

An Introduction

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The ancient city of Ur in the southern part of the lowlands of Mesopotamia (today Iraq, Figure 1) was excavated in the 1920s and 1930s by the British archaeologist Leonard C. Woolley. Among other architectural remains, a cemetery in the southeastern part of the central part of the city was excavated (Figure 2). This cemetery consisted of some 2000 graves. Of them, 660 dated to the Early Dynastic III period (ca. 2600–2500 BC). The 16 large shaft graves provided precious grave goods and thus represent enormous wealth. Woolley considered them to be the graves of the “kings” and “queens” of Ur and termed them “Royal Tombs” (Woolley, 1934)(Figure 3). After the end of the excavations in 1934, the finds were distributed among the National Museum in Baghdad, the

British Museum, London, and the University of Pennsylvania Museum of Archaeology and Anthropology in Philadelphia.

Once the finds and findings of these Royal Tombs have been known, a scholarly discussion began about the physical objects, the composition, craftsmanship, technology and provenance of the materials, about their social meaning and importance, the dating and the interpretation of the burials, and about the enigma that numerous attendants apparently followed the deceased of the main burial into the grave. The discussion is still ongoing to date. Based on the latest knowledge, the cemetery dated between c. 2500 – 2000 BC, i.e., until the beginning of the III Dynasty of Ur (see Vogel, 2014, p.170).

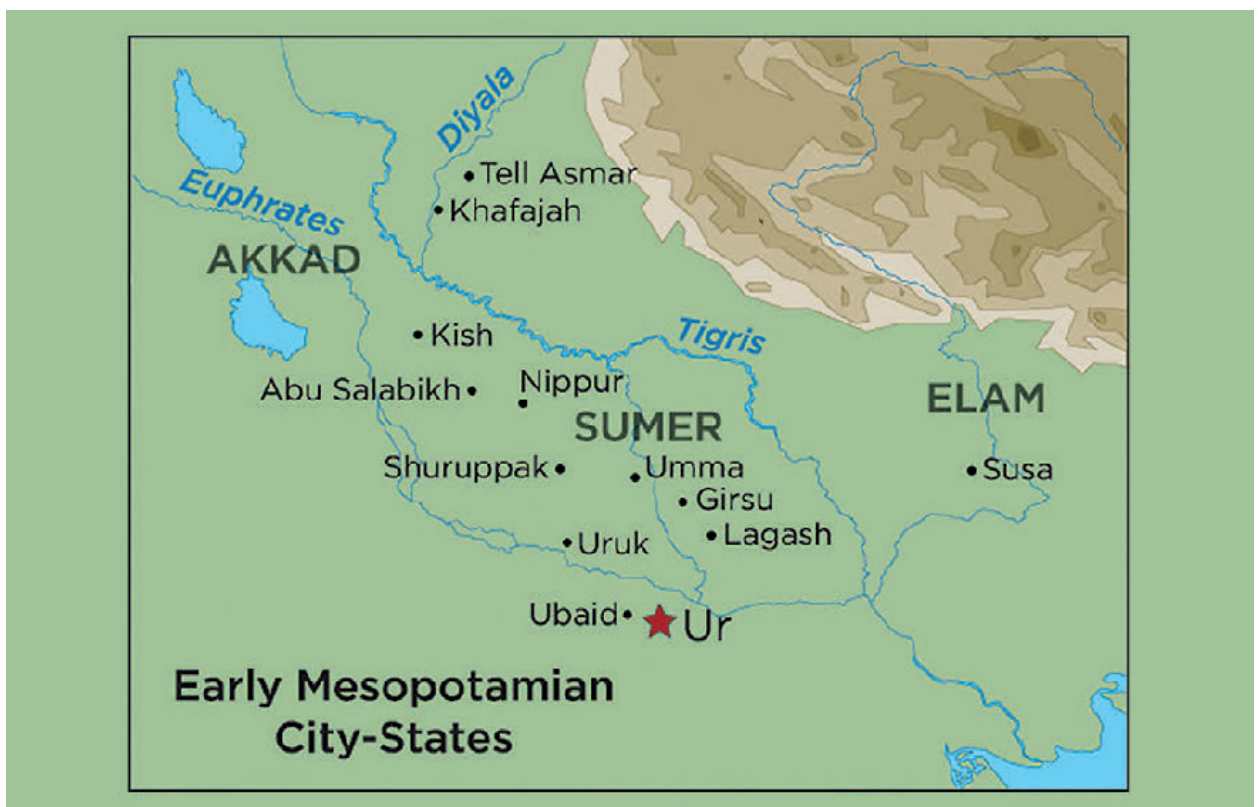
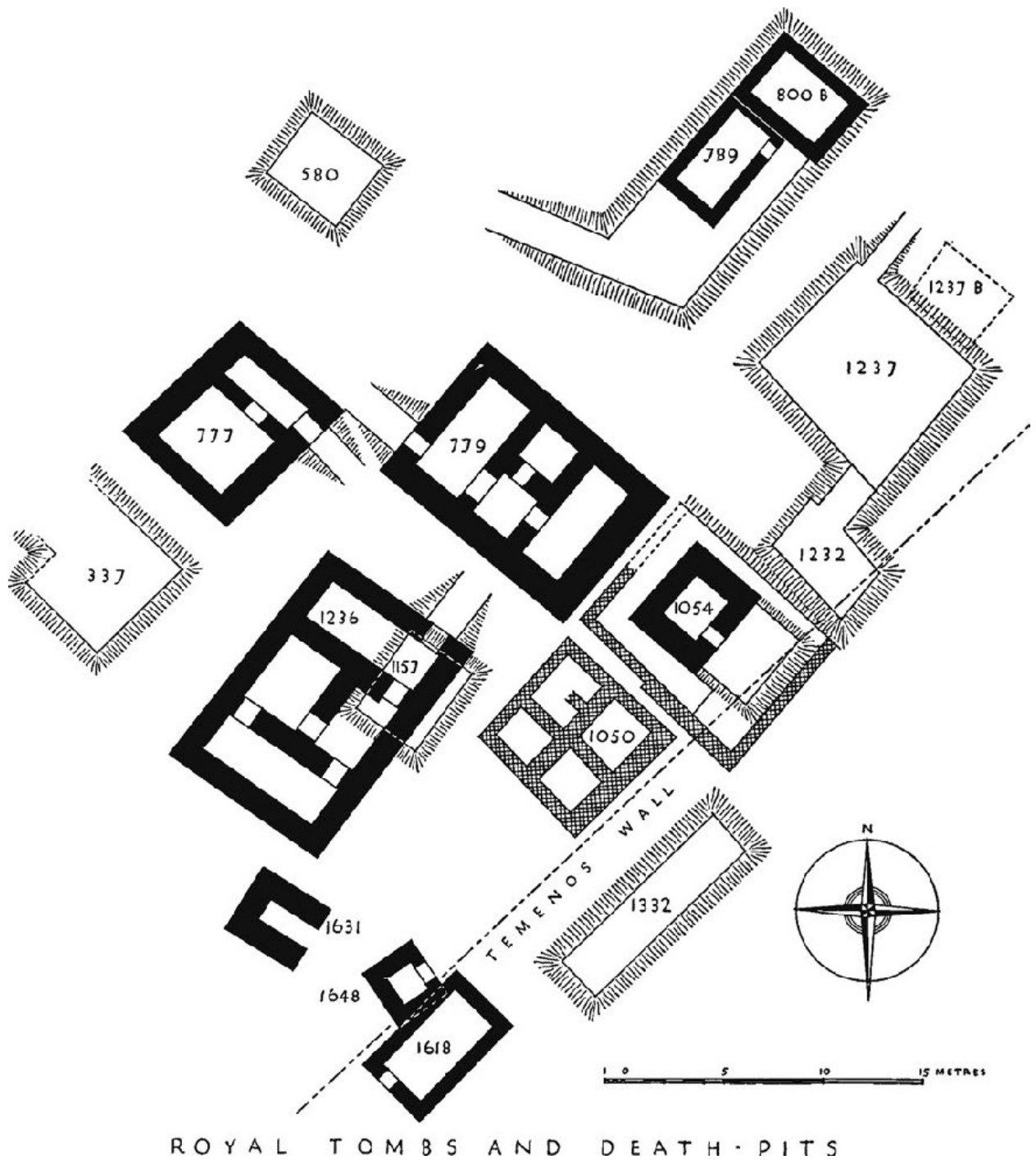


Figure 1. Topographic map of the southern part of Mesopotamia, the land of Sumer, between the rivers of Euphrates and Tigris, showing the location of the city of Ur and many of the other first cities of the 3rd / 2nd millennium BC. Note that in this map the ancient coastline of the Persian Gulf (“Lower Sea”, Heimpel, 1987) is not far from the city of Ur. Image courtesy of the Penn Museum, Philadelphia.



Figure 2. Aerial photograph taken in March, 1930, showing the excavations of the Royal Cemetery at the southeastern corner of the Nanna temple complex (bottom of photograph). Photo: University of Pennsylvania Museums Archive. Image courtesy of the Penn Museum, Philadelphia, Image no. 191616.



ROYAL TOMBS AND DEATH-PITS

Figure 3. Detail of the Royal Cemetery at Ur showing the sixteen tombs deemed “Royal” by Woolley (1934, pl.273). Image courtesy of the Penn Museum, Philadelphia.

Analytical investigations on the metal artifacts and other materials from the Royal Tombs were performed shortly after the completion of the excavations by Leonard Woolley. H. Plenderleith (1934) who was a conservator at the British Museum at that time, was the first to publish a very small number of chemical analysis of the gold, silver, copper and bronze artifacts. These were predominantly performed by C. H. Desch. Desch performed the first systematic program of analytical and metallographic studies of metals from Mesopotamia

after his appointment to the Sumerian Copper Committee by the British Association for the Advancement of Science in 1927 (Desch, 1929). Among all the finds he had investigated, there was a large number of metals that were shortly excavated at Ur. There were two objectives of these studies. 1) The natural resources should be identified from which these metals and alloys were manufactured because, especially in the southern part of Mesopotamia (Sumer, Akkad), no metal-bearing deposits occur. Consequently, all metal objects that were

found in Ur must have been imported from elsewhere. 2) The level of metal craft should be studied. The development of urban centers in Mesopotamia since the 4th and 3rd millennium was obviously connected to economic and technological growth. It was a period in which supra-regional contacts to the west and to the east were intensified. Raw materials can be seen to have moved over long distances. Amiet (1986) coined the term “Age of Exchange” (see also Helwing, 2014, p.413), and this was the period in which metals were deliberately mixed to produce alloys, e.g., the copper-tin alloys. Desch who had analyzed a number of elements such as lead, arsenic, nickel, tin, iron, silver and sulfur, found especially that nickel was almost invariably present in copper and copper alloys from Ur. Nickel is an element that is, for example, present in the copper-bearing minerals and as well as the smelting slags of Oman. He thus suggested that the copper ore district of Oman in the southeast Arabian Peninsula had to be considered as one of the major sources for copper in Mesopotamia.

Plenderleith (1934) benefitted from Desch's results, knowledge and experience. In his article on the metal finds from Ur, he published dozens of metal analyses of Desch, also analyses of objects from Ubaid, Nineveh, Susa, Kish and Bahrain. The Ur finds were primarily those allocated to the British Museum after the excavation. Plenderleith, who was a chemist and archaeologist by training, discussed and interpreted the chemical composition and textures of gold, silver, bronze and copper artifacts with great expertise. On the basis of trace element results, he latched onto Desch's idea, which was that the origin of the Sumerian copper was Oman or *Magan*. This idea was confirmed at a much later date through modern analytical techniques, more precisely, by comparing the lead isotope signatures of Sumerian copper with Omani copper mineralization (Begemann, et al., 2012). The interpretation of the cuneiform texts strengthened this interpretation by supporting a maritime trade of copper from *Magan* to the small island settlement Umm an-Nar and the island of Bahrain (*Dilmun*) in the „Lower Sea“ (Persian-Arabian Gulf) (Heimpel, 1987).

Unlike for the copper, the tin, as the second alloying constituent in the bronzes, thwarted any attempt to locate its origin and its source could be nothing but speculation. The tin deposits of Afghanistan were indeed known as being a potential source, but without any analytical nor textual proof.

The ambiguity of origin is also a problem for the gold objects. Plenderleith consistently found objects containing silver concentrations up to 40 wt.%, termed electrum, a variety of gold that can occur in nature con-

taining 20 % of silver or more. The gold was not refined to high-grade gold. The source locations for the gold from Ur still remain an mystery. But an important note in reference to the potential sources of the gold from Ur is the predominant and close association of gold with lapis lazuli in various objects within the Royal Tombs. The source of the blue colored semi-precious stone is known because deposits of lapis lazuli are extremely rare in the world: It was mined in the famous mines of Sar-i Sang in northeastern Afghanistan and was already traded in the 3rd millennium BC in the many regions of the Middle East. The deposit of Sar-i Sang is therefore treated as a regional „anchor“, so it is possible that the gold may have its origin in Afghanistan as well. On a visual basis (for reasons of conservation and the limited analytical capabilities of the time, no more was possible) and also with regard to excavated tools of the ancient goldsmiths, Plenderleith suggested a variety of fabrication techniques: Different joining techniques such as soldering using mouth blowpipes, cloisonné, repoussé, chasing and engraving, manufacturing of gold leaf and gold foil, hammering and casting of gold and silver.

Long after Plenderleith's investigation on the material, in 1980, the Mesopotamian Metal Project (MMP) was initiated at the University of Pennsylvania Museum of Archaeology and Anthropology in Philadelphia in order to answer basic questions about the nature of the metals and alloys used during the different time periods and in different areas of Mesopotamia (Stech, 1999). The MMP was the joint work of Stuart Fleming, J. D. Muhly, V. C. Pigott and T. Stech-Wheeler. It was the inception of J.D. Muhly after Max Mallowan (1977) stated that it is still not known whether the Sumerian used copper or bronze (see discussion in Plenderleith, 1934, pp.285-286). The project included elemental analyses of main and minor constituents of 350 copper-based artifacts (copper artifacts and tin bronzes) from a number of Mesopotamian cities such as Ur, Kish, Fara, Nippur, Gawra, Billa, Nippur and Khafajeh. No gold artifacts were investigated. Metallographic analyses were made from about 150 samples, which in part were analyzed by scanning electron microscopy. Elemental analyses were obtained using the PIXE-technique by S. Fleming. One major focus was again the question of tin: Tin bronzes were identified in the Royal Tombs of Ur (Stech and Pigott, 1986). The authors argue that the tin derived from Afghanistan and was brought to Mesopotamia along with other prized goods such as gold and lapis lazuli.

The Heidelberg project „Early metals in Mesopotamia“ (FMM) was focussed on the recording and analysis of numerous metal finds. It was developed to provide a

basis to link the development of metallurgy in Mesopotamia with the technological knowledge in the neighboring cultural regions of Eurasia (Hauptmann and Pernicka, 2004). Impetus for this project goes back to Dr. Michael Müller-Karpe, who had created an important basis with his work on the metal containers in Iraq. In their book „Die Metallindustrie Mesopotamiens von den Anfängen bis zum 2. Jahrtausend v. Chr.“ an enormous collection of more than 2500 chemical analyses of copper, bronze, silver and gold artifacts were presented. The analyses were mainly performed using a portable X-ray fluorescence spectrometer (pXRF), but also by neutron activation analysis (NAA). The authors mainly analyzed artifacts from the National Museum of Iraq in Baghdad. One of the major aims to be explored in this project was, once again, the question of the source or sources of tin for alloying copper to make tin bronze.

This study was followed up by Begemann and Schmitt-Strecker (2009). In a further investigation they analyzed the lead isotope ratios of 140 copper and bronze objects from the Heidelberg project. In this study, they also included more than 50 objects from the Museum in Philadelphia, which were analyzed for their elemental composition and metallographic texture. The lead isotope signature of the artifacts in comparison with their lead isotope database revealed new and interesting results and helped to confirm some of the existing theories and hypothesis. The authors found that the suite of metal sources supplying copper to Mesopotamian are in high probability to be located in Anatolia, Iran, Oman, Faynan in the Wadi Araba in Jordan and northwest India. Many tin bronzes, which appear in the middle of the 3rd millennium BC, deviate from the copper metal in their lead isotope ratios and suggest an import of tin bronze from yet unknown sources embedded in much older geological environments than the regions mentioned above.

In 2009, on recommendation of Prof. Dr. Richard Zettler, the authors received the permission from the University of Pennsylvania Museum for Archaeology and Anthropology to start a new project to investigate metal artifacts of gold, silver, copper and bronze and other materials from the collection of the Royal Tombs of Ur archived at the Museum in Philadelphia. This research project is a joint project of the Goethe-Universität Frankfurt am Main and the Deutsches Bergbau-Museum Bochum. The project is entitled “Die Königsgräber von Ur, 2600 v. Chr.: Analytische, archäologische und technologische Studien an Gold-, Silber-, Kupfer- und Bronzeartefakten aus der Sammlung des Penn Museums, University of Pennsylvania, Philadelphia”.

A first screening of the material was performed by

applying non-destructive analytical techniques to some dozens of gold objects from the collection in Philadelphia. In a second stage, we were permitted to sample 71 gold objects and 50 pigment powders which were typically stored in cockle shells. We were also allowed to borrow a collection of prepared mounted and polished samples (we named them “Nash-collection”), which included 89 samples of copper-based alloy fragments, 20 samples from silver objects and 2 gold fragments for investigations in Germany.

The scientific questions addressed in this ongoing project tie in with the problems addressed by Woolley and Plenderleith and by the authors previously mentioned. It continuously focusses on two aspects:

1.) The technological level of the craftsmanship of the metalworkers and the workers processing other materials: Are the technologies and innovations seen in the Ur metalwork a manifestation of the enormous political and cultural development of the urban settlements of Mesopotamia in the 3rd millennium BC? Were these techniques imported from elsewhere, i. e. from lands connected with Ur by its far-reaching trade contacts? This leads directly to the second major aspect:

2.) Provenance studies: Where did the metals and other materials come from? Much is known from archaeological sources, but there are many gaps of knowledge. Cultures and civilizations within distances of several thousands of kilometers in all directions from Mesopotamia have to be taken into consideration.

Today we are able to apply the most modern analytical methods with higher sensitivity than ever before, and the yield of the analysis of archaeological materials can be greatly intensified by micro-sampling methods that allow to take portions of the objects to the laboratories. We are able to analyze the isotope compositions of lead, copper and osmium. In addition, large databases are available today, for chemical compositions as well as for lead and copper isotopes of slags, metals and minerals all over Europe and beyond.

A workshop was organized to discuss the progress and preliminary results of the ongoing research project. The first results obtained in several sub-studies on the materials from Ur are promising. They were presented in a workshop at the Deutsches Bergbau-Museum Bochum, May 18th / 19th, 2015.

All people working scholarly in our project and some external colleagues working on the Ur collections and relevant themes were invited to attend this workshop.

The following colleagues attended the workshop and presented lectures:

- PD Dr. Barbara Armbruster, Université de Toulouse-Le Mirail, Toulouse, France: Technological Aspects of the Gold Objects from Ur – Preliminary Results and Perspectives.
- Dr. Kim Benzel, Department of Ancient Near Eastern Art, Metropolitan Museum of Art, New York City: Technologies of Jewelry at Ur: The Physics and Metaphysics of Skilled Crafting.
- Prof. Dr. Andreas Hauptmann, Research Laboratory for Archaeology and Materials Science, Deutsches Bergbau-Museum Bochum: Making and Provenancing of Cosmetic Pigments from Ur.
- Prof. Dr. Andreas Hauptmann, Research Laboratory for Archaeology and Materials Science, Deutsches Bergbau-Museum Bochum: Golden Artifacts from the Royal Tombs of Ur, Mesopotamia.
- Dr. Brad Hafford, University of Pennsylvania Museum of Archaeology and Anthropology: Ur-online and the Presentation of Scientific Data.
- MA Moritz Jansen, Research Laboratory for Archaeology and Materials Science, Deutsches Bergbau-Museum Bochum / University of Pennsylvania Museum for Archaeology and Anthropology: Where does the Gold from the Royal Tombs of Ur come from? Provenancing Gold Sources using Analytical Methods.
- Prof. Dr. Sabine Klein, J.W. Dept. of Geoscience, Mineralogy, Goethe University Frankfurt a.M.: Lead Vessels from the Jamdat Nasr-Period, Ur.
- Prof. Dr. Sabine Klein, J.W. Dept. of Geoscience, Mineralogy, Goethe University Frankfurt a.M.: New Analytical Results from the Ur-Collection of the British Museum.
- Dr. Stephen Merkel, Research Laboratory for Archaeology and Materials Science, Deutsches Bergbau-Museum Bochum: Silver Ores from the Panjhir Valley, Afghanistan.
- MA Eveline Salzmänn, J.W. Dept. of Geoscience, Mineralogy, Goethe University Frankfurt a.M.: Analytical Investigations on Silver, Copper and the Earliest Tin Bronzes from Ur.
- Dr. Judith Thomalsky, Deutsches Archäologisches Institut: New Activities of the German Archaeological Institute in Afghanistan.
- MSc. Hendrick Wick, Dept. of Geoscience, Mineralogy, Goethe University Frankfurt a.M.: Petrological and Geochemical Investigations of “Alabaster”-Vessels from Ur.
- Prof. Dr. Richard Zettler, University of Pennsylvania Museum of Archaeology and Anthropology: A

Horde of Copper-Alloy Vessels from PG 1422, a Late Akkadian Burial.

Extended abstracts of a eight of these lectures given at the workshop are presented in this supplement to METALLA 22(1). Due to the advanced stage of the results of the analysis on the pigments of Ur, they are presented as an independent contribution earlier in this issue.

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References

- Amiet, P., 1986. L'âge des échanges inter-iraniens, 3500-1700 avant J.-C. *Notes et documents des musées de France*, 11.
- Begemann, F., and Schmitt-Strecker, S., 2009. Über das frühe Kupfer Mesopotamiens. *Extrait d'Iranica Antiqua*, XLIV, pp.1-45.
- Begemann, F., Hauptmann, A., Schmitt-Strecker, S., and Weisgerber, G., 2010. Lead Isotope and chemical signature of copper from Oman and its occurrence in Mesopotamia and sites on the Arabian Gulf Coast. *Arabian Archaeology and Epigraphy*, 21, pp.145-179.
- Desch, C. H., 1929. Sumerian copper. In: *Report of the 96th Meeting of the British Association for the Advancement of Science, Glasgow, 1928, Sept. 5-12*. London: Office of the British Association Burlington House. pp.437-441. [online] available at <<http://www.biodiversitylibrary.org/item/96054#page/5/mode/1up>> [Accessed 15 March 2016].
- Hauptmann, H. and Pernicka, E., 2004. *Die Metallindustrie Mesopotamiens von den Anfängen bis zum 2. Jahrtausend v.Chr. Orient Archäologie*, 3. Rahden / Westfalen: Verlag Marie Leidorf.
- Heimpel, W., 1987. Das Untere Meer. *Zeitschrift für Assyriologie und vorderasiatische Archäologie*, 77, pp.22-91.

- Helwing, B., 2014. Silver in the early societies of Greater Mesopotamia. In: H. Meller, R. Risch, and E. Pernicka, eds. 2014. *Metalle der Macht – Frühes Gold und Silber*. 6. *Mitteldeutscher Archäologentag. Internationale Tagung*. Halle: Sachsen-Anhalt Landesmuseum für Vorgeschichte. pp.411-421.
- Lutz, J., 2004. Röntgenfluoreszenzanalysen. In: H. Hauptmann and E. Pernicka, eds. 2004. *Die Metallindustrie Mesopotamiens von den Anfängen bis zum 2. Jahrtausend v.Chr.* *Orient Archäologie*, 3. Rahden / Westfalen: Verlag Marie Leidorf. pp.109-150.
- Lutz, J., and Pernicka, E., 2004. Neutronenaktivierungsanalysen. In: H. Hauptmann and E. Pernicka, eds. 2004. *Die Metallindustrie Mesopotamiens von den Anfängen bis zum 2. Jahrtausend v.Chr.* *Orient Archäologie*, 3. Rahden / Westfalen: Verlag Marie Leidorf. pp.104-107.
- Mallowan, M. E. L., 1977. Recollections of C. Leonard Woolley. *Expedition*, 20(1), pp.3-4.
- Müller-Karpe, M., 1993. *Die Metallgefäße im Iraq I : von den Anfängen bis zur Akkad-Zeit. Prähistorische Bronze-funde*, II / 14. Stuttgart: Steiner-Verlag.
- Plenderleith, H. J., 1934. Metals and Metal Technique. In: C.L. Woolley, ed. 1934. *Ur Excavations, Volume 2: The Royal Cemetery. A Report on the Predynastic and Sargonid Graves Excavated between 1926 and 1931*. London / Philadelphia: British Museum / Museum of the University of Pennsylvania. pp.284-298. [online] available at <<http://www.etana.org/sites/default/files/coretexts/20263.pdf>> [Accessed 15 March 2016].
- Stech, T., and Pigott, V., 1986. The Metals Trade in Southwest Asia in the Third Millennium BC. *Iraq*, XLVIII, pp.39-64.
- Stech, T., 1999. Aspects of Early Metallurgy in Mesopotamia nad Anatolia. In: V. C. Pigott (ed.), *The Archaeometallurgy of the Asian Old World. University Museum Monograph*, 89. Philadelphia: University Museum, University of Pennsylvania. pp.59-71.
- Vogel, H., 2014. Der Königsfriedhof von Ur und das Problem der so genannten Gefolgschaftsbestattungen. In: T. Link and H. Peter-Röcher, eds. 2014. *Gewalt und Gesellschaft. Dimensionen der Gewalt in ur- und frühgeschichtlicher Zeit. Universitätsforschungen zur prähistorischen Archäologie*, 259. Rudolf Habelt: Bonn. pp.169-185.
- Woolley, C. L., 1934. *Ur Excavations, Volume 2: The Royal Cemetery. A Report on the Predynastic and Sargonid Graves Excavated between 1926 and 1931*. London / Philadelphia: British Museum / Museum of the University of Pennsylvania. [online] available at <<http://www.etana.org/sites/default/files/coretexts/20263.pdf>> [Accessed 15 March 2016].