BETWEEN CENTRE AND PERIPHERY: EARLY EGYPTIAN AND NUBIAN COPPER ALLOY ARTEFACTS IN THE COLLECTION OF THE KUNSTHISTORISCHES MUSEUM VIENNA (KHM)

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Abstract: *The article reports on the results of the project of non-destructive X-ray fluorescence analysis of 15 artefacts, deposited in the Egyptian and Near Eastern Collection of the Kunsthistorisches Museum Wien. Artefacts from the sites of Giza, Kubbaniya, Mostagedda, Tura and Toshka were chosen, predominantly from documented archaeological contexts. The periods represented are Early Dynastic, the Old Kingdom, the Middle Kingdom and the Nubian C-Group. The finds were excavated and published by H. Junker and G. Brunton, yet they were analysed for the first time only in the framework of this project. The analysis confirmed the use of copper with impurities in the Early Dynastic period and of arsenical copper in the Early Dynastic period, the Old Kingdom, the Middle Kingdom and the Nubian C-Group. Moreover, on a Dynasty-4 carinated bowl with spout (ÄS 7441) was discovered previously unknown inscription, most probably of the Vizier Seshathetep Heti.*

Keywords: *Ancient Egypt, copper metallurgy, X-ray fluorescence, arsenical copper, Early Dynastic period, Old Kingdom, Middle Kingdom, C-Group*

Contents

1. Introduction

In many earlier excavation reports from ancient Egyptian and Nubian sites, the material of the metal objects was very often determined visually rather than based on any kind of material analysis. Yet the specific type of copper alloy used for these objects is impossible to distinguish by the naked eye and many previous researchers determined the alloy purely on the basis of (unspoken) assumptions of the occurrence of metals and alloys in Egyptian history. These early identifications were published in the literature without any firm ground in the scientific knowledge of the material. Thus, an analysis of the chemical composition is often required to more precisely categorise artefacts that are determined as 'copper' or 'bronze' in museum collections and in early excavation reports. Very important in this regard are objects with documented and datable archaeological context.

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Therefore, the two-year project *Early copper metallurgy in Ancient Egypt – a case study of the material from the Kunsthistorisches Museum Wien*, funded by an internal grant of the Faculty of Arts, Charles University in Prague, was launched in 2015. The aim of this project was to collect more accurate specifications of the alloys used for the selected material. We have focused on early Egyptian and Nubian metalwork before the wider introduction of bronze to Egypt in the 18th Dynasty. The Egyptian and Near Eastern Collection of the Kunsthistorisches Museum Vienna (KHM) holds an important corpus of ancient Egyptian artefacts containing about 17,000 items[4] and from this extensive collection mainly artefacts with known archaeological contexts were selected, resulting in 15 objects that were expected to reveal important information. Unfortunately, it turned out that these items were in very different condition states, which will be discussed later on. The selected items have been published in excavation reports before, but not all of them were cleaned at the moment of publication. Therefore, the information on them in the literature is only partial.

In museum collections especially rare or even unique (metal) objects must be analysed either non-destructively, without any irreversible damage, or by taking only small samples. In the case of the KHM material, a non-destructive analytical method was required. Taking samples (using drilling or similar methods) to perform slightly invasive methods was not possible because of the fragile condition of the items and the general policy of the KHM. Therefore, x-ray fluorescence analyses (XRF), a non-destructive method, was chosen for the analyses of the selected objects, yielding the advantage that the investigations could be performed in the Conservation Science Department of the KHM.[5] The objects had not to leave the museum which is normally connected with a high bureaucratic effort and high costs for insurances or the like. Also, climatic conditions for analyses performed outside of the museum have to be considered.

Although XRF may work in a non-destructive manner, considerable corrosion layers have to be taken into account in the case of the Egyptian artefacts. This means that often the corrosion layer had to be removed on small parts – at rather inconspicuous areas on the object to reveal the composition of the core material. Consequently, this fact limited the number of artefacts that could be investigated by XRF. The results are presented in this paper, comprising new information on the artefacts and on their chemical composition.[6]

2. KHM collection and the selected corpus of artefacts

Altogether, fourteen artefacts from the 4th, 3rd and the early 2nd millennia BC (Table 1) with a documented archaeological context were selected, with one addition of an artefact of known type but only estimated provenance. In a few cases they are quite unique, with only a few comparable items existing in other archaeological contexts. Artefacts from the Egyptian sites of Giza, Tura, Mostagedda, Kubbaniya and the Nubian site of Toshka were chosen (Fig. 1). The periods represented are Early Dynastic and the third phase of the Naqada culture (31st – 29th century BC), the Old Kingdom (26th – 22nd century BC), the Middle Kingdom (20th – 18th century BC) and the Nubian C-Group (the relevant Phase IIb is contemporary with the Second Intermediate period, 18th – 16th centuries BC). The selected artefacts are examples of Egyptian and Nubian metallurgy from the 4th millennium BC to the early 2nd millennium BC. They represent working tools (two adze blades), model tools (four adze blades, one razor blade and two axe blades), weapons (two battle axes and a spearhead), toilet utensils (two mirrors) and a functional vessel. Eleven of the analysed artefacts were found during excavations of the Austrian Academy of Sciences led by Hermann Junker (1877–1962). Some of them were published more than a century ago, but again, they have not yet been subjected to quantitative analysis, and they have often been published before cleaning. Three of the analysed artefacts

[4] Satzinger 1994.

[5] Preliminary results were presented at the 10th ICAANE congress in Vienna, in April 2016 (Odler and Uhlir *et al.* 2016).

[6] In September 2012, the artefacts from the 4th–2nd millennia BC were documented by Martin Odler using conventional methods: drawing, description and photography. Some of these objects are included in his corpus publication on the Old Kingdom copper tools and model tools (Odler 2016) and are discussed in several articles (Odler and Dulíková 2015; Odler 2015a, 2015b).

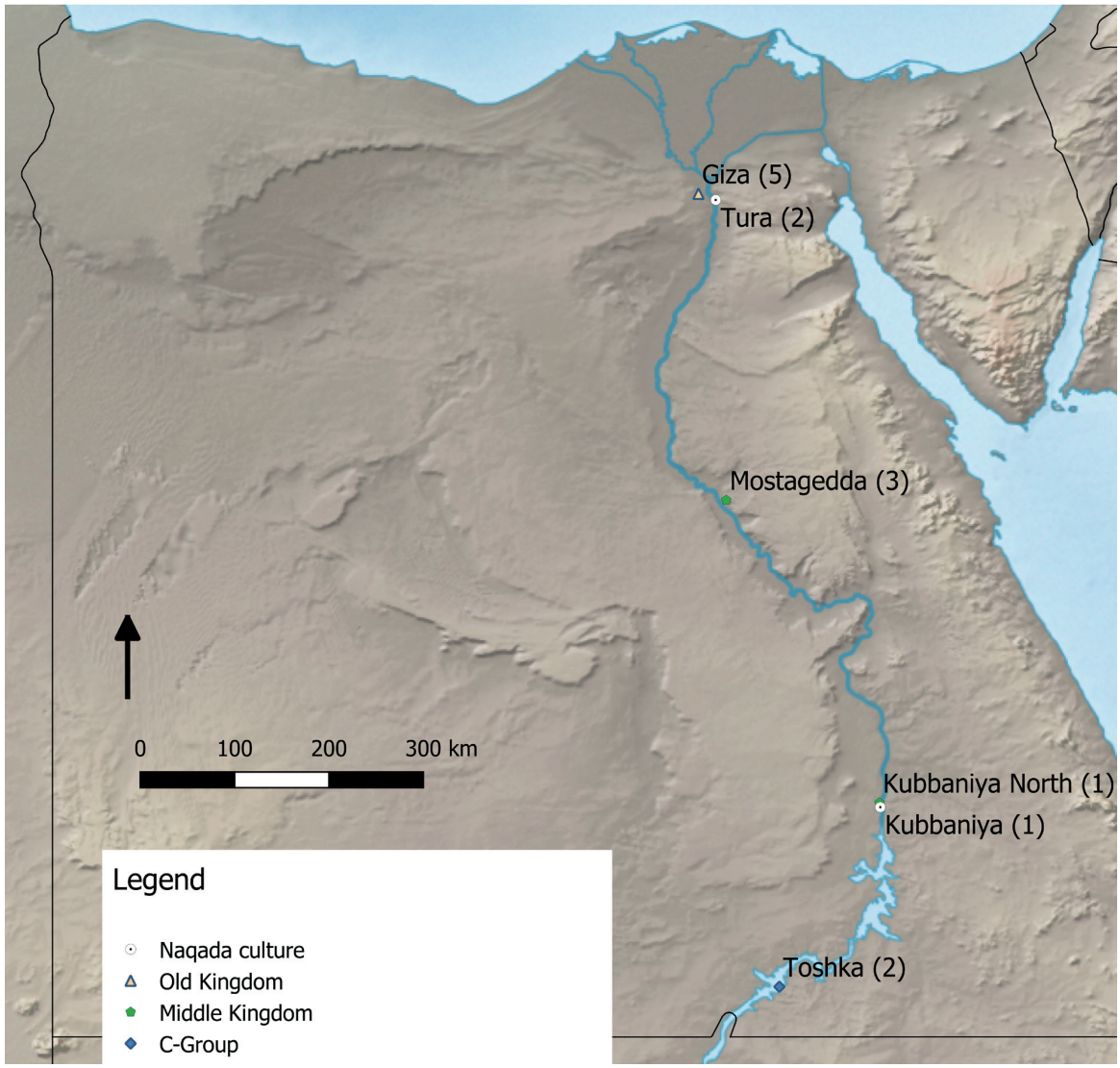

Fig. 1 Map of Egypt and Nubia with the location of the sites from which the analysed artefacts originate (M. Odler, software by QGis, map by Natural Earth).

were found at Mostagedda between 1927 and 1928 by Guy Brunton (1878–1948) for the British School of Archaeology. The last artefact, an Old Kingdom razor blade, is of unknown provenance (possibly also from Junker's excavations) but can be dated on the basis of artefactual analogies.

3. Analyses of early Egyptian metal artefacts from other museum collections

Although some analyses on early Egyptian metal artefacts exist and have been published, synthesis of the results is lacking; the first author of this article is attempting it in his PhD thesis.[7] The results of earlier analyses will be discussed in depth below. Here, we will mention several projects with results comparable to the selected KHM material. On the whole, there was meagre reflection of these publications and results in Egyptological literature.

The current state of knowledge demonstrates the use of almost pure copper tools in the latter half of the 4th millennium and in the 3rd millennium BC. The first arsenical copper artefacts occurred already in the Naqada culture.[8] Copper,

[7] Odler in preparation.

alongside with arsenical copper, was used in the Early Dynastic period, the Old Kingdom, the First Intermediate period and the Middle Kingdom. Both materials were used for the production of tools and model tools,[9] vessels and model vessels[10] and other objects. The details of the development are discussed within this paper; the presentation of the results on each object is followed by a general discussion.

The role of arsenical copper in early ancient Egyptian metallurgy has been long underestimated.[11] This was partly because some important articles were not published in the usual Egyptological journals and thus escaped the attention of some scholars. Historically, the first analyses that identified arsenic in ancient Egyptian objects were performed for Flinders Petrie on two adzes found at Meidum.[12] Widespread use of arsenical copper was shown for the first time by Michel's analysis of ancient Egyptian mirrors and other objects in the Louvre.[13] Arsenical copper ought to be counted among important ancient Egyptian alloys at least since the publication of the article by Eaton and McKerrell.[14] The material analysed, mostly deposited in the Ashmolean Museum, Oxford, consisted of objects from Abydos, Bet Khallaf, Diospolis Parva, Sedment, and Tarkhan, i.e. from ancient Egyptian "provinces".[15] On objects from these sites it has been demonstrated that arsenical copper was the most frequent alloy used in the Predynastic and Early Dynastic periods and in the Old Kingdom.[16] Since the Middle Kingdom, copper and arsenical copper were gradually replaced by tin bronze, although the process was not unidirectional in Egypt. At Tell el-Dabᶜa, G. Philip described a gradual decline in the contents of the tin (and thus bronze) in some artefact categories (predominantly weapons) through time. No clear pattern associating artefact types and chemical compositions was observed either.[17]

We should bear in mind that ancient Egyptians must have known tin bronze as well, at least from the Early Dynastic period. The published specimens comprise two bronze vessels of Egyptian forms from the Tomb of King Khasekhemwy at Abydos, Dynasty 2,[18] and an Early Dynastic to Old Kingdom fragment found at Buto.[19] Yet the proxy data from Egyptian pigments indicate that tin bronze was scarce before the Eighteenth Dynasty.[20] It can be assumed that more bronze objects of ancient Egyptian provenance will be identified from 3rd millennium contexts in the future.

4. X-ray fluorescence analysis (XRF)

The 15 selected objects were analysed using XRF in the Conservation Science Department of the KHM with the μ-XRF spectrometer PART II (portable art analyser II, Fig. 2)[21] of the museum.

Fig. 2 PART II analyser (© KHM-Museumsverband).

8 McKerrell 1993.

9 For Old Kingdom tools, see Odler 2016.

10 Radwan 1983, although the author did not deal with the question of the alloys used.

11 Even in the handbooks, due to the omission of some articles, Ogden 2000, 152–153.

12 Petrie 1892, 34, 36.

13 Michel 1972; Hours and Michel 1974.

14 Eaton and McKerrell 1976.

15 McKerrell 1971. I would like to thank the Ashmolean Museum, Oxford and curator Liam McNamara for access to H. McKerrell's results.

16 Eaton and McKerrell 1976, 174–175, Table 6, Fig. 10.

17 Philip 2006, 212–214.

18 Spencer 1980, 88, Cat nos. 596, 597.

19 Pernicka and Schleiter 1997.

20 Jaksch *et al*. 1983.

21 Built within the FWF Project No. L430-N19. Buzanich *et al*. 2010, Uhlir *et al*. 2012.

The PART II spectrometer is equipped with a vacuum chamber to reduce the absorption of low energy radiation in the air. For excitation, a low-power X-ray tube that can be operated up to 50 W is used. The focusing of the primary beam is done by using a polycapillary lens that produces an output focal spot of 145 µm at 5.42 keV (Cr K_α). The vacuum chamber can be pumped down to about 1 mbar and is sealed with a Kapton™ window. Two laser pointers are used to locate the investigated spot at about 1 mm distance outside of the chamber (coinciding with the focus of the polycapillary), thus minimising the absorption losses in the excitation and x-ray fluorescence radiation paths.

The programme WinAxil was used for quantitative evaluation. In the WinFund-routine, the Compare Mode was chosen for evaluation because of uncertainties in the transformation of the excitation radiation by the polycapillary. Therefore, fourteen standards bought from MBH Analytical LTD, including arsenical copper, were measured (at least 5 measurements per standard) under the same conditions as the sample objects and used for the creation and verification of the evaluation method.

As it is crucial for the creation of the quantification routine using Compare Mode to use standards whose composition is as close as possible as the one of the samples, the most important standards of this set are the arsenical coppers CUAS3 (36X CUAS3, batch A) and CUAS4 (36X CUAS3, batch A). As, unfortunately, these standards did not contain the trace elements found in the samples, other standards had to be used as well. Standards that include the whole set of necessary trace elements are 7835.8 (31X 7835.8, batch A), 7835.9 (31X 7835.9, batch A) and GM21 (33X GM21, batch A, without Se). The evaluation of these five standards using the created method is shown in Table 2. The elements of interest are copper (Cu), arsenic (As) and the trace elements of the items iron (Fe), nickel (Ni), zinc (Zn), selenium (Se), silver (Ag), lead (Pb) and bismuth (Bi). All concentrations given in this paper are in weight percentage (wt %).

As can be shown in Table 2, the error of the evaluated elements is in a very good range. The relative error for copper stays below 2 % and is even below 1 % in the arsenical coppers. For arsenic the relative error stays below 20 % for three of the standards, below 30 % for the rest. The partially higher error ranges for the standards 7835.9 and GM21 can be explained by the low concentration of arsenic in these standards and the presence of lead, coinciding with the arsenic K_α line. On the other hand, as the concentration in these standards is very low, the As K_β line could not be used. Nevertheless, as the investigated objects did not show a significant lead content, this influence can be excluded when performing the evaluation of the objects.

The relative error for the trace elements iron and zinc can be assumed with ± 5 %, for lead with ± 10 %, and the rest of the interesting trace elements except silver with ± 25 %. The relative error for silver is higher, because traces of silver cannot be detected/evaluated using the K_lines with the used setup due to a bad excitation in this energy range. The L_lines on the other hand coincide with the argon peak leading to higher error ranges especially for silver as a trace element. The error range can, therefore, not be estimated well. Nevertheless, silver was evaluated only once in the objects and a relatively high uncertainty should be considered.

Although XRF is a non-destructive technique, it was in most cases necessary to polish small areas (app. 3 mm in diameter) on the surface of the artefacts to be able to investigate the core composition of the alloys as the surface regions were strongly altered (see Table 1). The areas chosen for analysis were parts where it was either justifiable to polish a small section or where uncorroded surfaces were visible without polishing (fracture areas, etc.).

Nevertheless, some of the objects appeared to be entirely corroded, leaving only some rather greyish material for the analysis, leading to the question of reliability of these results. Some investigations regarding the influence of the corrosion layer on an arsenical copper will be shown below. Nevertheless, as the material investigated is almost pure copper with only some trace elements and eventually arsenic in the range from ppm to some percent, it should at least be possible to categorise the copper in pure copper, low arsenic copper or high arsenic copper.

A test of the influence of the preservation state of the investigated spot for arsenical copper was done on the object AE_INV_7334. The measurement points (MP) and their evaluated concentrations are described in Table 3. The indicated measuring points are shown in Fig. 3. The concentration of copper varies within the small blank area from 95.1 to 96.2 % with an average of 95.6 % and the arsenic shows concentrations from 3.4–4.8 %

Fig 3 Measuring points (MP) on the mirror AE_INV_7334 (© KHM-Museumsverband).

with an average of 4.1 %. The black corroded area does not show too large deviations. The copper value with 96.3 % lies within the error range whereas arsenic shows with 3 % a lower concentration, but nevertheless gives a good indication for the amount of arsenic in the alloy. The case is different for measuring point 7, the brown corroded area: in this measuring point the concentration of arsenic is approximately double to the other points, emphasising once again the importance of the choice of the right measuring area or the preparation of the measuring spot. Of course, also on conscientiously selected parts a moderate corrosion might be left, producing some uncertainty of the results, but this should be in an acceptable range and is a fact we have to accept when dealing with objects of cultural heritage.

At least five measurements per object/prepared area were taken for each of the artefacts, in order to obtain a representative average composition for the alloys used, as the chemical composition of historical metal artefacts was usually not homogenous and the concentrations of the elements might differ significantly even in a single artefact.[22] The results are presented in Table 4. Their interpretation is discussed in the following text.

5. Discussion of the sites, artefacts and analytical results

The results of the analysis confirmed in general the preliminary hypotheses concerning the alloys used: almost all artefacts were made of arsenical copper, which is assumed to have been the most frequent alloy used in Egypt in the 3rd millennium BC. Nevertheless, some surprising aspects have been uncovered. The results will be discussed in detail below, dividing the artefacts into subgroups based on their shape, use and chronology.

[22] This phenomenon was described on Egyptian artefacts by Wuttmann 1986.

5.1. Tools, model tools and weapons

As tools, model tools and weapons represent the largest group of analysed early Egyptian objects in our corpus, let us outline the general trends of the development of their application and the alloys used in order to set the analysed tools in their cultural context. In addition to traditional approaches, we also employ basic statistical methods to evaluate the data on the artefacts in greater depth using statistical software R.[23]

Artisan tool kits and single tools with metal blades started to be deposited in burial equipment in the second phase of the Naqada culture. The assemblages comprised of chisels, adzes, axes and saws exist in two general types of archaeological contexts. The better-preserved category is represented by lesser graves with a single tool or a few artisan tools from a kit. The second category can only be assumed indirectly and is represented by the largest tombs with the presence of tools among a wide array of other artefacts. The extent of such contexts can be imagined for example on the basis of a corpus of almost 500 copper alloy tools from Tomb 3471 at North Saqqara datable to the reign of Djer.

This approach, to deposit (assumed) full-size tools in the burial equipment, was custom in the Naqadan culture in Naqada II and IIIA–B and continued into Dynasty 1, i.e. Naqada IIIC. Large assemblages in the richest and largest tombs did not represent the craft activity of the tomb owners themselves but rather symbolised the interdependence of patron-craftsman and attached craft specialisation. In such way, they were interpreted already by W. Davis.[24]

Although hunting and fighting scenes are fairly frequent in Predynastic and Early Dynastic art, weapons were an unusual and marginal category of the burial equipment.[25] Violence seems to have been a prerogative of the elite – the chieftains and rulers. Only a few metal weapons were among the objects deposited in Predynastic and Early Dynastic graves; moreover, as we will see below, their explanation as weapons is highly dubious in some cases.

5.2. Full-size tools and a weapon of the Naqada culture and Early Dynastic period

5.2.1. Adze blade from Kubbaniya South (ÄS 7187)

The earliest object analysed in this project is a full-size adze blade from a cemetery at Kubbaniya (Fig. 4). The cemetery entered literature as an A-Group site, because of the presence of Nubian culture material datable to this period.[26] The reassessment of the sites north of Aswan due to the presence of A-Group material led to the interpretation that the sites are part of the Naqadan settlement network, with occasional Nubian presence.[27]

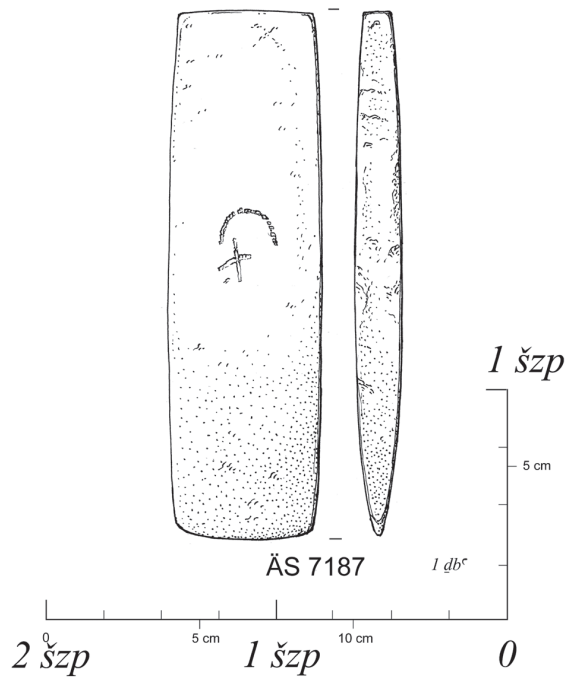

Fig. 4 Adze blade from Kubbaniya (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

The adze blade (ÄS 7187) was the only heavy metal tool found in the whole assemblage, other objects made of copper being needle, fish-hook, armlet, beads and a rectangle. 53 graves contained malachite and brochantite.[28] The adze was exca-

[23] On the basis of methods presented in Baxter and Cool 2016.

[24] Davis 1983.

[25] Gilbert 2004, 82–84, Appendix 6.

[26] Junker 1919.

[27] Gatto 2006.

[28] As determined by Prof. Berwerth, mentioned in Junker 1919, 90.

vated in the disturbed Grave P.193 of the Type Va – a rectangular pit with rounded corners.[29] The grave contained fragments of red polished and unpolished sherds, a fragmentarily preserved big jar (possibly a wine jar, not depicted in the original publication; the determination is followed by a question mark already in Junker's tomb register, we should treat it only as an assumption without possibility of confirmation), bowls and fragments of rough ware.[30] Other finds were a fragment of an ivory wristband of oval section, fragments of an almost complete ostrich egg with an intentional perforation on the upper side, and garnet discs.[31] A high diversity of objects was found in the burial equipment, which is important because it can be interpreted as a mark of a higher status. Based on the analysis of the A-Group funerary equipment, we tend to interpret this assemblage as a burial of a man with Egyptian imports (adze blade, wine jar??) and Nubian artefacts (an ostrich egg – otherwise known in children graves in southern Lower Nubia).[32] The cultural identity of the person buried is uncertain: was he a Nubian or an Egyptian?

The adze blade was found covered with verdigris but was cleaned later (removal of the corroded layer), so that the verdigris is not visible any more apart from a few spots. It has a well-preserved metal core, and the surface does not show any significant traces of use. The adze blade has a slightly convex shape with one bevelling slightly dominant on the blade section. The adze is of early Type A with a flat head; it can be assigned to Variant A2.[33] Marks in the shape of a semicircle and a cross punched by a pick were found on one of the faces of the blade during the cleaning.

XRF analyses has shown that this item is made of almost pure copper with only approximately 0.5 % of arsenic and traces of bismuth (Table 4).

We have not analysed the metallography of the object, but from the state of the preservation of the artefact and its metal core it can be assumed that it was hammered (and possibly also annealed?) into the final shape after casting.

The object entered the literature as an A-Group artefact. However, the only similar object, of which already H. Junker was aware, an axe blade, has been found in the area of the Naqada culture, at Tarkhan, in Tomb 1015.[34] This tomb assemblage is currently dated to Naqada IIIA2 based on pottery.[35] The possible ties of the adze blade ÄS 7187 to the Naqada culture are emphasised by the punched motive.

A punched "sign" on an object occurred also on an adze blade from the eponymous site of Naqada, in a shape roughly similar to the letter P described as a "crook" by J.C. Payne. The grave was dated to Naqada IID1.[36] Another Early Dynastic object with punched marks is an axe blade, possibly from Abydos.[37] Legible Early Dynastic inscriptions on copper tools refer to their owners – they were interpreted in that way for the inscribed royal names and also for non-royal individuals. It is impossible to decide whether the marks on Naqadan copper tools had the same meaning. The largest corpus of tool marks was preserved in the Middle Kingdom Papyrus Reisner II; these most probably represented place names.[38]

In the literature[39] the blade from Kubbaniya (ÄS 7187) has been determined as an axe blade, rather than an adze blade.[40] In order to ascertain its correct tool class, the available data about the length and width of adzes and axes have been displayed in a scatter plot (Fig. 5). Only assemblages in which adzes and axes have been found together in the same burial context are involved. In these cases, a distinction between a rather square shape of axe blades and a rather rectangular shape of adzes in ancient Egyptian material culture is clear.[41] A-Group cemeteries also show several examples of graves where adzes occur alongside axes; axe blades are distinguished by a rather square shape and a flaring of the blade, while adz-

29 Junker 1919: 116, 133, Taf. XXXIX.

30 Unfortunately, no other object from this grave was identified neither in the collection of the KHM nor in the published collection from Kubbaniya in Kraków (Śliwa 1982).

31 Junker 1919, 94, 114, 120.

32 Nordström 1996.

33 Odler 2015a, 97–99, Fig. 7.

34 Petrie, Wainwright and Gardiner 1913, Pl. V: 27, VI: 8. The object is in the collection of the Manchester Museum, accession number 5427.b (10804).

35 Lisa Mawdsley, pers. comm.

36 Grave 39; Payne 1993, 146; the object is in the Ashmolean Museum, Oxford, accession number AN1895.969.

37 Davies 1987, 27, Pls. 1, 31.

38 Andrássy 2009.

39 Kühnert-Eggebrecht 1969, 98; Davies 1987, 28.

40 As adze determined by Odler 2015a, 97.

41 For the definition of distinction between ancient Egyptian axe and adze blades, see Odler 2015a.

Fig. 5 Scatter plot of axe and adze blades from the A-Group and Naqada cultures and the Kubbaniya blade (plotted by Martin Odler in R).

es were rectangular and narrower (Classical A-Group Grave 23 from Debeira,[42] late A-Group Grave W 11 from Qustul,[43] Grave 1 of Cemetery 142 at Naga Wadi).[44] Naqadan graves also contained axes alongside adzes, namely Tomb 122 (Naqada IIIC2)[45] and the already mentioned Tomb 1015, both from Tarkhan. The largest assemblage where axes and adzes co-occur is a tomb deposit of copper alloy tools in Tomb 3471 at North Saqqara, datable to the reign of Djer of Dynasty 1.[46] The scatter plot shows a distinct grouping of axes and adzes, with the blade from Kubbaniya clearly falling into the adze group. Therefore, its correct tool class is adze blade. Another outlier of an apparent Naqada axe in the cluster of adzes, a blade from Tarkhan, can also be categorised as an adze.[47] The craftsman producing blades had a mental template with a clear aim of producing distinct blades. We can thus assume that there was a dependent variable in form of the ratio of length and width.

By careful comparison of the preserved objects, a few morphological differences between A-Group and Naqadan objects can be distinguished. The square shapes of blades from Tarkhan and Saqqara, attributed to axes, do not have flaring of the blade, which occurs more often on adze blades.[48] The only preserved axe blade with flaring from the area of the Naqada culture is an axe blade from Abydos.[49] The only remarkable difference between the axe blades of the A-Group and the Kubbaniya blade is flaring of the blade. Adze blades of the A-Group tend not to have flaring.[50] The absence of flaring on the blade would qualify the blade from Kubbaniya rather as an object of the Naqada culture. Concerning chemical composition, axes and adzes from the Naqada culture have contents of arsenic between 1 and 5 % according to the published results.[51] Regarding A-Group artefacts, there are blades with arsenic and bismuth below 1 %,[52] but also blades made of arsenical copper.[53]

42 Nordström 1972, 123–4, 154–5, Pl. 73: 9, 10, Pl. 193: 1; Anfinset 2010, 163–165, Figs. 6.49–6.50.

43 Williams 1989, 39, 63, Fig. 27c-f, Pl. 36a-d, 37a-d.

44 Firth 1927, 214, Pl. 22: b 1–4.

45 Petrie, Wainwright and Gardiner 1913, 23, 11, Pl. IV: 14; V: 25; VI, 3–5, LXVI.

46 Emery 1949, 18–57.

47 Tarkhan, Tomb 1015, now Manchester Museum, accession number 5427.c.

48 Axes discussed in Davies 1987 and adzes in Odler 2015a, with further references.

49 Davies 1987, 28; now in Leiden, accession number RMO, F 1938/8.87.

50 For a detailed list of examples, see Odler 2015a, 98–99.

51 McKerrell 1993; Spencer 1980, 88.

52 Halfa Degheim, Grave 58, axe: Nordström 1972, 123–4, 210, Pls. 117, 193: 1; Anfinset 2010, 163–165, Figs. 6.49–6.50; Debeira, Grave 23, adze: Nordström 1972, 123–4, 154–5, Pl. 73: 9, 10, Pl. 193: 1; Anfinset 2010, 163–165, Figs. 6.49–6.50.

53 Faras cemetery: Griffith 1921, 9–10; Spencer 1980, 86, Pl. 71.

The question of the definitive cultural attribution of the adze blade from Kubbaniya must remain open. The punched mark on the surface, a trait that is peculiar only to the Naqada culture and later Egyptian material culture, may favour the Naqada culture as the place of origin for the object. Another such trait is the absence of blade flaring, which is more frequent in the Naqada culture. However, similar chemical composition and morphologically similar artefacts occur also in the A-Group culture. Only a lead isotope analysis would bring us nearer to answering the question of the ore source and possible production place of the object.

5.2.2. Adze blade (ÄS 6944) and spearhead (ÄS 9252) from Tura

Contrasting with the "outpost" location of Kubbaniya, the cemetery of Tura is located on the eastern side of the Nile Valley, opposite the administrative centre of the early Egyptian state at Memphis. The Tura area is famous for its source of white limestone in quarries to the east of the cemetery.[54] The Early Dynastic cemetery at Tura is listed among the sites with elite and lesser tombs, interpreted as burial grounds of the secondary and tertiary centres of the state.[55] In contrast to Kubbaniya, metal finds were scarce at the cemetery of Tura, with c. 10 objects preserved.[56] Besides the analysed adze blade and spearhead, the 583 explored graves only contained one other spearhead,[57] another adze, a harpoon, two small bowls and five probably full-size vessels, one ring and three armbands.

The adze blade (ÄS 6944) was found in the undisturbed Grave 18.k.3, a pit dug out in sand. The tool was deposited behind the head of a skeleton, a plain incomplete blade without a haft (Fig. 6). The grave contained also a cylindrical travertine vessel, described as squat ('gedrungene Form') by Junker.[58] The adze blade is damaged by corrosion and collapsing into layers of material. It has a trapezoid shape with a single bevelled and flared convex blade, a common trait of Naqadan and Dynasty 1 adze blades. The adze is of early

Fig. 6 Grave 18.5.3 with an adze blade (after Junker 1912, Taf. XXXII, upper left photo).

Type A, with a presumed flat butt; more precisely Variant A1 (Figs. 7, 8).[59] Although the butt is missing, the tool blade was not much longer than the surviving part.

Dynasty 1 complete adze blades form a bimodal distribution on a histogram of lengths (Fig. 9), exemplified also by a superimposed density plot.[60] With a length of 161 mm, the adze from Tura belongs to the first group of shorter adzes. Several size categories of adzes are supposed to have existed in the Old Kingdom.[61] We can see that this assumption works also for Dynasty 1; presumably, the shorter adzes might have been used by carpenters and the longer ones by shipwrights. In terms of morphology, the adze has a distinct flaring of the blade, which occurs also on Dynasty 1 adzes from other sites, e. g. from the Early Dynastic cemetery at Saqqara.[62]

54 The latest map of the area, albeit without the location of the cemetery, in Harrell 2016, Fig. 1.

55 Köhler 2008, 397, namely the sites of Abusir/Abu Ghurab, Giza, Abu Rawash, Old Cairo and Tarkhan.

56 Junker 1912, 54–56.

57 Junker 1912, 55, Abb. 74.

58 Junker 1912, 52, 55, 73, Taf. XXXII, XLVII.

59 Odler 2015a, 97–99, Fig. 7.

60 For references to the find spots of Dynasty 1 adze blades and source data of Figure 9, see Odler 2015a.

61 Odler 2016, 133.

62 For references to find contexts, see Odler 2015a, 99–100.

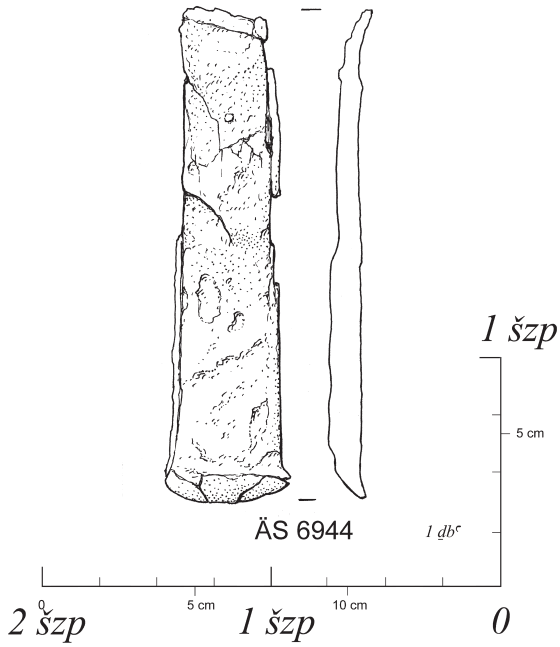

Fig. 7 Adze blade from Tura (ÄS 6944) (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

Fig. 8 Adze blade from Tura (ÄS 6944) (© KHM-Museumsverband).

The adze blade from Tura (ÄS 6944) was made of almost pure copper (Table 4). As pure copper is rather soft, the tools were probably made only as burial equipment. As we have discussed in detail in the case of the previous adze blade (ÄS 7187), the analysed artisan tools (adzes, axes and chisels) from Dynasty 1 were made from either arsenical copper or copper with impurities of other metals; both groups occur in burial assemblages.[63]

The spearhead (ÄS 9252) was the only object found in the disturbed Grave 18.e.3, a mudbrick structure with remains of wood from the roofing.[64] The blade has a lozenge shape with deltoid section, the blade tip missing, and a short tang with a hook. It was cleaned of verdigris in the museum collection (Fig. 10). With the spearhead from Tura, we move to another material in the assemblage. The spearhead ÄS 9252 was made of arsenical copper (2.8 % As, Table 4). Its shape is unique in Egypt, having no exact analogies to our knowledge. Predynastic and Early Dynastic spearheads known from the Nile Valley come from the A-Group cemetery at Qustul,[65] Predynastic Tarkhan,[66] probably Dynasty 1 Abydos, Tomb O.31 (although this object has been also categorised as a leather-cutting knife; it was made of copper with a half percent of arsenic)[67] and finally Dynasty 2 Abydos, Tomb of Khasekhemwy, possibly a model with slightly more than one percent of

63 Spencer 1980, 88; Cowell 1987, 111, Table 1d.

64 Junker 1912, 54–55, 62, Abb. 73, Taf. XIII.

65 Williams 1986, 128, 359, Fig. 170, Pl. 64b, 65b; now in the Oriental Institute Museum, University of Chicago, E23727.

66 Petrie, Wainwright and Gardiner 1913, 23, 10, Pl. I, IV: 6, LXIII; datable to Naqada IIIA2 (Lisa Mawdsley, pers. comm.)

67 Petrie 1901, 8, 24, Pl. VI: 18, 23–26; Spencer 1980, 88. Now in the British Museum, EA67565.

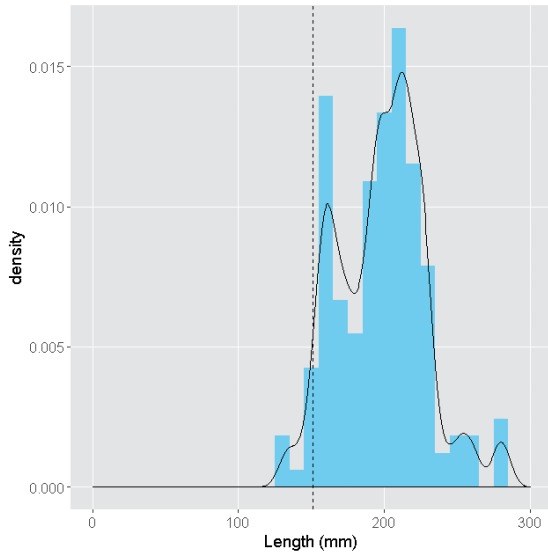

Fig. 9 Histogram and density plot of the lengths of adze blades from Dynasty 1. Length of adze blade from Tura is marked by a dashed line (plotted by Martin Odler in R).

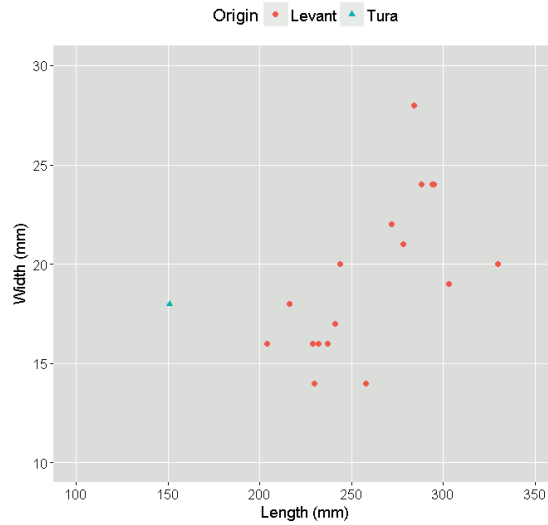

Fig. 11 Scatter plot of the spearhead from Tura and of Early Bronze Age spearheads from the Levant (data points after Philip 1989, 323–326; plotted by Martin Odler in R).

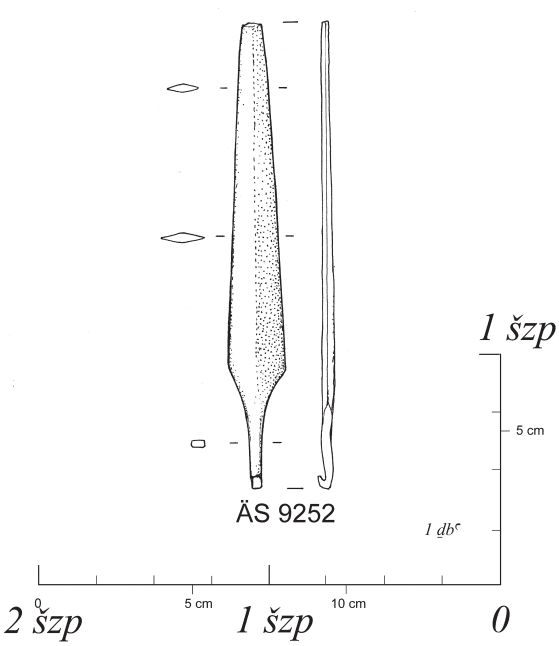

Fig. 10 Spearhead from Tura (ÄS 9252) (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

arsenic.[68] Late Old Kingdom to First Intermediate period spearheads from Dara were made of copper with impurities and arsenical copper.[69] None of these spearheads are similar to the morphology of the Tura spearhead; most importantly they do not possess the distinct hook at the end of blade. Another object, an artefact with a similar lozenge shape in the deposit of copper model tools in the tomb of Khasekhemwy, is in reality a sheet model of a saw blade.[70] Analogical artefacts were used in the Levant: Type 6 spearheads with hooks which are dated to the Early Bronze Age.[71] Yet, the artefact needs not to be an import; the chemical composition may indicate that the object is of Egyptian origin. The size does not correspond either: the spearhead from Tura is much smaller than the artefacts from the Levant, as can be observed on a scatter plot (Fig. 11). The spearhead from Tura is most probably an object made in Egypt but inspired by the Levantine form of spearheads with hooks.

5.2.3. Old Kingdom model adze blades from Giza

Beginning in Dynasty 2, the situation in the use of copper alloy tool blades in the burial equipment

[68] Golden 2002, 229–230, Figs. 14.5, Table 14.1; now in the University of Pennsylvania Museum, E 14730.

[69] Hours and Michel 1974, 69, Tab. 1.

[70] Petrie 1901: Pl. IXA; now in the Ashmolean Museum Oxford, accession number AN1896-1908 E.631.

[71] Philip 1989, 323–326, Fig. 16, 6.

changed in favour of a lesser total weight of metal and models usually cut out of metal sheets.[72] Later, most preserved Old Kingdom tool blades in the burial equipment were models of full-size tools, modelling the practically used objects on a smaller scale.[73] The models retained only some of the morphological characteristics of full-size artefacts, they were produced by hammering and annealing to the shape, the same techniques used for production of full-size blades.[74] Weapons disappeared from the burial equipment after the Early Dynastic period. Old Kingdom ideology of kingship retained the right to violence against the enemies of Egypt, and military scenes are extremely rare in non-royal contexts. This absence of evidence, especially metal blades of weapons, does not mean that they were not known to the Old Kingdom Egyptians; they were rather not represented in the burial equipment and material culture preserved e. g. at settlements.

Giza is currently the best known site from the point of view of Old Kingdom archaeology. Old Kingdom tools in the form of so-called model tools are the most frequent category of metal finds in the burial chambers of the elite.[75] They occurred in the usual combination of chisels, adzes, axes and saws, with occasional inclusion of razors and needles, in Dynasty 6 also mirrors. We have analysed five artefacts from Old Kingdom Giza, four model adze blades (Z5_C6_8_II_1, Z5_C6_8_II_2, Z5_C6_6_II_1, Z5_C6_6_II_4) discussed in this section and an inscribed carinated bowl (ÄS 7441) discussed later in the article.

Two adze blades were found in Tomb G 4970 (Z5_C6_8_II_1, Z5_C6_8_II_2, Fig. 12).[76] The tomb has an L-shaped chapel with two false doors in the southeastern part of the structure and two burial compartments in the centre; the larger southern burial chamber and shaft belonged to the tomb owner, the official Nesutnefer, active in the provincial administration and in the administration and funerary cult of the pyramid town of Khafra,[77] the smaller northern shaft and burial

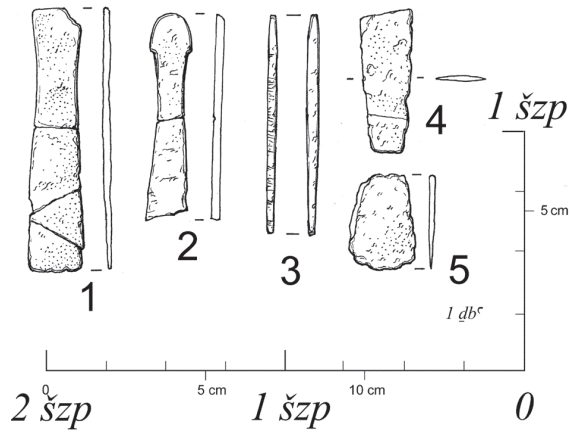

Fig. 12 Model tool assemblage from Tomb G 4970 at Giza (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

chamber most probably to his wife Khentetka who bore the titles of priestess of Hathor and Neith and of the king's acquaintance. The decoration of the tomb was based on imitation of the reliefs from Tomb G 5150 (Seshathetep Heti) with some minor changes.[78] The inscriptions (also based on the imitated tomb) claimed that the offerings were coming from the settlements of the tomb owner's funerary foundation or estate (*pr d.t)*. The offerings were counted by the scribes of Nesutnefer's household; food, animals and other objects (headrest, bed, sandals, staff, etc.) were depicted. The finds from the burial chambers can perhaps be also seen in this context, as provided from the household of the tomb owner. The metal finds have been found in the debris of the northern shaft of the tomb, together with a fragment of a red bowl and an amphora. The fragments of the combed ware amphora enabled to reconstruct the shape of the complete vessel. K. Sowada collected various datings of the vessel, ranging from Dynasties 4 to 5.[79] The most frequent dating of the tomb itself is early to middle Dynasty 5, but an earlier chronological position of the tomb is still favoured by some authors.[80]

[72] In the royal burial of Khasekhemwy at Abydos (Petrie 1901, 12–13, 28, 38–40, Pl. XLV: 65–80; Pl. IXA) and at Helwan Köhler 2014.

[73] For a detailed discussion, see Odler 2016.

[74] Maddin *et al*. 1984.

[75] Odler 2016.

[76] Junker 1938, 166; Jánosi (2006, 84–85, Abb. 66) dealt with the local development in the vicinity of Tomb G 4970.

[77] Moreno-García 2013, 97, 101.

[78] Junker 1938, 172–185, Abb. 28–31.

[79] Sowada 2009, 64.

[80] Of recent works, Moreno García (2013, 97, 101) dates Nesutnefer to Dynasty 4 and Roeten (2014, 429–431) dates both Seshathetep Heti and Nesutnefer to early Dynasty 5 based on the chapel decoration. As the vessel was not identified in any contemporary museum collection, it cannot be decided whether it was a genuine import from the Levant or an Egyptian imitation.

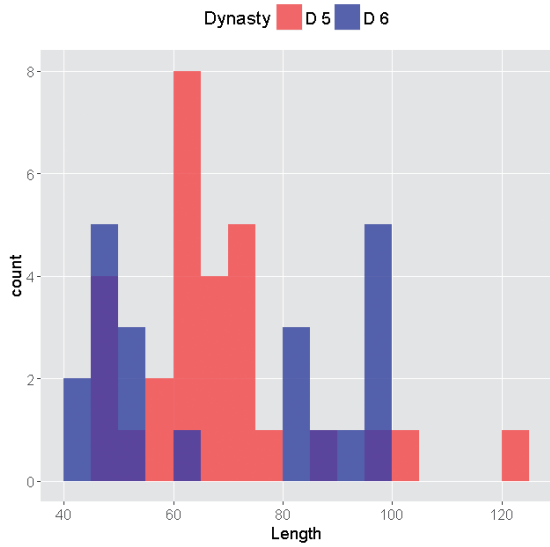

Fig. 13 Superimposed histograms of length of the adze blades of Variant D1 from the Dynasty 5 and 6 (plotted by Martin Odler in R).

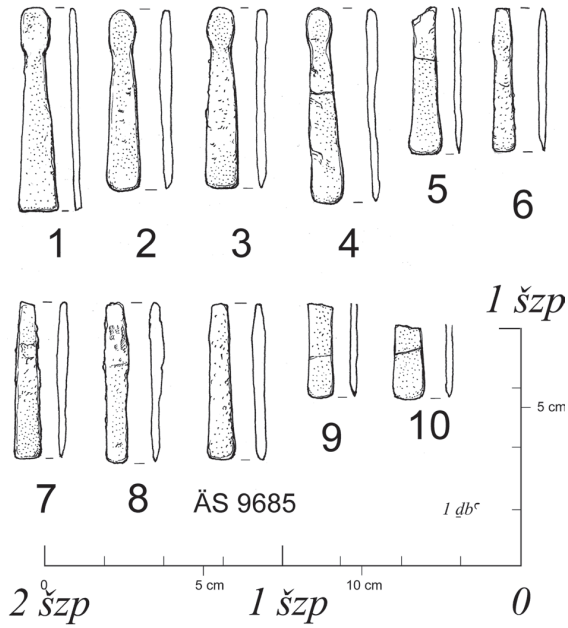

Fig. 14 Model tool assemblage from Shaft 315 at Giza (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

The first analysed adze with a flat butt and a neck in one-third of the length (Z5_C6_8_II_1), consisting of 4 fragments, is of Variant D1.[81] The histogram in Fig. 13 depicts the lengths of Variant D1 complete model adzes from the Dynasties 5 and 6.[82] Yet, compared to all model adze blades, this blade is one of the longest model blades preserved from the Old Kingdom. It is an "oversize" model, exceeding one ancient Egyptian palm (c. 75 mm). Such adzes could have been issued from the royal treasury for the burial equipment of non-royal persons of high status,[83] which contradicts the information stated in the tomb decoration (but as discussed before, the inscriptions were copied from another tomb with only minor changes). The second adze with a rounded butt with edges and a neck (Z5_C6_8_II_2), consisting of two fragments, is of Variant D4.[84] The blade part of the adze is unfortunately broken off and the maximal length of the adze cannot be ascertained. Both analysed model adze blades, much corroded, were made of copper with impurities (with arsenic below 1 %, Table 4). Besides them, the assemblage contained a fragment of a chisel, a saw blade and possibly also a fragmentarily preserved axe blade (Fig. 12).[85]

Two model tools were found later on the eastern side of Tomb G 5070 (Z5_C6_6_II_1, Z5_C6_6_II_4). Junker considered the Mastaba of Shafts 309–316 as a later building than Mastaba G 5070, with a corridor chapel and a rather large serdab.[86] The tomb must have been built after late Dynasty 5, in the course of Dynasty 6.[87] The supposed tomb owner was buried in Shaft 316 and his supposed spouse in Shaft 315; no information has been preserved about their names or social position. Shaft 315 was found undisturbed, with the body deposited in a sarcophagus pit sunk into the floor of the chamber. The body had a faience necklace. Model vessels made of travertine and pottery lay to the east of the burial, covered with wooden planks. The tomb can be dated to Dynasty 6 based on the model stone vessel assemblage.[88] The model

[81] Odler 2016, 141–142.

[82] The datasets are described and discussed in Odler 2016.

[83] Odler 2016, 234–235.

[84] Odler 2015a, Fig. 7; 2016, 142.

[85] The assemblage has been published in Odler 2016 and before that in Odler and Dulíková 2015, Fig. 7: BE6, selection; the complete assemblage in Odler 2015b, Fig. 4.8: BE5.

[86] Lehmann 2000, Katalog-Nummer: G302.

[87] Junker 1944, 46.

[88] Jirásková 2016.

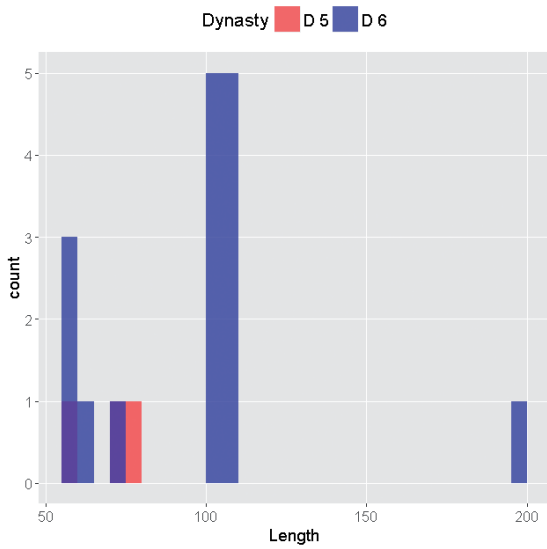

Fig. 15 Superimposed histograms of length of the adze blades of Variant D2 from the Dynasty 5 and 6 (plotted by Martin Odler in R).

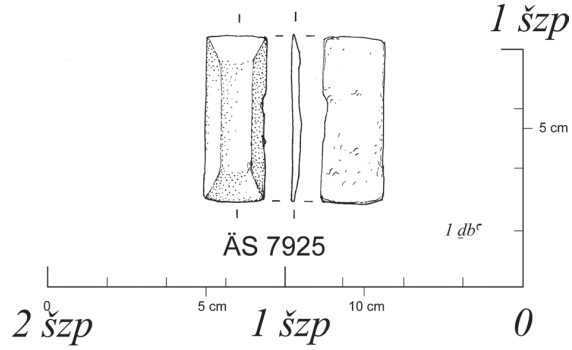

Fig. 16 Model razor blade, probably of Old Kingdom dating (ÄS 7925) (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

tools were found at the south end of this concentration, on and beside a ceramic bowl (Fig. 14).[89] A miniature mirror was found together with the model tools; unfortunately, the KHM collection contains three model mirrors supposedly from Giza, and it cannot be determined which one is from this assemblage.[90]

Both models are necked adze blades of Type D, the former without a clear attribution to a variant due to the corrosion of the butt (Z5_C6_6_II_1), the latter (Z5_C6_6_II_4) of Variant D2[91] and consisting of two fragments but beside that preserved completely. Based on the histogram of complete Dynasties 5 and 6 model adze blades of Variant D2, the adze blade is one of the shortest preserved with only 62 mm (Fig. 15).[92] It might have been a product of the tomb owner's estate, which could have included metalworkers.[93] The first adze blade (Z5_C6_6_II_1) was made of arsenical copper (with 2.2 % As), which makes it one of the first confirmed Old Kingdom model blades made of this material, with the exception of arsenical copper axe blade from Dynasty 6 Dendera.[94] The latter adze (Z5_C6_6_II_4) contains less than 1 % of arsenic.

5.2.4. Unprovenanced Old Kingdom model razor blade (ÄS 7925)

The gifts to the Imperial Academy of Sciences in Vienna include a rectangular model razor blade (ÄS 7925). Based on morphology, the artefact can be dated to the Old Kingdom; it is a Type A razor with a symmetrical blade and without a tang, Variant A1, of a rectangular shape and trapezoidal section, with no apparent tang or tang joint (Fig. 16).[95] It is cleaned, but still shows traces of verdigris and corrosion in orange colour. This is a luxury counterpart of flint rectangular razor blades and occurs throughout the Old Kingdom, in Giza from Dynasty 4 to Dynasty 6 and also in Dynasty 6 Abydos, Balat and Bubastis.[96] In the past, they were often confused and interchanged with Old Kingdom model rectangular basins of similar shape (but hollowed out). There is not always enough information available to distinguish between these two different artefact classes.[97] From a scatter plot of the lengths and widths of the verified Old Kingdom razor blades of Variant A1, we can see that the model blade is rather an outlier, narrower than other complete specimens (Fig. 17). It was made predominantly of copper, with some impurities, including arsenic (Table 4). A possible explanation of the rather high number of trace elements in the above-mentioned models (the razor blade and the adze blades from Giza) is

89 Junker 1944, 61–62, Taf. XIII: a.
90 Context G126 in the catalogue of Odler 2016, also Fig. 46.
91 Odler 2015a, Fig. 7.
92 The datasets are described and discussed in Odler 2016.
93 Odler 2016, 234–235.
94 Cited in Odler 2016, Figure 4.
95 Odler 2016, 178–179.
96 Kobusiewicz 2015, 18.
97 Odler 2016, 178–179.

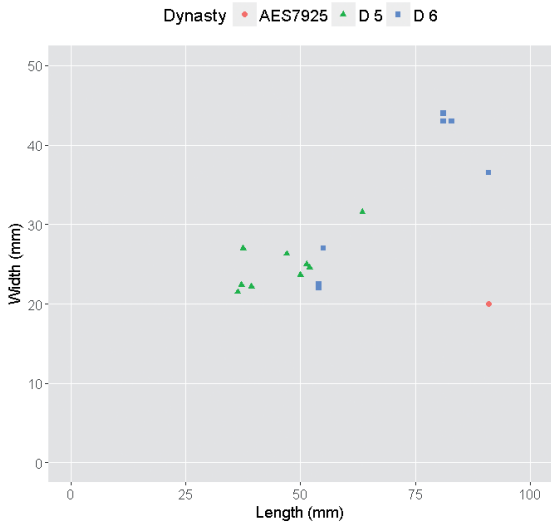

Fig. 17 Scatter plot of the lengths and widths of model razor blades of Variant A1 (plotted by Martin Odler in R).

that they were made from already used and several times recycled metal. We will return to this issue in the penultimate section of the article.

5.2.5. Weapons and model tools of the First Intermediate period and Middle Kingdom

Several large necropoleis south of Asiut were excavated by G. Brunton from 1922 to 1931, including Mostagedda.[98] Hundreds of graves from the Egyptian prehistory until the Roman period were uncovered here.[99] The First Intermediate period to early Middle Kingdom assemblages of model tools excavated at Mostagedda can be identified by the presence of models of battle axes, lugged axe blades and model spearheads.[100] Full-size metal weapon blades were rare at the site.[101] Brunton assumed that all these burials were male.[102]

The undisturbed male Grave 5118 contained a battle axe blade (ÄS 8124) and two blades of lugged model axes (ÄS 8126, ÄS 8127) (Fig. 18). The burial was deposited in a shaft with a burial niche leading to the south. There was pottery in the niche, but the excavation report provides no

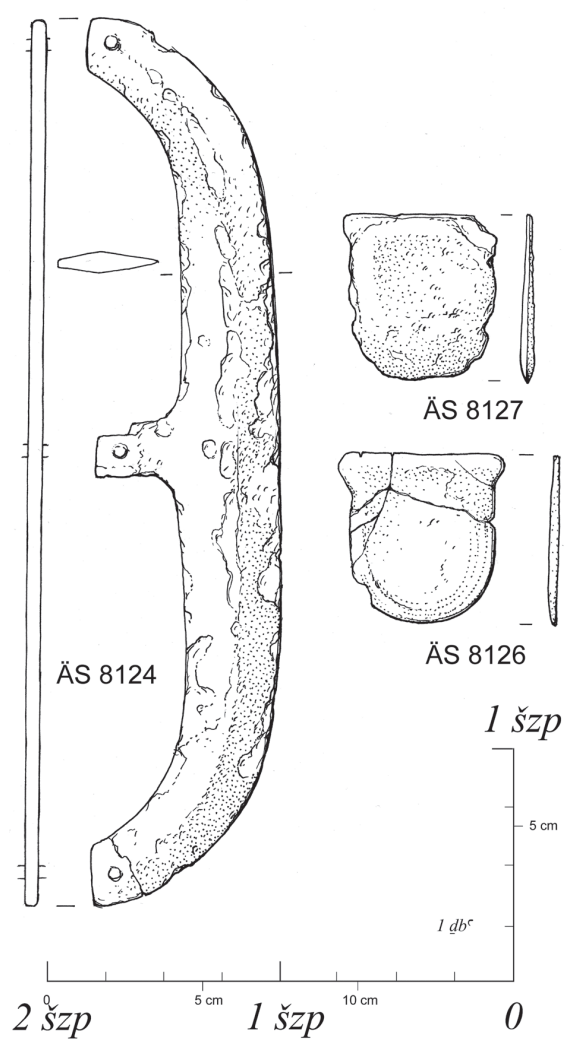

Fig. 18 Battle axe blade and model tool assemblage from Mostagedda, Grave 5118 (after Brunton 1937, Pl. LXI 5, Pl. LXII 3; ÄS 8124, ÄS 8126, ÄS 8127; updated by Martin Odler and Martin Černý).

information about its position. Green and red stuccoes, possibly from the face mask, were found as well. A chisel, an axe-blade and model tools (two lugged axe blades, two adze blades, a cross-cut chisel, a flat chisel and a saw blade, the last three with remains of wooden handles) have been found "at the foot of the coffin, some over and some

[98] The published material has been studied again by Stephan Seidlmayer 1990; 2009. See also works of U. Dubiel (e. g. 2008).

[99] Brunton 1937.

[100] Assemblages analogical to the grave with the analysed objects have been found in eight cases (Seidlmayer 1990, 133–139), dated to Phases IIC (Tomb 5112), and predominantly IIIB (Graves 721 with a full-size lugged axe blade and 1814 with an epsilon battle axe; 1621, 1658, 1690, 1693 with a model tool assemblage).

[101] Besides the analysed axe, there were similar axe blades from Graves 1690 and 1814 and a full-size spearhead from Grave 1920.

[102] Brunton 1937, 108.

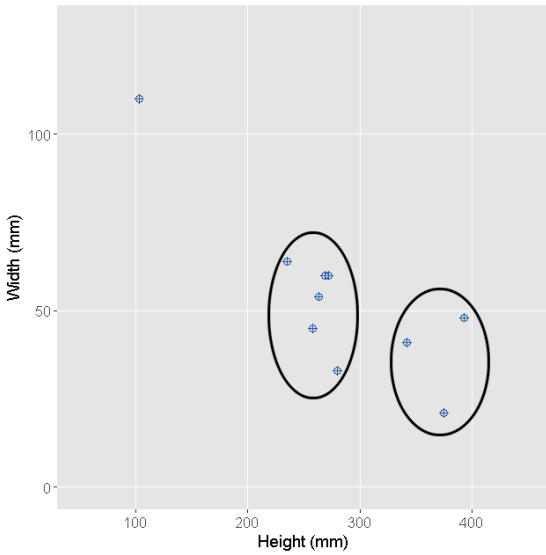

Fig. 19 Scatter plot of epsilon axe blades, data points in Table 5 (plotted by Martin Odler in R).

under it".[103] Brunton dated the assemblage to the First Intermediate period, Dynasties 9–11.[104] According to the seriation by Stephan Seidlmayer, it belongs most probably to late Dynasties 11 or early 12, to Phase IIIB of the cemeteries.[105] The models from Grave 5118 were among the largest found at Mostagedda.[106] The occurrence of weapons in the graves was the highest about at the end of the First Intermediate period; according to Seidlmayer, this can be explained by higher social esteem for the bearers of weapons in this time period.[107]

The full-size battle axe blade (ÄS 8124) is of a long straight blade with three back tangs, each with a perforation and a rivet in it. The corroded surface does not reveal any marks of use. The blade has a mid-rib. We have gathered information on the existing epsilon axe blades (Table 5) and displayed it in a scatter plot (Fig. 19). One axe blade from Grave 1749 at Kau is an outlier due to its rounded shape and its size. Other specimens of the type are split into two groups, the first including shorter blades from Abydos, Beni Hasan, Dendera and all three blades from Mostagedda, with a length below four Egyptian palms (c. 300 mm). Larger blades, with a length around five palms (c. 375 mm), come from Abydos, Beni Hasan and Qau. Both longer and shorter blades occurred in almost the same chronological phase of the early Middle Kingdom, and the size distinction is thus rather caused by the functional differentiation, as the efficiency of the blade probably increased with its length.

The blade ÄS 8124 was made of arsenical copper (with the highest analysed percentage of arsenic – 5.9 %, Table 4). Two other provenanced axe blades of the same variant that has been analysed are axe blades from Beni Hasan and Dendera,[108] made of arsenical copper also with a rather high percentage of arsenic.[109] Four similar, but unprovenanced elongated axe blades from the British Museum were also made of arsenical copper (with a slightly lower percentage of arsenic), one of bronze.[110] The model blades of lugged axes have been preserved incomplete, with one lug broken off from either blade (ÄS 8126, ÄS 8127). They were made of an arsenical copper (1.9 % and 2.3 % As respectively, being quite similar from their composition), nevertheless showing the same trace elements as the battle axe (Table 4). This type was originally dated as early as Dynasty 6 by Petrie. The assemblages present now show that this type did not occur until the First Intermediate period, and there is no solid basis for dating of the occurrence of lugs on axe heads in the Old Kingdom.[111]

The results of the present analysis show that the models (ÄS 8126, ÄS 8127) and the full-size blade (ÄS 8124) were not made of the same alloy, mostly differentiated by the arsenic content in this case. Similar differences between full-size tools and models have been identified for the material from the site of Kahun, a settlement and burial ground of the pyramid builders of King Senwosret II. Different alloys were used there, with a mean arsenic content of 1.28 % for full-size tools and of 0.66 % for models.[112] Full-size models from the British

103 Brunton 1937, 103.

104 Brunton 1937, 103, Pl. LXI, 5, Pl. LXII, 3.

105 Seidlmayer 1990, 135.

106 Brunton 1937, Pl. LXI.

107 Seidlmayer 1990, 194.

108 Beni Hasan, Tomb 757: Garstang 1907, 162, Fig. 165; Davies 1987, 42; Dendera: Schulz 2003, 246. Both now in the Ashmolean Museum, Oxford, accession numbers AN 1896–1908 E.2290 and E.1744.

109 McKerrell 1971, with 5–10 % of arsenic for Beni Hasan and 1–5 % of arsenic for Dendera.

110 Davies 1987, Cat. Nos. 96–100; Cowell 1987, Table 1a. Contents of arsenic was in the range from 2.5 to 4.1 %.

111 Odler 2016, 154–155.

112 Gilmore 1986.

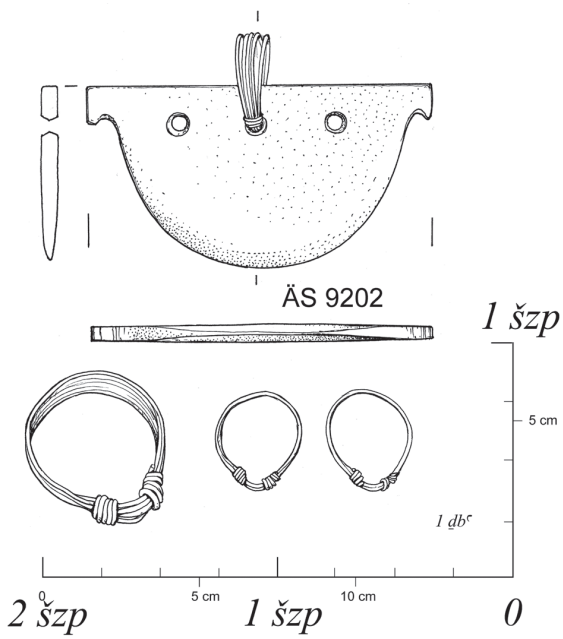

Fig. 20 Axe blade from Kubbaniya North (ÄS 9202) (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

Fig. 21 Vertical polishing marks on axe blade ÄS 9202 (photograph by Martin Odler).

Museum were made of both pure copper and arsenical copper. Other models from Mostagedda have been analysed in the British Museum, but they were too corroded to provide useful results.[113]

5.2.6. Battle axe from Kubbaniya North (ÄS 9202)

The second analysed artefact from Kubbaniya is a much later axe blade from Kubbaniya North, from the so-called intermediary or mixed group burial ground of the Nubian population, dated by Junker to the Middle Kingdom. Later reassessments also accept the original dating of the cemetery to Dynasty 12.[114] The axe blade was the only metal find at the cemetery with 63 graves, except for gold beads in another grave.[115] The axe blade was found in the disturbed Grave 16.i.1, at the knees of a skeleton (probably lying on its right side), inside the remains of a wooden coffin. The rectangular grave was aligned with mudbrick covered with mud plaster.[116] The axe blade is segment-shaped, with two hooked lugs and three perforations at the butt drilled into the finished blade from both sides, leaving a bi-conical section of perforation (Fig. 20). The blade is cleaned and bears no marks of use, visible scratchings are most probably from the polishing of the blade (Fig. 21). Wires holding the blade on a haft have been preserved as well, one in the central perforation, two others loose (Fig. 22). According to the scatter plot (Fig. 23), this axe blade is a rather small specimen of its type, together with axes from Ghurab, Kafr Ammar and Sheikh Farag. Larger axe blades come from Diospolis Parva, Kau, Rifeh and Nubia (Table 6). The axe blades range in dating from the First Interme-

[113] Davies 1987, 30–32.

[114] Bietak 1968, 37–38; Näser 2013, 143.

[115] Junker 1920, 120.

[116] At the feet were green and blue faience beads, shells for cosmetics and gazelle bones. Junker 1920, 123, 125, Blatt 23, 27.

Fig. 22 Two more wires holding an axe haft of ÄS 9202 (photograph by Martin Odler).

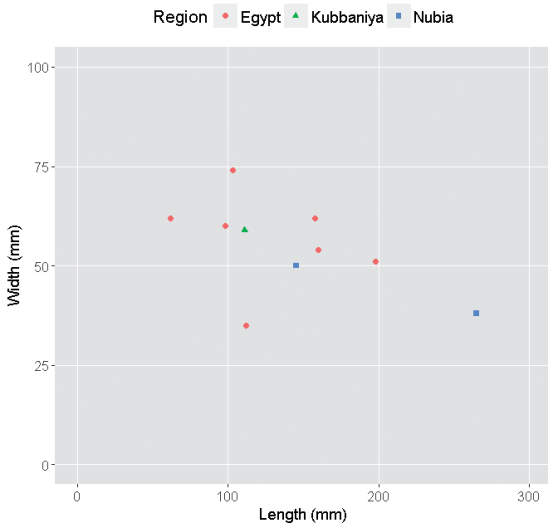

Fig. 23 Scatter plot of segmental axe blades, data points in Table 6 (plotted by Martin Odler in R).

diate period to the Second Intermediate period in Nubian contexts, but not all of the excavated contexts have been sufficiently published, unfortunately including the items of Ghurab and Sheikh Farag. The battle axe blade ÄS 9202 was made of arsenical copper (with 1.5 % As, Table 4), as a similar axe blade from Aniba.[117] Most of the 17 unprovenanced axe blades of the same type from the British Museum were made of arsenical copper, ranging from 1.3 % to 6.7 % As; three of them of bronze. Nevertheless, there are doubts about the ancient origin of the bronze specimens.[118]

5.3. Mirrors

5.3.1. C Group mirrors from Toshka (ÄS 7334; ÄS 7337)

201 stone tumuli of the Nubian C-Group have been uncovered at Toshka. Metal finds were scarce on the cemetery. Apart from an armlet made of golden wire circles in Tumulus C 147,[119] the only metal objects are the two analysed mirrors. They were found in two tumuli in the northern part of the necropolis built at a distance of almost 10 metres from each other. They are from the later phase of the necropolis.[120]

The first mirror from the site was found in Tumulus C 131 (ÄS 7334, Fig. 24).[121] The tumulus had a shaft, with the mirror deposited near the supposed position of the skull; only some scattered bones were found from the burial. The skull is preserved and probably from a woman. The tomb cannot be dated to a narrower time frame.[122] The mirror is the heaviest artefact in the analysed corpus, with a weight of more than 1,000 g. It was cleaned and inclining lines, most probably from polishing of the object (Fig. 25), are visible on the frontal side of the tang and on the reverse side of the disc. The mirror was not cleaned when the material was published and an inscription on one of the lower sides of the disc escaped the attention of H. Junker. It was cut out by a chisel into the surface of the finished disc (Fig. 26). The inscription was published after cleaning by H. Satzinger.[123] It reads: *ꜥnḫ-mȝȝ-ḥr jr.n mr mšꜥ Jn n sȝ.t=f Jtw*, translation: "a mirror for seeing face[124] being made by the overseer of troops In for his daughter Itu". Overseer of army In on this mirror was the only person with this title and name in the contemporary Nubian sources.[125] Itu was a name of at least six individuals, four men and two women.[126] The text was dated by H. Satzinger to Dynasty 13. The answer to the question whether the woman buried in the tumulus was Itu remains open. Both names

[117] Grave N 352: ÄMUL 4698; results in Kmošek and Odler *et al.* (2016b), with 1.75 % of As.

[118] Davies 1987, 35–37.

[119] Junker 1926, 73.

[120] Bietak 1968, 39.

[121] Junker 1926, 74, 84.

[122] Satzinger 1991, 102. The skull: Inv. Nr. 5714, Naturhistorisches Museum Wien, Anthropological department.

[123] Satzinger 1991.

[124] For the translation of *ꜥnḫ-mȝȝ-ḥr* as mirror, see Lilyquist 1979, 66–71.

[125] Stefanović 2006, 184, Cat. No. 989.

[126] Gratien 1991, 40. Because of the year of publication, this object is missing from this prosopography of Nubians and Egyptians in Nubia before the New Kingdom.

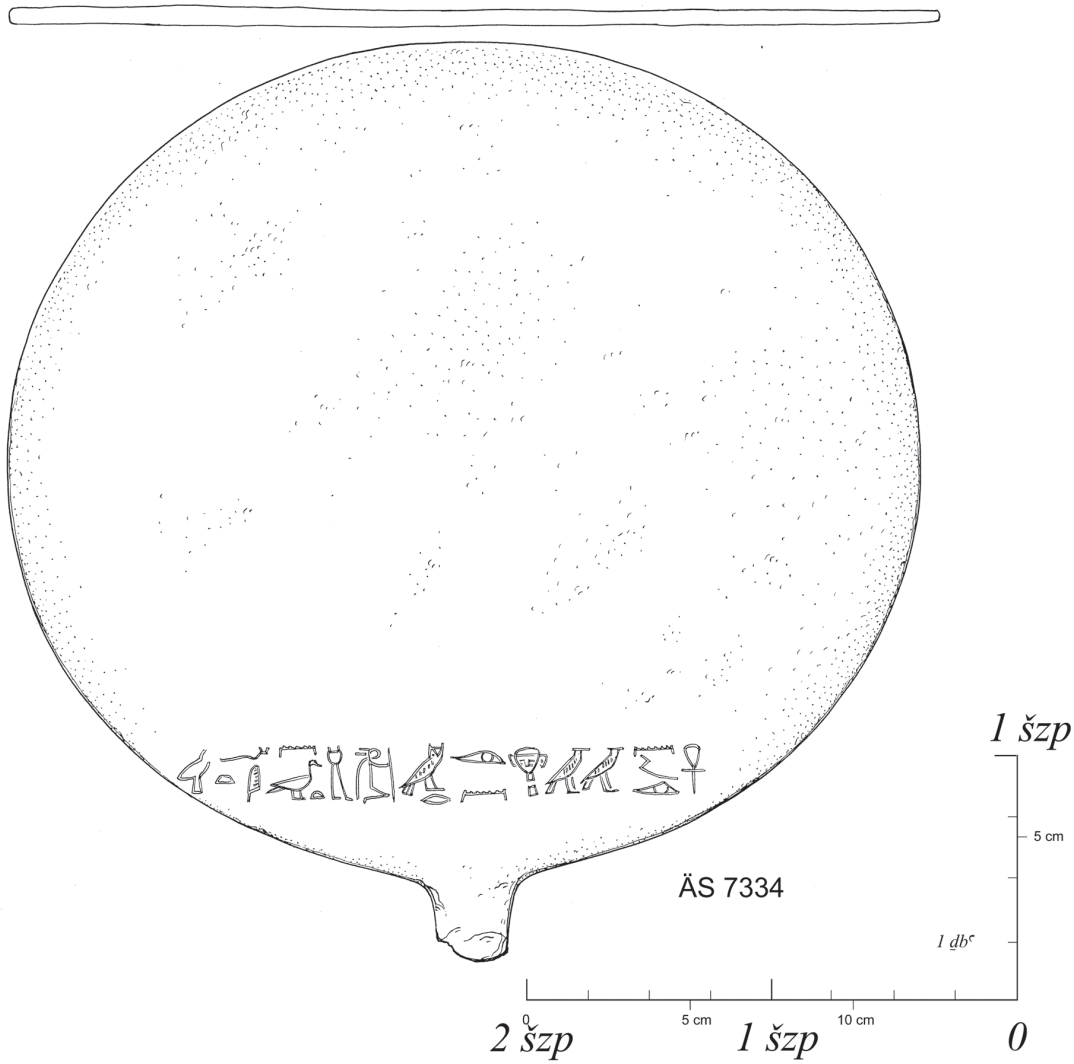

Fig. 24 Mirror from Toshka, Tumulus C 131 (ÄS 7334) (the scale displays ancient Egyptian and modern standard measuring units; drawing by Martin Odler, Martin Černý).

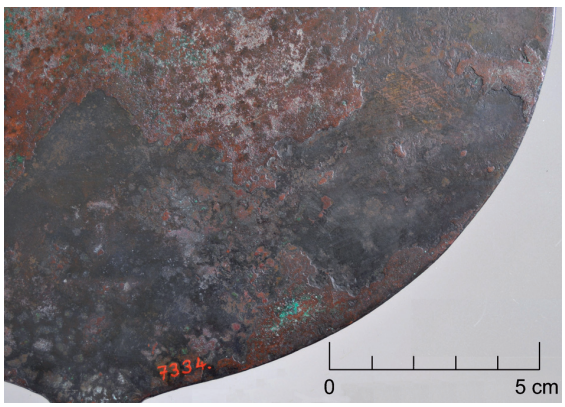

Fig. 25 Inclining scratches from the polishing of the mirror disc (© KHM-Museumsverband).

could occur also in Nubia, yet the inscription must have been produced by a person using regular Egyptian hieroglyphs.

We have two remarks on the margin of the interpretation of the text by H. Satzinger. The context is rather unusual in comparison with other inscribed mirrors,[127] with an inscription referring to the object on which it is inscribed. Mirrors were usually named in object friezes but not on the mirrors themselves. This unusual context provides important information as for the production of the mirror. The relative form *jr.n* refers to the situa-

[127] Lilyquist 1979, *passim*.

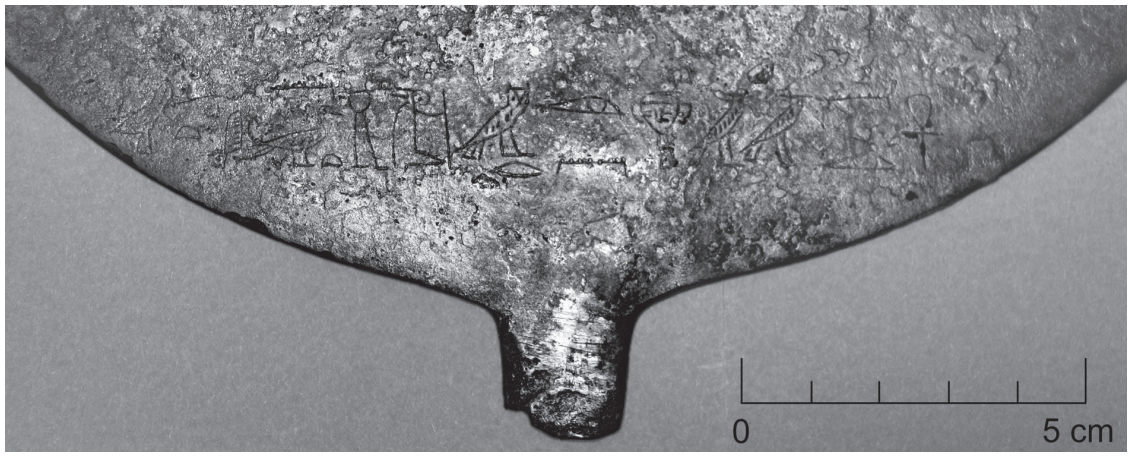

Fig.26 Detail of an inscription on a frontal side of mirror ÄS 7334 (photograph by Martin Odler)

tion, the overseer of army In provided the mirror for his daughter. The craftsman who made the mirror is the least important actor in this transaction (assuming that the overseer did not produce the mirror by himself). In similar cases within Egyptian culture, the provider is not named, like in the case of the mirror for the governor's daughter in Dynasty 6 Balat.[128]

The mirror is made of arsenical copper (with 3.9 % As, Table 4). H. Junker and also H. Satzinger assumed in their original publications of the mirror that the object was made of bronze. This assumption, not based on an analysis of the object, represents an important caveat against the use of previously published information about objects without analysing the material itself.

The second mirror (ÄS 7337) from the site was found in Tumulus C 134, where an undisturbed burial of a crouched woman[129] wrapped in leather, with a necklace and a mirror, was discovered without further details on the position of the body and the items.[130] A red polished ointment jar[131] and a fragment of the forehead of a bovine skull were found at the tumulus.[132] The mirror is of a fairly common shape with an oval disc and a trapezoid tang made together with the blade. Polishing marks and possible faint traces of a margin decoration of inclining lines are visible on one cleaned side of the mirror (Figs. 27, 28). The mirror ÄS 7337 was made of arsenical copper (with 2.5 % As, Table 4). A collection of several ancient Egyptian mirrors analysed at the Louvre showed different concentrations of arsenic for Old Kingdom (0.24 % – 7.5 % As), First Intermediate (one mirror from Dara with 2.5 % As) and Middle Kingdom (0.01 % – 2.2 % As) mirrors. The mirror from Toshka has a similar content of arsenic.[133] Three more C-Group mirrors and one mirror handle from Aniba in Leipzig were analysed by the team in Prague and have a range from 0.6 % to 6.7 % arsenic.[134]

5.4. Inscribed carinated bowl with spout from Giza (ÄS 7441)

Besides 14 tools and weapons, the examined corpus contained a single vessel. Copper alloy vessels were objects of ancient Egyptian conspicuous consumption and have been studied concerning their typology.[135] Their forms and development have to be viewed regarding the interplay of materials, stone, ceramics and metal.[136] The examined vessel was included in the corpus published by A. Radwan; it was later cleaned and its surface revealed traces of a previously unknown inscription shedding a different light on its archaeological and

[128] Valloggia 1998, 87, Fig. 23, Pl. LXXVI, B.

[129] According to the new examination of the skull, the female gender was confirmed (Satzinger 1991, 102). The skull: Inv. Nr. 5700, Naturhistorisches Museum Wien, Anthropological department.

[130] Junker 1926, 84–85, 74, 125, Taf. XXVI, Abb. 444.

[131] Junker 1926, 57, Taf. XXII: 347.

[132] Junker 1926, 145.

[133] Michel 1972.

[134] Kmošek and Odler *et al*. 2016b.

[135] Radwan 1983.

[136] This issue was already discussed by Radwan 1983, for the Old Kingdom, see also forthcoming Arias Kytnarová, Jirásková and Odler (in press).

social context. Moreover, the analysis of its chemical composition adds to the still meagre set of copper alloy vessels from earlier parts of Egyptian history with known contents of elements.[137]

An unnumbered mastaba at the West Field of Giza had a limestone offering table at its eastern side, inscribed for the funerary priest – ka servant Neferihy. The vessel was the only find besides a disturbed skeleton in the robbed Shaft 261, the only shaft of the mastaba.[138] The bowl, standing upside down, is probably visible on a photograph from the tomb's excavation (Fig. 29).[139] The vessel was found covered by verdigris, and was cleaned in the KHM. It has a small flat base, a carinated profile and a spout that must have been formed separately and soldered to the vessel body, which was produced by hammering. The spout with a widening circular section was situated below the maximal diameter of the vessel, leading upwards.

Junker defined the type as *Schale mit Ausgußrohr*, a carinated bowl with a spout (Fig. 30).[140] The shape of the vessel is known as

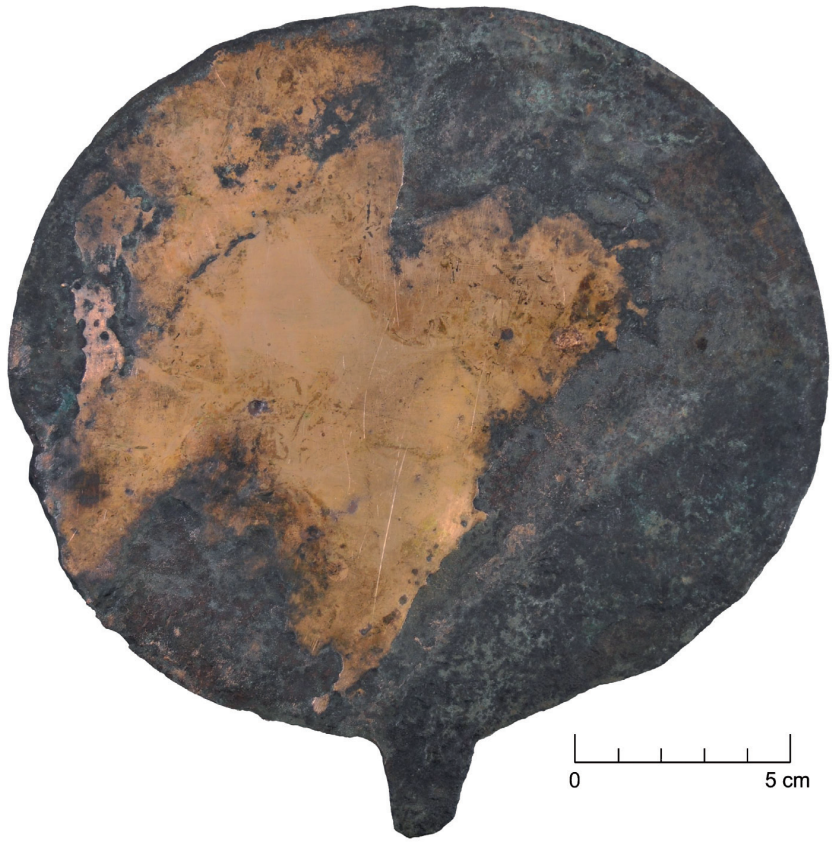

Fig. 27 Mirror from Toshka, Tumulus C 134 (ÄS 7337) (© KHM-Museumsverband).

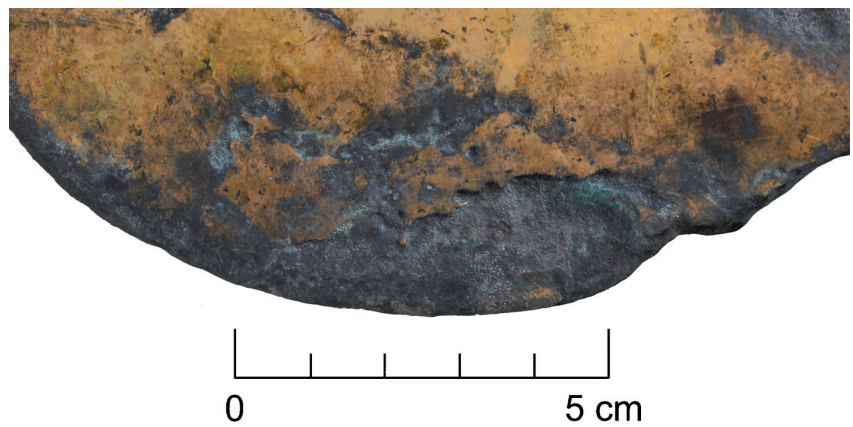

Fig. 28 A detail of a possible decoration on the rim of the mirror ÄS 7337 (© KHM-Museumsverband).

[137] Some vessels were included in the material analysed in the Ashmolean Museum, Oxford (McKerrell 1971). A fragment of a Predynastic vessel was analysed recently from Grave 913 at Kafr Hassan Dawood (Hassan *et al*. 2015); it was made of arsenical copper and according to lead isotopes, the ore was most probably coming from Sinai. X-ray fluorescence analyses of ancient Egyptian vessels from Giza are published in this poster (Kmošek and Odler *et al*. 2016b) and in article Kmošek and Odler *et al*. 2018.

[138] Junker 1943, 161 –162, Abb. 51, 54–55.

[139] Photo AEOS_I_5360, deposited at KHM, accessed via Giza Archives.

[140] Radwan 1983, 73.

Fig. 29 Location of the vessel in the shaft of the Mastaba of Neferihy (encircled; photo no. AEOS_I_5360, © KHM-Museumsverband).

Fig. 30 Spouted carinated bowl from Giza (ÄS 7441) (© KHM-Museumsverband).

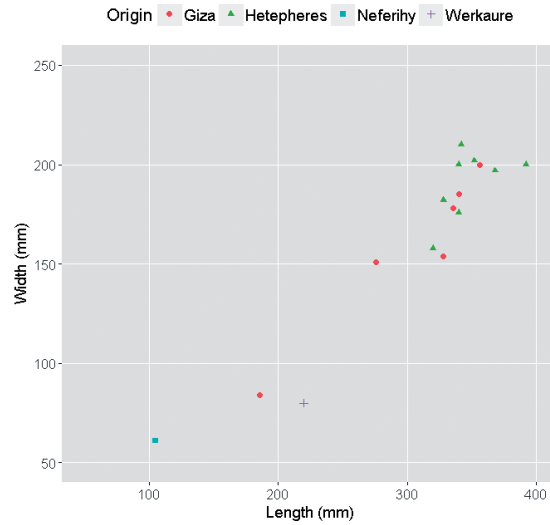

Fig. 31 Scatter plot of the diameters and heights of spouted carinated bowls from Dynasties 4 and 5 (plotted by Martin Odler in R).

early as from the Early Dynastic period. The largest Dynasty 4 assemblage of these vessels has been found in the structure G7000× at Giza belonging to Queen Hetepheres.[141] They were made of "mostly red brown ware of fine texture with a smoothed brown surface",[142] probably imitating the reddish colour of copper without significant admixtures of other elements. Similar vessels were also found in other Dynasty 4 tombs at Giza.[143] A common trait of all these vessels is an upward spout. In Dynasty 5, a similar ceramic vessel is known from the Tomb of Werkaure at Abusir, interestingly with a downward spout, open from the upper side.[144] An assemblage from the mortuary temple of Raneferef consisted mostly of incomplete vessels shaped with upward, straight, but also downward spouts.[145] We have gathered the available data on the diameters and heights of spouted bowls,[146] and the resulting scatter plot clearly shows that the examined vessel is much smaller than the ceramic vessels (Fig. 31). The question is whether it was a miniaturised version of the ceramic vessel,[147] or whether the ceramic vessels were cheaper imitations of metal vessels.[148] The find contexts for both ceramic and metal vessels of this type are elite burials, and the choice of material was probably optional, connected to the process of the preparation of burial equipment.[149] The form of the vessel ÄS 7441 is of Dynasty 4 and it is most probably a vessel from this period, yet the tomb itself is later.

141 Reisner and Smith 1955, 66, Figs. 73–74; Faltings 1998, 282, Abb. 27.

142 Reisner and Smith 1955, 66.

143 Reisner and Smith denoted them as 'Group D: Type XXXVI. Flat-bottomed bowls and basins with recurved rim and long tubular spout': Reisner and Smith 1955, 84, Fig. 119.

144 Type B-3 as defined by Arias Kytnarová, Dynasty 5, Arias Kytnarová 2014, 152, Fig. 4.40.

145 Bárta 2006, Class XLVII: "bowls with recurved rim, in several cases with spout.

146 Based on Reisner and Smith 1955 and Giza Archives.

147 For this interpretation of some vessels, see Arias Kytnarová, Jirásková and Odler in print.

148 Following Reisner's idea, Radwan assumes that prior to the ceramic and stone form, the vessel had been produced in metal. Analogous shapes to this bowl were listed already by Radwan 1983, 73.

149 Bigger bowls made of copper of a slightly different technological solution, with open spouts on the rims, are known from late Dynasty 6, e. g. from the burial assemblage of Ptahshepses Impy found at Giza: a vessel on flat base, Museum of Fine Arts, accession number 13.2948.

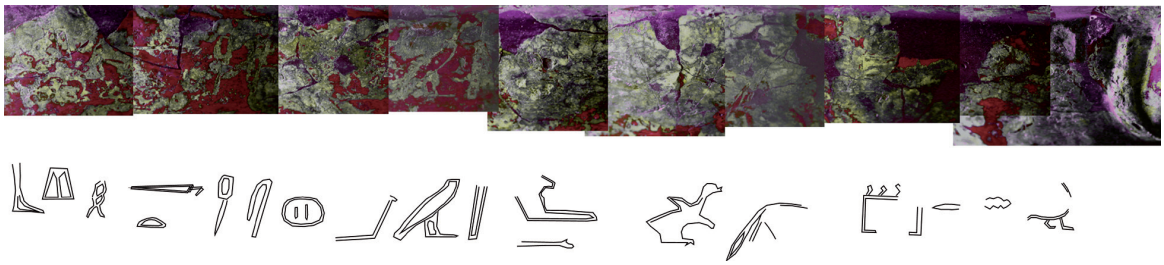

Fig. 32 First part of the inscription, composed from several photographs, processed in software ImageJ and its plugin D-Stretch by Martin Odler (ÄS 7441).

The examined vessel was made of arsenical copper (with 4.5 % As, the second highest percentage analysed during this project) and it is one of the first known Old Kingdom vessels made of arsenical copper (Table 4). The comparable late Dynasty 6 assemblage from Giza was made of almost pure copper[150] and model vessels from Dynasty 6 Dendera were made of arsenical copper with varying content of arsenic.[151]

The cleaning of the vessel has brought an unexpected discovery. During the study of the vessel in 2012, Martin Odler discovered faint traces of hieroglyphic inscriptions that were visible only when viewing the vessel from certain angles (Fig. 32), indicating that the vessel did not belong to the tomb owner but to a different person, who bore significant titles of the highest position in Old Kingdom administration and was of royal descent. The whole inscription is difficult to read, the inscription was damaged by corrosion, together with conscious attempts to efface some parts of the inscription (most importantly the name), and not all parts are fully understandable. The inscription was photographed under different light and filter conditions in the KHM and also by M. Odler, the images were then processed in the DStretch programme, a plugin of the software ImageJ.[152] The legible parts can be transcribed and emended as: "*z3 [nśwt n] ḥ[t=f], t3yty t3ty (n) z3b, ḥ'ty-['], jmy-jz, mnjw nḫn, śmr w'.ty, ḥry ḥb[t], jmy-r k3t nbt [n] nśwt p(r.t-ḫrw??) r' nb Sš3t-ḥtp(??)*", in translation: 'king's son of his own body, vizier, count, councillor, protector of Nekhen, sole companion, lector priest, overseer of all royal works, (*pr.t ḫrw* offering?) every day, Seshathetep(?)'. The title string is arranged according to the importance of titles, and it is opened by the prince – king's son of his own body – who was an actual son of a king (because this title could be also of honorary nature, without reference to the actual offspring of a king).[153] Then follows a "vizier", the highest administrative position of the Old Kingdom state.[154] After vizier, a rank title count comes.[155] The sole companion (of the king) can be included to the same category of rank titles.[156] It was a rather important title in the early Old Kingdom, and six holders of it were also overseers of the work.[157] After the first honorific title, two others with more specific meaning follow, that of a councillor, he who is in the *jz*-bureau,[158] and protector of Hierakonpolis.[159] This last one has a religious connotation as well as the title of lector priest.[160] The lector priest co-occurs with the overseer of works in the titles of higher-ranking officials.[161] The overseer of all royal works is the second most important title in this string, one of the six highest titles in Old Kingdom administration (Fig. 33),[162] with twelve holders attested from Dynasty 4 and 33 from Dynasty 5.[163] Up to now, we know 34 Old Kingdom holders of both the vizieral title and that of the overseer of all royal works. The duties of the bearer lay in the

[150] Maddin *et al*. 1984, Tab. 1; mostly with absent arsenic, utmostly with 0.1–0.2% in a single artefact (miniature deshret vessel, inv no. 13.2981).

[151] Excavated by Flinders Petrie and analysed by McKerrell 1971, with 1–5% As.

[152] See http://www.dstretch.com/. We would like to thank Jon Harman for providing us with the plugin.

[153] Jones 2000, 799. See also Dulíková 2011.

[154] Strudwick 1985, 300–335.

[155] Jones 2000, 496–497.

[156] Jones 2000, 892; Strudwick 1985, 310–311.

[157] Strudwick 1985, 224; Jones 2000, 892.

[158] Jones 2000, 49.

[159] Jones 2000, 433.

[160] Jones 2000, 781; Strudwick 1985, 315–316.

[161] Strudwick 1985, 226; Jones 2000, 781.

[162] Strudwick 1985, 217–250; Krejčí 2000; Jones 2000, 262–263.

[163] Krejčí 2000, Table 1.

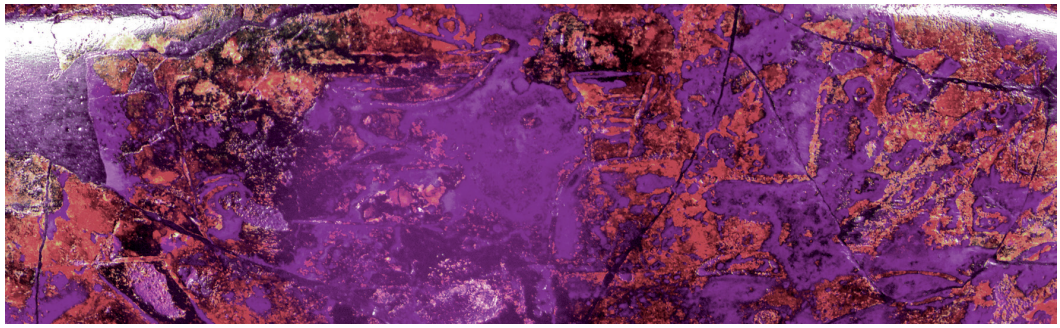

Fig. 33 Title of the overseer of all royal works on vessel ÄS 7441 (© KHM-Museumsverband, processed in software ImageJ and its plugin D-Stretch by Martin Odler).

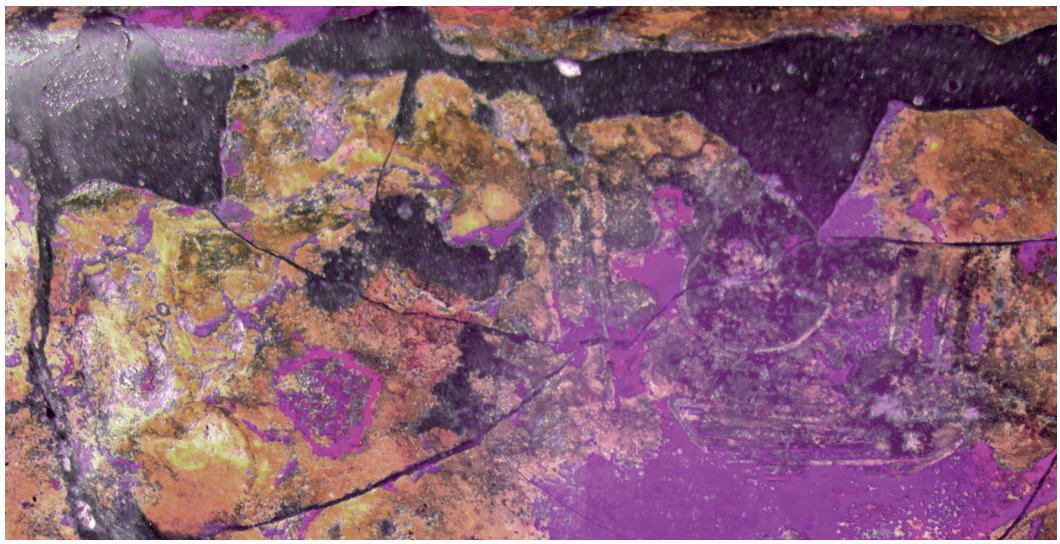

Fig. 34 End part of the inscription with the name of the owner, most probably Seshathetep (Heti) (© KHM-Museumsverband, processed in software ImageJ and its plugin D-Stretch by Martin Odler).

organisation of all kinds of work for the king, i.e. for the Old Kingdom state.

The most difficult part of the whole inscription is at the end (Fig. 34). The name is preceded with a possible reference to the *pr.t-ḫrw* ritual. After the expression *rˁ nb* follows the name of the person.[164] A rectangular sign *ḥtp* seems to be represented, with the phonetic complement of *p*. Regrettably, the rest of the name of the person is almost unreadable. The vessel is of Dynasty 4 form and this date can be confirmed also by the occurrence of titles on the vessel. From the existing princes, viziers and overseers of all royal works, the Dynasty 4 candidate for the vessel owner can be Seshathetep (Heti), as the initial sign in the spot with the name most probably represents the sign R 20 of the Gardiner's Sign List with phonetic value *sš3.t*. The same titles of the official as on the vessel are prince, vizier, sole companion, lector priest and overseer of all royal works.[165] The mastaba G 5110 of Seshathetep (Heti) was built in an air-line distance of c. 100 m from the rather small mastaba of Neferihy, where the bowl ÄS 7441 was excavated. The recognisable parts of the name favour the reading Seshathetep.

Yet, we have to bear in mind that the owner of Dynasty 4 Tomb G 7310–7320 on the Eastern Cemetery, holding a selection of the same titles, is

[164] Generic reference for time in offering formulas is one of the possibilities (Lapp 1986, 109–110), the other being naming the specific festival.

[165] See table of Dynasty 4 viziers in Dulíková 2011, Table 2. His tomb was published by Junker 1934, 172–195. Prosopography of Seshathetep Heti in Strudwick 1985, 136–137.

Fig. 35 Complete inscription on vessel ÄS 7441 (transcribed by Martin Odler in VisualGlyph).

anonymous, relief decoration with his name has not been preserved.[166] We assume from the surface of the vessel and the difficulties in reading the inscription that an effort was made before the deposition of the artefact to efface the inscription on the vessel and to impede the reading of his name and titles.

The cases of the occurrence of other names found in the structures of certain owners were most often the names of earlier kings in later mortuary complexes and royal names found on objects in non-royal contexts. The objects bearing names of earlier kings have been explained as the vestiges of the ancestor cults and rituals enabling the participation of earlier kings in later mortuary cults, as in the mortuary temple of Raneferef.[167] Even the presence of uninscribed Naqadan and Early Dynastic objects can be proven in the Old Kingdom mortuary temples, especially in the case of Sahure.

The vessels with royal names in Old Kingdom non-royal contexts have been interpreted as royal gifts to non-royal persons within the vertical social exchange of prestige goods.[168] Even in the absence of the inscriptions, stone vessels can be interpreted as products of royal workshops understandable to Old Kingdom Egyptians.[169] The vessel

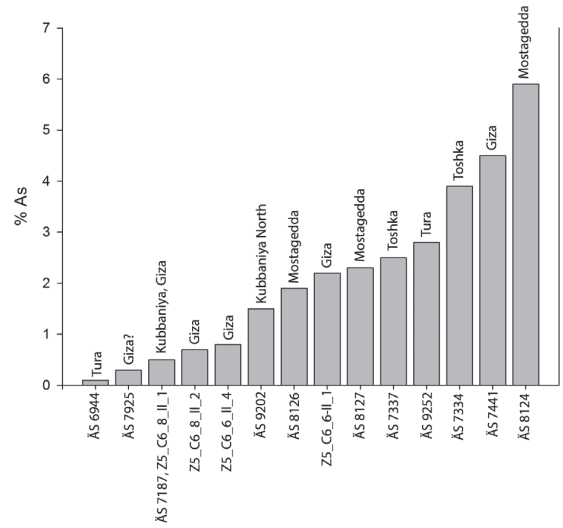

Fig. 36 Bar chart of the results of X-ray fluorescence analysis.

from Giza represents neither of the above-mentioned cases. There is a case of a find of displaced objects in the complex of the sons of vizier Qar at Abusir South.[170] From the comparison with other cases, it rather seems that the object found in the Giza tomb was removed from its original context, most probably stolen from the burial equipment and reused in the burial context where it was discovered. An effort was made to efface the original inscription and render the name of the original owner unintelligible.

6. Arsenical copper in ancient Egyptian metallurgy

From the table of results (Table 4) and a histogram displaying the contents of arsenic in the artefacts (Fig. 36), it is clear that all objects contained arsenic, ranging from trace concentrations in some objects to artefacts than can undoubtedly be clas-

166 Strudwick 1985, 168–169.

167 Most recently on the Old Kingdom cases of "remembering Snofru" and other occurrences of earlier objects in later, Old Kingdom contexts: Kuhn 2014. Earlier objects in the mortuary temple of Sahure on Abb. 5.

168 Gathered contexts with interpretation in Eichler 1993, 310–316.

169 Seidlmayer 2009, 318–321.

170 Barta *et al*. 2009, 267–273, Figs. 6.3.161, 6.3.166. A sacred oil palette (Find No. 150/HH/2002), inscribed for the sealer of the king of Upper and Lower Egypt and keeper of Nekhen Senedjemib (who was buried in Shaft A), has been found in Shaft C of the complex, owned by Iykai. The complex was significantly disturbed by tomb robbers and the situation could be interpreted as an intrusion from Shaft A. The only problematic aspect is that Senedjemib already had a sacred oil palette in his burial equipment of Shaft A (Find No. 122/HH/2001). As the burial chamber of Iykai was plundered more and devoid of finds, it cannot be ruled out that Iykai also used some other burial equipment originally for Senedjemib. The inscription on the palette in the "alien" context is readable, without an attempt to rewrite the name of the addressed person.

sified as arsenical copper. The results have confirmed the initial working hypothesis that a large part of the corpus would consist of almost pure copper or arsenical copper, and was not made of bronze, as was assumed by the original excavators.

Arsenic enhances the technological properties of the object, most importantly its hardness.[171] Alloys of 2–7 % of arsenic have comparable properties to the similar contents of tin in the tin bronze.[172] Out of the three possibilities of the arsenical copper production listed recently by D. Killick,[173] ores containing copper together with arsenic cannot be ruled out in Egypt. A copper ore with arsenic contents sufficient for the production of arsenical copper is known from the site Wadi Tar on the Sinai Peninsula.[174] However, this site is located far from the areas with Egyptian presence on Sinai and it is questionable whether to count this site among the possible sources. Additionally, an evidence for the third possibility of co-smelting is provided by the Site 702B in Wadi Ahmar west, at Bir Nasib on Sinai. Old Kingdom mixing of chalcopyrite and arsenopyrite with iron oxide flux was reported from the site. Further information on the site has not been published until now.[175] Due to the lack of arsenical copper ores, intentional alloying of different ore sources is possible and likely as well.

Increased levels of arsenic were documented for full-size weapons, for the mirrors and the vessel (Table 4). Exceptions are two adzes with early dating, from Tura and Kubbaniya. The first artefact categories were already known to be made of arsenical copper in some cases (analogical specimens are cited in the previous text). Arsenical copper was more frequently used for weapons and mirrors, yet more analyses of copper alloy vessels in the future could reveal more cases of the use of this alloy. The present corpus widens the known cultures using arsenical copper with the C-Group.[176] The objects with a low percentage of arsenic are on the one hand models of their full-size counterparts (and might have been made of already recycled metal), on the other hand the two adzes with early dating, from Tura and Kubbaniya, which contain trace elements that might be associated with copper mineralisation (arsenic, bismuth, lead and iron).[177]

The examined objects contain the following most frequent trace elements: iron, nickel and lead (Table 4). Iron is present in all objects, nickel is detectable only in eleven cases. The iron contents might be interpreted as an indication of the use of oxide ores for the production of the objects (e. g. malachite).[178] In nine objects, a low contents of lead could be detected, which would enable lead isotope analysis and furthermore means that lead accompanied copper and was not added intentionally. Since there are several possible ore sources in 3rd millennium Egypt and only a few lead isotopes ratios analysed from this period,[179] it would be futile at the present state of knowledge to try to determine the ore sources for the examined objects. For the New Kingdom, a period with a wide array of available sources, the interpretation of lead isotope analyses is only in its beginning.[180] To our knowledge, at least two teams published recently a corpus of 3rd millennium copper alloy objects from Egypt with lead isotope analysis included in the applied methods.[181]

A detailed comparison of the results of various analytical approaches in the past and present is hindered by a restricted comparability of the results of the methods used, which are predominantly X-ray fluorescence, atomic absorption spectroscopy and neutron activation analysis. Nevertheless, the application of X-ray fluorescence proves to be meaningful in the classification of the alloys used.

Concerning technology, although corroded, the artefacts reveal traces of hammering on their surface. Additionally, traces of the final polishing of the surface are traceable on the mirror disc from Toshka and the axe blade from Kubbaniya North.

171 McKerrel and Tylecote 1972.

172 Lechtmann 1996, 506.

173 Smelting of antimony-bearing copper arsenates: fahlores; direct smelting of arsenates; or co-smelting of the copper oxides with sulphidic minerals bearing also arsenic: Killick 2014, 39–42.

174 Hauptmann *et al*. 1999.

175 El-Gayar and Rothenberg 1995.

176 Arsenical copper for C-Group material was confirmed also at Aniba (Kmošek and Odler *et al*. 2016b).

177 Such as in the Eastern Desert or Sinai (Abdel-Motelib *et al*. 2012, 36).

178 Pernicka 1999, 166.

179 Most of them recently published in Abdel-Motelib *et al*. 2012.

180 Rademakers *et al*. 2017.

181 Team in Brussels and Leuven (preliminary results in Rademakers *et al*. 2016) and team in Prague (preliminary results in Kmošek and Odler *et al*. 2016a; 2016b). Final results recently in Kmošek and Odler et al. 2018 and Rademakers et al. 2018.

7. Summary

The analysis of 15 artefacts has confirmed the use of copper with impurities in the Naqada culture and the Early Dynastic period, and of arsenical copper in the Early Dynastic period, the Old Kingdom, the Middle Kingdom and the Nubian C-Group. Eaton and McKerrell's as well as Cowell's conclusions concerning the predominant use of arsenical copper have been confirmed independently also on the corpus of provenanced artefacts from the Kunsthistorisches Museum Vienna. Arsenical copper was widely used in Egypt before its (not unidirectional) replacement by bronze. It is surprising that some Old Kingdom model tool blades were also made of arsenical copper, as model tools and vessels made of pure copper have been almost exclusively known so far.[182] The presence of arsenic in models and even their classification as arsenical copper in some cases may be explained by the recycling of scrap metal and its reuse for models. For a better insight into the circulation of copper alloys in earlier periods of Egyptian history, we need further studies with the use of a wide range of presently applicable archaeometallurgical methods on the material deposited in the museums worldwide (as recent studies of ancient Egyptian material in Leipzig).[183]

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[182] Maddin *et al*. 1984; Wuttmann 1986. An unclear connection between the contents of arsenic and general category of artefact (full-size vs. model) was observed on the Old Kingdom assemblage from Giza in Leipzig (Kmošek and Odler *et al*. 2016a). More data is needed.

[183] Kmošek and Odler *et al*. 2018.

Structure	Period	Category and object class	Corrosion state	Inventory number	Max. length (mm)	Max. width (mm)	Max. thickness (mm)	Weight (g)
Grave P.193	Naqada culture	full-size tool: adze blade	less corroded surface, solid core	ÄS 7187	170	50	10	916
Grave 18.e.3	Naqada culture	full-size weapon: spear-head	corroded, except small solid core along axis	ÄS 9252	151	18	4	22
Grave 18.k.3	Early Dynastic period, Dynasty 1	full-size tool: adze blade	corroded surface, solid core	ÄS 6944	161	41	11	272.8
Tomb G 4970, shaft of Khentetka	Old Kingdom, Dynasty 5	model tool: adze blade	entirely corroded	Z5_C6_8_II_1	87	17	1.5	11.1
Tomb G 4970, shaft of Khentetka	Old Kingdom, Dynasty 5	model tool: adze blade	entirely corroded	Z5_C6_8_II_2	65	13	3	7.8
Mastaba of Neferihy, Shaft 261	Old Kingdom, Dynasty 5	full-size(?) vessel: spouted carinated bowl	entirely corroded	ÄS 7441	112	105	61 (height)	194.2
Tomb at G 5070, Shaft 315	Old Kingdom, Dynasty 6, early	model tool: adze blade	entirely corroded	Z5_C6_6_II_1	64	11	2	4.6
Tomb at G 5070, Shaft 315	Old Kingdom, Dynasty 6, early	model tool: adze blade	entirely corroded	Z5_C6_6_II_4	62	10	3	4.2
unknown	Old Kingdom	model tool: razor blade	corroded surface, solid core	ÄS 7925	52	20	2	10.7
Tomb 5118	Middle Kingdom	full-size weapon: axe-head	entirely corroded, small blank point on the rivet	ÄS 8124	280	33	7.3	259.5
Tomb 5118	Middle Kingdom	model tool: axe-head	corroded surface, solid core	ÄS 8126	54	52	2.7	27.2
Tomb 5118	Middle Kingdom	model tool: axe-head	corroded surface, solid core	ÄS 8127	53	48	4	25.7
Tomb 16.i.1	Middle Kingdom, Dynasty 12	full-size weapon: axe-head	less corroded surface, solid core	ÄS 9202	111	59	6	215.9
Tumulus C 131	C Group	full-size mirror disc	corroded surface, solid core	ÄS 7334	200	213	6.7	1028
Tumulus C 134	C Group	full-size mirror disc	corroded surface, solid core	ÄS 7337	184	181	4.5	435.4

Table 1 Basic data on the assemblage of the analysed artefacts.

Standard		Mn	Fe	Co	Ni	Cu	Zn	As	Se	Ag L	Cd	In	Sn	Sb	Pb	Bi
7835.8	CV	0.093	0.100	0.313	0.158	69.930	24.830	0.143		0.463	0.087		0.516	0.115	3.150	0.112
	MV	0.11	0.10	0.29	0.18	70.9	24	0.13		0.34	0.09		0.46	0.13	2.9	0.14
	SD	*0.04*	*0.03*	*0.07*	*0.01*	*1.6*	*0.7*	*0.06*		*0.07*	*0.01*		*0.14*	*0.02*	*1.4*	*0.08*
7835.9	CV	0.001	0.408	0.081	0.100	78.480	14.340	0.107	0.34	2.120	0.067		1.480	0.445	1.024	0.81
	MV	<DL	0.43	0.10	0.13	78.4	13.8	0.13	0.36	0.86	0.12		1.4	0.4	1.0	0.91
	SD	*0*	*0.04*	*0.01*	*0.01*	*0.4*	*0.1*	*0.06*	*0.11*	*0.08*	*0.01*		*0.07*	*0.03*	*0.4*	*0.37*
GM21	CV		0.751		0.129	78.900	5.050	0.464	0.194	0.694	0.255		4.550	1.049	6.990	0.452
	MV		0.73		0.14	77.5	5.2	0.36	0.17	0.36	0.19		4.6	1.0	7.3	0.53
	SD		*0.15*		*0.01*	*2.6*	*0.2*	*0.11*	*0.14*	*0.06*	*0.06*		*0.09*	*0.06*	*2.9*	*0.22*
CUAS3	CV		0.001		0.001	97.080		2.900				0.005	0.009		0.001	
	MV		< DL		< DL	97.5		2.7				< DL	< DL		< DL	
	SD					*0.6*		*0.45*					*0.28*			
CUAS4	CV		0.001			95.760		3.660			0.109	0.093	0.375		0.001	
	MV		< DL			95.4		3.7			0.17	0.07	0.71		< DL	
	SD					*0.8*		*0.72*			*0.04*	*0.03*	*0.19*			

Table 2 Evaluation of the standards with the created method (wt %). Explanation of shortcuts – CV certified values; MV mean value; SD standard deviation of the mean value; DL detection limit.

AE_INV_7334	MP	Description Measuring Area	Cu K_a	As K_a	Fe K_a	Ni K_a	Trace Elements/ Patina
	1	small blanc area	95.1	4.6	0.32		Ni?
	2	small blanc area	95.0	4.8	0.24		Ni?
	3	small blanc area	95.9	3.8	0.30		Ni?
	4	small blanc area	96.2	3.4	0.29	0.06	
	5	small blanc area	95.8	3.9	0.21	0.05	
	6	black corrosion	96.3	3.0	0.66	0.06	
	7	brown corrosion	91.2	8.4	0.33	0.06	Ca+++
MV (MP1 - 5)			**95.6**	**4.1**	**0.27**	**0.06**	
SD (MP1 - 5)			*0.5*	*0.6*	*0.05*	*0.01*	

Table 3 Measurements on the object AE_INV_7334 (wt %).

Site	Inv. No.	Artefact	Cu	As	Fe	Ni	Zn	Pb	Ag	Bi	Trace elements / Patina
Kubbaniya	ÄS 7187	full-size adze	99.3	0.5	0.04			0.04		0.2	
Tura	ÄS 6944	full-size adze	99.6	0.1	0.04			0.06		0.2	
Tura	ÄS 9252	full-size spear-head	97.0	2.8	0.04	0.11					
Giza	Z5_C6_8_II_1	model adze blade	99.3	0.5	0.3						
Giza	Z5_C6_8_II_2	model adze blade	98.5	0.7	0.1	0.13	0.6				
Giza	ÄS 7441	spouted carinated bowl	95.3	4.5	0.2	0.09					
Giza	Z5_C6_6_II_1	model adze blade	97.3	2.2	0.3	0.08		0.1			
Giza	Z5_C6_6_II_4	model adze blade	98.3	0.8	0.2			0.3	0.3		Se
Mostagedda	ÄS 8124	full-size axe-head	93.4	5.9	0.3	0.09		0.3			
Mostagedda	ÄS 8126	model axe-head	97.1	1.9	0.7	0.20		0.1			
Mostagedda	ÄS 8127	model axe-head	96.7	2.3	0.7	0.07		0.2			
Kubbaniya North	ÄS 9202	full-size axe-head	97.8	1.5	0.5	0.09		0.2			
Toshka	ÄS 7337	full-size mirror	97.0	2.5	0.4	0.08					
Toshka	ÄS 7334	full-size mirror	95.7	3.9	0.3	0.06					
Giza?	ÄS 7925	model razor blade	98.4	0.3	0.09	0.04		1.0			Se, Bi, Zn?, Ca, Cl

Table 4 Results of x-ray fluorescence analysis of the artefacts (wt %).

Site	Structure	Dating	Maximal length (mm)	Maximal width (mm)	Present location	Inventory number	Bibliography
Kau	**Grave 1749**	**Phase IIIB (Dynasty 11 – early Dynasty 12)**	103	110	Pitt-Rivers Museum, Oxford	1924.35.3	Brunton (1927, 59. Pl. XXXVIII: 12); Seidlmayer (1990, 137); http://objects.prm.ox.ac.uk
Dendera			235	64	Ashmolean Museum, Oxford	E.1744	Schulz (2003, 246)
Beni Hasan	**Tomb 655**	**Phase II (Dynasty 11 – early Dynasty 12)**	258	45	World Museum, Liverpool	55.82.430	Garstang (1907, 162, Fig. 165); Davies (1987, 42); Seidlmayer (1990, Tab. 64)
Abydos	**Grave 20**	**Dynasty 12**	263	54	Manchester, Manchester Museum	Manchester 6791	Petrie (1925, 6, Pl. V: 25–26); Davies (1987, 42, 81)
Mostagedda	**Tomb 1690**	**Phase IIIB (Dynasty 11 – early Dynasty 12)**	268.5	60	Neues Museum, Berlin	ÄM ?	Brunton (1937, 102–3, Pl. LXI: 1, LXII: 2); Davies (1987, 40, Pls. 5:30, 15: 89); Seidlmayer (1990, 135)
Mostagedda	**Tomb 1814**	**Phase IIIB (Dynasty 11 – early Dynasty 12)**	272	60	Neues Museum, Berlin	ÄM 23274	Brunton (1937, Pl. LXII: 2); Seidlmayer (1990, 135)
Mostagedda	**Tomb 5118**	**Phase IIIB (Dynasty 11 – early Dynasty 12)**	280	33	KHM Vienna	AE_INV_8124	Brunton (1937, 103, Pl. LXI: 5, Pl. LXII: 3); Seidlmayer (1990, 135)
Abydos	**Grave 30B**		342	41	National Museum Copenhagen	NM 7845	Petrie (1925, 6, Pl. V: 27); Davies (1987, 42, 81)
Kau	**Grave 330**		375	21	Egyptian Museum, Cairo	JE 47633	Brunton (1927, Pl. XXXVIII: 11, 25)
Beni Hasan	**Tomb 757**	**Phase III (early Dynasty 12)**	393	48	Ashmolean Museum, Oxford	AN1896-1908 E.2290	Garstang (1907, 162, Fig. 165); Davies (1987, 42); Seidlmayer (1990, Tab. 64)

Table 5 Provenanced epsilon axe blades of straigh blade with available data on their size. See also Type II in Schulz 2003.

Site	Structure	Dating	Maximal length (mm)	Maximal width (mm)	Present location	Inventory number	Bibliography
Sheikh Farag		**Middle Kingdom**	62	62	Museum of Fine Arts, Boston	13.3725	DAVIES (1987, 37); MFA collection online
Kafr Ammar	**Grave 509**		98	60	unknown		PETRIE and MACKAY (1915, 32, Pl. XXVI: 1)
Sheikh Farag	**Grave 25c**	**Middle Kingdom**	103	74	Museum of Fine Arts, Boston	13.3572a-b	LILYQUIST (1979, 21); MFA collection online
Kubbaniya	**Grave 16.i.1**	**Middle Kingdom, "transitory group"**	111	59	KHM Vienna	ÄS 9202	JUNKER (1920, 123, 125, Blatt 23: 27)
Ghurab			112	35	Charleston		BRUNTON and ENGELBACH (1927, 7–8, Pl. XII: 74)
Aniba	**Grave N 352**	**Phase IIb of C-Group, Second Intermediate period**	145.5	50	Ägyptisches Museum – Georg Steindorff – der Universität Leipzig	ÄMUL 4698	STEINDORFF (1935, 150, Taf. 70: 6); BIETAK (1968, 112)
Rifeh	**Grave 195**		158	62	unknown		PETRIE (1907, 14, Pl. XIII: 4); DAVIES (1987, 37)
Diospolis Parva	**Grave Y 162**	**First Intermediate period**	160	54	Ashmolean Museum, Oxford	AN1896-1908 E.1791, AN1896-1908 E.1788–1790	PETRIE (1901, 41)
Kau	**Grave 301**	**Phase IIIA (early Dynasty 11)**	198	51	unknown		BRUNTON (1927, Pl. XXXVIII: 5, 13; XXXIX: 13); SEIDLMAYER (1990, 136)
Aniba	**Grave N 21**	**Phase IIb of C-Group, Second Intermediate period**	265	38	Ägyptisches Museum – Georg Steindorff – der Universität Leipzig	ÄMUL 4697	STEINDORFF (1935, 127, Taf. 70: 10); BIETAK (1968, 112)

Table 6 Provenanced segmental axe blades with available data on their size.

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