artefact also displays short vertical grooves that seem to have been punched rather than chased since the patterns are repetitive and no metal has been displaced to the top edges of the grooves as might be expected if the latter technique had been used, Figures 7c and 7d [8]. In contrast, long lines, such as the fine horizontal groove seen at the top of Figure 7c and bottom of Figure 7d, have most likely been chased with a tracer-punch [5; p. 123], traveling first from one end and then in the other direction before the surface was polished smooth.

The use of punches to produce matting or graining (Figure 8c: [5; p. 124]) is well illustrated by the decoration of several pairs of hollow and chunky hinged anklets (mutal), Figures 1 and 8a. These traditional heavy anklets were worn by women from the northern and interior regions of Oman on special occasions. They are decorated entirely with intricate chased designs including hatched lines, circles and floral, vegetal or geometric motifs, Figure 8a. The anklet is designed to open from the front and its clasp is locked with a solid silver pin that is sometimes attached by a chain. These anklets are worn in paired sets with the broad flat side facing inward. Mutal are produced and decorated in a similar manner to jingling elbow bracelets and the enhanced three-dimensionality of the designs on their flat rectangular fronts and annular back sections is created by the contrast between matt textures or lightly hatched lines on shallow surfaces against polished raised areas, Figure 8b. This contrast is further emphasized by the dark-coloured dirt that has accumulated in these recessed areas through years of wear on skin that would have been covered in cosmetics such as oils, creams or henna. Regional
variations in the design of these anklets are recognizable in some instances, such as the typical Nizwa-style vine leaf pattern, and elements of the anklets are occasionally embellished with gold leaf decoration.
Silver wires

In addition to silver sheet, a variety of silver wires forms an essential component of Omani jewellery. For example, rows of twisted and beaded wire are applied as surface decoration to create borders and frames on jewellery, while several sets of loop-in-loop chains have been soldered as ‘danglers’ on the bottom of Qur’an case necklaces with jingling pendants and bells soldered in turn to the ends of these chains.

To make wires, Salim al-Shareqi initially anneals commercially bought silver rod with a gas blowtorch and quenches it in water before pulling it through a hand-turned rolling press to reduce its diameter, Figure 5a. Once the rod has a smaller diameter, he draws it manually through a steel drawplate to produce a thin wire. Different wire-drawing techniques are detailed in the literature [5; pp. 150–154, 6; pp. 165–173, 7; pp. 42–45], but this combination of a mechanical rolling press and manual drawplate seems to have been common practice among Omani silversmiths [1; pp. 167–168, 2; pp. 46–47].

On the pieces in the Museum’s collection, the uniform diameter of the wire and the numerous fine parallel grooves clearly visible on the surface along their length are typical of pulling through holes of specific diameters in a drawplate, Figure 4a. These wires can subsequently be twisted, punched or used to make links for loop-in-loop chains. The latter are produced by cutting long silver wires into short fragments of similar sizes, brazing the two ends of the wires to create the links and finally assembling the links together to create the loop-in-loop chains, Figure 4a [5; p. 188]. Wires have been further twisted and punched to create a variety of three-dimensional patterns, for example through attaching them to silver sheets by brazing, Figure 4b. The decorative wires to the left of Figure 4b are pairs of plain wires twisted in a clockwise manner. On other objects, for example the bracelets in Figure 9b, the thick outer wires are twisted anticlockwise while the adjacent thinner wires are twisted clockwise creating an opposing pattern. Similarly the cast false-filigree twisted wires on the bracelet in Figure 10c are also twisted in opposition. Additionally, there are a few examples of granulation on smaller pieces of jewellery and several pairs of earrings combine twisted and punched wires to create filigree work.

HOLLOW RATTLING ELBOW BRACELETS AND ANKLETS

The beauty of Omani jewellery lies not only in its intricate patterns and gold highlights, but in the pleasing jingling sound it makes when worn. This is particularly true for the northern Omani hollow elbow bracelets (‘adud) that are worn on the upper arm and rattle in response to movement of the body. Figure 2 illustrates how an elbow bracelet can be used as a rattle during wedding festivities. Hollow rattling crescent-shaped anklets (hajul) from northern Oman are worn by Omani women of Baluchi descent and are often decorated with chased floral patterns that end in talismanic snakes’ heads to ward off evil. Both bracelets and anklets are always worn in pairs, Figures 6a, 11c and 11d.

A selection of 17 pairs of hollow rattling elbow bracelets and anklets varying in size and shape – 10 annular and closed and seven crescent-shaped and open – was
submitted to X-radiography in an attempt to identify the nature of the materials contained within that were responsible for producing the rattling noise. The X-radiographs show that these small pieces are a combination of beads, spheres and irregular-shaped fragments of various materials, sometimes mixed together in the same artefact, as shown by the difference in densities in the images (the paler the area, the denser the material), Figure 11. It has not been possible to determine more precisely the nature of the internal items in these pieces using other, more intrusive, analytical techniques, as all the objects are complete and totally closed. As a comparison, Salim al-Shareqi uses only small fragments of thin copper wires as rattling material.

The main body of all the bracelets and anklets is composed of one sheet of silver that has been annealed and shaped around a core to achieve a cylindrical shape, with the long edges brazed together. The joins can be seen macroscopically, in the SEM and in the X-radiographs as a bright rim on the inside curve, Figure 11. This cylinder would then have been bent into an annular shape around a hard former, brazed at one end with a silver disc and filled with a material with sufficient resilience to allow the silver sheet to be worked from the outside by chasing, punching and stamping [5; pp. 118–119, 122–126 and 132–134, 7; pp. 84–110]. This material might have been a resin or pitch [5; pp. 121–122, 7; p. 95], which are substances widely available in the Middle East and often referred to as ‘lakk’ [2; p. 169]. The filling materials were not identified more precisely since there are no incomplete or open artefacts that might offer access to the contents for analysis. For the crescent-shaped anklets, each end of the tube has been closed, following the removal of the filler, by brazing onto the end of the tube a silver sheet cut to fit the oval hole. The closed bracelets display two types of closure: the two ends of the cylinder either overlap and were directly brazed together (Figures 12a and 12b), or they were inserted into, and brazed onto, an additional silver sheet coiled into a tube that hides the join, Figures 12c and 12d. In either case, the porosity of the solder is evident from the darker ‘bubbles’ that appear in the brazed areas in the X-radiographs, Figure 12. These silver sealing rings are generally decorated with chasing and punching.

Figure 10. Features of a pair of c-shaped cast ‘spiked’ bracelets, which have a diameter of 6 cm: (a) overall view; (b) BSE image of the granular dendritic surface texture typical of a casting; (c) a large casting defect seen under the stereomicroscope (image width c.22 mm); and (d) BSE image of the two-phase eutectic microstructure in which the paler phase is richer in silver and the darker phase richer in copper.
‘SPIKED’ BRACELETS

Many different types of bracelets with bosses (protrusions) are popular throughout Oman and in other parts of the Middle East. They are produced with single, double or triple rows and are usually called ‘bracelets with thorns’ (banjiri bu shawkah) if the bosses are spiked or ‘bracelets with stars’ (banjiri bu nujum) if the bosses are more rounded.

The British Museum collection includes several pairs of both closed and hinged ‘spiked’ bracelets, Figures 9a and 9b. The conical spikes have most probably been created by pushing the metal from behind by hammering a convex punch into a doming block with a conical hole [5; pp. 115–116]. This has resulted in a relatively smooth outer surface (Figure 9c), with tool marks on the back of the hollow spikes that are visible under the microscope. Some of these bracelets have been lined with a sheet of silver to give a smooth inner surface, Figure 9a.

One unique pair of bracelets (2009,6023.37–38, Figure 10a), most likely for a child, is however very different in its manufacturing technology. These bracelets are possibly the only artefacts amongst the objects studied that have been cast, with surfaces that show the characteristic granular dendritic structure of a cast artefact (Figure 10b) and, on one inside surface, a large casting defect, Figure 10c. Within the dendritic surface, high-magnification SEM imaging also revealed the two-phase eutectic microstructure that is typical of silver–copper alloys, Figure 10d. Although mentioned in the literature, casting does not seem to be widely used by Omani silversmiths, the only notable exception being the manufacture of men’s belt buckles using a cuttlefish bone mould [1; pp. 36–37, 2; pp. 227–228, 4; pp. 41–42, 5; p. 484]. These bracelets may have been imported from Pakistan, which could explain their distinctive manufacturing technique [1; p. 110].

SILVER: COMPOSITION AND ORIGIN

Semi-quantitative XRF analyses of the surface of the objects were used to determine the compositional range of the jewellery: silver 82.0–99.9 wt% (average c.96 wt%); copper 0–15.5 wt% (average c.3.0 wt%); and zinc 0–2.5 wt% (average c.0.8 wt%). One thick wire showed very high levels of copper (39 wt%) and zinc (3.7 wt%) and it may be that this particular component could represent a recent repair using lower quality silver. The lead content of the alloys averages c.0.2 wt%, with the highest content being around 1.4 wt%. Traces of gold in the silver alloy have only been detected in three of the 27 components analysed.

The silver in the objects examined is, therefore, generally of high purity, with relatively small quantities of copper and zinc, and traces of lead. The copper and zinc most likely derive from alloying the silver with small quantities of brass, while the lead probably comes from the original
silver ore. Traces of gold in silver are generally considered to indicate the use of pre-nineteenth-century silver, so the very small number of gold-containing components in this Omani silver jewellery suggests a more recent date for most of the silver used. Today, the silversmith Salim al-Shareqi acquires his silver in one kilogramme bars from the Emirates, although the silver itself originates from Pakistan.

SILVER BRAZING SOLDER

Semi-quantitative surface analysis by XRF showed that the silver solder contains 5–22 wt% zinc, 2–17 wt% copper and 0.3–0.7 wt% lead, with zinc generally present in greater amounts than copper. The original solder was an alloy of silver with zinc, copper and traces of lead, which is typically used for contemporary brazing of silver [5; p. 393, 7; pp. 330–331]. This zinc-rich solder would have been applied in association with a flux, most likely a water-borax (sodium tetraborate decahydrate) paste. The flux helps to form a stronger join by preventing the formation of oxides on the cleaned surfaces and increasing the flow of the solder [5; pp. 403–404; 9–11]. The silversmith Salim al-Shareqi gave one of the authors (FS) a sample of borax during a field trip to Oman and this is the only flux he has ever used.

Because of the possible heterogeneity of the area analysed, the depth of penetration of the X-ray beam and hence the partial inclusion of the subsurface, it is difficult to ascertain whether one unique composition of solder was used or whether the silversmith produced various solders with a range of compositions. The situation is further complicated...
as some zinc would have been lost by vaporization when the ternary silver–zinc–copper alloy was prepared, most likely by melting silver and scrap brass together. Finally, the silver may be stained by the heated flux and, to remove this, pickling in acid may be required, which might also modify the surface composition of the original solder.

The use of silver–zinc–copper solder in Oman for brazing silver has been documented as previously [12; p. 15], and Morris and Shelton mention alloys made of either silver containing 8 wt% zinc or silver and brass in a 3:1 ratio [1; p. 37].

GILDING

Gilding can be seen on several artefacts in the collection, from necklace pendants to anklets. It proved difficult to determine the exact composition of the gilding layers as they are very thin and generally worn (Figure 13a), so that during XRF analysis the X-ray beam most likely passed through the gilded layer and excited the underlying silver. The silver detected in these areas is, therefore, mostly within the silver sheet, but some probably derives from the gilding. Although the exciting electron beam in the SEM does not penetrate to the same depth as the X-rays emitted by the XRF tube, the EDX analyses were also inconclusive. However, SEM imaging proved very useful because the BSE images showed differences in elemental composition at the surface, with heavier elements appearing paler and lighter elements darker. The high contrast created by the difference between areas of silver and gold provided some indication of the extent of the gilding and its degree of wear. The gilding was seen to be almost completely lost on the corners and edges of the silver-gilt components and better preserved in recessed areas, Figure 13b.

Only one semi-quantitative analysis by XRF seemed to give the composition of a gilding layer without including the substrate: the gilding on headdress ornament 2009,6023.159 is composed of 96 wt% gold, 3 wt% copper and 1 wt% silver. Additional analyses of the gilded layers, without interference from the underlying silver, would be needed to give a more accurate identification of the composition. No mercury was detected in any of the areas analysed, suggesting that fire gilding was not used here.

On each object studied, the gilding layer appears to be not only very thin but also relatively porous (Figure 13c), both of which are characteristic of electroplating or chemical/electroless plating of silver sheets with gold, rather than leaf gilding. These plating processes involve the chemical or electrical reduction and deposition of gold ions onto clean silver surfaces [5; pp. 677–679]. Electroless plating is sometimes referred to as ‘gold wash’ or ‘wash gilding’ in the literature [1; p. 45]. Several other gilding techniques have been documented by Morris and Shelton [1; p. 45], but these would not result in such a porous surface.

On every item the gilding is on either square or rectangular fragments of silver sheet brazed onto the main body of the artefact, Figure 13. Observations made at high magnification suggest that gold was plated onto relatively large, thick sheets and strips of silver, which were then cut to the desired size and shape, punched or stamped into a die and finally brazed onto the relevant areas of objects. Examples of
CONCLUSIONS

The scientific investigation of this collection of 1950s silver jewellery from Oman has offered a significant insight into the raw materials and manufacturing techniques used by Omani silversmiths. It has also been possible to compare these data with first-hand information from a practising Omani silversmith. It has been shown that this type of jewellery is traditionally made from hand-worked silver sheet and wire by shaping, chasing, punching and drawing, and by adding surface finishing treatments such as gilding and polishing. Jewellery was assembled from small components by extensive and meticulous silver brazing with a zinc-rich hard silver solder or mechanically as loop-in-loop chains and rings. These artefacts are also occasionally ornamented with beads and amulets composed of other materials, such as coral, carnelian, ceramic and glass. Most of these amulets carried a symbolic meaning connected to their material and colour. The documentation of this collection is very important because of the rapid decline in demand for Omani silver as it is increasingly replaced by gold jewellery. Most of these objects are no longer manufactured, and the technique may soon be forgotten as silversmiths in Oman age without passing their craft on to the next generation. There is, unquestionably, scope for more research, as many questions remain unanswered. While the first meeting between the Omani silversmith Salim al-Shareqi and one of the authors (FS) proved essential to an understanding of the use of specific tools, a number of outstanding questions remain unanswered. For example: most of the materials in the rattling bracelets and anklets have yet to be fully identified; the gilding technique has been identified on only a few objects (and further examples would be useful to assess whether they are representative of methods used throughout Oman); and whether various local workshops employ different techniques and construction sequences to those used by Salim al-Shareqi. Future fieldwork is planned to study the traditional silversmithing techniques used by Salim al-Shareqi and by other Omani silversmiths still in practice.

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AUTHORS

Aude Mongiatti (amongiatti@thebritishmuseum.ac.uk) and Nigel Meeks (nmeeks@thebritishmuseum.ac.uk) are scientists in the Department of Conservation and Scientific Research and Fahmida Suleman (fsuleman@thebritishmuseum.ac.uk) is a curator in the Department of the Middle East, all at the British Museum.

REFERENCES

NOTES

2. The components of the jewellery not made of silver have been analysed using Raman spectroscopy and SEM-EDX, but the results are not discussed here.
3. Lead is also mentioned in the literature as a possible filling material [1; p. 37, 2; p. 169]. The inside of the silver artefact would first be lined with a mixture of clay, sand and/or silt to prevent the molten lead from adhering to the silver surface. After chasing, the object would be heated and the molten lead poured out. Any residual lead would appear much paler than silver in the X-radiographs and no such features were seen for the jewellery examined here.
4. The term ‘wash gilding’ can also sometimes refer to mercury gilding, but elemental analysis showed that mercury was not used in the gilded objects examined here.