Invisible Connections

An Archaeometallurgical Analysis of the Bronze Age Metalwork from the Egyptian Museum of the University of Leipzig

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Cover: Exhibited copper alloy finds in the Egyptian Museum of the University of Leipzig before the World War II, ÄMUL Fotothek 2130, Karton 13, photo by Friedrich Koch © Ägyptisches Museum – Georg Steindorff – der Universität Leipzig.

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To Ivana (Martin)

and to Zuzana (Jiří)

Contents

Author shortcuts

MO – Martin Odler
JK – Jiří Kmošek
VD – Veronika Dulíková
LJ – Lucie Jirásková
KA – Katarína Arias
Chapters without shortcuts in the title were co-written by Martin Odler and Jiří Kmošek.

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Foreword

The archeometallurgical study presented in this volume is the first of its kind, which is dedicated to a broad range of objects housed in the Egyptian Museum of the University of Leipzig. Conducted by two young scholars from the fields of Egyptology, Chemistry and Technology in Prague, it presents a fresh approach to the physical properties of Bronze Age tools as discovered in documented excavations across Egypt proper and Lower Nubia such as Aniba. A special focus will be on the location of the ores exploited by the ancient miners, the metallurgical compound and properties of the objects produced from the raw materials processed in the end.

The investigation accomplished by Mgr. Martin Odler, PhD. and Ing. Jiří Kmošek serves as a prime example of interdisciplinary research on the history of ancient metallurgy in general and ancient Egyptian and Nubian metallurgy in particular from the 3rd and 2nd millennium BCE, covering the so-called Early to Late Bonze Age periods at a number of sites. The Egyptian Museum and the Egyptological Institute at the University of Leipzig are extremely proud of being offered the results of their in-depth study herewith. We would also like to embrace the opportunity by taking this book as a wonderful token of the long-established partnership of the Charles University in Prague and the University of Leipzig, who share a common history since 1409.

Prof. Dr. Hans-W. Fischer-Elfert
Ägyptologisches Institut / Ägyptisches Museum der Universität Leipzig
-Georg Steindorff-
director

The comprehensive study of copper artefacts kept in the collection of the Egyptian Museum of the University of Leipzig represents one of the latest meticulous studies of ancient Egyptian artefacts within their social and historical contexts. In fact, reliable studies of the origins and use of copper have been badly missing in Egyptology, and this publication highlights the value and potential of such studies for the shaping of a broad and multidisciplinary picture of Egyptian civilisation and its significance.

Every civilisation, and ancient Egyptian civilisation was no exception to this rule, has been determined by its resources and sources of energy. Ancient Egyptian history, punctuated by several periods of low complexity when resources and energy were heavily limited which we traditionally call, however inappropriately, intermediate periods, is an illustrious example for this law. The heterogeneous selection of copper objects presented in this study covers several periods in the history of ancient Egypt and amply illustrates the role played by different sources of the copper ore in different periods. Obviously, different places of copper ore origin were due to the shifting geopolitical situation and the preferences by the society and elites of the day. Copper, once a strategic metal important to all possible sectors of the Egyptian economy and society, played a central role for centuries. In the Old Kingdom, it was imported into the Nile valley from the Eastern Desert and Sinai; later on, especially during the New Kingdom, its major place of origin was Wadi Araba and the famous Solomon's mines in Timna, along with Cyprus and probably also Nubia.

The study presented by J. Kmošek and M. Odler offers a fascinating reading, a rare attempt to combine historical data and results of chemical analyses. Merged together, they offer a different, significantly more complex picture of one of the earliest civilisations on this planet.

Prof. Mgr. Miroslav Bárta, Dr.
Czech Institute of Egyptology, Faculty of Arts, Charles University, Prague
director of the Czech archaeological excavations in Egypt

1. Introduction

The book you just have opened is the final output of the student project 'Early copper metallurgy in Ancient Egypt – a case study of the material from Ägyptisches Museum der Universität Leipzig' that took place in 2015 and 2016 in Prague, based on samples of copper alloy artefacts deposited in the Egyptian Museum of the Leipzig University in Germany. The sampling was kindly allowed by the curator of the collection, Dr Dietrich Raue, without whom the whole enterprise would not have been possible. The principal investigator of the project was Martin Odler, a PhD candidate of Egyptology at the Czech Institute of Egyptology, Faculty of Arts, Charles University in Prague, and the project greatly benefited from the expertise of Jiří Kmošek, then a student at the University of Chemistry and Technology in Prague; both are the main authors of the present text. Our initial aim was to use the analyses of the samples to enrich the knowledge on the specific artefacts. In this book, we aim particularly to establish copper alloy artefacts as a specific Egyptological and archaeological source category, independently contributing to the evidence of written and iconographic sources, which are traditionally used in Egyptology. The contribution of scientific examination of ancient metallurgy can bring to light fresh and unexpected points of view and uncover 'invisible connections' of the material culture. Using truly interdisciplinary research, we are able to answer questions that could not be answered or even posed when the studied material was being excavated and published. Nevertheless, the conclusions are as good as are the background data on the used ores and analysed artefacts, and some of the interpretations might change as these background data become richer.

The Ägyptisches Museum – Georg Steindorff – der Universität Leipzig (usually abbreviated ÄMUL; located in the Free State of Saxony in Germany) holds an important collection of ancient Egyptian and Nubian artefacts, one of the largest in Germany and Europe in general, counting c. 9,000 inventory numbers (Figure 1). It is the largest university collection of the ancient Egyptian artefacts in Europe. It was founded as early as the 19th century, but its collection was enriched largely during the curatorship of Georg Steindorff (1861–1951), one of the most important German Egyptologists of late 19th and early 20th centuries. Our project, generously approved by one of Steindorff's successors, Dr Dietrich Raue, could incorporate a broad selection of 86 artefacts (i.e. inventory numbers) representing the development of ancient Egyptian metallurgy over more than one and

Figure 1: Metal artefacts in the Egyptian Museum of the University of Leipzig, photo by Jiří Kmošek © Faculty of Arts, Charles University, Czech Institute of Egyptology.

a half millennia, from Dynasty 1 until almost the end of the New Kingdom (Table 1; Figure 2).[1]

The most important early assemblages come from Early Bronze Age Dynasty 1 Abusir (Bonnet 1928), Dynasty 2 Tomb of King Khasekhemwy at Abydos (Kuhn 2011) and the Old Kingdom cemetery at Giza (Steindorff, Hölscher and Grimm 1991). The largest sampled corpus comes from the Nubian site of Aniba, from the Middle Bronze Age Nubian C-Group Cemetery N and from the Late Bronze Age Second Intermediate Period and New Kingdom Cemetery S (Steindorff 1935; Steindorff 1937). The sampled artefacts can be divided into several morphological categories: full-size tools, model tools, full-size vessels, mirrors, and other metal objects, e.g. specimens of ancient Egyptian hardware. A diachronic change of the ore sources and technology as well as other issues can be studied in detail on the corpus (see Chapters 3 and 4 for the methodology of the case study).

A selected corpus of the artefacts was X-rayed and documented by computer tomography in 2015 at the Institute of Mineralogy, Crystallography and Material Science of the Leipzig University (Institut für Mineralogie, Kristallographie und Materialwissenschaft der Universität Leipzig). Altogether 86 artefacts (i.e. inventory numbers) were eventually sampled with almost 100 samples.

'Invasive' sampling of archaeological material has a bad reputation in contemporary archaeology and Egyptology, even though, speaking specifically for archaeometallurgy, very little material is needed for detailed information (Pernicka 2014), and uncritical use of the seemingly 'non-invasive' X-ray fluorescence does more harm than good (Killick 2015; Pearce 2019). Due to the intensive corrosion deterioration of ancient copper alloy artefacts, surface of the majority of analysed objects needs to be locally cleaned from corrosion products to the level of metallic surface. Therefore, applications of the non-destructive surface analyses (XRF, SEM/EDS, PIXE, etc.) are in fact invasive as well. Our sampling methodology for ED-XRF, INAA and ICP-MS analyses required in total a maximum amount of c. 50 milligrams of the metal, but usually much less, around c. 20 milligrams. This corresponds approximately to the circular drill-hole with a diameter of c. 1mm and a depth of c. 3mm. For metallographic analysis, combined with microhardness and SEM/EDS or WDS analysis, a sample with a volume of 1–2 mm3 (10–20 mg) is enough, taken from a representative location, not disturbing the physical integrity and aesthetic value of the artefact. Neutron-based methods could theoretically help with 'non-invasive' analysing of the objects, but these facilities are not yet available in sufficient number in Europe and are not dedicated solely to the archaeological purposes. The logistics of the transport and insurance of the objects is costly. It is a legitimate question whether this is reasonable spending of the research funding. A cost/benefit analysis may result in accepting 'invasive' sampling as a reasonable method for an in-depth study of a museum collection, especially for ancient Egyptian and Nubian metallurgy where interdisciplinary research with attention paid to the archaeological and Egyptological contexts of the artefacts besides the results of the archaeometallurgical methods has been lacking, with

Table 1: Chronology of relevant periods for Egypt and Nubia.

Period	Tentative absolute dating
Badarian	**ca. 4400–3700 BC**
Naqada I – IIIB	**ca. 3700–3100 BC**
Dynasty 1 (Naqada IIIC): Dee, Wengrow, et al. (2013)	**ca. 3100–2900 BC**
A-Group (Lower Nubia)	**ca. 3700–3000 BC**
Early Dynastic Period: Hornung – Krauss – Warburton (2006)	**ca. 2900–2545+25 BC**
Dynasty 1 (Naqada IIIC)	ca. 2900–2730+25 BC
Dynasty 2 (Naqada IIID)	ca. 2730–2590+25 BC
Dynasty 3	2592–2544+25 BC
Old Kingdom	**ca. 2543–2150+25 BC**
Dynasty 4	ca. 2543–2436+25 BC
Dynasty 5	ca. 2435–2306+25 BC
Dynasty 6	ca. 2305–2150+25 BC
First Intermediate Period	**ca. 2150–1980+25 BC**
Dynasty 8	ca. 2150–2118+25 BC
Middle Kingdom	**ca. 1980+16–1760 BC**
Dynasty 11	ca. 2080–1940+16 BC
Dynasty 12	1939+16–1760 BC
Second Intermediate Period	**1759–ca. 1539 BC**
Dynasty 13	1759–ca. 1630 BC
Dynasty 15 (Hyksos)	ca. ?–ca. 1530 BC
Dynasties 16 and 17	ca. ?–1540 BC
C-Group (Lower Nubia)	**ca. 2300 – 1630 BC**
Kerma culture (Upper Nubia)	**ca. 2500–1500 BC**
New Kingdom	**ca. 1539–1077 BC**
Dynasty 18	ca. 1539–1292 BC
Dynasty 19	1292–1191 BC
Dynasty 20	1190–1077 BC
Third Intermediate Period	**1076–723 BC**
Late Period	**722–332 BC**
Napatan Period (Nubia)	**ca. 750–270 BC**

[1] Chronological table is based on (Hornung, Krauss and Warburton 2006; Dee, Wengrow, *et al.* 2013).

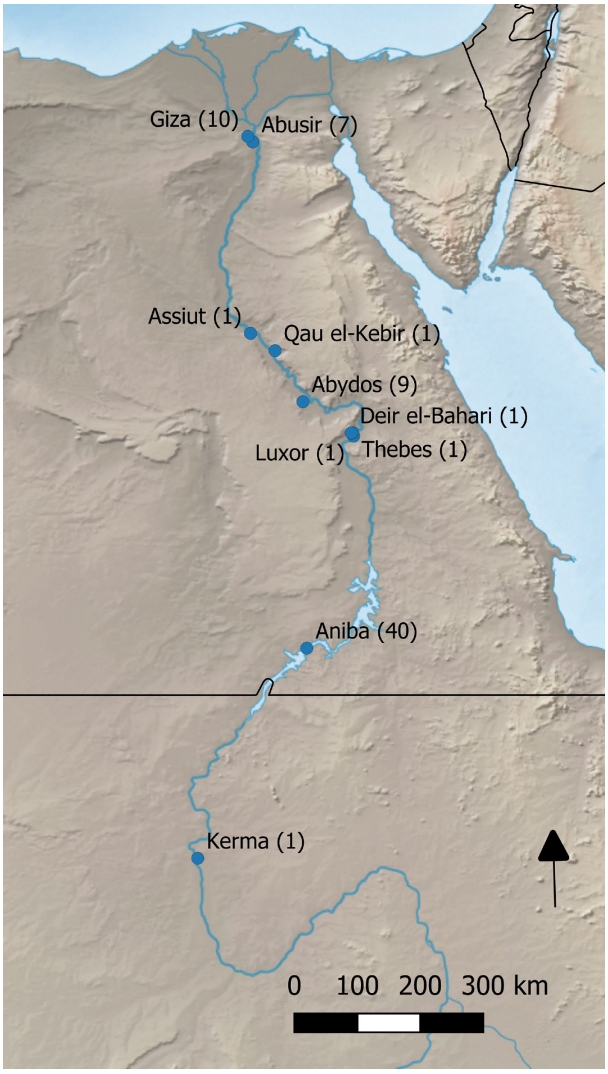

Figure 2: Provenance of the analysed artefacts, mapped on the background from Natural Earth by Martin Odler in qGIS.

some notable exceptions, e.g. (Vandier d'Abbadie 1972; Michel 1972; Davies 1987; Cowell 1987; Lang 1987; Philip 2006; Philip and Cowell 2006).

Most of the analyses took place after the sampling of the objects in August 2015 (for their specification, see Chapter 4, Methodology). The decision to sample each object was done after discussion with the restorer of the collection, K.-H. von Stülpnagel. Some famous pieces from the collection of the Egyptian Museum of Leipzig University are lacking in our analysed selection, especially a copper diadem covered with a gold foil (ÄMUL 2500), a unique piece of jewellery from Old Kingdom Giza, and two famous open-work stands from New Kingdom Aniba, the undisturbed lower chamber of Tomb S 91 (ÄMUL 4803 and 4804). Despite these omissions, our selection gives a representative overview of the Bronze Age metalwork in the museum.

Preliminary reports on the project were published in Czech and German (Odler, Kmošek, *et al.* 2016; Kmošek and Odler 2016). Early results were presented since late 2015 in Leipzig, as part of the exhibition Gegossene Götter on ancient Egyptian metallurgy, predominantly of Late Period, focusing on the production of bronze statuettes (Fitzenreiter, Loeben, *et al.* 2014). In 2016, a poster presenting the first results of the project received an honourable mention in the Best Student Poster Award competition at the 41st International Symposium on Archaeometry (Kmošek, Odler, Jamborová, Šálková, *et al.* 2016). The symposium took place on 15–21 May 2016 in Kalamata (Greece). The student award has been bestowed by the Society for Archaeological Sciences (USA) since 1998, and the authors of the poster are its first laureates from the Czech Republic.

A thorough interpretation of the results of analyses took longer than expected, however. In 2018, a report on the results of the analyses of Early Dynastic and Old Kingdom artefacts was published in the *Journal of Archaeological Science* (Elsevier) (Kmošek, Odler, *et al.* 2018), being part of a special series of articles dedicated to the interpretation of lead isotopes of early Egyptian copper alloy metalwork (Ben-Yosef 2018; Rademakers, Verly, *et al.* 2018). The announcement of the publication of the articles was included in a press release by Elsevier in August 2018, and the results received media attention around the globe.

Preliminary results and interpretations of the project have been presented at many international conferences in Europe, Africa, Asia and Central America. The results presented herein, especially for the C-Group and New Kingdom material of Aniba, are reassessed in comparison to what was presented at the conferences. In cases of both C-Group and the New Kingdom, these are the most complex corpora of copper alloy metalwork analysed from ancient Egypt and Nubia. Each artefact is described as an 'individual' piece with its own physical form and chemical properties. Rather than a definitive contribution on the subject, this monograph is meant as a continuation of informed discussion on the complex study of ancient Egyptian and Nubian copper alloy metallurgy.