An unusual example of gold cloisonné from Central Anatolia

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Abstract Presents the examination and XRF analysis of a gold cloisonné object dating from ca. 1800 BCE, discovered by the Japanese Institute of Anatolian Archaeology (JIAA) in the Kaman-Kalehöyük excavation of 2010 in Turkey, representing the Assyrian Colony Period in Central Anatolia. Kaman-Kalehöyük is a rural settlement along the ancient Silk Road trade route dating from the Bronze Age (2300 BCE) through the Ottoman Empire. The object is constructed from hammered sheet gold and gold rings that may have portrayed a rearing lion. The composition was found to range from 87.3% to 96.1% gold, 1.8% to 10.5% silver, and 1.3% to 3.1% copper. The evidence for joining techniques is discussed based on elevated silver content in some areas indicating a gold-silver solder and overheating of the gold in places possibly resulting from any number of fusing methods. Areas of partially melted gold, the absence of inlays, and little evidence of use wear suggest that this object may have been damaged during manufacture, unfinished, or destined for reuse.

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Introduction

An unusual gold object was unearthed from the Kaman-Kalehöyük excavation, Turkey, in 2010 dating to ca. 1800 BCE, the Assyrian Colony Period in Central Anatolia (Figure 1) (Omura 2008; Paterakis 2011). The gold object (KL10-1) was unearthed in room R409, grid XXXIV-54, Sector VI, from Stratum IIIC. Excavation of Stratum III has revealed a sequence of cultures from the Early Bronze Age to the Iron Age (Omura 2015). Stratum IIIC dates to the Assyrian Trade Colony Period. Kaman-Kalehöyük is located 192 km northwest from Kultepe-Kanesh, the capital of the Assyrian Trade Colonies in Central Anatolia. Room R409 was made up of walls W29 and W32 and a hard floor covered with a thin layer of white ash. A hearth in front of W29 measured 35 cm in diameter and 10 cm deep. The earthen surface of the hearth had hardened from intense heating.

The object was recovered in a very distorted condition and was partially opened in the laboratory without the knowledge or involvement of the conservation department (Omura 2015). Its current dimensions are approximately 8 cm by 5 cm by 3 cm. The object is constructed from hammered sheet gold that was cut to form the figure. Empty gold cells (cloisons) attached to the base plate on one side suggest a cloisonné object (Figure 2). The other side is undecorated and unchased (Figure 1). A preliminary hypothetical reconstruction of the disfigured object suggests a lion rearing on its hind legs (Figure 3).

Cloisonné is an ancient technique for decorating metal objects; in older periods with inlays of cut gemstones, glass, and glass paste and in more recent centuries with vitreous enamel. Examples of cloisonné have been found that pre-date the Kaman object: A gold bead and gold ring inlaid with lapis lazuli and dating to 2600 BCE from the Royal Cemetery at Ur (BM 121378) (Woolley 1934; Maxwell-Hyslop 1974; Tait 1976) and inlaid gold objects dating to ca. 2000 BCE from Byblos in present day Lebanon (Montet 1929). A gold pin with a cloisonné rosette, with an estimated date of ca. 2000 BCE, was discovered by Schliemann in Troy in western Anatolia (Maxwell-Hyslop 1974). The Trojan gold from this period is identified with the earliest examples of cloisonné and “gold to gold soldering” by local workshops (Yakar 1985, 29). Schliemann describes the cloisonné pin as having been “soldered” without providing further details. An example of contemporaneous gold cloisonné includes a ring from the Tomb of the Lord of the Goats from Ebla, Syria (1825–1700 BCE) (Arzu et al. 2008). Other cloisonné from this period and slightly later examples include a gold pectoral (BM 1892,0520.7) and falcon pendant (BM 1876,1120.2) from Greece (Higgins 1979). A contemporaneous cloisonné gold pectoral...
from the Middle Kingdom in Egypt (MMA16.1.3a, b) preserves inlays of garnet, carnelian, feldspar, and turquoise (Brunton 1920; Dodson and Hilton 2004).

Another pectoral from the Middle Kingdom, 12th Dynasty, 1897-1841 BCE (probably from Dahshur) resembles the Kaman object for its many empty cloisons (Eton College ECM 1585). These Middle Kingdom pectorals were decorated by chasing the smooth gold side mirroring the design on the inlaid side, strung through two hollow attachments, and worn around the neck displaying either side. The plain side of the Kaman lion was not chased, as is typical of Western Asiatic cloisonné, and therefore the inlaid side was meant to be viewed.

Metallurgical Joining Techniques

The metal joining techniques that are known in this period include 1) hard soldering, 2) autogenous fusing, 3) copper colloidal fusing, and 4) sintering (Roberts, 1973; Eluère 1989; Schorsch 1995; Guerra 2008; Troalen et al. 2009; Prévael 2009, 2014). Hard soldering involves the application of an alloy with a melting point lower than that of the metal to be joined (Tate et al. 2009; Troalen et al. 2014). Hard soldering was used in areas subjected to stress requiring a stronger bond, e.g. suspension loops. Copper colloidal fusing involves the application of a copper oxide or copper carbonate with an organic binder that forms a copper gold alloy bond while heating (Pantazis et al. 2002). Copper colloidal fusing was especially suited for non-structural joins. Although copper colloidal soldering can be difficult to detect even with the most sophisticated analytical means (Eluère 1989), it has been successfully identified in some cases (Pantazis et al. 2002; Harrison et al. 2012). Autogenous fusing involves heating two homogeneous metals without adding a filler metal, posing a risk for accidental melting of the components to be fused. Sintering involves the application of powdered metal (matching the composition of the metal to be joined) with an organic adhesive into the seams and heating to within 65% to 80% of the solidus temperature (of the powdered metal) until the grains coalesce, creating a seam (Harrison et al. 2012).

The autogenous fusing technique has been found on Sumerian gold objects from the Tomb of Queen Puabi in the Royal Cemetery of Ur that predate the Kaman-Kalehöyük object (Maxwell-Hyslop 1977). Copper colloidal fusing is considered to be an innovation of Syrian, Anatolian and Mesopotamian goldsmiths mostly for filigree and granulation work (Prévael 2014). Examples of sintering and copper colloidal fusing are known from Syria in 2600-2300 BCE (Prévael 2014). Sintering is assigned frequent usage in these parts of the world for the assemblage of structural gold elements (Prévael 2014). Soldering, autogenous fusing, and sintering are likely candidates for the Kaman object.

Description of the Object

The object was found in a very distorted condition that hindered its study, analysis, and interpretation. The
The object was partially unfolded in the laboratory revealing the lower half of the figure while the upper part remains distorted (Omura 2015). The object weighs 104 grams and was cut from gold sheet hammered to different thicknesses. The gold figure may be divided into four main components: thick sheet forming the base plate and cloisons, thinner sheet covering the lower part of the figure, cloisons, and rings. Holes in the figure suggest mounting (Figure 4) and a pivot joint mobilizes one row of rings (Figure 5). The thicker gold sheet forming the base plate is a very uniform thickness of 0.7 mm, the cell walls vary in thickness from 0.6 to 0.8 mm, the cell wall height varies from 1.9 mm to 2.8 mm, the thinner gold sheet varies from 0.25 mm to 0.4 mm, and the rings range in thickness from 0.4 to 0.7 mm.

The iconography of the gold find recalls a hybrid creature called a winged ‘lion-dragon’ standing on its hind legs (Omura 2015). Similar Assyrian motifs have been recovered on seals from Kaman-Kalehöyük. The hybrid creature consists of the head and torso of a lion and the wings, hind legs, tail, and talons of a bird of prey. In Mesopotamian art the lion-dragon may be related to the hybrid creature Anzū in Akkadian or Indugud in Sumerian from Akkadian to Neo-Babylonian times (Omura 2015). This hybrid creature was introduced into Anatolia through the Assyrian merchants along with Akkadian and Sumerian myths. The discovery of the Mesopotamian ‘lion-dragon’ attests to the participation of Kaman-Kalehöyük along the trade route between Western Anatolia and Mesopotamia.

Goals of the Project

This object is a rare example of gold cloisonné from Central Anatolia dating to the Assyrian Colony Period. The goals of this study are to determine the composition of the metal, the means of manufacture, the methods and materials used for joining the components, and the function of the object. Specifically the following points are of greatest interest:

1. Compositional evidence for the methods and materials used to adhere gold to gold, such as the formation of the cloisons and the rings;
2. Compositional differences between the various components of the object (base plate, cloisons, rings);
3. Evidence of manufacture such as cutting, heating, tool marks, etc.;
4. Evidence for the intentional use of alloyed metals in manufacture (e.g. to increase the strength of areas subjected to stress or to lower the melting point for joining).

This contribution provides a preliminary study of the Kaman-Kalehöyük gold object that included two analytical campaigns using portable XRF. The various components of the object are examined and discussed in detail based on microscopic examination and XRF analysis.

Analytical Method

The gold object underwent two analytical campaigns using portable X-ray Fluorescence spectroscopy (Table 1). In the first campaign eleven spot analyses (samples 1 -11) were carried out with a Niton XL3t Thermo Scientific Handheld X-ray Fluorescence analyzer on August 20, 2013, by Daichi Sawamura and Izumi Nakai from the Tokyo University of Science. The XRF gun was set on precious metal mode and calibrated with Standard Reference Material in Japan prior to
the analysis. In a second analytical campaign three spot analyses (samples 12–14) of the base plate were carried out with a Bruker Tracer III SD portable laboratory X-ray Fluorescence analyzer in July 2014. The specific values in the analysis were validated using the calibration gold standard 40XXS22KY_394 (Au 91.7%, Ag 3.2%, Cu 4.9%) from the Excalibur Company. The beam diameter of the spots analyzed for both campaigns was 3 mm.

### Results

87.3% to 96.1% gold, 1.8% to 10.5% silver, and 1.3% to 3.1% copper were determined (Table 1). The gold composition of the Kaman ‘lion-dragon’ is similar to that of Sumerian gold jewelry from Ur (Early Dynastic Period) that predates the Kaman object (Maxwell-Hyslop 1977), reinforcing the theory of cultural exchange at this time. The purity of the Kaman gold exceeds that found in most Egyptian gold from the 2nd millennium BCE (Ogden 2000; Troalen et al. 2009). Variation in the gold to silver ratio in some areas may be attributed to soldering with a gold-silver hard solder of increased silver content to lower the melting point.

#### Thick sheet for base plate

The first analytical campaign of the base plate showed a range in gold content from 93.1% to 95.8%. A second analytical campaign was carried out in which the gold content of the base plate was determined to be 95.6% to 96.1%. These figures coincide with those of the first analysis and are therefore considered representative of the gold content of the base plate. Marks from cutting the base plate are visible on the edges, perhaps made by the goldsmith for reuse (Figure 6).

#### Thinner sheet on lower portion of figure

The thinner sheet is similar in composition to the base plate, varies in thickness from 0.25 mm to 0.4 mm, and most likely was formed by hammering the same gold. The thinner sheet covers one side of the rings, serving both a functional and cosmetic purpose by simultaneously hiding and reinforcing the ring seams (Figure 7 and 8).

### Table 1  XRF Analysis (wt %).

| Sample | Au     | Ag     | Cu     | Base Plate | Foil | Cell walls | Rings |
|--------|--------|--------|--------|------------|------|------------|-------|
| 1      | 93.1   | 3.1    | 3.1    | x          | x    |            |       |
| 2      | 94.0   | 2.5    | 2.8    | x          |      |            |       |
| 3      | 95.6   | 2.0    | 1.9    | x          |      |            |       |
| 4      | 92.5   | 4.5    | 1.9    |            |      |            | x     |
| 5      | 87.3   | 10.5   | 1.8    | x          |      |            | x     |
| 6      | 88.4   | 7.8    | 1.6    | x          |      |            | x     |
| 7      | 92.5   | 5.3    | 1.6    | x          |      |            | x     |
| 8      | 94.9   | 3.1    | 1.5    | x          |      |            | x     |
| 9      | 93.3   | 3.2    | 2.8    | x          |      |            | x     |
| 10     | 93.2   | 3.9    | 2.2    |            |      |            |       |
| 11     | 95.6   | 2.1    | 2.0    | x          |      |            | x     |
| 12     | 95.9   | 2.1    | 1.3    | x          |      |            | x     |
| 13     | 95.6   | 1.8    | 1.9    | x          |      |            | x     |
| 14     | 96.1   | 1.9    | 2.0    | x          |      |            | x     |
silver content to lower the melting temperature. The melted and fused metal between the rings is visible (Figure 9) and melted areas can be seen on the exterior of some of the rings (Figure 10).

**Cloisons**

Hard solder cannot be confirmed in the joins of cell wall to base plate. The cell walls have become detached from the base plate in many areas (Figure 11). Open seams are not uncommon with copper colloidal fusing and were probably invisible before the object was distorted. In these areas where the cells do not appear to have been joined to the base plate with hard solder, copper colloidal fusing or sintering may have been used. What was once a successful fusion between the cell wall and base plate is evidenced today by a fracture through a fused seam exposing the grain structure (Figure 12). This may be the result of stress corrosion cracking caused by bending the object or by localized higher copper levels from copper colloidal fusing.

**Platinum group metals**

Alluvial sources are sometimes indicated by the Platinum Group Metals (PGM) that are common in Anatolian gold: iridium, ruthenium, and osmium. The detection limits of the handheld XRF are too high to detect the PGM and the random distribution of the small inclusions of PGM preclude identification in this study. The application of other analytical techniques that can detect trace amounts of PGM, combined with a more comprehensive examination of the surface, would be required.
Discussion

Gold cloisonné

Gold cloisonné objects from the Early Bronze Age and Middle Bronze Age found in Mesopotamia, the Near East, the Levant, and Egypt have been reviewed in the introduction. Anatolian, Near Eastern, and Egyptian influences converged at Ugarit (situated today in Syria 685 km from Kaman-Kalehöyük) in the Middle and Late Bronze Age (Prévalet 2014). Advancements in gold working technology in the north Levant are known to have spread, perhaps reaching Kaman-Kalehöyük by 1800 BCE. The Assyrian colony at Kültepe-Kanesh in Anatolia, located approximately 175 kilometers east of Kaman-Kalehöyük, traded in metals with Ashur, the capital of the Old Assyrian Kingdom, from 1950 to 1750 BCE (Maxwell-Hyslop 1974). Influence of Mesopotamian goldsmithing and connections with North Syria preceding the Assyrian Colony period have been discovered at Kültepe-Kanesh (Maxwell-Hyslop 1974). A cultural, artistic, and material trade existed between Kültepe-Kanesh, Syria, and Mesopotamia resulting in the influence of metalwork from Kültepe-Kanesh on Syrian metallurgy. Trade with western Anatolia reached as far as Troy creating a homogeneity of western and central Anatolian jewelry (Maxwell-Hyslop 1974). Itinerant metalsmiths who traveled over the trade routes passing through Kültepe-Kanesh have left physical evidence supporting the link between Mesopotamia and the Troad. The gold jewelry found by Schliemann in Troy (ca. 2000 BCE) shows similarities with jewelry from Ur in Mesopotamia. The attribution of the Kaman gold lion to the Mesopotamian ‘lion-dragon’ is yet another piece of evidence attesting to this trade and to the fact that Kaman-Kalehöyük was well situated in cross-cultural exchanges between Mesopotamia and western Anatolia.

Evidence of joining techniques

Although a precise characterization of the materials and methods for the construction of the ‘lion-dragon’ could not be determined, analytical results and microscopic examination indicate that more than one joining technique was used. Each joining technique - hard alloy soldering, copper colloidal fusing, autogenous fusing, and sintering - would have involved heating the object to a different temperature. The stages in the manufacture process could be traced once the joining methods are identified. Heating could have softened this Type I AuAgCu alloy object in order to fuse the cell walls to the gold base sheet in autogenous fusing (MacDonald and Sistare 1978). Therefore it is not surprising to find evidence of partial melting in several areas of the base plate next to the cell walls (Figure 13). A rippling effect on the surface of the gold as evidence of overheating is visible in many areas of the base plate and cell walls. The dendritic structure of the metal is evident in some areas indicating that the melting point was
almost reached (Figure 14) (Eluère 1989). Thus overheating may have occurred during any of the steps in the manufacture process: the attachment of the cloisons or the rings, the fusing of the rings, or the attachment of the foil. Another example of damage to gold from overheating during manufacture can be seen in the Mesopotamian Dilbat Hoard necklace in the Metropolitan Museum of Art, New York (MMA 47.1a-h) from the Old Babylonian period (ca. 1894-1595 BCE) (Lilyquist 1994).

Function of object
The function of the two rows of rings, one of which is attached by a pivot joint, has not yet been determined. The use of hard solder indicates the need for a stronger construction to accommodate the undetermined function of the rings. Considering the unchased back (Figure 1) and the holes that pierce the base under the legs of the lion (Figures 1, 2, and 4), the intention most likely was to mount the object onto a wooden support perhaps as a decorative or religious plaque.

Conclusions
The evidence gathered to date from the examination and analysis of the Kaman-Kalehöyük gold lion suggests the use of more than one joining technique. A gold-silver hard solder appears to have been used to join the rings, based on chemical and physical evidence. Copper colloidal fusing, autogenous fusing, and sintering are all candidates for the construction of the cloisons. Physical evidence suggests the use of
copper colloidal fusing of the cloisons to the base plate. Evidence of partial melting in some areas indicates accidental overheating of the metal during fusing. XRF has been applied successfully for the analysis of ancient gold artifacts (Pantazis et al. 2002). The XRF results in this study can be considered semi-quantitative at best on account of the large beam diameter (3 mm), the uneven surface of the metal, surface effects that can skew the results, and the inability to access many seams. The irregular configuration of the object hindered access to the seams between cell wall and base plate. In order to determine with greater accuracy the joining methods and materials used on the gold lion other x-ray based analytical techniques are called for such as Scanning Electron Microscopy with an Energy Dispersive X-ray system (SEM-EDX), Proton-Induced X-ray Emission (PIXE), and Synchrotron Radiation X-ray Fluorescence (SR-XRF) (Guerra 2000, 2008) and other techniques such as Proton-Induced Gamma-ray Emission (PIGE), Rutherford Backscattering Spectroscopy (RBS), and Nuclear Reaction Analysis (NRA) (Demortier 1996; 2005).

No evidence of inlays has been found in the cloisonné cells of the gold lion to date and little has been found in the way of scoring marks on the base plate, sometimes applied by goldsmiths to increase the adhesion of the inlays. These factors, taken into consideration with little evidence of use wear and the rough cut edges of the gold base plate, point to an unfinished or damaged object that was perhaps destined for reuse.

Given the fact that the lower half of the object has been opened and flattened, a completion of this task would expedite an accurate iconographic rendition. In the absence of the physical reconstruction a 3D laser model could be created for a virtual reconstruction of the object. A complete reconstruction of the ‘lion-dragon’ will contribute to historical interpretation and enable a comprehensive examination of the manufacture and function of the object. Due to the uniqueness and value of this artifact in central Anatolia, stringent limitations have been placed on access, handling, examination, and transport of the artifact. Permission must be obtained from the Ministry of Culture and Tourism in order to transport the object to a SEM-EDX facility in Ankara for the analysis of this unusual cloisonné artifact, discovered in the heart of Central Anatolia.

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