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The gold of Queen Amanishakheto – research with different methods

Das Gold[1]

Denk es wäre nicht: es hätte müssen
endlich in den Bergen sich gebären
und sich niederschlagen in den Flüssen
aus dem Wollen, aus dem Gären

ihres Willens; aus der Zwang-Idee,
dass ein Erz ist über allen Erzen.
Weithin warfen sie aus ihren Herzen
immer wieder Meroë

an den Rand der Lande, in den Äther,
über das Erfahrene hinaus;
und die Söhne brachten manchmal später
das Verheißene der Väter,
abgehärtet und verhehrt, nachhaus;

wo es anwuchs eine Zeit, um dann
fortzugehn von den an ihm Geschwächten,
die es niemals liebgewann.
Nur (so sagt man) in den letzten Nächten
steht es auf und sieht sie an.

Rainer Maria Rilke
(Paris, 1907)

When looking at the numerous treatises dealing with the objects from the tomb of the Meroitic queen Amanishakheto, one cannot escape the impression that everything has already been written on the subject.[2] However, this impression is deceptive. Important basic work has yet to be presented. Having drawn attention to the ongoing research in a presentation at the International Conference for Nubian Studies 2018 in Paris, here our focus is on to the continuing results that can be derived from the analyses of the metal compositions.[3] As can be seen in the following, it was a chain of circumstances and first of all the primary interest in the origin of the Mycenaean gold that brought us together. In order to be able to answer the questions posed by Moritz Numrich and Ernst Pernicka and to draw conclusions about queen Amanishakheto's collection, a selection of 19 objects was made available for scientific analyses from the Berlin collection, taking into account different groups and condition of the objects. The selection also considered results of previous material analyses and optical inspections concerning technological questions.

Even though the iconographic features of the representations and objects were not the primary criterion for the selection, the focus lies on the signet rings, which overall make up the largest group within the collection. Nine of the signet rings from the Berlin collection were examined in detail.[4] These have oval or rectangular ring plates on which representations of deities in various guises can be found alongside supposedly unspecific depictions of birds and, moreover, include clearly recognisable representations of the goddesses Isis and Mut as well as the god Amun.[5]

1 The fascination with the yellowish shimmering gold continues to this day. In particular, however, it is the finds from the legendary Meroë that moved Rainer Maria Rilke to write about the precious metal. The poem is cited in the German original without translation.

2 This is not the place for an extensive study of the hoard of the qore Amanishakheto. Various perspectives and approaches have been published by, e.g. Bianchi 2004, 256–260; Eltze 2017, 75–79; Haynes/Santini-Ritt 2012, 180–184; Helmbold-Doyé 2014, 128–131; Lacovara/Markowitz 2012, 48–51; Lacovara/Markowitz 2019, 10–17, 153–171; Lohwasser 2001, 285–302; Markowitz/Doxey 2014, 130–133; Markowitz/Lacovara 1996, 1–9; Priese 1992; Priese 1993; Schäfer 1909, 93–188, 213–238 (Ferlini's report and catalogue); Schäfer 1910, 92–188; Wildung 1996, 302–303, 306–327, cat. 325–368.

3 Helmbold-Doyé/Hertel 2023, 463–480.

4 ÄMP Berlin, ÄM 1698, ÄM 1704, ÄM 1710, ÄM 1720, ÄM 1725, ÄM 1728, ÄM 1732, ÄM 1734, ÄM 1745.

5 ÄMP Berlin, ÄM 1698 (Amun), ÄM 1704 (bird), ÄM 1710 (Isis), ÄM 1720 (vulture with depiction of an enemy), ÄM 1725 (lion), ÄM 1728 (Mut), ÄM 1732 (rooster), ÄM 1734 (bird), ÄM 1745 (Mut).

Fig. 1: Signet ring with a rooster (h. x w. (sealing surface) x w. (ring): 1.63 x 0.7 x 1.53 cm); photo: SMB/ÄMP – Iris Hertel.

The first example is the ring ÄM 1732 (Fig. 1), which has a rooster as a motif on the sealing surface. Chickens and roosters originally came from South Asia. We know from the annals of Thutmose III (Urk. IV 700.13–14) that chickens were already known in Egypt from the 18th dynasty onwards.[6] Despite the very small amount of evidence, Emma Brunner-Traut believes that chickens were kept in Egypt as early as the 19th dynasty – this can no longer be assumed today.[7] Houlihan points out that the bird was not to become a regular feature of the Egyptian farmyard at least until the Ptolemaic Period.[8] What is certain, however, is that the evidence for roosters in Egypt only increased from the 30th Dynasty onwards.[9] In contrast, roosters in Greece, Lower Italy, and Sicily can be documented since the 6th century BC.[10] As a bird of the deity of light, whose crowing heralds the imminent sunrise, the rooster was, according to Persian custom, an attribute of Hermes, Helios-Apollon, Eros, and Mithras and was supposed to keep demons, such as the basilisk, away. In this apotropaic capacity, it often adorns gravestones, urns, weapons, etc.[11] One of the best-known representations in Egypt comes from the tomb chapel of Petosiris in Tuna el-Gebel, where processions of bearers are shown bringing offerings to the tomb owner. Included amongst the gifts are two Red Junglefowl.[12] The largest group of evidence from Egypt consists of figures of roosters, some of which are no older than the 2nd century BC, but most date from the 1st–3rd centuries AD.[13] In Roman art, representations of roosters, whether single, in pairs in battle, or together with a palm frond, are often iconographic elements symbolising victory over death. Cockfights were intended to instil martial virtues in the young Romans – even beyond death.[14] For this reason, representations of roosters are often found in the wall paintings of tombs or corresponding burial objects.[15] Interestingly, the aforementioned aspects of rooster portraits can also be found in Christian iconography, where they are expanded to include other views, such as the rooster as a symbol of Christ.[16] Even in this period, the reference to resurrection, redemption, and life after death remains.

A comparable situation can be found in Kush – only very few objects depicting roosters are detectable in the Napatan tombs.[17] On two inlays from Nuri, the roosters are supplemented by depictions of lotuses. This may be the explanation for the sporadic depictions: Roosters are symbolic animals endowed with magical powers that have an apotropaic effect comparable to other amulets. These appear here in combination with the symbol of rejuvenation and rebirth linked to the cyclical behaviour of the lotus flower.[18]

6 Helck 1962, 413.

7 Brunner-Traut 1980a, 70. The evidence of an ostracon with a drawing of a Red Junglefowl (Gallus gallus) is found in the Valley of the Kings in undisturbed strata between the tomb of Ramesses IX and KV 55 is often cited. Published for example: Egypt's Golden Age (1982), 48–49, no. 18 (with a list of earlier literature); Houlihan 1986, 79. See also the discussion of the other documents: Boessneck 1988, 90–91; Houlihan 1986, 79–81.

8 Houlihan 1986, 80.

9 Houlihan 1986, 81.

10 Hünemörder 1998b, 749.

11 Hünemörder 1998b, 750.

12 Cherpion, Corteggiani & Gout 2007, 115–116 (scène 88), 145 (scène 93).

13 Lamps, stamps, terracottas: Boutantin 2012, 116 (no. 73), 118–119 (nos. 75–76); Boutantin 2014, 363–377 (nos. 255–270); Dunand 1990, 295–296, 319 cat. 891–897, 965; Fischer 1994, 293, 425–426, 434 cat. 678, 1153–1156, 1193 pl. 71, 122, 126; Hayes 1980, 41 cat. 194 pl. 20; Kaufmann 1915, 149–150 pl. 65.

14 Hünemörder 1998b, 749–750; Müller 1998, 78–79; Rottloff 2006, 24.

15 On a wall painting with a rooster and mythical creatures in a tomb of unknown location at Tuna el-Gebel: Gabra/Drioton 1954, pl. 17. On the motif: Bruneau 1965, 90–121; Froschauer/Harrauer 2004, 40–41. An example on a sarcophagus (130–140 AD) is: Herdejürgen 1996, 109 cat. 50 pl. 53, 55.

16 Dresken-Weiland 2010, 146–162; Gerlach 2015, 206–210; Giebel 2003, 136–137; Kretschmer 2008, 173–175.

17 Dunham 1950, fig. 10c (Ku. 3, tomb of Queen Naparaye: 19-3-610 – identification as a rooster (Dunham 1950, p. 28) questionable); pl. LXVII.A2/6 (Ku. 15, tomb of King Shabako: 19-3-174; faience figure of a rooster, brown and yellow glaze, white body); Dunham 1955, fig. 22 (Nu. 53, tomb of Queen Yeturow (reign of Tanwetamani): 18-1-467 b, d; ivory plaques). The reference to some of the objects is due to Angelika Lohwasser, to whom we would like to express our sincere thanks. For this already: Hofmann/Tomandl 1987, 35, 37.

18 See, for instance, Brunner-Traut 1980b, 1091–1096; Pieke

The second example is the signet ring ÄM 1720 (Fig. 2) depicting an enemy lying on the ground with a vulture grasping him with its claws and attacking his head with its beak. In the Meroitic depictions, scenes showing enemies in combination with various animals occur most frequently.[19] In contrast to other animals, vultures appear as single entities.[20] In Egypt, two essential aspects are associated with the exclusively female depictions of vultures: motherliness and the protective function towards the male ruler.[21] These are probably related to the natural behavior of vultures. Thus, goddesses such as Nekhbet and Wadjit in particular are protective and maternal deities of the king, who are depicted with outstretched wings. In contrast, the vultures in the Meroitic cultural area appear to be more closely associated with the queens.[22] However, the function of the birds as supporters against the enemies is also recognizable here.[23] The scene on the signet ring can be explained in this way – the scavenger destroys the enemy of Amanishakheto.[24] The ring, however, seems to depict a vulture attacking a group of foreign people represented by one person on the signet ring. This consideration becomes clear through comparison with very similar depictions on bronze bells from Meroë, which provide an unmistakable parallel for the interpretation based on iconographic details.[25]

In addition, pendants of various shapes were selected for the study, which were most likely formerly threaded into chains and/or worn individually as amulets. These include the magically charged *ankh* sign (ÄM 1758/3), the *udjat* eye (ÄM 1754/6, ÄM 1758/10), and the Hathor head (ÄM 1664) next to a small bell (ÄM 1677). All the elements mentioned are attested by numerous individual finds and entire sets

Fig. 2: Imprint and original of the signet ring with a vulture attacking a lying enemy (h. x w. (sealing surface) x w. (ring): 1.76 x 1.2 x 1.7 cm); photo: SMB/ÄMP – Iris Hertel.

Fig. 3: Chain pendant in the shape of a crescent moon (lunula; h. x w. x d.: 2.1 x 1.81 x 0.34 cm); photo: SMB/ÄMP – Iris Hertel.

from the consistently robbed tombs at Meroë.[26] In addition, appliqués were examined, including those in the form of *ankh* marks (ÄM 1756/5, ÄM 22874) as well as a specimen of the so-called bracelets (ÄM 1639).[27]

Unlike the previously mentioned objects, the crescent-shaped *lunula* pendant ÄM 1679 (Fig. 3) consists of a silver-copper-gold alloy. It is still unclear why a different composition of metal was chosen for it. There may be a connection here between the silver-coloured moon in contrast to the gold-coloured sun. So far, it has been assumed that *lunula* pendants tend to be a typical component of female burials and that

2006, 259 note 3.

19 Hofmann/Tomandl 1987, 185.

20 Hofmann/Tomandl 1987, 186.

21 Blumenthal 2003, 12–15. Iconography in Egypt includes the vulture headdress, which can be regarded as an attribute of the reigning and designated king's mother. Further information: Roth 2001, 273–275.

22 Hofmann/Tomandl 1987, 187–188.

23 Hofmann/Tomandl 1987, 127.

24 The feeding of corpses to vultures is also documented from other regions in antiquity. In contrast to Egypt, however, vultures in Greece seem to have been associated more with male gods, such as Zeus and Mars (see e. g. Hünemörder 1998a, 864–865), but if there is an embodiment with a female being, then the origin was in Egypt (see e.g. Mielsch 2005, 43, 130).

25 Bells with similar motifs: Meroë, tomb unknown – ÄMP Berlin, ÄM 4384 and Dunham 1957, fig. 110 (21-3-329b/ Beg. N. 29=Takideamani, c. AD 140–155; Boston, MFA 24.857a) pl. LVI. Näser 1998, 155–162. For depictions of northern enemies on bells, see e.g. Matić 2015, 251–252.

26 Even though ankh, udjat, Hathor, and bells from Meroë are attested, there is a lack of identical objects of comparison to the objects examined here.

27 For the terminology, see the explanations in the articles mentioned in note 3.

Fig. 4: Ring-shaped earring with a globular pendant (h. x w. x d.: 2.24 x 1.24 x 1.15 cm); photo: SMB/ÄMP – Iris Hertel.

these were a symbol of Isis or Aphrodite.[28] Pendants of the *lunula* type or crescent shape pendants are known since the Hellenistic period, when they were particularly widely distributed in southern Italy and on the Black Sea coast, from where they very quickly spread across the Danube Valley. There, *lunulae* can be found as part of hoard finds dating mainly to the 1st century BC to 1st century AD.[29] In Egypt, jewellery of this type is frequently found in connection with Roman female mummy portraits.[30]

The ring-shaped earring ÄM 1692 (Fig. 4) with a globular pendant made of a silver-gold-copper alloy with 4% copper admixture is also associated with female burials. This material is the so-called electrum with a rather high silver content (59%), which has a yellowish colour. Here, too, comparable examples are known from Meroitic tombs.[31]

Precious metal from Meroë – production technology

Of the total of 219 pieces of jewellery, like rings, arm and neck jewellery, earrings etc. from the Amanishakheto tomb treasure, 198 (90.5%) are made of gold and 21 (9.5%) of silver. However, the composition of the alloys for either gold or silver objects is not identical. Some of the objects were decorated with vitreous enamel or inlays, some of which are lost. In order to understand the manufacturing processes, extensive technological examinations continue to be accompanied by scientific analyses. Thus, the necessity to determine the precise compositions of the used material became obvious.

First, non-destructive analysis methods were applied, which can provide information of the surface composition of the objects. In this way, all jewellery objects of the burial treasure were measured with X-ray fluorescence (XRF) at the Rathgen Research Laboratory (RFL) of the Staatliche Museen Preußischer Kulturbesitz in 2018 to 2019.[32] The disadvantage of this method is that the composition of the material on the surface is not representative of the bulk due to possible depletion and enrichment of individual elements on the surfaces of the objects (see below). However, conclusions concerning the material properties and the manufacturing processes can be drawn from the knowledge of the alloy composition unveiled by the XRF analyses.

In addition, three very small hollow jewellery objects filled with a putty were examined by computer tomography. These CT images provided important insights into the manufacturing process, which will be included in a possible reconstruction and traceability of the work steps (see below). Furthermore, the filling material from a small chain

28 Odgen 1990, 213–215. Bertinelli 1999, 506 (exemplified by the moon as a feminine element both with regard to the celestial calendar and the deity). The feminine connotation remains largely intact even in Christian times (LCI 2015, 279–280). According to Altmann-Wendling 2018, 757–765, the lunar aspect of the goddesses Hathor and Isis only appears in very specific cases as one of several cosmic attributes before the Roman Period. This can only be proven for Isis-Selene from the Roman Period onwards.

29 Guštin – Popović 2017, 53–74.

30 Evidence of lunulae, mummy masks and mummy portraits include: ÄMP Berlin, ÄM 10974, ÄM 11413 (For a possible exception, see Helmbold-Doyé 2017, 50–51.), ÄM 12125, ÄM 12699; Odgen 1990, 395–397, 399; Parlasca/Seemann 1999, cat. 1 (ANT Berlin, 30219.342)–2 (BM London, EA 74716); Walker/Bierbrier 1997, cat. 17–19, 77, 188–190. Lunulae from Meroë: Boston, MFA 22-1-19a (Beg. N. 15), 23.817 (Beg. W. 308); Dunham 1957, fig. 89 (22-1-19/Beg. N. 15), 99 (21-3-608f/Beg. N. 18).

31 Boston, MFA 22-1-60 (Beg. N. 21), 24.492-3 (Beg. W. 18), 24.504, 24.525, 24.533 (Beg.); Dunham 1957, fig. 51 (21-12-171/Beg. N. 20), 55 (22-1-40, 22-1-57a-b/Beg. N. 21) pl. LXI D–E, G, I.

32 Unpublished analysis reports of the RFL 12_020618, 49_070819 and 98_110518.

(h. x w. x d.: 0.92 x 0.33 x 0.3 cm) (h. x w. x d.: 0.96 x 0.38 x 0.33 cm)

Fig. 5: Pendants in the shape of date kernels; photo: SMB/ÄMP – Iris Hertel.

link was analysed by FT-IR.[33] The investigations of the vitreous enamel and inlays are still in progress.[34]

From the basic manufacturing processes of casting or mounting, more detailed knowledge can be obtained through closer examination. For example, the large group of signet rings can almost exclusively be assigned to casting. Only one ring was mounted, i.e., the ring and sealing plate were soldered together. However, even though the method of manufacture is seemingly the same, each ring must be considered individually. Thus, some rings are interpreted as frequently worn, while others seem to have been produced only for the burial. For the casting of signet rings, the use of three-part moulds has been proven. However, lost-wax casting was already known in the Meroitic period.

In this context, the question arose as to whether the very deep cut seal images were perhaps already created in the wax model. Moreover, the results of the analyses indicate that a few rings may have actually been produced by casting, which, in turn, offers new approaches to the examination of the entire complex. Taking the two small pendants ÄM 1685/1–2 (Fig. 5)[35] as examples, the manufacturing process can be largely reconstructed based on the available analysis results and the CT images as described below. The pendants imitate a date kernel.[36] Comparative examples of application can be found on the shield rings ÄM 22870 (Berlin) and Ant. 24464 (Munich).

- Preparing a two-part mould by moulding a date kernel (e.g., clay) or working in the shape of a date core into e.g. sandstone.
- Working in thin metal sheets (material thickness approx. 0.1 mm) into the mould.
- Alloy ÄM 1685/1: 84.6% Ag, 12.2% Au, 3.0% Cu and 0.1% Pb
- Alloy ÄM 1685/2: 84.3% Ag, 12.6% Au, 2.9% Cu and 0.1% Pb[37]
- According to the analyses of both chain links, it can be concluded that they were made of the same material batch.
- The two halves were then soldered / welded together. No other alloy or higher copper content could be found in the area of the joint.
- At least on one half of the mould, the hole for the suspension must have already been made for soldering reasons. The cavity created was then filled with putty through this hole.[38] The second hole was pierced after the filling, which can be seen from the material pressed inwards.
- The soldered joint could be reworked only after the filling of the cavity.

Chemical analyses of the gold finds from the tomb of Amanishakheto

In 2021 it became possible to examine 19 of the more than 130 jewellery objects from this burial treasure by means of portable laser ablation (pLA) in the Ägyptisches Museum Berlin in combination with subsequent inductively coupled plasma mass spectrometry (ICP-MS) in the laboratory. The pLA-ICP-MS method offers more precise quantitative results of the bulk compositions of the alloys and also provides information on a number of trace ele-

33 Unpublished analysis report of the RFL 102_112018.
34 First results by XRF are included in the (unpublished) analysis report of the RFL 98_110518.
35 For first results on other jewellery objects from the tomb treasure see note 3.
36 By Schäfer 1910, 156, they are called shells.
37 Unpublished analysis report of the RFL 49_070819.
38 Visually, it could be an alumina-wax mixture; analysed at ÄM 1758/20.

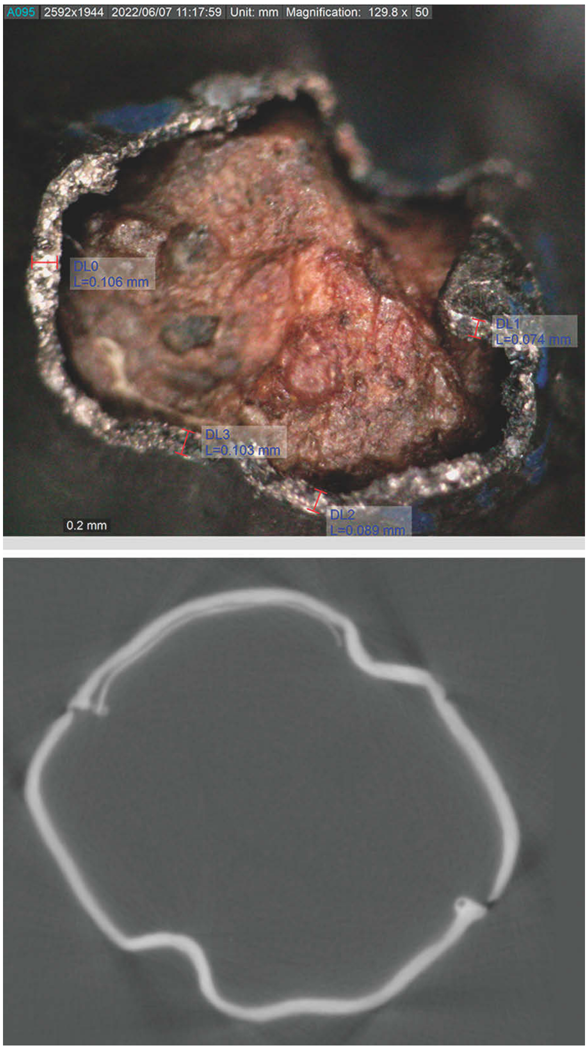

Fig. 6: Tomographic representation of the two soldering points through which the halves were joined together (w. of the opening 0.26 cm); photo: SMB/ÄMP – Iris Hertel & Tomo 10514/Helmholtz-Zentrum Berlin, Institut für Angewandte Materialforschung – André Hilger & Nikolay Kardjilov.

ments that can possibly be used for a discussion on the geological sources of the metal.

Although laser ablation (LA) is a minimally invasive sampling method it nevertheless removes a small amount of material. Accordingly, the sampling procedure of the objects was preceded by in-depth discussions, with regards to whether it should be performed laterally or on the bottom, and if the object was thick enough to prevent penetration of the laser beam. The sample mass needed for ICP-MS analysis is so small (<10 µg, see below) that the removal spots are so small that they can only be observed under a microscope (diameter of the crater ca. 0.1 mm, depth ca. 0.2 mm).[39] Other selection criteria were different alloy compositions of different parts that were known from the XRF analyses. Thus, the group of signet rings is also more strongly represented, along with chain links, arm, and ear jewellery.

Inter alia, Egypt and Nubia were considered as possible regions for the origin of the gold used in Mycenae. However, only little quantitative information is available on the trace element patterns of the gold deposits of these regions. Moreover, the comparison of mostly tiny natural gold samples with larger objects is fraught with some uncertainties, as will be explained later in more detail. An alternative to the analysis of natural gold samples, which are difficult to obtain in sufficient quantity, is the analysis of gold objects from the region in question and from a secure find context. In view of the gold wealth of Egypt and Nubia[40], which was already known in antiquity, it can be assumed that the gold used for the objects from these regions is very likely to originate from local or regional deposits. It is thus legitimate to consider the composition of such objects as representative of the gold in circulation in the region under study.

An ideal example of this approach is the study of a selection of gold objects from the tomb of the Meroitic queen Amanishakheto. Although her reign dates much later than the Mycenaean culture (ca. 1600–1100 BC), it is nevertheless well suited to study the composition of Nubian gold, assuming that the gold objects from her tomb originated in the region. This assumption is justified by the fact that these objects represent a Meroitic regional style, i.e. they were most likely made in Nubia and should not be regarded as imported goods. A total of 21 analyses with the innovative portable laser ablation technique in combination with mass spectrometry (pLA-ICP-MS), which will be explained below, were carried out on 19 objects. Via the analysis of the major and trace element patterns of jewellery objects from the tomb of Amanishakheto we aimed to characterise the composition of ancient Nubian gold in order to gain deeper insights into the supply of gold in the Late Bronze Age eastern Mediterranean.

As mentioned above, all gold objects from the tomb of Amanishakheto were previously analysed in a completely non-destructive manner by the Rathgen Research Laboratory (RFL) using a mobile X-ray fluorescence system (ArtTAX Pro, formerly Röntec GmbH, now Bruker). Accompanying the pLA-ICP-MS analyses, three gold objects were again analysed with XRF, but with a different

39 cf. Numrich et al. 2023.

40 For an overview of the textual evidence on the knowledge of gold sources in Egypt and Nubia see Quirke 2023 and for field evidence Klemm et al. 2001 and Klemm/Klemm 2013.

equipment (Niton XL3t 900 portable XRF instrument, Thermo Scientific[41]). A comparison of the analytical data from these three objects with both XRF setups as well as with the pLA-ICP-MS method is presented in Table 1.

The non-destructive measurement with X-ray fluorescence only covers the surface to a depth of approx. 0.01 mm, so that it only reflects the composition of the surface at the measured spot and is therefore generally not representative of the object as a whole. This is due to corrosion and abrasion processes during usage as well as chemical changes during burial: All this can easily lead to depletion and enrichment of individual elements on the surface. Accordingly, the analytical results obtained with XRF may deviate from the composition of the bulk material.

Another limitation of XRF is the relatively low detection sensitivity of 0.05 to 0.1% for most elements. Since gold is usually very pure, this method therefore only detects the major components gold, silver, and copper, the latter of which has often been intentionally added. In summary, these components allow only very limited statements about the geological origin of the gold.

Currently, provenance analyses of gold objects are based on sensitive analyses of major and trace elements. Initial expectations that inclusions in gold of the so-called platinum group elements (PGE) (see below) could not be confirmed.[42] Such analyses offer the possibility to identify different types of gold, which can also be compared with natural occurrences if necessary.[43] The most powerful analytical method for many elements is mass spectrometry with plasma excitation (ICP-MS) in combination with laser ablation (LA). Alternative methods are particle-induced X-ray emission (PIXE) and XRF with synchrotron radiation excitation. However, all these methods require the objects to be examined to be brought to the laboratory, which is in most cases not possible for insurance and sometimes also for political reasons. In addition, these methods are sometimes limited in terms of the dimensions of the artefact to be examined, which excludes larger objects from scientific analyses.

Therefore, the innovative technology of a portable LA-ICP-MS analysis (pLA-ICP-MS) was applied in this study. Here, the ablation process is spatially and chronologically separated from the actual analysis, so that the sampling of the objects can be performed worldwide in museums or collections.

The basic idea of the portable pLA-ICP-MS method is to separate the sampling with a laser and the subsequent analysis with a mass spectrometer in the laboratory. A portable laser ablation (pLA) setup previously developed by the ETH Zurich[44] was used for sampling. It consists of a diode-pumped solid-state laser[45], which generates pulsed green laser radiation (wavelength $\lambda = 532$ nm). The laser is coupled to the ablation unit via an optical fibre, in which the laser light is focused on the sample surface. The focused laser beam vaporises the material and detaches it from the surface of the object (the so-called ablation process), resulting in an ablation spot diameter of 120 µm. The sampling process can thus be considered as minimally invasive, as the ablation points are barely visible to the naked eye and only a mass of about 10 µg is removed from the object.

Suitable ablation positions can be selected using a CCD camera on the ablation unit. The material removed during the ablation process is collected with a membrane pump and then deposited onto hydrophilic polycarbonate filters. After sampling, the filters are stored in sealed containers, which can be subsequently transported to the laboratory for analysis. There the ablated material is dissolved and analysed in an inductively-coupled plasma mass spectrometer (ICP-MS). Details of the procedure are provided in another publication.[46]

Results and discussion

As stated above, three different measurements were applied on three signet rings using three different methods. The results (Table 1) show a slight tendency towards higher silver and copper contents when the analyses were performed with pLA-ICP-MS. In light of the considerably higher penetration depth of the laser and that the less noble elements silver and copper are often depleted in gold objects at the surface (see above) these results reflect the alloy composition better than those with XRF. Nevertheless, the agreement between all three methods is very good; the XRF analyses achieved with two different setups even show an excellent agreement.

The results obtained with the pLA-ICP-MS method for the major components of all investigated

41 The X-rays are generated by an X-ray tube with a silver anode and a voltage of 50 kV. The measuring spot on the sample has a diameter of approx. 8 mm and can be reduced to approx. 3 mm.

42 Meeks/Tite 1980; Junk/Pernicka 2023; Pernicka 2014.

43 e.g. Ehser et al. 2011; Borg et al. 2019.

44 Glaus et al. 2012; Glaus et al. 2013; Glaus 2013.

45 Wedge HB 532, BrightSolutions S.r.l., Pavia (Italy).

46 Numrich et al. 2023.

Inv. no.	Method	Au [%]	Ag [%]	Cu [%]
ÄM 1710	XRF (RFL)	96	3.1	0.06
ÄM 1710	XRF (CEZA)	97	2.8	0.10
ÄM 1710	pLA-ICP-MS (CEZA)	96	3.2	0.09
ÄM 1725	XRF (RFL)	74	24.0	1.32
ÄM 1725	XRF (CEZA)	74	24.3	1.20
ÄM 1725	pLA-ICP-MS (CEZA)	73	25.1	1.44
ÄM 1734	XRF (RFL)	88	9.5	1.64
ÄM 1734	XRF (CEZA)	89	9.1	1.50
ÄM 1734	pLA-ICP-MS (CEZA)	87	10.2	1.69

Table 1: Comparison of the results of three different analytical setups for the major components of three signet rings from the tomb of Amanishakheto (data in mass percentages). RFL = Rathgen Forschungslabor, Berlin, CEZA = Curt-Engelhorn-Zentrum Archäometrie, Mannheim

objects are compiled in Table 2, while the results obtained for the trace elements will be published in Moritz Numrich's dissertation. At this point they are solely presented and discussed in the form of diagrams. In these (Figures 7 to 10), the silver lunula pendant ÄM 1679 and the earring with globular pendant ÄM 1692, which also consists primarily of silver, are not shown. Furthermore, for the benefit of clarity, the inventory numbers ÄM 1664, 1754/06, 1756/05, 1758/03, 1758/10, and 22874 are summarised under the label "chain links" in the diagrams.

Fig. 7 shows the copper and silver contents of all analysed objects. Clearly, the high silver content of the signet ring ÄM 1725 is an exception. The majority of the objects contain less than 10% silver. In general, natural gold always contains silver in a range between 5 and 40%[47], and there have been repeated attempts to distinguish different deposits by their silver contents.[48] However, this succeeds only rarely and in smaller regions. Nevertheless, one could assume a different origin for the gold of the signet ring ÄM 1725 than that of the other objects.

An alternative explanation is the alloying of silver. This is not as unusual as one might assume from today's perspective: Already in the Middle Bronze Age of the Levant, gold was diluted with silver in Qatna as demonstrated by lead concentrations[49], and gold with high silver contents have been observed in Egypt as well[50] as in the early electrum coins of Sardis also seem to consist of a deliberately produced gold-silver alloy.[51]

In antiquity, silver was almost universally produced from silver-bearing lead ores in a two-step process. First, the ore was smelted to lead, which contained the total amount of silver. Then the lead was melted and oxidised (cupellation), leaving the silver as a non-oxidisable precious metal. However, the silver produced in this way always contained about 0.1 to 1% lead. This is also the case with the silver lunula pendant ÄM 1679, which contains 0.10% lead. The earring with a globular pendant (ÄM 1692), which consists of a silver-gold-copper alloy, also contains 0.14% lead, while most of the gold objects contain less than 0.01% (Fig. 8). In this respect, it is striking that the signet ring ÄM 1725 also has a higher lead concentration compared with the other objects, namely 0.044% (Fig. 8). Accordingly, this object possibly consists of an alloy and not of native gold with a high silver content.

Another aspect concerning the silver content in archaeological gold objects is the possible desilvering of the gold. In native gold, apart from sometimes very pure micronuggets, a silver content at least in the mid-single-digit percentage range is always to be expected (see above). Lower contents, on the other hand, indicate a purification process of the gold by depletion of the silver through cementation.[52] The earliest archaeological evidence for this process is (currently) dated to the 6th century BC[53] but it has been suggested that it may have been occasionally applied earlier.[54] Recently it has been found that the use of the cementation technique can be proven with the help of the isotope ratios of silver even with a very small quantity of sample material.[55]

Regarding the copper concentrations, it is difficult to decide whether copper was intentionally added to the gold or whether it can be regarded an impurity. This is because the concentrations are too low to cause a change in the colour of the alloy, which can only be observed above about ca. 3% copper. Therefore, copper concentrations between ca. 0.1 and 3% may result from an intentional alloy or an impurity. Here, the copper contents show a tendency

47 e.g. Jones/Fleischer 1969.
48 e.g. Pochon et al. 2021.
49 Schwab/Pernicka 2021.
50 Guerra et al. 2023.
51 Wartenberg 2016; Cahill et al. 2020.
52 Wunderlich et al. 2014 with a review of the evidence.
53 Ramage/Craddock 2000.
54 Klemm 2001, 85; Gebhard 2001, 93; Klemm/Klemm 2013.
55 Berger et al. 2021.

Inv. no.	Lab no.	Object	Au [%]	Ag [%]	Cu [%]
ÄM 1639	MA-215692	Bracelet with uraeus snakes and gods	95	4.2	0.21
ÄM 1664 rear	MA-215694	Hathor head, rear plate	81	17.5	0.88
ÄM 1664 front	MA-215695	Hathor head, front plate	88	10.6	0.62
ÄM 1677	MA-215705	Bell	93	6.4	0.71
ÄM 1679	MA-215703	Lunula pendant	0.13	97	1.88
ÄM 1692	MA-215704	Earring with globular pendant	37	59	4.0
ÄM 1698	MA-215690	Signet ring with a ram's head	96	3.1	0.08
ÄM 1704	MA-215686	Signet ring with a standing eagle	92	7.0	0.28
ÄM 1710	MA-215691	Signet ring with running Isis	96	3.2	0.09
ÄM 1720	MA-215687	Signet ring with a vulture over a dead man	92	7.2	0.21
ÄM 1725	MA-215683	Signet ring with winged sitting lion	73	25.1	1.44
ÄM 1728	MA-215688	Signet ring with goddess Mut	94	5.0	0.09
ÄM 1732	MA-215684	Signet ring with a standing rooster	88	10.2	1.46
ÄM 1734	MA-215685	Signet ring with a standing bird	87	10.1	1.69
ÄM 1745	MA-215689	Signet ring with the head of goddess Mut	95	4.6	0.12
ÄM 1754/06 side	MA-215697	Udjat eye, side part	90	8.7	0.81
ÄM 1754/06 rear	MA-215698	Udjat eye, tubular plate on the back	93	6.6	0.51
ÄM 1756/05	MA-215699	Ankh sign	92	6.7	0.35
ÄM 1758/03	MA-215700	Ankh sign	93	6.4	0.25
ÄM 1758/10	MA-215701	Udjat eye	92	7.4	0.17
ÄM 22874	MA-215702	Ankh sign	82	16.7	0.91

Table 2: Chemical composition obtained with pLA-ICP-MS (major elements) of the examined objects from the tomb of Amanishakheto (data in mass percentages).

towards higher values with increasing silver content, however, they are too low to have significantly changed the pale colour of silver-rich gold. Only the already mentioned earring (ÄM 1692) contains 4% copper, which results in a yellowish colour of the silver-gold alloy. This copper was most likely added intentionally, apparently using unalloyed copper. The correlation of copper and silver in Fig. 7 could perhaps also be due to the addition of silver containing copper to the gold, which is supported by the correlation of silver and lead (Fig. 8). The silver lunula pendant (ÄM 1679) also contains just below 2% copper. However, this is not to be expected for silver obtained by cupellation. Since pure silver is very soft, quite often small amounts of copper were added (e.g., in silver coins) to increase the hardness of the metal.

In principle, this could also apply to gold, because natural gold typically has very low copper contents of less than 0.1% and can be hardened by the addition of copper. Another reason for elevated copper concentrations in gold may be the enrichment of copper minerals together with alluvial gold, as these also have a higher specific gravity than silicates. On panning they would thus be collected together with the gold. On melting of the gold dust, the copper would be reduced and would enter the gold.

The presence of tin in all samples (Fig. 9), although in some cases at relatively low concentrations, is generally considered as an indication of the use of alluvial gold (placer gold) instead of primary gold. Alluvial gold often accumulates in certain places in rivers together with other minerals resistant to weathering and with high specific gravity like cassiterite (SnO_2). While the co-occurrence of gold and cassiterite is not uncommon in alluvial deposits, it is extremely rare in primary gold deposits. Alluvial gold usually consists of very small particles (<0.1 mm diameter), so it had to be melted for further processing. Like with copper minerals, the cassiterite can be reduced to tin metal reducing conditions and thus be absorbed by the gold.[56] Such conditions are quite likely, as the

56 Gumprich 2004.

gold dust in the crucible was probably covered with glowing charcoal.

To decide whether copper or (tin) bronze was added to the gold objects, the ratios of tin and lead with copper must be considered. As can be seen from Fig. 9, most objects have tin concentrations between 50 and 300 µg/g, which are also correlated with copper. Therefore, tin bronze with a tin content in the single-digit percentage range was probably added. This may not necessarily have been intentional, because gold was probably largely reused at all times, i.e., old objects were melted down to make new ones. This could easily have resulted in contamination with copper alloys.

Almost all analysed objects also show a clear presence of the trace elements platinum and palladium (Fig. 10). Only in the case of the arm jewellery with uraeus serpents and deities (ÄM 1639) platinum was not detected. The presence of these elements, especially platinum, is another indicator for the use of alluvial gold. Both metals belong to the platinum group elements (PGE; together with ruthenium, rhodium, osmium, and iridium) and occur mostly together in the form of platinum group minerals (PGM). These elements – especially platinum – do not occur together with gold in primary deposits.[57] However, they can be mixed with other weathering-resistant heavy minerals in streams following the weathering of various rock types due to their high specific gravity which is comparable to the one of gold.

Platinum group minerals were first observed in archaeological objects from the Royal Cemetery of Ur[58] and later in many prehistoric gold objects[59], as they have much higher melting points than gold and are also insoluble in liquid gold, with the exception of palladium and platinum. Such PGM inclusions were not observed in this study. However, there are a number of PGMs containing mainly platinum and palladium (e.g. ferroplatinum, hollingworthite (Rh,Pt,Pd)AsS and the like), from which both elements can be taken up when gold is melted, at least in small quantities. As both elements and especially their ratios are not affected by metallurgical processes such as (s)melting, they are of great importance to compare objects with another and may, in exceptional cases, even help to pinpoint the source of the natural gold.

The palladium and platinum contents of the analysed objects range between 1 and 30 µg/g (palladium) and 0.7 and 200 µg/g (platinum) (Fig. 10). While part of the objects show great variations with respect to the ratios of both elements, especially regarding the chain links, it is particularly noteworthy that some of Queen Amanishakheto's gold artefacts have more or less comparable palladium platinum-ratios[60], which may suggest a uniform geological origin of the natural gold. On the basis of the trace element patterns, one may even assume a single batch of gold for certain objects. The following objects (exclusively finger rings) have similar compositions regarding major and trace elements and/or ratios of platinum and palladium:

ÄM 1728 and 1745
ÄM 1698 and 1710
ÄM 1732 and 1734

As stated above, the study of the chemical composition of the artefacts, especially the trace element patterns, makes it possible – in principle – to infer the geological origin of the gold used. However, determining the geological origin of the gold is particularly difficult when alluvial gold is involved. For it must be taken into account that this was most likely extracted from a mixture of very fine-grained heavy minerals. This means that even for the small amount of 1 g of gold, about 20,000 micro nuggets of 0.1 mm diameter and 0.02 mm thickness are needed. Low concentrations of tin and platinum can in principle be caused by a single cassiterite or PGM grain. A direct comparison of artefact gold with analyses of single micro nuggets of gold from rivers is therefore problematic.

Nevertheless, by comparison with the material composition of other contemporaneous finds and from general geological and geochemical considerations, delimitations of a possible origin can be made. First and foremost, Axel Hartmann's most comprehensive study[61] of the chemical composition of prehistoric gold objects was carried out using atomic emission spectrometry, a method less sensitive to detection than the one used for this study. In almost 5,000 objects the major components gold, silver, and copper were analysed, in many cases tin and (more rarely) platinum could also be detected. Based on these five elements, he formed eleven material groups and examined their distribution in space and time. It turned out that practically all material groups form clusters in this respect.

Hartmann's large-scale study was connected with the hope of being able to narrow down the

57 Velasquez 2014.
58 Young 1972.
59 e.g. Ogden 1976; Meeks/Tite 1980; Junk/Pernicka 2003; Jansen et al. 2016; Jansen 2019.
60 This applies to objects ÄM 1639, 1698, 1710, 1720, 1728, 1745, 1756/5, and 1758/10.
61 Hartmann 1970; Hartmann 1982.

	Major elements [%]			Platinum group elements [µg/g]				
	Au	Ag	Cu	Ru	Rh	Pd	Ir	Pt
Spot 1	97	2.71	0.16	<0.30	<0.03	<0.10	<0.06	<0.09
Spot 2	97	2.43	0.71	<0.30	<0.03	<0.10	<0.06	<0.09
Spot 3	97	2.42	1.11	<0.30	<0.03	<0.10	<0.06	<0.09
Spot 4	94	5.5	0.13	<0.30	<0.03	<0.10	<0.06	<0.09
Spot 5	94	5.5	0.14	<0.30	<0.03	<0.10	<0.06	<0.09

Table 3a: Concentrations of major and platinum group elements (PGE) in a native gold ore sample".

	Trace elements [µg/g]										
	Mn	Co	Ni	As	Cd	Sn	Sb	Te	Hg	Pb	Bi
Spot 1	<0.40	<0.20	<1.05	<0.32	<0.22	<0.25	2.47	1.29	9.1	0.07	0.03
Spot 2	<0.40	<0.20	<1.05	<0.32	<0.22	<0.25	1.73	<0.40	12.6	<0.04	0.03
Spot 3	<0.40	<0.20	<1.05	<0.32	<0.22	<0.25	1.57	<0.40	15.9	0.07	0.04
Spot 4	<0.40	<0.20	<1.05	<0.32	0.29	<0.25	2.31	<0.40	6.1	0.05	0.05
Spot 5	<0.40	<0.20	<1.05	<0.32	0.31	<0.25	2.32	<0.40	5.7	0.09	0.25

Table 3b: Concentrations of several trace elements in a native gold ore sample".

geographical or geological origin of the gold on the basis of the chemical composition of the gold objects. However, this proved to be more difficult than initially assumed. This is due to the purity of natural gold, as only very sensitive analytical methods can detect relevant trace elements in addition to the major components.[62] As already mentioned, natural gold typically only contains silver in the percentage range. The silver content, however, is not very meaningful with regard to the origin of the gold, since the concentration fluctuations within a deposit are in the range of at least one order of magnitude, so that a single element does not have sufficient distinguishing potential between different deposits. In addition, the assumption that gold does not undergo any chemical change on its way from the deposit to the end product is unfortunately not true. Depending on the conditions under which gold is smelted, the base elements are oxidised and thus removed. Even if the more likely assumption is that the gold was reductively melted under a charcoal cover, a number of elements are lost, especially the volatile ones such as selenium, cadmium, and tellurium as well as – to some extent – lead and bismuth.

It has, however, been shown that when looking at several elements, it is possible to narrow down the region of origin by comparing the pattern of element abundances with analyses of natural gold. There have already been extensive analyses of natural gold from Europe in regard to the origin of the gold inlays on the Nebra Sky Disc.[63] For this purpose, the concentrations of copper, silver, palladium, platinum, cobalt, nickel, tin, antimony, and lead have been used. Cornwall was identified as the most likely region of origin, as silver-rich gold is rarely associated with tin and platinum metals. Other possible regions of origin were also discussed, as similar mineral associations are either known or expected in principle, such as Brittany and the Massif Central in France, northern Portugal or the Kreuzeck Group in the Alps.[64]

The gold deposits in Egypt and Sudan on the other hand have been described intensively in the literature.[65] First analyses showed that Nubian primary gold apparently tends towards lower silver contents.[66] During this study, the low silver contents have been confirmed for Nubian gold objects, which makes it all the more likely that the natural gold used to make these gold objects was also obtained from local, Nubian sources. However, based on the concentrations of tin and platinum in the objects, the exclusive use of primary gold can be ruled out.[67]

The low silver content of Nubian primary gold is also confirmed by the analysis of a gold inclusion in an ore sample from the Duweishat gold deposit[68], about 100 km south of Abu Simbel on the east bank of the Nile in hilly terrain. The sample probably originates from the remains of a modern mining dump. The gold occurs there in layers and lenses of milky quartz, mostly in association with complex, finely disseminated Cu-Fe-Pb-SbAs sulphide mineralisation. The ore sample was in the form of a polished section and gold inclusions were analysed at five locations by conventional LA-ICP-MS in the laboratory. The results are summarised in Table 3. The silver grades are unusually low for primary gold. Nevertheless, it is unlikely that this primary gold could be the (sole) raw material for the gold objects in the Amanishakheto tomb due to the absence of tin and platinum metals (cf. above). However, it is possible that this primary gold was mixed with allu-

62 Pernicka 2014.
63 Borg/Pernicka 2017; Pernicka et al. in prep.
64 Borg et al. 2019.
65 Klemm/Klemm 2013.
66 Klemm/Klemm 2013, 42.
67 Velasquez 2014.
68 The sample was kindly provided by Dr. Klaus-Peter Martinek (Munich).

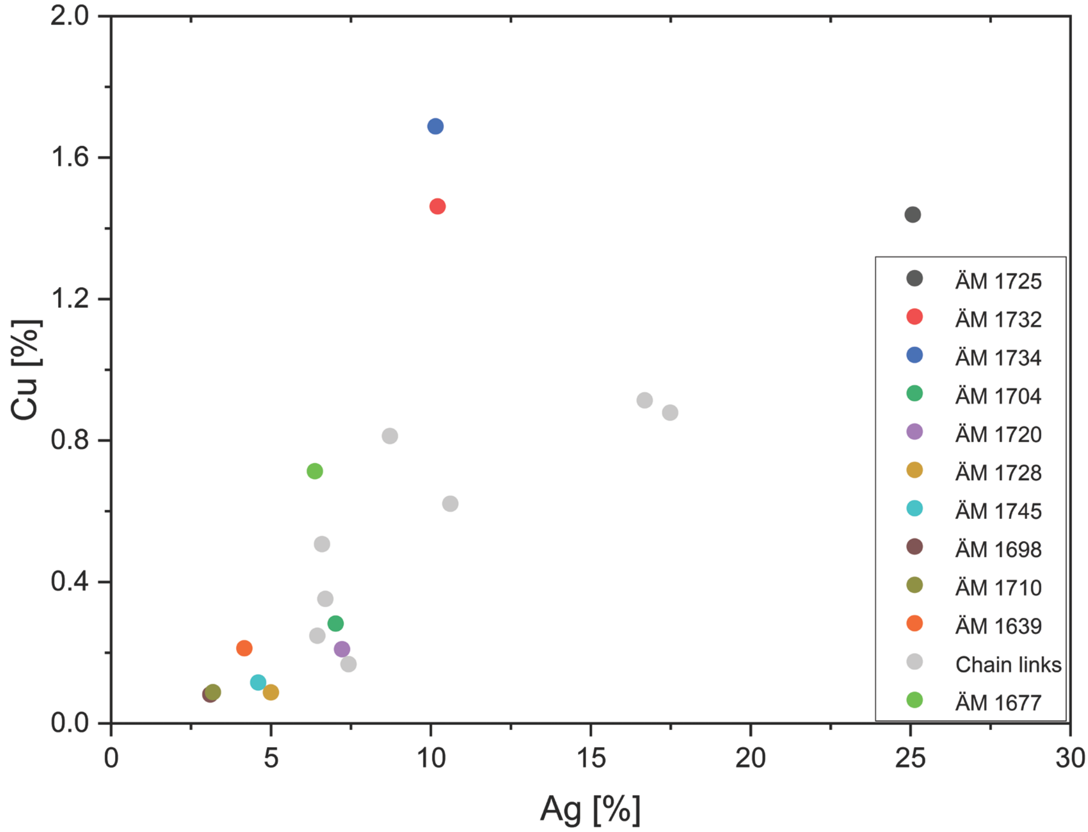

Fig. 7: Concentrations of silver (Ag) and copper (Cu) in the objects investigated with pLA-ICP-MS (except ÄM 1679 and ÄM 1692).

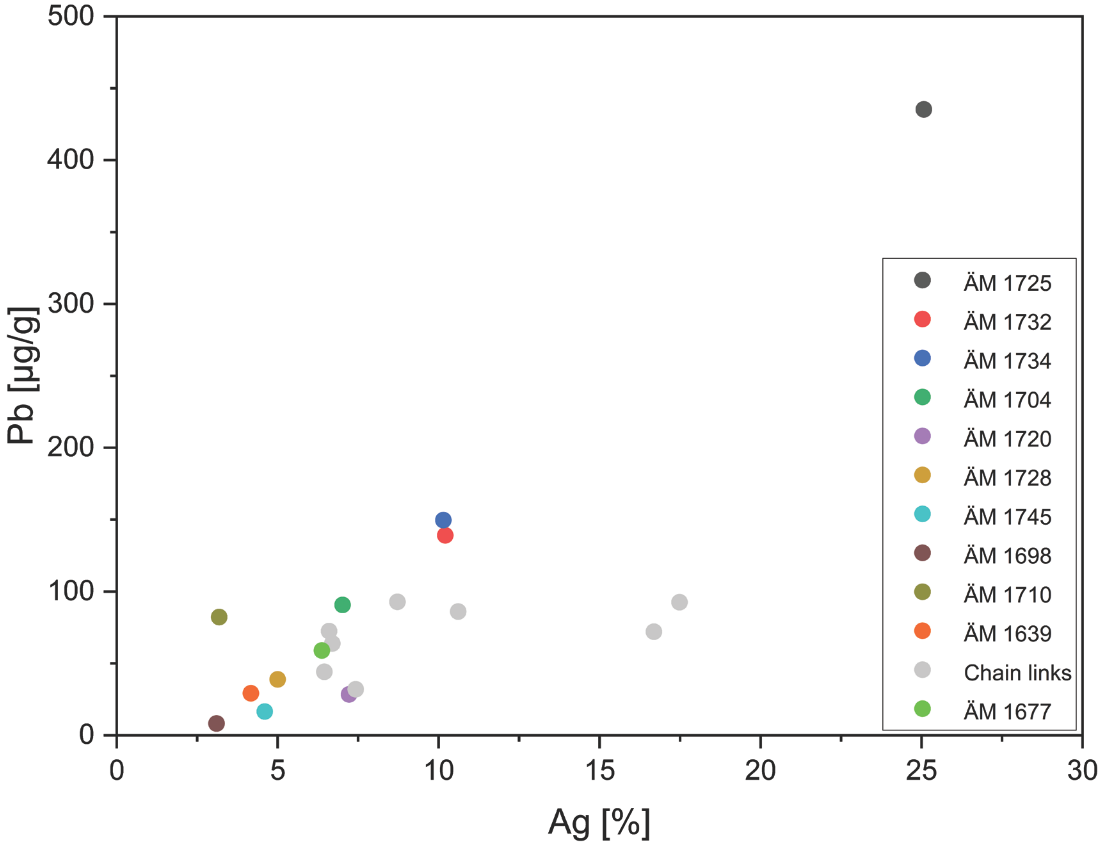

Fig. 8: Concentrations of silver (Ag) and lead (Pb) in the objects investigated with pLA-ICP-MS (except ÄM 1679 and ÄM 1692).

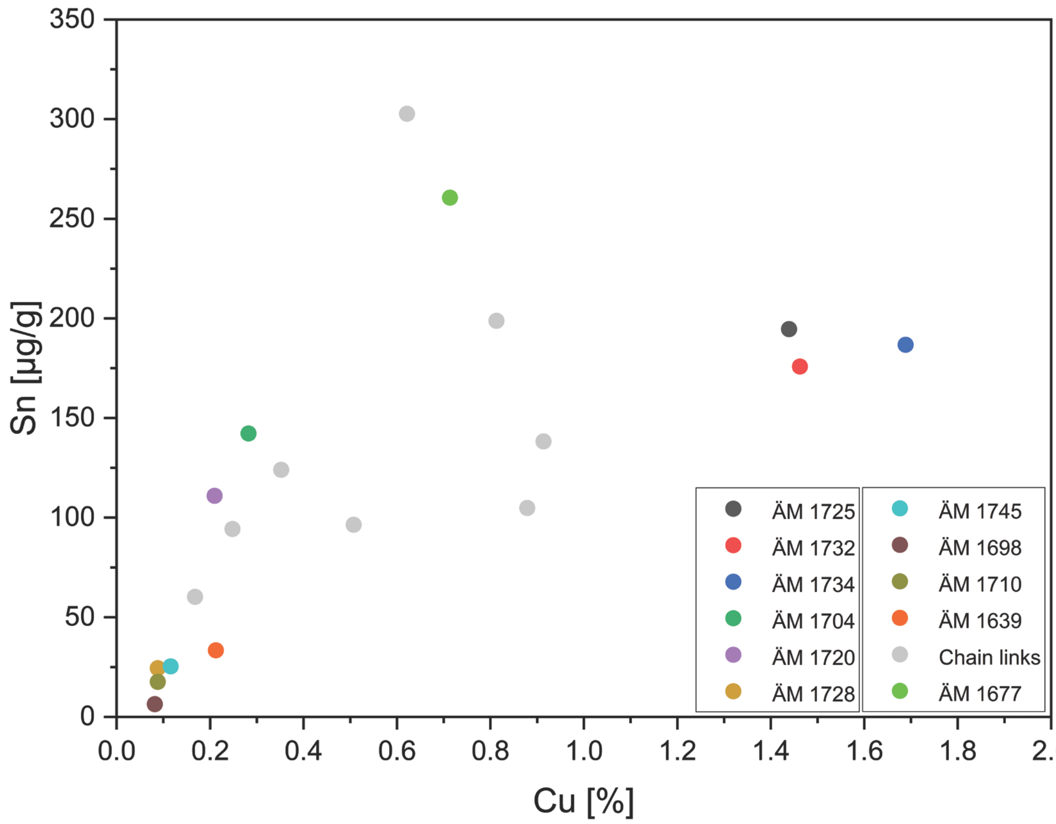

Fig. 9: Concentrations of copper (Cu) and tin (Sn) in the objects investigated with pLA-ICP-MS (except ÄM 1679 and ÄM 1692).

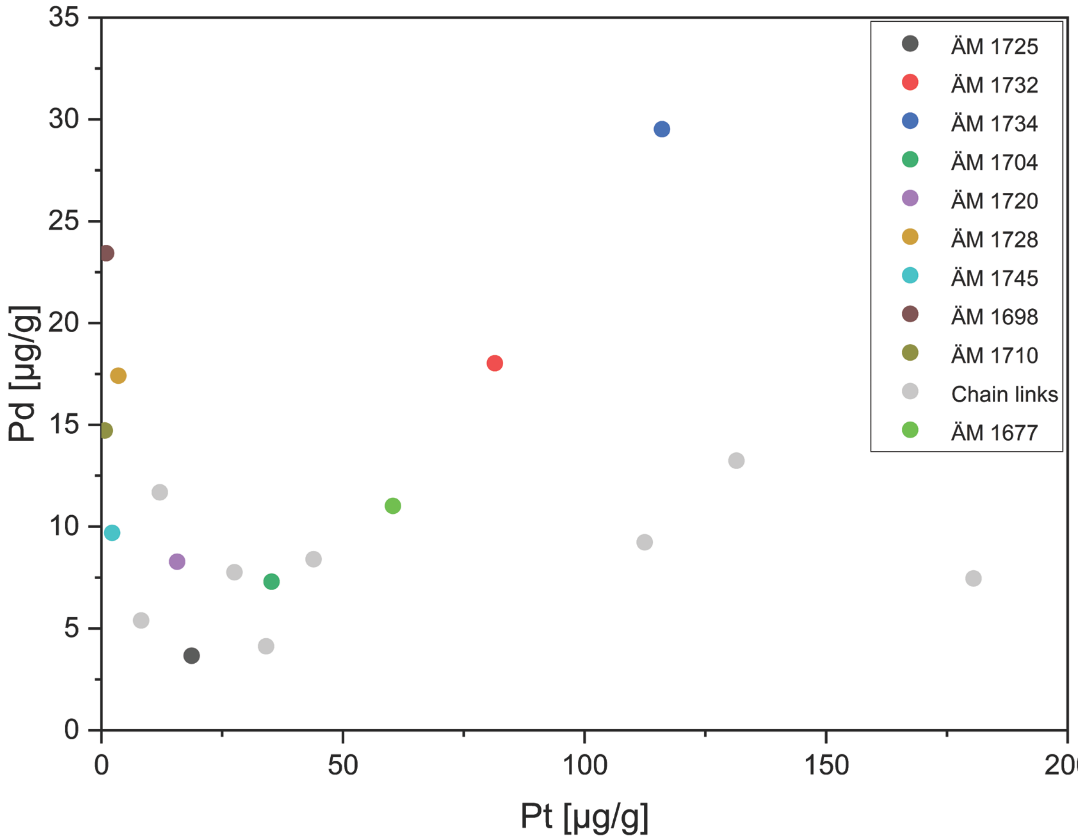

Fig. 10: Concentrations of platinum (Pt) and palladium (Pd) in the objects investigated with pLA-ICP-MS (except ÄM 1679 and ÄM 1692).

vial gold from this region, resulting in the observed composition of the analysed objects.

Furthermore, it can be deduced from our study that the Nubian gold may possibly be characterised by low concentration ratios of Pt/Pd of generally less than 5, with consistent contents of tin and antimony.

Summary

The comments on the diversity in the iconography of some of the selected pieces, which are brief at this point, make it clear that an astonishing depth of meaning can be gained even from the most inconspicuous representations – even though no generalising insights into the treasure find can be derived from the few pieces that have been addressed here. This approach will only be possible in combination with all the individual results within the framework of the intended multidisciplinary project. Nevertheless, the analyses provide useful information on the composition and possibly the origin of the Nubian gold in combination with new technological knowledge. Currently there are still no indications of workshops from the Meroitic period in which gold was processed. The reason for this may be sought in the way the gold was extracted and possibly also in the location of the workshops. This is indicated by the tin contents and the presence of platinum and palladium in all samples, which can be interpreted as evidence for the extraction of gold by panning and not by mining primary gold. In connection with this, it is also possible to narrow down the possible geological origin of the gold. These findings can be supplemented by evidence of manufacturing techniques such as casting and soldering. Furthermore, first results are given with regard to the organisation of work. For example, the analyses indicate, based on the material composition of the alloy, that the two signet rings with the depictions of the goddess Mut (ÄM 1728, ÄM 1745) were possibly made from the same material batch or were at least made from gold that came from a single geological deposit. From this, in turn, a commissioned work for the decoration of the queen's tomb can be deduced. With these initial reflections on broader questions, this article makes clear the importance of combining the various aspects of interdisciplinary investigations, which will ultimately provide us with new insights into the crown jewels of Amanishakheto.

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Zusammenfassung

In dem vorliegenden Beitrag werden Untersuchungsergebnisse zu einer Auswahl an Objekten aus dem Grabkonvolut der meroitischen Königin Amanishakheto vorgestellt, die sich heute im Ägyptischen Museum in Berlin befinden. Diese bestehen aus Gold oder Silber in unterschiedlichen qualitativen und quantitativen Zusammensetzungen. Von den dort vorhandenen Objekten wurden 19 mit unterschiedlichen Analysemethoden wie portabler Röntgenfluoreszenz (pRFA) und Laserablation (pLA) im Museum in Kombination mit anschließender induktiv gekoppelter Plasmamassenspektrometrie (ICP-MS) im Labor untersucht. Während die zerstörungsfreien Messungen (XRF) an den Oberflächen vom Rathgen Forschungslabor der Staatlichen Museen Preußischer Kulturbesitz 2018–2019 durchgeführt wurden, folgten 2021 die weiterführenden Untersuchungen durch Moritz Numrich und Ernst Pernicka. Die pLA-ICP-MS-Methode lieferte genauere quantitative Ergebnisse über die Zusammensetzung der Legierungen und zudem Informationen über eine Reihe von Spurenelementen. Darüber hinaus können die XRF-Ergebnisse zur Klärung technologischer Fragen herangezogen werden. So lag einer der Schwerpunkte auf den Analysen und der sich daran anschließenden Diskussion über die geologischen Quellen des Goldes. Dies ist insbesondere im Vergleich mit anderen Objekten aus dem mediterranen Raum interessant. Des Weiteren wurden Objekte näher betrachtet, um deren Herstellung zu ermitteln. Es geht hier demnach nicht um eng gefasste regionale Räume oder zeitliche Abschnitte, sondern in erster Linie um das Material und deren Verarbeitung und Vergleichbarkeit. Zudem repräsentieren die Objekte einen Teil der meroitischen Grabfunde, unter denen sich königliche Siegelringe und unterschiedlich gestaltete Amulette befinden, deren ikonographische Darstellungen am Beginn des Beitrags kommentiert werden. Die an dieser Stelle kurz gefassten Kommentare zur Vielfalt in der Ikonographie einiger ausgewählter Stücke machen deutlich, dass sich selbst in den unscheinbarsten Darstellungen eine erstaunliche Bedeutungstiefe gewinnen lässt – wenngleich sich aus den wenigen hier thematisierten Stücken keine verallgemeinern-

den Erkenntnisse über den Schatzfund ableiten lassen. Dieser Ansatz wird nur in Kombination mit allen Einzelergebnissen im Rahmen des angestrebten multidisziplinären Projekts möglich sein. Dennoch liefern die Analysen weitere Erkenntnisse über die Herkunft des nubischen Goldes in Kombination mit neuen technologischen Erkenntnissen. So gibt es beispielsweise noch keine Hinweise auf Werkstätten aus der meroitischen Zeit, in denen Gold verarbeitet wurde. Der Grund dafür ist in der Art der Goldgewinnung und möglicherweise auch im Standort der Werkstätten zu suchen. Darauf deuten die Zinngehalte und das Vorhandensein von Platin und Palladium in allen Proben, was als Beleg für die Gewinnung von alluvialem Gold aus Flüssen und nicht von primärem Gold durch Bergbau interpretiert werden kann. In diesem Zusammenhang ist es auch möglich, die geologische Herkunft des Goldes einzugrenzen. Ergänzt werden können diese Befunde durch Hinweise auf Herstellungstechniken wie Gießen und Löten. Darüber hinaus gibt es erste Ergebnisse zur Arbeitsorganisation. So deuten die Analysen aufgrund der Materialzusammensetzung der Legierung darauf hin, dass die beiden Siegelringe mit den Darstellungen der Göttin Mut (ÄM 1728, ÄM 1745) möglicherweise aus der gleichen Materialcharge oder zumindest aus Gold gefertigt wurden, das aus derselben geologischen Lagerstätte stammt. Daraus wiederum lässt sich eine Auftragsarbeit für die Ausstattung des Grabes der Königin ableiten. Mit diesen ersten Überlegungen zu übergeordneten Fragestellungen verdeutlicht dieser Artikel auch, wie wichtig die Verknüpfung der verschiedenen Aspekte der interdisziplinären Untersuchungen ist, die uns letztlich neue Erkenntnisse über die Kronjuwelen von Amanishakheto liefern werden.