‘The Good Bright Metal’: Towards a Holistic Understanding of Southern Mesopotamian Metalwork c. 2300-1300 B.C.

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Abstract

Despite a lack of native ores, archaeological and textual evidence demonstrates that metal occupied a key role in the society and material culture of ancient southern Mesopotamia. The repertoire of metal objects uncovered from the region is expansive, encompassing a wide variety of tools, weaponry, jewellery and personal adornment, as well as examples of statuary, grooming instruments, musical instruments and various other object types. Cuneiform evidence in the form of economic texts indicates extensive trade routes through which metal moved; at times, even by the tonne. Metalwork also features significantly in the contemporary literature, whether in references to metalwork in myths, through the use of metal and its inherent shine as a metaphor for divinity, or in personified forms in a disputation text.

This project aims to further current understanding of southern Mesopotamian metalwork by expanding the existing body of compositional data and information from extant assemblages and utilising approaches informed by recent developments in the wider discipline to contribute interpretations that provide new holistic insights into southern Mesopotamian metalwork. Simultaneously, this thesis seeks to address fundamental issues in previous approaches to the collection, recording and analysis of Mesopotamian metalwork and demonstrate the benefits of utilising approaches which vary from those traditionally employed.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

http://www.library.manchester.ac.uk/about/regulations/) and in the University's policy on Presentation of Theses

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Finally, I would like to dedicate this thesis to my brilliant sister, Evie. It is an honour to be your big sister, and I hope I continue to do you proud.

Chapter 1
Introduction

Despite a lack of native ores, archaeological and textual evidence demonstrates that metal occupied a key role in the society and material culture of ancient southern Mesopotamia. The repertoire of metal objects uncovered from the region is expansive, encompassing a wide variety of tools, weaponry, jewellery and personal adornment, as well as examples of statuary, grooming instruments, musical instruments and various other object types. The range of metals in use was also significant; while copper and its alloys dominate the material from the region, gold, silver, lead and iron objects are also present in the archaeological record. Cuneiform evidence in the form of economic texts indicates extensive trade routes through which metal moved; at times, even by the tonne (Leemans 1960; Oppenheim 1954). Metalwork also features significantly in the contemporary literature, whether in references to metalwork in myths, through the use of metal and its inherent shine as a metaphor for divinity, or in personified forms in a disputation text.

This project aims to further current understanding of southern Mesopotamian metalwork by expanding the existing body of compositional data and information from extant assemblages and utilising approaches informed by recent developments in the wider discipline to contribute interpretations that provide new holistic understandings of southern Mesopotamian metalwork. Simultaneously, this thesis seeks to address fundamental issues in previous approaches to the collection, recording and analysis of Mesopotamian metalwork and demonstrate the benefits of utilising approaches which vary from those traditionally employed.

Leonard Woolley's excavations at the southern Mesopotamian city of Ur in the 1920s and 1930s yielded a rich body of metalwork that is easily one of the most significant and influential archaeological discoveries of the 20th century (Figure 1.1). An array of gold, silver and copper-alloy objects of high quality and intricate design, many inlaid with precious stones, was uncovered predominantly from the so-called 'Royal Cemetery' at the southeast part of the site (Woolley 1934). The cemetery held approximately 2,000 graves and has been dated to between 2500 B.C and 2000 B.C. (Hauptmann & Klein 2016: 75; Woolley 1934). Much of the resulting work from the study of the Ur material in the 20th century proved pioneering in the early study of ancient metallurgy (Millerman 2008).

Despite this significant role in the early study of ancient metalwork, southern Mesopotamia soon fell to the periphery of archaeometallurgical focus. Concentration on researching the origins of metallurgy combined with the rapid advancement of related methods of scientific analysis led to a strong research emphasis on investigating initial processes of metal exploitation and the development of support technologies (Moorey 1982:13). Subsequently, regions such as Mesopotamia which lacked native ores were eclipsed in archaeometallurgical analysis by regions such as Anatolia, the Negev and Sinai, and Iran (Moorey 1982: 13). While research into southern Mesopotamian metallurgy and metalwork continued, work remained limited and typically small in scale. Literature concerning extant bodies of southern Mesopotamian metalwork and analyses of objects mainly constituted various scattered studies and publications or small parts of wider publications. As a result, understanding remained largely in its infancy.

Figure 1.1: Goldwork from the excavations at Ur under Leonard Woolley. The top left image is of a fluted gold bowl from Puabi's tomb chamber. The top right shows a wreath of lapis lazuli and carnelian gold poplar leaves from the "Great Death Pit". The bottom left object is a gold vessel in the form of an ostrich egg, covered with a mosaic of lapis lazuli, red limestone, and shell bits set in bitumen. Finally, the bottom right photo depicts an electrum adze (Horne 1998).

Towards the latter portion of the 20th century, several publications concerning metallurgy and metal use in Mesopotamia (such as Moorey 1985, 1994; Potts 1997) were pivotal in synthesising and beginning to contextualise the scattered body of previous research. The breadth of compositional analysis conducted on southern Mesopotamian metalwork was also dramatically increased during this period by two key projects. The first, the Mesopotamian Metals Project (MMP), was set up in 1980 and produced compositional analyses of over 350 copper-based objects from southern Mesopotamia dating to the 3rd and 2nd millennium B.C. (Stech 1999: 59). The second, the *frühe metalle in mesopotamien* study, was set up in the 1990s and contributed compositional data for 2,623 metal objects dating to between the 5th and 2nd millennium B.C. from a total of 68 sites in Mesopotamia and Syria (Hauptmann & Pernicka 2004). Yet while these projects greatly expanded the available information concerning the composition of southern Mesopotamian metalwork, both failed to provide further in-depth discussion of these data concerning their wider social, economic and political context.

Outside the realm of southern Mesopotamian metalwork, theoretical and methodological developments within the field of archaeometallurgy and archaeology more broadly were leading to wider and more in-depth applications of social theory, exploration of the active role of individuals and materials, and the integral role of material culture in the creation and shaping of social relations. From the 1990s onward, approaches within archaeometallurgy increasingly adopted a combination of both scientific and anthropological methods of inquiry, often resulting in more nuanced and holistic understandings (for example, Childs 1991; Epstein 1993; Friedman 1998; Hosler 1994). The field of Mesopotamian archaeology, however, was slow to engage with these wider disciplinary developments. As a result, the study of Mesopotamian metallurgy and metalwork continued to lack consideration of its wider social context.

A significant factor that hindered the understanding of the metal industry and metal use in southern Mesopotamia, as well as the engagement with broader disciplinary developments, was the inability to excavate in southern Iraq for several decades. Following the 1990 invasion of Kuwait and subsequent conflict, foreign excavation in Iraq was nearly entirely halted and excavation by Iraqi teams became highly restricted. Economic sanctions imposed by the UN made it impossible for foreign research teams to spend their research funding (Ur 2017: 176-7). This resulted in major excavations being abandoned despite years of upcoming planned excavation, leaving incomplete work and unanswered research questions. Furthermore, from the mid-1990s onwards, large-scale illicit digging of archaeological sites became a huge problem (Al-Hussainy & Matthews 2008: 93).

Excavation in Iraq was further halted following the 2003 US-led invasion and subsequent occupation. In addition to impacting the undertaking of excavation and survey, this invasion and occupation also had a tremendously negative impact on existing archaeological sites and material. The US-led coalition did not provide the cultural heritage of Iraq, and the structures originally in place to preserve it, with adequate protection (Al-Hussainy & Matthews 2008: 93). Museums around Iraq, most notably the Iraq Museum, were badly looted. Despite some of this material resurfacing, much of it never has. Furthermore, in some instances, key information and hardcopy documentation related to archaeological sites and excavation was lost. For example, the site of Shmet in the Dhi Qar province was excavated by the Iraqi State Board of Antiquities between 2001 and 2002, but all of the paper documentation of the excavation was lost following the invasion when looters burned and looted the location at which they were being kept (Fahad & Abbas 2020: 3). The lack of new primary data resulted in many academics and their students refocusing their research interests on different regions and caused Mesopotamian archaeology to stagnate, leaving the field in severe need of re-alignment with modern scientific and theoretical advancements.

The study of southern Mesopotamian metallurgy and metalwork has also long been severely impacted by the temporal, geographical and contextual limitations of extant material. Due to a deep-routed tradition of urban bias in Mesopotamian excavation and research, highly selective traditional collection and retention strategies during excavation, an overwhelming dominance of material from burial contexts, and persistent issues concerning a lack of contextual information and either extremely broad dating or no dating at all, the extant body of material from southern Mesopotamia is fundamentally limited in its ability to provide a comprehensive reconstruction of metallurgy and metal use as a whole. Therefore, while extant bodies of material retrieved through earlier excavations could be, and were, still studied in the absence of new material, reliance on them continued to limit research due to the constraints of earlier methods of data collection and retention on these assemblages. Despite these problems being recognised as early as the 1970s (see Adams *et al.* 1974; Moorey 1994; Muscarella 1988), the inability to excavate for several decades significantly impeded the correction of these limitations.

While research into the metallurgy and metalwork of southern Mesopotamia has continued, typically using this existing body of material, and various valuable studies have continued to progress understanding, current reconstructions of southern Mesopotamian metallurgy and metalwork are still severely skewed and limited by these temporal, geographical and contextual limitations, and much of this research continues to lack in-depth examination of the wider social context and application of broader theoretical developments in the discipline. Subsequently, current understanding of southern Mesopotamian metalwork is still far less advanced than that of many of the surrounding regions. Not only is this an issue with regard to better understanding southern Mesopotamian metallurgy, material culture and craft specialism, but it also has a large impact on our ability to fully understand metal use for the wider Near Eastern region. Spatially, as well as economically and culturally, Mesopotamia occupied a central position in the ancient Near East. Despite the metalwork assemblages of neighbouring regions being broadly better known and receiving more extensive analysis and study over the years, it is, as Philip *et al.* (1995: 119) highlight, "difficult to assess the degree of interrelationship between patterns of production and distribution in the various regions while we lack an adequate understanding of processes at the geographical heart of the system". It is therefore not only imperative for Mesopotamian archaeology that we pursue a more comprehensive understanding of Mesopotamian metalwork, but also to Near Eastern archaeometallurgy as a whole.

An initial aim of this project was to expand the extant body of compositional analyses by conducting new readings on other UK-based collections, particularly as most previous compositional analysis of southern Mesopotamian metalwork collections in the UK has been limited to material held at the British Museum. Throughout this process, however, it became clear that, while these new analyses are valuable contributions to the extant body of data, this material was still fundamentally limited by the aforementioned temporal, geographical and contextual limitations and was therefore similarly skewed in its potential to elucidate southern Mesopotamian metal use. Fundamentally, the study of southern Mesopotamian metalwork needs new material to correct these issues and a new paradigm for interpretation. The generation of new material will, of course, be a long-term process, and will be shaped significantly by future changes in the ability or inability to excavate in southern Iraq. Nevertheless, it requires crucial changes in excavation strategy and finds processing. This thesis contributes the study, analysis and discussion of a new body of southern Mesopotamian metalwork excavated from the Sealand site of Tell Khaiber between 2013 and 2017 (Campbell et al. 2017, 2019, forthcoming). Unlike traditional approaches, a strategy of total collection was employed in the Tell Khaiber excavations, subsequently providing a drastically different assemblage type which includes material from a much wider range of contexts of deposition than typically exist in previous collections, and includes a large number of fragmentary pieces from various points along the lifecycle of metalwork. It is also the first substantial body of metalwork uncovered which can be reliably dated to the Sealand Dynasty, a particularly elusive period of southern Mesopotamian history. Finally, as a small fortified site of rural administration, Tell Khaiber is also a significantly different site type to those which typically dominate Mesopotamian metalwork. Not only is the contribution of this material an important step forward in progressing the understanding of southern Mesopotamian metallurgy, but I also hope that the results of this material will emphasise the immense importance and benefits of similar approaches being utilised in further excavation.

In addition to the generation of new material, the study of southern Mesopotamian metalwork is also in need of greater awareness of the limitations of extant material and traditional approaches, in addition to the application of more socially-focused approaches, influenced by wider theoretical developments. This thesis adopts a fundamentally holistic approach that bridges various gaps in previous work. A combination of archaeological, chemical and textual evidence is used throughout the thesis to achieve a more comprehensive understanding of southern Mesopotamian metalwork than can be achieved using one evidence type in isolation. While more traditional approaches to the interpretation of data are critically and pragmatically applied, this thesis also progresses beyond these by utilising more theoretically nuanced approaches, incorporating materiality-based theories as well as explorations of metal’s lifecycle as inspired by object biographies. Ultimately, this thesis not only intends to progress understanding of southern Mesopotamian metalwork, but also to directly address fundamental issues within the study of the topic that require correction through future work.

1.1 Study Aims, Structure and Scope

The primary aims of this project are threefold:

1. To expand the existing body of compositional data and information relating to extant collections of Mesopotamian metalwork.
2. To address fundamental issues in previous approaches to the collection, recording and analysis of Mesopotamian metalwork and demonstrate, through the use of new material, the benefits of utilising approaches which vary from those traditionally employed.
3. To expand and develop current understanding of southern Mesopotamian metalwork by contributing interpretations that progress beyond traditional approaches to new holistic understandings of metal's social, symbolic and socioeconomic significance.

Chapters 1 and 2 of this thesis will provide an introduction to the project, and the relevant contextual background regarding both southern Mesopotamia and current archaeological understanding of metal use in the region. Following these initial chapters, the thesis is structured into three parts.

Part I encompasses four chapters (3-6) which will present, utilise and critique traditional approaches to the study of metallurgy. The first chapter in Part I, Chapter 3, will position this project within its wider intellectual context and delve further into the key issues that this thesis aims to address and begin correcting. Chapter 4 will outline the material used in this project, the chemical analysis methods utilised, and the approaches employed in the selection and organisation of data. In Chapter 5, to lay a solid foundation of understanding of both broader trends and more specific potential patterns within extant analysed Mesopotamian metalwork, I will begin my examination, exploration and subsequent analysis by providing an overview of the legacy data. This chapter will present general patterns of metal usage, composition types, and the broader patterns detectable concerning composition and object type as well as examination of smaller potential patterns and connections within the material. In the latter portion of Chapter 5, I will examine the new data collected for this thesis; both in its own right, and how it fits within the legacy data. This new data constitutes chemical analyses collected using pXRF equipment to analyse material held at three key UK museum collections: Manchester Museum, the Ashmolean Museum and Birmingham Museum and Art Gallery. As previous research including UK-based collections has tended to focus on material from the British Museum, contributing these new data will expand the body of available compositional data, aiding further research into Mesopotamian metalwork even in the instance of limited new material or the absence of new material entirely; something which is particularly important due to continued socio-political tensions in the region.

While Chapter 5 provides a crucial foundation of understanding, it also – just as, if not more, importantly – illustrates and emphasises the challenges and fundamental limitations implicit in the use of this material due to the problematic ways in which metalwork has been collected, recorded and approached in Mesopotamian archaeology previously. Crucially, while the contribution of the new data in this chapter is certainly beneficial, these three bodies of Mesopotamian metalwork are still victim of the same fundamental problems as the legacy data. This thesis therefore also contributes compositional data, analysis and discussion of the new body of metalwork uncovered from Tell Khaiber that is significantly different from the majority of previous southern Mesopotamian metalwork assemblages. In Chapter 6, I will present and examine this new assemblage and dataset and how it fits into the legacy data, while also demonstrating how this material can provide a much fuller insight into southern Mesopotamian metallurgical processes. Through the inclusion of this material, this thesis strives to begin redressing the current imbalance in material and regional coverage that dominates previous work, as well as to demonstrate the critical need for future excavations to adopt a similar approach.

Part II of the thesis encompasses two chapters (7 and 8) which will explore the application and use of approaches and theory less traditionally used in archaeometallurgy. While the examination and discussion in Chapters 5 and 6 will provide a sturdy foundation of understanding of both the legacy data and the new data, the more traditional approaches used in these chapters such as typological discussion, traditionally-defined compositional categories, and a temporal-based structure is fundamentally limiting and even, in some ways, ill-suited to this particular dataset with regard to how much it can elucidate the social, socioeconomic and symbolic significance of Mesopotamian metalwork. Subsequently, as per the third aim of this project, in Chapters 7 and 8 I will further examine this data using less traditional approaches and utilising the inclusion of textual sources to provide further insight. In Chapter 7, investigation and discussion will focus on examining the broader lifecycle of southern Mesopotamian metalwork. In Chapter Eight, I will adopt a materiality, and particularly a sensory, centred approach to investigate the data. Finally, Part III (Chapter 9) summarises the conclusions of the project and provides discussion of future directions within southern Mesopotamian archaeometallurgy.

In addition to the three central aims of this project, this thesis will also make a significant contribution towards the continued and advancing application of modern scientific techniques within archaeology. The utilisation of social theory and of sensory- and materiality-focused archaeological approaches to Mesopotamian metalwork will also make a significant contribution to the wider field of archaeometallurgy, and its progression towards a more socially-minded interpretative structure in the study of the ancient Near East. Furthermore, it will join crucial work striving to realign research in Mesopotamian archaeology with advancements in the wider discipline; both scientifically to the Third Scientific Revolution (Kristiansen 2014), and theoretically. Finally, the inclusion of the Tell Khaiber material will make a significant contribution to Mesopotamian archaeology more broadly by shedding much-needed light on the elusive Sealand Dynasty.

Four appendices are also submitted alongside this thesis. The first, Appendix A (see https://figshare.com/s/727e5f92f2124ea0758e), is a table of sites included in this thesis. For each site, basic information concerning occupation and history of excavation is provided, as well as a note concerning how many objects from each site have been included and to which publications or collections they belong. The second, Appendix B (see https://figshare.com/s/fe3201770a3fa4422189), is the Objects Database; a database created cataloguing all of the objects that are included in this thesis. The third, Appendix C (see https://figshare.com/s/a70670cec772b850a7a1), is the Analyses database; a database created recording all of the compositional readings used in this project. Finally, the fourth, Appendix D (see https://figshare.com/s/28abeead45ab62e85a81) comprises all of the photographs taken of the UK museum collections visited for this project and the Tell Khaiber assemblage.

1.1.1 Temporal and Geographic Parameters

This thesis adopts a broad temporal scope of approximately 1000 years, stretching from c. 2300 B.C. until c. 1300 B.C.[1]. The selection of such a long period of focus was predominantly influenced by the limitations of available data discussed above; extant metalwork from southern Mesopotamia is extremely inconsistent in temporal, geographical and contextual coverage due to a combination of poor levels of preservation, frequent metal re-use and recycling, ancient plundering, modern looting, highly selective traditional collection strategies by archaeologists, and long-held biases within Mesopotamian excavation (Moorey 1994: 256; Phillip 1995: 119). In addition to these extensive influencing factors on material availability, a further issue exists concerning the dating of Mesopotamian metalwork. Much of the extant material is either assigned a very broad period or is assigned no date at all. As a result, it is difficult to select a short period of time without limiting an already heavily limited dataset even further. Instead, adopting a broad temporal scope for this project allows for a fuller body of metalwork with which to work. It also allows access to valuable textual evidence that would otherwise be nearly entirely missing. In the latter part of the 3rd millennium, there is a significant increase in textual sources, aiding a much more comprehensive reconstruction of the period than is possible for the periods prior (Van De Mieroop 2015: 67). From the fall of the First Dynasty of Babylon in 1595 B.C., however, textual evidence becomes incredibly scant. Due to this paucity of textual evidence in the latter half of the 2nd millennium, inclusion of the late 3rd and early 2nd millennium also benefits the study by allowing for the utilisation of textual sources the reconstruction of metal's significance.

Further contributing to the need for a broad temporal scope is that a vital part of this project is the inclusion of new material from the Sealand site of Tell Khaiber, dated to the mid-2nd millennium B.C. (Campbell forthcoming). As previously noted, this is the first substantial body of excavated Mesopotamian metalwork from a known Sealand Dynasty period site; a period of the Mesopotamian 'Dark Age' with very little existing archaeological information. Supporting and comparative data for the Tell Khaiber metalwork is therefore extremely sparse. The broad temporal scope of this thesis allows for the inclusion of this new metalwork from Tell Khaiber, whilst also facilitating further

[1] Middle Chronology is used throughout this thesis. For discussion see section 1.2.

discussion of the information gained in light of the wider archaeometallurgical context of southern Mesopotamia.

The dataset utilised for this study comprises material from a total of 22 sites in southern Mesopotamia (see Figure 1.2 and Appendix A (https://figshare.com/s/727e5f92f2124ea0758e)). Nearly all of these sites span several periods, and they range from large urban sites to small rural sites. The geographic parameters used in this study begin at the south of Iraq and stretch up to the Diyala region as the most northerly point. This broadly follows the traditional borders of the southern Mesopotamian plains, also sometimes referred to as lower Mesopotamia, defined as stretching south from the site of Samarra (Oats 2012: 466). While the Diyala region lies at quite a northerly point, clear cultural connections have been demonstrated; for example, through architectural and ceramic evidence (Glatz & Casana 2016). Sites in the Hamrin region sites were not included as they have previously been included in north Mesopotamian studies (for example, Philip *et al.* 1995).

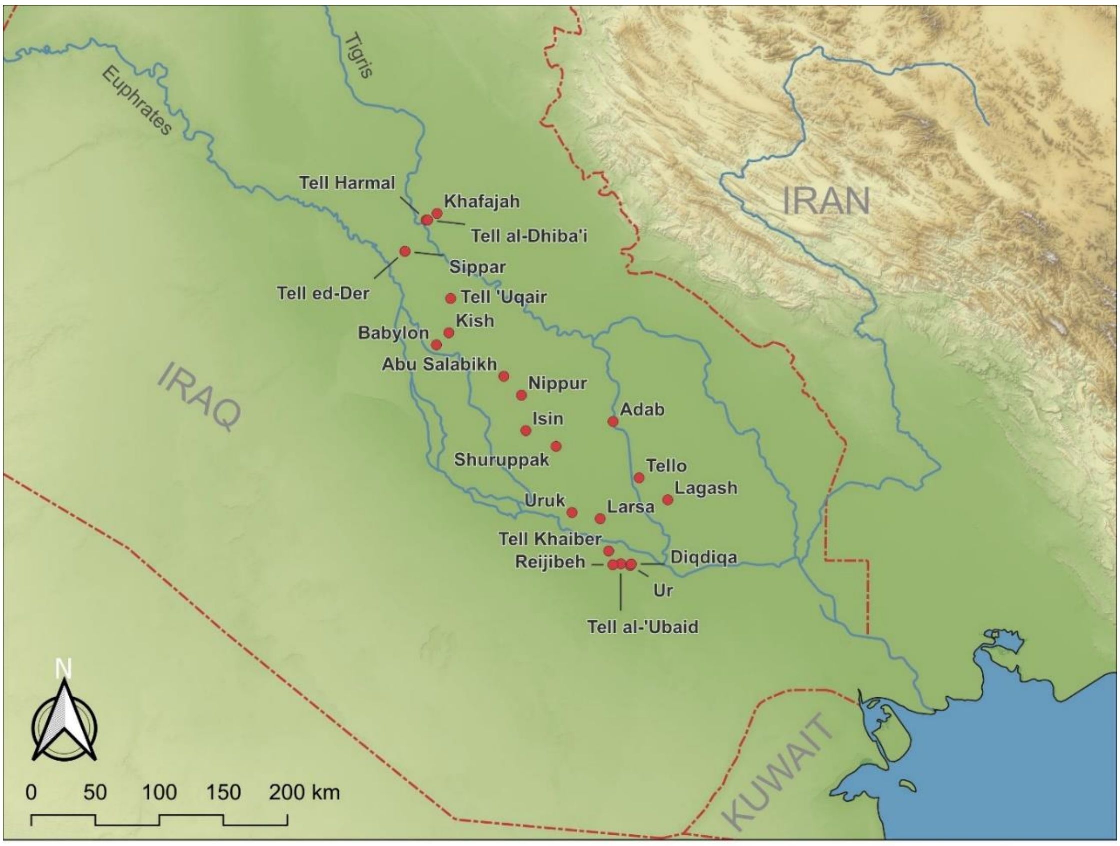


Figure 1.2: Map showing the 22 sites included in this study.

1.2 2nd Millennium Chronology

The chronology of the first half of the 2nd millennium B.C. in Mesopotamia has been subject to extensive debate and study for over a century. The latter half of the millennium is mostly secured by Assyrian chronological sources which provide an absolute chronology for Assyria and, through the use of synchronisms with Babylonian texts, are also able to provide an absolute chronology for Babylonia. The most central Assyrian chronological source is Assyrian royal chronology; unfortunately, however, this only stretches back to approximately 1420/30 B.C. (Pruzsinszky 2009: 17).

There is a severe lack of chronological sources from Mesopotamia dating to around the middle of the 2nd millennium B.C., following the fall of the Babylon I Dynasty; a period referred to as the so-called 'Dark Age'. Despite the establishment of a relative chronology using the reigns of rulers and the order of known events, a lack of absolute dates with which to anchor this relative chronology to the Christian Era has long impeded the construction of an absolute chronology for the period. The actual calendrical dates that this relative chronology definitively matches up to can vary by up to 150 years depending on which proposed chronology is being used (see Table 1.1).

Table 1.1: Commonly used dates for the end of the Babylon I Dynasty and the reigns of Ammisaduaqa and Hammurabi within the Babylon I Dynasty (after Pruzsinszky 2009: 24, Table 1).

	NC	**LC**	**MC**	**HC**
End of Babylon I Dynasty	1499	1531	1595	1651
Reign of Ammisaduaqa	1550-1530	1582-1562	1646-1626	1702-1682
Reign of Hammurabi	1696-1654	1728-1686	1792-1750	1848-1806

Originally, Mesopotamian chronology was focused on three key proposed chronologies: High (or Long) Chronology (HC), Middle Chronology (MC) and Low (or Short) Chronology (LC). All three were based on varying interpretations of the Venus Tablet, an omen tablet from the Enūma Anu Enlil collection, and other astronomical data (see Pruzsinszky 2009: 69-83). Further work, however, moved towards incorporating more king list data and textual synchronisms, dendrochronological data, radiocarbon data and archaeological data (see Pruzsinszky 2009 for a detailed overview). Some of this research has been used to argue for either the Long, Middle or Short chronologies, while some resulted in new chronologies being proposed; the most prominent being New Chronology (NC). Sometimes also referred to as New Low Chronology (NLC) or Ultra-Low Chronology (ULC), New Chronology was argued for by Gasche *et al.* in their 1998 publication and is even shorter than Short Chronology. It was based on analysis of stratigraphic data, a study of ceramic development in 2nd millennium B.C. Babylonia, and specific interpretations of the Venus Tablet and lunar eclipse omen tablets.

Despite ongoing debates and various proposed chronologies, the majority of students and scholars of Mesopotamian history for over half a century have used Middle Chronology when providing dates. As such, large degrees of confusion over differing chronologies have been mostly avoided (Roaf 2012: 171). In 2011, however, Warburton called for Middle Chronology to be rejected, and New Chronology adopted instead. Multiple academics (e.g. Pruzsinszky 2009; Roaf 2012) have cautioned against a premature rejection of Middle Chronology. Roaf (2012: 171), in particular, has argued that "until there is a scheme to which the majority of scholars can subscribe, the most sensible course to follow is to continue to give dates according to the Middle Chronology".

Recent research relevant to Mesopotamian chronology, however, has provided robust evidence that Middle Chronology, or at least a chronology very close to it, is most correct. Central to this has been dendrochronological analysis, using archaeological wood samples from Kültepe and Acemhöyük in Turkey which provide a 1599-year dendrochronological sequence stretching from the late 3rd millennium B.C. until the early 1st millennium B.C. (see Manning *et al.* 2016; 2017; 2020). Absolute dates for this sequence have been proposed using analysis of dendro-sequenced high-precision radiocarbon dates. This data has then been combined with associated documents linked to Assyrian officials to propose an absolute chronology for Mesopotamia[2]. Further to this, the recently excavated southern Mesopotamian Sealand site of Tell Khaiber has yielded rare mid-2nd millennium chronological data and accompanying radiocarbon dates that support a chronology very

[2] Also see Höflmayer & Manning 2022 for further evidence supporting Middle Chronology across Egypt, the Levant and Mesopotamia

close to Middle (see Campbell forthcoming). Four tablets constitute the chronological data found. They provide dates from three different years of the reign of Ayadaragalama, a king of the First Sealand Dynasty. Although in its early stages, the use of synchronisation and combination with early-stage radiocarbon dates from the site indicates that the data from Tell Khaiber is compatible with Middle Chronology dates and incompatible with New Chronology dates.

Beyond this brief overview, it is beyond the scope of this thesis to delve into a detailed discussion or debate over which chronology is most likely to be correct. In light of these most recent advancements indicating that some form of Middle Chronology is most accurate, Middle Chronology will be used throughout this thesis; this denotes the dates for the reign of Hammurabi as 1792-1750 B.C. and the date for the Fall of Babylon as 1595 B.C. (Pruzsinszky 2009: 24-25). While the true chronology may be a variation of Middle Chronology that differs slightly from Middle Chronology, a small change in dates will not impact any of the results of this thesis due to the resolution used of ca. 1000 years.

Chapter 2

Southern Mesopotamian Historical and Metallurgical Context

One of the ways in which this project strives toward a holistic understanding of southern Mesopotamian metalwork is through the positioning of results within their wider historical, archaeological and metallurgical contexts. Metal consumption and metallurgical activity within southern Mesopotamia, as anywhere, was undoubtedly deeply entwined with wider geographical, geological, technological, political, economic and social factors. Awareness of these factors, and their inclusion in examination and discussion where necessary, therefore plays an important role in the pursuit of a more comprehensive reconstruction of southern Mesopotamian metalwork throughout the middle to late Bronze Age. This chapter aims to provide a succinct overview of two distinct, but equally essential, contexts relevant to this project and particularly to the results and discussion presented in Chapters 5, 6, 7 and 8. Section 2.1 of this chapter focuses on the historical context of the study period, divided into the late 3rd millennium and the 2nd millennium B.C., while Section 2.2 focuses on the metallurgical context of the period, broken down by metal type.

2.1 Historical Context

The broad temporal focus of this thesis spans various changes in social, political and economic structure within southern Mesopotamia. Material culture should always be studied within these wider contexts, as the meaning bestowed upon objects is fundamentally influenced by the social, political and economic worlds within which they exist. As elements of that wider context change, so, too, can the way people view and engage with objects. A brief but important summary of the wider historical context of the study period of this project is therefore presented in this section.

2.1.1 The Late 3rd Millennium B.C

Much of the 3rd millennium B.C. in Mesopotamia is categorised as the Early Dynastic period, which is typically defined as ranging between c. 2900 and c. 2350 B.C. The political situation in southern Mesopotamia throughout the Early Dynastic period was characterised by a complex network of competing city-states (Van De Mieroop 2015: 44). These city-states were eventually conquered and unified by Sargon of Akkad, who was the first to unify and rule Mesopotamia, and founder of the world's first empire (Foster 2015: xv). For the remaining three centuries of the 3rd millennium, control over southern Mesopotamia was held first by the city-state of Akkade (or Agade) in the 23rd and 22nd centuries (referred to as the Akkadian period) and then by the city-state of Ur in the 21st century (referred to as the Ur III period but occasionally also referred to as the Neo-Sumerian period). It is with these final three centuries of the 3rd millennium that the temporal coverage of this thesis begins.

The unification of city-states consolidated a new political structure in southern Mesopotamia; one with a goal of political, administrative, and ideological centralisation (Foster 2015: 275). This can be seen through various changes that occurred in the Akkadian period such as the switch from Sumerian to Akkadian as the language of administration, a greater level of centralised taxation, standardisation of weights and measures, and new accounting systems (McMahon 2012: 650). Military influence greatly expanded under the Akkadian kings, stretching far beyond southern Mesopotamia and into the wider Near East (Van De Mieroop 2015: 67). There exists a substantial and varied body of textual evidence from the Akkadian period and an extensive body of archaeological material. There are, however, issues of textual rewriting and intentional destruction of Akkadian material during subsequent periods to contend with, as well as persisting disagreement within the academic community regarding dating (Foster 2015: xv).

As briefly summarised by Foster (2015: 24-5), the fall of the Akkadian Empire is a topic that has found itself at the centre of significant debate. Weiss and Courty (1993) have stressed the possibility that a major contributing factor was abrupt climate change or 'desertification' causing the abandonment of the Habur Plains and large-scale population movement down through Mesopotamia causing a "sudden doubling of sedentary occupation in the south" (Weiss and Courty 1993: 144). In a recent study by Cookson *et al.* (2019), analysis of simulations from the HadCM3 climate model similarly demonstrated significant climate change in Mesopotamia. They concluded that regional aridification in combination with land mismanagement may have led to social disruption and the eventual collapse of the Akkadian empire. Yoffee (1991: 48) has instead laid blame on what he perceives to be the failure of the Akkadian ruling family to "integrate the traditional leadership of the city-states into the new venture of imperial expansion" and their preoccupation with foreign ventures to the detriment of internal problems.

Following the collapse of the Akkadian Empire, there was a loss of central control and a period of fragmented power thought to have lasted for approximately 50 years (Van De Mieroop 2015: 79). Centralised power re-emerged under the rule of Ur-Namma, founder of the Third Dynasty of Ur, with Ur as the capital. The geographic spread of the state extended from the Persian Gulf and upward to encompass most of southern Mesopotamia (Garfinkle 2013: 153). The region was further divided into provinces administered by governors who acted on behalf of the king (Van De Mieroop 2015: 81). The Ur III kings excelled in their exploitation of resources both locally and abroad, and in channelling them towards the crown and its clients (Garfinkle 2013: 164). Both Sumer and Akkad thrived economically throughout this period, and various royal building programmes demonstrate the availability of significant wealth (Van De Mieroop 2015: 82). Levels of urbanisation also rose; as did population density (Van De Mieroop 2015: 82).

This period of Mesopotamian history has provided an astounding quantity and variety of cuneiform documentation. More textual records exist from the century of Ur III rule than from any other period in Mesopotamian history (Zettler 2003: 49). These texts provide significant insight into economic life in particular, but also shed some light on other aspects including political structure and socially imposed values. Crucially, however, use of these texts should account for the fact that they are almost exclusively produced by the state and are therefore both biased and imbalanced in their coverage and representation (Van De Mieroop 2015: 81).

Similar to the Akkadian period, the Ur III period was one of political focus on state formation and centralisation (Van De Mieroop 2015: 81; Zettler 2003: 49). Garfinkle (2013: 154) has, however, cautioned that the textual sources and their sheer volume portray a stricter centralisation than appears to have existed. The Ur III kings relied heavily on local and regional elites that could be co-opted by the crown (Garfinkle 2013: 164). Various state-wide institutions remained fundamentally embedded in regional social networks and retained local control. Yoffee (1995: 295-6) argues that, rather than the success of the Ur III Dynasty occurring as a result of true centralisation of government, it occurred despite its absence. This appears to be further illustrated by the manner with which regions reverted to old habits and continued apparently undisrupted following the collapse of the Ur III state in 2004 B.C. As Van De Mieroop (2015: 86-7) highlights, “[this] would not have been possible had their economies become specialised and interdependent components of a single system”.

2.1.2 The 2nd Millennium B.C.

In the early 2nd millennium, the political geography of Mesopotamia was characterised by a complex mosaic of political power, previously referred to as a ‘heptarchy’, as opposed to a strict centralisation of authority (Gadd 1965: 188; Seri 2005: 29; Stone 2005: 141; Yoffee 1995: 296). The region was dominated by a handful of powerful states and rulers continuously vying for control, including the city-states of Isin, Larsa, Babylon, Uruk, Eshnunna, and Marad (Ur 2012: 546; Van De Mieroop 2015: 91). These were, however, fewer and larger than seen in the early to mid-3rd millennium. Moments of political centralisation were short-lived. Extensive textual evidence from the city of Mari, which was situated on the border between Babylonia and Syria, paints a picture of continuous warfare and precarious allegiances between kings (Van De Mieroop 2015: 91).

The early 2nd millennium was a period of abundant textual evidence, including epistolary, legal and administrative documents, as well as tablets shedding light on mathematics, divination, and literature (Boivin 2018: 1). The variety, quantity and distribution of textual sources has lead Ur (2012: 546) to suggest this was “perhaps the time of greatest literacy in Mesopotamian history”. Texts were produced not only by palaces and temples but also by smaller ‘households’[3]. A significant amount of archaeological evidence exists from the early 2nd millennium, however, the quality of excavation and standard of publication poses significant issues in terms of its availability and reliability (Philip *et al.* 1995: 119; Porada *et al.* 1992: 119). As argued by Philip *et al.* (1995: 119), understanding of the relationships between Mesopotamia and the material culture of its neighbouring regions during the early 2nd millennium has been considerably limited by the lack of reliable data from Mesopotamia for that period.

[3] As defined by Ur (2012: 545) the term ‘household’ was a “structuring metaphor” used in Mesopotamian society to refer to “buildings ranging in size from a single room to an entire palace, but also to social units like families, lineages, or dynasties, and also their property, including fields, animals, and slaves”.

Two key periods make up the early 2nd millennium in southern Mesopotamia: the Isin-Larsa period followed the Old Babylonian period. Over the first two centuries, dominance over southern Mesopotamia was fought for predominately between the two great city-states of Isin and Larsa. After years of power shifting between the two, Isin was finally defeated by Larsa under Rim-Sin, who added Isin's kingdoms into his own. As is the pattern in early 2nd millennium Mesopotamia, this centralisation of power was fleeting. In c. 1792, Hammurabi of Babylon seized the region, unifying southern Mesopotamia (Charpin 2012: 24). At the start of Hammurabi's reign, Babylon held only modest political sway, but through direct military intervention, political alliances and expansion of infrastructure with various building projects, Babylon under Hammurabi was transformed from a typical city-state to the centre of an empire (Gadd 1965: 176-184; Oppenheim 1977: 156-157; Van De Mieroop 2004: 111-119). Despite extensive work in pursuit of stable unification, which included the rehabilitation of the region's water systems and the Code of Hammurabi law codes, investigation of the available material demonstrates that in contrast to the general impression that stable unification was achieved, the reality was much more nuanced. Somewhat similar to that seen during the Ur III period, a degree of independence was maintained at settlements, and allegiances generally revolved around cities rather than the state (Richardson 2012; Van De Mieroop 2004: 79-80).

By the mid-2nd millennium, the landscape was one of severe political fragmentation, as the First Dynasty of Babylon lost control of southern Babylonia. Simultaneously, written and material sources become much sparser and, as discussed in Section 1.4, the period's chronology becomes far less clear. Mesopotamian history enters what is often referred to as a 'Dark Age' (Boivin 2018: 1; Van De Mieroop 2015: 122). The severe lack of textual and archaeological evidence from this period has resulted in it being one of the least understood periods of Mesopotamian history (Ur 2012: 550). Understanding is particularly limited for the 17th and 16th centuries B.C. (Podany 1996: 564). Where textual sources do exist, they are often contradictory. Richardson (2005: 282) argues that pursuing a better understanding of the countryside is imperative to improving our understanding of the period. Notably, Richardson (2005: 283) hypothesises that rural fortresses developed a degree of economic and social autonomy and that this may have contributed to the political destabilisation of the hinterlands, and potentially the eventual fall of the First Dynasty of Babylon in 1595 B.C. Partially due to the long-standing urban bias within Mesopotamian archaeology, there are very few excavated rural sites of the early 2nd millennium. There are, however, two valuable excavated and published examples: Khirbit ed-Diniye (Haradum) (Kepinski-Lecomte 1992) and Tell Harmal (Shaduppum) (Baqir 1946, 1948, 1959; Hussein 1999, 2001; Hussein & Miglus 1998, 1999). These sites shed light on the existence of planned peripheral settlements with apparently high levels of political autonomy (see Joannès *et al.* 2006; Kepinski 2005; Kepinski-Lecomte 1992, 1996). They also contradict traditional assumptions about the nature of rural settlements; instead, they demonstrate the characteristics of an urban centre. Rather than the long-held view of a dichotomy between rural settlements and urban centres, the current evidence suggests highly similar functions at both small- and large-scale sites, and economic and social cohesion (Steinkeller 2007: 200-202).

As the Old Babylonian Dynasty began to lose control in the south, the region was once more left with a major power vacuum. While the Old Babylonian Dynasty continued to clutch onto power in the north, the south became what Boivin (2018: 1) has described as a "wasteland" following a rebellion against Samsuiluna, successor and son of Hammurabi. The first group to obtain power in the south was the Sealand Dynasty, an autonomous political entity which is understood to have overlapped with the end of the Old Babylonian Dynasty (Brinkman 2017: 6). There is much debate surrounding the geographic boundaries of the Sealand kingdom, but it appears to have controlled large amounts of southern Babylonia, including portions of the Euphrates and Tigris (Boivin 2018: 61). The Sealand Dynasty is known predominantly from occasional textual references in king lists and chronicles written much later (see Dougherty 1930; 1932; Gadd & Thompson 1936; Leemans 1957-58; Lambert 1974). More recently, however, 474 tablets dated to the Sealand Dynasty and held in the Schøyen private collection were controversially published by Dalley (2009) despite being unprovenanced. They predominantly shed light on the economic structure of the region under the Sealand kings, and the movement of commodities and materials. As a result of the political deterioration in the south alongside Old Babylonian control to the north, Sealand sites such as Tell Khaiber, which is included in this project, may well have been occupied contemporaneously with Old Babylonian sites and Old Babylonian occupation levels at more northerly sites.

The Sealand Dynasty came to an end when the last Sealand king, Eagamil, supposedly fled to Elam following defeat by Kassite king, Agum III in approximately 1475 B.C. (Grayson 1975; Zadok 1987: 13; van Koppen 2017: 74-77). The latter part of the 2nd millennium was politically dominated by the Kassite Dynasty. With a span of nearly 450 years, the Kassite Dynasty was the longest-running political dynasty in Mesopotamian history (Ur 2012: 550). There appears to be some overlap between the Sealand Dynasty and the early Kassite kings (Brinkman 2017: 6). Not only was the length of Kassite power impressive, but so, too, was their geographical hold. They occupied the region stretching from the Gulf up to the Zagros foothills. In terms of development and focus, however, the Kassites appear to have placed emphasis on the south, illustrated by extensive building projects and redevelopment of Sumerian centres (Brinkman 2017: 23). Despite the Kassites originating from outside of Mesopotamia, they adopted much of Mesopotamian culture, particularly Sumerian culture (Ur 2012: 550). The Kassite period has received highly limited focus in Near Eastern research, with archaeologists tending heavily to focus instead on earlier periods (Ur 2012: 550). This is partially a result of the fact that textual evidence from the Kassite period is sparse. The one major exception to this is an archive of 10,000 records from Nippur that are mostly unpublished and have received very little study (Ur 2012: 550).

2.2 Metallurgical Context

Due to the significant focus on composition throughout this thesis, it is important to contextualise these data in light of current knowledge on the sourcing and use of each of the main metals utilised in southern Mesopotamia between 2300 and 1300 B.C. Although kept brief and concise, the background provided here will aid understanding during Chapters 5 and 6, as well as provide the necessary context to central topics of discussion in Chapters 7 and 8 such as metal procurement, metalworking practices and materiality-related approaches to alloying.

As noted by Muhly (1973: 220), archaeological and textual evidence from various sites around Mesopotamia, including Uruk and Ur, demonstrated that an impressive Mesopotamian metal industry was already in existence in the early 3rd millennium. By the middle of the millennium, the rich body of metalwork uncovered from the so-called Royal Tombs at Ur evidenced “knowledge of virtually every type of metallurgical phenomenon except the hardening of steel that was exploited by technologists in the entire period up to the end of the 19th century A.D." (Smith 1970: 499).

The temporal focus of this thesis, therefore, begins at a point where the metallurgical industry in southern Mesopotamia is already considerably advanced. The metals used throughout this period were primarily copper, lead, gold, silver and tin. This section provides a succinct overview of each metal type.

2.2.1 Copper and Copper Alloys

Of the main metals used within Bronze Age southern Mesopotamia, copper and its alloys were by far the most widely used, owing to the wider availably of copper ore deposits, copper's lower price compared to other metals, its lower melting point and decreased metal porosity (Garfinkel *et al.* 2014; Patterson 1971; Powell 1990, 1996; Moorey 1988; Oudbashi *et al.* 2020; Radivojević 2017; Rahmstorf 2017: 195). The range of objects made from copper and its alloys from Mesopotamia is incredibly vast, including weapons, tools, utensils, dress, grooming instruments, jewellery and personal adornment, and various other object type categories (Moorey 1994: 254).

Within early research, the place names of Dilmun, Magan and Meluhha were drawn from Mesopotamian textual evidence as key areas related to copper sources and trade. Although matching place names in texts with geographical locations is highly challenging, it is now generally believed that Dilmun corresponds to the Upper Gulf, particularly the island of Bahrein, Magan to the Lower Gulf, particularly modern Oman, and Meluhha to the greater Indus Valley (for further discussion see Bibby 1969; Edens 1992; Glassner 1996; Oppenheim 1954; Potts 1990; Weisgerber 1983, 1991).

Of the three regions, Magan/Oman is the region most clear to be an actual source of Mesopotamian copper (Giardino 2019; Steinkeller 2013). Magan is referenced in Mesopotamian texts from the Akkadian period to the end of the Ur III period (Weeks 2016: 14). In these references, it is frequently mentioned that Magan was the supplier for part of Mesopotamia's copper (Begemann *et al.* 2010: 135; Potts 1990: 165-9). Extensive fieldwork in the eastern region of Oman has provided substantial archaeological and geological evidence for large-scale copper production from at least the middle of the 3rd millennium B.C. (Weisgerber 1981; 1983; Hauptmann 1985). Using the results of both chemical and lead isotope analyses of Mesopotamian metalwork, Begemann *et al.* (2010) found metal bearing an Omani signature dating to all cultural periods between the Uruk period and the Akkadian period. Their results indicate that between the Early Dynastic III and Akkadian periods, as much as half of the metal appears to have had an Omani source.

After the Ur III period, references to Magan in cuneiform sources substantially decline, with emphasis falling instead on the role of Dilmun in Mesopotamia's procurement of copper (Crawford 1998; Potts 1990: 168; Weeks 2016: 14). Based on textual evidence, including a particularly notable group of Isin-Larsa period texts from Ur which appear to list materials to be exchanged, it is currently understood that Dilmun was an important trading post in the acquisition of copper in the first quarter of the 2nd millennium B.C. (Begemann *et al.* 2010: 136; Muhly 1973: 221). Dilmun did not appear to produce copper itself; instead, it has been described as a 'middleman' within a complex trade network involving southern Mesopotamia, Oman and the Indus Valley (Crawford 1996: 13). Another important group of texts relating to copper trade and Dilmun are the letters written to a merchant named Ea-nasir dating to c. 1750 B.C. These letters contain complaints concerning the quality of copper ingots provided, describing them as "good" versus "bad"; a subject matter that will be revisited in greater depth in Chapter 7. Copper trade at this point in time was on a vast scale, with merchant's texts recording the movement of copper by the tonne (Leemans 1960; Oppenheim 1954).

Figure 2.1: Map of the eastern Mediterranean and Middle East region.

Despite Omani copper comprising a large percentage of the copper in southern Mesopotamia, it does not account for it all. Another significant potential source of copper for southern Mesopotamia is Iran. The Talmessi mine, located in Anarak in central western Iran, has been suggested due to its arsenic-rich copper and the dominance of arsenic-copper alloys throughout Western Asia at this time (Potts 1990: 165), Aside from the Talmessi mine, Weeks (2016: 13) has argued that previous models of Gulf exchange systems have failed to incorporate archaeological evidence of Iranian materials throughout the Persian Gulf to the same degree that evidence from Oman, Bahrain and the Indus have been incorporated. Indeed, significant archaeological and geological evidence indicates significant copper production, including production centres in southeastern Iran which have been dated to the 5th, 4th and 3rd millennium B.C. (Frame 2012; Hakemi 1997; Hauptmann *et al.* 2003; Pigott 1999; Pigott & Lechtman 2003), and as many as 70 sites dating to the 3rd millennium in the Halil Rud region of southeastern Iran have been found to contain surface evidence of metallurgy (Madjidzadeh 2008: 73; Weeks 2016: 16).

Following the end of the Isin-Larsa period, references to Dilmun in southern Mesopotamian texts become far less common, and Mesopotamian copper sources appear to shift dramatically away from Oman (Begemann *et al.* 2010, 137; Weisgerber 2007). Several potential contributing factors have been suggested to explain this change. Rim-Sin of Larsa, who reigned from 1822 B.C. to 1763 B.C., pursued the designation of Larsa as the commercial centre of southern Mesopotamia, replacing Ur which had previously occupied this position and had been the major port involved with trade up the Gulf (Crawford 1996: 16). Hammurabi, who succeeded Rim-Sin, seized control of the whole of the middle Euphrates following his sacking of Mari; subsequently also gaining control of trade along this crucial portion of river (Crawford 1996: 16). This allowed new trade routes to be established with much more northerly points, providing Babylon with access to mines in Anatolia. Contemporaneously, Cyprus was gaining significant prominence as a supplier of copper throughout the Mediterranean and in parts of the Near East, and these new trade connections would have also allowed Babylonian access to Cypriot copper (Begemann *et al.* 2010, 137; Potts 1990: 168). By the middle of the 18th century B.C., Cyprus began appearing in cuneiform texts. From this point onwards, Cyprus and Anatolia appear to be particularly central to the supply of copper to Mesopotamia (Potts 1990: 168).

The majority of Mesopotamian metal was most likely produced from sulphide ores, as these are by far the most common type of ores found in the copper deposits of Oman, Cyprus, Anatolia and Iran (De Ryck *et al.* 2005: 261; Hauptmann 1985: 25; Muhly 1973:171). As discussed by Muhly (1973:171), most early smelting of sulphide ores was probably done in two stages. The first stage reduces the raw ore down to a material known as *matte*, an impure mixture of copper and copper sulphide. To further refine the *matte* into a pure enough metal to be used, a second stage of processing is required, wherein the *matte* is roasted to oxide and then reduced using charcoal. Iron-bearing sulphide ores are even more difficult than regular sulphide ores to process, and it is possible that some iron content could remain, even after two-stage processing (Potts 1997: 168).

It is generally believed that copper was exported to Mesopotamia in an already processed form, ready for further working into a finished object (see Moorey 1994: 242). This is influenced by the understanding that smelting nearly always occurs near the source region due to the high cost involved with transporting raw ore. Evidence of smelting at various key copper sources such as those in Oman further supports this understanding (e.g. see

Begemann *et al.* 2010); as does archaeological evidence in the form of copper ingots found in southern Mesopotamia, and references to ingots in cuneiform sources (Muhly 1973: 221). There is, however, a regular distinction made in Mesopotamian textual sources between refined *(urudu-luh-ha)* and unrefined *(urudu)* copper (Potts 1997: 168-9). It has been argued by Potts (1997: 168-9) that this distinction in the texts, as well as that between "good" and "bad" copper, indicates that the metal being imported into, and transported around, Mesopotamia was not solely processed metal ready for working, but also included metal which had only received the first stage of processing and was still in the form of *matte*. This is supported by a potential piece of *matte* found at Nimrud (see Moorey *et al.* 1988 for results of analysis).

Not only did copper occupy a key role in Bronze Age Mesopotamian metalwork, but so, too, did copper alloys. The two most common copper alloys were arsenic-copper alloys such as arsenic bronze, and tin-copper alloys such as tin bronze. Arsenic-copper alloys were commonly in use throughout Mesopotamia from approximately the end of the 4th or the beginning of the 3rd millennium B.C. until the late Bronze Age (De Ryck *et al.* 2005: 261-2; Wischnewski 2017: 212). Use of tin bronze began in the middle of the 3rd millennium B.C., but it was not widely used until approximately 1500 B.C. when it has been argued that it replaced arsenic-copper alloys (De Ryck *et al.* 2005: 261-2; Wischnewski 2017: 212).

Alloys can be intentional or inadvertent, and disagreement persists regarding the intentionality of arsenic-copper alloys both within and beyond Mesopotamia. As copper ores often contain arsenic, arsenic-copper alloys occur commonly in nature. Furthermore, arsenic content in arsenic-copper alloys varies considerably (De Ryck *et al.* 2005: 262). It is therefore impossible to assess, based on composition alone, whether an arsenic-copper alloy was intentionally alloyed or natural (Lechtman 1996; Lechtman & Klein 1999; Moorey 1994: 242). As Moorey (1994: 242) highlights, a word for 'arsenic' in Sumerian or Akkadian textual sources has yet to be reliably identified, suggesting that arsenic may not have been recognised as a native metal at that point in time. This is echoed by Muhly (1999: 15) who emphasises the improbability that metallic arsenic was deliberately alloyed with copper and contends instead that any arsenic content in Mesopotamian copper is either from arsenic-bearing copper ores or the inclusion of arsenic-rich minerals. Arguments in favour of intentional alloying of copper and arsenic in Mesopotamia, whether through the use of metallic arsenic or arsenic-rich minerals, predominantly focus on the substantial improvements provided by intentional alloying (for example, Frangipane 2017: 172). The addition of arsenic brings about various changes to the physical and visual properties of copper. Visually, copper takes on a silvery appearance, and one of increased brilliance (Frangipane 2017: 171; Hansen 2017: 140; Hosier 1995). Regarding workability and durability, the addition of arsenic creates a harder metal with greater elasticity, and one with improved flow leading to better workability (Allen *et al.* 1951; Hansen 2017: 140; Junk 2003; Lechtman 1996: 494). It is not within the scope or aims of this project to delve further into evaluating the intentionality of arsenic-copper alloys and, due to the inability to reliably determine intentionality based on composition alone, a general stance of ambiguity is assumed within this project. Exact definitions of how arsenic bronze is defined in this thesis is set out in Chapter 4.

The limited occurrence of tin in nature, particularly in the Near East, makes the intentionality of copper-tin alloying far less ambiguous. It is possible for copper from some source zones to contain tin due to an occurrence of tin alongside copper ores. In southwestern Afghanistan, for example, tin levels can produce a composition of ≥2% tin (Cleuziou & Berthound 1982: 15). In Southwest and Southcentral Asia, however, it is rare for tin to jointly occur with copper ores (Stech 1999: 62). It is therefore typically believed that even low levels of tin in copper were deliberately alloyed. The optimal composition for tin bronze, in terms of facilitating the best cold working, hot working and casting, lies between 8% and 12% tin (Salzmann *et al.* 2016: 142). Lower concentrations, however, are still sufficient to significantly alter the properties of the copper. It is at only 2% tin that copper becomes noticeably harder and stronger (Stech 1999: 62). As a result of this, and to reduce the possibility of attributing inadvertently produced tin-copper alloys with intentional tin-copper alloys, 2% has widely been used as the boundary between natural and artificial tin copper alloy (Rahmstorf 2017: 185). Arguments have been made for categorising copper with tin content as low as 1% as tin bronze (for example Chernykh 1966; Pollard 2018); but for the purposes of this thesis, 2% shall be used throughout.

Tin bronze offers several advantages over arsenic bronze; most prominently, it possesses greater structural strength allowing for the creation of longer and more durable tools and weapons. Tin bronze is also more easily recycled and reused than arsenical copper, as the volatility of arsenic can result in its evaporation during smelting causing metal degradation as well as the production of toxic fumes (Greenfield 2017; Mödlinger *et al.* 2017). An apparent preference for arsenic bronze is still typically found at Mesopotamian sites throughout the Bronze Age, however, and the adoption of tin bronze appears to have happened very gradually despite its advantages (De Ryck *et al.* 2005: 261-2; Wischnewski 2017: 212). Using material from the Royal Cemetery at Ur, Müller-Karpe (1991: 111) argued that tin bronze became the dominant alloy used throughout southern Mesopotamia by the ED IIIa period. Analyses of the Royal Cemetery material carried out by Pernicka and Paszthory and the University of Pennsylvania for their *Mesopotamian Metals Project* do indeed demonstrate large amounts of tin bronze objects from the site, yet these results are based on small samples and the material from the Royal Cemetery at Ur is most certainly not representative of everyday metalwork. Further research has instead demonstrated that tin bronze, at least until the mid- to late-2nd millennium, was not as common as originally assumed (De Ryck *et al.* 2005: 261-2; Wischnewski 2017: 211-2). Wischnewski (2017: 195) has also highlighted high levels of variation in the presence of tin bronze at different sites, but significant further examination of potential patterns has yet to feature in previous literature. One general pattern identified concerning object types, however, is that cast objects such as weapons and tools appear to be more likely to be made of arsenic bronze, while metal vessels are more likely to be made of tin bronze (Cuénod *et al.* 2015: 25-6; Müller-Karpe 1993; Potts 1997: 170). Most interesting about this pattern is that, based on the difference in strengths and weaknesses between tin bronze and arsenic bronze, it would be more logical for this to be the reverse (Cuénod *et al.* 2015: 25-6). Müller-Karpe (1993) suggests that the scarcity of tin may have given it a high status, resulting in a preference for using tin bronze for the creation of 'elite' vessels over the use of arsenical bronze. Alternatively, it may have been possible to achieve thinner sheet metal out of tin bronze and therefore to produce lighter vessels (Potts 1997: 170-1).

2.2.2 Tin

The relevance of tin to metalwork in the Near East rests predominantly on its role in the creation of tin bronze. Often referred to as 'the tin problem', the source of tin in the Near East has long been a highly debated topic (for example, Charles 1975; Cleuziou & Berthoud 1982; Crawford 1974; Cuénod *et al.* 2015; Dayton 1971; Muhly 1985; Nezafati *et al.* 2006; Weeks 1999, 2016). There exist very few tin deposits of substantial size between Eastern Europe and South and Central Asia (Weeks 2016: 17). In the 1970s, tin deposits were found in Afghanistan during expeditions led by Cleuziou and Berthoud and, in conjunction with textual references to tin sources in the east discussed further in this section, this led to Afghanistan seeming like a strong potential source for Mesopotamian tin. In the several decades since, identification of other deposits and research into their exploitation in antiquity has expanded further (see Alimov *et al.* 1998; Boroffka *et al.* 2002; Cleuziou & Berthoud 1982; Helwing 2009; Muhly 1973; Weeks 2004; Yener 2000). Notably, the work of Yener *et al.* (1989), Yener and Özbal (1987) and Yener and Vandiver (1993) has emphasised the possibility of potential exploitation of tin deposits in southern Anatolia, and more recently near Kültepe in Anatolia (Yener *et al.* 2015). Research by Nezafati *et al.* (2006, 2009) has also highlighted Deh Hosein mine in Iran as a major potential source.

Cuneiform texts regarding tin sources and transportation are sparse. Meluhha is named as a source of tin by Gudea of Lagash in the early 3rd millennium (Potts 1997: 174). In the late 3rd millennium there are references to tin of Magan, indicating that both copper and tin were sourced from Oman and may, therefore, have been moved along the same trade routes (Cohen 1975: 31). This appears to be supported by textual evidence from Ebla in Syria which mention Dilmun tin (Pettinato 1983: 77-8). Weeks (2016: 17) has highlighted textual references to the movement of finished tin bronze items which suggests that some of the tin bronze objects in southern Mesopotamia may have originally been made outside of the region (see Limet 1972: 14-17). Concerning the 2nd millennium, texts from Mari document tin moving in the form of ingots from Susa (Susiana) and Anshan (Elam) via donkey caravan, through Tell Asmar to get to Mari (Joannès 1991; Limet 1985; Moorey 1994: 299). The transmission of tin is noted as being not only a case of general trade but also of royal gift exchange (Moorey 1994: 299).

Regarding the use of tin outside of its use in making tin bronze, Moorey (1985: 127, 1994: 298) has highlighted textual references to the use of tin beads, bracelets and utensils. The only Bronze Age Mesopotamian objects currently identified purely as tin, however, are a group of bracelets from the Old Babylonian site of Tell ed-Der found in the graves of children (see Lerberghe 1984). As Moorey (1994: 301) observes, tin has a very similar appearance to silver, and the use of tin as personal ornaments may have been wider spread practice than we are currently aware. The scarcity, higher value, and apparent higher social status of tin would presumably have resulted in regular recycling, further reducing the likelihood of finding it in the archaeological record.

2.2.3 Silver

It is currently understood that argentiferous lead ores, from which silver can be extracted, were the source of most silver used throughout the Bronze Age, as opposed to silver ore itself. References to sources utilised for silver in Mesopotamian texts are sparse (Limet 1960: 94). However, Pettinato (1972: 80-1) identified several potential sources from his analysis of Sumerian textual evidence; these included Dilmun, Aratta, Marhashi, Elam and Meluhha. Anatolia also features in the texts as an important source of silver. Sargon of Akkad refers to an area in Anatolia as ‘silver mountain’, and other Old Assyrian sources note Anatolia as the source *par excellence* (Moorey 1985: 110-111; Potts 1997: 174). The best textual evidence for Mesopotamia using Anatolian silver begins in the early 2nd millennium B.C. (Moorey 1994: 234). Geologically, in addition to the Pontic mountains in Anatolia, silver sources could be found in the Upper Euphrates in the Taurus or Ergani regions, or from the Iranian plateau (Lehner & Yener 2014, 531–32, fig. 20.1; Sherratt 2018: 99). Sources during the Old Babylonian period are less clear, not least due to the severe lack of textual sources. There is, however, some evidence suggesting that silver was coming up the Gulf (see Oppenheim 1954).

The rarity of silver means, of course, that it is far less common than copper in the archaeological record. The repertoire of silver objects recovered includes vessels, personal adornments, small-scale statuary, pre-monetary currency and plating other materials such as wood (Moorey 1994: 238). Several silver objects from Mesopotamia have become particularly well-known. The vase of Entemena of Lagash, for example, found at Tello in southern Mesopotamia is probably the most famous silver artefact from the region. Compositional analysis of material from the Royal Tombs indicates that, from the middle of the 3rd millennium onwards, silver was regularly alloyed with copper (see Woolley 1934: 294). This was likely done to make the metal easier to work with, as pure silver is extremely soft. Silver also naturally occurs in nearly all gold and is therefore found in much of the goldwork from Mesopotamia.

Overall, Mesopotamian silver has received less attention and research than that copper and its alloys. Where research has occurred, it has predominantly focused on the role of silver as currency. Between the mid-3rd millennium and the end of the Old Babylonian period in the mid-2nd millennium, silver was used to express measurements of value (Van De Mieroop 2014: 21; Paoletti 2008: 128; Powell 1996: 228). This changes in the late 2nd millennium, with Powell (1990: 79-80) explaining:

> "After which we find both silver and gold as means of valuation, with gold seeming to predominate down to the end of the Bronze Age (at least in the surviving sources), when silver emerges once again as the standard metal money. Exactly what this 'gold interlude' means is still unclear."

Textual evidence demonstrates the existence of ideal equivalences between silver and not just other metals, but other commodities in general such as oil, bitumen, wool and salt (Van De Mieroop 2014: 21). In the Ur III and Old Babylonian periods, there are references to 'ring money'. This has been interpreted as metal, often silver, kept in the form of rings or coils, from which small sections may have been cut to use as payment (Krauss *et al.* 1983; Powell, 1978, 1996: 235; Sollberger 1965; Van De Mieroop 2014: 24). This may be one possible explanation for hoards found of 'scrap' silver such as those from Tell Agrab, Tell Asmar, and Khafajah (Delougaz 1967: 45) which date to the Early Dynastic and Akkadian periods, those at Larsa (Parrot 1933; Arnaud *et al.* 1979) which date to the Old Babylonian period, and one from Nippur (McCown 1967: 98, pl. 147: 1) which dates to the Old Assyrian period.

2.2.4 Lead

As with the majority of silver, lead would have been acquired through the exploitation of lead ores; presumably, therefore, sources for lead overlap considerably with those for silver (Potts 1997: 176). Archaeological and textual evidence from Mesopotamia demonstrate the employment of lead in creating vessels, pipes, weights and pendants, as sheets for covering both artefacts and structures, and in statuary to form the bases (Moorey 1985: 121). In the late 4th and early 3rd millennium, lead was clearly already readily accessible in southern Mesopotamia and subject to relatively intensive use. For example, Müller-Karpe (1993b) estimates that 51.6% of Jamdet Nasr vessels and 22% of Early Dynastic vessels were made of lead. Use of lead for vessels appears to severely decrease, however, in the 2nd millennium B.C. when it is succeeded by more extensive consumption of copper and its alloys (Stech 1999: 66).

Two particularly appealing attributes of lead are its shiny, metallic appearance, and the ease with which it can be obtained from the ore (Moorey 1994: 292). There is also evidence of lead being alloyed with copper and tin bronze to make leaded copper and leaded bronze respectively. Moorey (1985: 121) has argued for three key potential reasons for this:

> "to ease the filling of complex moulds; to lower the temperature to assist with casting in lengthy or slender moulds; or to assist the casting of several objects from one melt; and to increase the weight of metal available".

As highlighted by Philip (1991: 99), however, the inability of lead to dissolve in copper, forming discreet globules, can result in interface cracking when hammer worked. This would, of course, be problematic in the case of any objects requiring hammer-working, or indeed, as Philip describes, "in the case of weapons designed to take a sharp edge". It is therefore possible in these instances, that the objects were created more for display and status than for warfare (Philip 1989: 174).

2.2.5 Gold

Most of the goldwork found in southern Mesopotamia comes from the Early Dynastic III Royal Tombs at Ur and the royal graves at Nimrud dating to the Neo-Assyrian period (Moorey 1994: 221). The exceptions to this are sparse scatterings of gold fragments, sheet metal and small pieces of jewellery. As a result, archaeological understanding of the use of gold in Mesopotamia is based on a severely limited body of evidence. The stark contrast between this limited record and the rich bodies of metalwork discovered from the above sites has been observed by Potts (1997: 177), who highlights that while gold does occur in Mesopotamia prior to the Early Dynastic III period, the sudden appearance of such an impressive collection at Ur appears to be almost "explosive". Such limited evidence of gold is nearly certainly a result of its high status as a material; not just in Bronze Age Mesopotamia, resulting in regular recycling and only sparing deposition in graves, but also in later periods, resulting in it being plundered and looted from sites. This includes recent looting, which has resulted in potential pieces making their way into unprovenanced collections such as the Sackler collections.

Study of textual sources has provided extensive references to gold as a prestige material, and its uses predominantly centring on ceremonial purposes. For example, gold was typically used as religious offerings, gifts, personal adornment for individuals of high social status, or decoration of buildings (Moorey 1994: 221). The goldwork from the Royal Cemetery of Ur demonstrates evidence of an extraordinarily impressive range of techniques, including gilding, chasing, inlaying, casting, filigree work, cloisonne, hard soldering and granulation (Alexander 1976: 99-106; Potts 1997: 178). Despite there being only a very limited amount of gold predating this body of goldwork, it indicates that Mesopotamian smiths were highly skilled. In cuneiform sources, a distinction is made between different types of gold based on colour; for example, "red gold" is described in the texts as being twice as expensive as "bright gold" (Powell 1996: 230). Administrative documents of the Ur III period provide detailed information concerning metal processing and the qualities of gold used. More specifically, texts from the craft archive of Ur and the treasure archive of Puzriš-Dagān detail three different types of gold in terms of the quality, price and the object types for which each was used (Hauptmann *et al.* 2018: 113-4).

Textual references to the potential sources of Mesopotamian gold mention several different areas. Meluhha and the Ḫaḫum region which is located on the border between modern Syria and Turkey are mentioned in an inscription of Gudea of Lagash dated to the 22nd century B.C. (Hauptmann *et al.* 2018: 118). Moorey (1985: 73, 1994: 219) and Potts (1997: 178-9) have also mentioned references to Mardaman in southeastern Turkey, Egypt, and Harali, possibly located in Iran. Hauptmann *et al.* (2018: 118) have questioned these, however, arguing that the reference to Mardaman can now be safely excluded, and Harali may be a name substitute for Meluhha. Recent work (see Jansen *et al.* 2016) using geochemistry and osmium isotopes of inclusions in gold from Mesopotamia has indicated potential source zones of northern Afghanistan and Zarshouran (western Azerbaijan) in Iran, although it is highlighted that these results need further support from additional analyses. Notably, the deposits of northern Afghanistan are close to mines that were exploited for lapis lazuli (Hauptmann *et al.* 2018: 118).

2.2.6 Iron

The transition between the Bronze Age and Iron Age in the Near East is typically dated to 1200-1000 B.C., yet this is a very different phenomenon from that of the beginnings of iron use and extractive iron technology. Iron was used in Mesopotamia, and the wider Near East, throughout much of the Bronze Age, although it was a rare material used predominantly only for jewellery or ornamental and presentation objects (Erb-Satullo 2019: 557; Moorey 1985: 101). The high value of iron and its difficulty to obtain is referenced in Old Assyrian texts of the early 2nd millennium (Dercksen 2005; Larsen 2015: 118, 219; Veenhof 2016). In these sources, it is also mentioned that iron was only being traded in small quantities. In southern Mesopotamia specifically, iron is referenced as early as the Archaic texts from Uruk which date to the late 4th and early 3rd millennium B.C. (Vaiman 1982: 33-8). Use of iron increased dramatically at the start of the 1st millennium B.C., and soon became the main metal utilised in the manufacture of tools and weapons. Following the great expansion of iron use, iron became considerably cheaper; from the Neo-Babylonian period onwards, iron overtook copper as the cheapest metal (Moorey 1994: 242).

Iron can broadly be divided into two main categories: meteoric iron, which is metallic iron found in meteorites, or terrestrial iron, which is formed on earth and requires extraction from ore using smelting[4]. The main way to distinguish meteoric iron from terrestrial iron is through analysis of nickel content, as meteoric iron tends to possess high levels of nickel. Exact percentages vary slightly in the literature, but generally, a range of 6%-20% (see Yalçın 1999) or the somewhat wider 5%-35% (see Comelli *et al.* 2016) are used. In general, iron with nickel levels of below 5% is deemed to be terrestrial (Medenbach & El Goresy 1982: 358-66; Yalçın 1999: 180). The majority of recent high-quality analyses of iron objects that predate 2000 B.C. have demonstrated a meteoric source (see Comelli *et al.* 2016; Jambon 2017; Johnson *et al.* 2013; Rehren *et al.* 2013).

It should also be noted that iron can be produced as a by-product of smelting copper or lead (see Cooke & Aschenbrenner 1975; Gale *et al.* 1990). As Moorey (1994: 279) explains:

[4] Metallic iron does also occur in extremely rare terrestrial deposits of native (telluric) metal, but the only known deposit is located in Greenland.

> "If iron oxide in any one of its three forms (haematite; limonite; magnetite) was accidentally or deliberately added to the furnace charge as a fluxing agent, in smelting copper or lead, the iron would combine with the silica in the ore to form slag the would melt and eventually run off. In circumstances of high temperature and extreme reducing atmosphere, small bits of relatively pure iron would have been produced"

It is, therefore, possible that some of the early pieces of iron found which are compositionally terrestrial, but which do not seem likely to have been smelted, are the by-product of copper or lead smelting.

The origin of iron smelting in the Near East has received significant research in recent years (see Charlton *et al.* 2010, 2013; Charlton & Humphris 2019; Killick 2015; Lam 2014; Radivojević 2015; Roberts & Radivojević 2015). The most robust textual, archaeological and analytical evidence for early smelted iron currently comes from Anatolia in the early 2nd millennium B.C.; subsequently, this has been pinpointed as the most likely origin of iron extractive technology (Erb-Satullo 2019). However, there is a dearth of analytical work on early iron objects, therefore it has been emphasised by Erb-Satullo (2019: 566) that alongside further research this picture could change.

There is very little surviving iron from the Bronze Age in southern Mesopotamia. Of course, this is mainly due to its rarity, resulting in only a small amount in circulation, as well as the likelihood that it would have been regularly recycled due to its lack of availability. A further contributing factor is how poorly iron preserves in the ground, particularly in the high saline type of ground found in southern Iraq. Due to the lack of material and the known rarity of iron, iron in Bronze Age Mesopotamia has received very little previous research.

The sparsity of iron objects means that they do not feature prominently in this study, however, low iron content is found in compositional readings of large amounts of metal from Mesopotamia and is observed in the material used in this project (see Chapter 5). There are two main potential explanations for this. The first is that small amounts of iron content can be the result of contamination affecting the compositional reading. This most commonly occurs when some soil remains on the surface of the object, often consolidated into surface corrosion and remaining even after conservation (see, for example, Notis *et al.* 2007). In instances of soil contamination, it would be reasonable to also expect an elevated level of other elements that would be found in the soil such as calcium, aluminium, silicon, potassium and titanium. In some cases, a surface corrosion layer can be created in the ground through a complex interaction between the copper object, iron content in the surrounding soil, and the production of sulphur caused by the decomposition of surrounding organic matter in an environment that is nearly entirely lacking oxygen (see Ingo *et al.* 2006: 584-5). In these instances, however, a visible “dull, brilliant and gold-like” layer is visible on the surface, and Ingo *et al.* (2006: 584) note that this occurs only rarely. The second explanation is that of iron from the ore used remaining in the finished object. Iron is universally present in copper ores (Pollard 2018: 20) and, as discussed in Section 2.2.1, the use of iron-bearing sulphide ores in particular means that significant iron content may remain after processing, either because the material analysed is actually *matte*, or, most commonly, because even the full two-stage processing was not enough to remove all of the stubborn iron content (Potts 1997: 168). The presence of iron in entire, or near entire, bodies of copper alloy objects as a result of remaining iron content after processing has similarly been found and discussed elsewhere (see, for example, Charalambous *et al.* 2014; Fernandes *et al.* 2013: 4).

Part I

Utilising Traditional Approaches to Metallurgy

Chapter 3

Approaching Southern Mesopotamian Metalwork

As outlined in Chapter 1, the central aims of this thesis do not purely revolve around the contribution of new data, analyses and interpretations, and a subsequently improved understanding. At the heart of this thesis is also a much-needed examination of the way Mesopotamian metalwork has been, and continues to be, approached during both excavation and subsequent study and analysis. This thesis strives to highlight why it is critical that we re-evaluate our handling of Mesopotamian metalwork, and demonstrate new, alternative approaches and avenues of potential. This chapter, therefore, seeks to position this project within its wider intellectual context by presenting and discussing the research background on which it is built, and delving further into the key issues that this thesis aims to address and begin correcting.

The previous study of Mesopotamian metalwork has been strongly shaped, but also significantly limited, by both traditional frameworks in the wider field of archaeometallurgy and traditional frameworks within the field of Mesopotamian archaeology. Section 3.1 examines broader, foundational research traditions, approaches, themes and theoretical frameworks within the field of archaeometallurgy which significantly influenced early archaeometallurgical research in Mesopotamia. In section 3.2., focus narrows to centre on Mesopotamian archaeology and archaeometallurgy specifically, providing an overview and critical evaluation of the available body of material and how it has previously been studied. It should be highlighted that in addition to the intellectual context provided in this chapter, further intellectual context is included in various later chapters of this thesis where relevant; particularly, in Chapter 4 concerning chemical analysis and its applications within archaeology, and Chapters 7 and 8 concerning alternative approaches to interpretation.

3.1 Studying Ancient Metalwork: Approaches, Research Foci and Theoretical Frameworks

Archaeometallurgy is the study of all aspects of the production, use and consumption of metal from the beginning of human metal use approximately 8000 B.C. to the present day (Killick & Fenn 2012: 559). It is an exceptionally interdisciplinary field, utilising the work of a variety of professions and specialists, from geologists, material scientists, chemists and physicists, to mining engineers, goldsmiths and blacksmiths. The very beginnings of archaeometallurgy as a field of study can be traced back to the 19th century, with the work of scientists such as British metallurgist John Percy (Thornton & Roberts 2014: 5). This early period in the history of archaeometallurgy has been termed by Thornton (2009) as the first of three waves that characterise the progression of the discipline. The second wave he defines as encompassing the influential theories of Engels (1884) and Marx (1857) concerning their conceptualisation of metals as indicators of social evolutionary stages. Following this direction of thought came the prominent work of archaeologist V. Gordon Childe (particularly 1930, 1936, 1944) regarding social evolution and technological advancement with particular emphasis on metals. Partially as a result of Childe's work, archaeological research into metalwork became far more popular and much more widely studied by the mid-20th century. Thornton defines the third wave as beginning in the 1970s, and considers the first true archaeometallurgical paradigm to have been created in the 1970s and 1980s (Thornton 2009: 25). This crucial period of advancement within archaeometallurgical theory and practice is characterised by the work of a wealth of key scholars; for example, Ronald Tylecoat and Beno Rothenberg in the UK, and Cyril Stanley Smith, Martha Goodway, Heather Lechtman, Robert Maddin, Tamara Stech and James Muhly in the US (Thornton & Roberts 2014: 5). In the decades that followed, archaeometallurgy as a research field has continued to expand and evolve substantially, particularly in light of improved scientific capabilities, and changing theoretical schools of thought.

This section is organised into two halves: the first, 3.1.1, examines traditional areas of focus within archaeometallurgy and the early expansion of scientific analysis, and the second, 3.1.2, discusses changing archaeological paradigms, the integration of sociological theory, and recent theoretical and methodological developments.

3.1.1 Traditional Areas of Focus and Expansion of Scientific Analysis

For much of the existence of the field of archaeometallurgy, certain topics have dominated research; namely, function, provenance and the origins of metallurgy. These topics align well with the early functionalist, functional-processual and processual archaeologies that heavily influenced archaeological research for much of the 20th century (see Trigger 2006: 314-483). Archaeometallurgy has often been, and often continues to be, defined in a manner which solely emphasises the study of ancient metallurgical technology (Thornton 2009: 26). Problematically, this definition typically excludes the crucial human aspect of producing, using and interacting with metal objects. Undoubtedly, the topics of technology, provenance and metallurgical development are highly valuable areas of investigation. Decades of emphasis on these topics have produced a large body of crucial archaeometallurgical work that has progressed the subject in various ways, yet, as discussed in this section, there have also been adverse consequences of this heavy focus. The way these topics have been approached for a significant length of archaeometallurgy's history, and the theoretical structures that typically underpinned this research, have also frequently produced a view of past metal use and metallurgy that we now know is limited and often lacking in nuance.

The origins of metallurgy has been a central topic in the field of archaeometallurgy since its inception and has had a substantial impact on the previous archaeometallurgical study of Mesopotamian metal. A major driving force behind this emphasis has been evolutionism. Fundamental to the dominating anthropological theories of social and cultural evolution in the 19th century, was unilineal evolutionism; the notion that social evolution progresses in stages from 'primitive' to 'civilised' (Barnard 2022: 30). Heavily inspired by evolutionist theory and notions of unilineal progress, influential archaeologist V. Gordon Childe applied these concepts to the study of human prehistory and the 'progression' of civilisation in a broad body of work published in the early to mid-20th century. A significant element of Childe's theories was that of metallurgical technology and metal use, arguing (see 1930, 1939, 1944 in particular) that metal was essential to social complexity. In his 1944 publication titled 'Archaeological ages as technological stages', Childe presented a sequence of technological, and predominantly metallurgical, advancements and the sociological implications that he believed were tied to them. Naturally, this emphasis on the notion of metallurgical technology as a measure of unilineal progression resulted in a strong focus placed on the study of the origins of metallurgy, and the understanding that civilisation began in the Fertile Crescent drew Mesopotamia into some of these early discussions (Amzallag 2009: 497; Courcier 2014: 582). Further inspiring focus on metal in Mesopotamia at this point was the rich body of metalwork uncovered from the southern Mesopotamian site of Ur in the 1920s and 1930s during Woolley's excavations. Nevertheless, this early focus was short-lived. The origins of metallurgy remained a central point of focus within archaeometallurgy throughout much of the latter half of the 20th century, and as research concentrated on investigating initial processes of metal exploitation and the development of support technologies, places such as Mesopotamia which were devoid of native ores were eclipsed by regions such as Anatolia, the Negev and Sinai, and Iran (Moorey 1982: 13).

A major debate dominating much of archaeometallurgical research in the latter half of the 20th century was that between diffusion and independent innovation. Diffusionism, as an anthropological concept, can be defined as "the transmission of things (material or otherwise) from one culture to another, one people to another, or one place to another" (Barnard 2022: 48). Alternatively, independent innovation refers to innovation occurring without influence from external cultures, peoples or places. Concerning metallurgy, the application of these concepts relates to whether metallurgy was originally innovated in one place followed by the diffusion of this technology outward to other places and peoples, or whether metallurgy was independently innovated in multiple different places. In the early 20th century, Childe (1944) argued that, due to the complexity of copper metallurgy, it could not have been innovated more than once. He believed that metallurgy was innovated in the Near East, and then knowledge of metallurgy dispersed outward. Arguments in the latter half of the 20th century had generally become more nuanced than Childe's original interpretations, particularly in light of new methods of scientific analysis. Based on spatial distribution of early calibrated radiocarbon dates, Renfrew (1969) identified the Near East, the Balkans, and Iberia as three separate locations where he argued metallurgy was independently innovated. Key figures in Near Eastern archaeometallurgy specifically who waded significantly into these debates include Stronach (1957), a proponent of independent innovation in Anatolia, and Muhly (1980, 1988) who argued in favour of cultural evolution and diffusionism. These debates also covered the direction that the innovation of metallurgy took. Most notably, Wertime (1964, 1973) and Charles (1980) proposed a unilineal evolutionary sequence for metallurgy which proposed that anywhere metallurgy was innovated, it would always follow the same sequence of beginning with native copper, then moving to smelted copper, then to arsenical copper and finally to tin bronze. Within Near Eastern archaeometallurgy, this strong focus on the origins of metallurgy and debates around diffusion and independent innovation attracted criticism from scholars (for example, Gale *et al.* 1985; Yakar 1984, 1985a, 1985b) who felt that the continued focus on already known information and re-evaluation of previous conclusions concerning the development of metallurgy and early production centres was greatly hindering the progression of the discipline. As Moorey (1982: 13) also critiques, the persistent focus on the origins of metallurgy resulted in a significant degree of comparative neglect within the archaeometallurgical study of regions such as Mesopotamia.

In modern research, the field of archaeometallurgy has moved away from the heavy influence of unilineal evolutionism and the concept that technological advancement is fundamentally connected to social or cultural progression[5]. Indeed, many recent publications have emphasised the *in*significance of early adoption of metallurgy (see Bartelheim 2007; Kienlin 2010). Research concerning the early use of metallurgy has generally become more nuanced, shifting from a strong emphasis on the notion of 'origins' to exploring concepts such as adoption and adaption (Roberts & Thornton 2014: 2). Recent work has recognised and demonstrated the highly complex, multi-faceted realities of early metallurgical development, a key example of which is Yener's seminal 2001 publication on early metallurgy in Anatolia. Despite this progression, however, decades of limited overall archaeometallurgical focus on Mesopotamia has significantly contributed to a degree of methodological and theoretical stagnation within the study of the region's metalwork; an issue which will be discussed in depth in section 3.2 of this chapter.

The avenues of function and provenance have also been prominent within archaeometallurgy since its infancy. Research into these topics expanded dramatically alongside the scientific advances of the latter half of the 20th century. The application of scientific methods to the analysis of metal can be traced back to the late 18th century when Martin Heinrich Klaproth conducted and published the first quantitative analysis of a metal alloy (Pernicka 2014: 239). Scientific analysis of metalwork experienced an explosive expansion from the 1960s onwards, however, following a period that Kristiansen (2014)

[5] Although, see Kienlin 2016, for example, on continued shortcomings of evolutionist theory in the study of early metallurgy.

has termed the ‘Second Scientific Revolution’ in archaeology. This occurred within the wider context of a shift in archaeological theory throughout Anglo-American practice away from ‘Culture History’ and towards ‘New Archaeology’, now typically referred to as ‘Processual Archaeology’ (for an in-depth discussion, see Trigger 1996). A key element of the processual archaeology movement was a strong emphasis on the use of the scientific method. As a result, the utilisation of scientific approaches and methods within archaeology vastly increased, and one major direction in which this occurred was in the study of pyro-technologies such as ceramic firing, and glass and metalworking (Pigott 1996: 139). With new technology and analytical techniques and approaches came new potential regarding the types and depth of information that could be obtained from archaeological metal.

Scientific analysis of metalwork within archaeometallurgical research, particularly within Near Eastern archaeometallurgy, has focused primarily on the topics of function, composition, and identifying sources for raw materials (Hansen 2017: 137; Pigott 1996: 139). Theoretically, approaches have tended to overlap strongly with those of processual archaeology and a ‘macro’ archaeology approach which prioritises understanding of large-scale processes. Over the last 50 years, there have been various important studies and research projects within the realm of Near Eastern archaeometallurgy that have furthered current understanding of the beginnings of metallurgy, the location of early ore deposits, and the technology behind copper alloys and iron. Particularly notable examples include the Wertime Expeditions throughout Iran undertaken by Theodore A. Wertime in the 1960s, the publications of which not only shed substantial light on metallurgy in ancient Iran but also heavily influenced wider theoretical approaches in archaeometallurgy (see Wertime 1964, 1968, 1973), the work of the Deutshes Bergbau-Museum in Oman which provided substantial evidence of Bronze Age copper production and thus supported previous hypotheses that Oman corresponds to Magan in Mesopotamian texts (see Hauptman 1985; Hauptman *et al.* 1988; Weisgerber 1977, 1980, 1981), and the Max-Planck Institute Survey in Anatolia which provided, among other results, a comprehensive database of ore samples for ‘geo-fingerprinting’ to provenance metal (see Pernicka *et al.* 1984; Seelinger *et al.* 1985; Wagner *et al.* 1989)[6].

[6] For an overview of each of these projects and others see Pigott (1996: 139-176) and for more in-depth discussion refer to the original publications provided here.

Despite the value that these particular research projects have brought to Near Eastern archaeometallurgy, this is certainly not the case for all research focusing on these topics. Much like Yakar's (1984, 1985a, 1985b) observations on how preoccupation with the origins of metallurgy stilted the growth of the discipline, so, too, does preoccupation with technology and provenance as it results in an overshadowing of various other research avenues that are integral to our understanding. Fundamentally, however, the key issue is less that these topics have received such emphasis, and more that the rooting of much of this work in functional-processualism and processualism resulted in approaches and research questions that revolved around a passive conceptualisation of material culture, and a lack of contextual and social underpinnings. Analysis of archaeological metalwork, and indeed any archaeological material, needs to be integrated into the wider social context that the object existed within and influenced to prove most useful in advancing archaeological understanding. As argued by Pigott (1996: 139-40), analysis of the physical makeup of archaeological metalwork should be undertaken with the primary aim of obtaining data that can be used to better reconstruct and understand the social world within which such technology was being created and used. Pigott (1996: 166) emphasises that Near Eastern archaeometallurgy must move beyond these topics and begin to instead utilise the available body of data in gaining a better understanding of metallurgical technologies in their wider sociocultural context.

3.1.2 Changing Paradigms, Material Culture and Materiality

Since the 1980s, greater focus within archaeology, and particularly in theoretical discussions within the field, has fallen on the integral role of material objects in the social and economic systems of the past. Changing theoretical paradigms within the discipline, notably from processualism to post-processualism, propelled the advancement of theoretical approaches towards the interpretation of material culture. Within processual models of the past, material culture was typically designated with a passive role, viewed as the outcome of economic and adaptive concerns of their wider social groups (Jones 2004: 328). Processual approaches typically utilised a 'macro' archaeological approach and emphasised 'systems thinking' (Johnson 2010: 24-5). This allowed archaeologists to more clearly identify and understand large-scale social and economic systems, but it also resulted in limited focus on a more contextual and specific study of material culture.

Another major emphasis in processual archaeology fell on the effort to make archaeology more scientific. As a result, strong focus was placed on using the scientific method and scientific analytical approaches, and on the collection and use of quantitative data (Johnson 2010: 22).

Shanks and Tilley (1987:77), key figures in the post-processual movement, notably criticised processual archaeology for "dehumanis[ing]" the past. A criticism similarly vocalised by others (for example Leone 1986: 432). As a response to this, and various other perceived flaws of processualism, post-processualism was designed, drawing from anthropological theory, to emphasise the active role of individuals, materials and the archaeologist in the present (Shackel & Little 1992: 6). Early post-processual models of the past highlighted the active and integral role of material culture in the creation and shaping of social relations (see Hodder & Hutson 1986). Much greater focus also fell on meaning, historical context and change, and social and physical environment (Shackel & Little 1992: 6). In contrast to the 'macro' archaeological approaches utilised in processualism, post-processualist approaches tended to adopt a 'micro' perspective.[7]

In addition to, and often as a result of, these changing theoretical schools of thought, ethnoarchaeological research played an immense role in shaping the archaeological study of ancient materials and technology (Bisson *et al.* 2000; Budd & Taylor 1995; Kingery 1985; Thornton 2012: 174). A key example of how ethnoarchaeological work utilising post-processualist approaches advanced the archaeological study of material culture is the ethnoarchaeological surveys conducted by Ian Hodder and his students in sub-Saharan Africa (see Hodder 1982). While previous processual models had tended to view material culture simply as a reflection of socioeconomic structures, Hodder's work demonstrated a far more nuanced reality wherein material culture exists as an active element, able to be used to disguise, invert or distort social relations (Trigger 2006: 452-3). More specific to metalworking, the research undertaken on iron smelters in Africa (for example, Childs and Killick 1993; Herbert 1993; Schmidt 1997; van der Merwe and Avery 1987) played a substantial role in shaping archaeometallurgical approaches to the study of ancient technological behaviour (Thornton 2012: 174).

[7] More detailed and nuanced discussion of processualiam and post-processualism than can be included here can be found in the work by Trigger (2006: 386-483) and Johnson (2010).

As observed as early as 1935 by sociologist Marcel Mauss, even our most casual acts are socially determined and, therefore, so are our actions involving tools. Subsequent research into the anthropology and sociology of technology and technological behaviour has further demonstrated the fundamental importance of understanding the social context of technology. Conklin (1982: 16) said that technologies are the "material expression of cultural activity"; and yet, for decades, archaeologists tended to study material culture in isolation from the social phenomena that shaped the technology created, selected and used (Ingold 1997). As discussed in section 3.1.1 of this chapter, archaeological approaches to technology long centred on function or typological styles; yet, as highlighted by Lemonnier (1992: 3):

> "There are more subtle informational or symbolic aspects of technological systems that involve arbitrary choices of techniques, physical actions, materials, and so forth that are not simply dictated by function, but which are integral components of the larger symbolic system."

The early utilisation of approaches informed by anthropological and social theory within the field of archaeometallurgy can be found to some degree in the influential work of Cyril Stanley Smith, who famously repeated that "metallurgy is a fully human experience" (Killick & Fenn 2012: 569). In a string of papers (1970; 1971; 1978; 1981), Smith emphasised the relationship between technology and art, and the ability of technology to create material that possesses much greater cultural and social meaning than can be detected using scientific analysis alone. He also utilised an approach which would broadly fit into the realm of materiality in more modern discourse, arguing that pursuit of the origins of metallurgy should be sought through a focus on what he believed were the most important initial properties of metal: colour, lustre, tonality and ductility (see Smith 1970, 1981). It was not until the 1990s, however, that archaeometallurgists began to more widely utilise sociological theories of technology and technological behaviour in their research. Many archaeometallurgists adopted the approaches of the North American Smith-Lechtman school of technology and behaviour which emphasises studying ancient metalwork through both scientific and anthropological methods of inquiry (for example, Childs 1991; Epstein 1993; Friedman 1998; Hosler 1994).

In a 1991 paper, metallurgist Martha Goodway contended that the field of archaeometallurgy was undergoing a paradigm shift, wherein focus was shifting "from metals to materials, from art history and the history of technology to archaeology and material culture". Thornton (2009) argues that Goodway's assertions in that paper were premature, and instead presents an argument for being in the midst of a current paradigmatic shift within archaeometallurgy, moving toward a more holistic approach which combines scientific analysis, archaeological interpretation and anthropological theory (Thornton 2012: 175). Similar observations have been made by Cleere (1993) and Ehrenreich (1991; 1996). Different areas of archaeometallurgy, however, have adopted such approaches to differing degrees, and many aspects of the more analytical study of material continue to lack anthropological theory, and sometimes also even significant archaeological interpretation. This is largely due to the perception that approaches with strong utilisation of anthropological theory are incompatible with the scientific method and a continued perception of disconnect between archaeological theorists and archaeological scientists. Indeed, Thornton (2009: 26) himself acknowledges a widening division between archaeological science and theory. This perceived disconnect was, and continues to be, created and reinforced by several contributing factors. One is the issue of communication and language; a reoccurring challenge that arises between different fields of research both within and beyond archaeology (see Edmonds 1990; Thomas 1990; O'Connor 1991; Dunnell 1993). Another major factor, however, is the perceived focus of archaeological theorists versus archaeological scientists. As Jones (2004: 239) succinctly encapsulates: "fundamentally, the division between the approaches of theoreticians and archaeological scientists is founded upon this worldview; sciences study the behaviour and properties of objects, while the arts and humanities are concerned with the study of subjects." For the archaeological study of material culture to develop and advance further, this strict division must be challenged and ultimately deconstructed.

The concept of materiality which attracted significant traction from the mid-1990s onwards, particularly following Chris Gosden's 1994 publication, has been proposed by some as a new approach that could potentially tackle these issues. Through materiality the view is explored that the material world and the social practices within that world are mutually reinforcing; therefore, the study of one is not complete without the study of the other (Jones 2004; Miller 1987). Crucially, recognition and consideration of the materiality of material culture emphasise the integral role of material qualities in the way in which materials are perceived, used and symbolised. It also draws focus to how those particular material properties featured in the life of humans in the past, and how humans interacted with the materials in question (Jones 2004: 330). Importantly, it emphasises the role of sensory perception and engagement; a fundamental element of human-material interaction which had previously been missing as a key area of focus in most previous archaeological work. This approach also has the potential to bridge the gap between archaeological theorists and archaeological scientists, in that it centres both subjects and objects.

Thornton (2009: 30) has previously argued that theoretical schools of thought such as materiality are "mostly archaeological paradigms with little to no interest in scientific data", and argues that utilisation of materiality within archaeometallurgy will only further widen the gap between archaeological science and archaeological theory. Despite materiality seeming to be a new theoretical approach, however, similar themes and theoretical underpinnings can be seen in integral previous archaeometallurgical research including that of Smith discussed above. In terms of recent research, work such as that by Kuijpers (2017; 2018) demonstrates that a materiality-informed approach can undoubtedly be combined with scientific data to great success, bringing highly valuable new research to the table.

3.2 The Archaeological Research Context of southern Mesopotamian Metalwork: Challenges, Themes and Gaps

As introduced earlier, previous research into Mesopotamian metalwork has been shaped, but also limited, by both traditional frameworks in the wider field of archaeometallurgy and traditional frameworks within the field of Mesopotamian archaeology. Section 3.1.1. provided an overview and discussion of some of the key traditional frameworks within archaeometallurgy that have impacted the study of Mesopotamian metalwork. Throughout the current section, this chapter delves further into how this impact manifests both in previous literature and in the extant body of material from southern Mesopotamia, while also critiquing the influence and limitation of traditional frameworks within Mesopotamian archaeology more generally; particularly, the influence of cultural-historical approaches and functional-processual and processual archaeologies.

Section 3.1.2 discussed crucial methodological and theoretical developments within archaeology and archaeometallurgy over the last several decades that have significantly progressed archaeometallurgy as a field, leading to a wealth of innovative and nuanced studies, often utilising social theory, across various archaeological contexts around the world. As will be discussed in this section, however, these developments have barely been applied to the study of southern Mesopotamian metalwork. In part, this has been due to a general reluctance within the discipline to advance from traditional frameworks and engage with recent shifts in archaeological thought and method. It has also been strongly influenced by the inability to excavate in southern Iraq for several decades, with excavation only recommencing recently and tentatively. Without the ability to retrieve new primary data, Mesopotamian archaeology began to stagnate, leaving the field in severe need of re-alignment with modern scientific and theoretical advancements, including those within the broader field of archaeometallurgy. Furthermore, while extant bodies of material retrieved through earlier excavations could be studied, this work is heavily impacted by the constraints of earlier methods of data collection and retention on extant assemblages.

This section delves into the traditional approaches that have held back archaeometallurgical research and progression, and presents a critical evaluation of previous research, evaluating current gaps and issues that need addressing. It is divided into two halves. The first, 3.2.1., addresses the challenges posed by extant collections, and discusses contributing factors and important considerations for future progression. The second half, 3.2.2., provides a critical overview and discussion of previous research into the metalwork and metallurgy of southern Mesopotamia.

3.2.1 The Material: Temporal, Geographical and Contextual Limitations

Fundamentally, analysis and interpretation are shaped by the material available and that, in turn, is shaped by traditional research strategies. Much of the previous research into Mesopotamian metalwork has tended to be inconsistent in temporal, geographical and contextual coverage, and these patterns echo the same issues with coverage in Mesopotamian archaeology more generally. This has resulted in a body of material and an understanding of metal use and the metal industry that is overly focused on specific periods, sites and contexts and therefore provides a limited, unrepresentative and potentially skewed reconstruction.

The first key issue of coverage is the near-exclusive focus on the metalwork from large urban centres. Excavation, along with much of the previous literature in Mesopotamian archaeology, has focused overwhelmingly on cities and their material (Banning 1996: 25; Curvers & Schwartz 1990: 3; Van De Mieroop 2004: 81). Mesopotamia is the location of some of the earliest and longest continually occupied cities in the world, such as Eridu, Uruk and Ur. It is also the location of one of the earliest known writing systems in the world, which is understood to have been invented towards the end of the 4th millennium B.C. (Woods 2010: 15). Mesopotamian cities have therefore left unparalleled archaeological and literary evidence of urban life (Stone 2004: 141). The vast bodies of material available at these large urban centres have undoubtedly fed into their prioritisation in excavation, and the consequent dominance of the material uncovered from these sites in extant collections has heavily skewed subsequent avenues of study, analysis and interpretation. A further contributing factor is the urban-centric nature of the textual evidence from Mesopotamia. The majority of written sources were produced by temple and palace institutions and provide a city-focused view of society (Ur 2012: 533-4); an issue discussed in further depth in section 3.3 later in this chapter.

Other roots of this urban bias run deeper. In the 19th and early 20th centuries, early stages in Western approaches to Mesopotamian archaeology, and Near Eastern archaeology more broadly, revolved around the construction of a grand historical narrative concerning the rise of civilisation, and were heavily influenced by biblical narratives and classical texts (Matthews 2013: 7). The development of Mesopotamian archaeology was significantly influenced both by imperialism (see Bahrani 2002) and, as discussed in section 3.1.1 of this chapter, cultural evolutionism that centred on notions of unilineal social progression from ‘primitive’ to ‘civilised’. As Bahrani (1998: 172) explains: “the image of Mesopotamia, upon which we still depend, was necessary for a march of progress from East to West, a concept of world cultural development that is explicitly Eurocentric and imperialist”. As previously discussed in relation to Childe’s assertions concerning metallurgy, the fixation on theories of cultural evolutionism, the construction of a grand historical narrative concerning social progression, and culture-historical thought resulted in heavy focus placed on aspects deemed fundamentally indicative of civilisation and social complexity; one of which being urbanism.

Despite theoretical and methodological development within Mesopotamian archaeology in the 20th century that included a significant movement away from the influence of these elements in the discipline's early stages, the regions outside of the cities remained substantially under-researched and continued to be discussed only in relation to large urban sites. These urban-centric approaches consistently positioned cities as central to the state and central to understanding society, while smaller, and more rural sites were designated with a passive political role and positioned on the periphery of academic study (Richardson 2005: 282). These approaches often reduced the Mesopotamian landscape to a dichotomy of city versus countryside when the reality was far more complex. Regions outside of the cities were less urbanised and populated but encompassed a range of settlement types (Stone 2005: 153). In contrast to assertions that large urban sites are crucial to understanding Mesopotamian society, widely disproportionate focus on them has instead resulted in a highly limited understanding of social, political, and economic networks beyond urban centres, and therefore a skewed understanding of the true breadth and complexity of these networks within Mesopotamia as a whole (Richardson 2005: 282; Stein 2002: 901).

Over the last several decades this has slowly begun to change. From the 1970s, as a reaction to major engineering projects which threatened large areas of landscape with destruction, salvage and rescue excavation was carried out at a range of sites, many of which, such as Haradum, fell outside of the traditional site types excavated by international teams (Al-Hussainy & Matthews 2008: 93). The results of excavation at these sites have helped to improve current understanding of smaller-scale, rural sites, as well as providing excavated sites for periods that had previously been severely understudied. Crucially, they have also helped to emphasise the importance of excavating sites outside of the typical urban centre site type. In 1974, Adams *et al.* (1974: 15) argued that "city and countryside on the lower Mesopotamian plain are only to be understood as parts of an interacting system". Unfortunately, however, the nature of these rescue projects meant that excavation was limited, and with a greater emphasis on regional survey techniques (Matthews 2013: 17). Projects were often of shorter duration which failed to facilitate the same degree of in-depth exploration conducted at many previously excavated sites. Nonetheless, research into these smaller sites and recognition of their vital importance in our understanding of Mesopotamian society and key parts of Mesopotamian history continued to increase in the literature (for example, Banning 1996; Curvers & Schwartz 1990; Falconer & Savage 1995; Liverani 1996; Richardson 2005; 2009; 2010).

Regardless of this slow shift towards greater focus away from the major cities, progress has been strongly hindered by the inability to excavate in the region for several decades, particularly the region corresponding to southern Mesopotamia. Following the 1990 invasion of Kuwait and subsequent conflict, excavation in Iraq by foreign teams was almost completely halted and excavation by Iraqi teams became highly limited. Ability to excavate in Iraq then virtually ceased entirely following the 2003 US-led invasion and subsequent occupation. Therefore, despite the issue of urban bias being recognised decades ago (see Adams 1974), without the ability to excavate and generate bodies of material from sites outside of the urban centres, it has been difficult to make significant progress in correcting the long-persisting urban bias of the discipline. Subsequently, by far the most extensive bodies of Mesopotamian metalwork still originate from large cities such as Ur (Hall 1923, 1925; Woolley 1934, 1939, 1946; 1955, 1965, 1974; Woolley & Legrain 1927; Woolley & Mallowan 1962, 1976) and Kish (Field 1929; Gibson 1969, 1972, 1976-80; Langdon 1924; Langdon and Harden 1934; Langdon & Watelin 1930, 1934; Mackay 1925, 1929; Moorey 1978; Ross 1930). Although there do exist a limited number of smaller bodies of metalwork excavated from more rural sites, the much more extensive bodies of material from the large-scale, long-term city excavations have received much greater attention and analysis. As a result, the vast majority of previous research on Mesopotamian metalwork has revolved around metalwork found at these major urban centres, and while this research is still important and beneficial, it is not representative of metal use across Mesopotamia as a whole and therefore should not be treated as such.

Another major issue that has dramatically impacted both the size and range of extant collections is that of traditional collection and retention strategies during excavation. Throughout much of the history of Mesopotamian archaeology, there has persisted a strong preference towards collecting relatively complete, reasonably well-preserved metalwork, as well as objects made of precious metals. Metalwork that was collected and recorded typically did not include fragmentary, scrappy and very poorly preserved pieces. Where they were collected, they were very rarely retained. In part, this was an extension of the prioritisation of type and function as areas of interest and analysis as discussed in section 3.1.1. Until the tightening of laws around the exportation of artefacts in 1924 under the Law on Antiquities, and then the complete halting of exportation from 1974 onward, a further influencing factor was the desire to export conventionally impressive examples of metalwork, particularly for museum collections (Brodie 2011: 117; Millerman 2008: 9). It was the case, and still largely is, that museums prioritise complete or near-complete, reasonably well-preserved material for their collections. Museums have even occasionally prioritised replicas of objects that fit these criteria over authentic objects which do not. One such example is when the British Museum had replicas made of goldwork from Ur that was to be sent back to the Iraq Museum because these "wonderous" objects were deemed a vital part of attracting visitors and funding (Millerman 2008: 9). As a result, the collections of Mesopotamian metalwork in most museums are skewed heavily in favour of these types of objects, making them unlikely to be representative of everyday metalwork or of the Mesopotamian metal industry as a whole.

There has also long been a general dearth of metallurgy-related evidence collected beyond finished objects. Even when exceptions are initially collected or mentioned briefly in subsequent publications, such as the occasional piece of slag, it is rare for them to be retained and kept in collections for future study. As with scrappy objects, metalworking waste products have often been deemed largely unhelpful in comparison to near-complete or complete finished objects. As argued by Shimada (2007), however, the study of ancient metallurgy must adopt a holistic approach that includes the study and analysis of material from all points along the metallurgical process including fuel, mining sites, reaction vessels such as crucibles and furnaces, tools and waste products. As with the correction of urban bias, the confrontation and correction of these traditional, highly selective collection strategies have been dramatically limited by the inability to excavate in southern Mesopotamia for the last several decades.

Another crucial point worth emphasising concerning this issue is the potential influence on collection strategy caused by a lack of archaeometallurgical specialism on excavations. Traditionally, during Mesopotamian excavations, metalwork is recorded by small-finds specialists, rather than an archaeometallurgist. In excavation reports and other subsequent publications, sections dealing with metal assemblages are, similarly, usually written by directors or small-find specialists rather than metalwork specialists. The lack of archaeometallurgical specialism on projects undoubtedly influences what material is deemed useful and important, and what is not. While it may not be possible for all future Mesopotamian excavations to include an archaeometallurgist on their team, the use of a total collection strategy would, at least, result in a much wider body of material collected and recorded. These records can then be sent for specialist archaeometallurgical study, and material retained in Iraq can be (re)visited for further study.

A final key issue of coverage is the limited contexts from which previously studied objects have originated. Much of the metalwork from Mesopotamia has thus far originated from burials (Wischnewski 2015: 214). As Moorey (1994: 254) states, “if a period is not well represented in the archaeological record by graves, its metalwork is likely to be correspondingly little known”. It is extraordinarily rare to find a site rich in metal finds. Typically, this situation is due to the practice of recycling and the frequent occurrence of looting (Moorey 1994: 254). Problematically, although grave goods can potentially provide insight into how metal may reflect identity, the type of objects in circulation, and craftsmanship and technology, the highly limited context hinders a wider understanding of metal within society. Furthermore, the reasoning behind the inclusion of specific objects as grave goods in Mesopotamian society, and the function they were intended to have, greatly influence the types of objects found in grave contexts. It is usually accepted that grave goods were intended to accompany the individual into the afterlife, but more specific assertions about use vary (see Barrett 2007: 13-19). For example, it has been argued that some grave goods were intended as offerings to netherworld deities (Tinney 1998: 28; Zettler 1998: 32). In cases such as these, or where metal grave goods were made specifically for depositional purposes, the material is unlikely to be representative of the everyday metalwork typically in circulation.

An additional issue relating to context, and one even more problematic, is that of missing contextual information for a large amount of material. As has been highlighted by Muscarella (1988), the study of ancient Near Eastern bronzework continues to be hindered by the sheer amount of ‘attributed’, or entirely unprovenanced, material. Often, this material is the result of looting (ancient or modern) or a by-product of problematic early attitudes during excavation. For example, during his excavations of Ur, Woolley permitted the workmen to collect archaeological material from Diqdiqqa, a suburb of Ur, under the condition that they hand the material over to the archaeological team despite the subsequent entire lack of archaeological context for the finds (Woolley & Mallowan 1976: 82). Without contextual information, it is incredibly difficult, if not impossible, to know enough about an object to gain any useful information from its study.

Collectively, these various issues in previous excavation and survey work have fundamentally shaped the available body of metalwork from southern Mesopotamia in ways which hinder its ability to inform a comprehensive reconstruction of southern Mesopotamian metallurgy and metal use. Nevertheless, the available material still holds a wealth of valuable potential information. It is crucial, however, that research using this body of material involves awareness of its implicit challenges. Awareness of these issues is also crucial in its ability to inform future excavation strategy and research. As excavation tentatively resumes in the region, and Mesopotamian archaeology experiences an influx of new research inspired by innovative work in other archaeological areas, a new opportunity presents itself for these issues to be confronted.

3.2.2 Previous Research into Southern Mesopotamian Metalwork

Early archaeological study of southern Mesopotamian metalwork was predominantly propelled by the rich body of metalwork uncovered by Leonard Woolley at the Royal Cemetery of Ur in the 1920s and 1930s. This body of material is easily one of the most significant and influential archaeological discoveries of the 20th century. The cemetery from which this metalwork was found, termed the 'Royal Cemetery' due to the high-status objects uncovered, held approximately 2,000 graves which date to between 2500 B.C and 2000 B.C. (Woolley 1934). Prompted by this discovery, the first systematic scientific analysis of Mesopotamian metalwork was undertaken by C. H. Desch and the Sumerian Copper Committee between 1928 and 1938 (Hauptmann & Klein 2015: 79). This committee, on behalf of the British Museum, sought primarily to establish sources for the metal used in Mesopotamia, and to assess the level of metalcraft employed to make the objects (Hauptmann & Klein 2015: 79; Stech Wheeler *et al.* 1975: 31). Material from different sites around Mesopotamia was included, although most of the material was from the Royal Cemetery of Ur (Hauptmann & Pernicka 2004: XI). The method of wet chemical analysis was utilised to determine the chemical composition of both artefacts and ores in a very early attempt at 'geofingerprinting'. Desch's research positioned the investigation of copper sources using trace elements as a primary topic of interest within the realm of analytical study of Mesopotamian metalwork. This early work was not only pioneering within Mesopotamian archaeology but also in the much wider realm of archaeometallurgy and archaeological science as a whole (Stech Wheeler *et al.* 1975: 31).

Initial analysis focusing exclusively on the metalwork from Ur was published in 1934 by then-British (see Woolley 1934: 284-298). Museum conservator, Harold J. Plenderleith, as part of the Ur excavation publications. Many of these original analyses of Ur metalwork were conducted by jeweller and goldsmith, J. R. Ogden (Millerman 2008: 1). This early work had a tremendous impact on the archaeometallurgical study of Mesopotamia. It should be noted, however, that much of the subsequent work on Mesopotamian metalwork has used these original analyses, interpretations and conclusions relatively uncritically (Millerman 2008: 1).

Throughout the following decades, scientific analysis of Mesopotamian metal continued and, strongly influenced by the dominance of early functionalist, functional-processual and processual archaeologies discussed earlier in this chapter, it constituted much of the work being done on Mesopotamian metalwork at that point. The scope of analysis, however, remained limited. The focus of analysis largely fell on material from Ur, and secondarily from Kish, but analysis of material from other sites was extremely sparse. In his 1985 publication, Moorey collates various compositional readings that had been taken on Mesopotamian metalwork by that point. Of the southern Mesopotamian sites, analyses of copper-alloy objects were predominantly from Ur and Kish, analyses of silver objects were predominantly from Ur with a small amount from Tello and Kish, analyses of lead objects were of two Ur objects, one from Tell al-Ubaid, and all of the analyses of gold objects were on material from Ur. Compositional analysis was also often conducted without specific research questions in mind, and further discussion and interpretation of this data was often missing.

Some of the scientific analysis undertaken on Near Eastern metalwork over the latter half of the 20th century focused on metal from culture-history oriented excavations and was undertaken with the intent of simply supplementing understanding about the sites rather than expanding understanding of metallurgy and metal use in its own right; this certainly included some of the analysis conducted on metalwork from Ur (Pigott 1996: 166). As discussed in section 3.2.1, the prioritisation of cities driven by culture-historical archaeology was a dominant aspect of Mesopotamian archaeology during this time. The disproportionate focus on Ur is also the result of the type of, and extent of, material found there. A large amount of metal material was excavated from the site, much of which is in good condition compared to most other recovered archaeological metalwork from

Mesopotamia. It also included far more gold and silver than is typically found at other southern Mesopotamian sites. Due to the high value of gold in modern western society, it has long captured the fascination of the public and researchers alike; for example, at the time of the Royal Cemetery's discovery, Woolly was able to monopolise the presence of gold to attract further funding for his excavations (Millerman 2008).

Largely, however, the gold objects from Ur have attracted attention from scholars because they demonstrate absolute mastery of metalworking techniques. Close analysis has highlighted the use of gilding, casting, inlaying, chasing, filigree work, hard soldering, granulation and cloisonné (Potts 1997: 178). The Ur gold, therefore, demonstrates that, if the objects were crafted in Mesopotamia and not imported as complete objects, Mesopotamian goldsmiths were highly skilled craftsmen. One of the most extensive studies of the Ur gold was carried out by Maxwell-Hyslop (1971) as part of a wider examination of Western Asiatic jewellery. Not only does Maxwell-Hyslop provide a detailed examination of the jewellery from Mesopotamia, but also places it within the wider geographical area to facilitate greater exploration of sources, trade routes and stylistic influences. Much of the previous work on Mesopotamian silverware has also focused on the material from Ur. However, Moorey (1994: 238) highlighted that, by the point of publication at least, silver jewellery had received less analysis than gold jewellery, and that subsequently there are significant gaps in knowledge concerning the manufacture of silver.

The key issue with the Ur metalwork attracting a disproportionate degree of focus in past scientific research is that the metalwork found from the Royal Cemetery is not representative of everyday metalwork. As a result, the results of the analysis of this material do not provide an understanding of the Mesopotamian metal industry as a whole for that period; instead, they provide an extremely small snapshot. The same issue applies, of course, with a disproportionate focus on gold objects. As a result, very little was known about the wider picture of the Mesopotamian metal industry until the very tail-end of the 20^{th} century. In 1977, Mallowan (1977: 4) commented that at that point, it was still not known whether Sumerians used copper or bronze.

For much of the 20^{th} century, the literature concerning extant bodies of Mesopotamian metalwork and analyses of objects mainly constituted various scattered studies or small parts of wider publications. The primary form of publication for much of the metalwork from southern Mesopotamia is that of subsequent excavation publications, but there is a large degree of variation in how thoroughly the metal material is included and presented, and some excavations have never been fully published. Aside from excavation reports, there have been several key publications of extant metalwork from Mesopotamia. Most notably, much of the bronze metalwork found from Mesopotamia up until the 1980s is documented in three volumes of the *Prähistorische Bronzefunde* series (Braun-Holzinger 1984; Müller-Karpe 1993; Rashid 1983). Despite the magnitude of the contribution made by these volumes, the region covered by them is that of modern-day Iraq and not Mesopotamia. As a result, studies of southern Mesopotamia are not too badly affected, but this volume is less helpful for the study of northern Mesopotamian metalwork. Concerning publications of chemical analyses, these have often been included in publications that are essentially catalogues and which do not include further discussion or interpretation of the data (such as Hopp *et al.* 1992; Muscarella 1988).

Several pivotal contributions were published in the latter half of the 20th century relating to metallurgy and metal use in Mesopotamia that sought to synthesise and contextualise this scattered body of previous work. Some of these feature as part of wider studies of Near Eastern metalwork, particularly because, as discussed above, past approaches have tended to adopt a 'macro' perspective that subsequently lends itself to the study of large geographical areas. Additionally, Mesopotamia was part of various expansive social and economic networks across the Near East for millennia. Of particular note in this regard is Muhly's seminal 1973 publication on copper and tin resources and trade in the Bronze Age which synthesises the vastly scattered body of data on copper and tin that existed up until approximately 1971. This in-depth study covers a wide stretch of regions in the Mediterranean and adjacent areas, with specific sections dedicated to Mesopotamia (see Muhly 1973: 220-232, 259-260, 288-355). Muhly's investigation into Mesopotamia's copper and tin sources has formed a crucial basis of research on the topic. Muhly draws predominantly on textual sources, providing a crucial reference point for discussion of copper and tin use, trade and resources mentioned in ancient Mesopotamian texts, yet he also links this research with existing archaeology evidence. Although thoroughly analysed, however, the textual sources used by Muhly all derive from southern Mesopotamian sites, making his conclusions applicable to southern Mesopotamia but potentially less so to northern Mesopotamia (Moorey 1994: 245). Aside from this study, Muhly has also published various other key works concerning copper and tin (see Muhly 1973a, 1973b, 1977, 1985).

The most prominent figure within previous research who produced multiple crucial publications on Mesopotamian metalwork specifically is Roger Moorey, whose 1985 and 1994 publications on Mesopotamian material culture include extremely detailed and comprehensive chapters on Mesopotamian metalwork. In addition to these, Moorey also produced various other papers concerning Mesopotamian metalwork; both in terms of general overviews and more specific studies of material (see 1971, 1980, 1982, 1988; Moorey & Flemming 1984; Moorey & Schweizer 1972). Similarly, Potts' 1997 publication on Mesopotamian materials includes a chapter on metal and metalworking that provides a valuable synthesis of previous research up until that point. The work of Müller-Karpe includes several key publications concerning metallurgy and metalwork in Mesopotamia (see 1990, 1991, 1993). The value of these publications on the field of Mesopotamian archaeometallurgy, particularly concerning furthering understanding of ore sources, metal acquisition, technology and the object types that different metals were typically used for, is undoubtable; however, significantly lacking in this work is the exploration of the wider social context of Mesopotamian metallurgy and metal use. Despite the changing paradigms in archaeology more broadly in the latter portion of the 20th century, and the methodological and theoretically progression of archaeometallurgy, particularly from the 1990s onward (as discussed in section 3.1.2), approaches to Mesopotamian metal generally retained the traditional themes and approaches discussed above.

At this stage in the history of Mesopotamian archaeometallurgy, emphasis on scientific analysis, particularly in the form of compositional readings, further expanded. To some degree, this was influenced by the above-mentioned continuation of processual frameworks. It was also, however, a response to the still-limited understanding of Mesopotamian metalwork due to decades of inadequate archaeometallurgical attention while the region was overshadowed by concentration on regions such as Anatolia (discussed in section 3.1.1). As a result of Mallowan's (1977: 4) observations, included earlier in this section, on the lack of understanding regarding Mesopotamian copper and copper-alloy use, J. D. Muhly, at the University of Pennsylvania in Philadelphia, set up the Mesopotamian Metals Project (MMP) (Stech 1999: 59). Founded in 1980, the MMP was set up with the stated aim of providing "a reliable scientific framework for the social and economic interpretation of the metallurgical industry in the early urban complexes that emerged in southern Iraq around 3000 B.C."; acknowledging that craft specialisation in Mesopotamia had thus far received little in the way of scientific analysis (Mesopotamian Metals Project, 2015). The research team was made up of Stuart Fleming, James D. Muhly, Vincent C. Pigott, Robert Maddin, Tamara Stech and later Sam Nash. All of the objects analysed for the study were from the University of Pennsylvania Museum collections. Compositional analysis using particle-induced X-ray emission (PIXE) was conducted on approximately 350 copper-based objects, metallographic observation was conducted on approximately 150, and scanning electron microscopy (SEM) was conducted on approximately 75 (Stech 1999: 59). The temporal and geographical range of this material stretched from 3rd millennium Ur, Kish, Fara, Gawra and Billa, through 2nd millennium Nippur, Khafajeh, and Billa, and to Neo-Assyrian Billa (Stech 1999: 59).

The research undertaken as part of the MMP produced a much-needed body of data for a much wider collection of Mesopotamian metalwork than had been provided before. There are, however, several drawbacks. Firstly, the analyses collected as part of this project were all from museum material in the United States of America, yet the bulk of Mesopotamian metalwork is held elsewhere. In particular, the largest body of Mesopotamia artefacts is held at the Iraq Museum in Baghdad, and up until this point, there had been no systematic scientific analysis of the metalwork in this collection. So, whilst this project certainly expanded the range of material analysed, it still left the majority of Mesopotamian metalwork unanalysed. Secondly, and most crucially, the results of this project were never published in their entirety. A preliminary publication by Stech (1999) provides a discussion of the results, used in combination with data from Moorey (1985: 51-68; 1994: 276-278) and Müller-Karpe (1990). Within this chapter, the upcoming publication is referenced; it does not, however, appear to have ever been published. Currently, the results of these analyses are published online at www.avirtualmuseum.org. Problematically, however, the composition for each object only includes readings for Arsenic (As), Tin (Sn) and Nickel (Ni). There is also no detail given online concerning the methodology used. Despite the work of Stech, this also means that further discussion, placing the results into their wider social and economic context, is ultimately missing from the project's output.

In light of some of the shortcomings in prior research, and particularly the lack of interaction with the material held by the Iraq Museum, the *frühe metalle in mesopotamien* study was set up in Heidelberg in the 1990s to document and analyse as many metal objects of the 5th to the 2nd millennium B.C. as possible. Their goal was to "create a solid basis for relating the development of the Mesopotamian metal industry from the Uruk period onwards to the contemporaneous technological level of neighbouring cultural regions of Eurasia" (Hauptmann & Pernicka 2004: XI). Analysis for this study was conducted on material held in museums in Iraq, France, Germany and the United Kingdom, in addition to including material previously analysed for the MMP in the United States of America.

The results of this study were intended to be published in two volumes. The first was published in 2004 edited by Hauptmann and Pernicka. Compositional data for 2,623 metal objects from a total of 68 sites in Mesopotamia and Syria are presented. All of these readings were taken using X-ray fluorescence (XRF). Of these objects, 145 were also analysed with neutron activation analysis (NAA). The second volume was intended to present evaluation and discussion using a "combined interpretation of the archaeological contexts and the typological information as well as the chemical and isotope analysis" to provide an "overall picture of the Mesopotamia metal industry" (Hauptmann & Pernicka 2004: XII). Unfortunately, this second volume is still yet to be published. Since the publication of this data, its use in new studies appears to be limited. The draft typological work available by Helwing is a welcome addition to Mesopotamian metalwork studies, and it would be a benefit to the subject area if this second volume were to be published.

Overall, this project was much needed in the realm of Mesopotamian metalwork studies, filling several large, crucial gaps in previous scientific analysis. The first volume is not without flaws but does provide all of the (normalised) readings, drawings for each object, and the catalogues include measurements. One key issue with the volume, however, is that there is very little accompanying information included. There is no methodology provided, hindering the ability to assess the methods that were used and making use of these data much less straightforward. Information about which chronological framework is used is also missing. The publication itself fulfils the basic need of compositional data, but the production of data without further work can often reduce its effectiveness, particularly if the methodology is not also fully published to assist future researchers working with the data.

As part of both the MMP and the *frühe metalle in mesopotamien* study, it was recognised to some extent that the data collected and presented as part of these projects needs to be interpreted and discussed in context for it to successfully expand current understanding of the Mesopotamian metals industry, yet only limited amounts of this came out of either project. Acknowledgement of the data produced by these projects exists in subsequent publications and has led to some observations concerning issues such as the use of tin bronze and how it relates to the use of arsenic bronze (for example De Ryck *et al.* 2005; Wischnewski 2017). Aside from this, the outputs from these projects have not included nor led to in-depth discussion of these results in light of their wider social context.

In more recent years, the field of Mesopotamia has continued to be slow in its engagement with wider disciplinary developments. Despite this, there have been various publications that have propelled this progression, particularly in light of theories concerning material culture, materiality and sensory perception (such as Balke & Tsouparopoulou 2016; Benzel 2015; Feldt 2015; McMahon 2019; Shepperson 2017; Sonik & Steinert 2022; Steinert 2022; Tsouparopoulou 2016; also see Chapter 8). Archaeological study of southern Mesopotamian metalwork has, however, largely remained lacking in consideration of these topics and exploration of wider social contexts. There have continued to be valuable studies published which contribute important scientific analysis of material to shed greater light on Mesopotamian metal. Key topics of focus have included the sources of Mesopotamian copper (see Begemann *et al.* 2010, Begemann & Schmitt-Strecker 2009[8])[9] and continued work on the metalwork from Ur (such as Hauptmann *et al.* 2018; Salzmann *et al.* 2016). Much of this work includes further discussion and interpretation than could often be found in older publications, although most still fail to progress discussion deeper and wider in pursuit of a more comprehensive interpretation. A clear exception to this, however, is a paper by Hauptmann *et al.* (2018) which includes analysis of metalwork from Ur but focuses on colour variations based on composition and discusses these results in light of relevant textual evidence. Approaches such as this, which progress beyond simply producing data and instead utilise compositional readings alongside wider contextual understandings and alternative evidence types, are much-needed in the field.

[8] This publication includes work undertaken as part of the MMP
[9] Various other publications of pertinence to sources of Mesopotamian metal are presented at length in Chapter 2

3.2.2.1 Use of Textual Sources

Within Mesopotamian archaeology, there is a historical academic division between the study of texts and philology by Assyriologists and the study of other archaeological evidence by archaeologists (Zettler 1996: 81). As is often the case with any divide due to the need for specialisation, this has resulted in instances of a lack of communication and collaboration, skewing understandings and causing dissonance between interpretations (for key examples see Zettler 1996). There are also fundamental differences between archaeology and philology and their respective practitioners that undoubtedly feed into this division. To use the terminology of Zimansky (2005: 311), philology is culturally specific and particularistic, while archaeology tends to pursue an understanding of the human past in the aggregate. Ultimately, this disunion has long impeded the full realisation of integrated study between textual and archaeological evidence (Liverani 1996). Despite this polarisation, however, the relationship between philological and material evidence, in reality, is one of fundamental interconnection, overlap and mutual dependency (Zimansky 2005: 308-10). Despite this, there are several crucial caveats in the use of textual sources that should be recognised and discussed. It is not the aim of this section to provide a comprehensive overview of the utilisation of textual sources in previous studies of southern Mesopotamian metalwork; however, due to the use of textual sources in this thesis, particularly in Chapters 7 and 8, it is necessary to include some discussion here on their use.

Written sources from southern Mesopotamia span various types including literary, religious, administrative, legal and lexical texts. Despite their largely fictional nature, literary sources, such as myths and poetry, can provide valuable insight into Mesopotamian society and worldview (Veldhuis 2003: 36). Disputation texts, for example, which feature debates between two inanimate objects, animals or seasons, provide an insight into contemporary beliefs and realities (Veldhuis 2003: 36). Furthermore, despite some versions of Mesopotamian myths remaining virtually unchanged for over a millennium, others varied over time alongside the fluctuating Mesopotamian socio-political landscape to evidence, and in some instances possible to influence, changing attitudes (Kirk 1970: 86). A disputation text of particular relevance to southern Mesopotamian metalwork is the Debate Between Silver and Mighty Copper which is discussed in Chapter 7 and provides an unparalleled insight into contemporary attitudes towards the social roles of silver and copper. Religious texts are often included in the broader category of literature and, similarly, provide valuable insight into contemporary worldviews. While these predominantly shed light on religion and religious practices, they can also demonstrate connections within contemporary Mesopotamian thought between divinity and the material world. As explored in depth in Chapter 8, the study of religious texts demonstrates a clear connection between metal, shine and the divine (Brüschweiler 1987: 187-9 and Winter 2002: 13; 2008: 85). Finally, another crucial type of textual source that is highly relevant to the study of Mesopotamian metallurgy and metalwork are those which relate to trade and exchange. As demonstrated in Chapter 2, textual evidence has played a key role in elucidating potential trade routes in the acquisition of metals, such as copper from Magan through Dilmun (Crawford 1998; Giardino 2019; Potts 1990: 168; Steinkeller 2013; Weeks 2016: 14), tin from Meluhha or Magan (Potts 1997: 174), and silver from Anatolia (Moorey 1985: 110-111; Potts 1997: 174).

Despite the myriad of benefits to utilising textual sources in the study of southern Mesopotamian metalwork, there are various limitations involved that should be addressed. From a practical perspective, the highly complex literary system and the often poor condition that clay tablets are found in can make translating and interpreting textual evidence challenging (Dalley 1998: xv). In a similar vein, there remains, and likely always will, various disagreements over the translation of words and phrases (Kirk 1970: 84). As briefly discussed in Chapter 2, there is also significant disparity between the volume of textual evidence from different periods of Mesopotamian history. As highlighted by Foster (2015: xv) concerning Akkadian material in particular, textual sources were sometimes rewritten during later periods for political motives.

One of the most prominent issues with textual sources, however, is that written evidence is typically produced by individuals representing the state, seeking to present social, economic, and political organisation in a way that is supportive of the crown (Fleming 2009: 227). These texts also regularly focused on the actions of individuals that occupied the upper echelons of society, leading Yoffee (2014: 260) to observe that “the perspective of non-elites in Mesopotamia is notoriously difficult to comprehend”. Finally, as discussed in section 3.2.1., these sources are typically highly urban-centric, further perpetuating the urban-centrism that is already prevalent in previous excavation and literature in Mesopotamian archaeology, and often resulting in problematic and limited exploration of alternative social groups and rural regions (Fleming 2009: 227).

Despite these various challenges, the body of textual material available from southern Mesopotamia offers a wealth of important evidence concerning the metal industry and metal use. Alongside critical awareness of the issues involved in the use of these sources, their integration can undoubtedly produce a much more comprehensive and complex understanding. Throughout this thesis, textual evidence is predominantly incorporated in Chapters 7 and 8 and plays a significant role in the holistic approach adopted by this project.

3.2.2.2 Typological Work

Typology is not a focus of this thesis, nor does typological analysis feature to a large degree in any of the chapters. Some use of typology is included in Chapter 6, however, and due to the significant role of typological study in previous work in Near Eastern metalwork it is pertinent to include a brief section on typology here.

Central to early typological work regarding ancient Near Eastern metalwork is Maxwell-Hyslop, who produced the first typology of ancient Near Eastern metalwork in 1946. This initial publication focused specifically on daggers and swords, spanning the period between 2700 B.C. and 600 B.C. In 1949, Maxwell-Hyslop published a further typological study of Near Eastern metalwork across the same temporal stretch, this time focusing on shaft-hole axes. By Maxwell-Hyslop’s admission (1946: 2), these typologies were not comprehensive, owing largely to the many limitations on research faced by Maxwell-Hyslop at the time due to the Second World War. Of most prominent issue was that these studies only include material held in British Museums. A further, more extensive typological study, centring specifically on Western Asiatic jewellery between approximately 3000 B.C and 612 B.C., was published by Maxwell-Hyslop in 1971. This study is far more comprehensive and was certainly an extremely valuable contribution to the early typology of ancient Near Eastern jewellery. There are, however, issues throughout the volume with the clarity of images included, the dating used, and the typological classifications (see, for example, Rudolph 1974).

Following the initial work of Maxwell-Hyslop, key typology publications of Near Eastern metalwork include that of Stronach (1957) which focuses on metalwork from early Bronze Age Anatolia, Jean Deshayes (1960) which covers material across the region stretching between the Indus and the Danube and spans the entire Bronze Age and Kenyon (1960) which focuses on material from Jericho. Beginning in 1966, the *Prähistorische Bronzefunde* series, directed by Müller-Karpe, has produced a vast range of in-depth publications of ancient metalwork from Europe and its surrounding regions. These publications predominantly consist of object catalogues and typologies. Much of the bronze metalwork found from Mesopotamia up until the 1980s is documented in three of these volumes (Braun-Holzinger 1984; Müller-Karpe 1993; Rashid 1983). The volume by Rashid compiles bronze foundation figures. The volume by Braun-Holzinger compiles bronze statuary. The volume by Müller-Karpe compiles bronze vessels dating to between the Late Uruk period and the Akkadian period. Despite the magnitude of the contribution made by these volumes, there are some key issues. One such is that the region covered by these three volumes is that of modern-day Iraq and not Mesopotamia. As a result, studies of southern Mesopotamia are not too badly affected, but this volume is less helpful for the study of northern Mesopotamian metalwork. In 1995, Phillip *et al.* published a body of metal weaponry from Hamrin sites and accompanying typological analysis. As a result, they provided typological information that could be applied to north Mesopotamian metal weaponry, and potentially also to southern Mesopotamian weaponry.

Despite these smaller typologies focusing on specific object types, there does not exist any published comprehensive typology specifically for metalwork from Mesopotamia which encompasses all types of metalwork found. Key publications in the realm of Mesopotamian metalwork have regularly used types from these wider Near Eastern typologies. Recently, however, a typology of Mesopotamian metalwork was created by Barbara Helwing. It was originally written as part of the *Frühe Metalle in Mesopotamien* study to be published as part of a second volume to the project's first which was published in 2004. Unfortunately, this typology has yet to be published but is made available online in draft form on www.adademia.edu and is the main typology used and referenced throughout this thesis.

3.3 Concluding Statement

To meaningfully progress the field of southern Mesopotamian metallurgy and metalwork, future research must address the various gaps and issues discussed throughout this chapter, particularly in section 3.2. The huge bodies of chemical analyses produced by the MMP and the *frühe metalle in mesopotamien* study constitute a crucial source of further information and understanding but have thus far been severely under-utilised; they require further exploration and interpretation, particularly in light of social theory and theoretical advancements in archaeology and archaeometallurgy more generally. It is also vital for future work to explore compositional data alongside other evidence types, particularly textual sources, to provide a more comprehensive reconstruction of the metal industry, metal use, and the social role and significance of metal, metalworking and metalworkers.

This thesis aims to begin redressing these gaps and issues in previous research and the under-utilisation of key sources of information and data. By using the compositional data contributed by the MMP and the *frühe metalle in mesopotamien* study, alongside other legacy datasets and new data collected specifically for this project, this thesis re-engages this important body of previous work and expands it with crucial new material to begin correcting some of the issues concerning coverage discussed in section 3.2.1. The in-depth examination of these data in Chapter 5 using more traditional approaches contributes discussion of important broad patterns both temporally and regionally that can help to expand understanding and guide future research. The inclusion of the body of metalwork from Tell Khaiber, discussed in detail in Chapter 6, which is the only current body of metalwork with a known Sealand date, plays a crucial role in addressing fundamental aspects of bias within extant material, providing material from a smaller site type than the cities that dominate current collections, and providing fragmentary pieces of metal from various points along the lifecycle rather than the near-complete objects that nearly all come from burial contexts that made up the majority of objects in other assemblages. By exploring these data within the broader context of the metallurgical life cycle (Chapter 7) and in light of materiality and sensory perception (Chapter 8), this thesis also contributes examination of southern Mesopotamian metalwork that utilises modern theoretical approaches, helping to re-align the study of southern Mesopotamian metalwork with wider disciplinary developments, while also providing crucial consideration of wider social context largely missing from previous work.

Chapter 4

Material and Methods

This chapter outlines the material utilised in this project and the methods employed in its analysis and organisation. Section 4.1 presents the project material and the sources of data used. Section 4.2 details the methods employed in the selection and organisation of the data, and the analytical approaches adopted. Section 4.3 concerns itself with the application of chemical analysis.

4.1 The Material

The primary data utilised in this thesis comprises three key categories:

a) Object information and compositional readings taken specifically for this project using UK museum collections.
b) Object information and compositional readings taken from metal uncovered at the site of Tell Khaiber, southern Iraq.
c) Object information and compositional readings from previous research.

Categories a) and b) contribute new data, while category c) requires the use of legacy datasets. It is important to note that, with regard to discussions of composition, this thesis exclusively utilises objects that have received compositional analysis. Objects that have been assigned a composition type but without analysis to support this designation are not included. Due to the high level of error involved in assigning a composition type to metal objects without analysis the use of unanalysed objects in discussion of composition would be highly unreliable. Furthermore, as it is only possible for an excavator to form an opinion of the main element of composition, this information would not facilitate the more detailed exploration of composition included in this project.

4.1.1 Museum Collections

With the exception of scientific samples, the export of archaeological artefacts from Iraq has been illegal under domestic Iraqi law since 1974 (Brodie 2011: 117). Prior to that, however, large amounts of archaeological material from Iraq, including metalwork, were acquired by various European and US museums and still reside in their collections. Some of the metal objects in these collections have received previous compositional analysis. As discussed in Chapter 3, the largest catalogue of compositional analyses of this kind was published by Hauptmann and Pernicka in 2004. Previous analysis of UK bodies of southern Mesopotamian metalwork, however, has predominantly concentrated on the material held at the British Museum, leaving significant collections at other UK museums unanalysed. For this project, object information and compositional data were collected from collections of southern Mesopotamian metalwork held at three UK museums: Manchester Museum, the Ashmolean Museum, and Birmingham Museum and Art Gallery. Readings were taken using new, up-to-date portable X-ray fluorescence (pXRF) technology. Not only does this broaden the amount of metal analysed from southern Mesopotamia, but it also includes the re-analysis of previously analysed material to compare the reliability and precision of older analyses.

Manchester Museum, located in Manchester, is a university museum connected to the University of Manchester. Its collections began with those of manufacturer and collector John Leigh Philips (1761-1814). This initial body of material was a fundamental focus of the newly created Manchester Natural History Society, and the collection grew rapidly in the years that followed (Manchester Museum 2019). The museum in its current location, built to house this now-expansive collection, was first opened to the public in 1890. Manchester Museum's Mesopotamian collections contain a significant amount of material from the excavations at Ur under Woolley. Analysis for this project was conducted on 59 objects. Of these, 53 are included in this thesis; this is due to six of the objects falling outside of the temporal and/or geographical parameters of this study[10].

The Ashmolean Museum, located in Oxford, is also a university museum connected to the University of Oxford. The origins of the museum begin in 1682 when antiquary Elias Ashmole donated his collections to the university. In 1683, the Ashmolean Museum opened as the world's first public museum (Ashmolean 2020). The museum holds a rich collection of Near Eastern material, including a significant collection from Mesopotamia. Its body of southern Mesopotamian metalwork comes nearly exclusive from the site of Kish, which was jointly excavated by the University of Oxford and the Field Museum of Natural History. Roger Moorey, whose extensive and highly influential work on

[10] These constitute an iron object (60), a situla from northern Mesopotamia (63) and a set of silver pellets (9, 10, 11, 12) which, although Manchester's online records suggested that they may be from Ur, were with a note indicating that they were, in fact, Roman.

Mesopotamian metalwork has previously been discussed in Chapter 3, was Keeper of the Ashmolean Museum for almost two decades, and also compiled and published a catalogue of objects from the Kish excavations (see Moorey 1978). Analysis was conducted on 72 objects held at the Ashmolean Museum. Of these, 39 fell outside of the temporal parameters of this study and were therefore not included leaving a total of 33[11].

Finally, Birmingham Museum and Art Gallery, located in Birmingham, is run by Birmingham Museums Trust. The museum was first opened in 1885. It holds a significant collection of Mesopotamian material, including a substantial body of Mesopotamian metalwork; most of which comes from the site of Ur. Analysis was conducted on 66 objects held at Birmingham Museum and Art Gallery's Museum Collection Centre. Ten of these were excluded from this thesis due to having an Early Dynastic dating, leaving a total of 56 objects.

4.1.2 Tell Khaiber

Tell Khaiber is located in southern Iraq, approximately 19km northwest of Ur and 25km south of Larsa. It is one of two mounds that are part of the same archaeological landscape (Campbell, forthcoming). Throughout this thesis, 'Tell Khaiber' is used to refer to the southern of the two mounds which dates to the Sealand Dynasty, and 'Tell Khaiber 2' is used to refer to the northern mound which lies approximately 1km north of Tell Khaiber and dates to a slightly later date (Figure 4.1). The material used in this thesis is nearly exclusively from Tell Khaiber, except for two metal objects and one piece of slag from Tell Khaiber 2.

[11] These constitute 22 objects dating to the Early Dynastic period, 11 objects dating to the Achaemenid Empire (c. 550 - 330 B.C.), and six dating to the Sasanian Period (A.D. 226 - 651).

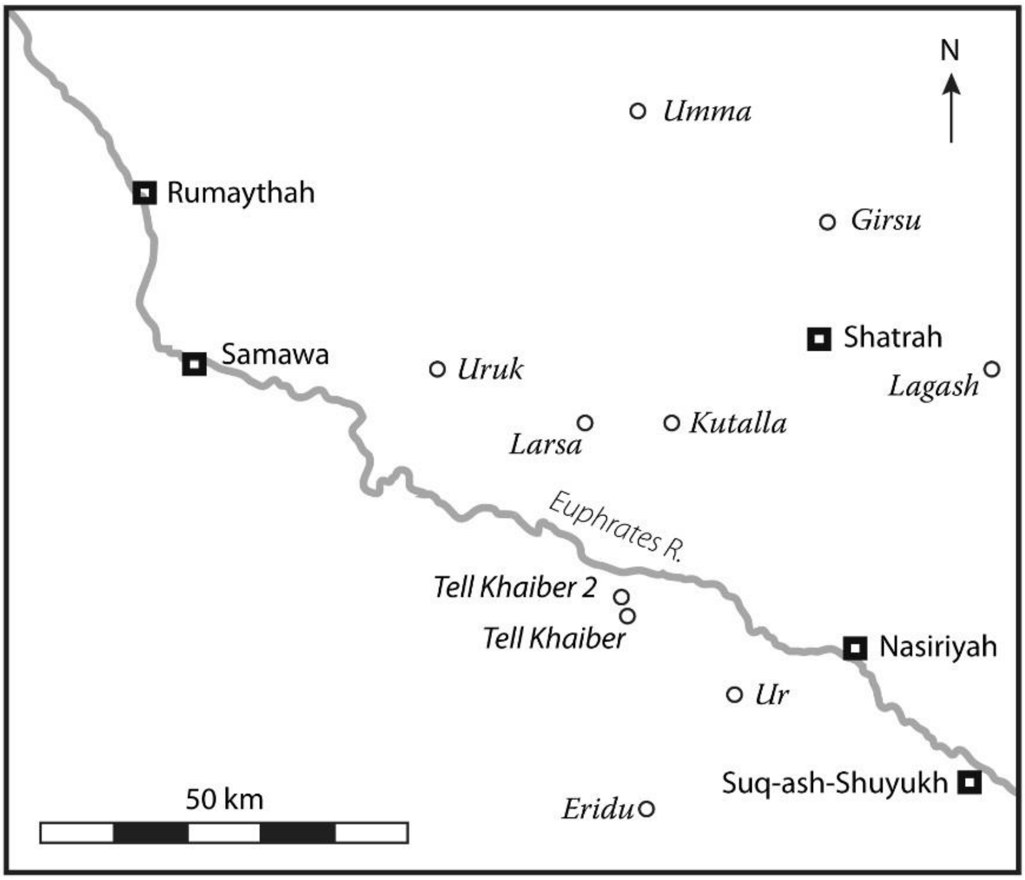


Figure 4.1: Map showing the location of Tell Khaiber, Tell Khaiber 2, and surrounding sites (Campbell et al. 2017: 22).

The earliest known reference to the site appears in the 1953-4 'Survey of Central Sumer', in which the site is referred to as Ishan Khaiber (Jacobsen 1960: 174-185). A survey of the Ur-Eridu region was undertaken and published by Henry Wright in 1965-6 which includes a detailed surface survey of Tell Khaiber (see Wright 1981: 340, Site 60). Recent satellite imagery of the site demonstrated the presence of a large, multi-room building near the surface, and a series of further structures to the southeast (Figure 4.2). The site was selected for excavation by co-directors Stuart Campbell, Robert Killick and Jane Moon following suggestion by Abdulamir Hamdani and Elizabeth Stone, and due to promising satellite images, lack of recent significant looting or damage, and the accessibility and safety of the area. Excavations were initiated at the site in 2013, led by the University of Manchester as part of the Ur Region Archaeology Project. The excavations ran between 2013 and 2017 and revealed a large public building and an area of private houses. Throughout the excavations 162 pieces of metal were uncovered; 94 of these were compositionally analysed in the field by Stuart Campbell. I joined the team as a find assistant for the 2017 season and was therefore able to work directly with all of the metal uncovered that year. In addition to the excavations at Tell Khaiber, surface survey and limited soundings were also conducted at Tell Khaiber 2.

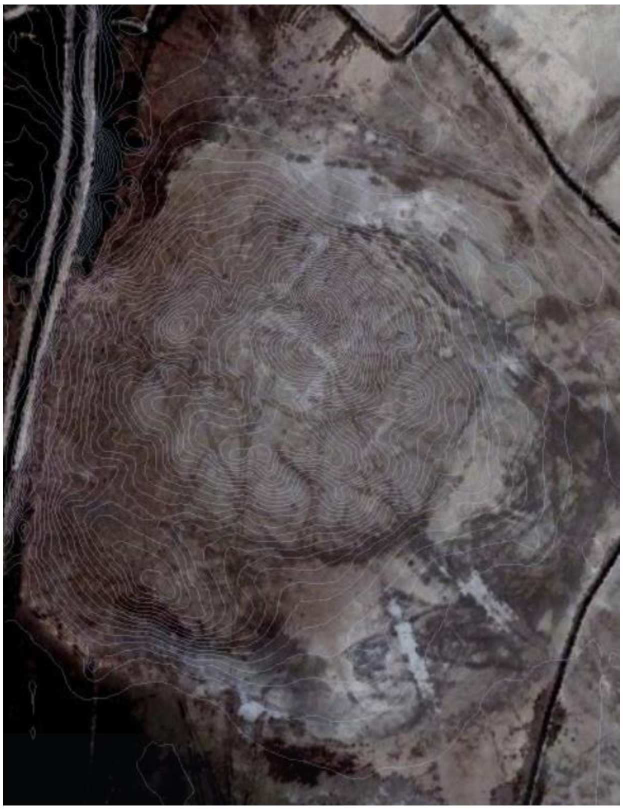


Figure 4.2: Satellite image of Tell Khaiber (DigitalGlobe Foundation 2010)

Tell Khaiber offers material from a significantly different type of site than the large cities, such as Ur and Kish, that have traditionally dominated Mesopotamian archaeology, and from which the vast majority of Mesopotamian metalwork has been uncovered. Rather than being a large urban centre, Tell Khaiber was a small centre of rural administration. Despite its smaller size and more rural location, however, it is clear that Tell Khaiber was an important administrative outpost, not least due to its strategic location. Tell Khaiber was positioned close to a network of crucial waterways that were active in the mid-2nd millennium. The Eridu channel of the Euphrates ran less than 20km east of Tell Khaiber, and both Tell Khaiber and Tell Khaiber 2 were positioned directly on the canal that forms Ur channel 1, and extremely close to the junction between the Ur channel 1 and the Ur channel 2, as well as a probable canal running to Larsa (Campbell, forthcoming). As a result, Tell Khaiber and Tell Khaiber 2 would have had the ability to monitor and control water-borne transport between the north and south, and most probably also between the east and west (Campbell, forthcoming). Furthermore, despite being surrounded largely by areas which would have been wetlands for much of the year, Tell Khaiber lay on an area of drier land which may have supported agriculture (Campbell, forthcoming). With its careful and strategic positioning, Tell Khaiber would have had the ability to control both surrounding rural regions, including the potential collection and administration of crops, as well as control of water-born transport to a vast range of areas further afar (Campbell, forthcoming).

Further distinguishing Tell Khaiber and its body of metalwork from most others from southern Mesopotamia is the type of material that was collected, recorded and analysed from the site. Due to the utilization of a total collection strategy, the material recorded from the excavations includes objects from a range of different contexts, and at varying different degrees along its lifecycle, contrasting with the grave-good heavy bodies of metalwork in extant collections. Tell Khaiber's Sealand Dynasty date also sets it apart from the other sites included in this thesis; this is the first substantial body of metalwork with a known Sealand Dynasty date. As discussed in Chapter 2, the Sealand Dynasty remains a largely elusive period of Mesopotamian history, therefore the study of this material, and the inclusion of sites like Tell Khaiber in new research, are crucial in expanding current understanding of the period.

4.1.3 Legacy Data

The majority of data used in this project are legacy data, meaning published data from past research projects. By far the largest contribution is the catalogue of object information and compositional data for 2,623 metal objects published in 2004 by Hauptmanna and Pernicka as part of the *frühe metalle in mesopotamien* study previously discussed in Chapter 3. In total, 1,293 of these objects and their readings are included in this thesis; the rest were excluded due to falling outside of the temporal and/or geographical parameters of the project. A further source of legacy data used in this project is the Mesopotamian Metals Project (MMP), also previously discussed in Chapter 3. The object information and compositional readings for 82 objects included in the MMP are included in this thesis. These data, among others from the MMP, were publicly accessible online at www.avirtualmuseum.org at the time of conducting the research and analysis for this project. Lastly, a very small number of compositional data were selected from two smaller publications. The first is a study of ancient Near Eastern artefacts in the Metropolitan Museum of Art by Muscarella (1988), from which eight are included in this project. The second is a short publication by Hopp *et al.* (1992) that predominantly focuses on Iranian metal, but information and compositional data from two southern Mesopotamian objects from this publication are included in this project. Other analyses of Mesopotamian metalwork exist (such as Krause 2003; Moorey 1985; Ponting 2013) but have not been included in this project either due to them falling outside of its temporal or geographic scope or because the objects are also included in the catalogue published by Hauptmann and Pernicka (2004).

The use of legacy data in new research helps to provide a much broader body of data with which to work. This can result in more comprehensive research and, as argued by Pollard (2018: 61) regarding the methodology behind the 'Oxford System', the wider the dataset, the more reliable the inferences made. The use of legacy data also allows for new research to be conducted on material that has been previously analysed, but which is no longer accessible for re-analysis. Similarly, it helps to reduce re-analysis of objects as, despite many methods of analysis being non-destructive, it is still often better to avoid disturbing valuable and/or fragile objects in collections where possible (Lyubomirova *et al.* 2014: 677).

Alongside these benefits, the use of legacy data also presents some potential challenges; most prominently, issues of consistency between datasets. As discussed by Lyubomirova *et al.* (2014) comparison of analytical data taken from different investigations into metal composition can be made challenging due to differences in technique and method, or the homogeneity of the material analysed. Each different method of compositional analysis possesses different strengths and weaknesses, and these are discussed in detail in section 4.3 (also see Pollard 2018: 63-3). Of the 1,522 compositional readings used in this project, 1,417 (93%) were taken using energy dispersive X-ray fluorescence (ED-XRF). This includes nearly all of the Hauptmann and Pernicka readings, all of the readings taken at the three UK museums specifically for this project, and all of the readings of the metal from Tell Khaiber. XRF is discussed in depth in section 4.3; in summary for the time being, however, the key strengths of XRF are that it is multi-elemental, comparatively low-cost, can be used non-destructively, has a low turn-over time, and can be used portably (Pillay 2001: 593). A key disadvantage of XRF is that readings typically only penetrate between a few micrometres and a few millimetres into the object being analysed. As a result, surface geometry and corrosion can significantly affect readings.

The use of XRF in both the legacy data taken from Hauptman and Pernicka (2004) and the new data contributed here lessens many of the potential challenges and incompatibilities often confronted with using significant bodies of data analysed with drastically different methods. Despite this, two key differences should be addressed. Firstly, the readings published by Hauptmann and Pernicka do not include antimony (Sb) while the new readings contributed here do. As antimony does not play a substantial role in the analysis and discussion of these objects throughout the thesis, this is not a significant issue. Secondly, the new museum-based and Tell Khaiber readings contributed in this thesis were taken using a modern handheld portable XRF (HHpXRF) machine, while the Hauptmann and Pernicka readings were taken in the 1990s, therefore using an older form of XRF technology (Hauptmann & Pernicka 2004: XI-XII). To assess the difference in compositional readings between these datasets, multiple objects from the Hauptman and Pernicka publication were re-analysed for this project, and the results were compared (Figure 4.3 and Table 4.1). For each element, the r^2 value was calculated to determine the proportion of variation between the Hauptmann and Pernicka readings and the readings taken for this project. The r^2 value for Cu is 0.9907, for Pb it is 0.9966, for Fe it is 0.8219 and for Ni it is 0.8379; all of which demonstrate a strong correlation. The Sn results are heavily skewed by object 291, the reading for which is 0.9% in the readings taken for this project but 8.85% in the Hauptmann and Pernicka readings. Similarly, the As results are heavily skewed by object 308, the reading for which is 0.3% in the readings taken for this project but 6.11% in the Hauptmann and Pernicka readings. Due to the strong correlation demonstrated between the other object readings, and following detailed checks of the readings, it seems most likely that these results are errors made at some stage of the Hauptmann and Pernicka readings prior to normalisation. With these objects included, the r^2 value for Sn is 0.5421 and for As it is 0.5009. Without them included the the r^2 value for Sn rises to 0.9453 and for As it rises to 0.8586. Therefore, without these two objects, comparison of all of the other objects analysed demonstrates a strong correlation. The overall high correlation in these comparisons demonstrates that the Hauptmann and Pernicka readings are adequately comparable in accuracy and precision to the more modern technology utilised here.

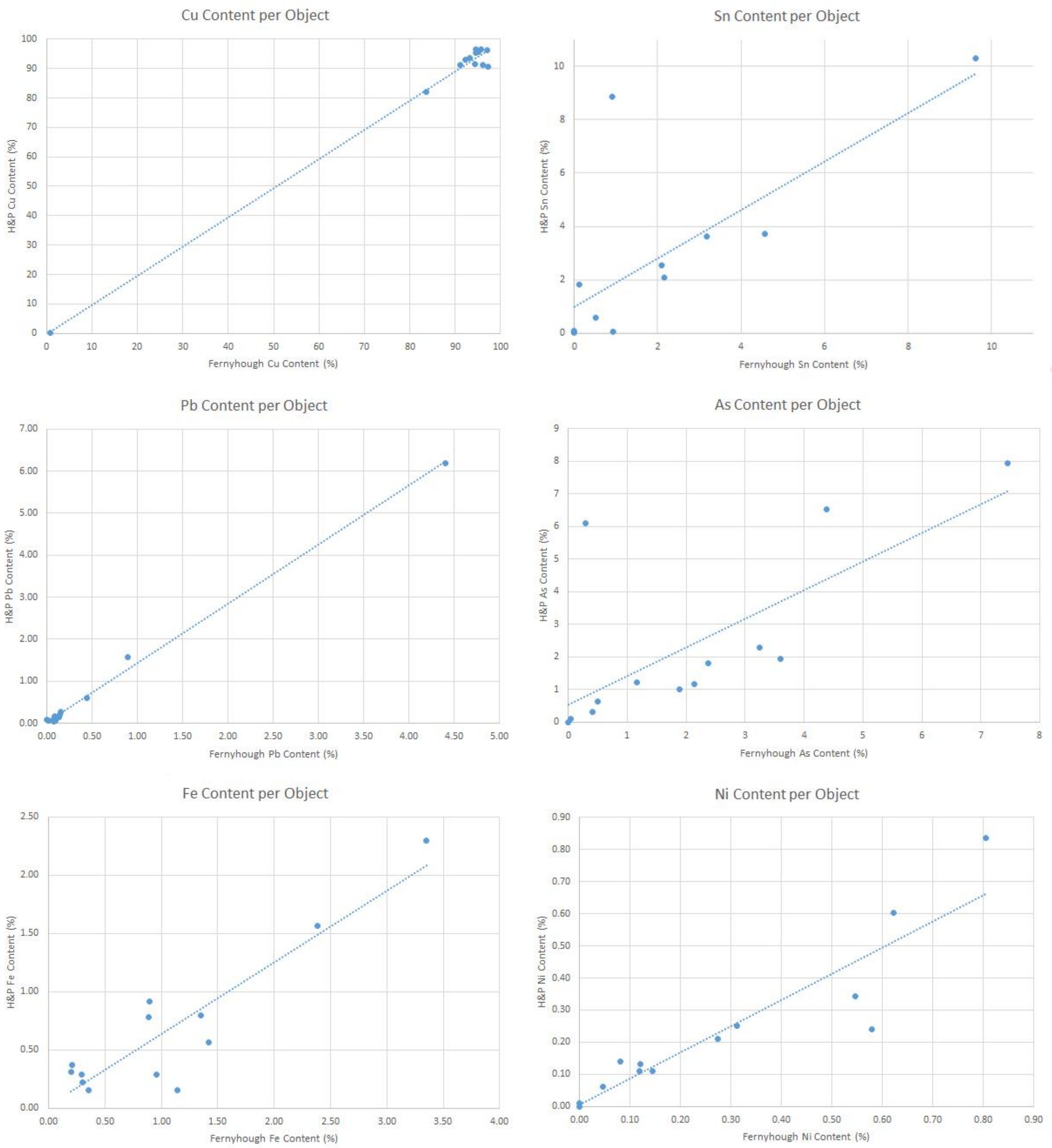


Figure 4.3: Graphs for each element depicting the proportion of variation between the compositional readings taken by the author (along the x-axis) and those published by Hauptman and Pernicka (2004) (along the y-axis).

Table 4.1: Comparison of compositional readings published by Hauptmann and Pernicka labelled ‘a’ and those collected specifically for this project labelled ‘b’.

Object Number	Cu	Sn	Au	Ag	Pb	As	Fe	Zn	Ni	Sb
286a	95.42	3.72		0.05	0.06	0.31	0.31		0.13	
286b	94.60	4.58	0.00	0.00	0.02	0.42	0.20	0.00	0.12	0.06
289a	95.59	2.08			0.06	0.63	0.79		0.84	
289b	95.04	2.16	0.00	0.00	0.09	0.50	1.35	0.00	0.81	0.06
291a	90.51	8.85			0.14	0.11	0.15		0.24	
291b	97.21	0.90	0.00	0.00	0.13	0.04	1.14	0.00	0.58	0.00
296a	0.31	0.07		99.22	0.11		0.29	0.00	0.00	
296b	0.93	0.93	0.09	97.01	0.08	0.00	0.96	0.00	0.00	0.00
308a	91.16	0.02			0.27	6.11	2.29		0.14	
308b	96.00	0.00	0.00	0.00	0.15	0.30	3.35	0.12	0.08	0.00
335a	93.52	2.53		0.51	0.59	1.80	0.78		0.25	
335b	93.29	2.09	0.00	0.53	0.44	2.38	0.89	0.00	0.31	0.08
336a	92.89	3.63		0.04	0.11	2.29	0.92		0.11	
336b	92.21	3.17	0.03	0.00	0.08	3.24	0.90	0.00	0.14	0.23
337a	96.62	0.59		0.09	0.20	1.93	0.22		0.34	
337b	94.50	0.52	0.00	0.00	0.14	3.60	0.30	0.00	0.55	0.40
339a	91.61	0.09		0.02	1.57	6.54	0.15		0.01	
339b	94.38	0.00	0.00	0.00	0.89	4.38	0.35	0.00	0.00	0.00
340a	81.98	10.30		0.10	6.20	1.02	0.29		0.11	
340b	83.62	9.62	0.03	0.00	4.40	1.88	0.29	0.00	0.12	0.03
343a	91.36				0.09	7.93	0.56		0.06	
343b	91.09	0.00	0.00	0.00	0.00	7.45	1.42	0.00	0.05	0.00
345a	96.52	0.04			0.04	1.23	1.57		0.60	
345b	95.72	0.00	0.00	0.00	0.07	1.17	2.38	0.00	0.62	0.04
354a	96.25	1.82		0.02	0.16	1.16	0.37		0.21	
354b	97.11	0.13	0.03	0.00	0.08	2.14	0.21	0.00	0.27	0.04

Of the remaining 105 compositional readings included in this thesis that were not taken with XRF, 82 were taken using particle-induced X-ray emission (PIXE), 13 by neutron activation analysis (NAA), six by inductively coupled plasma mass spectrometry (ICP-MS) and four have no analysis method provided. The 13 NAA readings are also taken from Hauptmann and Pernicka (2004). NAA is an extremely sensitive method of analysis, almost always producing results that are more accurate than XRF. NAA is better than XRF at reading below the surface, although it is also usually used as part of destructive analysis where samples are drilled from within the objects in question. Analyses using NAA are therefore typically less likely to be impacted by the issue of surface corrosion affecting readings. Therefore, for the objects analysed in the Hauptmann and Pernicka publication using NAA, the NAA readings have been used in this project rather than the XRF readings. Crucially, however, in the previously mentioned study by Lyubomirova *et al.* (2014) which sought to compare a range of different methods for analysing the composition of archaeological bronze, comparable results were obtained across a vast range of different methods including XRF, PIXE and NAA. The main difference was the range of elements picked up by each method. Further studies (see Lutz & Pernicka 1996; Merkl 2011; Pernicka 1986; Rychner & Northover 1998) where multiple different analytical techniques have been employed on the same objects have similarly demonstrated generally comparable results.

Alongside key differences between the actual capabilities, strengths and weaknesses of different analytical methods, there is also the issue of differences in methodology. Problematically, published data often lacks sufficient accompanying information about the standards employed, the exact settings used, and the estimated levels of detection and accuracy (Pollard 2018: 62). The Hauptmann and Pernicka publication does not include detailed information about the methodology employed, nor does the website displaying the Mesopotamian Metals Project readings. Similarly, no methodology is provided by Muscarella (1988) or Hopp *et al.* (1992). In the same vein, different projects also sometimes report a different set of elements; where these differ and some elements are missed out, it makes cross comparison more challenging. In modern compositional analysis of copper alloys, the minimal set of elements reported is usually Cu, Pb, Sn, Zn, Fe, As, Sb, Ag and Ni (Pollard 2018: 62). The elements used in this project are Cu, Pb, Sn, Zn, Fe, As, Sb, Ag, Au and Ni. As mentioned above, all of these elements besides Sn were also reported by Hauptmann and Pernicka in their XRF readings. Problematically, this was not the case for the Mesopotamian Metals Project readings, where the published readings only include Sn, As and Ni. As seen with some older analyses (see discussion Pollard 2018: 62-3), it appears that the Cu measurement was not directly taken but is to be worked out by subtracting the combined Sn, As and Ni contents from the end total (100%).

4.2 Data Organisation and Categorisation for Analysis

4.2.1 Project Databases

To adequately organise the data used in this thesis in preparation for analysis, and to make it accessible for those reading this research and/or wishing to build upon it, all of the object information and compositional data for all of the above-mentioned material needed to be entered into databases. Two databases were created using Microsoft Excel. The first, named the Objects Database (see Appendix B (https://figshare.com/s/fe3201770a3fa4422189)), catalogues each of the objects included in this thesis. A unique object number specific to this project was assigned for each object, and an entry was created to record its measurements, description and all other available data. The second database, named the Analyses Database (see Appendix C (https://figshare.com/s/a70670cec772b850a7a1)), records the results of the compositional analyses of these objects. All readings were normalised before entry. Some of the objects analysed by myself and by Stuart Campbell were read at multiple different locations. Each of these is recorded in the Analyses Database. During subsequent analysis and interpretation of these data, readings were combined and averaged in instances where the difference was negligible and kept separate in instances of significant variation. Although this thesis focuses specifically on southern Mesopotamia between approximately 2300-1300 B.C., some material was analysed from the UK museum collections that fall outside of these temporal and geographical parameters. While they were excluded from inclusion in this thesis, their compositional readings are still included within the Analyses database in case they are of interest or use to other researchers.

Entry of the object information and compositional data collected for this project, as well as the data from the Tell Khaiber material, was relatively straightforward. The input of the legacy data used was far more challenging. Partially, this was a result of the many difficulties posed by the use of legacy data as discussed above. Additionally, however, the volume published by Hauptmann and Pernicka (2004), which provides the vast majority of the legacy data used in this project, exists only in hardcopy and therefore needed scanning and then converting into machine-encoded text using optical character recognition (OCR) so that it could be edited and entered into the databases. The converted text then needed to be checked against the original publication to make sure that everything was correct, including every single compositional reading; this was necessary because even with high-quality photocopies, OCR software can still make mistakes, particularly with numbers. These numbers were further checked by making a sum of the concentrations for each object. A secondary challenge was that the publication is entirely in German, and while this is a broadly minor issue the key challenge it did produce was the difficulty of translating object types from German into English. Due to the often-idiosyncratic nature of specific object type names, this proved tricky even with the help of native German speakers. Object types were therefore translated to the best of my ability, with the assistance of native German speakers and alongside continuous reference to the object drawings provided.

Finally, alongside the two databases, Appendix D (https://figshare.com/s/28abeead45ab62e85a81) provides object photographs for each of the objects recorded and analysed at the three UK museums, as well as object photographs and a small number of drawings of the metalwork from Tell Khaiber.

4.2.2 Period Categories

Of the 1,522 objects included in this thesis, 1,048 have an assigned date, 661 of which are dated to a broad stretch of time that spans multiple periods, and 387 are dated to one specific period. These dates are taken from existing publications and museum catalogues. Based on these dates, the material has been grouped into ‘analytical categories’. This grouping allows a general exploration of periods without excessively breaking up the material. The analytical period categories used, and their corresponding date ranges, are as follows:

Table 4.2: Analytical period categories used throughout this thesis.

Analytical Period Category	Date Range
Early Dynastic	c. 2900-2350 B.C.
Early Dynastic to Akkadian	c. 2700-2150 B.C.
Akkadian	c. 2350-2150 B.C.
Akkadian to Ur III	c. 2350-2047 B.C.
Ur III[12]	c. 2094-2047 B.C.
Ur III to Isin-Larsa	c. 2094-1800 B.C.
Ur III to Old Babylonian	c. 2094-1600 B.C.
Isin-Larsa Period	c. 2000-1800 B.C.
Isin-Larsa to Old Babylonian	c. 2000-1600 B.C.
Old Babylonian (and Sealand)	Old Babylonian: c. 2000-1600 B.C. Sealand: c. late 18th to early 15th centuries B.C. (Van De Mieroop 2019)
Kassite	c. 1600-1155 B.C.

The analysis and discussion of material divided by date in Chapter 5 focuses predominantly on the single-period categories of Akkadian, Ur III, Isin-Larsa, Old Babylonian and Kassite. Within this discussion, however, objects from the analytical periods which span multiple periods are also included and discussed where relevant. Although material dated to the Early Dynastic period is not included in this thesis, all objects dated to a broad period range beginning with the Early Dynastic period but stretching to a later period have been included. This choice was made to avoid excluding significant amounts of material that may have dated to within the temporal focus of this study. As previously discussed in Chapter 3, issues concerning dating, including the use of extremely broad dating, are a common problem concerning southern Mesopotamian metalwork and subsequently make temporally structured examination challenging. A final clarification should be made concerning the category ‘Old Babylonian (and Sealand)’. As discussed in Chapter 2, Sealand sites such as Tell Khaiber may have been occupied contemporaneously with Old Babylonian sites and Old Babylonian occupation levels at other sites included in this project. Although there is a clear political difference between the Sealand and Old Babylonian dynasties, it does not necessarily mean that there would

[12]Hauptmann and Pernicka (2004) provide the period ‘Ur III’ for some objects and ‘Neo-Sumerian’ for others, despite these terms being essentially interchangeable for the same period. This is possibly due to information being taken from various different original sources which may have used different dating nomenclature and traditions. Throughout this thesis, Ur III is used to apply in both instances.

be a substantial difference in material culture. As such, in Chapters 6, 7 and 8, the Tell Khaiber material is often discussed alongside other Old Babylonian material; in these instances, the analytical period category used is 'Old Babylonian and Sealand'. As the Tell Khaiber material constitutes the only Sealand material included in the thesis, the categorisation used in Chapter 5, which does not contain any Tell Khaiber objects, is simply 'Old Babylonian'.

It should also be noted, however, that the use of traditional period categories such as these is not always helpful. The creation of distinct chronological periods, typically defined by political changes, can appear to present a picture wherein all aspects of society and culture change according to these political shifts, yet the reality is typically far more complex. As such, these categories will be used in Part I, where traditional approaches are employed and critiqued, but they will be used far less in Part II, which seeks to utilise less top-down informed approaches.

4.2.3 Metal Type Categories

There are innumerable different ways to categorise and describe different metals. The most straightforward category of metals would seem to be that of 'pure' metals, yet this is made less straightforward by the fact that archaeological metal is not as pure as modern metal (Salzmann *et al.* 2016: 141). Archaeological metals which are not intentional alloys can still be expected to have detectable amounts of other elements present, depending largely on where the metal was sourced and how it was processed. For example, in its native state, gold will always have a composition that includes some amount of silver, and sometimes also copper and/or iron (Moorey 1994: 217). While this does make defining 'pure' archaeological metals more complex, it does help archaeometallurgists to identify potential sources, and better understand the technology that appears to have been used or not used.

Previous approaches to the categorisations of alloys have tended to use the same categorisation as is typically used for modern alloys and which are fundamentally based on technological function (Kuijpers 2017: 22; Pollard 2018: 115). Problematically, these categories and their application rely on various assumptions about desired properties and qualities that may apply to the modern day but cannot uncritically be assumed to apply to the past. As an extension of this, various seminal anthropological works (such as Miller

1995, 1998) on material culture have demonstrated that many of the issues, themes and factors that archaeologists place great emphasis on in their research can be of very little importance to those who actually engage(d) with the material in question (Hurcombe 2007: 535-7). This is not to argue against the use of categorisation and definition; the use of which is, of course, highly necessary in research, particularly when interpreting data. It is crucial, however, that our use of externally imposed classifications is approached with a critical awareness of their inherent limitations and, ideally, alongside the pursuit of evidence that can provide more of an emic perspective on the categorisations used within the context in question. The use of contemporary textual records can provide key insight into metalworking practices and how alloys were created and defined. The investigation of patterns between composition and object type can also help us to better understand the motives behind specific compositions; although, it should also be kept in mind that composition may also be the result of other, less intentional factors such as recycling, or simply of a lack of compositional control (Pollard 2018: 115). Similarly, the use of experimental archaeology and interdisciplinary work with metallurgists can help to improve understanding of composition choice from a craft perspective rather than that of a researcher in a laboratory (for example, Kuijpers 2017, 2018).

Within this thesis, it is necessary to use a pragmatic set of categories to facilitate interpretation, presentation and discussion of the data, particularly in Chapters 5 and 6. Three key categories are used and should be defined here: ‘high copper’, ‘arsenic bronze’ and ‘tin bronze’. Of the 1,522 objects included in this project, 1,280 (84%) fall into one or more of these three categories. The approach used throughout this thesis to metal types that fall outside of these three key categories is to describe rather than strictly define and categorise. The first key category to define is that of ‘high copper’. High copper is used throughout this thesis to refer to objects with a copper composition of above 95%. This category is fundamentally a descriptive one to illustrate the high prevalence of objects with a very high copper content in the dataset. The second key category used is that of ‘arsenic bronze’. As discussed in Chapter 2, there is debate concerning the intentionality of arsenic-copper alloys in southern Mesopotamia in the Bronze Age. The natural occurrence of arsenic in copper ores around the world, and the high degree of variation in the arsenic content found in arsenic-copper alloys, make it impossible to determine where an arsenic-copper alloy was intentionally created or natural (De Ryck *et al.* 2005: 262; Lechtman 1996; Lechtman & Klein 1999; Moorey 1994: 242). As a result, a general stance of ambiguity regarding intentionality is assumed throughout this thesis. Following the terminology and definitions set out by Hosler *et al.* (1990), arsenic bronzes are defined throughout this thesis as copper-based objects containing ≥0.5% arsenic, as it is with the addition of approximately 0.5% arsenic and above that a significant change in the properties of copper occur (Lechtman 1996: 481).

The final key category is that of tin bronze. Within the context of Bronze Age Mesopotamia, we do have access to some textual references which can help to shed light on tin bronze composition. Most prominent of these are alloy 'recipe' texts. Recipe texts for tin bronze vary somewhat in the level of tin required, with some stating 12.5% but others reading as high as 16.6% (Joannès 1993: 104; Potts 1997: 169). It is crucial to acknowledge, however, that recipe texts would not have been written by the smiths themselves (Robson 2007: 241-2). Furthermore, they would have been written within a palatial context which is not likely to be reflective of metalworking in non-palatial contexts. Realistically, metalwork in southern Mesopotamia would have been regularly recycled; therefore, strict ratios such as these are unlikely to be representative of most everyday metalwork in circulation. In a study by Salzmann *et al.* (2016) which examined material from the cemetery at Ur, the tin bronze objects were demonstrated to contain between 7% and 12% tin. Notably, however, these objects date to the Early Dynastic period which precedes the temporal focus of this study, and it should also be emphasised that material from the cemetery at Ur is highly unlikely to be representative of everyday metalwork in circulation; indeed, one-fifth of the material used in the study by Salzmann *et al.* (2016) comes from the Royal Tombs.

Despite a tin content of between 7% and 12% often being recognised as the optimal composition for tin bronze based on technological function (e.g. Salzmann *et al.* 2016: 142), it should not be assumed that tin bronze needs to fit into this range to be considered an intentional tin bronze. Similarly, it should not be assumed that all tin bronze was alloyed to fit these 'optimal' functional properties. As discussed in Chapter 2, lower concentrations of tin remain sufficient to significantly alter the properties of the alloy. Kuijpers (2018: 875) notes that with the addition of around 5% tin, the colour of copper shifts from an orange copper to more of a yellow copper. It is at as low as 2% tin that copper becomes noticeably harder and stronger (Stech 1999: 62). Subsequently, tin bronze is defined throughout this thesis as a copper-based object containing ≥2% tin. Throughout the thesis, however, there is also acknowledgement and discussion of the data in light of the above-mentioned more ‘traditional’ tin bronze ratios.

As previously mentioned, the pragmatic set of categories presented above is predominantly used in Chapters 5 and 6, where more traditional approaches to the examination, analysis and interpretation of metalwork are undertaken. In Chapters 7 and 8, in which alternative approaches are explored, the use of metal type categorisation becomes more fluid and incorporates different approaches to categorisation such as those which take into consideration alloying for sensorial factors such as colour and sound. In particular, the recent work of Kuijpers (2017, 2018) is drawn upon. In his research on skill, Kuijpers (2017) offers a different approach to alloy categorisation based on the sensorial perception of metal rather than specific percentages. Primary research conducted with metalworkers is shown to emphasise an aim towards qualities such as hardness and workability but highlights the importance of sensorial factors such as colour in knowing whether the desired composition has been reached (Kuijpers 2017: 865). Therefore, it is less a case of extremely specific percentages, and more a case of observing and reacting to the material itself, resulting instead in a degree of approximation. As a result, Kuijpers (2017) presents a new way in which to categorise alloys which focuses instead on colour. Colour is often an under-appreciated influencing factor in the creation and consumption of metal, particularly due to the frequency with which metal is described by its visual properties; something which is certainly true in Mesopotamian textual sources and is discussed in length in Chapter 8.

Through the combination of a pragmatic set of basic categorisations, the regular adoption of a more fluid, descriptive approach, and the utilisation of alternative approaches to categorisation that emphasise sensory perception and a craft perspective, this thesis provides a more holistic and flexible analysis and interpretation of southern Mesopotamian metalwork.

4.2.4 Typology and Object Type Categories

Typology is not a strong focus of this thesis and does not feature heavily in any of the analysis or discussion, but it is included occasionally, particularly to fit the Tell Khaiber material into the wider context of southern Mesopotamian metalwork types. As discussed in Chapter 3, a typology of Mesopotamian metalwork has been created by Barbara Helwing, originally written as part of the *Frühe Metalle in Mesopotamien* study to be published as part of a second volume. This typology has yet to be published but is made available online in draft form on www.academia.edu. As this is by far the most comprehensive typology of Mesopotamian metalwork to date, and also due to the large number of objects utilised from the project that it was created alongside, Helwing's typology is the main typology used and referenced throughout this thesis.

One of the biggest challenges regarding the use of typology was the inability to allocate types to fragmentary material which constitutes most of the metalwork from Tell Khaiber. Where a type could not be allocated, objects have been sorted into general descriptive categories such as 'sheet', 'rod', or simply 'fragment'. Objects that can be fitted into an object type are predominantly sorted into two object type categories: a broad one and a specific one. This is largely to facilitate easier broad discussion and presentation, but wherever relevant individual examples are drawn out and discussed. Most of the object type categories used in this thesis are self-explanatory, however, there are two object types which require some clarification. Firstly, axes can serve as either tools or weapons (Helwing, undated). As they appear to have been most commonly used as a tool, they are categorised as such here. Secondly, rings are broadly included in jewellery, but it should be noted that it is difficult to determine whether a ring was intended to be worn or whether it could have had some other use or been a part of another object. As such, this is taken into account during discussion, particularly in Chapters 7 and 8.

4.3 Chemical Analysis

Chemical analysis of composition plays a crucial role in modern archaeological investigation. At a basic level, compositional analysis provides a better understanding of the material make-up of objects, allowing for a more in-depth understanding of the exact nature of the material being found at a site and/or worked with. This data also aids judgement of best conservation strategies and management of materials following their excavation, as well as a better-informed assessment of appropriate forms of analysis (Karydas 2007: 419). When analysed in light of larger-scale and more complex research questions, however, data retrieved through compositional analysis can also shed light on a vast range of wider aspects of life and activity at a site (Glascock 2016: 1). Via the notion of geochemical fingerprinting, for example, analysis of some materials such as glass and obsidian can provide information relating to sources and provenance, which can then feed into wider topics such as social migration, interaction and exchange (Pillay 2001: 593). As another example, the analysis of soil samples can help to identify archaeological sites and indicate how space may have been used by inhabitants throughout the lifecycle of a site beyond the information provided by structural remains (Wilson *et al.* 2008: 412).

Most compositional analysis of archaeological material up until the end of the 19th century consisted of using gravimetric methods on metallic alloys (Pollard 2013). This destructive method required the dissolution, precipitation, filtration and evaporation of samples to produce solids that could then be weighed (Glascock 2016: 3). Using this method, only one element could be analysed at a time. These methods gave way to instrumental methods of analysis in the early 20th century (e.g. optical emission spectrometry (OES)) which paved the way for extensive compositional studies of archaeological metalwork. Unlike previous methods, these instruments allowed for multi-elemental analysis and were significantly more sensitive and efficient (Glascock 2016: 3).

It was with the first applications of neutron activation analysis (NAA) in the mid-1950s, however, that compositional analysis in archaeology advanced substantially, becoming far more accurate, precise and capable of analysing a much wider elemental range (Glascock 2016: 3; Speakman & Glascock 2007: 180). The decreasing use of NAA towards the end of the twentieth century was largely due to the decommissioning of research reactors which were deemed less safe than alternative options and are expensive to maintain and upgrade (Speakman & Glascock 2007: 181). NAA is still used occasionally within archaeology today and, in some respects, NAA is still the optimal option, particularly for the analysis of materials such as ceramics (Speakman & Glascock 2007: 180). Regardless, it has been surpassed in popularity and usage by other forms of analysis; for example, particle-induced X-ray emission (PIXE), X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS). As briefly mentioned earlier in this chapter, each of these forms of analysis has its own set of advantages and disadvantages. Both XRF and PIXE can be used non-destructively, they are both multi-elemental, both have low turn-over times and both can be used with low-level to no sample or surface preparation beforehand (Pillay 2001: 593). PIXE is typically less cost-effective and practical than XRF and also requires a particle accelerator (Pillay 2001: 593). Problematically, neither PIXE nor XRF is well suited to analysing heavy elements. In contrast, ICP-MS is ideal for such analyses whilst also being capable of analysing trace and ultra-trace elements. It has therefore been highlighted (Pillay 2001: 595) that ICP-MS often works well as a complementary form of analysis used alongside PIXE or XRF.

Out of the different forms of compositional analysis, XRF was largely chosen for use within this project due to its ability to be used in a highly portable form. As discussed below, HHpXRF instruments such as the one utilised in this project are excellently suited to use in the field and museums. Portability was essential in facilitating the fieldwork required for this project; without the ability of a single individual to easily transport the instrument around the UK this fieldwork could not have been undertaken. Of further key importance was the ability to set up and use the instrument efficiently at each of the different museums, and without needing to take up too much space as not all museums have extensive lab space available for visiting researchers.

4.3.1 XRF in Archaeology: Advantages and Disadvantages

XRF operates by displacing electrons from their atomic orbital positions by sending an X-ray beam capable of affecting the electrons in the inner shells of the atoms (Figure 4.4) (Hall 2016: 3-4; Shackley 2011a: 16-17). This causes a release of energy as the atom seeks to immediately correct the instability caused by the beam by filling the vacancies with electrons from higher orbits; a process otherwise known as fluorescence (Shackley 2011a: 16-7). The amount of energy lost during this process relates to the distance between the two orbital shells which is unique to each element. The burst of energy released during fluorescence is therefore characteristic of a specific element and subsequently, when the detector in the XRF instrument registers the energies travelling back it can categorise them by element (Hall 2016: 3-4). The depth of penetration by the X-ray beams varies slightly depending on the energy of the X-rays used for a reading, but typically they range from a few micrometres to a few millimetres.

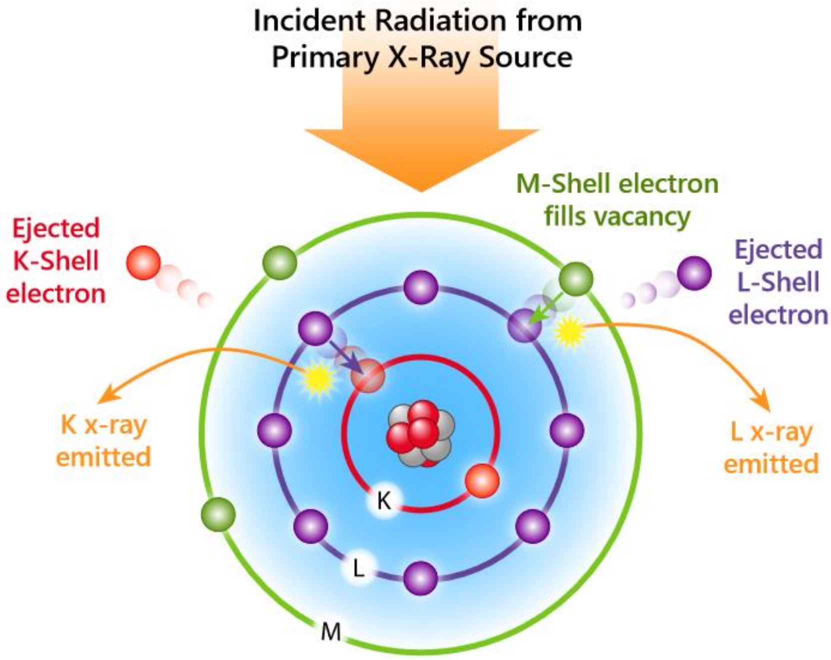


Figure 4.4: The process of XRF analysis (Thermo Fisher Scientific 2020).

Laboratory-based XRF has played a substantial role in archaeological science since the 1960s (for example Hall 1960; Olsen 1962; Hall *et al.* 1964; Yao and Stross 1965; Jack & Heizer 1968). Particularly over the past several decades, XRF has become a fundamental method of analysis. It can be used to analyse a wide range of archaeological materials such as metal, ceramic, glass, obsidian and even soil samples. One of the most archaeologically important and appealing advantages of XRF is its capability to be entirely non-destructive. Non-destructive analysis allows objects and samples to be retained for future reference and further testing using other methods. It also enables the analysis of objects and collections in situations where destructive analysis is not permitted such as in museum settings or when working with highly unique objects (Shackley 2011a: 8). The non-destructive capabilities of XRF have also made it highly popular in museums; XRF instruments in both static and portable forms can now be found in many museums and conservation laboratories (Karydas 2007: 419). XRF can also, however, be used alongside more invasive and/or destructive approaches such as using heavy surface preparation, sampling and cross-sectioning objects if it is permitted and deemed necessary to improve results. The options available with XRF, therefore, render it a particularly flexible analytical tool. The popularity of XRF in archaeology is also largely due to its numerous economic and practical advantages; these include relative ease of use, immediate results, relative low-cost particularly if employed routinely and, when used non-destructively, minimal requirements of preparation (Frahm & Doonan 2013; Shackley 2011a: 8).

There are, of course, also disadvantages to using XRF; for example, it is less useful on very small samples of material or for use on small components of a larger object as the reading area often needs to be 5mm or larger. XRF also has a slightly restricted elemental acquisition as it is cannot be used on lighter elements; usually, elements below magnesium. This is of no issue within the context of this particular study, however, as the elemental acquisition of XRF covers all relevant metals (Karydas 2007: 419; Shackley 2011a: 8). Another key disadvantage of XRF is that many archaeological materials have characteristics that can prove challenging when using XRF analysis non-destructively (Shugar 2013: 177). To get the most accurate possible results analysing metal, XRF should be used on bare, flat metal surfaces which therefore would require surface preparation. Often problematically, this would cause the analysis to be destructive, essentially negating one of the major advantages of this form of analysis. Conducting XRF, especially non-destructively, is therefore not a simple process and requires clear and careful consideration of the materials being analysed and how certain characteristics may influence results. This, of course, is an issue of pertinence to this study and is therefore addressed in detail later in this chapter.

4.3.2 XRF in Metalwork Analysis

XRF analysis has a long history of use in the study of metalwork and metalworking. The ability of XRF to read the chemical composition of metal not only allows archaeologists to better understand the type of metal that they are working with but can also provide insight into alloying activities and the ratios being used, the technology being employed to create the object, and can even determine the provenance of the metal in question. XRF can also help with identifying metalworking activities and workspaces which, for example, can be investigated through the analysis of metal residue on objects such as crucibles or in soil samples (such as Hafez *et al.* 2017; Tighe *et al.* 2018; Wijepala *et al.* 2022).

There are several key challenges involved with the use of XRF on archaeological metalwork. Consideration of these problems dates back to the 1960s and some of the earliest applications of XRF to archaeological metal (e.g. Roberts 1960). As previously mentioned, the main problem that can arise with any XRF metal analysis is the potential effect of surface corrosion on readings. Corrosion is an issue for compositional analysis because of how it alters the composition of metal. Put simply, corrosion occurs when metals chemically or electrochemically react with their environment; for example, with moisture in the atmosphere or oxygen (McCafferty 2010: Revie 2008). This irreversible reaction causes the formation of metallic oxides or sulphides as the metal begins to return to a more chemically-stable state (Patel 2014: 351). This occurs because, except for certain noble metals such as gold, metals do not occur in nature in their pure state; instead, they require refinement. As the X-rays used in XRF analysis typically only penetrate between a few micrometres and a few millimetres into the object being analysed, the impact of even light surface corrosion can be significant. Previous research into the impact of corrosion on XRF readings, particularly in the case of copper alloys, has demonstrated elevation of tin contents in some instances (such as Charalambous *et al.* 2014: 209; Ferretti 2014: 7; Robbiola *et al.* 1998). This is typically the result of preferential corrosion of the copper due to acidity in the burial context (Cuénod *et al.* 2015: 8). Studies have also demonstrated and discussed instances of copper depletion (such as Fernandes 2013: 5; Ferretti 2014: 7; Robbiola *et al.* 1998). Robbiola *et al.* (1998) found that copper depletion is found in objects of low-level corrosion, but it is only at higher levels of corrosion that elevation of tin content is found. With less reactive metals such as silver and gold, corrosion is less of a problem; however, essentially all archaeological metalwork is still prone to some degree of corrosion (Shugar 2013: 182).

The impact of corrosion on readings will depend partially on the instrument and settings used. It is also influenced by the type of metal being analysed and the degree of corrosion present. It is, therefore, important to test the potential impact of corrosion using the intended instrument and settings before conducting fieldwork. It is also important to understand the type of material that will be analysed, how it tends to corrode, and, ideally, the environment in which it has been buried as corrosion often incorporates elements from the surrounding soil (Shugar 2013: 182). It should also be noted that if an object has previously had its surface cleaned to remove any corrosion, the process may have caused a degree of contamination, especially if metal instruments were used. Older approaches to metal conservation regularly employed methods that emphasised returning archaeological metals to their original appearance. Commonly, these methods stripped away corrosion material entirely, often using harsh and damaging techniques. This was a particular issue in the late 19th and early 20th centuries. Metallurgist Ernest von Bibra, for example, was a proponent of the full removal of corrosion products to return their metallic finish (see Bibra 1869). Following the full removal of corrosion products, metal objects would also sometimes be polished to regain their original shine. Conversely, objects would sometimes have their corrosion entirely stripped, only to then be artificially patinaed (see Petrie 1888). Fortunately, most of the metalwork used in this project has not been subject to harsh and/or problematic cleaning.

In addition to corrosion, a further potential issue involved with surface readings is the potential impact of uneven surfaces. An uneven surface can change the way radiation is reflected, subsequently altering results (Shackley 2011a). Again, however, this is unlikely to be a significant problem with the objects analysed in this study, as discussed in greater detail further in this chapter. There is also some potential for compositional variability in the objects; however, the size of the area analysed in a reading helps to reduce this potential problem and, where necessary, multiple reading points can be taken.

4.3.3 Portable XRF (pXRF)

XRF systems can be laboratory-based systems, or they can be portable systems. Like laboratory-based XRF, portable versions of XRF (pXRF) also date back as far as the 1960s (see Bowie & Darnley 1965; Bowie 1968). The creation of portable forms of XRF enabled archaeologists to carry out analysis on bodies of material that could not be taken to a laboratory, resulting in a far wider scope of potential uses for XRF. The first applications of pXRF to archaeological contexts occurred in the 1980s. Hauptmann (1985) used pXRF in pursuit of identifying copper-smelting sites in Oman while Helmig *et al.* (1989) utilised it further in archaeometallurgical fieldwork in Jordan and Turkey (Frahm & Doonan 2013: 1426). Helmig *et al.* (1989: 181-2) also note, referencing personal communication, that in 1983 pXRF analysis was carried out by Pernicka on silver, copper, iron and lead ores from Anatolian mines as well as on copper and bronze artefacts from Greek museums. The value of using pXRF in archaeometallurgical studies was therefore identified from the very beginning of pXRF application in archaeology. The use of pXRF has expanded substantially in recent years resulting in comments on the notion of a ‘pXRF revolution’ and extensive, lively debate concerning its advantages, disadvantages and application (e.g. Frahm & Doonan 2013; Forster *et al.* 2011; Shackley 2011a; Shackley 2011b; Shugar 2013; Speakman & Shackley 2013). There is an important distinction, however, to be made between different forms of pXRF. Due to the flexibility of what can be classed as 'portable', pXRF has encompassed a range of different types of instruments over the years (Frahm & Doonan 2013: 1426). Handheld pXRF (HHpXRF) instruments are, as the name suggests, compact and light enough to be handheld. Non-handheld pXRF instruments can range in size and style but are often benchtop machines that are more challenging to transport and require a larger working area.

HHpXRF systems, like the one used in this project, are excellently suited to use in the field and for long-distance transportation. The ease by which HHpXRF can be transported is important when working with museum collections as permission to move material from museums to laboratories is often extremely hard to obtain. Analysis of museum collections therefore typically demands a highly portable form of analysis, especially if multiple collections are being analysed. HHpXRF is also especially valuable when conducting fieldwork abroad and particularly in countries where some material cannot be exported, as HHpXRF instruments can usually be transported internationally with relative ease. From the beginning of the 20th century onwards, legislation across various countries began to tighten concerning the exportation of archaeological materials. As mentioned in section 4.1.1, the export of archaeological artefacts from Iraq specifically has been illegal under domestic Iraqi law since 1974 (Brodie 2011: 117). The use of HHpXRF therefore facilitated analysis of metalwork from Tell Khaiber that could not otherwise have been analysed outside of Iraq.

Another major advantage of HHpXRF is the immediate feedback during analysis combined with the ability to make changes during fieldwork to the chosen sampling and/or reading strategies; something which is less possible with workstation-based pXRF (Frahm & Doonan 2013: 1427). Not only does this have the obvious advantage of being more time efficient due to a drastically shortened feedback cycle, but its efficiency and ability to be readily adjustable *in situ* facilitates the pursuit of a wider range of research questions and greater flexibility in the field. As Frahm and Doonan (2013: 1427) have argued, "the more we know about artefacts, sediments, or other materials while they are available and relevant, the better informed our sampling strategy can be".

Regardless of its clear advantages, however, HHpXRF also has the drawback of miniaturised and lower-power components (Frahm & Doonan 2013: 1426). While modern HHpXRF may not be able to rival modern laboratory-based or less-portable XRF machines in performance, their capabilities are still broadly equivalent to those of laboratory-based systems of the 1990s. Other potential issues with HHpXRF lie in its application. It has been highlighted (Frahm & Doonan 2013; Shackley & Steven 2009; Shugar 2013) that some archaeologists choose to use HHpXRF purely due to its convenience even when less portable instruments could be used instead. The perception by many that HHpXRF is easy and straightforward to use, earning the term of a 'point and shoot' instrument, has also occasionally resulted in its use by archaeologists who are not necessarily aware of key methodological steps required in its application (Frahm & Doonan 2013). Ultimately, pXRF is simply a more portable version of XRF and despite its user-friendly appearance, pXRF still requires the same considerations as laboratory-based XRF. It is therefore crucial that key methodological steps commonplace in broader XRF application be utilised for pXRF/HHpXRF analysis; for example, using internationally recognised standards, ensuring system reliability and stability, and forming a solid understanding of the material to be analysed and the potential challenges (Shackley 2010: 19; 2011; Shugar 2013).

4.3.4 Use of XRF in this Project

The compositional analysis conducted for this project was carried out non-destructively by taking surface readings on areas as flat and with as little corrosion as possible. As mentioned in section 4.1.3, the XRF used in this project is ED-XRF. The HHpXRF instrument used was a Thermo Scientific Niton XL3t 980 GOLDD+. The instrument generates X-rays via a miniaturized 50 kV, 200 μA tube with a silver anode. The XL3t GOLDD+ analyser has a silicon drift detector (SDD), with a resolution better than 155 eV., supplied by the University of Manchester. The internal instrument calibration is based on fundamental parameters.

The instrument was typically operated in an enclosed stand (Figure 4.5). The enclosed stand allows X-rays to reach the object, which is positioned in the compartment at the top, but stops X-rays from travelling outside of the compartment, subsequently dramatically reducing potential safety concerns. The enclosed stand also helps to reduce the potential for user error. In cases where the objects were too large to fit inside the compartment, they were positioned over the machine, supported by a rigid foam stand. Care was taken to ensure that no humans, myself included, were within 2m of the machine in these instances.

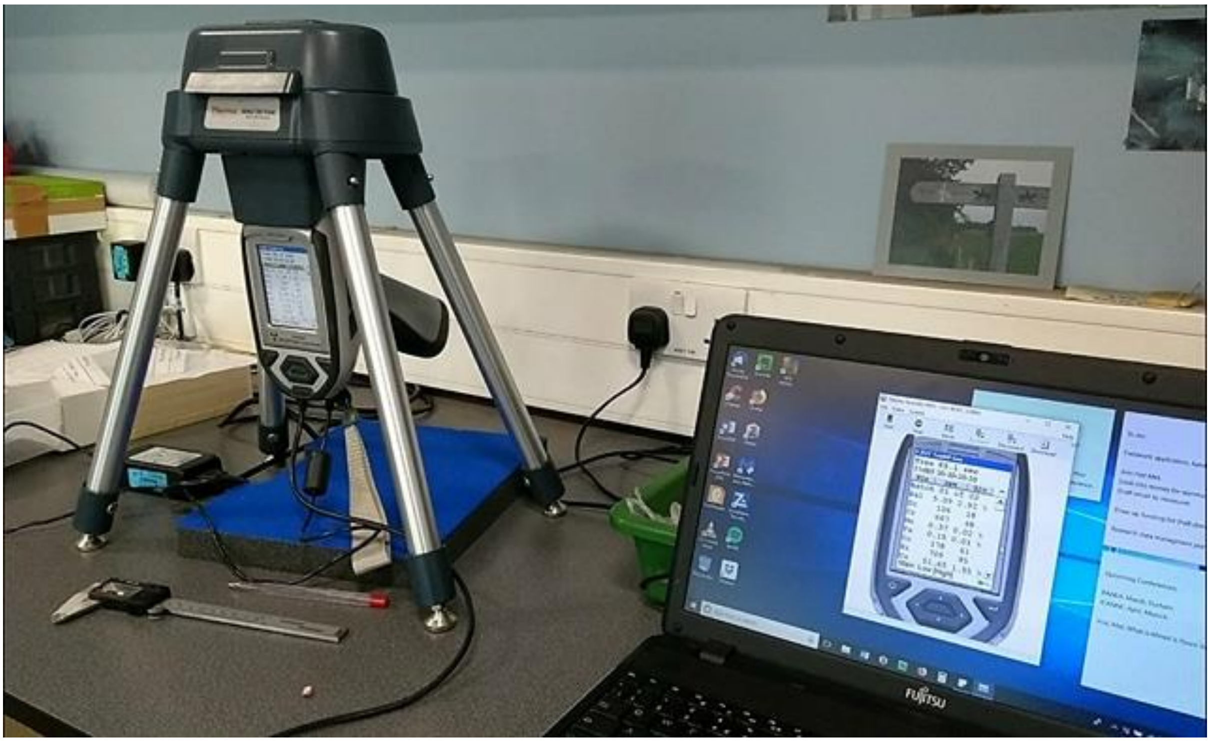


Figure 4.5: The general set up of the instrument, stand and connected laptop. The machine used is shown on the left, fixed to its stand. A laptop was connected to the machine, and the use of Niton software facilitated remote operation of the machine.

4.3.4.1 Basic Settings: Accuracy and Precision

Two modes were used for analysis: Test All Geo and General Metals. The General Metals mode, which uses three filters, is specifically designed to assess the composition of metals and provides the most accurate reading of metal content of all the available modes. This mode does not, however, include readings of important non-metallic elements such as arsenic. As such, analysis was also taken using Test All Geo mode which is a general analytical mode. Using four filters, Test All Geo mode analyses a broad spectrum of elements (from Mg to U) and is useful both to assess metal composition and also to indicate the extent of contamination, either from uncleaned soil, elements leaching into the metal during corrosion in soil, or post-excavation contamination while in storage.

Importantly, it also allows for the reading of arsenic which is particularly crucial when studying a period and region where the use of arsenical bronze was prominent. The selection of these modes was informed significantly by extensive previous work conducted at the University of Manchester (for example Frahm *et al.* 2016; Campbell & Healey 2016, 2018).

To calibrate results, standards from the Cultural Heritage Alloy Reference Material (CHARM) set were used at the start of every session (see Heginbotham *et al.* 2014). Multiple readings were taken on larger objects, and objects with more than one surface of interest. For smaller, simpler objects, one reading was taken. Alongside photographs of each object, photographs were also taken depicting the locations of all readings. To obtain a reading closest to the objects' original composition without including post-depositional contamination, and following modern standards (see Pollard 2018: 62), readings for the key metallic elements of copper (Cu), tin (Sn), gold (Au), silver (Ag), lead (Pb), iron (Fe), zinc (Zn), nickel (Ni), arsenic (As) and antimony (Sb) were selected from the results and normalised to 100%.

To select the most appropriate time frame for readings, previous studies (for example Asinelli & Martinón-Torres 2016; Charalambous 2015; Charalambous *et al.* 2014; Dussubieux & Walder 2015; Fernandes *et al.* 2013; Gliozzo *et al.* 2011; Ioannides *et al.* 2016; Karydas 2007; Lyubomirova *et al.* 2014) using pXRF to analyse copper alloy objects were first consulted. Using this information as a guide, a set of experiments was designed to evaluate the optimal reading protocol with this particular instrument. Tests were carried out using four of the Cultural Heritage Alloy Reference Material Set (CHARM) standards: 31X TB5 (brass), 32X SN7 (bronze). 33X GM21 (gunmetal) and 32X SN6 (bronze), selected from the wider set to cover concentrations of tin and copper in particular in the ranges likely to be encountered in Mesopotamian metalwork (see Heginbotham *et al.* 2014). Readings were run using both the General Metals mode and the Test All Geo mode at 10 seconds, 20 seconds, 30 seconds and 40 seconds for each filter. Each reading was run three times and the mean was calculated to reduce the spread of results. The instrument and standards were positioned in a stand to minimise user error such as movement during readings. The instrument was operated remotely from a laptop using emulation software.

Data from this analysis were sorted by standard and by element to see how the machine was performing both generally by standard and more specifically whether there were any issues with particular elements. The correlation coefficient and r^2 value were then calculated by both standard and by element. The final results were then compared to the reference composition of each of the CHARM standards used, which are established through consensus analysis of a wide range of major laboratories (see Heginbotham 2014). The findings showed little to no difference in results measured for longer than 20 seconds, indicating that 20 seconds is the best-suited duration for readings as it yields accurate results whilst also being time efficient (see Figure 4.6). Although longer reading times do typically increase precision, to halve the standard deviation – which is a true evaluation of precision – the reading time would need to quadruple. As a result, pursuing a result that is slightly more precise easily escalates reading times to unrealistic levels. The aim is therefore to establish a setting which is both precise but also time efficient.

Figure 4.6: The results of pXRF analysis of each standard at four different reading times illustrated per element.

It should be noted that these results are not optimal for all elements, and indeed the whole CHARM set was designed to support the analysis of copper alloys. Gold was not detected on any of the settings or for any of the time lengths and nearly all of the silver measurements were reading as < level of detection (LOD) with only a few exceptions. This is due to only very small amounts of silver and gold being present in the standards used. Where higher amounts are present, the machine detects both gold and silver accurately, something that to date has been tested using coins of known precious metal composition.

4.3.4.2 Corrosion Testing

As discussed earlier, the main challenge involved with using XRF to analyse metal composition is the potential impact of corrosion on the composition of the surface layers of artefacts. To set up an analytical protocol for non-destructive analysis, tests were carried out to judge the effect of different levels of corrosion on copper alloy objects on readings using the same settings that would be used on all of the museum metalwork and the metalwork from Tell Khaiber.

Readings were run on five objects that spanned a range of corrosion levels and age of corrosion allowing us to analyse how this might affect the level of impact on readings (Figures 4.7-4.11). Two of the objects, a pipe and a coin, were donated by Stoke-on-Trent Archaeological Service and date to the 21st and 20th centuries respectively. The remaining three, consisting of a spearhead, dagger and section of a tool, were borrowed from the University of Manchester teaching collections. Although the exact dates of these three are unknown, they are all likely to be Bronze Age. The spearhead was the most heavily corroded object of the five with thick, green powdery corrosion and little to no metal surface showing. The section and dagger were less corroded but still had a thin layer of corrosion on all surfaces. The pipe had patches of different types of corrosion and surface damage, one of which being heavy salt encrustation which was not present on any of the other objects. The coin was the least corroded of the objects.

The first set of readings was taken before any level of cleaning. Readings were taken at two or three points on each object to provide readings from more highly corroded areas and less corroded areas, or from areas with different types of corrosion and surface damage as displayed on the pipe section. The second set of readings was taken after a light amount of cleaning using a Dremel 4000 and a soft nylon attachment on the areas where the original readings were taken. The final set of readings was taken after heavier cleaning using the Dremel and a sandpaper attachment. The extent to which I was permitted to clean the objects down to bare metal was limited, so I chose to clean the areas where the previous readings had been taken at points of the highest corrosion. The two more modern objects were cleaned to bare metal, while the three older objects from the teaching collections were cleaned to just above bare metal. All cleaning was done with non-metal attachment heads to avoid contamination.

Figure 4.7: Section of pipe donated by Stoke-on-Trent Archaeology prior to any cleaning (above) and after the final stage of cleaning (below).

Figure 4.8: Coin donated by Stoke-on-Trent Archaeology prior to any cleaning (above) and after the final stage of cleaning (below).

Figure 4.9: Spearhead borrowed from the University of Manchester teaching collections prior to any cleaning (above) and after the final stage of cleaning (below) with the cleaned section circled in red.

Figure 4.10: Dagger borrowed from the University of Manchester teaching collections prior to any cleaning (above) and after the final stage of cleaning (below) with the cleaned section circled in red.

Figure 4.11: Tool section borrowed from the University of Manchester teaching collections prior to any cleaning (above) and after the final stage of cleaning (below) with the cleaned section circled in red.

When analysing the results, the main elements considered were Cu, Sn, As, Fe and Pb. Some of these results, particularly on the Test All Geo mode, however, were substantially under 100%. Each of the five objects was then studied to understand which other elements were significantly present. Al and Si made up a significant percentage in all five of the objects, possibly reflecting the soil matrix in which the corrosion originally took place. In the pipe, S and Ca also contributed a significant amount. Large percentages, predominantly falling between 20% and 36%, detected in Test All Geo mode for the spearhead, dagger and section were reflected in the residual balance (BAL), essentially individually unquantified light elements. This largely reflects the composition of corrosion oxides.

As expected, the results demonstrated that corrosion can have an impact on readings. For each object tested there was some change in compositional readings for at least some of the main elements of relevance. These differences were only dramatic, however, in the readings taken on the spearhead where the level of corrosion was extreme (Figure 4.12). Levels of corrosion on the museum objects used in this project were all substantially less corroded. At lower levels of corrosion, such as those on the coin, dagger or tool section, the impact of corrosion on readings was demonstrated to be slight. In these instances, the readings were capable of providing a good indication of original metal composition. Subsequently, these tests demonstrate that, where corrosion is light to moderate, the value of metals taken in isolation and normalised to 100% can act as a reasonable approximation for the original metal composition.

Figure 4.12: The results of pXRF analysis of each object at three different levels of corrosion illustrated per element.

4.3.4.3 Tell Khaiber

During the 2013, 2014, 2015, 2016 and 2017 field seasons of the Tell Khaiber excavation, compositional analyses using pXRF of 96 of the metal objects were taken by Stuart Campbell. These were conducted at the dig house, prior to the objects being moved to the Iraq Museum in Baghdad. This equated to approximately 68% of the Tell Khaiber metal objects. Analysis of 100% of the material was not possible due to time constraints. In 2014 a Niton XL2 950 GOLDD instrument was used, but in all of the following field seasons, the same Niton XL3t 980 GOLDD+ instrument used for all of the museum-based analyses was used. Although the reading modes vary slightly between the two instruments, they are broadly equivalent.

All of the analysed objects were read using the General Metals (XL3t 980) or General Alloys (XL2 950) modes. Based on measured standards, there is a close correspondence between metals measured using the General Metals (XL3t 980) or General Alloys (XL2 950) modes and the quoted values for the standards. For nearly all of the objects, readings at two different points on the object were made. To assess contaminants specifically, the Mining (Cu/Zn) mode was then used to take duplicate readings of the objects at one point per object. The standard data collection time varied slightly between the 2014 season and the following three seasons. In 2014, the standard data collection time was 60 seconds for large and/or thick objects which fully covered the sampling window, and 120 seconds for thinner and/or smaller objects, or objects which only partially filled the sampling window. The times for each reading were equally split between main and light elements. Following the 2014 season, this method was refined. For the following season, readings taken with the General Metals mode continued to use a 60-second collection time, with 30 seconds on both main and light elements, while readings with the Mining (Cu/Zn) mode were taken using a 90-second collection time, with the counting time split into 20 seconds, 20 seconds, 20 seconds and 30 seconds using the main, low, high and light element filters respectively.

At the beginning and end of every analytical run, as well as at random points within the run, a range of standards were read to monitor continued accuracy. Due to availability, the main standards used during the 2014 season were TILL-4, 2980, 2709a and IARM 35jn. As these standards do not have optimal metal compositions for this purpose, they were supplemented with repeat runs conducted on pre-1991 UK 1p and 2p coins with known copper, zinc and tin values, and a Canadian commemorative one-dollar coin with a known 50% silver 50% copper content. Although not ideal, comparisons of these standards from the Cultural Heritage Alloy Reference Material (CHARM) set indicate that these results can be used with moderate confidence. Standards from the CHARM set, particularly 32X SN6, 32X SN7, 33X GM21 A1 and 31X TB5, were used from the 2015 season onwards (see Heginbotham *et al.* 2014).

As is the case with much of southern Mesopotamian metalwork, there is surface corrosion on all of the metalwork from Tell Khaiber. Corrosion levels were between low and moderate for most of the objects. Readings were taken on areas that were as flat and with as little corrosion as possible; this was assisted by the careful work of the conservator before analysis.

Chapter 5

Period Overview

This chapter presents an overview of the compositional data, acquired through chemical analysis, utilised in this project from legacy datasets and from the three UK museum collections. Results of wider scale analysis and exploration are presented, utilising broadly traditional approaches and metal type categories. The primary aim of this chapter is to provide an overview of what the data can demonstrate using these approaches regarding metal usage. As discussed in Chapter 3, examination of some of the data included here has previously been discussed (for example, Cuénod *et al.* 2015; De Ryck *et al.* 2005; Wischnewski 2017); however, this discussion has tended to focus predominantly on the Early Dynastic objects due to their far greater number in comparison to objects of later periods. General patterns of usage regarding metal types and object types are presented to lay a groundwork of understanding, and then more specific patterns, connections and variations are explored. Secondarily, this chapter aims to further examine the extant body of metalwork from Mesopotamia, demonstrating the various contextual limitations previously discussed in Chapter 3, and how these hinder the drawing of conclusions that apply to southern Mesopotamian metal use and metallurgy as a whole.

The first section in this chapter, section 5.1, presents an overview of the legacy data utilised in this project. These data are divided into five key analytical periods as set out in Chapter 4: Akkadian, Ur III, Isin-Larsa, Old Babylonian, and Kassite. The data for each analytical period are explored with regard to object type and composition. Although many of the objects have been assigned a specific date and therefore fall into just one of these analytical categories, a large proportion have been assigned a span of potential periods and therefore straddle multiple analytical categories. A further amount of objects has not been dated at all. Exploration of the data that fall into these categories is presented in Section 5.1.6.

Section 5.2 focuses on the new data collected from Manchester Museum, the Ashmolean Museum, and Birmingham Museum and Art Gallery specifically for this project. Due to the lack of date for the majority of the objects in these collections, exploration of this data is instead structured by collection rather than analytical period. These data are explored in the same manner as the legacy data in section 5.1, although in slightly further depth due to them being new. Throughout the section, discussion is provided concerning how these new analyses compare to those discussed in section 5.1

All of the objects used in this study were sorted into broad object type categories and then sorted further into specific type categories. As discussed in Chapter 4, using two tiers of specificity with regard to object type allows for the investigation of both broader, overarching patterns, and smaller, less general patterns within these broader groups.

5.1 Legacy Data: Period Overview

This section presents the exploration of the compositional readings of 1,293 objects from the legacy datasets. This material spans 21 sites (Table 5.1). This spread is highly disproportionate, however, with 58% of the material originating from Ur. Seven of the objects do not have an assigned site[13].

Table 5.1: All objects categorised by the site at which they were found.

Site	Object Count
Abu Salabikh	2
Babylon	1
Adab	1
Diqdiqa	10
Isin	3
Khafajah	1
Kish	188
Possibly Kish	1
Lagash	7
Larsa	18
Nippur	31
Possibly Nippur	1
Reijibeh	1
Shuruppak	11
Sippar	3

[13] These seven objects all come from the 2004 Hauptmann and Pernicka publication and unfortunately only very limited information is provided about them.

Tell al-Dhiba'i	15
Tell al-'Ubaid	4
Tell ed-Der	4
Tell Harmal	19
Tell 'Uqair	9
Tello	162
Possibly Tello	5
Unknown	7
Ur	745
Possibly Ur	3
Uruk	39
Possibly Uruk	2
Total	**1293**

5.1.1 Akkadian Period

Of the 1,293 readings, 271 are taken from objects dated to the Akkadian period. This material spans seven sites, although an overwhelming 90% is from Ur (Table 5.2). Of the five key analytical period groupings used in this thesis, the Akkadian period category includes the largest amount of material.

Table 5.2: Akkadian objects categorised by the site at which they were found.

Sites	**Object Count**
Kish	5
Larsa	1
Nippur	10
Tell 'Uqair	3
Tello	5
Ur	243
Possibly Ur	1
Uruk	3
Total	**271**

Of the 271 Akkadian objects, the largest category of object is that of tools, followed by weapons and then vessels (Figure 5.1; Table 5.3). In terms of more specific object types, three object types dominate the material: axes, daggers and needles. There is much greater variation in object type in the material from Ur, but this is presumably due to the site providing such an overwhelming proportion of the material. As so much of the metal material from Ur came from burial contexts, this is most likely to be more representative of the types of metal objects used as grave goods and perhaps less representative of the types that were most commonly in circulation. Across most periods, including the Akkadian period, in both southern and northern Mesopotamia, metal vessels and jewellery were common grave goods; this applies to burials of both males and females (Barrett 2007: 12). Some grave goods were luxury objects, but use of utilitarian objects such as pots and tools was also highly common (Barrett 2007: 15). The deposition of utilitarian objects in graves is typically interpreted as an intention to prepare the deceased for the afterlife; but, as argued by Ucko (1969: 265), when studying grave goods, we cannot rule out the possibility that they were selected solely due to their connection to the deceased and therefore as a representation of key aspects of their identity. In some previous cultures, the deposition of these objects represents their death alongside their owner (Barrett 2007: 16; Soles 2001: 23).

There are no heavily fragmented objects or metalworking waste or by-products included in the dataset. In the Ur excavation publications, however, Woolley mentions the presence of metal slag on multiple occasions as well as areas that appear to have been metalworking areas, at which there would almost certainly have been some presence of metalworking waste material or scraps; the more modern analysis of which could have significantly improved current understanding. As discussed previously in Chapter 3, there are issues concerning both traditional collection and retention strategies; in instances where objects such as these were collected, they were often not retained and therefore are not available for further analysis.

Table 5.3: Akkadian objects categorised by site and broad object type category.

	Kish	Larsa	Nippur	Tell 'Uqair	Tello	Ur	Possibly Ur	Uruk	Total
Animal Equipment						1			1
Cylinder Seal						1			1
Dress						16			16
Figurines and Ornaments						1			1
Grooming Instrument				1	4	9			14
Musical Instrument				1					1
Jewellery						17			17
Misc.			1			3			4
Tool	3		5	1	1	94	1		105
Tool/Weapon						4			4
Utensil			1			2		1	4
Vessel/Vessel Accessories			3			45		2	50
Weapon	2	1				50			53
Total	**5**	**1**	**10**	**3**	**5**	**243**	**1**	**3**	**271**

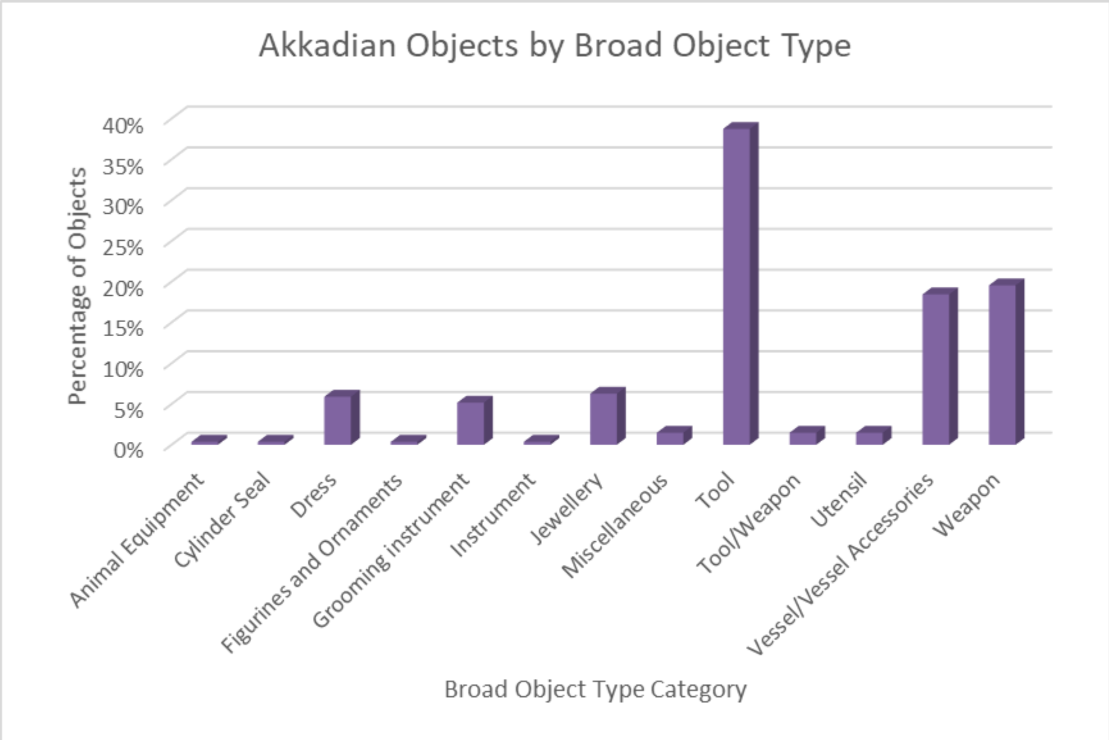


Figure 5.1: The percentage of Akkadian objects that fell into each broad object type category.

One of the most prominent compositional categories among the Akkadian objects is that of high copper composition (Figure 5.2). Of the 271 objects, 113 (42%) contain copper of 95% and above. These objects span all of the broad object type categories found among the Akkadian material more generally, with the only exception being that of figurines and ornaments (Figure 5.3).

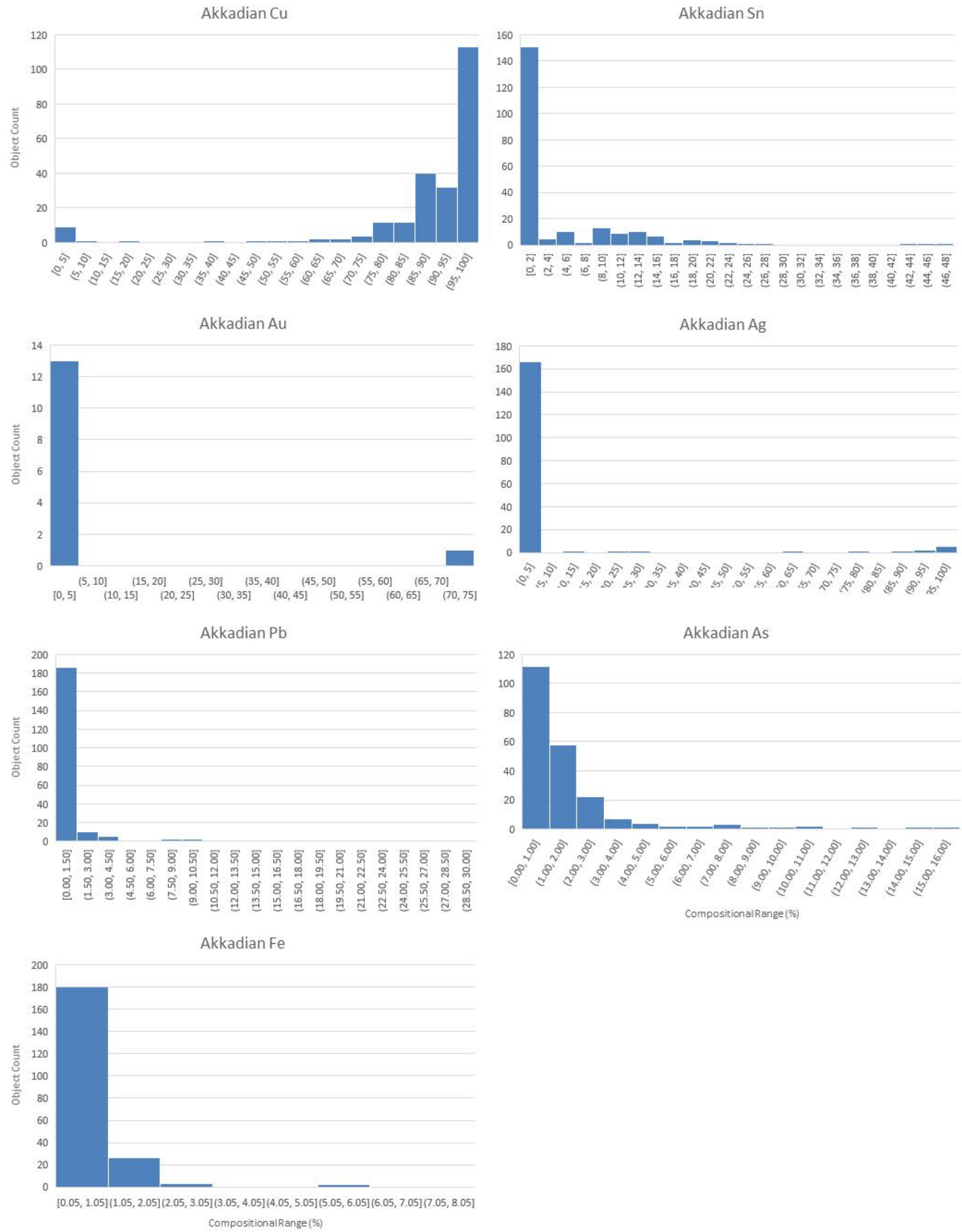


Figure 5.2: Results of compositional analysis of Akkadian objects illustrated by element.

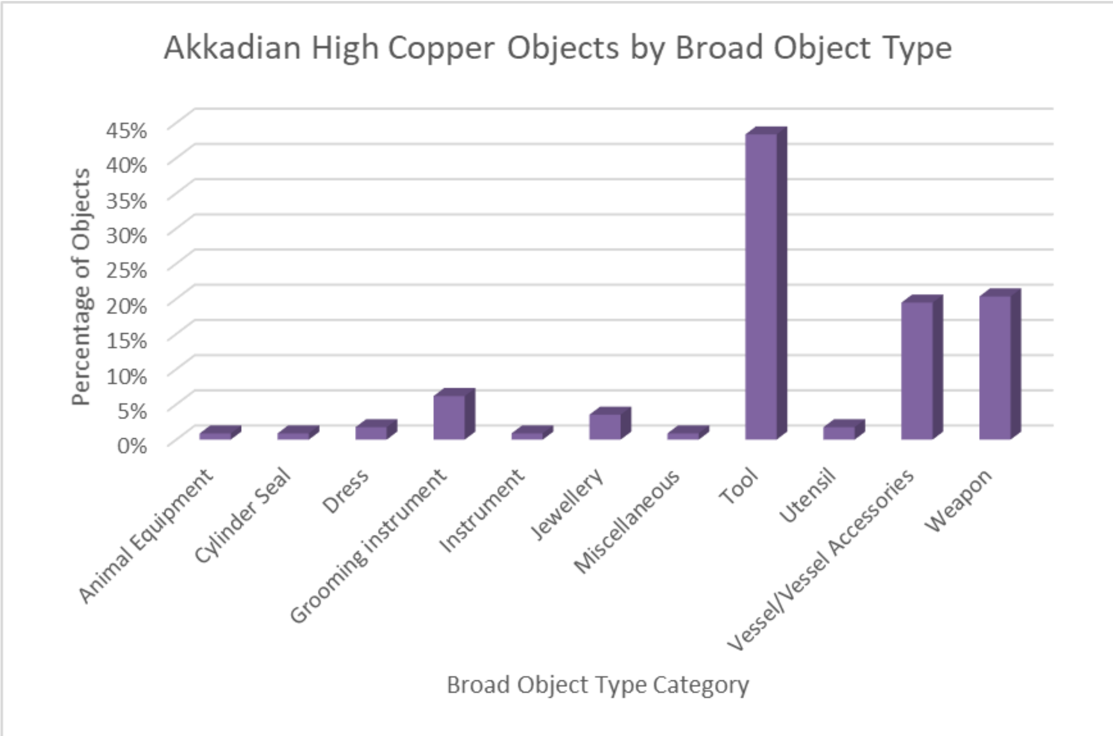


Figure 5.3: The percentage of high copper Akkadian objects that fell into each broad object type category.

Of the 271 objects, 150 (55%) contain ≥0.5% arsenic placing them into the category of arsenic bronze. A continued high prevalence of arsenic bronze throughout the Bronze Age has previously been observed in the literature (for example, Moorey 1985, 15-16; De Ryck *et al.* 2005, 261-262). Tin content of ≥2% is found in 36 of these, indicating either intentional alloying of copper with both tin and arsenic or the alloying of arsenic-rich copper with tin. As demonstrated in Figure 5.4, this type of composition appears to be used predominantly for vessels, tools and weapons. Due to the increased strength provided by both tin and arsenic when alloyed with copper, if this composition was intentional it is likely to have been driven by functional preferences. The vast majority of potential arsenic bronzes come from Ur (85%). The prevalence of arsenic bronze varies considerably between site. For example, 40% of the objects from Ur, 50% of the objects from Nippur, and 100% of the objects from Kish appear to be arsenic bronze. As the amount of objects from each site varies dramatically, this degree of variation may well be misleading. However, if it is accurately reflecting a significant variation, this may be the result of different sites procuring their copper from different sources; or, at least, different proportions of copper from more than one of the same source. Alternatively, if the arsenic bronze was intentional, it may reflect different access between sites to arsenic-rich minerals.

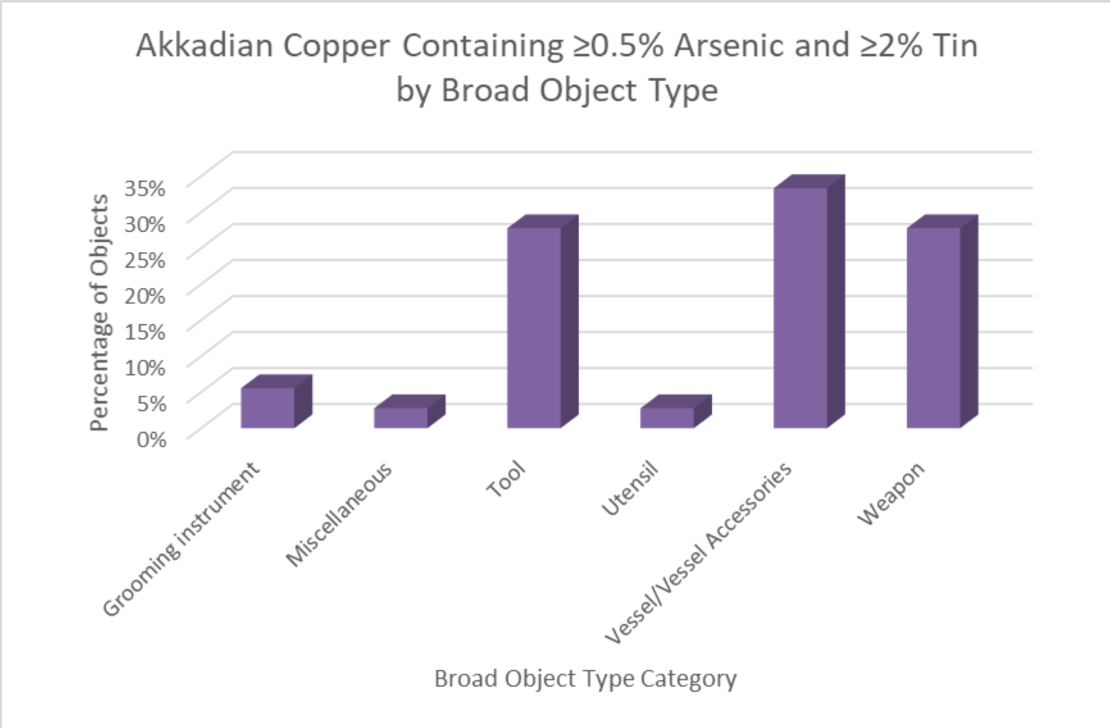


Figure 5.4: The percentage of Akkadian copper objects containing both ≥0.5% arsenic and ≥2% tin that fell into each broad object type category.

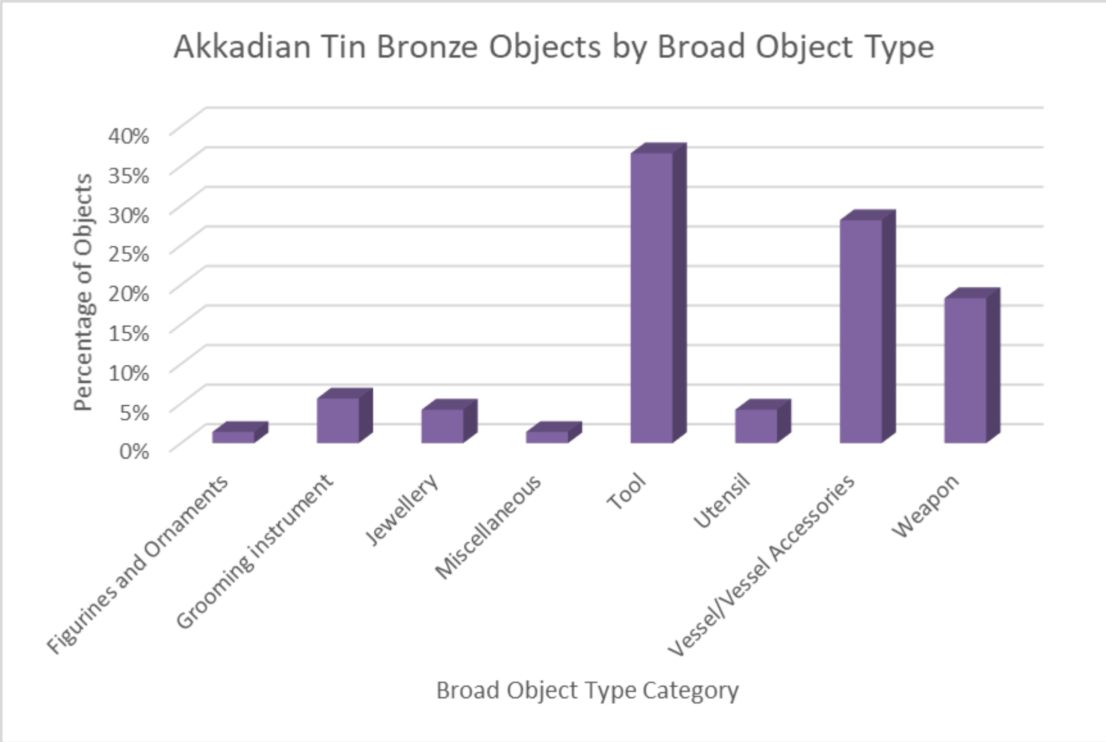
Among the Akkadian objects, 69 (25%) are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of tin bronze. Nearly all of these objects fit within a range of tin content between 2.8% and 26.2%, and 25 (36.8%) fall into the more traditional range of tin content for tin bronze. A further three, however, contain tin content of over 40%. All three of these objects are from Ur, but each falls into a different object type category: one is a vessel, one is a dagger and one is a needle. From around 16% tin and above, copper appears lighter in colour and takes on a grey-silver tint (Kuijpers 2018: 877).

High levels of tin in tin bronze also produce a metal that works well for casting, but it also makes the metal more brittle and, subsequently, more challenging to work with (Kuijpers 2018: 877). Copper with 20% tin above falls into what Kuijpers (2018: 878) terms a silver copper, which has a unique sonorous quality. Many of the high-tin tin bronzes may, therefore, have been intentionally alloyed to produce a metal well suited to casting despite a brittle nature, or perhaps in pursuit of the silvery appearance or sonorous quality possessed by this type of composition. There is, however, no clear pattern between the types of objects being made of a more traditional tin bronze composition and those of considerably less or more tin.

The wide range of tin content in these tin bronzes is also interesting in light of the tin bronze 'recipe texts' that exist, as these results demonstrate a far greater variation in the tin bronze in circulation. Material deviating significantly from the ratios discussed in these texts may indicate that these ratios were not adhered to as strictly as the texts imply. Alternatively, this deviation, particularly in terms of low-tin tin bronze, may largely result from recycling practices. Metal recycling is a common practice across a wide range of archaeological periods and regions, yet in a place such as southern Mesopotamia which had to import all of its metal, recycling is more likely to have been highly prevalent. While the initial, or 'first generation', alloying of a tin bronze may have fit the ideal composition written in these 'recipe texts', subsequent generations of recycling are likely to have diluted this original ratio if they were mixed with high-copper objects which were, as demonstrated above, highly common. As an extension of this, tin bronzes that contain tin content that falls into the ideal amount written in 'recipe texts' or higher may represent objects manufactured by smiths with access to raw metal resources, such as palace smiths, or objects without many stages of reuse.

As with arsenic bronze, the prevalence of tin bronze varies considerably depending on the site. For example, 25% of the objects from Ur appear to be tin bronzes, 67% from Uruk and Tell 'Uqair, and none from Kish or Tello. Considerable variation between sites in the prevalence of tin bronze has previously been acknowledged in the literature (Moorey 1994: 253). This may be the result of varying degrees of access to tin across the different sites. Alternatively, it could be another result of recycling. If regular recycling was diluting tin content then, after many cycles through the recycling system, objects would eventually contain too little tin to fall into the category of tin bronze. It should also be stressed, however, that these results should be viewed tentatively in light of the small bodies of Akkadian metal from sites besides Ur; if a more evenly spread body of material were available, this pattern may be significantly different.

The largest broad object type category across all three compositional categories of high-copper, tin bronze and arsenic bronze objects is that of tools (Figure 5.5-5.8). This is likely to be both a result of copper-based objects providing the durability and strength required for tools, as well as the high prevalence of tools in general. There appears to be a preference for using tin bronze for vessels and vessel accessories over arsenic bronze, as well as for utensils. This is surprising due to the better suitability of arsenic bronze for producing sheet-metal objects such as vessels (Lechtman 1996). Mesopotamia's slow progression into using tin bronze for tools and weapons, and its quicker pace at utilising it for vessels first and foremost, has been previously commented on by Cuénod *et al.* (2015: 25-6), who observe that "it must have had properties that made it desirable for the production of vessels in the eyes of the Mesopotamians" but do not expand further on why this may have been the case. This topic is discussed in further depth in Chapter 7.



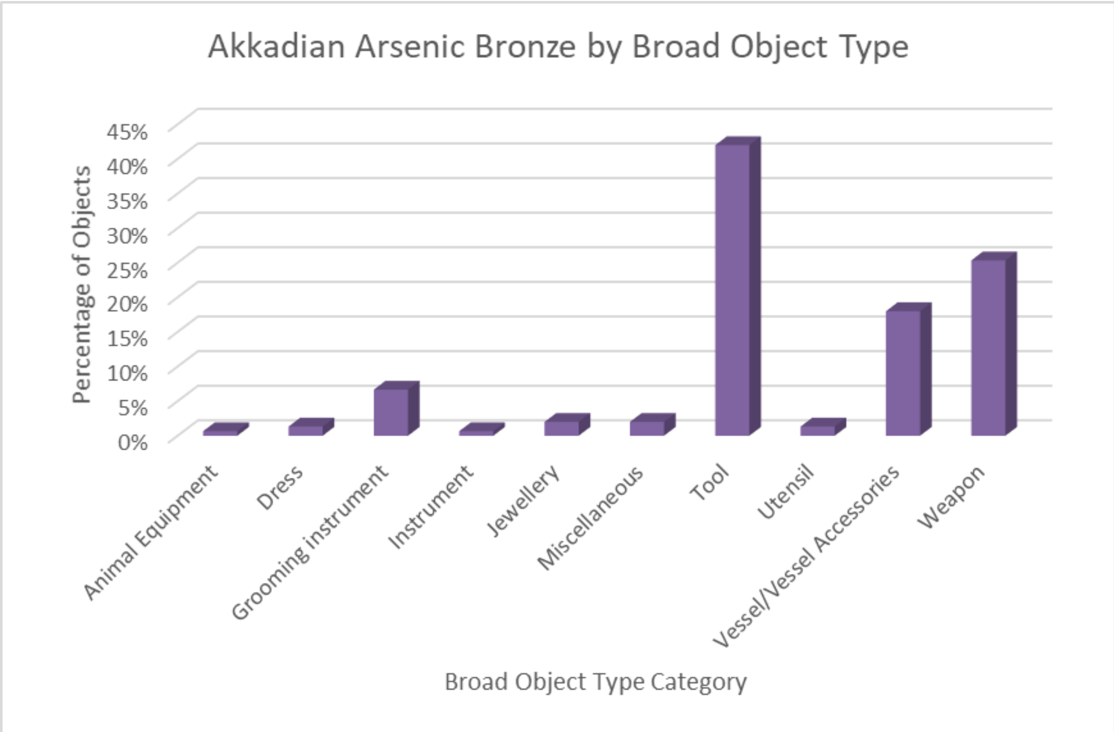


Figure 5.5: The percentage of tin bronze (top) and arsenic bronze (bottom) Akkadian objects that fell into each broad object type category.

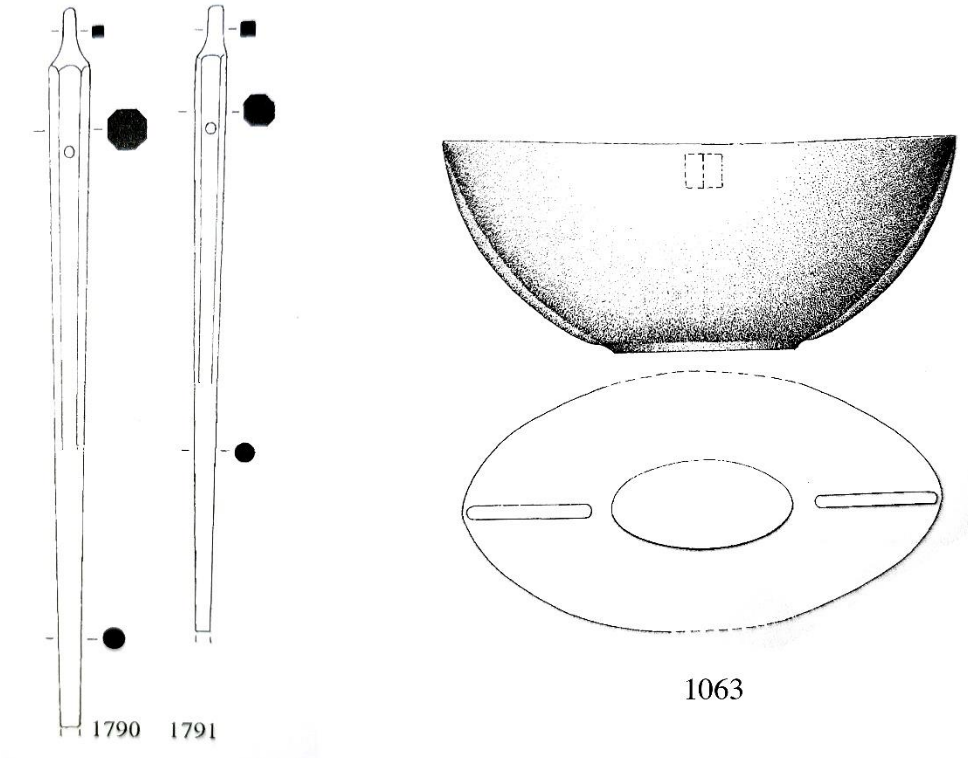


Figure 5.6: Example of two tin bronze objects from the Akkadian material. Tin bronze needles (left) and bowl (right). (Hauptmann & Pernicka 2004: Plates 63 and 116).

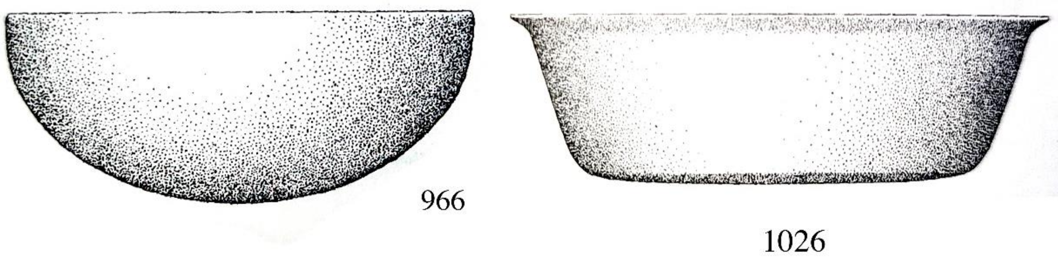


Figure 5.7: Example of two arsenic bronze vessels from the Akkadian material. (Hauptmann & Pernicka 2004: Plates 56 and 59).

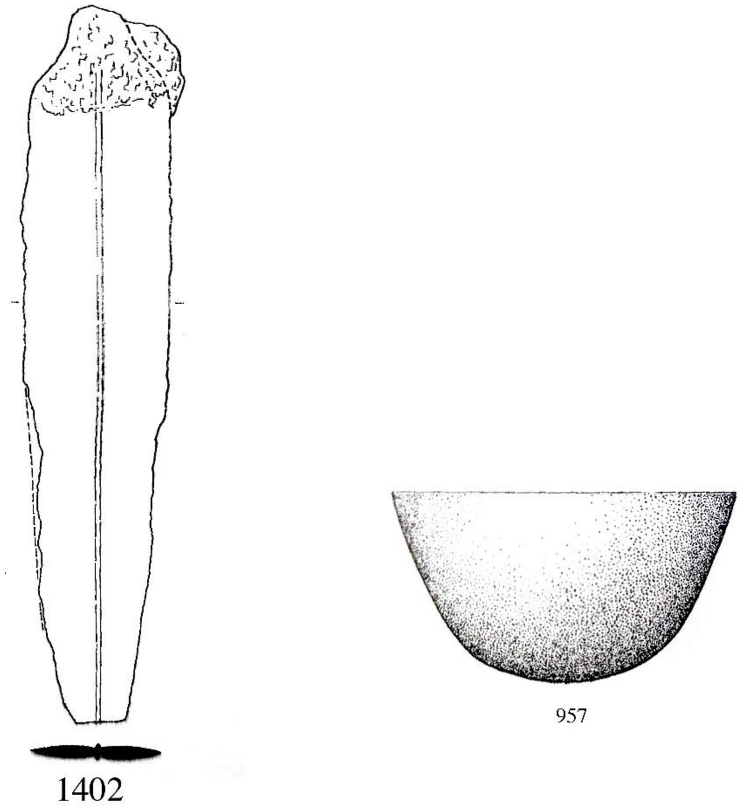


Figure 5.8: Example of two objects from the Akkadian material that contain both ≥0.5% arsenic and ≥2% tin. Dagger (left) and vessel (right) (Hauptmann & Pernicka 2004: Plates 94 and 56).

No entirely lead objects were dated to the Akkadian period. Lead was detected in 206 of the 231 objects (89%) for which it was analysed, ranging from 0.03% to 28.6%. Low levels of iron were detected in 209 of the 231 objects (90%) for which it was analysed, ranging from 0.05% to 7.5%. This could be the result of surface contamination or the result of iron-bearing sulphide ores; both possibilities have previously been discussed in Chapter 2 and are discussed in greater depth in Chapter 6. Gold was only detected in eight of these objects, all of which are predominantly made of silver. For seven of these, the gold levels register as less than 2%. One object[14] (2084), however, a sheet strip from Ur, is made predominantly of gold (71.3%) and secondarily of silver (26.1%). It is unclear exactly what this would have been used for.

Silver was detected in 178 objects, ranging from 0.01 to 99.6%. Silver is the main metal in the composition of 10 objects (Figure 5.9). Over half of these objects fall into the category

[14] Unfortunately, a photograph of this object was not included by Hauptmann and Pernicka

of jewellery: one is a ring and six are earrings (Figures 5.10 and 5.11). There is a clear preference for using silver for earrings among the Akkadian material. Of the nine earrings that date to this period, seven of these are predominantly made of silver, one is copper based but with 22.9% silver, one is tin bronze and one is arsenic bronze. In addition to these silver-based objects, two further objects are copper-based copper-silver alloys and one is a gold-based gold-silver alloy. The addition of silver to copper improves strength and durability (Moorey 1994: 236), but alloying copper and silver also substantially impacts colour. Alloys of silver and copper, as well as copper and gold or, indeed, all three, are attested from Mesopotamia from various periods. Silver-copper alloys are predominantly used for jewellery and would have possessed a distinct silver-white appearance (Helwing, undated: 244; Kuijpers 2018: 877). Similarly, gold-copper alloys would have possessed a much more golden appearance than pure copper.

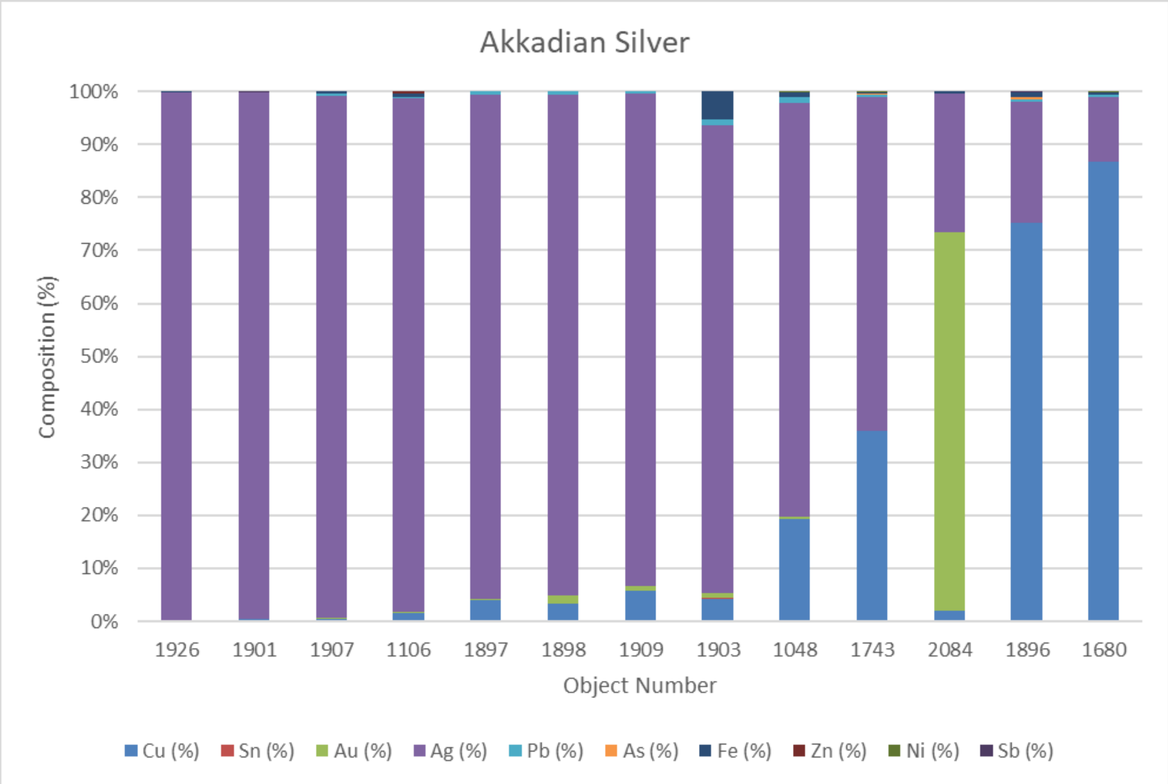


Figure 5.9: Results of compositional analysis of silver and sliver-alloy Akkadian objects.

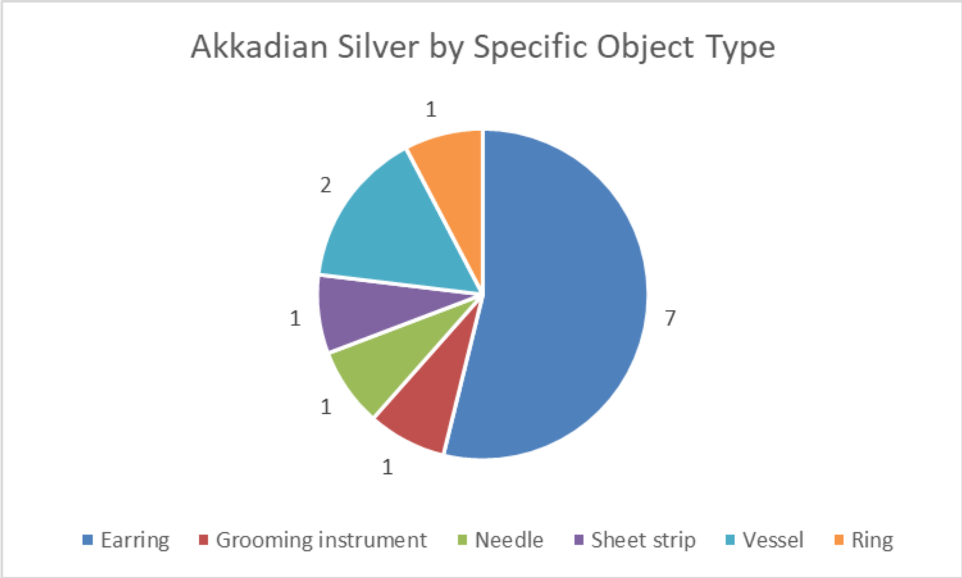


Figure 5.10: Akkadian silver and silver alloy objects categorised into specific object type categories.

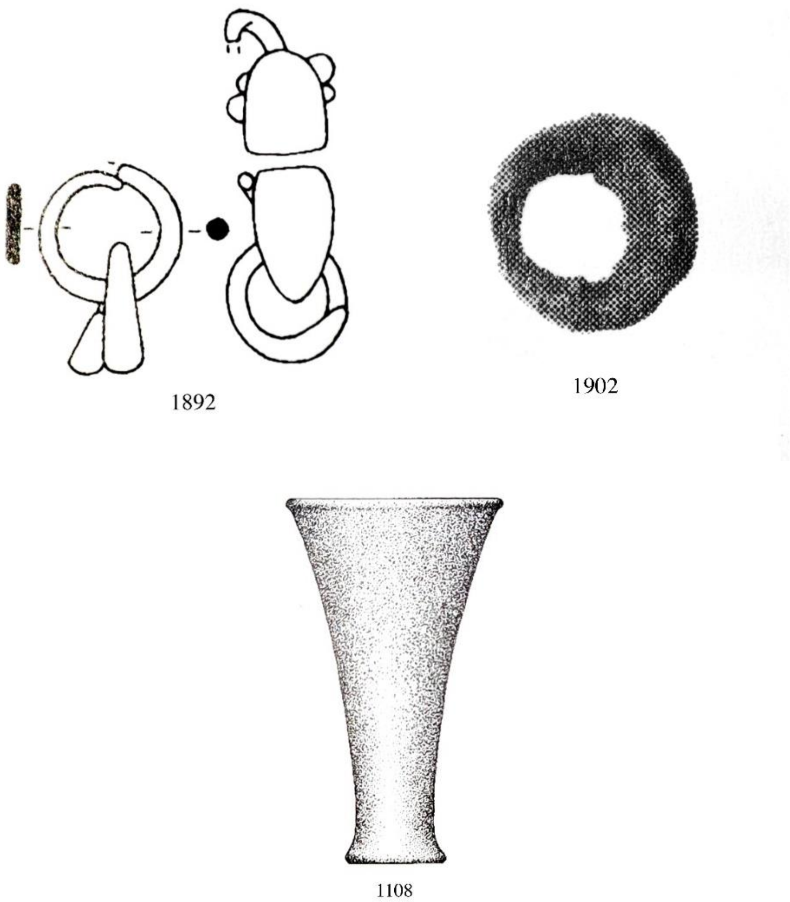


Figure 5.11: Example of silver objects in the Akkadian material. Two silver rings (top right and left) and a silver cup (bottom). (Hauptmann & Pernicka 2004: Plates 121 and 66)

Overall, the Akkadian material emphasises the heavy use of high-copper composition for essentially all object types. Over half of the objects are arsenic bronzes while around a quarter are tin bronze, demonstrating the use of both composition types during this period but indicating a wider use of arsenic bronze. There exists a preference for tin bronze in the creation of vessels which has been highlighted in previous work (for example Cuénod *et al.* 2015: 25-6; Moorey 1994: 253; Müller-Karpe 1991: 110-11). The use of both tin bronze and arsenic bronze appears to vary significantly between sites, although this may be the result of variation in object count from each site. There is a lack of gold among this dataset dating to the Akkadian period, but there appears to be a preference for silver in making jewellery, particularly earrings. Although the Akkadian material is the largest body of objects of each of the five key period categories, it is heavily dominated by material from Ur. As a result, exploration of this material predominantly provides an insight into Akkadian-period metalwork from Ur.

5.1.2 Ur III

Of the 1,293 readings, 71 are taken from objects dated to the Ur III/Neo-Sumerian period. This material spans four sites (Table 5.4). While 90% of the Akkadian material came from Ur, only 68% of the Ur III material is from Ur, 25% is from Tello and the rest are from Nippur and possibly Uruk.

Table 5.4: Ur III objects categorised by site and broad object type category.

Sites	Object Count
Nippur	4
Tello	18
Ur	48
Possibly Uruk	1
Total	**71**

Of the 71 Ur III objects, the largest category of objects is figurines and ornaments (30%), followed by tools (27%) and jewellery (18%) (Table 5.5). All of the figurines and ornaments come from Tello and reflect the specific contexts of excavation; 15 of these 18 objects were foundation figurines. The high proportional number of tools is in-keeping with the trends observed in the Akkadian material. Concerning more specific object types, the most prevalent object type is that of foundation figurines (Figure 5.12). Aside from these, the most common object types are needles (11%) and axes (10%). As with the Akkadian material, there are no pieces of metalworking slag included, nor any waste or by-products from metallurgical production.

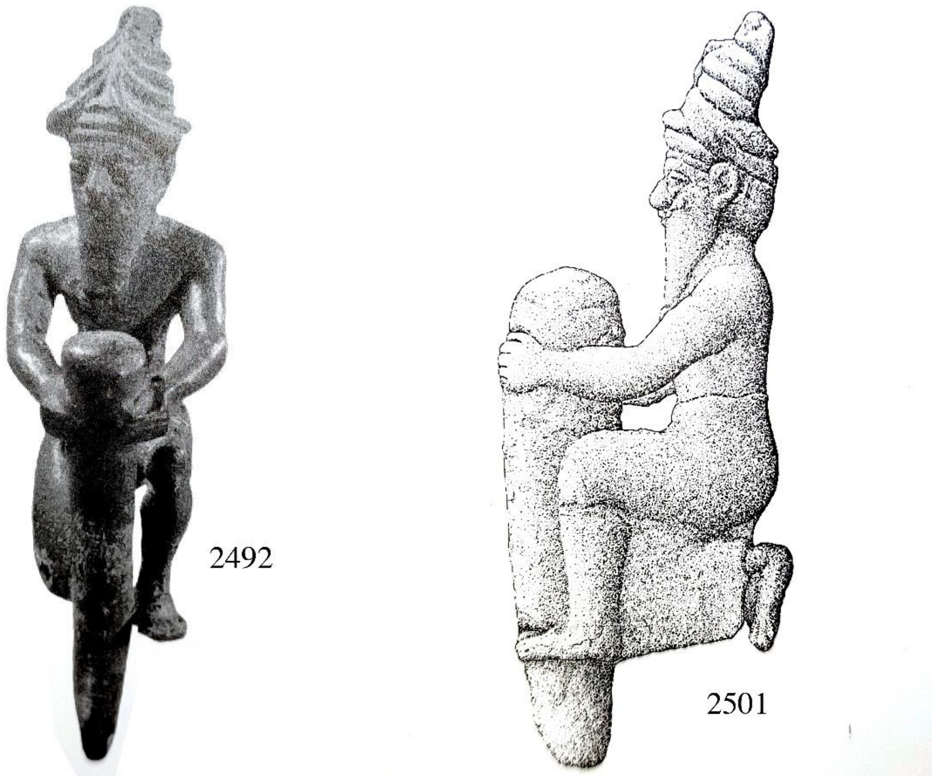


Figure 5.12: Examples of the foundation figurines in the Ur III material. Both of these foundation figurines are from Tello. (Hauptmann & Pernicka 2004: Plate 150)

Table 5.5: Ur III objects categorised by site and broad object type category.

	Nippur	Tello	Ur	Possibly Uruk	Total
Cylinder Seal			1		1
Figurines and Ornaments		18	2	1	21
Grooming instrument			1		1
Jewellery			13		13
Tool	3		16		19
Utensil	1				1
Vessel/Vessel Accessories			7		7
Weapon			8		8
Total	**4**	**18**	**48**	**1**	**71**

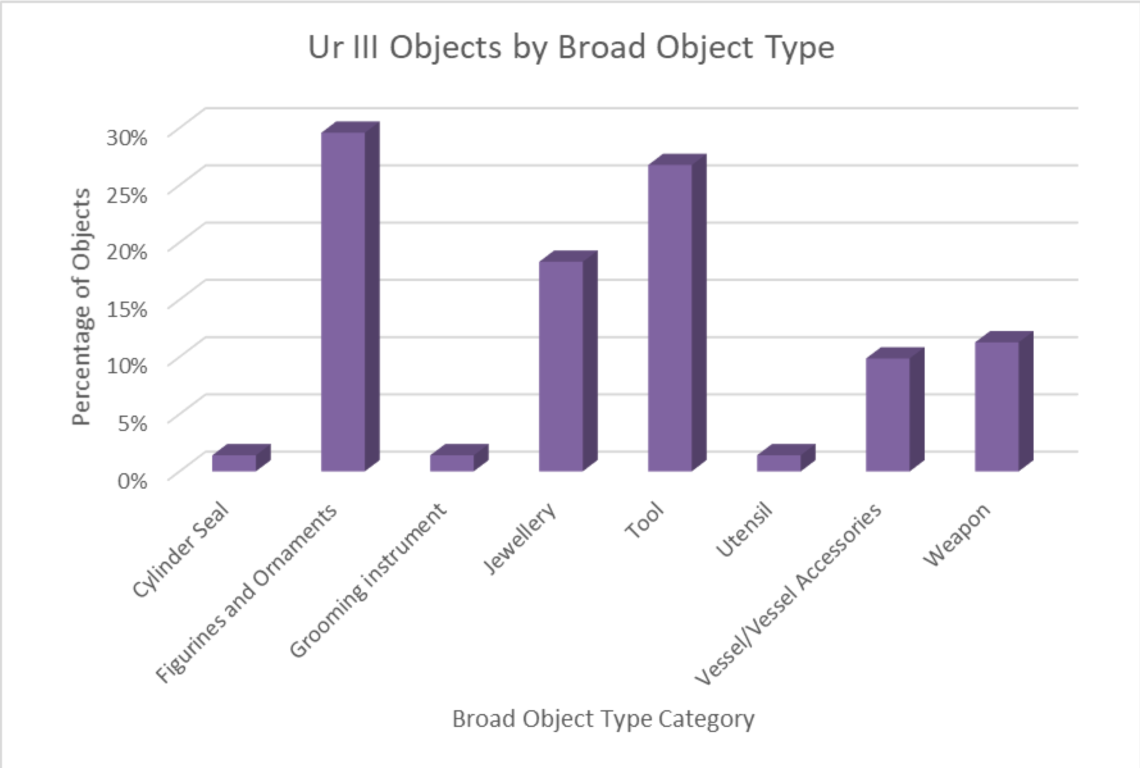


Figure 5.13: The percentage of Ur III objects that fell into each broad object type category.

Compositionally, the Ur III material follows similar patterns to those found in the Akkadian material. The most common compositional category is that of high-copper composition (Figure 5.14). Of the 71 objects, 41 (58%) contain copper of 95% and above. These objects span all of the broad object type categories found among the Ur III material more generally, with the only exception being that of cylinder seals (Figure 5.15).

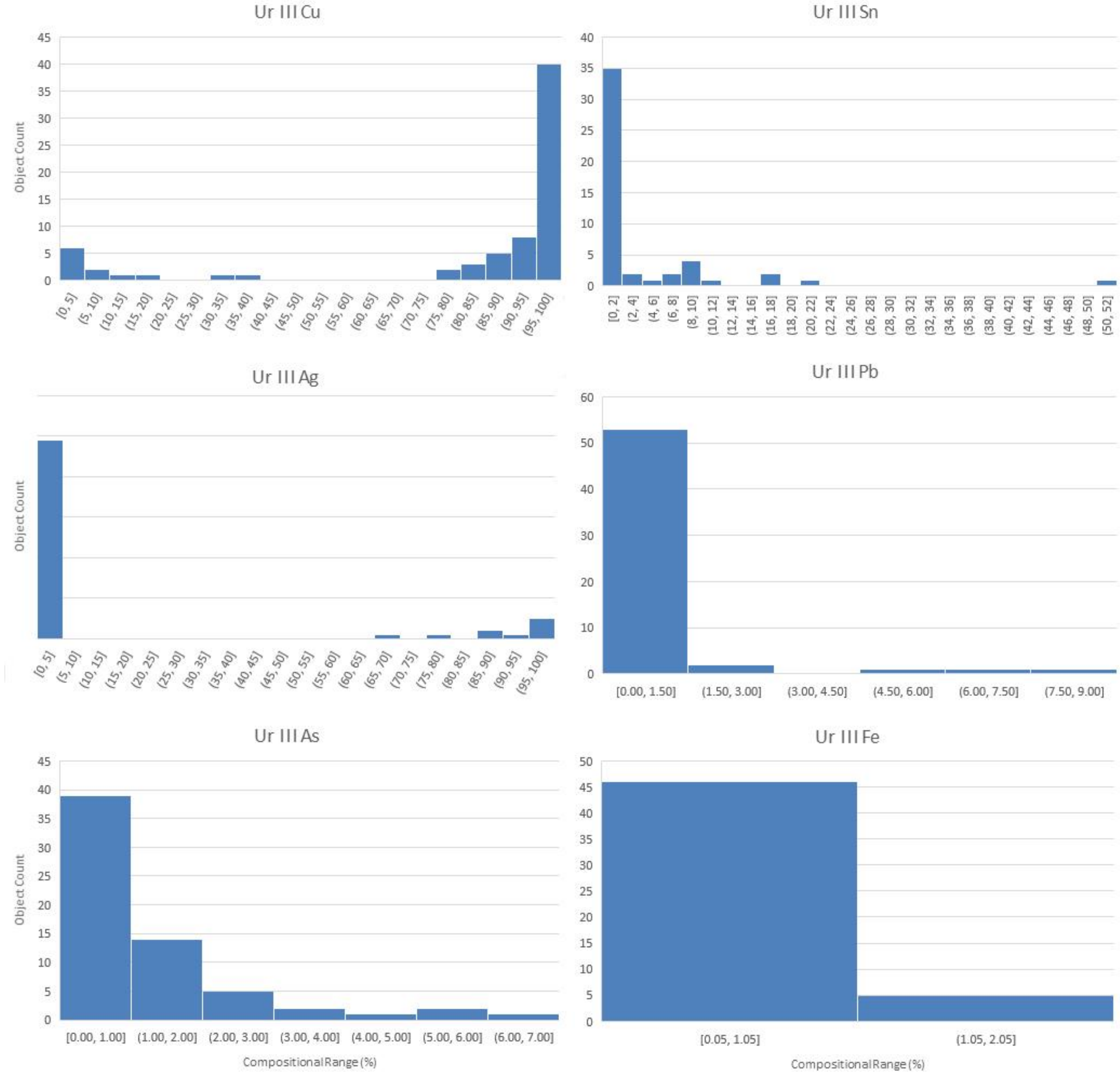


Figure 5.14: Results of compositional analysis of Ur III objects illustrated by element. Due to Au only occurring in three objects in very low levels, it is not included here.

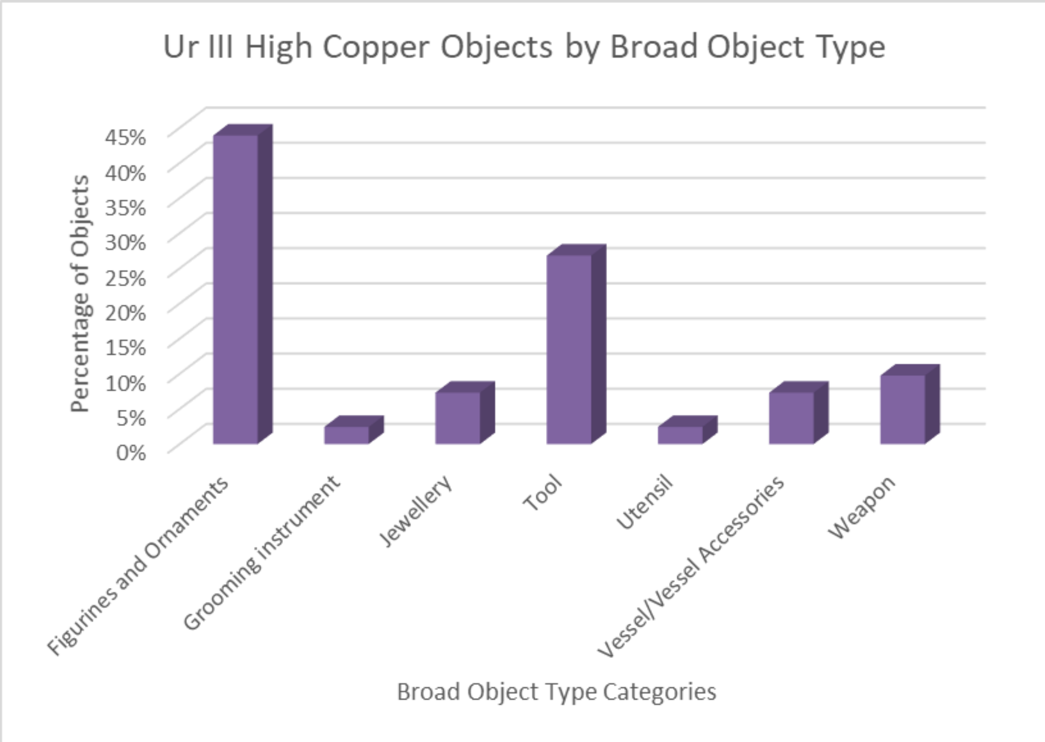


Figure 5.15: The percentage of high copper Ur III objects that fell into each broad object type category.

Of the 71 Ur III objects, 13 (18%) are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of tin bronze. One of these is from Nippur while the remaining 12 are all from Ur. The range of tin among these tin bronzes stretches from 2.6% to 20.03%; a similar range to the bulk of the Akkadian tin bronzes if the three outliers are discarded. Five (38.5%) of these objects fall into the more traditional range of tin content for tin bronzes. Interestingly, this is also a highly similar percentage to the percentage of Akkadian traditional tin bronzes. As with the Akkadian material, there is no clear pattern between the types of objects being made of a more traditional tin bronze composition and those of considerably less or more tin. Nearly all of the tin bronze comes from Ur (92.3%) and the remaining tin bronze (7.7%) comes from Nippur. No tin bronze was attributed to any of the other sites. Tin bronze objects make up 25% of the objects from both Ur and Nippur.

Thirty-six (51%) of the 71 Ur III objects contain ≥0.5% arsenic placing them into the category of arsenic bronze. Tin content of ≥2% is found in five of these. This type of composition appears to be used predominantly for vessels and tools; a pattern also seen in the Akkadian material (Figures 5.16 and 5.17). The one piece of jewellery is an armring from Ur. As with the Akkadian material, the vast majority of potential arsenic bronzes come from Ur (58%). Similar to the pattern observed with tin bronze, prevalence of arsenic bronze varies considerably between site. For example, arsenic bronzes make up 56% of the Tello objects, 44% of the Ur objects, and 100% of the Nippur and possibly Uruk objects.

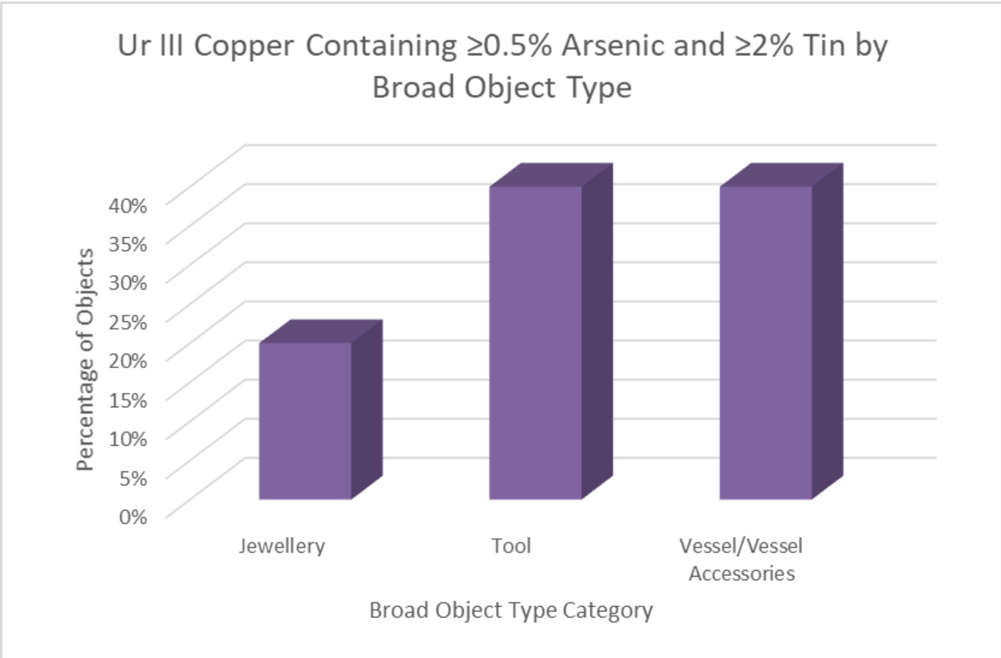


Figure 5.16: The percentage of Ur III copper objects containing both ≥0.5% arsenic and ≥2% tin that fell into each broad object type category.

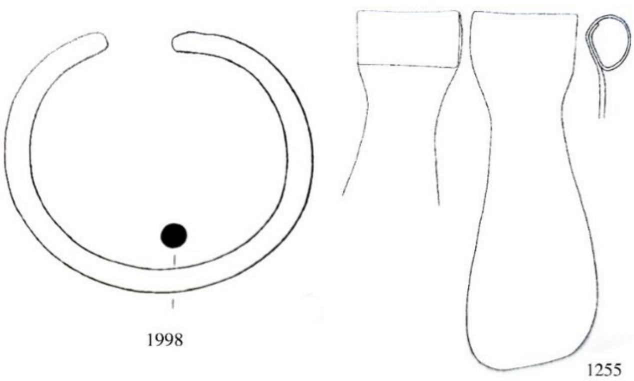
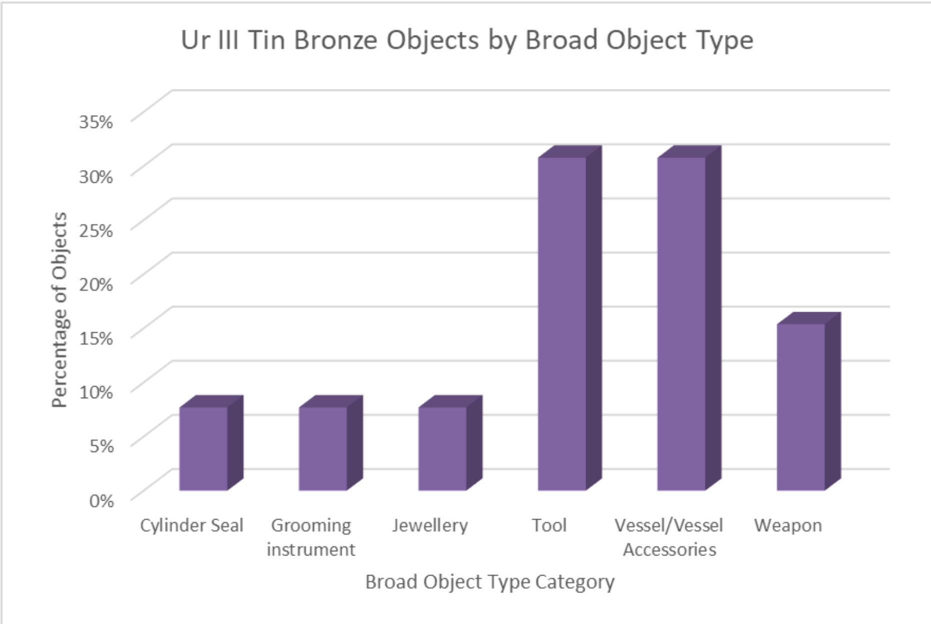


Figure 5.17: Example of two objects from the Ur III material that contain both ≥0.5% arsenic and ≥2% tin. An armring (left) and axe (right). (Hauptmann & Pernicka 2004: Plates 82 and 123).

The largest broad object type category in the compositional categories of tin bronze and arsenic bronze was that of tools (Figures 5.18 and 5.19). As mentioned above, the most prominent broad object type category among the high-copper objects is that of figurines and ornaments due to the large number of foundation figurines from Tello. Excluding these, tools is the most prominent category in this compositional category. As observed in the Akkadian material, there appears to be a preference for tin bronze in making vessels over arsenic bronze.



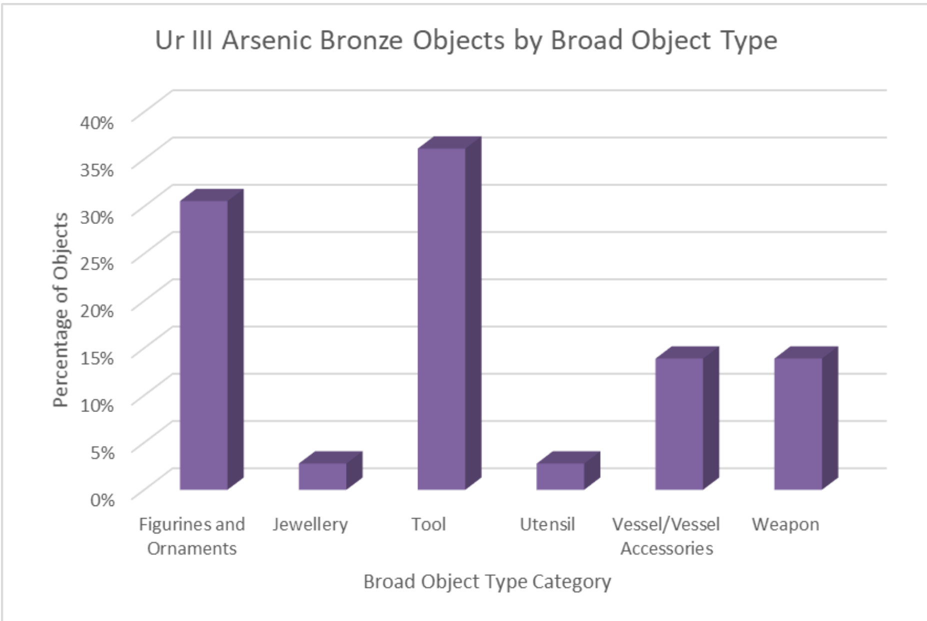


Figure 5.18: The percentage of tin bronze (top) and arsenic bronze (bottom) Ur III objects that fell into each broad object type category.

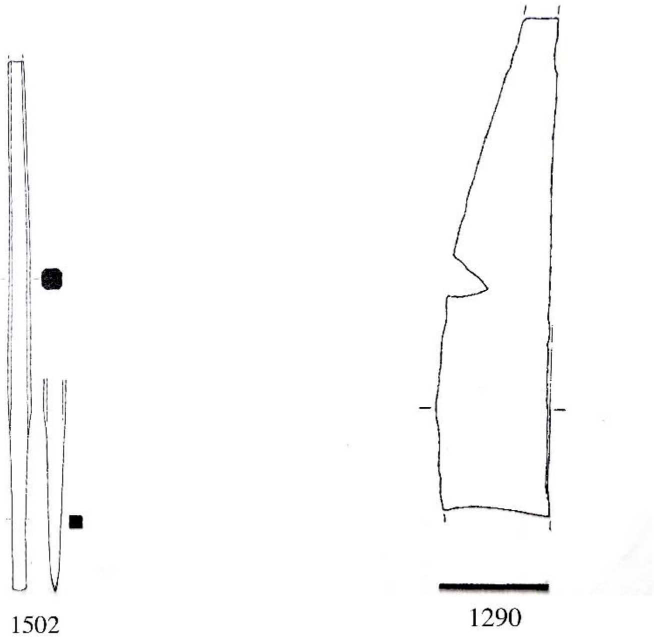


Figure 5.19: Example of a tin bronze spearhead (left) and arsenic bronze tool (right) from the Ur III material. (Hauptmann & Pernicka 2004: Plates 84 and 100)

As with the Akkadian material, no entirely lead objects were dated to the Ur III period. Lead was detected in 57 of the 71 objects (80%) for which it was analysed, ranging from 0.03% to 8.8%. Low levels of iron were detected in 51 of the 71 objects (72%) for which it was analysed, ranging from 0.05% to 1.9%.

Gold was only detected in three of the Ur III objects, all of which are predominantly made of silver. All three of these objects have gold levels below 3%. Silver levels were detected in 58 of the Ur III objects (Figures 5.20-5.22). Ten of these objects are predominantly made of silver and all of these come from Ur. Four of these are made nearly entirely of silver, while the remaining six have significant copper content. Nine of these ten objects fall into the category of jewellery. Three of these are armrings, three are rings, two are specifically described as finger rings, and one – the object with the highest silver content – is an earring. The tenth object is a needle with a silver-copper alloy composition.

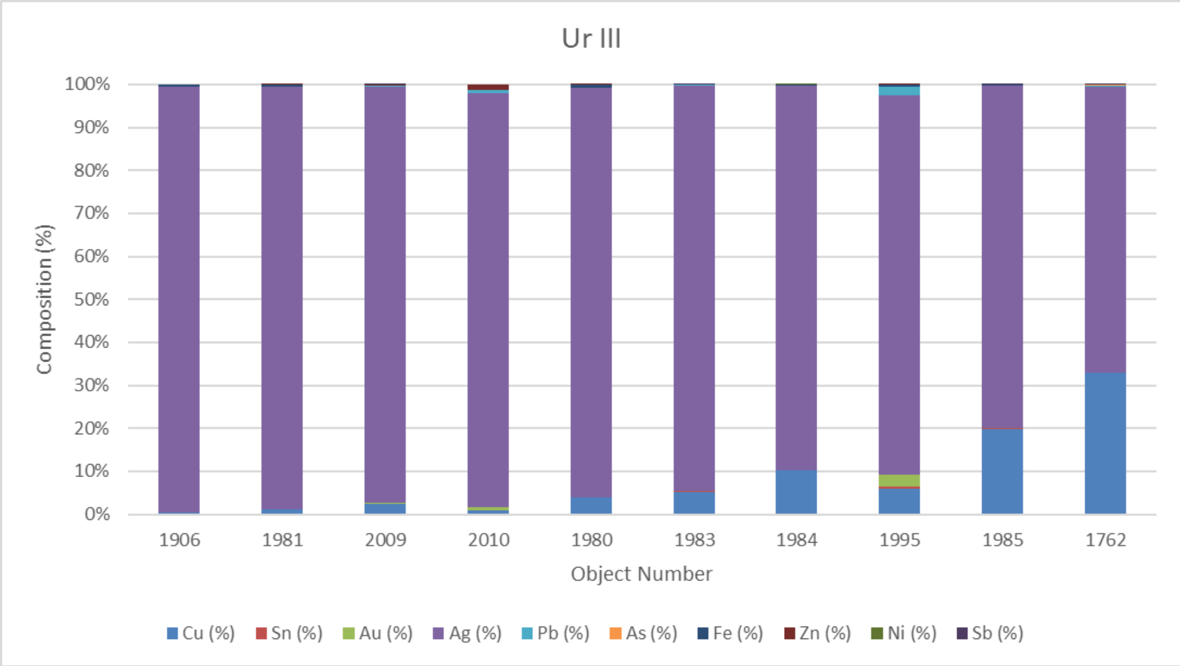


Figure 5.20: Results of compositional analysis of silver and sliver-alloy Ur III objects.

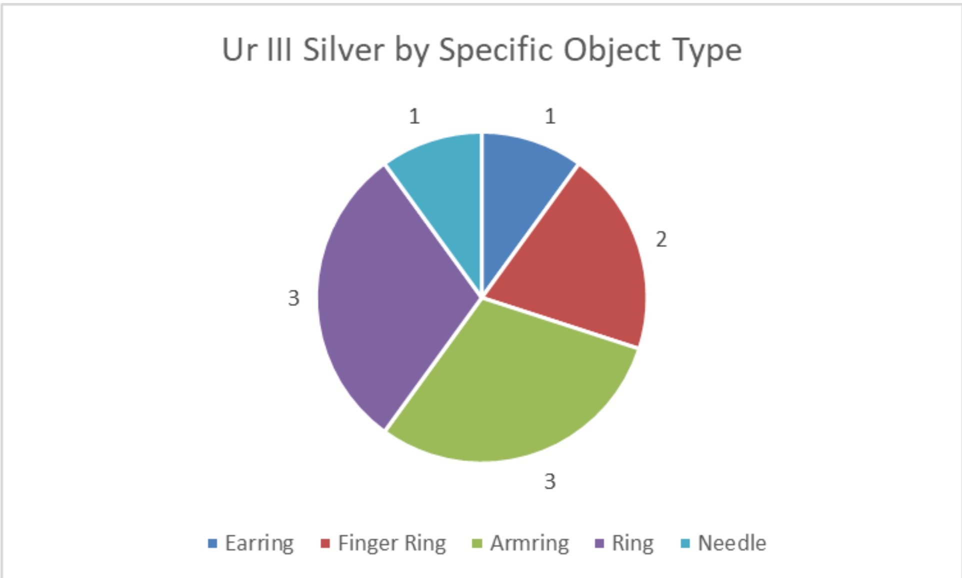


Figure 5.21: Ur III silver and silver alloy objects categorised into specific object type categories.

Overall, the Ur III objects follow similar patterns to those seen in the Akkadian material. There is a continued heavy use of high-copper composition for essentially all object types. As with the Akkadian material, approximately half of the objects are arsenic bronzes.

Fewer tin bronze objects have been dated to the Ur III period. The preference of tin bronze for making vessels observed in the Akkadian material is also seen in the Ur III material. There is also evidence of continued use of silver for jewellery, and specifically earrings, as well as continued use of copper-silver alloys for jewellery.

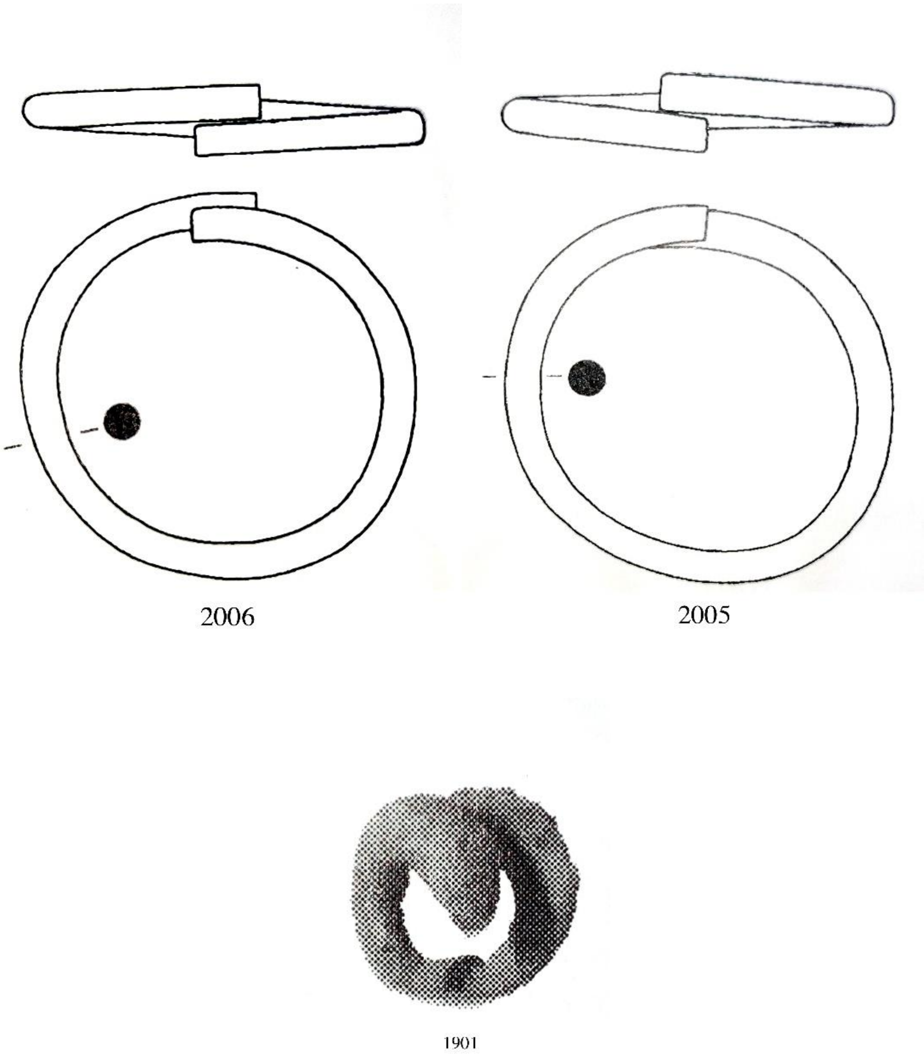


Figure 5.22: Example of silver objects in the Ur III material. Armrings (top right and left) and earring (bottom). (Hauptmann & Pernicka 2004: Plates 124 and 121)

5.1.3 Isin-Larsa

Of the 1,293 readings, 38 are taken from objects dated to the Isin-Larsa period. This material spans seven sites (Table 5.6). Material from Ur still constitutes over half (55%) of this collection.

Table 5.6: Isin-Larsa objects categorised by the site at which they were found.

Site	Object Count
Isin	3
Larsa	3
Nippur	1
Sippar	1
Tell Harmal	6
Tello	3
Ur	21
Total	**38**

Of the 38 Isin-Larsa objects, the largest category of object is that of vessels and vessel accessories (34%) followed tools (29%) (Table 5.7). Notably, there is no jewellery or personal adornment in this collection. As with the Akkadian and Ur III material, there are no pieces of metal slag nor objects of metalworking waste.

Table 5.7: Isin-Larsa objects categorised by site and broad object type.

	Isin	Larsa	Nippur	Sippar	Tell Harmal	Tello	Ur	Total
Miscellaneous	3						1	4
Tool		1			4		6	11
Utensil				1			1	2
Vessel/Vessel Accessories		2				3	8	13
Weapon			1		2		5	8
Total	**3**	**3**	**1**	**1**	**6**	**3**	**21**	**38**

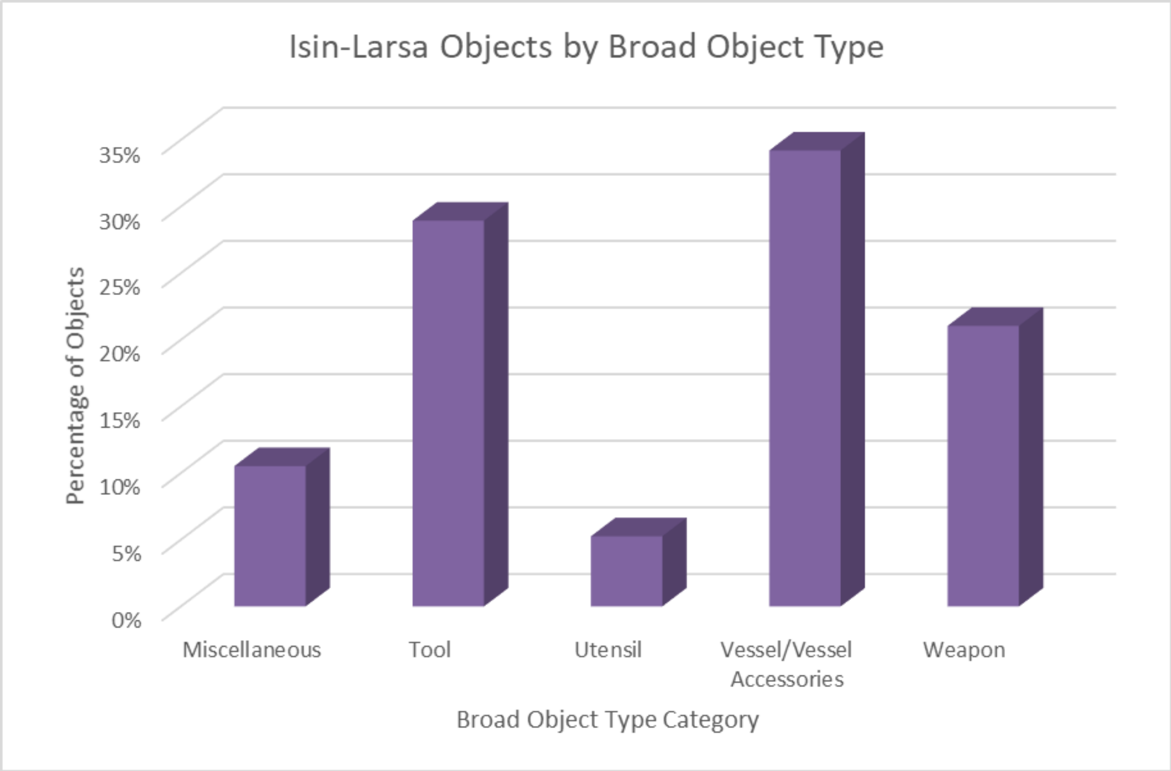


Figure 5.23: The percentage of Isin-Larsa objects that fell into each broad object type category.

The Isin-Larsa material follows the broad compositional patterns observed in the Akkadian and Ur III objects (Figure 5.24). Of the 38 objects, 21 (55%) contain copper of 95% and above. These objects span all of the broad object type categories found among the Isin-Larsa material more generally (Figure 5.25).

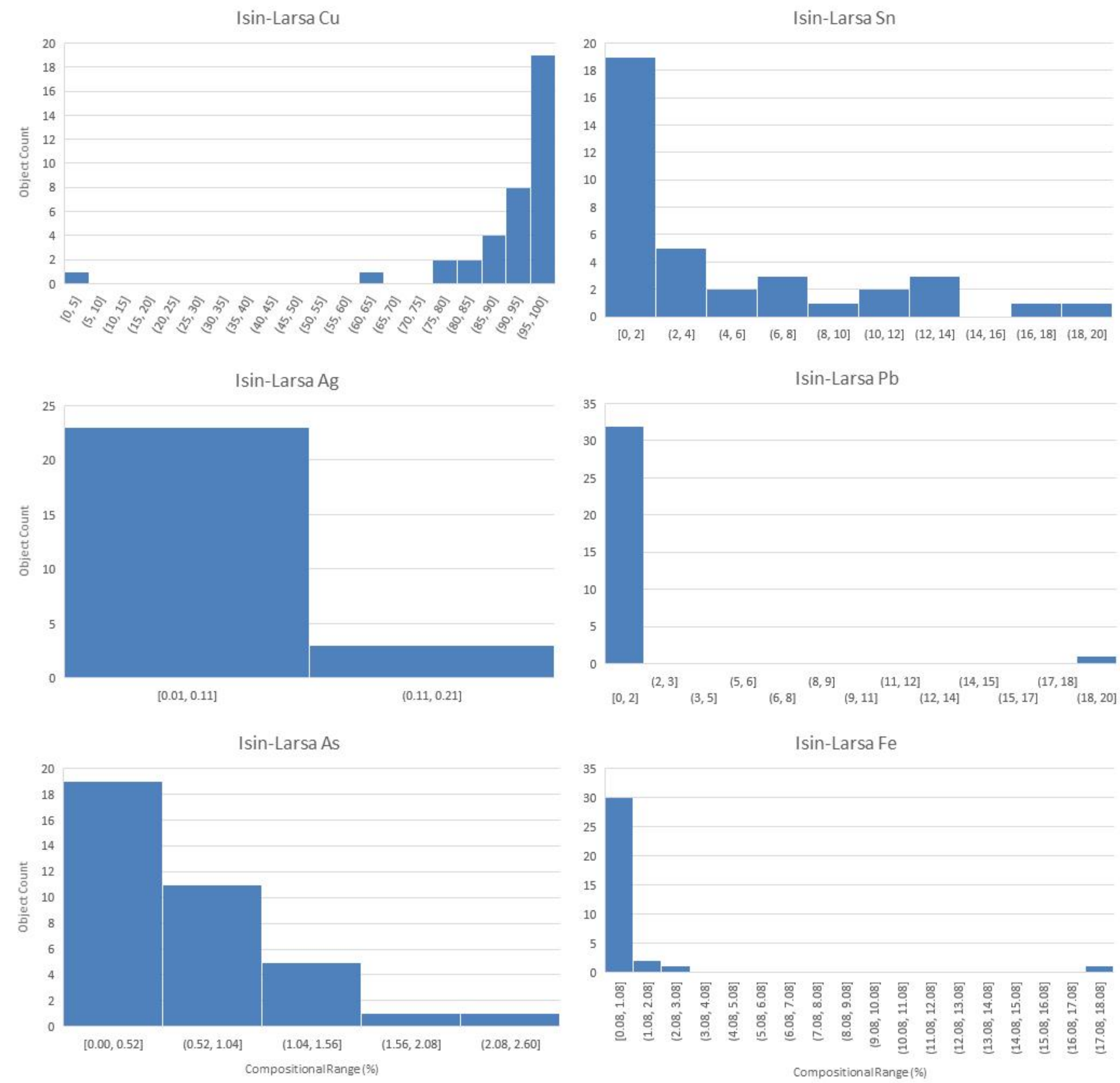


Figure 5.24: Results of compoistional analysis of Isin-Larsa objects illustrated by element. Due to Au only occurring in three objects in very low levels, it is not included here.

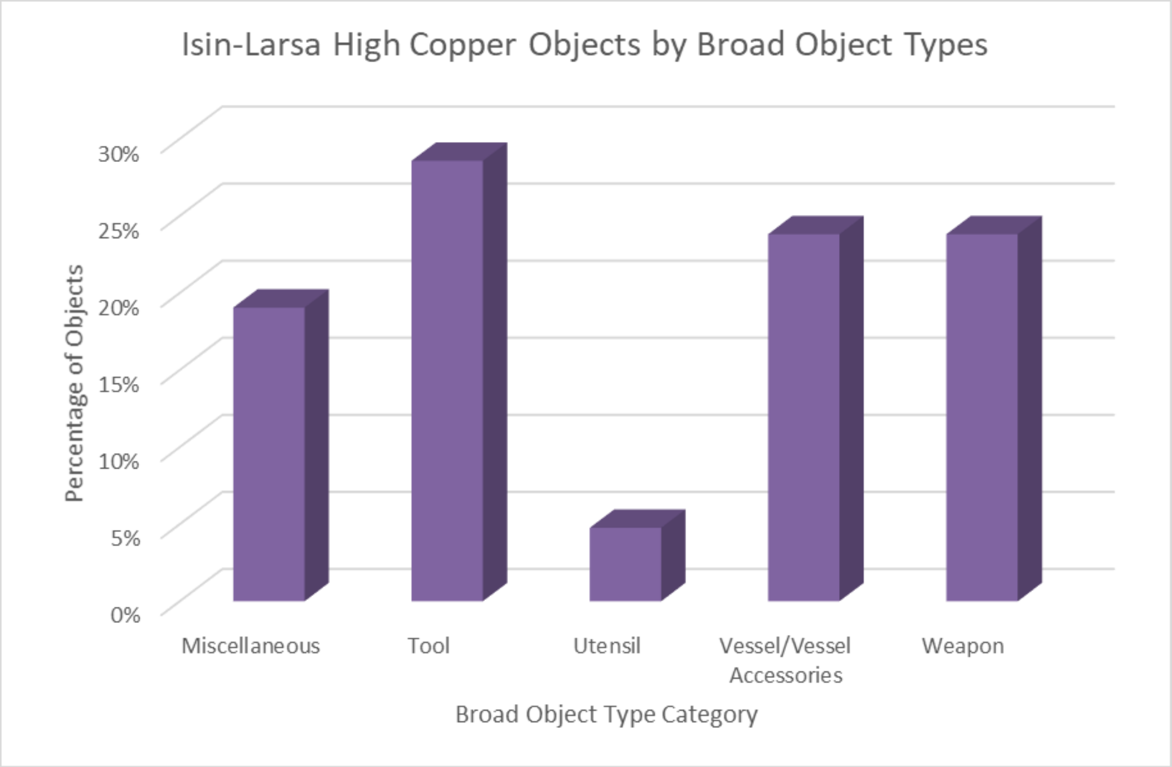


Figure 5.25: The percentage of high copper Isin-Larsa objects that fell into each broad object type category.

Of the 38 Isin-Larsa objects, 18 (47%) are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of tin bronze (Figure 5.26). This is considerably higher than observed within the Akkadian and Ur III material, and this range of tin among these tin bronzes stretches from 2.2% to 19.2%. This range is smaller than observed in the Akkadian material and smaller still than observed in the Ur III material. Four (22%) of these objects fall into the more traditional range of tin content for tin bronzes: two vessels and two daggers. This is significantly less than observed in both the Akkadian and Ur III material. One object (661), an axe from Larsa, is copper-based with ≥2% tin but also contain slightly more arsenic than tin.

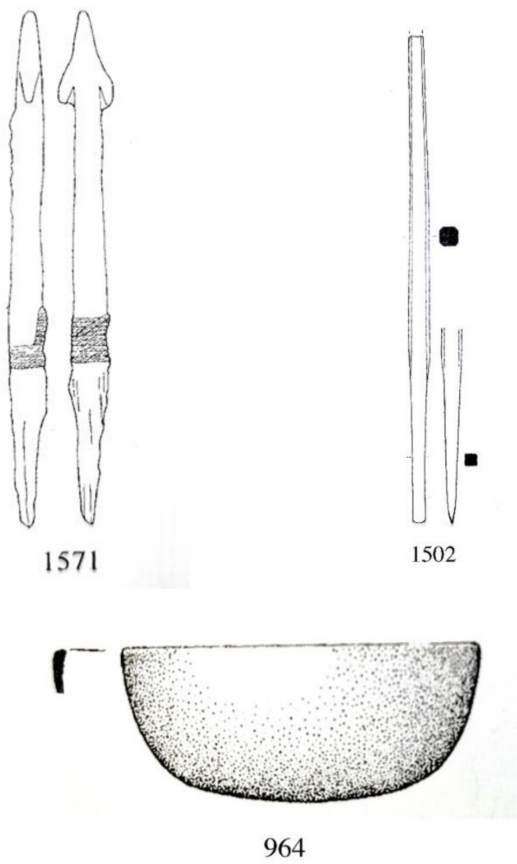
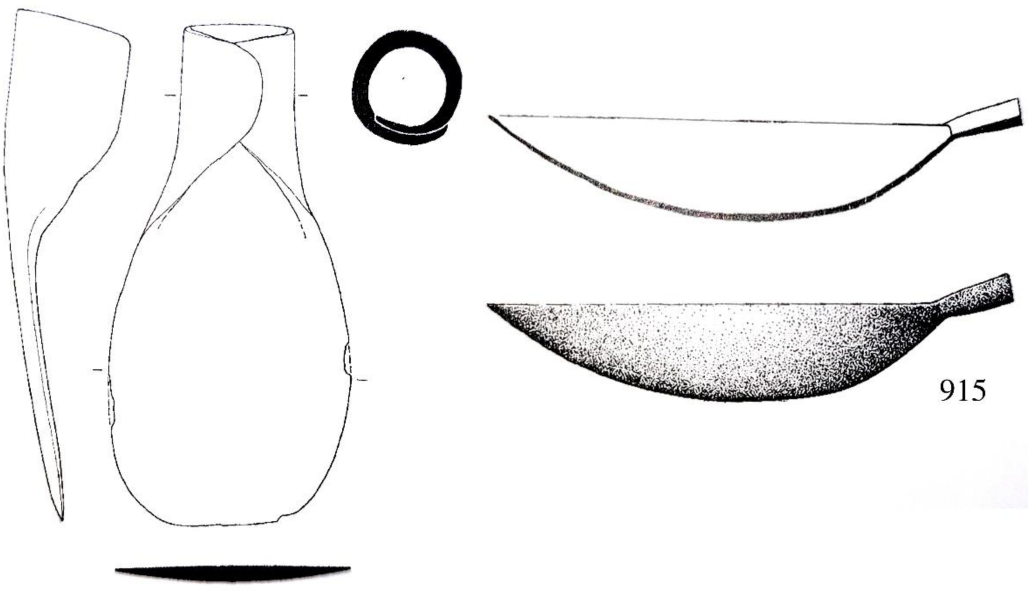


Figure 5.26: Examples of tin bronze spearheads (left and middle) and a tin bronze bowl (right) from the Isin Larsa material (Hauptmann & Pernicka 2004: Plates 56, 100 and 104).

While much of the tin bronze comes from Ur (56%) this is much lower than seen in the Akkadian and Ur III material. The variation in tin bronze between sites observed in the Akkadian and Ur III material can also be seen in the Isin-Larsa material, however. Tin bronze comes from five of the seven sites and makes up 100% of the material from Larsa and Nippur, 33% comes from Tell Harmal, 48% from Ur and 67% from Tello. If this variation between sites is the result of differences in access to tin at different sites, then this appears to demonstrate a continued variation in access in the Isin-Larsa period.

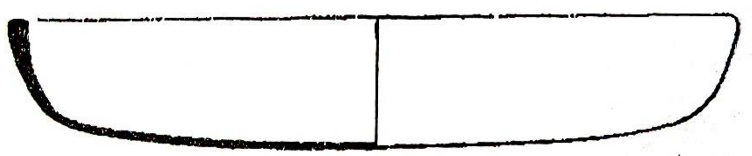
Eighteen (47%) of the 38 Isin-Larsa objects contain ≥0.5% arsenic placing them into the category of arsenic bronze (Figure 5.27). Tin content of ≥2% is found in 11 of these (Figure 5.28). This type of composition appears to be used for tools and vessels (Figure 5.29). This is the same pattern observed in the Akkadian and Ur III material. Similar to the pattern observed with tin bronze, prevalence of arsenic bronze also varies considerably between site.



1354

915

Figure 5.27: Example of an arsenic bronze axe (left) and vessel (right) from the Isin-larsa material (Hauptmann & Pernicka 2004: Plates 53 and 90).



662

Figure 5.28: Example of a copper vessel containing both ≥0.5% arsenic and ≥2% tin from the Isin-Larse material (Hauptmann & Pernicka 2004: Plate 39).

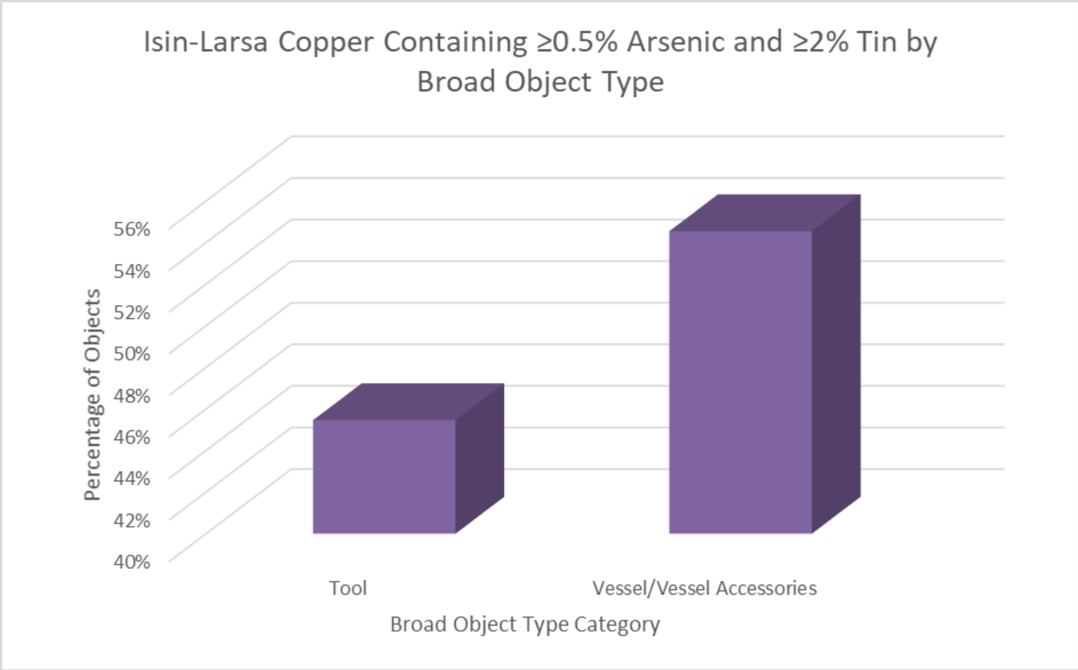
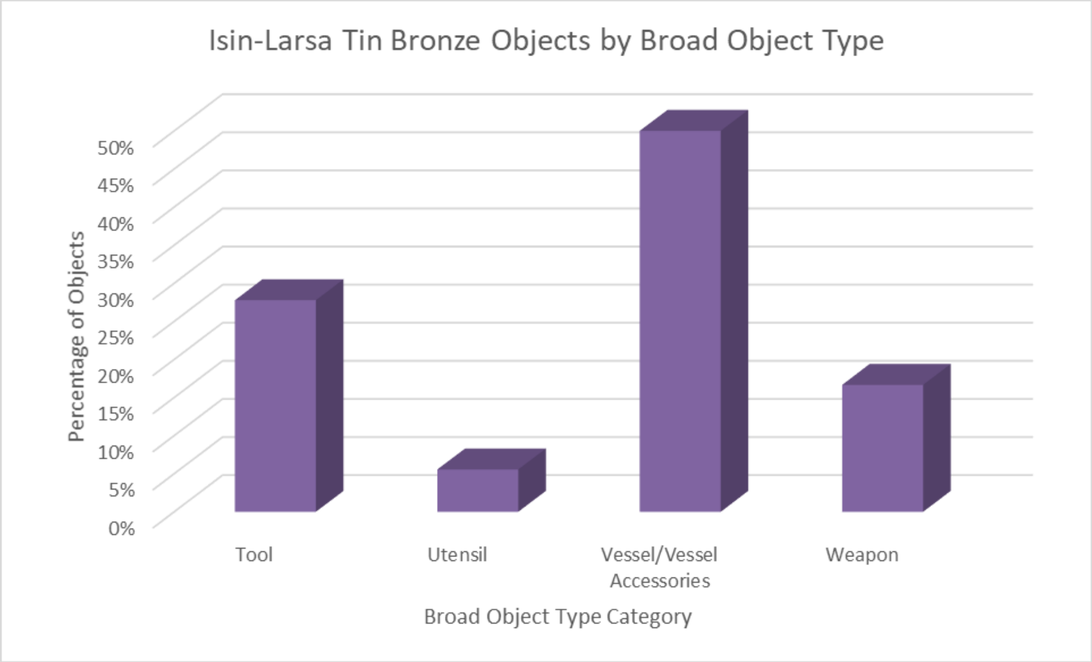


Figure 5.29: The percentage of Isin-Larsa copper objects containing both ≥0.5% arsenic and ≥2% tin that fell into each broad object type category.

The largest broad object type category in both the high-copper and arsenic bronze compositional categories is that of tool (Figure 5.30). This broadly follows the same pattern seen in previous periods. The largest broad object type category in the tin bronze compositional category is that of vessels. This preference for tin bronze in the creation of vessels has also been seen in the Ur III and Akkadian material.



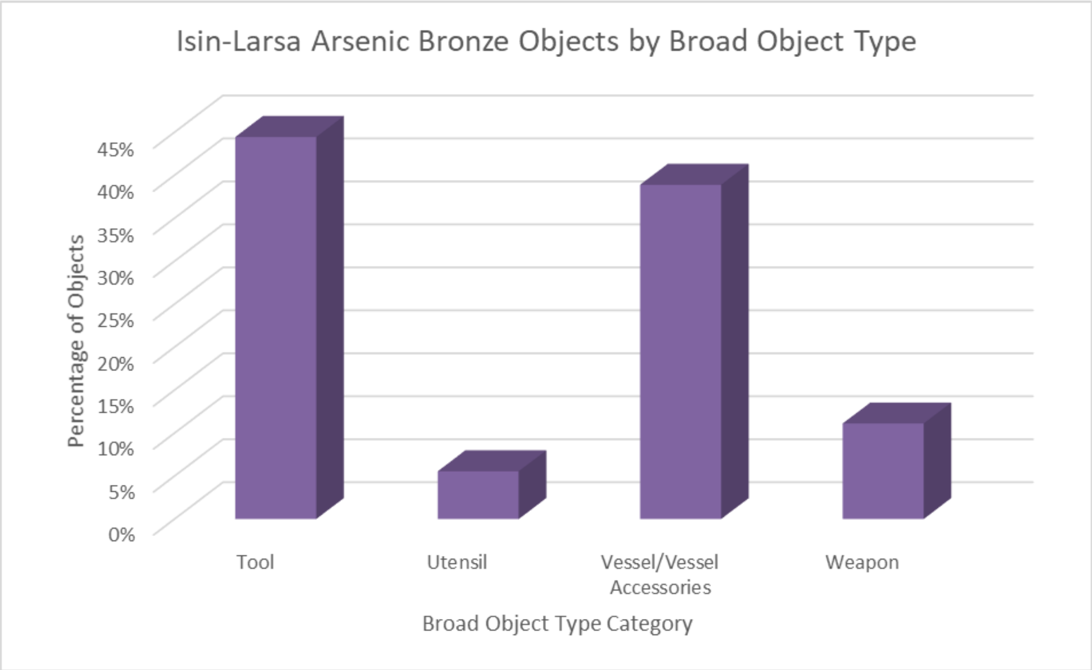


Figure 5.30: The percentage of tin bronze (top) and arsenic bronze (bottom) Isin-Larsa objects that fell into each broad object type category.

No entirely lead objects were dated to the Isin-Larsa period. Lead was detected in 32 of the 38 objects (84%) for which it was analysed, ranging from 0.03% to 18.1%. Iron levels were detected in 34 of the 38 objects (89%) for which it was analysed. The iron levels in 33 of these objects range from between 0.1% and 2.4%. The remaining object (1645) contains a much higher level of iron (Figure 5.31). This object is typed as a chisel or pocket anvil from Ur and contains 18% iron. While ingots and other lumps of metal from Mesopotamia have been found to include a high percentage of iron (see Potts 1997: 168-9), it is incredibly rare to find a finished worked copper-based object from this period with such high iron content. Such high iron content makes the explanation of contamination a highly unlikely one. Instead, it is perhaps most likely that this object was made with copper from an iron-sulphide ore which had only received one stage of processing.

1645

Figure 5.31: Isin-Larsa chisel/pocket anvil with high iron content (Hauptmann & Pernicka 2004: Plate 107)

Gold was only detected in one of the Isin-Larsa objects and it is only a very low level (0.1%). Silver levels were detected in 26 of the Isin-Larsa objects, although this content remains very low in all of them, ranging between 0.01% and 0.2%

Overall, the Isin-Larsa objects continue to follow the key patterns observed in the Akkadian and Ur III material; the heavy use of high-copper composition across essentially all object types and approximately half of the objects possessing a composition indicating that they are arsenic bronze. There is, however, a larger amount of tin bronze dated to the Isin-Larsa period than the Akkadian or Ur III periods, and this perhaps demonstrates the increase in popularity of tin bronze. This is the first period where there are more tin bronze objects than arsenic bronze. These readings also possibly indicate a continued tightening of tin content ranged within tin bronzes.

5.1.4 Old Babylonian

Of the 1,293 readings, 84 are taken from objects dated to the Old Babylonian period. This is the second largest grouping of material for any of the five key period groupings used here. This material spans 13 sites (Table 5.8); the widest range of site for any of the five key period groupings. The Old Babylonian material is also more evenly spread. It is the first period for which Ur does not contribute the bulk of material. Instead, Ur contributes just 8%, as does Kish. Uruk contributes the most material (20%), followed closely by Tello (17%) and Tell al-Dhiba'i (17%), and then Tell Harmal (15%). The remaining material is spread fairly evenly between the remaining seven sites.

Table 5.8: Old Babylonian objects categorised by the site at which they were found.

Site	**Object Count**
Diqdiqa	2
Kish	7
Larsa	2
Nippur	1
Reijibeh	1
Sippar	1
Tell al-Dhiba'i	14
Tell ed-Der	4
Tell Harmal	13
Tell 'Uqair	1
Tello	14
Ur	7
Uruk	17
Total	**84**

As seen with the Akkadian material, by far the largest category of object among the Old Babylonian material is that of tools (60%) (Table 5.9; Figure 5.32). This is, however, much larger than seen among the Akkadian, Ur III and Isin-Larsa material. This is influenced by the large body of tools found from Tell al-Dhiba'i, which notably include metalworker's tools found from the context of a metalworker's workshop (see Al-Gailani 1965; Davey 1983, 1988). In terms of more specific categories, the Old Babylonian tools can be broken up into 10 further categories (Figure 5.33). Of these, the most prominent are needles (34%) and axes (26%) which generally follows the patterns over the previous three period categories. Unlike the Akkadian, Ur III and Isin-Larsa material, however, the Old Babylonian material does include some objects related to the metalworking process. Three objects fall into this category: two potential ingots from Uruk and one piece of metal from Kish that appears to have been an unworked piece of copper or a 'primitive' ingot (Figure 5.34). In part, these slight differences in the material dating to the Old Babylonian material relate to the dramatically reduced influence of material from Ur, and the addition of multiple sites not represented in the previous three period categories.

Table 5.9: Old Babylonian objects categorised by site and broad object type.

	Diqdiqa	**Kish**	**Larsa**	**Nippur**	**Reijibeh**	**Sippar**	**Tell al-Dhiba'i**	**Tell ed-Der**	**Tell Harmal**	**Tell 'Uqair**	**Tello**	**Ur**	**Uruk**	**Total**
Fragment									1					1
Jewellery											1	1	4	6
Metallurgical Production		1											2	3
Miscellaneous							1						1	2
Tool	2	5	1	1	1	1	12		10	1	8	4	4	50
Utensil								1						1
Vessel/Vessel Accessories							1	2	1		5	2	1	12
Weapon		1	1					1	1				5	9
Total	**2**	**7**	**2**	**1**	**1**	**1**	**14**	**4**	**13**	**1**	**14**	**7**	**17**	**84**

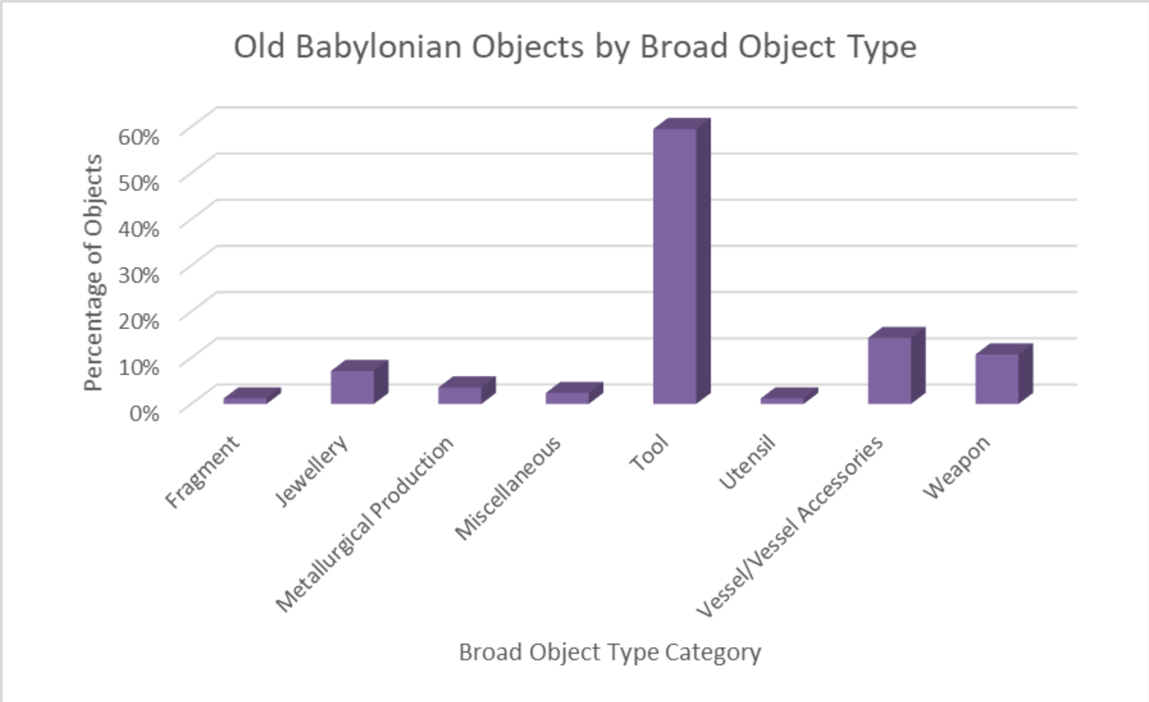


Figure 5.32: The percentage of Old Babylonian objects that fell into each broad object type category.

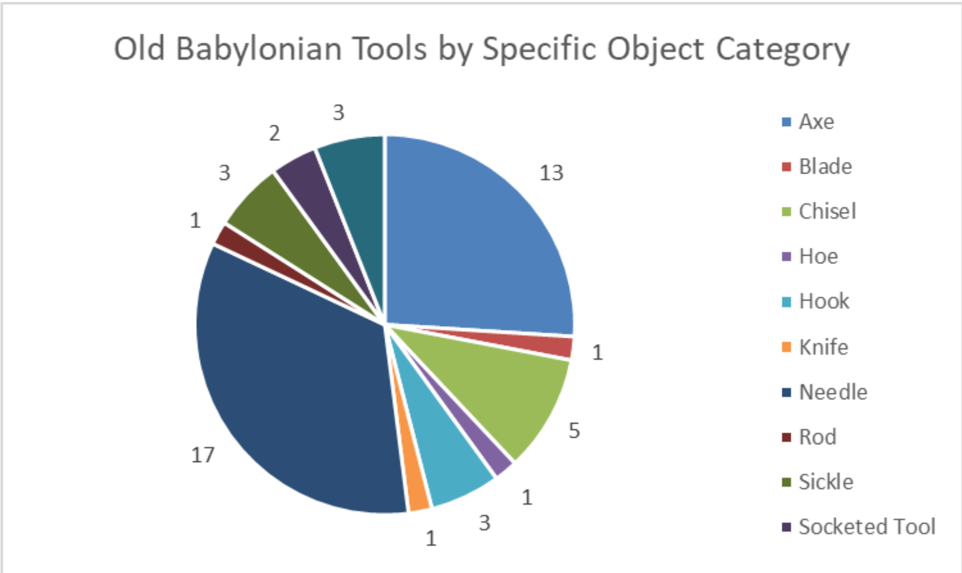


Figure 5.33: Old Babylonian tools categorised by specific object type category.

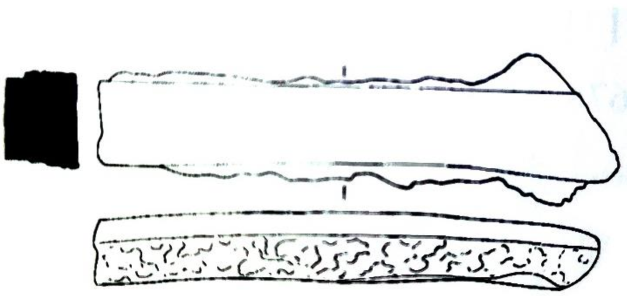

661

Figure 5.34: ‘Primative ingot’ from the Old Babylonian mateiral (Hauptmann & Pernicka 2004: Plate 39).

Of the 84 Old Babylonian objects, 48 (57%) contain copper of 95% and above (Figure 5.35). These objects span all of the broad object type categories found among the Old Babylonian material more generally, with the exception of fragment, miscellaneous and utensil (Figure 5.36). Of these high-copper objects, 21 are arsenic bronzes and four are tin bronzes.

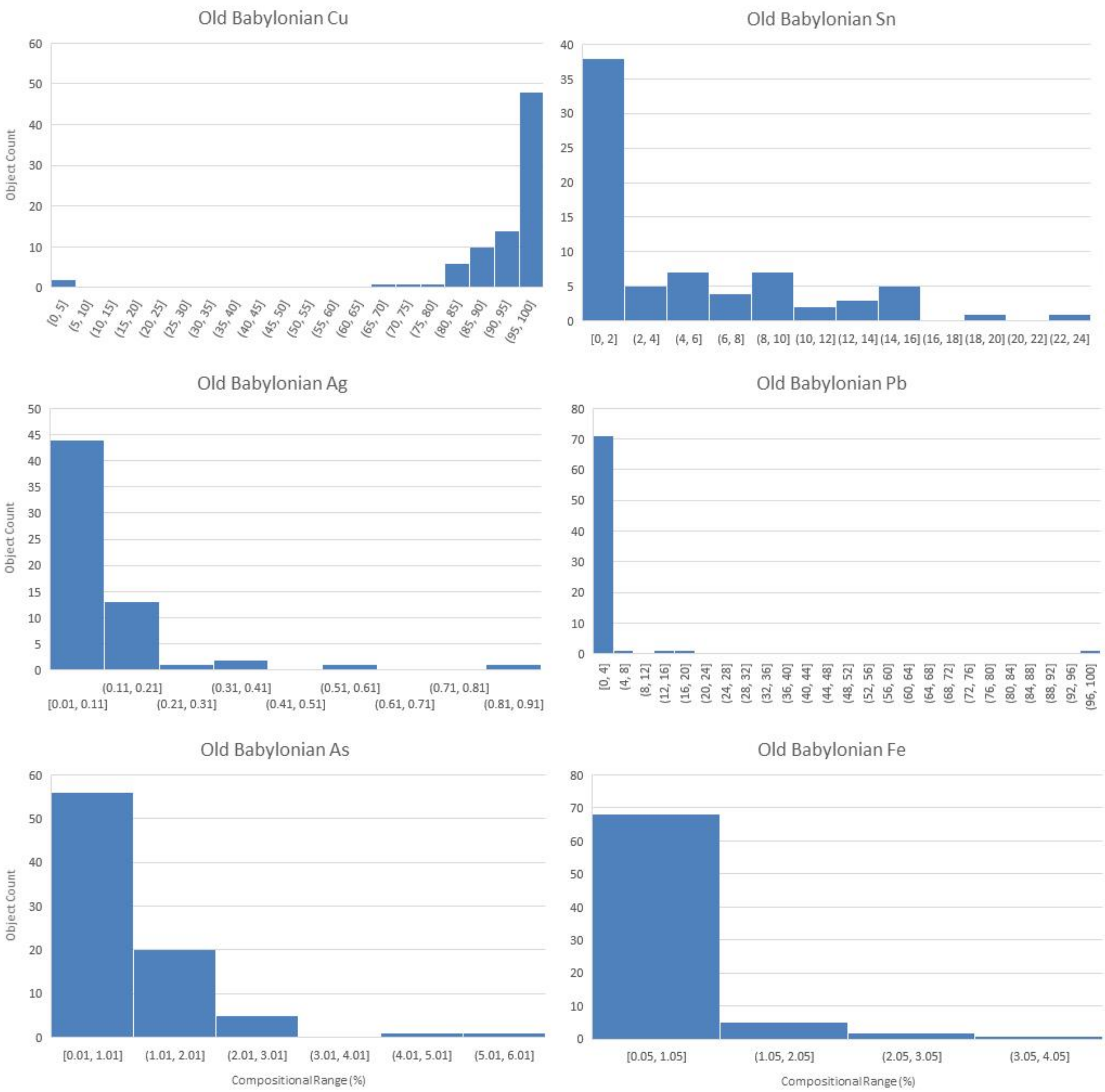


Figure 5.35: Results of compositional analysis of Old Babylonian objects illustrated by element. Due to Au only occurring in three objects in very low levels, it is not included here.

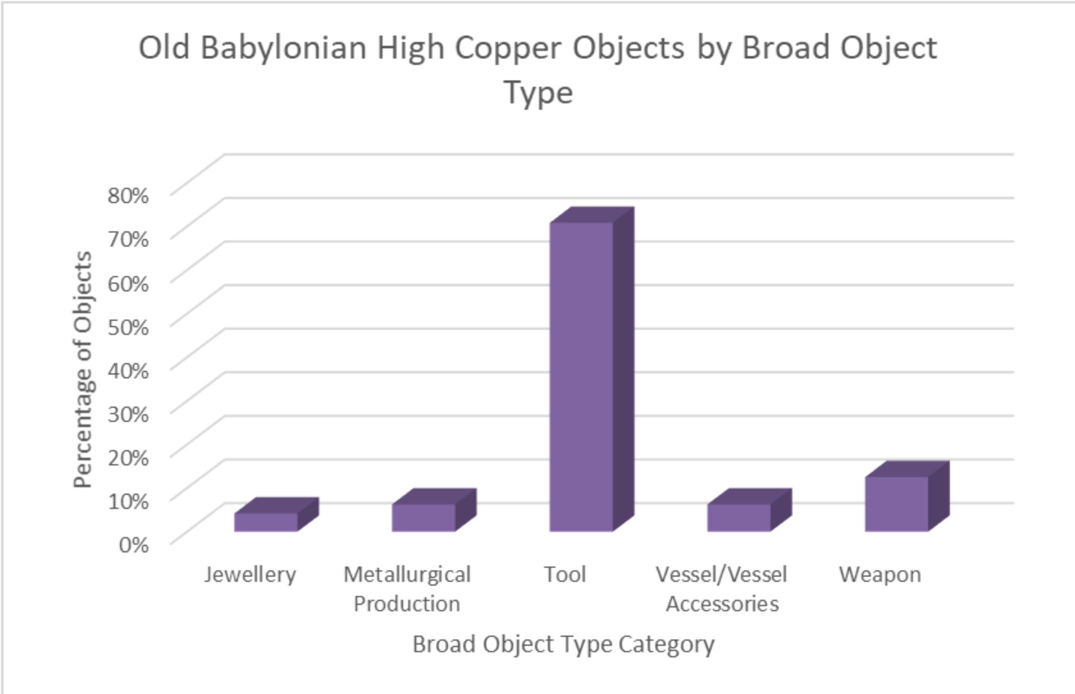


Figure 5.36: The percentage of high copper Old Babylonian objects that fell into each broad object type category.

Of the 84 Old Babylonian objects, 35 (42%) are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of tin bronze (Figure 5.37). This is less high than observed in the previous Isin-Larsa material, but much higher than in the Akkadian and Ur III material. The range of tin among these tin bronzes stretches from 2.3% to 23.9%. This range is slightly larger than that observed in the Ur III and Isin-Larsa material, and closer to the range observed in the Akkadian material. In the Akkadian, Ur III and Isin-Larsa material, the majority of the tin bronze came from Ur. In the Old Babylonian material, Ur contributes just 9%. Tin bronze comes from nine of the 13 sites. Due to the Old Babylonian tin bronze coming from a greater number of smaller sites compared to the Ur-dominated Akkadian material, it would be reasonable to expect to see a much wider range in the tin content due to the greater need to recycle at smaller sites but this is not the case.

Eight (23%) of the tin bronze objects fall into the more traditional range of tin content for tin bronzes: four tools, two vessels and two weapons. There does appear to be a possible pattern of vessels being made with higher tin content among these objects. The average tin content of tin bronze vessels is 11.8% while the average content of the tools is 7.5%. The variation in tin bronze between sites observed in the Akkadian, Ur III and Isin-Larsa material can also be seen in the Old Babylonian material.

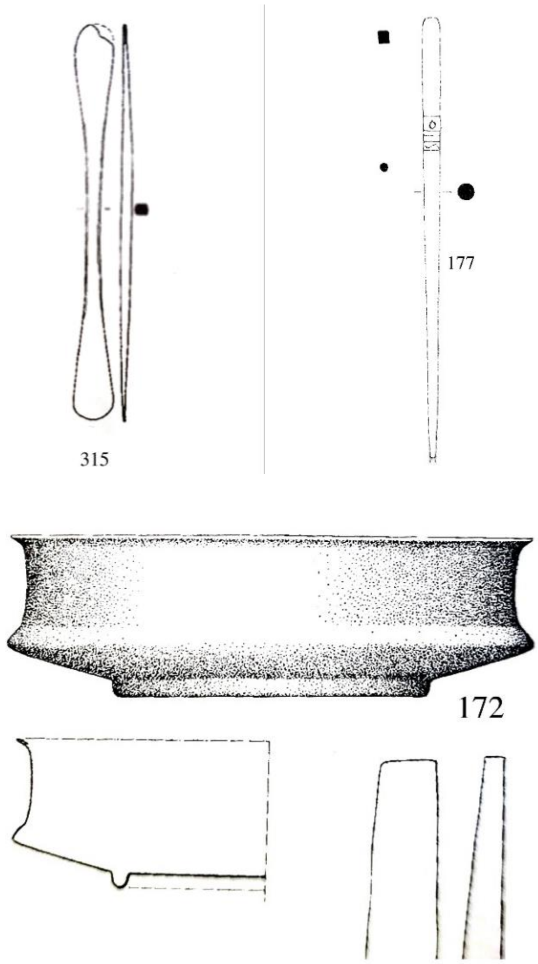


Figure 5.37: Example of some tin bronze objects from the Old Babylonian material. A tin bronze doubled-ended spatula (top left), needle (top right) and bowl (bottom). (Hauptmann & Pernicka 2004: Plates 13, 14 and 20).

Fifty-one (61%) of the 84 Old Babylonian objects contain ≥0.5% arsenic placing them into the category of arsenic bronze (Figure 5.38). Tin content of ≥2% is found in 28 of these. This type of composition appears to be used predominantly for tools and weapons, but is found in a wider range of object types than seen in previous material (Figure 5.39). Interestingly, the jewellery that falls into this composition category are armrings (Figure 5.40). In the Ur III material, the jewellery object that fell into this composition category was also an armring. There, therefore, appears to be an intentional choice to use this composition for armrings, or, at least, objects that have tended to be typed as 'armrings'.

Due to the strength of this alloy type, and the lack of its use for any other type of jewellery objects, it may be that these rings are not actually armrings and that they are rings used for more utilitarian purposes instead. Alternatively, this durable composition may have been selected due to the design of these armrings requiring physical adjustment in order to fit them to the body; therefore, it would have been important that these objects were not made be with a material that would easily just break with use over time. These armrings will be discussed further in section 5.1.6.

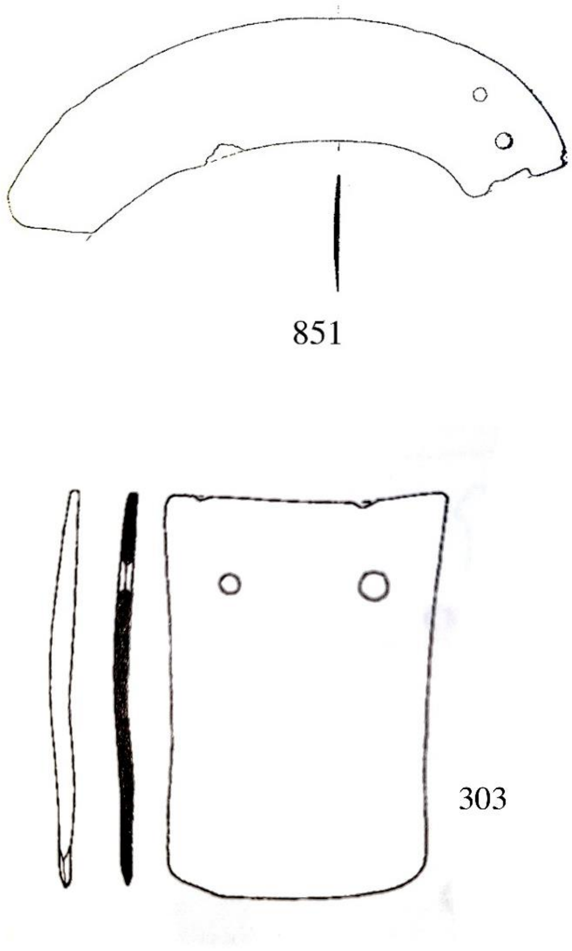


Figure 5.38: Example of arsenic bronze objects from the Old Babylonian material. Arsenic bronze sickle (left) and axe (right) (Hauptmann & Pernicka 2004: Plates 49 and 20).

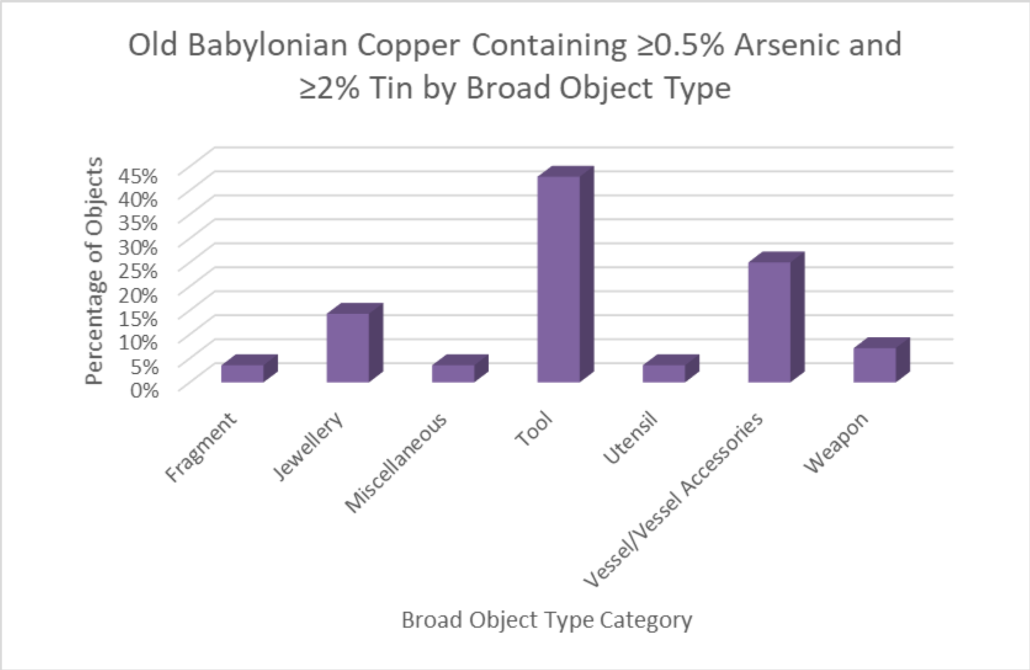


Figure 5.39: The percentage of Old Babylonian copper objects containing both ≥0.5% arsenic and ≥2% tin that fell into each broad object type category.

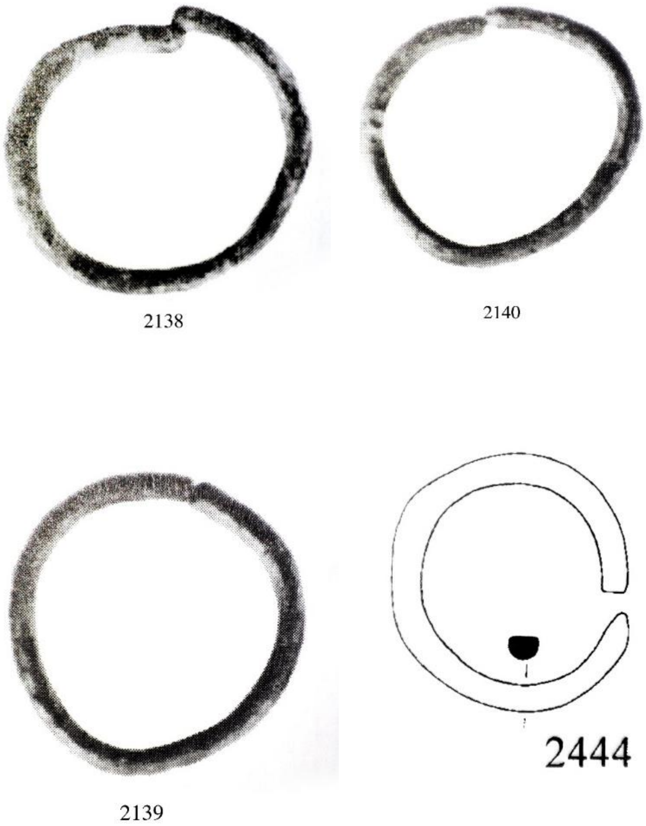
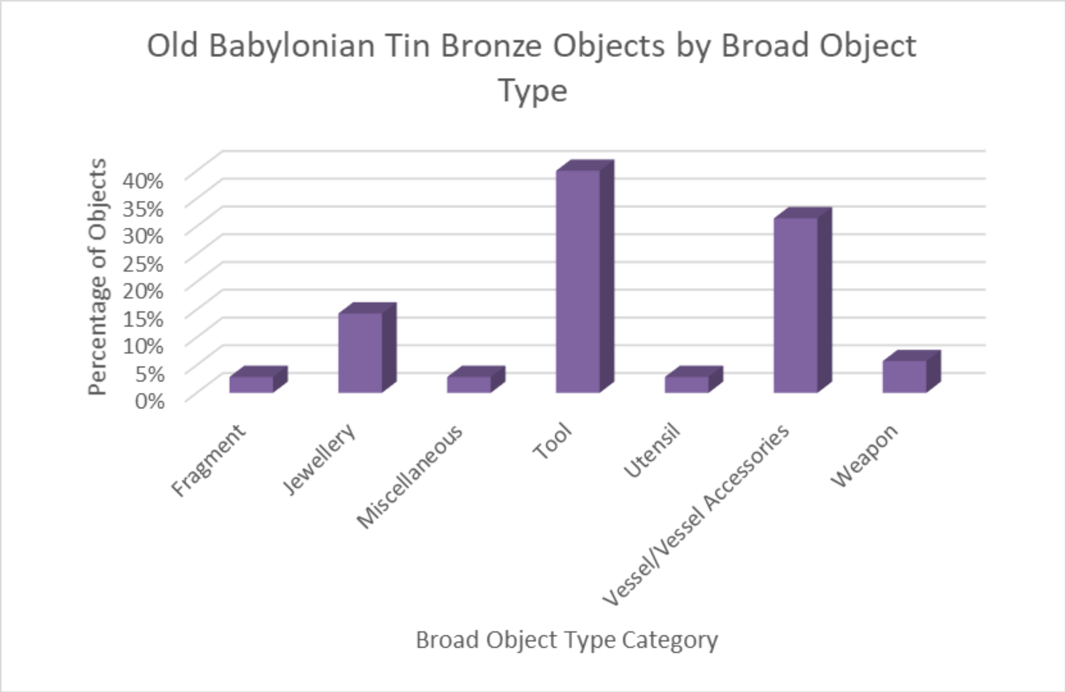


Figure 5.40: Four armrings from the Old Babylonian material containing both ≥0.5% arsenic and ≥2% tin (Hauptmann & Pernicka 2004: Plate 130).

Unlike the Akkadian, Ur III and Isin-Larsa material, the vast majority of potential arsenic bronzes do not come from Ur; instead, they come from Uruk (20%). This may perhaps indicate that Uruk was using a greater amount of copper from an arsenic-rich source at this point than other sites. Similar to the pattern observed with tin bronze, the prevalence of arsenic bronze varies considerably between sites. For example, arsenic bronzes make up 100% of the objects from Nippur and Reijibeh, 57% from Ur and 0% from Sippar and Larsa. In general, however, arsenic bronzes still make up the majority of the objects from most sites.

The largest broad object type category across all three compositional categories of high-copper, tin bronze and arsenic bronze objects is that of tools (Figure 5.41). As seen in the Akkadian, Ur III and Isin-Larsa material, the preference for tin bronze in the creation of vessels appears to continue.



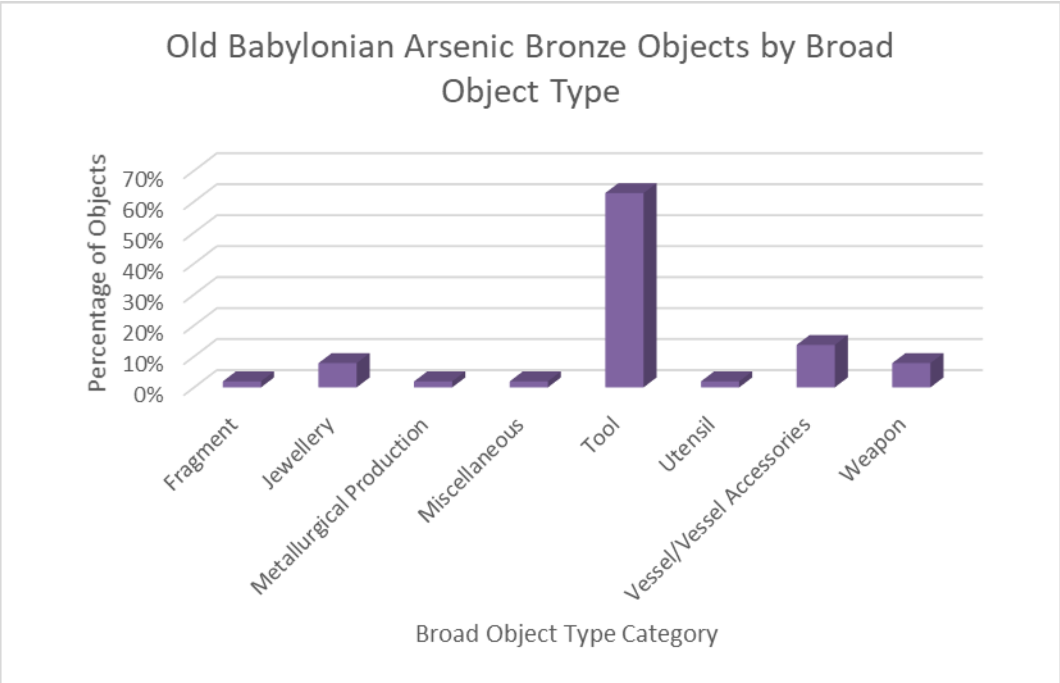


Figure 5.41: The percentage of tin bronze (top) and arsenic bronze (bottom) Old Babylonian objects that fell into each broad object type category.

Lead was detected in 74 of the 84 objects (88%) for which it was analysed. This lead content ranges between 0.03% and 99.8%, including one (nearly) entirely lead object (449), a possible needle from Tell Harmal. Due to the softness of lead, this is an unlikely choice for a pin, perhaps indicating that the actual function of this object may not align with this typological category. Low levels of iron were detected in 76 of the 84 objects (90%) for which it was analysed, ranging from 0.05% to 3.8%. Gold was only detected in one of the Isin-Larsa objects and it is only a very low level (0.06%). Silver levels were detected in 62 of the Old Babylonian objects, although this content remains very low in all of them, ranging between 0.01% and 0.8%.

Overall, the Old Babylonian material is somewhat similar to that dated to the Isin-Larsa period. There is a continued use of high-copper composition. There is a slightly lower percentage of tin bronzes than in the Isin-Larsa material and a higher percentage of arsenic bronze objects, indicating that arsenic bronze is still strongly in use during this period. In terms of broader patterns, there is still a strong preference for tin bronze in the creation of vessels and there appears to be a strong preference for arsenic bronze in the creation of tools.

5.1.5 Kassite

The Kassite Period stretches from approximately 1600 to 1155 B.C. The period therefore extends somewhat beyond the end of the temporal focus of this project, meaning that some objects here may technically also date to beyond the temporal focus. This cannot be avoided as this material is provided only with the dating of 'Kassite' and there is no specification as to whether it may be early or late Kassite. Only five objects date to the Kassite Period, making it the smallest of the five key period groupings. The material also only derives from two sites (Table 5.10).

Table 5.10: Kassite objects categorised by the site at which they were found.

Site	**Object Count**
Nippur	3
Ur	2
Total	**5**

The five Kassite objects fall into just three broad object type categories (Table 5.11; Figure 5.42). More specifically, the material consists of three daggers, one vessel and one socketed tool. As with the Akkadian, Ur III and Isin-Larsa material, there are no objects related to the metallurgical process and all of the objects are either fully or nearly complete.

Table 5.11: Kassite objects categorised by site and broad object type.

	Nippur	**Ur**	**Total**
Tool		1	1
Vessel/Vessel Accessories		1	1
Weapon	3		3
Total	**3**	**2**	**5**

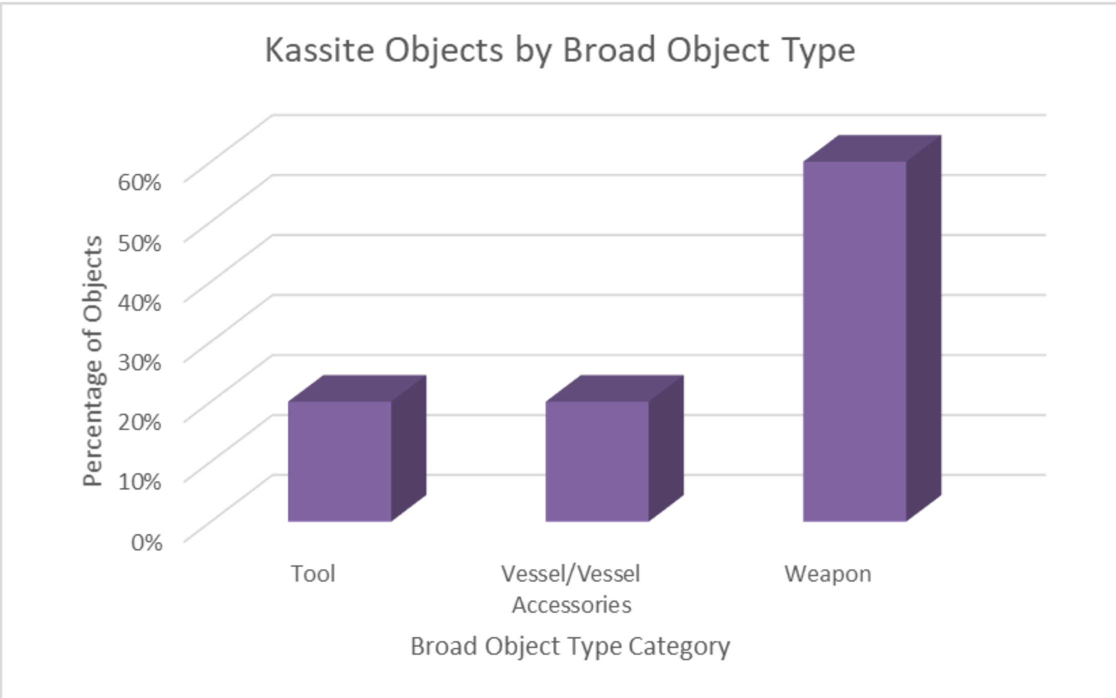


Figure 5.42: The percentage of Kassite objects that fell into each broad object type category.

One of the five Kassite objects, the tool from Ur, contains more than 95% copper and therefore falls into the high copper composition group (Figure 5.43). The three daggers from Nippur are all tin bronzes (Figure 5.44). Finally, the vessel from Ur is made nearly entirely of silver (Figure 5.45). There are no arsenic bronzes in the Kassite material. The levels of arsenic are very low in all four of the copper-based objects. Lead was detected in four of the five for which it was analysed, ranging from 0.07% to 0.46%. Low levels of iron were detected in four of the five objects for which it was analysed, ranging from 0.12% to 0.37%.

Due to the very small amount of Kassite objects, there is little that can be said with any confidence. Although, it is notable that there is a strong presence of tin bronze and no arsenic bronzes.

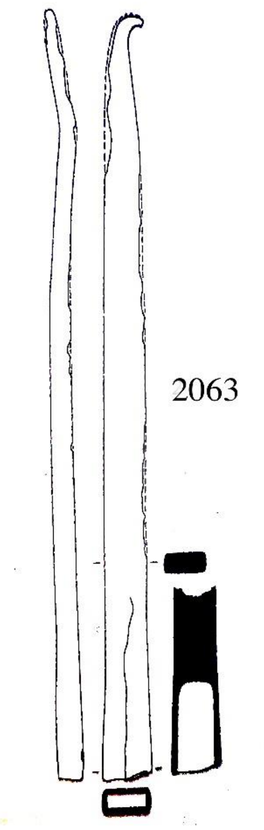


Figure 5.43: High-copper socketed tool from the Kassite material (Hauptmann & Pernicka 2004: Plate 127).

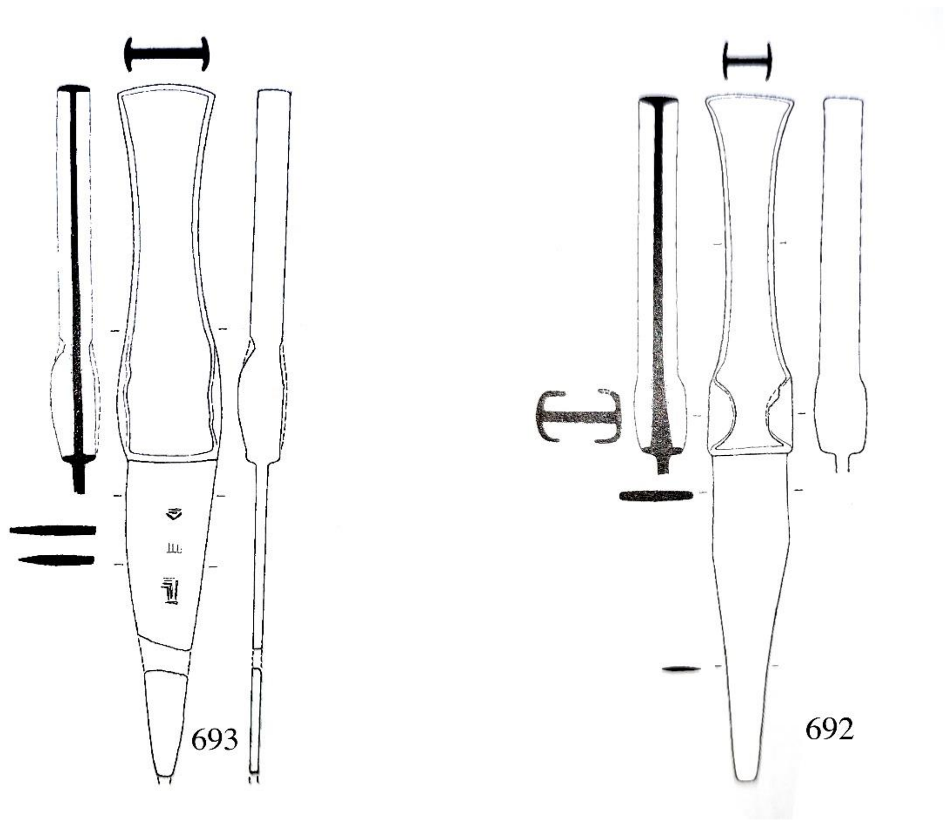


Figure 5.44: Two tin bronze daggers from the Kassite material (Hauptmann & Pernicka 2004: Plate 41).

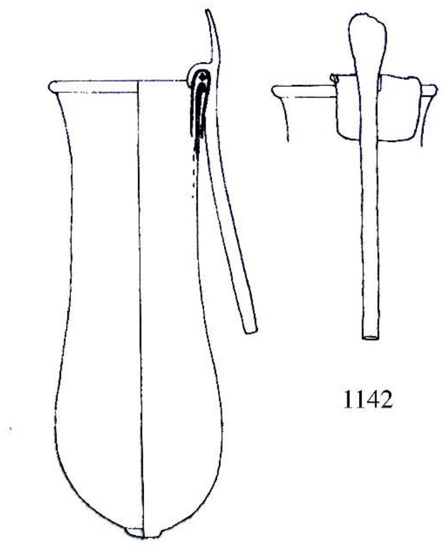


Figure 5.45: Silver vessel from the Kassite material (Hauptmann & Pernicka 2004: Plate 70).

5.1.6 Result Comparisons and Discussion: Undated and Broadly Dated Material

Of the 1,293 objects from the legacy datasets, 481 (37%) have been assigned a date that stretches across multiple period groups. A further 343 (27%) of the objects from the legacy data were not assigned any date. Although the broad dating of these objects somewhat reduces their usefulness in period-related discussion, they can be utilised alongside analysis of the more specifically dated material to better understand some of the patterns and findings that have been brought out in this chapter so far. Additionally, analysis of the broadly dated or undated material in light of current understanding derived from exploration of the more specifically dated material can perhaps highlight potential issues with the dating of some of this material.

Two key patterns that have been discussed above relate to the use, or changing use, of tin bronze and arsenic bronze. As discussed in Chapter 3, general patterns of continued arsenic bronze use and the eventual increase in tin bronze use have previously been observed, but more specific connections between arsenic bronze and tin bronze use with regard to sites over time have yet to be discussed in depth in previous research. As discussed so far, and shown in Figure 5.46, use of arsenic bronze continues to a high degree throughout the Akkadian, Ur III, and into the Isin-Larsa periods in a relatively stable manner, while use of tin bronze rises dramatically from the Isin-Larsa period onwards. These general trends are also observed at most of the sites, and exceptions appear to be the result of a lack of material first and foremost. Therefore, there does not appear to be a case of certain sites dramatically increasing or decreasing their tin bronze or arsenic bronze use alongside other sites that are demonstrating an opposite trend. This would suggest that access to tin did not dramatically change for some site and not others.

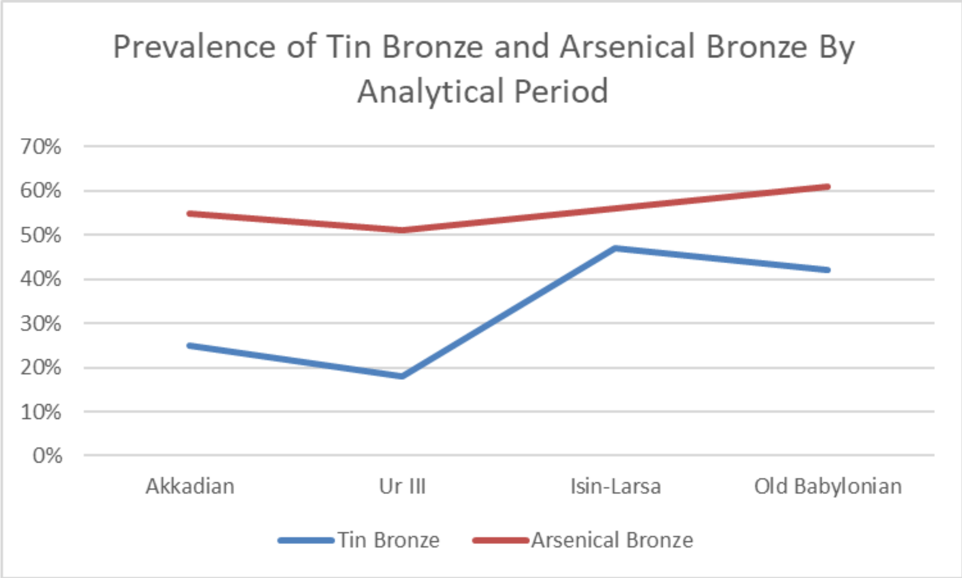


Figure 5.46: Prevalence of tin bronze and arsenic bronze for each analytical period in terms of percentage (%) of objects, demonstrating a clear difference in trend between arsenic bronze and tin bronze[15].

While the material dated to 'Early Dynastic to Akkadian' and 'Akkadian to Ur III' broadly follow these patterns, the material dated to 'Early Dynastic to Ur III' demonstrated a dramatically higher percentage of tin bronze (41%). This dataset constitutes 108 objects, 102 (94%) of which come from Ur. Despite these objects being dated to a period which stretches from the Early Dynastic period to the Ur III period, this high amount of tin bronze makes it most likely that much of this material dates more closely to the Ur III period than the Early Dynastic end of the dating range. The material which has been dated specifically to the Ur III material contained only 18% tin bronze, but it also contained considerably less material from Ur (68%). Of the Ur III tin bronzes, 92.3% of them came from Ur. This larger amount of tin bronze may therefore be explained by the high amount of material originating from Ur. Examination of tin bronzes from Ur specifically over time, however, demonstrates a very similar pattern to the general pattern presented above (Figure 5.47). This is due mainly to the Ur material constituting such a large amount of the dataset. It seems unlikely, therefore, that such a high prevalence of tin bronze would have been seen between the Early Dynastic and Ur III periods. Alternatively, given this material has been proscribed such a wider date range, and given so many of the metal object types

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[15] The figures from the Kassite material are not included here due to such a small dataset providing largely unhelpful results.

from southern Mesopotamian are chronologically insensitive (Helwing, undated), it is possibly that some of this material has been given a date which is too early.

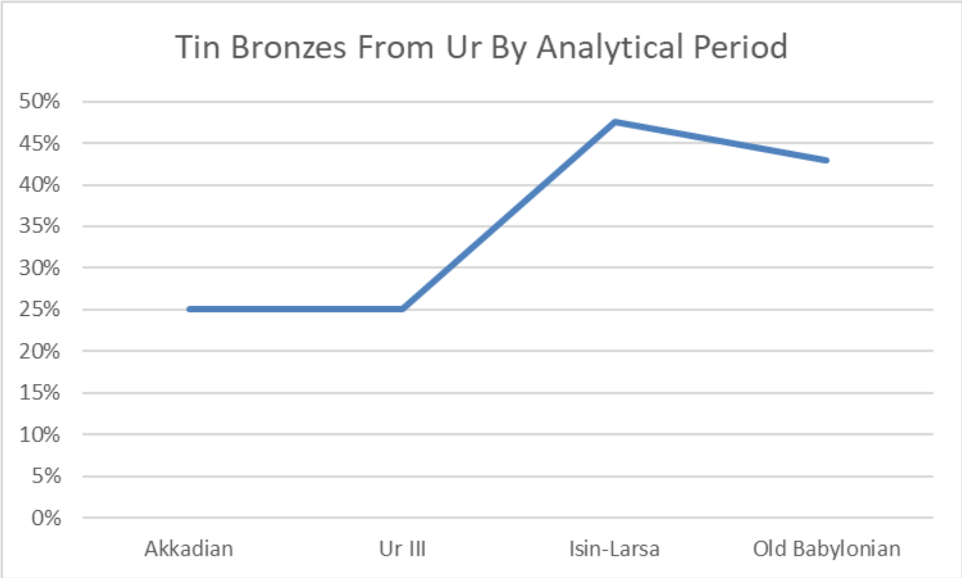

Figure 5.47: Prevalence of tin bronzes from Ur for each analytical period category.

In the period-focused discussion above, it was observed that there appears to be some change in the preferred object types used for tin bronze and arsenic bronze. Across all of the period categories, there appears to be a preference for using tin bronze for vessels and vessel accessories over arsenic bronze. In the Akkadian and Ur III periods there appears to be a slight preference for using arsenic bronze to make tools, although significant amounts of tools were also made from tin bronze. This preference appears to increase significantly in the Isin-Larsa and Old Babylonian periods, however. This pattern is particularly interesting as tin bronze use was significantly higher during these periods, so arsenic bronze seems to have been intentionally chosen for tools more commonly than tin bronze despite good access to tin and the increased strength of tin bronze. This may, therefore, have been a decision based on manufacturing techniques more so than metal properties. With the addition of the broadly dated and undated material, this pattern is seen more strongly. Across all of the broad period categories and the undated material, there is a strong preference for arsenic bronze for tools. There is greater variation regarding vessels, where arsenic bronze is actually often used for vessels more commonly than tin bronze. If much of the material that has been broadly dated or never assigned a date has fallen into these categories due to having poorly defined contexts, this variation in tin bronze use for vessels may be the result of tin bronze vessels more commonly being used as grave goods while arsenic bronze vessels were not.

Some key patterns related to metal choice and object type have been discussed above and can be explored further in light of the undated and broadly dated material. Across each of the analytical periods, the most common category of object type is that of tools. This is unsurprising given that the properties of metal are inherently well-suited for tools. One clear pattern across all of the period categories, however, is the prevalence of axes and needles. In the broadly dated material, needles still regularly occupy the position of most common object type. In the undated material, the most common objects are rings followed by needles. Of particular note concerning needles, is the high amount of them which are made of silver. While needles are typically categorised as tools, this suggests that perhaps a large amount of them were either never intended to actually be used as tools, or may not actually be needles; instead, they may be mistyped pins.

Another pattern drawn out in the discussion above is that of armrings made specifically with ≥0.5% arsenic and ≥2% tin; a composition which is otherwise generally only found in utilitarian objects. Of all 1,293 objects included in the legacy data, there are 35 armrings. Fourteen (40%) of these fit the abovementioned composition; seven of which are undated and therefore are missing from the above period-focused discussion. Those which are dated stretch from a possible Early Dynastic date all the way to the Old Babylonian period. They are found at Ur, Larsa, Uruk, Tello and Lagash. The undated material significantly extends this group of objects and suggests, perhaps, that this may have been an intentional composition choice that was in use at different sites and across different periods.

Overall, the legacy data can be examined to produce some potential patterns within extant Mesopotamian metalwork collections that can guide the development of future research questions and projects. These patterns demonstrate a strong sense of continuation of metalworking practices and preferences across a broad temporal scope. The following section provides analysis and discussion of the new composition data gathered specifically for this project, in light of both what these data can indicate in their own right, and how they compare to the legacy data.

5.2 New Analyses: UK-Based Museum Collections

The new analyses conducted on the Mesopotamian metalwork collections held at Manchester Museum, the Ashmolean Museum and Birmingham Museum and Art Gallery collectively contribute readings of 178 objects. As the vast majority of objects from each of the museums have no assigned date in the museum records, the data are grouped and analysed by collection rather than divided by period as is done in the preceding section. Discussion of these data in light of period is included as and where possible.

5.2.1 Manchester Museum

Analysis was conducted on 59 objects held at Manchester Museum. Of these, 53 are included here due to six falling outside of the temporal and/or geographical parameters of this study. For 31 of the 53 objects, readings were taken on both General Metals and Test All Geo modes. The remaining 22 were a set of rings that were read on General Metals mode only to facilitate the completion of readings for all objects within the time frame of the research visit. The information provided by Manchester Museum listed a date for only one of the objects. The site of Ur is recorded as the find site for 45 of the objects, and as the possible find site for the remaining eight objects (Table 5.12).

Table 5.12: Manchester Museum objects categrosied by site and period.

Site and Period	**Object Count**
Ur	**45**
Ur III	1
No Date	44
Possibly Ur	8
No Date	8
Total	**53**

In the Manchester Museum collection, the largest category of object type by a significant amount is jewellery (57%) (Table 5.13; Figure 5.48). This is not the case for any of the bodies of data discussed in section 5.1 divided by period. One possible explanation may be that when the collection of Ur material was gifted to Manchester Museum, jewellery was intentionally prioritised; as discussed in Chapter 3, traditional museum strategies regarding collections have often prioritised object types such as jewellery and objects made from precious metals due to their high appeal to visitors. The bulk of the material categorised as jewellery falls into the more specific categorisation of ‘rings’, however, and it should be highlighted that while rings – particularly smaller rings – are typically positioned within the category of jewellery, there may be instances where some of these rings were not used as any form of personal adornment and could instead have possessed a different function; for example, rings are often used on horse harnesses. Similarly, it has previously been suggested (Powell 1996: 235) that some spiral rings may have been a form of currency rather than rings that would have been worn. Most of the rings from the Manchester Museum collection do not fit into this spiral style, although some are broken and therefore it cannot be ruled out that they may have originally (Figure 5.49). Another notable difference between this collection and those included in the legacy datasets is the lack of axes and needles despite these categories containing the largest proportions of material across all of the periods.

Table 5.13: Manchester Museum objects categorised by object type.

Object Type	**Object Count**
Dress	3
Pin	3
Jewellery	30
Bead	3
Bracelet	3
Earring	1
Ring	23
Miscellaneous	4
Unknown Function	4
Tool	15
Blade	12
Nail	1
Needle	1
Rod/bar	1
Vessel/Vessel Accessories	1
Vessel	1
Grand Total	**53**

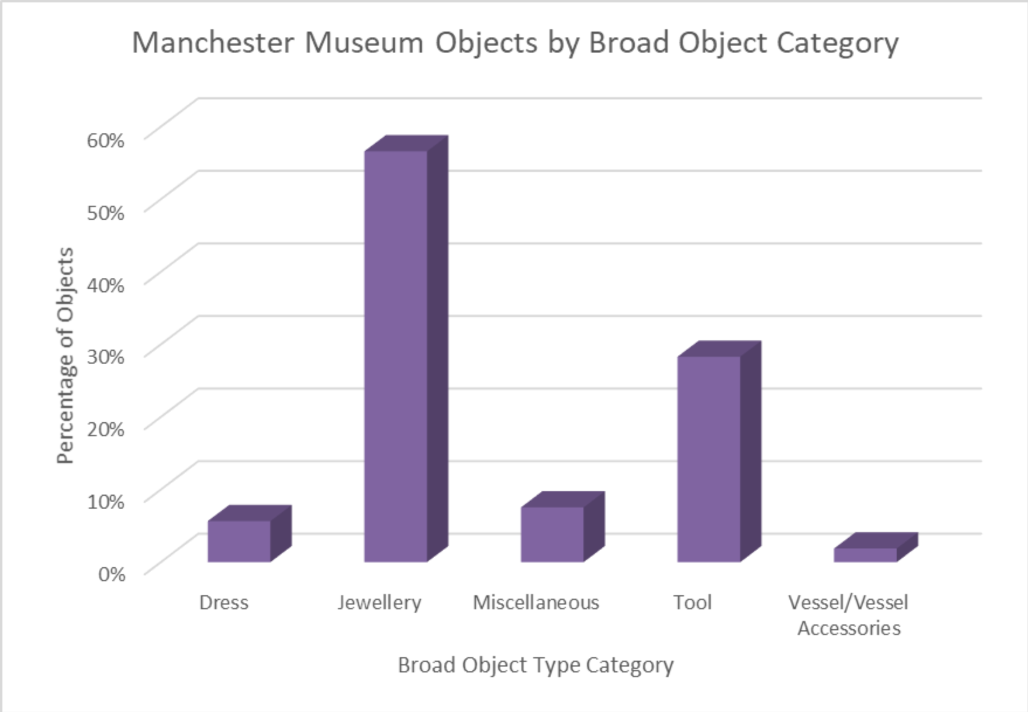

Figure 5.48: The percentage of objects in the Manchester Museum collection that fell into each broad object type category.

Figure 5.49: Eleven of the rings from the Manchester Museum collection, illustrating the types of rings in the assemblage (Objects 15-25).

Compositionally, the material from Manchester Museum fits within the legacy data discussed above (Figure 5.50). The most common compositional category by far was that of high-copper content. Of the material analysed at Manchester Museum, 36 of the 53 objects (68%) have average compositions of 95% copper or above. They span multiple object types; jewellery and personal adornment, tools/weapons and utensils (Figure 5.51).

Five (9%) of the objects from the Manchester Museum collection are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of tin bronze. All five of these are categorised as jewellery. This is dramatically lower than the general trends of tin prevalence observed in the legacy data. It is, however, similar to the prevalence of tin bronze found in the Early Dynastic material published by Hauptmann and Pernicka (2004) which rests at 10.7%. As such a sizeable amount of the material from Ur came from Early Dynastic contexts, it is plausible that – despite lacking an assigned date in the records – much, if not all, of the material from Manchester Museum is Early Dynastic. The tin content of these objects ranges from 3.1% to 20% which follows the same general range observed in the legacy data, but is much smaller than the general range observed in the Early Dynastic material (between 2.07% and 45.3%).

One of the Manchester objects (object 3), a dagger from Ur, was also predominantly composed of copper and tin, but rather than being copper-based with the addition of tin, this object contains more tin (53%) than copper (44%) (Figure 5.52). As mentioned in Chapter 2, only a small number of tin objects have been found from Mesopotamia, but it has been highlighted (see Moorey 1994: 301) that, due to its silver-like appearance, tin may have been used as a cheaper material to make objects of a similar appearance to silver. Object 3 may be an example of an object made with a high tin content in order to replicate a silver-like appearance, or at least change the colour of the object to look different to typical bronze. Unfortunately, the surface corrosion on the object limits study of use-wear on the dagger to deduce whether it was used or whether its intention was to be used purely for appearance; the latter would potentially support the notion of higher tin levels to change colour, if appearance was more important than functionality.

Figure 5.50: Results of compositional analysis of the Manchester Museum objects illustrated by element.

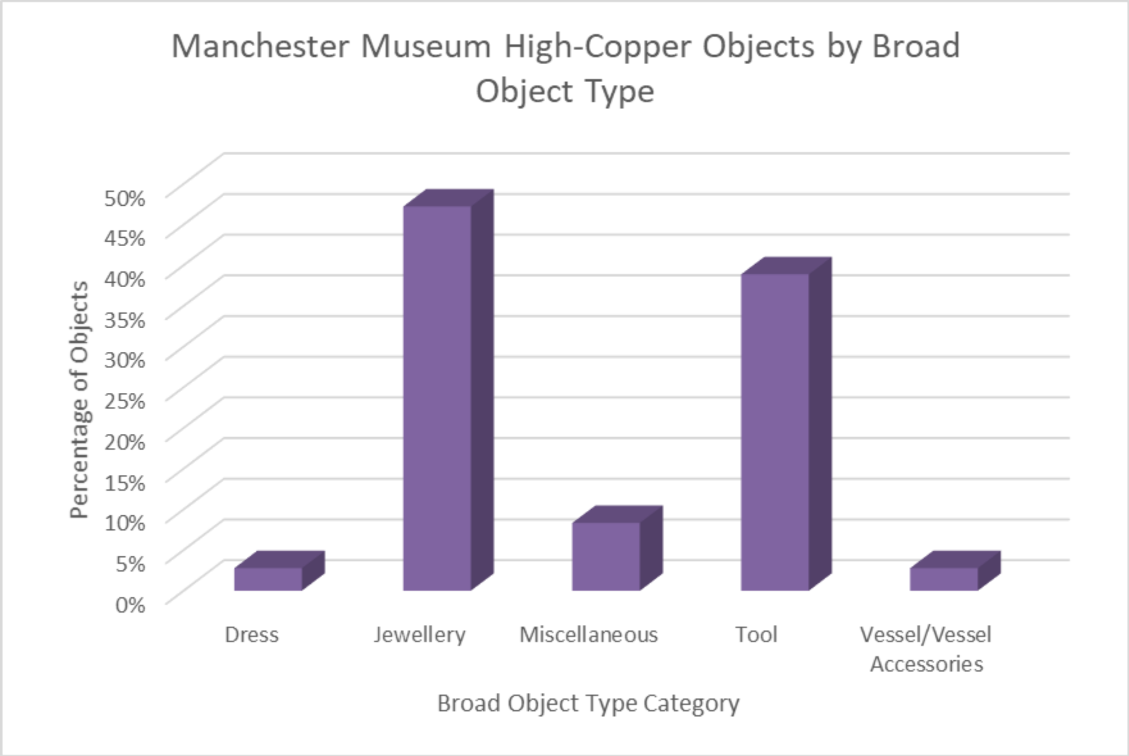

Figure 5.51: The percentage of high copper objects in the Manchester Museum collection that fell into each broad object type category.

Figure 5.52: Object 3 from the Manchester Museum collection.

Of the objects read for arsenic, 11 (46%) contain ≥0.5% arsenic placing them into the category of arsenic bronzes. Tin content of ≥2% is found in three of these. The largest object type category among this material is that of tools which follows the trend observed in the legacy data of preference towards arsenic bronze for tools (Figure 5.53).

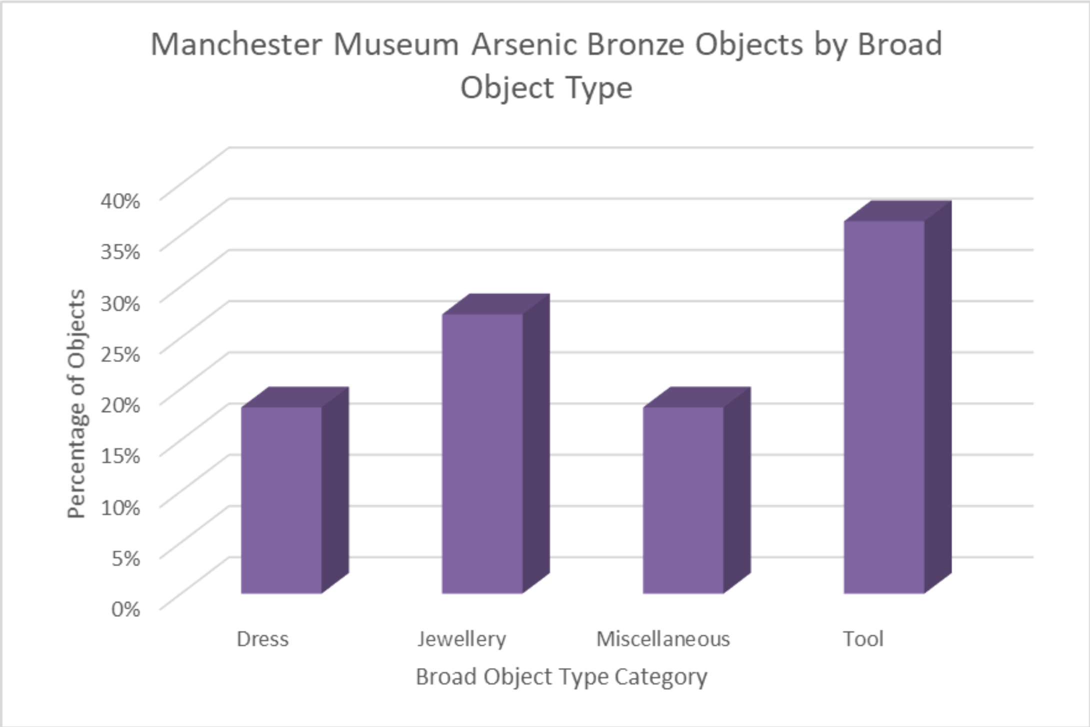

Figure 5.53: The percentage of arsenic bronze objects in the Manchester Museum collection that fell into each broad object type category.

One object was found with a high lead content. Object 19 (Figure 5.54), an apparent ring fragment from Ur, is copper-based (61%) but demonstrated a lead content of 37% lead. Unlike many of the other rings, this appears to be larger in size and circumference. The object contains more lead than is typically expected of a leaded bronze.

Figure 5.54: Object 19 from the Manchester Museum collection, which is an apparent ring fragment from Ur with considerable lead content.

Two of the objects (51 and 61; Figures 5.55 and 5.56) from Manchester Museum are silver. Object 51 has a silver content of 83% and is recorded only as an ‘artefact’. It is in several pieces and appears to be heavily conserved. The object is noted in the Manchester Museum records as possibly being from Ur. It also has a copper content of 17%. Due to the softness of pure silver, bronze was often alloyed with silver to make it easier to work, and alloying silver with copper also creates a more durable metal. Object 61 is a silver bead, also possibly from Ur. Unlike object 51, object 61 has a very high silver content, registering at 98%. Such a high silver composition suggests that the silver has been intentionally processed to separate it almost completely from gold. Aside from the silver objects, very low amounts of silver were also detected in some of the copper-based objects.

Figure 5.55: Object 51 from the Manchester collection, which is an artefact in several pieces with considerable silver content.

Figure 5.56: Object 61 from the Manchester collection, which is a silver bead.

The only object from Manchester Museum with a high gold content is Object 62 (Figure 5.57). It is a bead cap, possibly from Ur. The object's gold content is 68%. It also contains a significant amount of silver (29%). As discussed by Moorey (1994: 217), it is difficult to tell whether metals of gold and silver were intentionally alloyed, or whether the gold and silver were not separated during processing.

Figure 5.57: Object 62 from the Manchester Museum collection, which is a gold bead cap.

Iron was detected in all 53 of the Manchester Museum objects with the exception of four which have iron levels that registered as <LOD. For 44 of these objects, the iron levels increase gradually between 0.02% and 2.7%. For the remaining four, iron content increases more drastically. There is then a jump up to 6.42% in Object 54 and then increases steeply up to 30.74% in Object 32. Objects 23, 36 and 32 are rings. Object 54, however, is a bead. It is also the only object that Manchester Museum had a date in their records for, listing it as belonging to the Ur III Dynasty.

Overall, where comparisons can be made, the Manchester Museum appears to generally follow the broad patterns observed in the legacy data. The extent to which comparisons can be drawn is, however, significantly restricted by the nature of the Manchester Museum collection.

5.2.2 The Ashmolean Museum

Analysis was conducted on 72 objects held at the Ashmolean Museum. Of these, 33 are included here due to 17 falling outside of the temporal and/or geographical parameters of the study. An assigned date was provided for 31 of these 55 objects, either in the Ashmolean Museum records or in the volume by Hauptmann and Pernicka (2004) (Table 5.14). Twenty-nine of these objects are from Kish and the remaining four have no assigned site (see Table 5.15). All of the 33 objects were read using both General Metals and Test All Geo modes.

Table 5.14: Ashmolean Museum objects categorised by site and period.

Site and Period	Object Count
Kish	**29**
Early Dynastic to Akkadian	6
Early Dynastic to Old Babylonian	1
Old Babylonian and Sealand	2
No Date	20
Unknown	4
No Date	4
Total	**33**

The largest category of objects in this collection is tools; this fits with the above-discussed legacy datasets, although the most common tool type in this collection is nails, and there was only one axe (Figure 5.58). Jewellery and dress make up the joint second largest categories. There were no weapons in the collection. There was, however, one ingot. It was excavated from Kish but has no assigned date.

Table 5.15: Ashmolean Museum objects categorised by object type.

Object Type	Object Count
Dress	7
Pin	7
Dress/Tool	4
Pin/Needle	4
Grooming instrument	1
Razor	1
Jewellery	7
Bracelet	4
Ring	3
Metallurgical Production	1
Ingot	1
Miscellaneous	2
Fitting	1
Unknown Function	1
Tool	10
Axe	1
Chisel	1
Hoe	1
Knife	1
Nail	4
Needle	1
Sickle	1
Vessel/Vessel Accessories	1
Vessel	1
Total	**33**

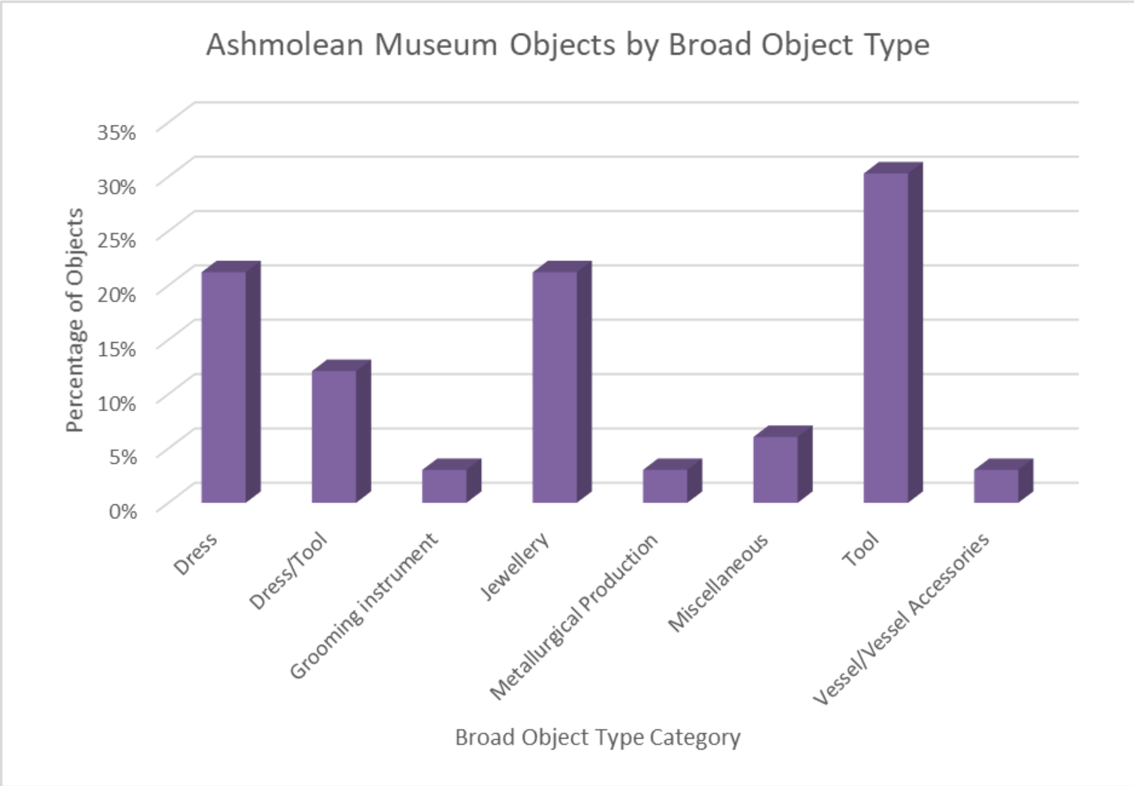

Figure 5.58: The percentage of objects in the Ashmolean Museum collection that fell into each broad object type category.

In terms of composition, the Ashmolean material broadly follows the patterns seen in previous material (Figure 5.59). The largest compositional category is that of high copper. Of the 33 objects, 13 (39%) had copper content of 95% and above. The vast majority of these have no assigned date. This is much lower than the 70% of objects in the Manchester Museum collection with 95% copper and above, but it is closer to the amount of high-copper objects observed in the legacy data.

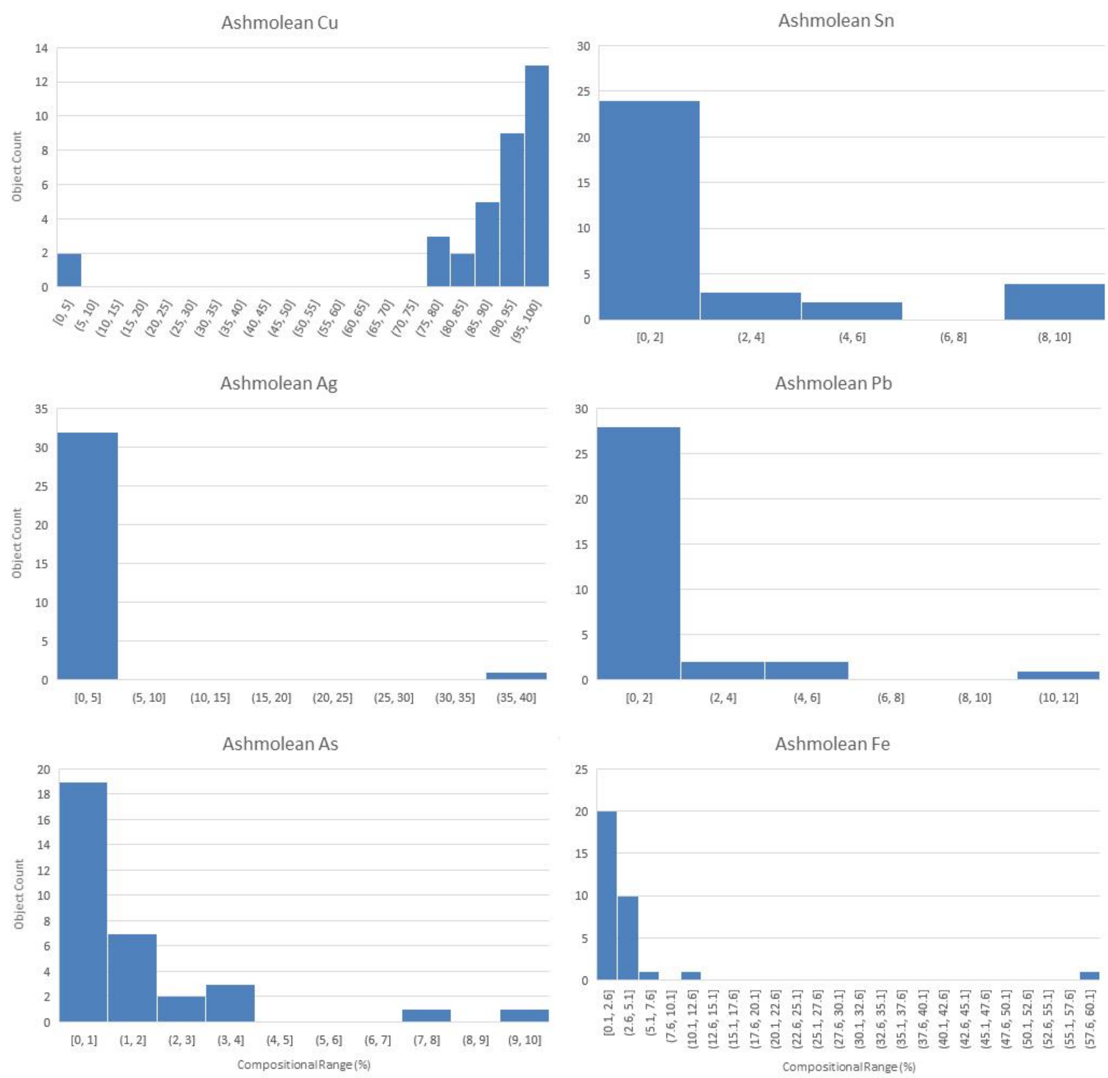

Figure 5.59: Results of compositional analysis of the Ashmolean Museum objects illustrated by element. Due to Au only occurring in three objects in very low levels, it is not included here.

Of the 33 Ashmolean objects, nine (27%) are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of tin bronze. All of these are from Kish. Six of these have no date, two are dated ‘Early Dynastic to Akkadian’ and one is dated ‘Early Dynastic to Old Babylonian’. Object 292 is a nail, 302 is a bracelet, 303 is a pin shank, 321, 335, 336 and 340 are pins, 322 is a possible pinhead, and 353 is a bracelet (for example, see Figure 5.60). Similar to the material from Manchester Museum, tin bronze is therefore being used for personal adornment and dress, not just for tools.

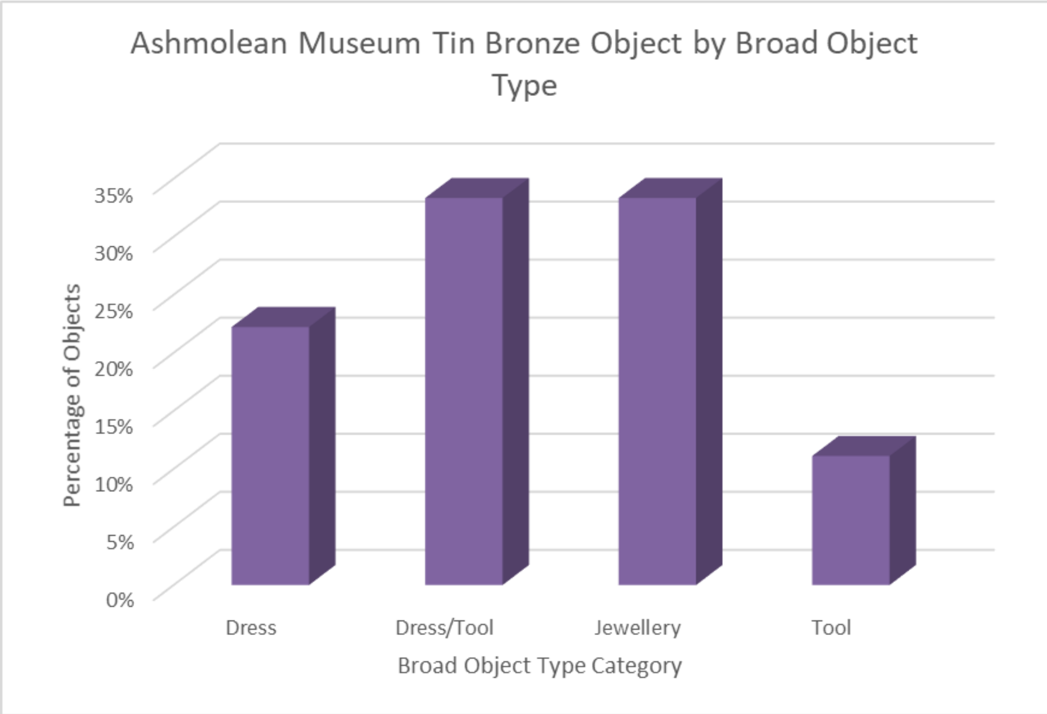

Figure 5.60: The percentage of tin bronze objects in the Ashmolean Museum collection that fell into each broad object type category.

Figure 5.61: Object 302 from the Ashmolean Museum collection, which is a bracelet from Kish.

Of the 33 objects, 19 (58%) contain ≥0.5% arsenic placing them into the category of arsenic bronze. Six of these also have tin content of ≥2%. The largest object type category among this material is that of dress objects; more specifically, pins (Figure 5.62). This does not follow the broader patterns observed in the legacy data of arsenic bronze being predominantly used for tools. The most probably explanation for this difference is that pins in particular were selected for this smaller-scale museum collection, making the collection much less representative.

Figure 5.62: The percentage of arsenic bronze objects in the Ashmolean Museum collection that fell into each broad object type category.

Considering lead levels in the collection, 29 of the 33 objects in the collection demonstrate lead content; 24 of which have levels lower than 1%. Five demonstrate lead levels between 1% and 5%, although this still falls too low for a classic leaded bronze. Only one object (324), a bracelet fragment from Kish, falls into the typical range for a leaded bronze.

Iron was also found in all of the objects from the Ashmolean collection. The iron content ranges from 0.1% to 59.65%. For 31 of the objects, there is a steady increase in iron levels from 0.1% up to 5.33%. There is then a step up to 10.9% in object 283, a possible knife handle from Kish. The object (323) with 59.65% iron also demonstrates a composition of 38.64% silver. Unfortunately, this object was highly fragmentary and corroded, and there was very little information for it in the Ashmolean records. It also was not given a site or date. It may have been possible that this was an iron silver composite object, causing the combination of high levels of both metals in the reading. A similar pattern is seen in the Early Dynastic material with a steady increase of iron in all of the objects between 0.2% and 5.06%. One object contains significantly higher levels: Object 344 which is a tool handle from Kish and contains 16.1% iron.

5.2.3 Birmingham Museum and Art Gallery

Analysis was conducted on 66 objects held at Birmingham Museum and Art Gallery. Of these, 56 are included here. All of the objects were read using both Metals and Test All Geo modes. Of these objects, one is dated to the Akkadian period and the remaining 55 have no assigned date (Table 5.16). Two of these objects are from Kish and 54 are from Ur.

Table 5.16: Birmingham Museum and Art Gallery objects categorised by site and period.

Site and Period	**Object Count**
Kish	2
Akkadian	1
No Date	1
Ur	54
No Date	54
Total	**56**

As with the Ashmolean material, the largest category of objects from the Birmingham collection is that of tools (Table 5.17; Figure 5.63). Notably, no axes are in the collection despite them being the most common tool in the legacy data. The second largest category is that of vessels (Figure 5.64). There are far more vessels and vessel fragments in this collection than seen in either the Manchester Museum or Ashmolean collections.

Table 5.17: Birmingham Museum and Art Gallery objects categorised by object type.

Object Types	Object Count
Dress	11
Pin	11
Grooming instrument	1
Razor	1
Jewellery	8
Bracelet	1
Finger Ring	1
Hair Ornament	1
Ring	5
Miscellaneous	2
Tube	1
Unknown Function	1
Tool	19
Adze	1
Awl	1
Chisel	1
Handle	1
Hook	1
Knife	2
Nail	10
Rod	1
Sickle	1
Utensil	1
Utensil	1
Vessel/Vessel Accessories	12
Vessel	12
Weapon	2
Spearhead	2
Total	**56**

Figure 5.63: The percentage of objects in the Birmingham Museum and Art Gallery collection that fell into each broad object type category.

Figure 5.64: Object 250, a vessel from the Birmingham Museum and Art Gallery collection.

With regard to composition, the objects from Birmingham continue to follow the broad patterns demonstrated in the legacy data, the Manchester Museum material and the Ashmolean material (Figure 5.65). The largest compositional category is that of high-copper composition. Of the material analysed at Birmingham Museum, 24 of the 56 objects (43%) have average copper readings of 95% or above. These high copper objects span multiple object types (Figure 5.66).

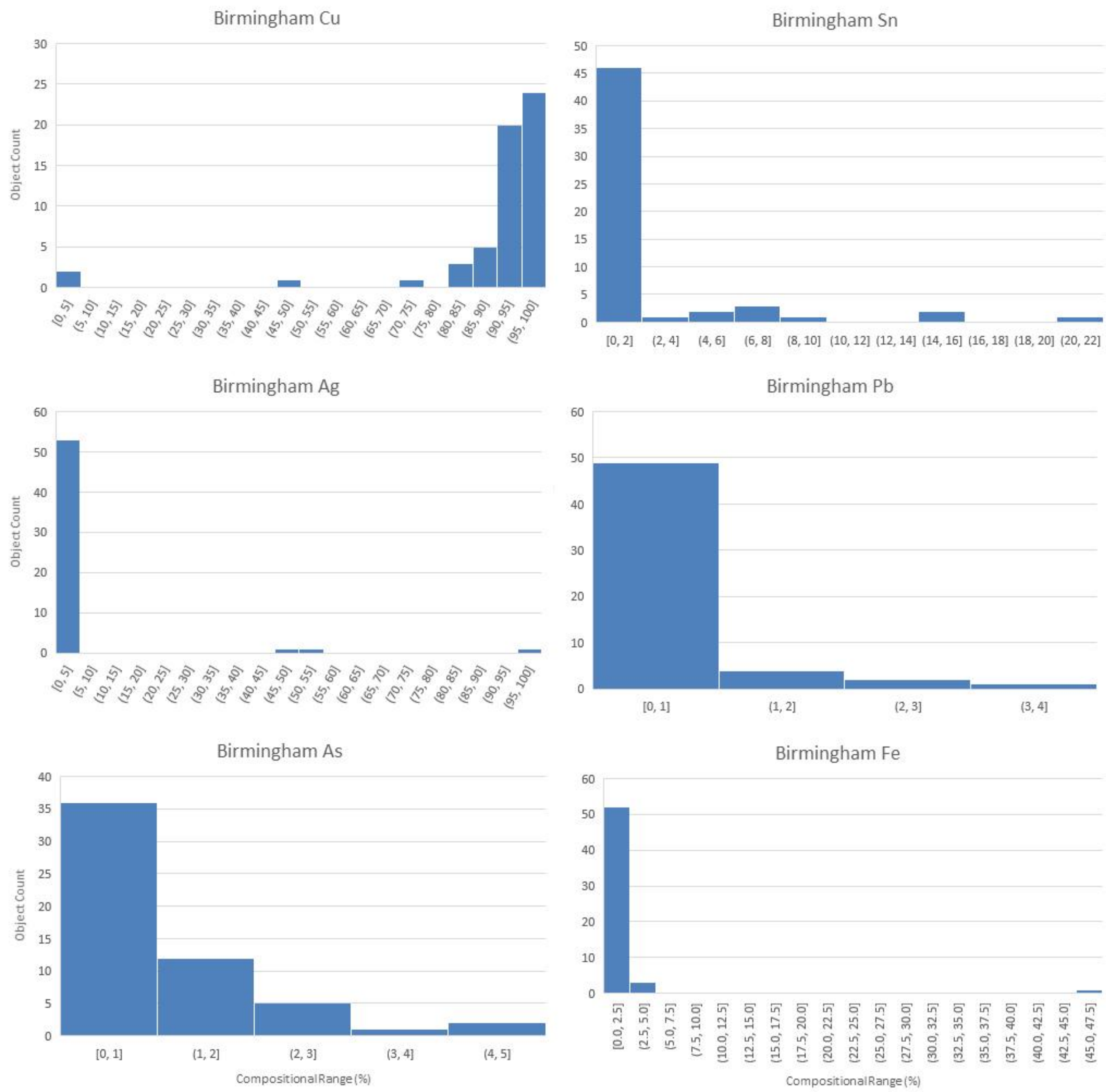

Figure 5.65: Results of compositional analysis of the Birmingham Museum and Art Gallery objects illustrated by element. Due to Au only occurring in three objects in very low levels, it is not included here.

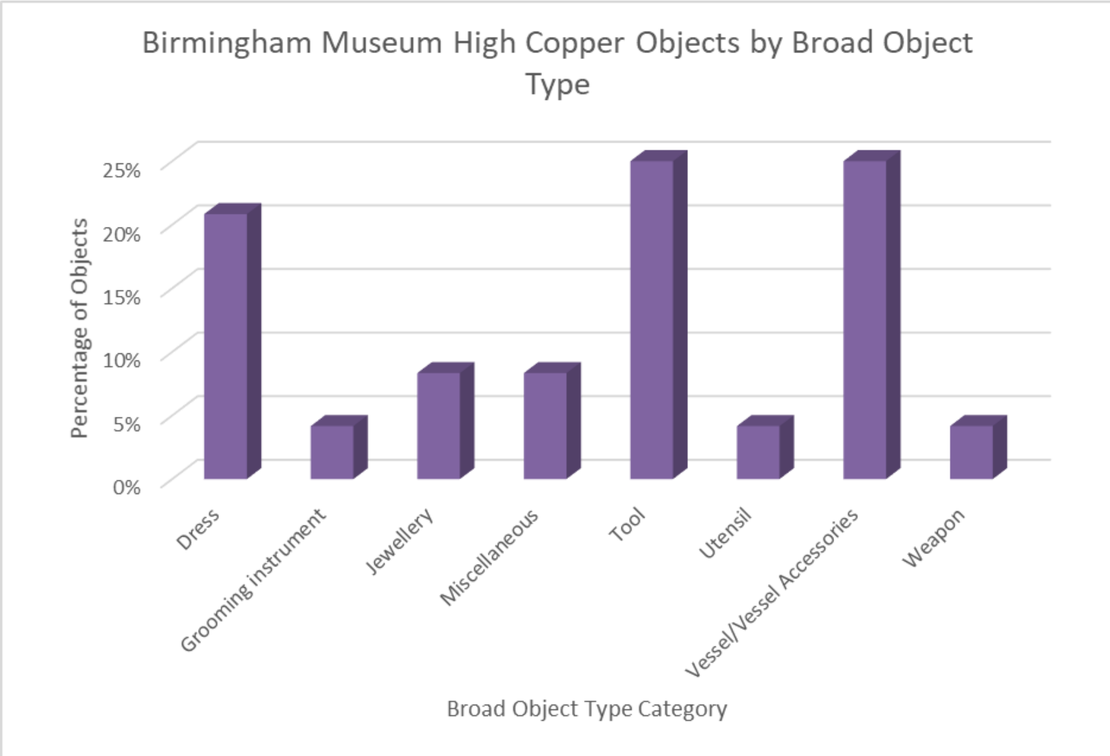

Figure 5.66: The percentage of tin bronze objects in the Ashmolean Museum collection that fell into each broad object type category.

Of the 56 Birmingham objects, 10 (18%) are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of likely tin bronze. All of these are from Ur and none have assigned dates. Tin content ranges from 2.62% to 20.56%. Five of the objects fit a more traditional tin bronze composition. In terms of object type, five of the objects (204, 270, 272, 269, 273) are vessels or vessel fragments, four (211, 206, 275, 248) are tools, and one (217) is a tube. There is no clear pattern between object type and higher tin content.

Twenty-six (46%) of the 56 Birmingham objects contain ≥0.5% arsenic placing them into the category of arsenic bronze. Tin content of ≥2% is found in three of these. The largest object type category among this material is that of tools which follows the trend observed in the legacy data and Manchester Museum data of preference towards arsenic bronze for tools (Figures 5.67 and 5.68).

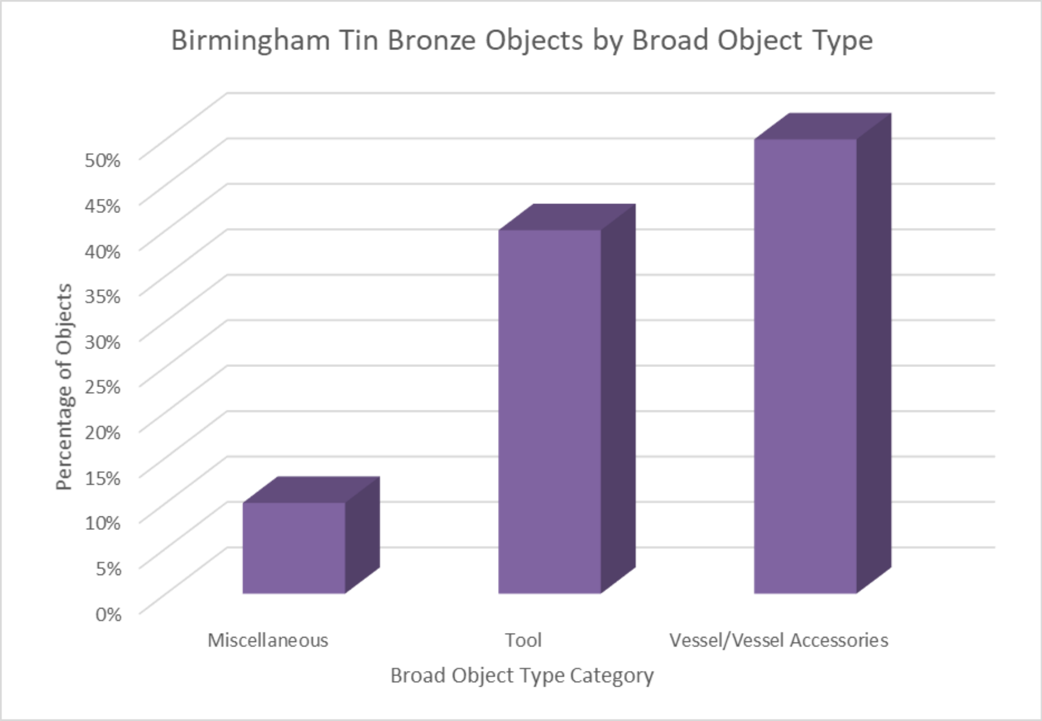

Figure 5.67: The percentage of tin bronze objects in the Birmingham Museum and Art Gallery collection that fell into each broad object type category.

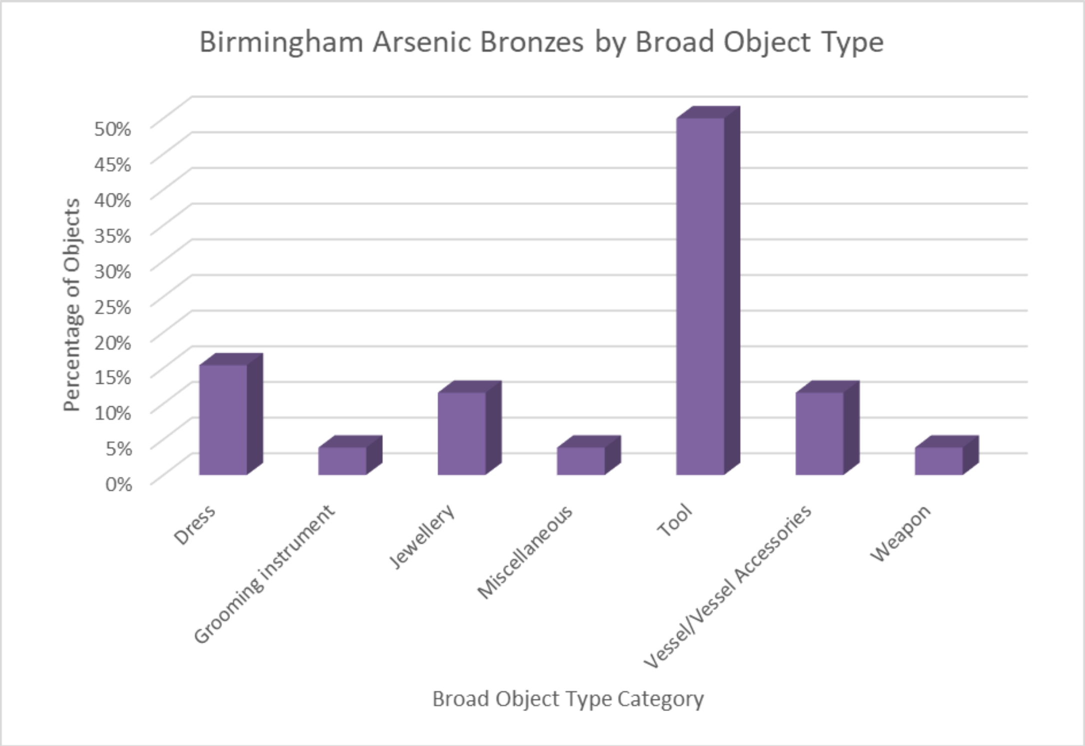

Figure 5.68: The percentage of arsenic bronze objects in the Birmingham Museum and Art Gallery collection that fell into each broad object type category.

Only low lead levels were detected in the Birmingham objects. No gold objects were part of the collection, but three do contain significant silver content. The first (261) is a ring from Ur with no date that is nearly entirely made of silver. The second (239) is another ring from Ur and is approximately half silver and half copper. Finally, the third (260) is a ring that has been described in the museum catalogue as a hair ornament and which demonstrates approximately half silver and half iron content (Figure 5.69). The use of both silver and copper-silver alloy for jewellery certainly fits with the legacy data and is unsurprising. The object of apparent silver and iron content, however, does not. It is possible that this object is actually of later date, and may either have been part of a composite object of silver and iron parts, or was deposited in a context next to an iron object. Iron was found in all of the metalwork, but excluding the iron and copper ring, the content is low and ranges from 0.02% to 4.8%.

Figure 5.69: Object 260, a ring from the Birmingham Museum and Art Gallery collection.

Overall, the Birmingham material follows many of the general patterns observed in the legacy data. As nearly all of the material comes from Ur, it is similarly unrepresentative of wider Mesopotamian metalwork as much of the legacy data is. However, it does help to further expand the extant dataset from Ur, and further solidify the patterns identified from this material.

5.3 Chapter Overview

The examination and discussion of the legacy data provided in section 5.1 has presented and expanded upon current understanding of trends within southern Mesopotamian metalwork in the Bronze Age. While macro-level change throughout the study period is illustrated, such as increased use of tin bronze across time, variation in tin content of tin bronze object, and variation in the most common object types, section 5.1 demonstrates a stronger picture of macro-level continuity than change. Various macro-level patterns are observed across most of the study period. Between the Akkadian and Old Babylonian periods, for example, there is continued high usage of high-copper and arsenic bronze compositions despite increased use of tin bronze. There is also a continued preference for making tools out of arsenic bronze and vessels out of tin bronze despite the opposite being far more typical outside of Mesopotamia (Cuenod *et al.* 2015). Similarly, continuity is observed in the preference for using silver for metal jewellery, and particularly earrings. As observed by Helwing (undated), many of the object types found in southern Mesopotamia can be described as chronologically insensitive, in the sense that they can be found across various periods, demonstrating significant continuity in object types across time.

At a macro-scale, it therefore appears that there is more evidence of continuity than of change, despite the complex and ever-changing political landscape of southern Mesopotamia in the 2nd millennium B.C. discussed in Chapter 2. Instead, more evidence of change and variation appears at a smaller scale. For example, across virtually the entire study period, the prevalence of tin bronze and arsenic bronze varies considerably depending on the site from which it was found, and changes in arsenic bronze and tin bronze across period categories also varies significantly depending on site. This could suggest, for example, varying accessibility of different metals between sites, differing metalworking traditions, or changes in the composition of metal objects used as grave goods. As highlighted in section 5.1.6., due to the overwhelming dominance of material from Ur, change and variation at sites beyond Ur is often lost when utilizing a macro-level approach.

The more conventional methods and approaches used within this chapter which typically focus on larger-scale patterns, divisions of material by period, and categorisation of metals by traditional compositional ratios can, as demonstrated, provide an informative examination of the material, but are flawed in their ability to draw out more specific, smaller-scale patterns, to explore individual artefacts in a meaningful way, and to provide an understanding of metal usage and metalworking that is not heavily influenced by top-down interpretations built on modern understandings. Subsequently, in Part II, less traditional approaches are utilised to facilitate a more detailed discussion of these smaller-scale patterns.

The new analyses collected from the UK-based museum collections and examined and discussed in section 5.2 expand the existing dataset. They offer analyses of various objects never previously analysed. Exploration of them in light of the discussion provided in section 5.2 allows for an understanding of this material against the relevant wider context of extant material, and utilisation of the same approaches to examination and exploration better facilitate cross-comparison.

These new analyses are, however, still analyses of very similar material to that which has been analysed to produce the legacy data utilised here. As such, the same issues with regard to highly limited collection and retention strategies, extremely limited contexts of deposition, and bias towards specific types of material, still apply. As such, while this is an important and valuable contribution and expansion, there remains the necessity to address the issues with extant material and consideration of how these can be overcome with changes in future excavation strategy and approaches to analysis. The differences in the object type patterns seen in the legacy datasets in comparison to the new data collected from the UK-based museum collections illustrate the key differences between the object types that large national museums hold in their collections and the object types that filter through to the slightly smaller museum collections. Not only is it important to recognise the influence of museum collection strategies on extant collections, but also how this may vary depending on the museum itself and the priority it may have held over certain material from excavations.

The majority of the objects from the new UK museum collection analyses were not well dated, and some were only given a possible site. Although, given the extents of excavation and the periods excavated (especially at Ur), it is likely that much of this undated material does in fact come from within the time span addressed in this thesis. It is important to acknowledge, however, that the various issues regarding dating that exist in both the legacy data and the new data from the UK-based museums have proved challenging during examination, presentation and discussion. The amount of objects that lack a date or have been dated to a very broad period hinders the successfulness of approaching the material in a strict manner. For example, despite not including the Early Dynastic period in the temporal parameters of this thesis, Early Dynastic material has inevitably ended up being included at points. If all material dated to a broad period that included the Early Dynastic were excluded, the dataset would be dramatically smaller. Furthermore, the broader the dating, the less precise results of examination can be. This further highlights how crucial it is for new excavation to provide new bodies of metalwork which are well provenanced and as securely dated as possible.

Objects relating to metallurgical production were incredibly sparse in the both the legacy dataset and the three UK museum collections analysed. As discussed in Chapter 3, the lack of this type of material dramatically limits our ability to form an understanding of the entire metallurgical process; it is therefore absolutely crucial that metalworking waste and scrap objects are collected, recorded and retained in future excavations. Standing in sharp contrast to various aspects to the material discussed in this chapter is the material from Tell Khaiber, which will be examined in the following chapter.

Chapter 6

Results from Tell Khaiber

The assemblage from Tell Khaiber provides vital new opportunities to further understand metal use and the metallurgical industry in southern Mesopotamia. As previously discussed and demonstrated, a fundamental problem with previous bodies of Mesopotamian metalwork has been highly selective collection during excavation, resulting in a dearth of evidence relating to the wider cycles of both metal use and metallurgical possesses. Unlike most previous excavations conducted in southern Mesopotamia, a strategy of total collection was utilised at Tell Khaiber, resulting in material being collected and recorded that would typically have been ignored in older excavations. These fragmentary and poorly preserved pieces of metal are likely to be typical of the type of metal material discarded at sites such as Tell Khaiber due to being too small to prove useful for recycling, yet they are perhaps more representative of the range of metal compositions used at the time. The complete and near-complete items that have traditionally been collected and recorded during excavation are probably a more biased selection, particularly those deliberately selected for inclusion in burials. The Tell Khaiber assemblage also includes metalworking waste such as slag, which can help to shed further light on metalworking. There currently exists very limited material from Mesopotamia relating to metalworking practices and, while the literature often acknowledges this, the point needs to be made that the paucity of material is largely caused by the tendency for this type of material to be ignored.

In addition to providing a significantly different body of metalwork in terms of contexts of deposition that can help us to begin correcting this issue with previous material, the Tell Khaiber assemblage is also a highly valuable contribution because it offers the first body of metalwork that has a known Sealand Dynasty date. As discussed in Chapter 2, the Sealand Dynasty is a particularly elusive part of southern Mesopotamian history; therefore, this body of metalwork, and, indeed, the broader site itself, is an extremely valuable contribution to the field of Mesopotamian archaeology. It is also possible that the Tell Khaiber metalwork is contemporary with metalwork from more northerly Old Babylonian sites. As discussed in Chapter 3, extant pieces of metalwork from southern Mesopotamia most commonly date to the Early Dynastic period and significant amounts cannot be reliably dated at all. As demonstrated in Chapter 5, Bronze Age metalwork dated to the periods following the Early Dynastic period is often dated to a very broad date range, and very few pieces have been reliably dated to the Old Babylonian period. The Tell Khaiber material therefore not only sheds light on metalwork at a Sealand Dynasty site, but also expands the broader body of potentially contemporary metalwork from southern Mesopotamia's 'Dark Age', providing much-needed insight into metal use and metalworking during the mid-2nd millennium B.C. (Boivin 2018: 1; Van De Mieroop 2015: 122).

Finally, the Tell Khaiber assemblage also provides material from a smaller-scale site in comparison to the large sites such as Ur and Kish that dominated the material explored in the previous chapter, and the discovery of textual sources from Tell Khaiber, which include references to metal and metalworkers at the site, are also vital additions to the current body of southern Mesopotamian archaeometallurgical evidence. This chapter provides an in-depth analysis of the Tell Khaiber assemblage, the wider metallurgical-related material uncovered, and the relevant textual evidence from the site. As a result of my role as finds assistant on the 2017 excavation season at Tell Khaiber, the analysis and interpretation presented in this chapter is also supported by direct experience working with part of this collection, and on the site more broadly[17].

6.1 Assemblage and Object Types

The assemblage of metalwork uncovered from Tell Khaiber throughout its excavation consists of 162 pieces of metal. While previous bodies of Mesopotamian metalwork are largely made up of material from burial contexts, only three of the objects from Tell Khaiber were uncovered from burials: two pins and one anklet. The two pins were found in Grave 5, a double pot burial in Room 403 of House 1 of the Eastern Houses. While the Eastern Buildings are stratigraphically isolated from the Fortified Building, pottery evidence and their construction in parallel alignment with the Fortified Building suggest that they are indeed contemporary (Killick, forthcoming). However, this burial was likely cut in from a later period, potentially from either a now-eroded building phase or from an entirely later period. Ceramic dating of the burial indicates an Early Kassite date. The

[17] All of the illustrations used in this chapter of Tell Khaiber and the Tell Khaiber assemblage are from the Tell Khaiber archives.

anklet was found in Grave 12, a child burial cut into Room 314, also termed 'the Southern Room', of the Fortified Building. Grave 12 may also have been cut in from a later period, potentially post-dating the Fortified Building.

The rest of the material was found throughout the excavated and surface-scraped areas of the Fortified Building and the Eastern Houses from fill deposits in rooms or the scraped areas above. Several of the metal finds are well stratified within room fills; the distribution of which is illustrated in Figures 6.1 and 6.2, with each metal object marked with a red asterisk. There is a particular concentration in Room 101, part of a row of several single-room units lining the external eastern wall of the building (Killick, forthcoming). The remaining objects cannot meaningfully be marked on a distribution map, as they were found through surface scraping, and while they clearly date from the Fortified Building, surrounding deposits were not fully excavated.

The architectural remains of the Fortified Building after significant erosion and deflation can be divided into just two phases of building: the initial construction (Level 1) and then a phase of expansion (Level 2) (Killick, forthcoming). Approximately 90% of the Fortified Building was surface scraped and only approximately 10% was fully excavated. There is little surviving of the Eastern Buildings; between the foundations and the modern surface, only approximately 30m of wall remains (Killick, forthcoming). Due to the nature of the site and the way in which it was excavated, therefore, the stratigraphic depth of the site is minimal. In combination with the fact that essentially all of the metal objects were found from fill, unsealed contexts or later cuts, this mean that there is no particularly meaningful approach to the stratigraphic analysis of this metal assemblage.

Figure 6.1: Plan of the Fortified Building at Tell Khaiber. Metal find locations are marked with a red asterisk.

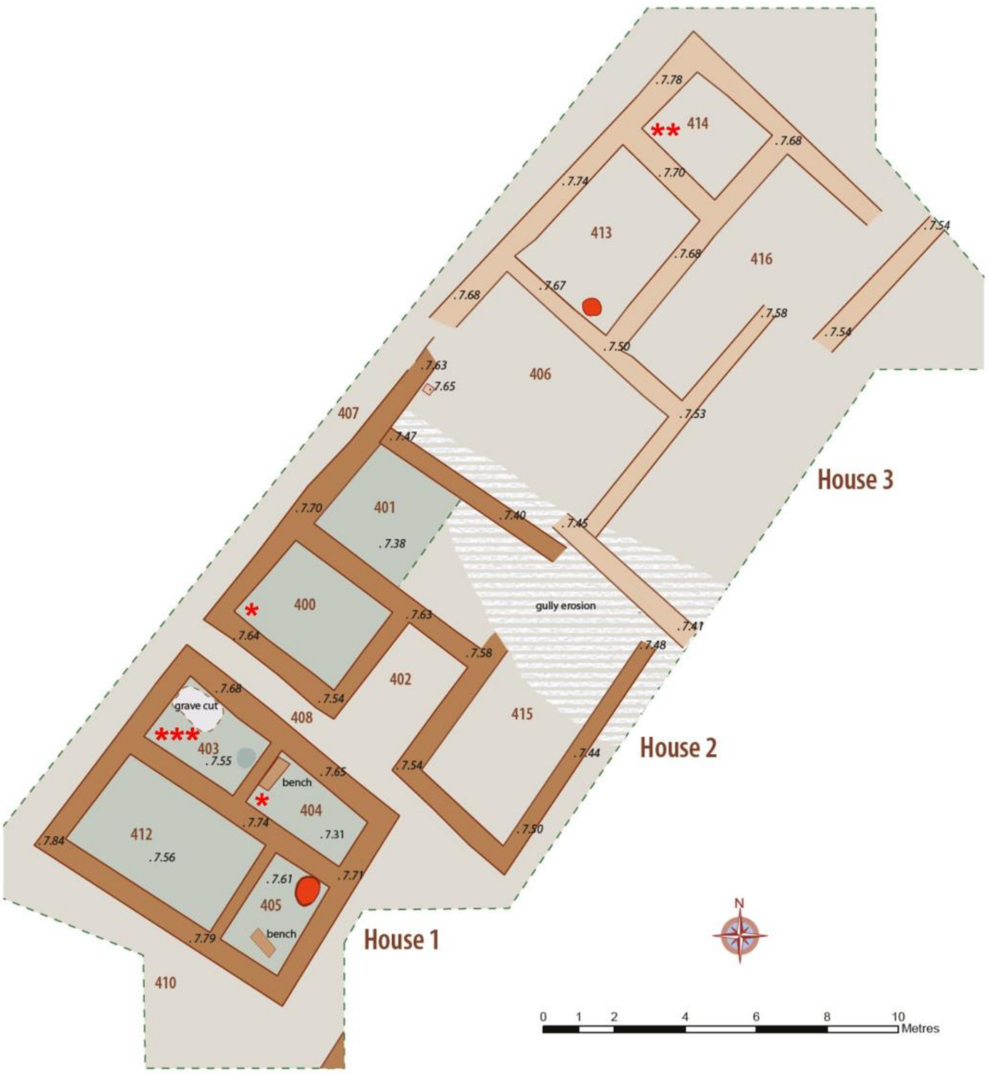

Figure 6.2: Plan of the Eastern Buildings at Tell Khaiber. Metal find locations are marked with a red asterisk.

In addition to the metal objects, a baked-clay mould fragment excavated from the Fortified Building and four pieces of metallic slag were also recovered from the site. On the interior base of the mould fragment, there is a thin layer of copper still present, evidencing that this mould was used for metal casting. Finally, two pieces of metal and one piece of metallic slag were found at Tell Khaiber 2 and are of Kassite date.

The majority of the Tell Khaiber metalwork is too fragmentary to enable exact determination of object type (Table 6.1). Of the 162 pieces, only 30 appear to be complete or nearly complete objects. Subsequently, most of the objects are categorised broadly as ‘rod/bar’, ‘sheet’ or simply ‘fragment(s)’. Some of these pieces of metal may be fragments of worked objects, while some may be metalworking waste products.

Table 6.1: Tell Khaiber objects categorised by broad object type category.

Weapon	**Tool/Implement**	**Jewellery/ Personal Adornment**	**Grooming/ Cosmetic Instrument**	**Vessel/ Vessel Accessories**	**Misc.**	**Frag.**[18]
5	13	14	1	1	84	44

The weapons found at Tell Khaiber constitute three arrowheads and two spearheads. The contexts of deposition for these weapons suggest that they were discarded within room fills of the Fortified Building rather than found *in situ* on the floor. It is possible that they were deposited in rooms when they were abandoned or during the process of rebuilding and renovation. It is unclear as to whether they were hafted or unhafted at the time of deposition. Weapons such as these could have been employed in hunting, but, within the context of Tell Khaiber as a site, it seems more likely that they had a military function. From the tablets found at Tell Khaiber, we know that auxiliary troops were administered from the Fortified Building, therefore, these weapons may have formed part of their equipment. If this was the case, these particular objects may have been made outside of Tell Khaiber rather than being made at the site, and could therefore be of a more standardised form.

Most of the jewellery and personal adornment items found from Tell Khaiber fall into the category of rings. In addition to these, three anklets and three pins were found. As discussed previously, one of the anklets and two of the pins were found in burial contexts. The two pins, which were likely to have originally been used for pinning clothing, were uncovered around the pectoral region of the remains and were found alongside other, non-metal jewellery. The anklet, excavated from a child burial, and potentially cut in from a later period, is made of iron with remnants of mineralised cloth still attached to the surface corrosion.

[18] 'Fragment' here is reserved for fragmentary pieces that cannot be categorised in any other way. Where objects are fragmentary but can be categorised – even broadly – they have been placed in one of the other categories.

The 13 tools and implements found from Tell Khaiber include awls, a spatula, a shaft-hole adze, a nail and a chisel. The singular object in the category of grooming and cosmetic instruments is a mirror, and the singular vessel found was a bowl. The vessel was found alongside the previously mentioned adze (Figure 6.3).

Figure 6.3: The adze and bowl from Tell Khaiber as found.

Due to the objects' fragmentary nature, not many of the pieces can be fitted accurately into established typologies (Figure 6.4). Typological evaluation of the more complete objects, however, demonstrates that the Tell Khaiber metalwork broadly fits within the wider context of mid-2nd millennium B.C. metalwork in southern Mesopotamia. One of the arrowheads, which appears to fit into type P-E of Helwing's typology, bares a particularly close resemblance to one from Tell Yelkhi, which is Old Babylonian in date (Figure 6.5; Hauptmann & Pernicka 2004, Plate 134, object 2203). Three awls appear to fit the M-A4 type which Helwing dates to between the Uruk period and the Old Babylonian period. The three possess a particular similarity to an awl from Tell Harmal that has been dated to the Old Babylonian period (Figure 6.6; Hauptmann & Pernicka 2004, Plate 20, object 309). Many of the other object types are chronologically insensitive and can be found across a wide range of periods.

Figure 6.4: Sample of the broken and fragmentary material from Tell Khaiber.

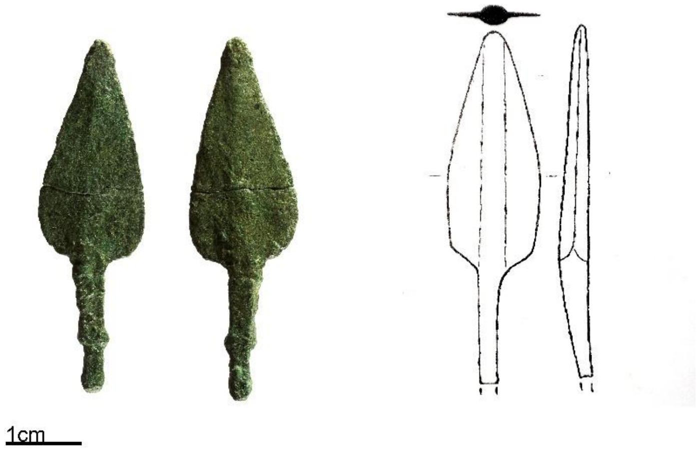

Figure 6.5: Arrowhead from Tell Khaiber (left) and arrowhead from Tell Yelkhi (right). (Hauptmann & Pernicka 2004: Plate 134)

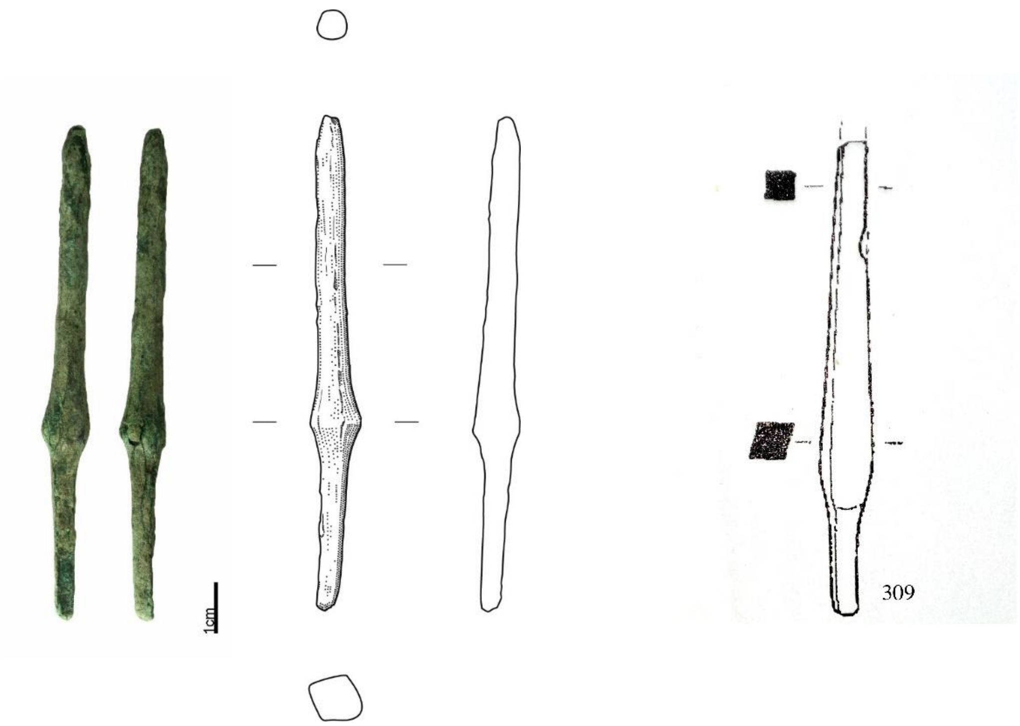

Figure 6.6: Awls from Tell Khaiber (left and middle) and awl from Tell Harmal (right). (Hauptmann & Pernicka 2004, Plate 20, object 309)

6.2 Compositional Results

Chemical analysis was untaken on 94 of the objects, approximately 58% of all the metalwork. Unless otherwise stated, where multiple readings were taken, the mean values from those multiple readings are presented for each object. The General Metals and General Alloys modes do not provide readings for arsenic, which is of interest regarding Mesopotamian metalwork. Accordingly, values for arsenic were taken from the Mining mode. The results were then normalised to 100%. The only occurrence of gold in the Tell Khaiber assemblage was as a minor contaminant (0.1%) in one of the copper-silver pins from Grave 5. Subsequently, gold is ignored here.

High copper content is by far the largest compositional category of metal objects from Tell Khaiber and nearly all object types are represented in this compositional category (Figure 6.7). Of the 94 analysed objects, 70 (approximately 74%) demonstrated copper content of 95% or above. This category spans all of the object types found at the site (Figure 6.8).

Eight of the copper-based objects fall into the category of arsenic bronze. This correlates to only 9% of analysed objects, which is dramatically lower than the percentages demonstrated in the legacy data and the material from the three museums. Examination of the Old Babylonian material presented in Chapter 5 demonstrated 61% of objects could be categorised as arsenic bronze. There is no clear connection between the object types of these eight pieces. Three of the objects are sheet fragments, one is a small lump of metal, one is a rod fragment, one is a pin or nail, one is a bar fragment and the last is a strip fragment (Figure 6.9). The level of arsenic present in the rest of the metal material from Tell Khaiber is generally very low.

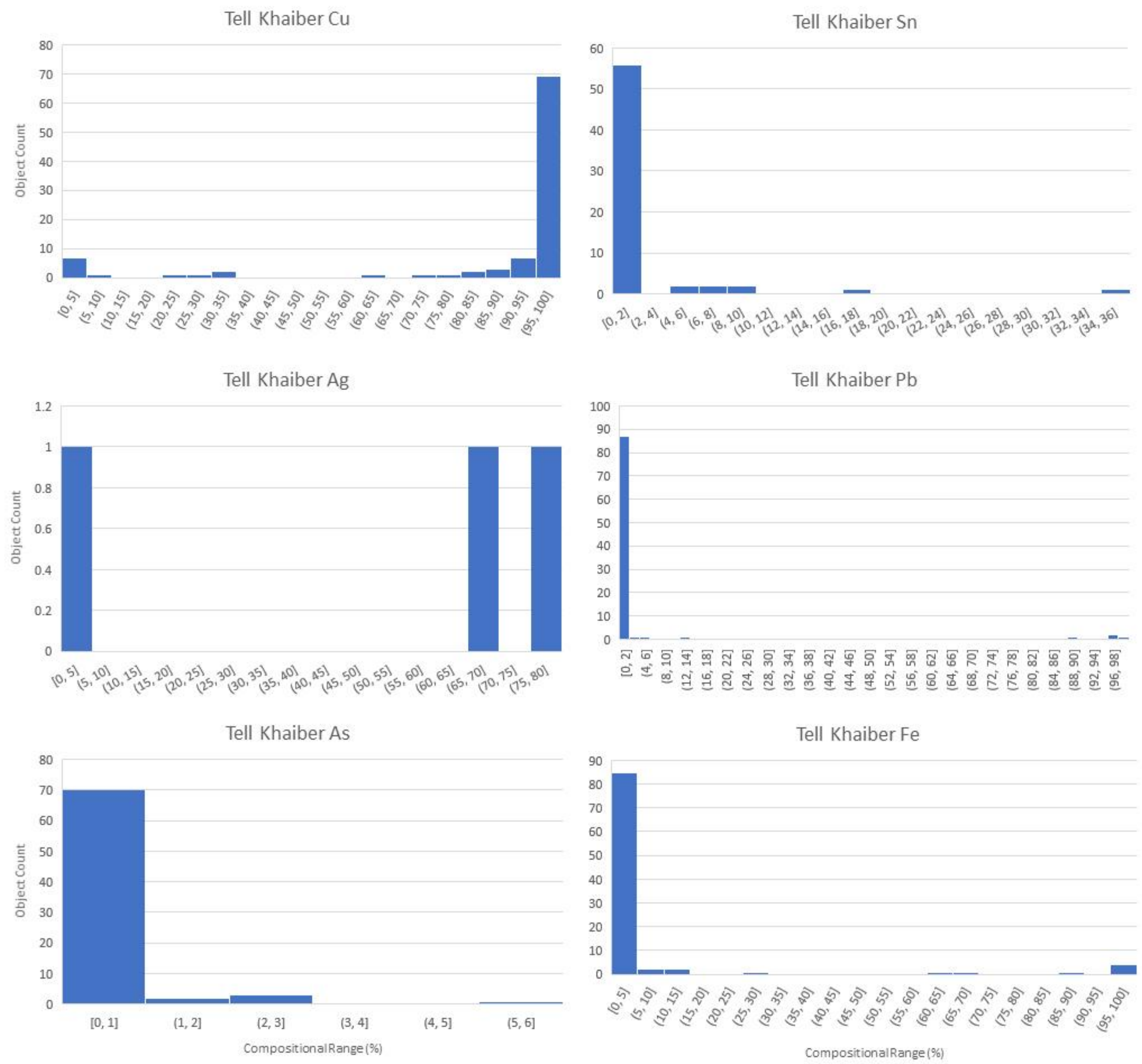

Figure 6.7: Results of compositional analysis of the Tell Khaiber illustrated by element. Due to Au only occurring in three objects in very low levels, it is not included here.

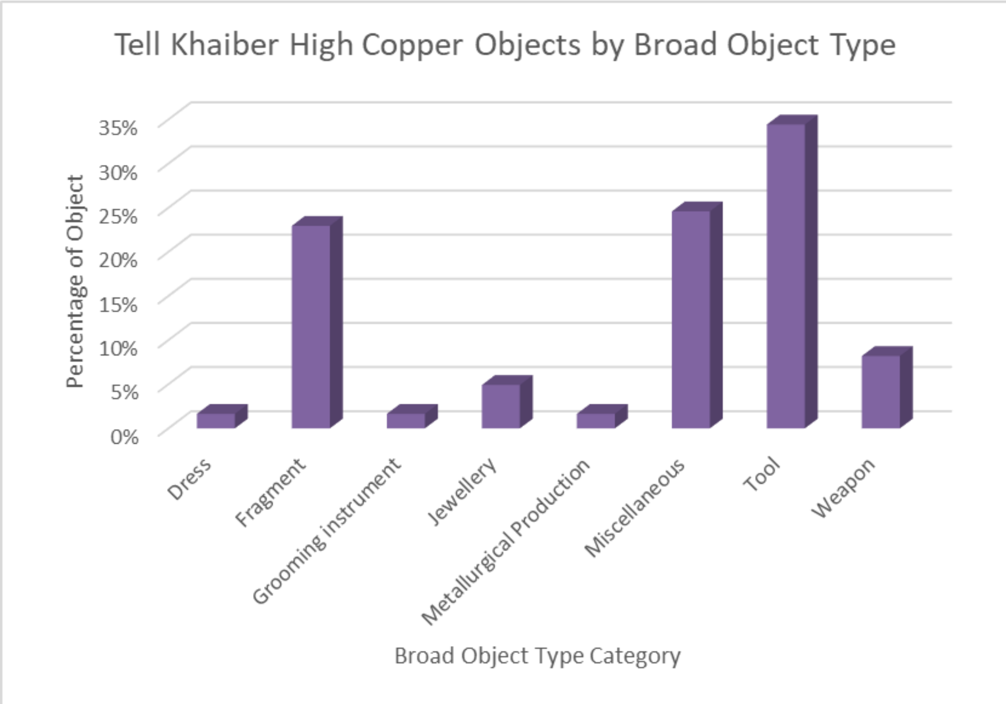

Figure 6.8: The percentage of high copper objects in the Tell Khaiber collection that fell into each broad object type category.

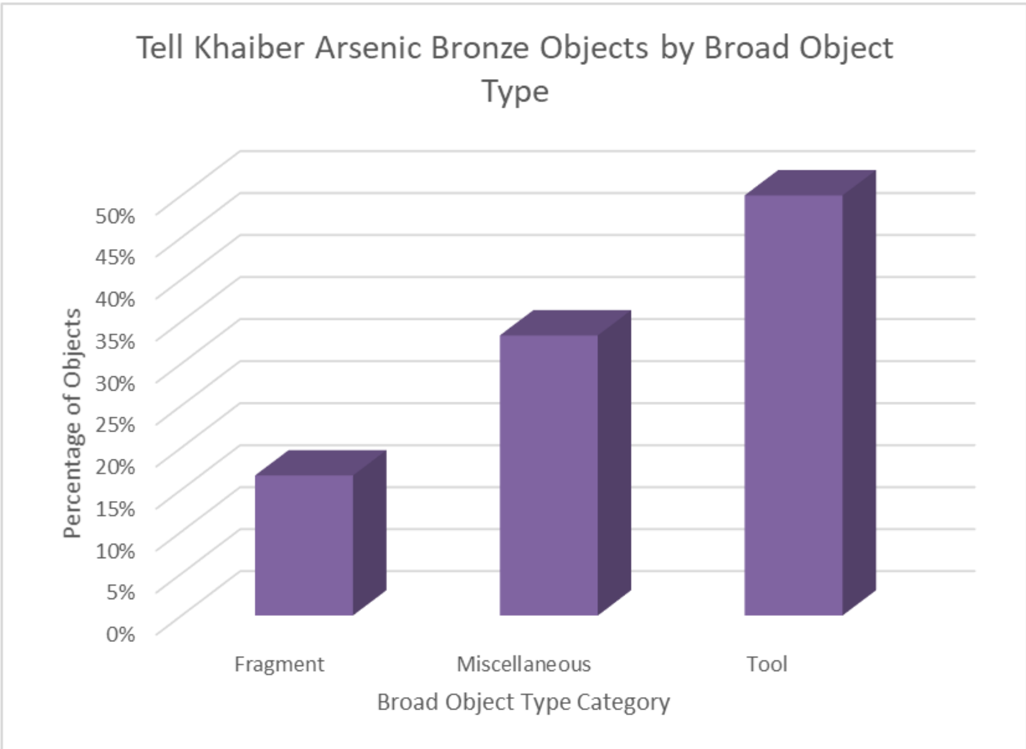

Figure 6.9: The percentage of arsenic bronze objects in the Tell Khaiber collection that fell into each broad object type category.

Nine (10%) of the Tell Khaiber objects are copper-based with tin (of ≥2%) as the main alloying element, placing them into the category of tin bronze. As with arsenic bronze, this is lower than typically seen in the legacy data and in the material from the three museums. Of the Old Babylonian material analysed in Chapter 5, 23% were tin bronze. Tin content in these objects ranges between approximately 4.7% and 35.1%. A tin content of between 2% and 12% was found in just seven of the copper-based objects. Two of these objects fit the classic tin bronze composition most closely: one is a sheet fragment while the other is a rod fragment. The remaining four are a ring, a nail, another rod fragment and an unidentifiable fragment (Figure 6.10). While the compositions of these other four do not fit the typical composition for tin bronze, their tin content is still within the range of a potential low-tin bronze. The much higher tin levels were found in two other copper-based objects: one small fragment that is 17.7% tin and a form of hook which is broken at both ends that is 35.1% tin. As previously discussed, from around 16% tin and above, copper looks lighter in colour and possesses a grey-silver tint (Kuijpers 2018: 877). High levels of tin in a tin bronze also aids casting but makes the metal more brittle and, subsequently, more challenging to work with (Kuijpers 2018: 877). These high-tin tin bronzes may have therefore been intentional with the aim of producing a metal well suited to casting, or perhaps one which will have a more silvery appearance or sonorous quality; alternatively, it may be that these objects are the result of recycling. Unfortunately, too little survives of either object to speculate much on their original function.

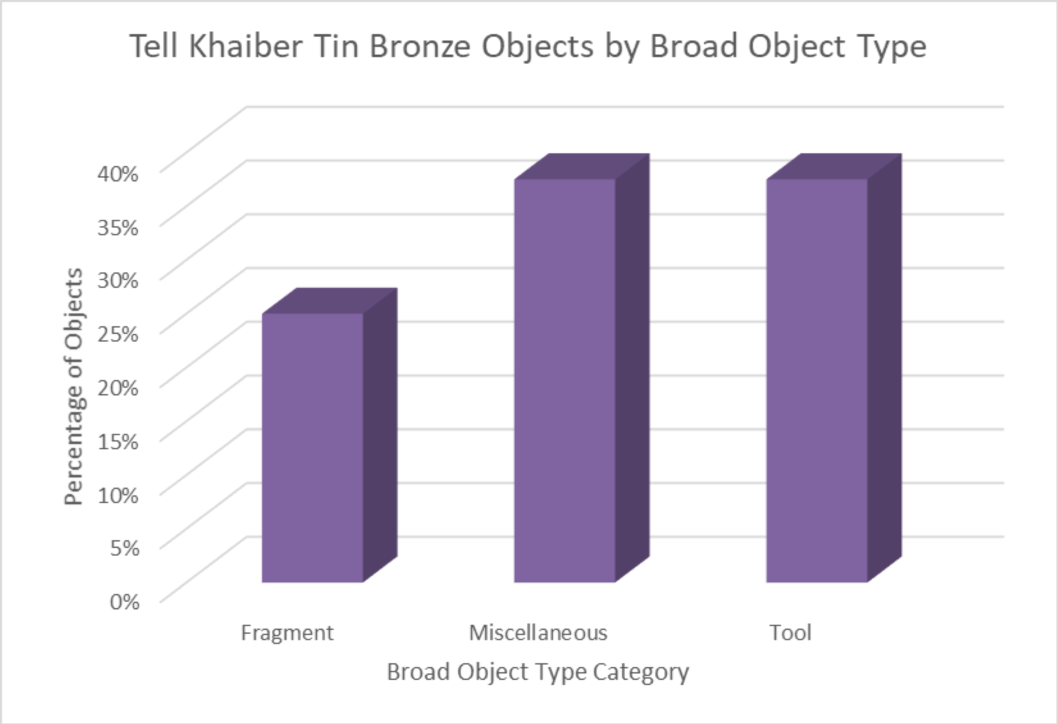

Figure 6.10: The percentage of tin bronze objects in the Tell Khaiber collection that fell into each broad object type category.

One object was found which could be a leaded bronze. The object is made from a thick sheet but is otherwise unidentifiable. Readings were taken at two different points on the object and the readings vary significantly. At the second point of reading, the composition is in line with that typically found in leaded bronzes, but in the composition read at the first point the lead is lower than would typically be expected. If the lead was an intentional addition, it may have been added to improve ease of casting (Moorey 1994: 293). Alternatively, the lead content may be the result of recycling.

Only a very small amount of silver found at the site, and exclusively in the form of copper-silver alloys. The two pins discussed earlier that were found in the double-pot burial of a woman were found to be copper-silver alloys (Figure 6.11). Multiple readings were taken on the pins at different point. The results demonstrated variation in the composition. As previously mentioned, heterogeneous compositions can be the result of low furnace temperatures causing an unequal distribution of elements (Özbal *et al.* 1999: 64). If averaged, the readings for the first pin demonstrated a composition of 55.5% silver to 42.5% copper, and the demonstrated a composition of 62.5% silver to 35% copper. One other object, a possible coin or otherwise sheet fragment, demonstrated silver content, although this was only 0.2%. The remaining composition of the object was nearly entirely copper. Such a low silver content suggests that this was the result of recycling, although it is also possible that this is an intrusive coin as it was uncovered in an unsealed context of superficial deposits.

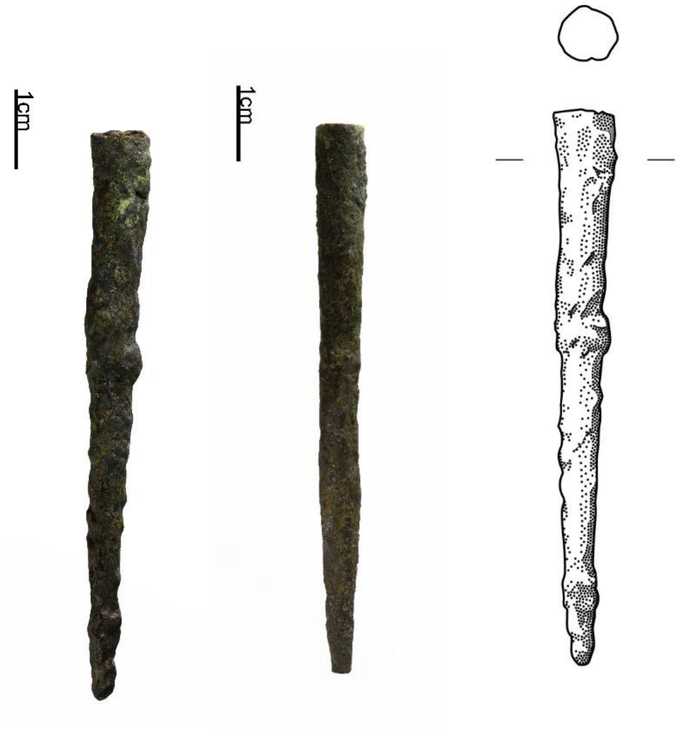

Figure 6.11: The two copper-silver alloy pins found from a double-pot burial at Tell Khaiber.

Low levels of lead were found in most of the objects, although rarely exceeding 1%. Three objects from the site were found to have compositions nearly entirely of lead. Two of these appear to be incomplete pins and the third is a rod. The compositions of the two pins are highly similar, particularly regarding their lead and arsenic content. A fourth object, a small, bent fragment of wire, was found which contains lower lead content (although still above 80%) and slightly higher arsenic content.

Iron content was detected in all of the objects. For 86 of the 94 pieces analysed, iron levels ranged steadily between 0.08% and 4.7%. As briefly introduced in Chapter 5, some iron content may be the result of surface contamination, and it would be reasonable to expect that in the instance of soil contamination, other elements from the soil (such as Ca, Al, Si, K and Ti) would also occur at elevated levels in the readings. For the readings from the Tell Khaiber metalwork, however, there does not appear to be any correlation between iron levels and these other elements. Alternatively, as mentioned in Chapter 2, most metalwork from Mesopotamia would have been made using iron-bearing sulphide ores (Cooke & Aschenbrenner 1975; Potts 1997: 168). Sulphide ores require a two-stage smelting process, and iron-bearing sulphide ores are even more difficult to process (Potts 1997: 168). Subsequently, even following the two-stage processing, it is feasible for a small amount of iron to remain.

Several objects from the assemblage, however, have considerably higher iron content, including three objects with an average iron content of over 97%. Two of these objects are fragments and, unfortunately, it is not possible to identify what type of object they may originally have been. One of the fragments was uncovered from a superficial deposit which also included debris that had been redeposited from higher on the slope. The other, however, came from a securely stratified context within the fill of Room 101. It is possible that these were part of crafted iron objects, although the possibility that they are by-products of copper smelting cannot be completely excluded.

The third iron object is an iron anklet, uncovered from the burial of an infant (Grave 12) located near to the surface of the mound (Fig. 6.12)[19]. The burial was cut in from a later period, although it is not clear what period the burial itself dates to. All three of these pieces of metal demonstrate a low nickel content that suggests that the iron is terrestrial rather than meteoric. As discussed in Chapter 2, iron with nickel levels of below 5% is generally deemed to be terrestrial (Medenbach & El Goresy 1982: 358-66; Yalçın 1999: 180).

[19] Unfortunately, only three of the objects with considerable iron content were photographed.

Figure 6.12: The iron anklet found in the grave of an infant at Tell Khaiber

There were also seven objects found from the site which demonstrated compositions of lower iron than the above-mentioned objects, but still with a considerable iron content. Two of these objects are copper-based but have sections of iron that are adhering to the surface (Figures 6.13 and 6.14). As a result, there is variation in the composition depending on where on the objects the reading is taken. The iron on the surface of one of the pieces in particular has a bubbled texture, indicating this object may relate to part of the metalworking process.

Figure 6.13: One of the copper-based objects with iron adhering to the surface found at Tell Khaiber.

Figure 6.14: Another of the copper-based objects with iron adhering to the surface found at Tell Khaiber.

A further three of the objects with considerable iron content are also small fragmentary pieces which are predominantly composed of copper but which also demonstrate iron content (26.8%, 8.8% and 14.8%). Unlike the previous two pieces, this iron content was part of the actual composition of the objects and not due to iron content adhering to the surface. One possible explanation for the composition of these objects is that they may have been *matte.* As discussed in Chapter 2, *matte* is an impure mixture of copper and copper sulphide. It is produced when a sulphide ore, which typically requires a two-stage smelting process, receives the first stage of smelting but has not received the second stage in order to refine it fully (Potts 1997: 168). Smelting typically occurs close to the source area as this helps to reduce transportation cost. Textual sources from Mesopotamia do suggest, however, that *matte* was being imported into Mesopotamia (Potts 1997: 168-9). Another possible example of *matte* from the archaeological record is a Neo-Assyrian ingot from Nimrud held at the British Museum. Analysis of its composition demonstrated approximately 15.5% iron (Moorey *et al.* 1988: 47). If these pieces are *matte*, it suggests that second-stage processing may also have been occurring at the site.

The last of the seven objects has a composition which is predominantly copper (87.8%) but which also contains 10.3% iron. In contrast to the previously discussed lumps of metal, this piece appears to be a sheet fragment. It is possible that the iron content demonstrated in this object is the result of it once being part of a copper and iron composite object. The use of metal in creating composite objects in Bronze Age Mesopotamia has been previously evidenced by both textual sources and a small amount of archaeological evidence. Often, these composite objects involved metal laid over wood; something which is referenced directly in the Tell Khaiber tablets (see Section 5.4). Occasionally, however, composite objects were made using different types of metal (Moorey 1994: 275). It is therefore possible that this sheet fragment may have been part of a composite object that included both copper and iron. Another possible explanation is that this reading may be the result of two objects that were buried together and subsequently fused together due to corrosion.

As previously discussed in Chapter 2, the use of iron in the Bronze Age in Mesopotamia is evidenced by both textual sources and archaeological material. Textual references to iron are found in the Archaic texts from Uruk, and early iron material has been found from Ur, Uruk and Tell al-Ubaid (Potts 1997: 177). Iron was rare and typically reserved only for use as jewellery and personal adornment, ornamentation, or presentation weaponry (Moorey 1985: 101). Textual sources dating to the Old Assyrian period in northern Mesopotamia and Anatolia show that iron was well-known, but also that it was typically traded in small amounts and particularly difficult to obtain (Erb-Satullo 2019). Although it is clear that the anklet post-dates the excavated Fortified Building, our understanding that iron was used occasionally for jewellery in the Bronze Age means that it should not be assumed that the anklet must post-date the Bronze Age due to its composition.

6.3 Metalworking

Due to the total collection strategy used in the Tell Khaiber excavations, metalworking waste was collected and recorded. As a result, we are able to achieve some insight into metalworking activities at the site. Four pieces of slag were found at Tell Khaiber that appear to be from metalworking. Three of these were uncovered from a deposit outside the main wall of the Fortified Building, and the fourth was found in surface clearance. Of the four pieces, one was analysed. The results demonstrate that it is almost entirely composed of copper, further confirming that metalworking was occurring at the site.

A piece of slag was also found at the site of Tell Khaiber 2. Although the three different readings taken on the piece yielded three varying results, presumably because it is heterogeneous waste, it appears that this piece is composed predominantly of iron and secondarily of copper. Tell Khaiber 2 is broadly Kassite in date; therefore, it is entirely possible that iron was being worked at the site. In a recent study that focused on archaeological material from the Caucasus, Erb-Satullo *et al.* (2020) concluded that iron and copper-alloy were being manufactured in the same workshops. Many of the recovered pieces of slag used to evidence this possessed similar compositions to that of the slag found from Tell Khaiber 2. This may therefore be the result of copper and iron smelting occurring at the same workshops at the site. While Tell Khaiber 2 is a separate site to Tell Khaiber, current understanding is that Tell Khaiber 2 existed as a continuation of Tell Khaiber after the site was abandoned. It is therefore feasible that metalworking activities and traditions that occurred at Tell Khiaber 2 were a continuation of, or at least significantly influenced by, the metalworking activity and traditions at Tell Khaiber.

A fragment of a baked clay mould used in metalworking was also found at the site, uncovered from the Fortified Building (Figure 6.15). One end of the mould and the base is intact, but the rest of the mould no longer remains. On the interior base of the mould is a thin layer of copper, demonstrating its use in metalworking. As previously discussed, primary metalworking from Mesopotamia is sparse, but baked clay copper mould fragments where found as part of the assemblage of metalworking material from the 2nd millennium B.C. site of Tell edh-Dhiba'i (see Al-Gailani 1965; Davey 1983). The mould may have originally been an open mould. Based on the size of the mould indicated by the fragment, it must have been used for casting a sizable object. Unfortunately, not enough of the mould exists to demonstrate the type of object that it would have made.

As mentioned above, some of the fragmentary pieces found at the site may also be metalworking waste. The pieces of iron, in particular, appear to be either waste from copper processing or possible experimentation with iron working. Either way, they appear to be further proof of metalworking at the site.

Figure 6.15: The mould fragment found from Tell Khiaber.

6.4 Textual Sources

The excavations at Tell Khaiber yielded a body of 150 cuneiform tablets; the first archaeologically contextualised body of tablets found from southern Iraq since the period of halted international fieldwork discussed in Chapter 3. The majority of the tablets were found in two rooms of the Fortified Building. The first is Room 300, otherwise termed the Tablet Room, and the second is Room 309, otherwise termed the Letters Room. Approximately 85% of the tablets from Tell Khaiber relate to the administration of personnel. Robson (forthcoming), the epigraphist for the excavation, broadly divides the tablets into the categories of numerical lists, tabular accounts, memoranda, letters and school exercises. Robson (2019: 9) notes that the scribes at Tell Khaiber belonged to, or at least aspired to, an intellectual level of cuneiform culture, despite the site occupying a peripheral administrative position.

There are references to both metal and metalworking in the tablets. The tablets reference the presence of smiths. Two chief smiths are mentioned by name. The first is Damiq-Šakkan, who is recorded on tablets 3064.136, 1096.48, 1114.04 and TK1 PN composite. The second is Ṣilli-Šamaš, who is listed on tablets 3064.033, 1096.47 and 1096.53. Both individuals are noted as being the son of Iddin-Erra, suggesting that the two were brothers. Based on this, it is possible that this was a family profession. A third son of Iddin-Erra is recorded on tablet 1096:40, but a profession for him is not provided. That both of these smiths were chief smiths indicates that they were particularly experienced, and possibly had other smiths working under them. It is possible that other smiths worked at the site but were not named in the tablets because they were smiths that moved between different sites, while both Damiq-Šakkan and Ṣilli-Šamaš were based at Tell Khaiber.

References to metal and metal type in the tablets are small in number. There are nine references to silver on tablets 1114.21, 1114.29, 1114.38, 1114.41, 1114.49, 1114.51, 1114.07, 1114.10 and 1114.11. All of these occur in payment records, detailing amount of barley and silver shekels. There are no references to copper or bronze. Gold is mentioned three times in the texts, although only as references to gold and not indicating its use at the site. The first reference is on tablet 3064.129 which is a memorandum, which mentions a ring of lapis and gold being placed in the hand of Enki. The second, found on tablet 3064.135 which is a numerical list, mentions the installation of several wooden statues overlaid with “red gold”. Colour variation in gold and the way in which it appears to have influenced value is discussion in Chapter 7. Finally, the last mention of gold is in a word-list known as Ur_5-ra. The reference, which is in tablet 3080.19, includes the line “Chlorite seal with gold cap placed on it”. These latter two mentioned of gold highlight its decorative use alongside other materials.

References to other metals are found in Ur_5-ra, which would have been copied out as a cuneiform-learning exercise. As with the gold references, these mentions do not evidence the actual use of these metals at the site. Robson (forthcoming) observes that this list includes exotic materials such as lapis lazuli and carnelian rather than everyday materials that these scribes are likely to have seen regularly. There are general references to metal but also more specific mentions of tin (3064.084, 3080.15) and a tin spoon (3080.15). There is also reference to a *sudaŋ*-metal or *sudaŋ*-stone. *Sudaŋ* is defined in the Oracc dictionary as "a precious metal or material (possibly amber); (to be) shiny". In a similar vein, there is also mention of ‘*antasura*-stone’. *Antasura* is defined by the Pennsylvania Sumerian Dictionary as ‘a metal’. In other references to *antasura,* it appears that a stone is being referred to as opposed to a metal: “its stone part is of *antasura*, a stone which has no equal” found in An Axe for Nergal: c.5.7.3 (Behrens 1988). Furthermore, the Pennsylvania Sumerian Dictionary has a further entry: Akk. antasurrû "(a precious stone or metal)". It has been argued by Muhly (1973: 178) that it is only in later sources that we begin to see a distinction between metal and stone with regard to ores and rock and, although the reference to ‘*antasura* metal’ remains unclear, this may explain the use of *antasura* to also mean stone.

Beyond the textual sources found at Tell Khaiber, the previously mentioned body of 474 tablets held in the Schøyen private collection and dated to the Sealand Dynasty that were published by Dalley in 2009 is highly relevant to Tell Khaiber and deserves brief acknowledgement here. Unfortunately, however, there is very little in these texts that relates to metal and metalworking, and what does occur fits within that which is already known.

6.5 Conclusion

The metal assemblage from Tell Khaiber offers a valuable insight into metal use and metalworking at Tell Khaiber, and potentially more broadly of Sealand region sites and even possibly contemporary Old Babylonian sites. Although the majority of the assemblage is too fragmentary to typologically evaluate, the more complete objects fit broadly into the types found more generally across southern Mesopotamia, and across a wide temporal period. Despite this being the only Sealand site included in this thesis, the forms uncovered do not suggest a drastic difference to those used elsewhere in Mesopotamia contemporaneously, and multiple bear close similarities to those found of Old Babylonian date at Ur, Larsa, Tell Harmal, Haradum and Failaka. Therefore, although the sites included in the grouping of Old Babylonian and Sealand sites span different political situations, there is an overall cohesiveness evidenced in the metalwork. There are also multiple object types found at the site which are chronologically insensitive, and suggest a continuation of tradition across a wide range of time.

A greater number of Tell Khaiber objects fall into the category of high-copper composition than found at Old Babylonian sites explored in Chapter 5, and there is dramatically lower prevalence of arsenic bronze and tin bronze. As discussed above, this is perhaps most likely to be the result of limited access; an issue which will be examined in greater depth in the following chapter. Aside from this difference, the composition of the Tell Khaiber material broadly fits with general patterns observed in the legacy and museum data. The use of a silver-copper alloy for pins used as burial goods is reminiscent of the copper-gold-silver alloys uncovered from graves at Ur (Hauptmann *et al.* 2018), and of various other copper-gold-silver alloys previously explored in the legacy data.

Another key difference between the Tell Khaiber assemblage and other contemporary material, is that the Tell Khaiber material included iron objects and objects with higher iron than typically found at other sites. Although iron was rare during the Bronze Age, we know that it was in use (see, for example, Moorey 1985: 101). It is clear that the iron anklet discovered post-dates the occupation of the Fortified Building, but the other iron found perhaps suggests that iron was being experimented with at the site. As discussed above, this is not the only possible explanation for the iron that is present, but it certainly should not be ruled out simply because it predates a period when iron was widely used.

The iron slag from a Kassite context at Tell Khaiber 2 further supports the presence of iron working in the region during the Bronze Age.

Although large-scale metalworking is not evidenced at Tell Khaiber, the presence of smiths in the texts from Tell Khaiber, in addition to the metal slag and the mould fragment clearly indicates that some degree of metalworking was certainly taking place. No evidence from the site suggests where this may have been taking place, although, due to the anti-social nature of the craft, it is possible that the metalworking was taking place beyond the present boundaries of the site, and therefore in regions that were not excavated. The proof of metalworking occurring at Tell Khaiber is an important progression within understanding of Mesopotamian metalworking and metal use, because consideration of metalworking has tended to focus on its occurrence at large sites and the transportation of worked material outward to peripheral site; again, this is a topic which will receive further exploration in the following chapter.

The finding of three pieces of metal which may be *matte* highlights just how crucial it is to adopt a total collection strategy. Previous work has tended to assume metal was imported in an already processed state or that it was transported in a raw, unprocessed state (Moorey *et al.* 1988: 47), but there has been very little discussion with regard to the transportation of partially processed metal which would then have received its final processing on-site (Potts 1997: 168-9). This is important because it is a crucial part of the metallurgical process that is poorly understood due to such limited evidence. While the metalworking evidence from Tell Khaiber is small it still contributes significant value to the highly limited body of metalworking evidence that currently exists from Mesopotamia.

Overall, the Tell Khaiber assemblage demonstrates elements of similarity and cohesion, but also significant differences to the collections explored in Chapter 5. These differences may be the result of the dramatically different nature of the assemblage, in the sense that it includes a large amount of material that would not have been collected, recorded and analysed in older excavations, and certainly would not have found its way into museum collections. If this is the case, it could be more representative of the metal composition generally in circulation than most other extant collections. Of course, it may also be that these differences simply reflect differences in chronology, type of site, geographical position, or political situation to the other sites in the dataset used in this project. Ultimately, it is perhaps most likely to be a slightly complex combination of both explanations. Nevertheless, this assemblage is a valuable contribution to the study of southern Mesopotamian metalwork and will undoubtedly become increasingly informative when this material and the results of its analysis can be viewed in light of new assemblages using similar strategies. Fundamentally, if a much greater amount of metal and metalworking-related evidence had been collected during excavation of the large sites that dominate the extant body of metalwork from Mesopotamia, our current understanding of metalworking and metal use in the region would undoubtedly be much more in-depth and more representative. While small, the Tell Khaiber assemblage emphasises this issue clearly, and hopefully can inform decisions made on future excavations in relation to collecting and recording metalwork.

Part II

Exploring the Application of Less Traditional Approaches to Metallurgy

Chapter 7

Exploring the Life Cycle of Southern Mesopotamian Metal

Fundamentally, the study of objects within archaeology is born out of the aim of providing a better understanding of the social world in which they existed. Through the discovery, analysis and interpretation of material evidence, we can more accurately reconstruct the past. In a seminal 1988 anthropological publication on the 'social life' of material culture, Appadurai (1988: 5) encapsulates this eloquently:

> "We have to follow the things themselves, for their meanings are inscribed in their forms, their uses, their trajectories. It is only through the analysis of these trajectories that we can interpret the human transactions and calculations that enliven things. [...] it is the things-in-motion that illuminate their human and social context."

Scientific methods of examination, such as compositional analysis, certainly occupy a vital position within this; however, as discussed in Chapter 3, previous research within this realm of study has, at times, become preoccupied with generating data and failed to progress findings further by adequately examining these data in terms of their implications regarding the wider social worlds in which this material initially existed (Pigott 1996: 139-40). Although this issue is certainly not new, dramatically increased use of 'big data' within archaeology has made this approach more common and therefore more pervasive and problematic. Vocal proponents of big data have, in their declaration of its supposedly revolutionary capabilities, argued that a fundamental strength of big data is the way in which it shifts focus from the *why* to the *what* (Mayer-Schönberger and Cukier 2013). Yet, emphasis on the *what* rather than the *why* lies precisely at the heart of many problematic approaches to (big) data use in archaeology.

Throughout the last two chapters, the legacy data, the new data collected specifically for this project and the data collected during the Tell Khaiber excavations have been presented and further examined. As demonstrated, the more traditional approaches used in Chapter 5, such as typological discussion, traditionally-defined compositional categories and temporal-based structuring of analysis, are capable of elucidating some important patterns and facilitating general evaluation of how the data from different periods or sites can compare to one another in light of these trends. In combination with a dataset that is substantially skewed and limited by traditional excavation strategies, however, these traditional approaches are, in many ways, also significantly limiting. For example, the extreme dominance of material from Ur resulted in many of the broader-scale examinations being representative only of Ur, and only of a particular set of depositional contexts. Traditional approaches built on typically top-down defined categories and broad-scale patterns do not lend themselves well to more nuanced, focused exploration or consideration of wider social contexts, and the lack of integration between different evidence types fails to counteract key issues with the extant material evidence. In Chapter 6, examination of the Tell Khaiber material further emphasised the biased nature of the legacy data, and the potential issues involved in the application of more traditional approaches.

It is critical that we move beyond a strict focus on compositional data by broadening the scope of investigation to incorporate other sources of evidence and information. This is even more crucial when working with assemblages from previous excavations that are subject to the various issues of coverage discussed in length in Chapter 3. It is also imperative that data is examined within its wider social context, and with the intention of expanding understanding of the social worlds in which such objects and technology existed, and how such objects and technology shaped, and were shaped by, society. Fundamentally, the generation of data and/or the generation of apparent patterns mean little if they exist entirely in a vacuum, failing to inform, or be informed by, understanding of the broader networks of which they were a part. Subsequently, as per the third aim of this thesis, Chapters 7 and 8 facilitate further examination of this data using less traditional methods and the adoption of a more holistic approach.

When studying archaeological metalwork, it is vital to acknowledge and understand that finished metalwork exists as part of a much wider process. For that object to come into existence, the crucial stages of ore sourcing, ore preparation, smelting, and then the casting and working of the metal all have to occur. As discussed in Chapter 3 and further demonstrated in Chapter 5, a large issue with extant metalwork collections from southern Mesopotamia and with much of the previous research is a dominance of finished objects and their analysis but a dearth of material related to the other key points along the cycle. The focus in previous work on complete, better-preserved metalwork has hindered the ability to shed adequate light on metallurgical processes. It is also important to study the life cycle of metal after the creation of finished objects. This involves its distribution, use, reuse, and ultimate deposition of material. Each of these different stages involves various social and economic networks of interaction. Furthermore, technology, including metallurgy, is a cultural and social process. The examination of these aspects of metallurgy can provide an increased understanding of wider social and economic structures.

Despite the limited available material and data relating to wider parts of the life cycle of metal in southern Mesopotamia, this chapter seeks to examine the life cycle of southern Mesopotamian metalwork by investigating various key aspects along this cycle using a combination of archaeological and textual evidence. Ultimately, this chapter aims to move beyond the more traditional approaches to the interpretation of compositional analyses. There are different approaches to dividing up the lifecycle of metal for study, just as there are for the lifecycle of any archaeological material. On paper it is possible to draw a relatively simplistic cycle where steps occur in order; in reality, however, lifecycles of objects are rarely that straightforward. Throughout this chapter, the general lifecycle of metal is broadly explored in three key sections. The first, contained in section 7.1, discusses access, procurement and the movement of metal. In Section 7.2, the focus of this chapter shifts instead to consider metalworking and metalworkers, considering the structure of metallurgical activity both within and beyond large cities, as well as a re-evaluation of previous interpretations of smaller-scale and 'peripheral' sites. Section 7.3 relates most prominently to use and value, exploring themes of social and economic value, functionality and intentionality. The final portion of the lifecycle of metal examined in this chapter is that of recycling and deposition in Section 7.4. Collectively, these sections explore a broad range of points along the lifecycle of metalwork, in pursuit of a fuller reconstruction of Mesopotamian metal and its role within society.

7.1 Access, Procurement and Movement of Metal

The earliest stages involved in the use of metal are ore sourcing, extraction, first-stage processing and the subsequent movement, trade and exchange of processed or semi-processed metal. General discussion of sources for the metal used in southern Mesopotamia throughout the Bronze Age is presented in Chapter 2, and it is upon that foundation that this section builds. This thesis does not concern itself with further examination of potential sources for Mesopotamian metal, nor with provenancing the metalwork included in this project; however, some of the patterns observed in the legacy data discussed in Chapter 5 necessitate further discussion with regard to wider understanding concerning access, and the material from Tell Khaiber brings important new potential for further examination and consideration of this understanding in light of new Sealand Dynasty evidence.

As mentioned in Chapter 5, there is considerable variation in the prevalence of arsenic bronze and tin bronze at different sites; something which has previously been observed but rarely attracted significant further examination and discussion (Moorey 1994: 253; Wischnewski (2017). It is possible that this variation could be the symptom of varying degrees of access to different metals at different sites. Previous literature concerning metal procurement has focused heavily on the site of Ur. This is unsurprising given Ur's long-enduring position as the major port involved with trade up the Gulf (Crawford 1996: 16). Ur features heavily in the relevant cuneiform sources and, as demonstrated clearly in Chapter 5, metalwork from Ur also dominates much of the extant material from southern Mesopotamia, particularly during the Akkadian, Ur III and Isin-Larsa periods. Presumably, this leads to interweaving biases. Far more material dates to the Akkadian period than the Ur III, Isin-Larsa or Old Babylonian periods, but generally there appears to be a relatively consistent proportion of arsenic copper found across each analytical period category (Figure 7.1). The apparent consistency between the Isin-Larsa and Old Babylonian periods is particularly striking; as discussed in Chapter 2 and in further depth below, shifting trade links connected to a dramatically changing political landscape could have been expected to result in noticeable changes in the prominence of arsenic copper at this point, depending on changing source zones. The proportion of tin bronze in the Ur dataset across the Akkadian, Ur III, Isin-Larsa and Old Babylonian periods appears to increase, particularly in the Isin-Larsa period.

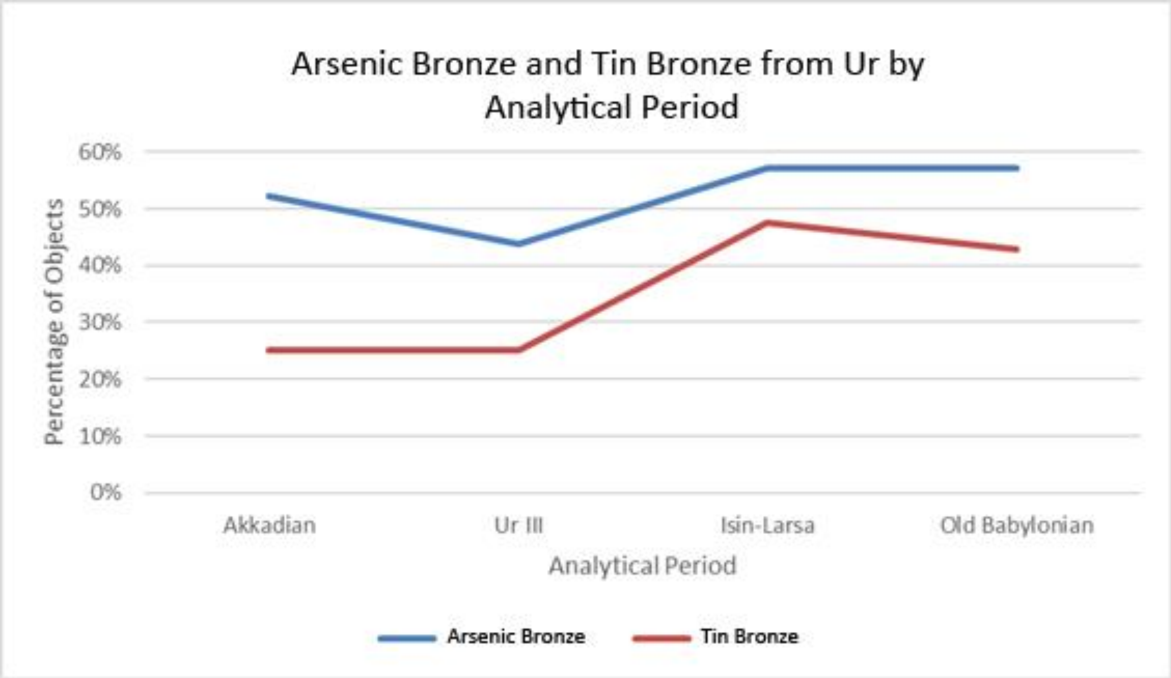

Figure 7.1: Prevalence of tin bronze and arsenic bronze from Ur for each analytical period in terms of percentage (%) of objects.

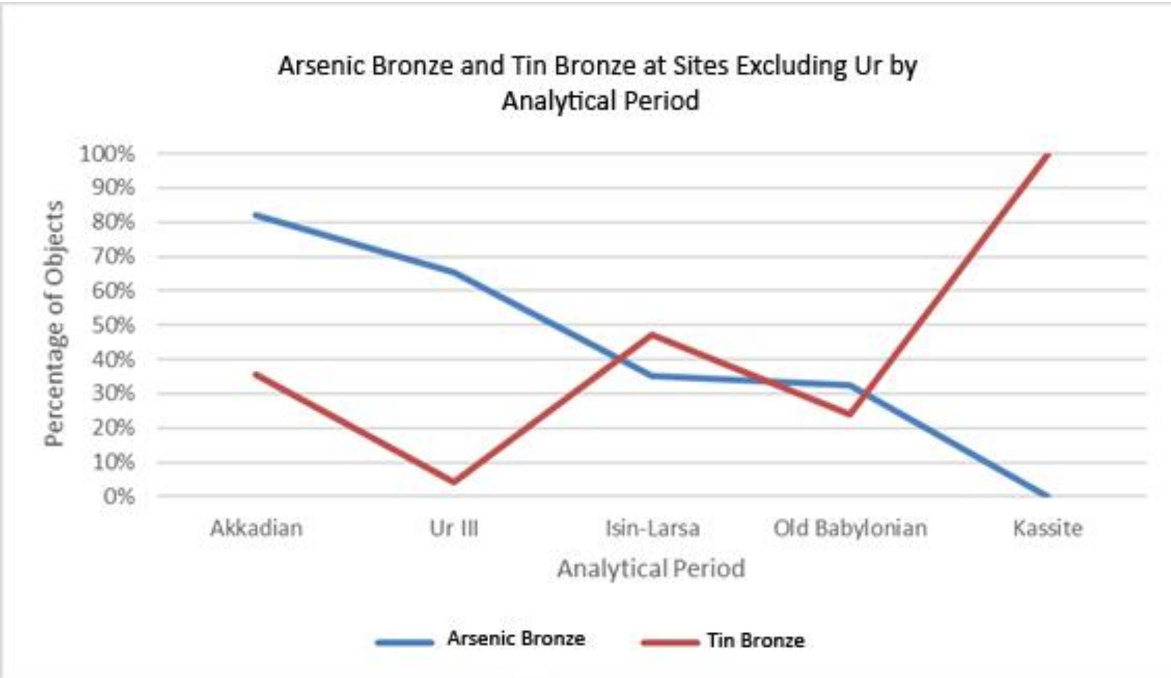

Figure 7.2: Prevalence of tin bronze and arsenic bronze from sites excluding Ur for each analytical period in terms of percentage (%) of objects.

Once the Ur data is removed, however, the patterns of tin bronze and arsenic copper use change (Figure 7.2). Where arsenic bronze use continues at Ur, there is a general trend towards a decline in use at other sites. It is possible that this reflects higher use outside of Ur of copper from a low-arsenic source zone. Potentially, copper with higher arsenic content was intentionally being concentrated in Ur due to its observable improvements in strength and workability over low-arsenic copper. Use of tin bronze follows a similar pattern to that observed in the Ur material, although its use falls much lower in the Old Babylonian period. Notably, this is influenced quite considerably by the material from Tell Khaiber. It is generally understood that occupation at Ur during the Sealand period may have been very restricted; presumably, therefore, so, too, may have been the import of tin (Adams 1981: 331; Clayden 2020: 93). Problematically, the dominance of the Ur material and the small, regularly inconsistent amount of non-Ur material make the dataset severely skewed and, therefore, it is difficult to further interpret this variation in a meaningful way. For example, Kish provides the second largest body of metalwork in the legacy data, although it is dramatically smaller than the collection of Ur material and the dating of the Kish material makes it difficult to analyse across time. Of the Kish objects, 63% have the very broad dating of 'Early Dynastic to Akkadian', and 29% have no assigned date.

There are, however, some important potential points of discussion regarding access and metal procurement in the later periods included in this project. As discussed in Chapter 2, towards the latter end of the Bronze Age, Cyprus took over as a major supplier of copper throughout the Mediterranean and part of the Near East. It has, therefore, been argued that much of the copper from this period is likely to be Cypriot or Anatolian, rather than Iranian or Omani (Begemann *et al.* 2010, 137; Potts 1990; Crawford 1998). This shift in copper sources and trade routes was likely to have been significantly influenced by political changes under Rim-Sin and later Hammurabi (Crawford 1996: 16). The decline of Ur alongside these political changes had a dramatic impact on access and trade routes to and around southern Mesopotamia, which undoubtedly impacted access to, and movement of, metal.

The Sealand area, however, may have been impacted differently. Ceramic evidence demonstrates connections between the Sealand-controlled region and the Gulf, potentially suggesting a continued trade route down the Gulf. Comparison of Old Babylonian and Sealand period material by composition type per each site demonstrates a large degree of variation between most of the different assemblages (Figure 7.3). The Tello, Ur and Uruk material follows very similar patterns, but each of the other sites vary significantly. Broadly, it is notable that Tell Khaiber has far less tin bronze and arsenic bronze than most other sites within this category.

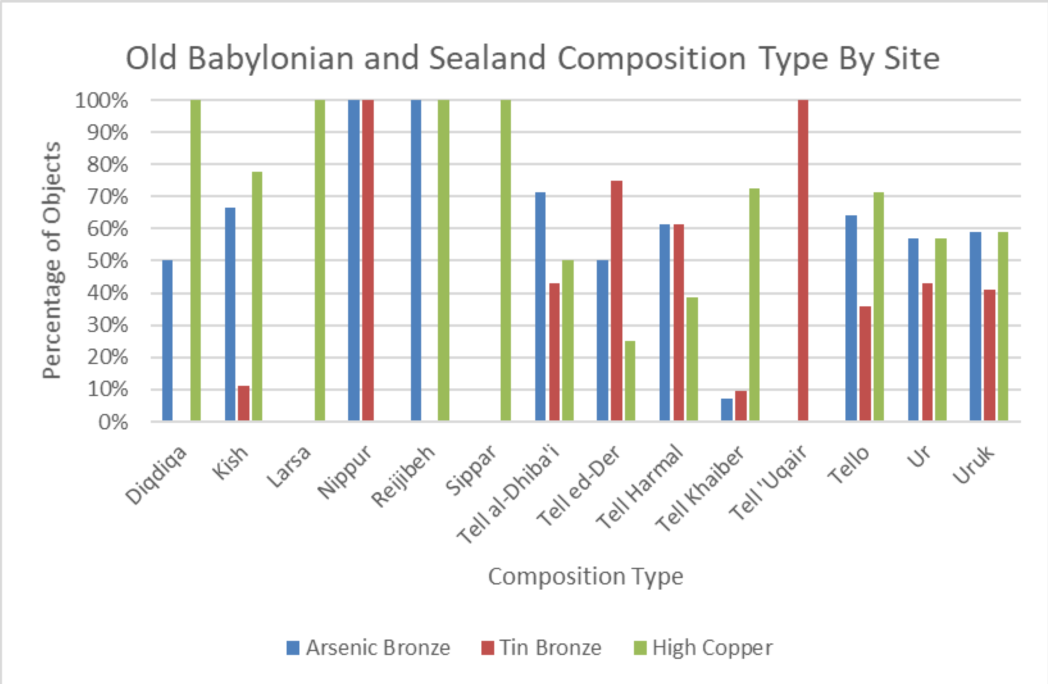

Figure 7.3: Prevalence of high copper, tin bronze and arsenic bronze compositions with an Old Babylonian or Sealand date from each site in terms of percentage (%) of objects. All illustrated, objects can, and regularly do, fall into more than one category.

While previous research into metal sources and trade routes used in southern Mesopotamia have focused predominantly on pinpointing geographical locations, consideration of the social or symbolic significance of Mesopotamia's metal sources within southern Mesopotamian society is missing from the discourse. Mesopotamia's lack of native ores and subsequent need to import all metal would undoubtedly have significantly shaped the region's relationship with, and view of, metals. As a material coming from far away, metal may have possessed a certain exoticism which would have influenced how it was perceived and what significance it held. Research elsewhere in the field of archaeometallurgy, material culture studies and ethnography has delved into social relationships with non-local materials, and the impact of their perception as an exotic material. Within the realm of African archaeology, Insoll (2015) has highlighted the importance of exoticism in endowing materials with increased significance and power, for example, when used as bodily adornment or in divination or medical practices. Similarly, Rekdal (1999: 473) has previously described "the healing power of the culturally distant".

As we know that metal objects were often used in ritual or medical practices in southern Mesopotamia – a topic which is explored in more depth in Chapter 8 – it is possible that the exotic nature of metal played a role in endowing these objects with greater socio-symbolic meaning. Furthermore, the exotic nature of metal, and certain metals to an even higher degree in particular, would potentially have played a significant role in the dynamics of political power. As argued by Fragipane (2017: 181), "wherever real power of control, not only political but also economic, was exercised over the population, the 'prestige' objects were mainly used to emphasise and confirm that power."

Another important aspect regarding composition in the Tell Khaiber assemblage is the iron content present, both in terms of iron content detected in copper objects and iron objects in their own right. As demonstrated in Chapter 5, iron content is found in most copper objects in the legacy and newly-analysed UK museum material to some degree. As previously mentioned, the presence of iron content in copper-based objects has, when noted at all, nearly exclusively been explained in previous research as being the result of contamination and corrosion. In some instances, this certainly may be the case. Soil contamination, however, cannot realistically account for higher levels of iron, and in cases of soil contamination it is reasonable to expect elevated levels of other contaminating elements, but often this is not the case. As discussed previously, another explanation for iron content in copper objects is remaining iron due to the use of iron-bearing sulphide ores, from which iron can be particularly difficult to fully remove. Neither contamination nor remaining iron levels despite two-stage processing can explain some of the highest iron content in copper objects, including some of the pieces from Tell Khaiber. Instead, as previously discussed, it is possible that this material is actually *matte*. If so, further examination of the material in light of this possibility can shed further light on the movement of processed or non-processed metal into and around southern Mesopotamia.

As previously mentioned, it has typically been assumed that metal brought into southern Mesopotamia was brought in in an already processed state. This assumption is broadly logical, in that metal was typically processed close to the source site due to weight. Potts (1997: 168-9) has previously suggested, however, that some semi-processed metal was being imported into southern Mesopotamia. In support of this, Potts references a Neo-Assyrian ingot from Nimrud held at the British Museum which contains 15.5% iron and therefore appears to be *matte*, the result of an iron sulphide ore which has received only one of the necessary two stages of processing. He also references textual sources in which differentiation between 'good' and 'bad' copper is made, and which Potts interprets to refer to the difference between processed, semi-processed and unprocessed metal. The potential pieces of *matte* from Tell Khaiber, previously discussed in Chapter 6, support Potts' suggestion, which appears to be the best explanation for the high iron content in these particular pieces. Semi-processing the metal prior to its transportation would reduce the weight, making its movement much easier. Therefore, it would not be surprising at all if this were a relatively common practice.

The importance of this issue is not only one with regard to understanding the practicalities of metallurgical production in southern Mesopotamia, but also with regard to understanding the potential deeper ideological, social and symbolic roles of metal and metalworking technology within southern Mesopotamian society. For example, technological capability and innovation can often be tied up in wider demonstrations of prestige and power (Kassianidou & Knapp 2005: 232). Using Late Bronze Age Cyprus as an example, Kassianidou & Knapp (2005: 232) argue, "various "paraphernalia of power" associated with the newly developed technology of smelting sulphide ores not only served ideological functions and symbolized political or economic aspirations, they also helped entrepreneurs and metal producers to establish their social position and legitimize their authority". Despite the metal industry of Late Bronze Age Cyprus looking extremely different to that of Late Bronze Age southern Mesopotamia, it is possible that elements of power and prestige involved in metallurgical technology influenced choices concerning the import of unprocessed, semi-processed and processed metal.

7.2 Metalworking and Metalworkers

The archaeological evidence of metalworking from southern Mesopotamia is relatively sparse. In part, this is due to the aforementioned tendency in traditional excavation practices in the region of not retaining waste materials such as slag or scrappy bits of metal, and also the tendency of archaeologists to focus their excavations on the central parts of sites despite anti-social practices such as metalworking typically occurring on the peripheries. Scholars have previously attempted to identify the locations of Mesopotamian metalworking workshops, yet their success has largely been impeded by the sheer difficulty of identifying these sites with any level of certainty (Moorey 1985: 36). There have been assertions, based predominantly on loose textual references or small amounts of potential physical evidence, that workshops existed at various locations; Ur, Uruk, Mari, Kish, Tell Asmar and Khafajah (Potts 1997: 179). All of these, however, have since been refuted (see Moorey 1985: 36-7, 1994: 265-68). There exist very few Mesopotamian sites that have been definitively identified as locations of metalworking activity. The first is Tell edh-Dhiba'i, a site near modern Baghdad, Iraq, and one of the sites included in this thesis (see al-Gailani 1965; Davey 1983, 1988). Various metalworking tools, dating to the Old Babylonian period, were discovered at this site, including baked clay moulds, baked clay pot-bellows, a model clay axehead, crucibles, and *tuyère* fragments (Davey 1988: 63; Moorey 1985: 36-7; Potts 1997: 179). Through the study of the Tell edh-Dhiba'i material, Davey (1988) has argued for the identification of a metalworking tradition termed the 'Southern Tradition'. Davey (1988: 63) suggests that this tradition may have developed in Mesopotamia from the late 4th millennium onwards, spanning the region between Mesopotamia and Egypt, and standing separate from the traditions evidenced in the Mediterranean, the Levantine coat, Anatolia and Iran. The main basis for this assertion is formed by similarities between the objects found at Tell edh-Dhiba'i and metalworking tools used in ancient Egypt. Since the work of Davey (1983; 1988), no further work has been conducted with the Tell edh-Dhiba'i material. Another site demonstrating clear evidence of metalworking is the Old Babylonian site of Mashkan-shapir, where concentrations of copper and bronze slag have been found (see Stone and Zimansky 1992, 2004). Aside from these sites, only the occasional metalworking-related tool has been found, and many of these have instead been at sites in northern Iraq such as Tepe Gawra (see Moorey 1985: 38-9; Speiser 1935).

Although it is hard to glean much of an insight into the metalworkers of southern Mesopotamia through the material record alone, textual evidence has significantly aided understanding. Through the exploration of a range of text types, it is possible to gain insights into the structure of the profession, the techniques, technologies utilised, and even names of the metalworkers themselves. As discussed in Chapter 3, however, there has long persisted a disconnect between Assyriology and Mesopotamian archaeology that has limited successful combination and simultaneous study of both evidence forms. Both archaeological and textual evidence will be considered here in pursuit of a more holistic understanding. There is very little material included in the legacy data, or, indeed, the museum data collected specifically for this project, that can shed further light on the presence of metalworking workshops, or the presence and structure of metallurgical activity. As presented in Chapter 6, however, the total collection strategy utilised at Tell Khaiber has provided a small but important contribution of metalworking evidence at a smaller-sized site. Although ultimately only a very small body of evidence, exploration of it in light of other textual evidence from Mesopotamia, current understanding of wider Mesopotamian society, and even archaeological evidence of metalworking and metalworkers outside of Mesopotamia, can offer some progression of current understanding and highlight potentially fruitful avenues of future investigation.

An important aspect of the Tell Khaiber assemblage is that it originates from a smaller-scale site than those which typically dominate previous bodies of Mesopotamian metalwork. As the majority of textual sources concerning metalworkers and metalworking originate from large, central sites, their ability to elucidate metalworking activities at smaller sites is highly limited. Influenced by urban-centric assumptions, previous approaches to the study of rural sites and their role within the wider socioeconomic landscape have also frequently used models such as 'world-systems', 'core-periphery' and 'spheres of influence', yet these have increasingly been critiqued for their simplification of flawed and typically Eurocentric (Dusinberre 2013: 3). Models such as these depict unidirectional power dynamics with economic, political, and ideological influences flowing outward from large urban sites (Dusinberre 2013; Stein 1998, 1999, 2002). Rural sites are depicted as dependent and passive (see Figure 7.4). Problematically these models are typically highly reductionist and overly focused on geographics. Within Mesopotamian archaeology, the world-systems model, which was devised by Wallerstein in 1974, has most prominently been applied to the Uruk expansion (see Aglaze 1993). However, the core-periphery structure of interpreting the relationship between large urban sites and smaller rural sites has often found its way into interpretations of various other periods. Needless to say, the economic, political, and social relationship between cities and smaller sites of varying urban or rural natures is far more complex than the notion of 'core' and 'periphery'.

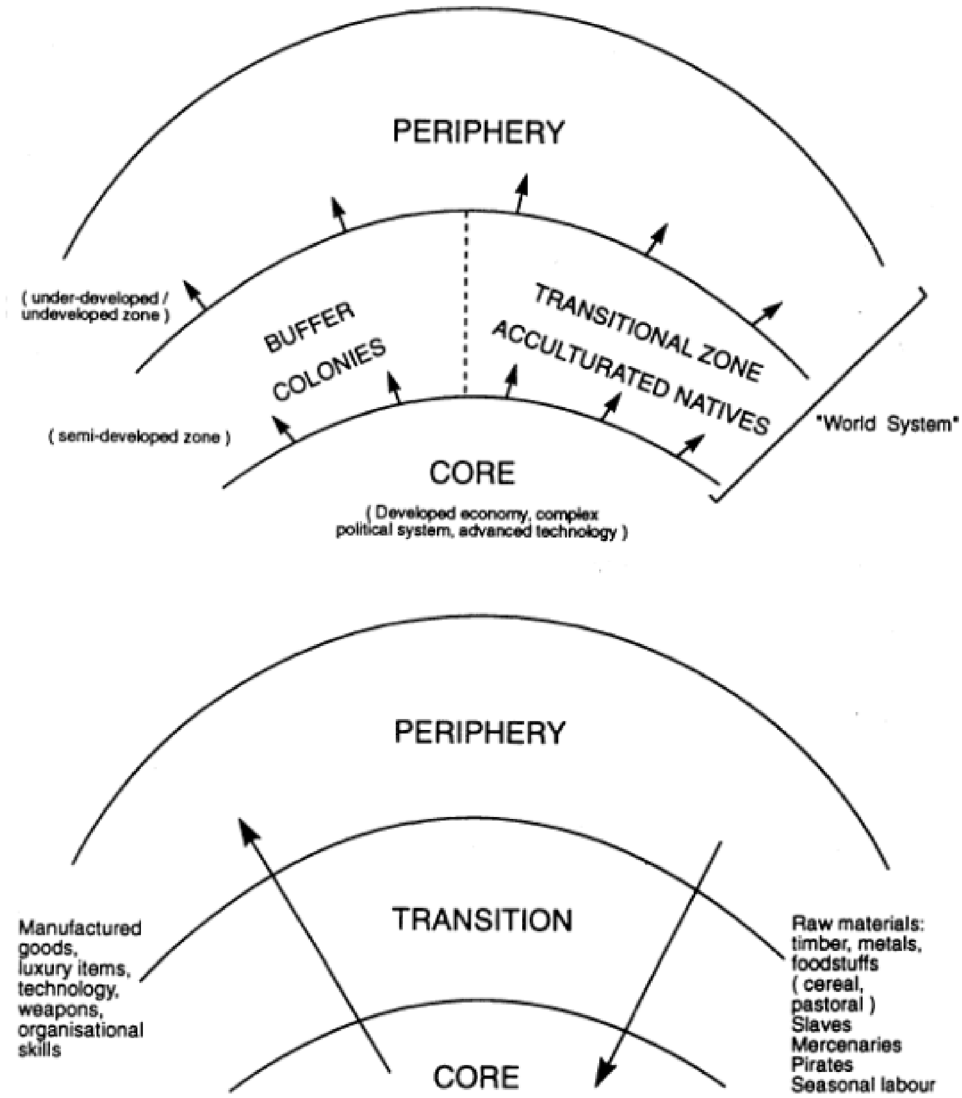

Figure 7.4: Diagram of the world systems model (after Douglas 1995: 250).

As part of core-periphery models, it is usually depicted that raw materials move from the periphery to the core where they are manufactured into finished objects which then get transported back outwards. Fundamentally, this implies that rural sites were not manufacturing their own material culture, including metalwork. There is also commonly an assumption that rural sites used significantly different material culture than at the large urban centres. The lack of previous research explicitly evaluating whether villages and smaller settlements shared the material culture of cities and larger settlements has previously been highlighted by Matthews (2013: 55).

The metalworking evidence at Tell Khaiber, however, appears to refute these interpretations. At Tell Khaiber, the presence of multiple pieces of metalworking slag, a mould fragment that had clearly been used for metal casting, and several pieces of what appear to be metalworking waste or by-product, clearly evidence some degree of metalworking occurring at the site. If the above discussion is accurate and semi-processed metal was also being secondarily processed at the site, this further indicates a substantial presence of metalworking beyond simply mending objects. There has been no evidence to indicate exactly where metalworking may have been occurring at Tell Khaiber. It is possible that, due to its anti-social nature, it was taking place outside of the site's boundaries. As previously mentioned, however, recognising metalworking areas in the archaeological record can be highly challenging.

As presented in Chapter 6, of the reasonably complete objects from Tell Khaiber that can be typologically evaluated, some appear highly similar to those found at other, largely contemporary sites. Some, however, do not appear to fit a known type according to Helwing's typology. One example is the adze (Figure. 7.5). Objects such as this perhaps alternatively point to a degree of originality in the Tell Khaiber assemblage, caused by independent metalworking rather than importation of metalwork from larger sites.

Figure 7.5: The adze head found at Tell Khaiber.

Fundamentally, the dichotomies of 'rural vs. urban' and 'core vs periphery' are significantly misleading and reductionist, because sites rarely fit squarely into separate and distinct categories with no overlap (see Richardson 2005). Ultimately, all sites are composite entities with different types of social groups, occupation, structures and dynamics. Initially, Tell Khaiber was thought to be a small, rural site and therefore conceptualised in line with existing preconceptions about small, rural sites in southern Mesopotamia. Throughout the excavation and subsequent further study of the site, however, it has become clear that despite its small scale, Tell Khaiber occupied a highly strategic position near various key canals, providing it with access to resources from various directions and a direct palatial connection (Campbell forthcoming). There is also significant variation within Tell Khaiber itself. There are at least three clearly different contexts of consumption. The first is the elite end of the Fortified Building where administration is based and who have direct palatial connections, the second in the royal ancillary troops who will have equipment from the centre, and finally the genuinely rural people who occupied the site otherwise.

The site of Mashkan-shapir, which was of particular prominence during the Old Babylonian period, also appears to somewhat refute some of the aspects embedded in traditional core-periphery models with regard to metalworking. The location of the copper and bronze slag concentrations at Mashkan-shapir indicates that the metalworking areas appear to have been predominantly located on the central mound. However, Stone and Zimansky (1992: 216-7) have further suggested that smaller concentrations scattered at each of the residential areas, or 'neighbourhoods', around the site demonstrates that each of these divisions may have had their own smith. The dispersal of smithing into sub-communities indicates a metallurgical structure that accommodates degrees of independence and autonomy, rather than being strictly centrally controlled. Both Tell Khaiber and Mashkan-shapir therefore evidence local, smaller-scale metalworking activity. Stronger presence of local metalworkers may be the result of shifting practices and structures over time; alternatively, this structure may have occurred throughout the Bronze Age but a lack of archaeological evidence is holding back understanding. It is notable that there are important parallels between object types from Tell Khaiber and types from other contemporary sites, yet sites which were not in the Sealand region, indicating perhaps that despite a political difference between Sealand and Old Babylonian sites, there may not have been a distinct difference in material culture. As control over material culture and the forms used can play a significant role in asserting political power, further examination alongside the turbulent political landscape of Bronze Age southern Mesopotamia following further excavation and the generation of new material may prove particularly fruitful.

The topic of local metalworking activities also draws into question the wider applicability of the previously discussed alloy 'recipe' texts found at large urban sites. We cannot assume that these ratios were being adhered to outside of large urban sites without evidence – archaeological or textual – to support it. As discussed in Chapter 4, these recipe texts provide valuable insight into copper alloy compositions, but the chemical analysis of southern Mesopotamian copper alloys clearly demonstrates a much wider range in composition. As previously suggested, this may be the result of recycling, or perhaps indicates that these 'ideal' ratios written down in text may have been adhered to more strictly within palatial contexts but may not have been outside of these specific contexts. Recent work by Kuijpers (2017, 2018) into skill and metalworking has proposed new ways of considering how metalworkers were working with metalwork, including using colour to determine composition and guide discussions about alloying. During work with metalworkers, it was emphasised that metalworking in practice relies far more on reacting to the material itself rather than using strict percentages. As this topic moves further into the realm of materiality, however, it will be discussed in much further depth in Chapter 8. At this point, it is most relevant the emphasise that greater awareness of local metalworking practices requires consideration of continuity or difference in the alloy ratios being used.

Analysis of textual sources can, of course, shed some further light on the general structuring of metallurgical practices and metalworkers. Analysis of the terminologies used in Mesopotamian textual sources regarding metalworking demonstrates clear distinctions between the different roles involved. Smiths who were involved with the smelting and casting of metals are referred to as *simug* in Sumerian or *nappahum* in Akkadian (Potts 1997: 179). Metalworkers who worked with metal at a later stage and were responsible for finished objects are referred to as *tibira* in Sumerian and *gurgurrum* or *qurqurru* in Akkadian (Pennsylvania Sumerian Dictionary; Potts 1997: 179). A separate title existed for gold and silversmiths (Sum. *ku-dim/dim*, Akk. *kutīmu*) specifically, and jewellers (Sum. *zadim*). The Pennsylvania Sumerian Dictionary also acknowledges one term for silversmith specifically (Sum. *kugbabbardim*), but this is only found once, dating to the Old Babylonian period. There is also, according to the Pennsylvania Sumerian Dictionary, a term for a 'chief smith' (*saĝĝasimug* or *simuggal*), demonstrating hierarchy within the profession. A chief smith, named Beliš-tikal, features in the text Sargon and Ur-Zababa:

> "Beliš-tikal, chief smith, man of my choosing, who can write tablets, I will give you orders, let my orders be carried out!"
> Sargon and Ur-Zababa: c.2.1.4 (Afanas'eva 1987)

> "Thus he met the chief smith of the king only at the gate of the fated house. After he delivered the king's bronze hand-mirror (?) to the chief smith, Beliš-tikal, the chief smith, …… and threw it into the mould like statues."
> Sargon and Ur-Zababa: c.2.1.4 (Afanas'eva 1987)

In the myth, Beliš-tikal is ordered by Ur-Zababa to kill Sargon, but he is unsuccessful. Although the texts state that Beliš-tikal was able to write tablets, it has been argued by Robson (2007: 241-2) that this is more likely to be a plot device than an accurate reflection of the capabilities of smiths, even chief smiths. Literary mentions of a 'chief smith' are relatively limited, and it is difficult to assess the difference in Sargon and Ur-Zababa between realistic depiction and artistic licence. The references in textual sources to chief smiths clearly highlight their status within the profession and also appear to emphasise their palatial connections. Due to the aforementioned palatial bias in textual sources, however, it is important not to uncritically interpret this as applying also to chief smiths outside of palatial contexts.

One other reference to a chief smith is found in The building of Ninĝirsu's temple (Gudea, cylinders A and B): c.2.1.7 (Edzard 1997):

> "The shepherd was going to build the house with silver, so he sat together with silversmiths. He was going to build the E-ninnu with precious stone, so he sat with jewellers. He was going to build it with copper and tin, so the mother-goddess of the Land directed before him the chief of the smiths."

As seen in the above quote, the chief smith is described as being directly involved with tin bronze. This may, therefore, demonstrate a hierarchy within the profession based on the type of metal with which individuals work.

In the textual sources from Tell Khaiber, it is mentioned that there are two smiths present at the site, and both of these are referred to as chief smiths. This suggests that a similar, if not identical, hierarchical structure and titles were used at the site as were used at large central sites. Their presence at Tell Khaiber also indicates that chief smiths were not confined to large, urban sites, and also that the metalworking being undertaken at Tell Khaiber presumably required, or at least received, a high degree of skill. As we know that troops were stationed at Tell Khaiber, the presence of two chief smiths may have been, at least in part, to support the troops. This further illustrates the more complex nature of smaller-scale sites beyond a simple urban vs. rural dichotomy; while Tell Khaiber was more rurally located and small in scale, it also appears to have had access to more central roles due to its strategic position and special status.

It is also noted in the Tell Khaiber texts that the two chief smiths are brothers. Smithing as a hereditary craft is certainly not uncommon in the archaeological and anthropological record, and can be found evidenced around the world and across various different contexts from Medieval Scotland (Atkinson 2003; Photos-Jones 2001) to Kenya (Kusimba 1996) and Nigeria (Yusuf 2012). In these instances, smithing is often a male-dominated craft passed down from fathers or other male relatives (Yusuf 2012: 278). It appears that the smiths at Tell Khaiber were permanent residents rather than travelling or 'itinerant' smiths. The notion of travelling smiths has received much debate within archaeology since Childe first introduced it in the early 20th century to support theories of diffusionism (see Childe 1930). Potential examples of travelling smiths have been found in the archaeological record (for example Sherratt 2000: 87); however, these are rare. Similarly, travelling smiths are not widely documented in ethnographic research (Rowlands 1971: 212). Rowlands (1971: 212) instead argues that, as skilled metalworkers, smiths would have been more likely to be strongly integrated within society and subsequently possess stronger obligations to the community. Childe is also first responsible for assumptions that smiths must have been full-time specialists (Childe 1958). Rowlands (1971: 212) has instead argued that smiths would rarely spend all of their time metalworking because of a fluctuation in demands. Ultimately, however, the amount of time spent by smiths metalworking will of course vary depending on the context in which they are working; the site type, the population levels, the types of people and professions found at the site, how ubiquitous metal-use was at a particular site, and even wider political factors such as regular warfare could all potentially have an impact. In the Tell Khaiber texts there is no explicit mention of whether the smiths were full-time, although no other profession is listed for them. As previously mentioned, the positioning of troops at the site may have resulted in high enough demand to warrant two full-time chief smiths.

Throughout broader Mesopotamian textual sources, it is also made undoubtedly clear that there existed deep respect towards the exceptional expertise and abilities possessed by metalworkers who are consistently hailed for their skill and noted as being responsible for "creating masterpieces" in A hymn to Asarluḫi (Asarluḫi A): c.4.01.1 (Charpin 1986). Mention of metalworkers is often found alongside references to other highly skilled professions such as stonemasonry, sometimes emphasising the notion that skilled craft workers such as smiths and stonemasons were deemed to be a crucial part of society:

> "If he carries off from the city its worked metal and smiths, if he carries off its worked stones and its stonemasons, if he renews the city and settles it, all the moulds of Aratta will be his."
> Lugalbanda and the Anzud bird: c.1.8.2.2 (Black 1988)

Some quotes attest to an almost magical or mysterious power held by metalworkers:

> "…the goldsmith shall puff and blow on you with his breath. You shall be shaped by him to form a matrix for his creations. People shall place the first fruits of the gods on you at the time of the new moon."
> Ninurta's exploits: a šir-sud (?) to Ninurta: c.1.6.2 (Black 1992)

The perception of metalworkers as possessing magical or mysterious powers is found in cultures from all around the world and across a broad range of time periods due to the highly visual and transformative nature of their work (for example Barndon 2004; Blakely 2006: 15; Tormey 2017). In their seminal paper on the role of the metalworker, Budd and Taylor (1995) critique previous approaches to studying metalworkers in the archaeological record purely as full-time specialised metallurgists without crucial simultaneous and interlocking religious or ritualistic social roles. Instead, they argue that ritual and magical dimensions should be considered more centrally, and propose a broad social-developmental perspective for forming interpretations that includes them. While there is little current evidence of southern Mesopotamian metalworkers possessing a significant religious or ritualistic social role, the above textual references indicate some degree of magical association between metalworkers and their transformative skills.

In a similar thread to relationships between rulers and metalworkers, there is one ruler named Meš-ḫe (Mesh-he) in the Sumerian king list that is referred to as 'the smith'. Unfortunately, very little is known about Meš-ḫe. Whether the epithet of 'the smith' was literal or metaphorical, however, it further iterates the notion that being a smith was held in high regard.

7.3 Use and Value, Functionality and Intentionality

Having explored key aspects of the creation of metalwork in terms of the procurement, movement, processing and working of metal, this next section concerns itself with some of the key aspects of how metal appears to have been valued, and examines decisions behind compositional and object type in light of value. Two key, overlapping categories of 'value' are explored in this section: economic value and social/symbolic value. Although it is clear in a general sense that metal was considered a valuable material – for example, texts often making reference to 'precious metals' – some textual sources provide more specific information about the value and significance of the different types of metal or metal objects. Some of these sources provide explicit references to the economic and socio-economic value of metals or metal objects, such as texts pertaining to trade. Other sources refer more generally to the less tangible social or symbolic significance of particular metals and metal objects.

Through the study of available textual evidence, scholars have deduced the economic value of different metals in southern Mesopotamia at various points in time. Potts (1997: 171-3) provides multiple illustrations of changing value of different metals across different periods. The value of both copper and tin vary significantly between different periods but, crucially, tin retains a high cost in comparison to copper. The higher price of tin is presumably heavily influenced by it being harder than copper to obtain. In part, this may explain the use of tin bronze for vessels far more commonly than tools. As discussed in Chapter 2, Müller-Karpe (1993) has suggested that the scarcity of tin may have given the metal a high status, resulting in a preference for using tin bronze for the creation of 'elite' vessels. Alternatively, Potts (1997: 170-1) has argued that it may have been possible to achieve thinner sheet metal out of tin bronze. As a result, it may have been easier to produce lighter and more attractive-looking vessels.

As discussed in Chapter 5 in particular, the material used in this thesis clearly illustrates the aforementioned preference for tin bronze in manufacturing vessels. When we compare the number of vessels made from each of the main three composition categories to the overall amount of each category in the dataset, it is clear that above-average use of tin bronze was found among vessels and below-average use of high copper (Figure 7.6). These tin bronze vessels span a variety of form types.

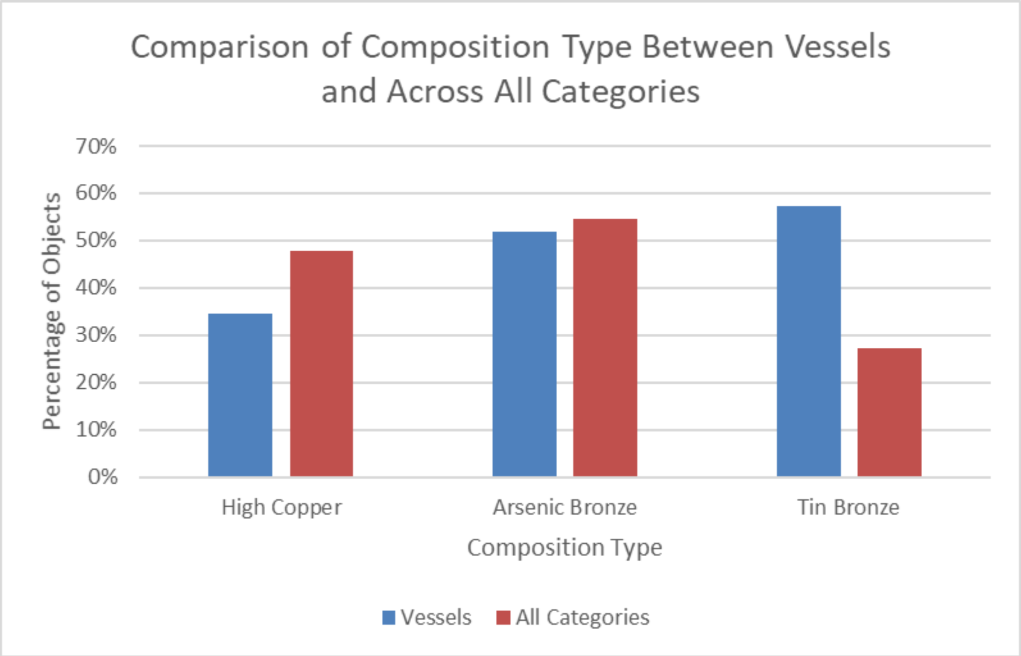

Figure 7.6: Comparison of composition between vessels vs. all categories in terms of percentage (%) of objects.

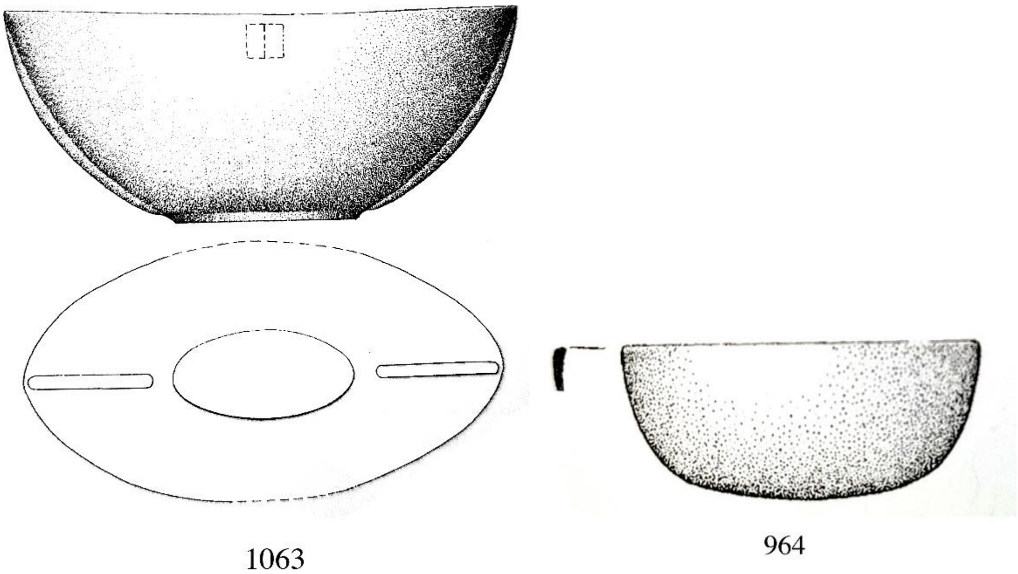

Figure 7.7: Examples of tin bronze vessels from the legacy dataset. Akkadian tin bronze bowl (left) and Isin-Larsa tin bronze bowl (right) (Hauptmann & Pernicka 2004: Plates 63 and 56).

Powell (1996) observes various materials that were used in southern Mesopotamia as what we can consider to be akin to money, defined as an intermediate commodity that can be used to state value and aid transactions. Powell (1996: 227) describes lead, copper and bronze as ‘cheap monies’, tin as occupying a mid-range value, and silver and gold as occupying the most valuable tier of monies. Silver, along with barley, was used as a ‘basic’ money that would most likely to have been accepted anywhere from approximately the mid-3rd millennium (Powell 1996: 228-9). While other scholars prefer to only use the word ‘money’ when coinage begins being used, Powell’s work provides an important understanding of the relationships between different materials in terms of economic value (Van de Mieroop 2014: 24). Most prominently, however, as laid out in chapter 2, between the mid-3rd millennium and the end of the Old Babylonian period in the mid-2nd millennium, silver was used as a common denominator for value (Van De Mieroop 2014: 21; Paoletti 2008: 128; Powell 1996: 228).

Powell (1996: 235) has previously argued that more Mesopotamian metal money is in museum collections than we realise, simply because we are not aware of what objects exactly were, or could be used as, money, as being used as ‘money’ does not preclude an object from also possessing another function. As introduced in Chapter 2, references to ‘ring money’ can be found in textual evidence from the Ur III and Old Babylonian periods. These rings are thought to have been metal rings or coils, often silver, from which small sections may have been cut to use as payment (Krauss *et al.* 1983; Powell, 1978, 1996: 235; Sollberger 1965; Van De Mieroop 2014: 24). There are a great many rings in the material included in this thesis; many of which do not clearly have one definitive function. Some may have actually been money coils rather than rings. It has also been argued that axes were used as money. Powell (1996: 238) observes that the word *gin* in Sumerian is used to mean both shekel and axe, and the Sumerian sign for shekel resembles an axe. In some textual sources, axes are directly referred to as money. This likely, therefore, explains the occurrence of axe hoards.

Figure 7.8: An example of 'ring money' (Oriental Institute 2011).

In addition to scarcity and ease of access influencing economic value, textual evidence also indicates that so, too, did colour. In reference to gold specifically, it is documented that "gold that is 'red'… is twice as expensive as gold that is bright" (Powell 1996: 230). As Powell notes, this is essentially opposite to what we may assume based on our modern colour perspective, supporting previous issues discussed previously in this thesis concerning how archaeologists approach the categorisation of metals.

While economic and administrative texts have shed extensive valuable light on the economic value of different metals, so, too, can other types of texts. In various texts, comparisons are made between the values of different metals, demonstrating the hierarchy of significance. In The cursing of Agade: c.2.1.5. (Attinger 1984) which dates to the Old Babylonian period, for example, one of the lines declares:

> "May your gold be bought for the price of silver, may your silver be bought for the price of pyrite (?), and may your copper be bought for the price of lead!"

Importantly, however, these texts are also able to more directly indicate co-occurring social and/or symbolic value too. In 'The message of Lu-diĝira to his mother', Lu-diĝira is describing his love for his mother by comparing her to a list of objects that hold a significant social value. Amongst objects such as a cornelian jewel and an ornamental drinking cup, Lu-diĝira also says "She is a bracelet of tin, a ring of antasura metal. She is a nugget of shining gold and silver". The inclusion of gold and silver is unsurprising, although, once again, it is notable that he makes a point of specifying the shiny quality of the metal. The inclusion of tin bracelets in the list is particularly interesting. Tin bracelets have been found from the Old Babylonian site of Tell ed-Der in the graves of children (see Lerberghe 1984). The use of these bracelets as grave goods supports the suggestion in this source that tin bracelets were deemed of substantial social significance. It has been argued by Moorey (1994: 301) that the similarity in appearance between tin and silver may have made tin a popular choice for objects of personal adornment and that the practice of wearing tin to mimic silver may have been far widerspread than currently believed. More in-depth discussion of colour is provided in Chapter 8.

In addition to references to known metals such as copper, tin, silver, gold and lead, there are also references to apparent metals but which currently have no known equivalent. One such example is "*antasura* metal" which has previously been discussed in Chapter 6 following a reference in texts from Tell Khaiber. The Pennsylvania Sumerian Dictionary defines *antasura* as a precious metal or stone. Muhly (1973: 178) has argued that it is only in later sources that we begin to see a distinction between metal and stone with regard to ores and rock and, although the reference to '*antasura* metal' remains unclear, this may explain the use of *antasura* to also mean stone.

Another ambiguous reference, seemingly to an unknown metal, is *kugmea*:

> "not gold, nor copper, not genuine kugmea metal nor silver, not cornelian, nor lapis lazuli*"*
>
> Enmerkar and the lord of Aratta: c.1.8.2.3. (Cohen 1973)

Kugmea is defined in the Pennsylvania Sumerian Dictionary as 'a bright metal'. The note that it is genuine also suggests that *kugmea* was something that was susceptible to forgery, which further solidifies the implication that *kugmea* was of high social, symbolic and/or economic significance. *Kugmea* is also mentioned in the following quote:

> "let Aratta pack nuggets of gold in leather sacks, placing alongside it the *kugmea* ore; package up precious metals, and load the packs on the donkeys of the mountains"
>
> Enmerkar and the lord of Aratta: c.1.8.2.3. (Cohen 1973)

The specification of 'ore' suggests that *kugmea* is unlikely to be an alloy. As *kugmea* is mentioned alongside the explicit naming of gold, silver and copper, it seems most logical that *kugmea* refers to a specific metal not otherwise listed. According the Pennsylvania

Sumerian Dictionary, *kugmea* appears only nine times, and always from an Old Babylonian context dating to approximately 2000 B.C.

A key source for elucidating the significance of silver and copper in Mesopotamian society is the Sumerian poem ‘The Debate Between Silver and Copper’ (van Dijk 1953), which provides an unrivalled insight into how the two different metals were used and conceptualised. Although most Sumerian poetry originates from either before or at the very beginning of the temporal focus of this thesis, it plays a fundamental role in the cultural literary history of Mesopotamia which undoubtedly impacted the subsequent periods. The literature produced by the Sumerians spans a range of genres; one, in particular, is referred to as ‘wisdom literature’ (Kramer 1951). Falling into this genre are literary debates between two different animals, objects or elements of nature. In this case, it is a debate between the two metals silver and bronze. Throughout this poem, both metals are personified, and a long argument ensues between the two regarding who is superior.

Throughout the poem, copper is referred to as ‘strong Copper’ and it is continuously reiterated that he is resilient and capable of a vast range of strenuous jobs, particularly those relating to labouring and work in the fields. In contrast, Copper accuses Silver as belonging only at banquets, in palaces and in graves, and refers to Silver as a “sacred mouse in a silent house” (van Dijk 1953: D38-46). There is, therefore, a clear distinction between the social, and to some degree also socio-economic and symbolic, significance of the two metals; silver is being used to convey symbolic and social value in graves and in high-status arenas and activities, while bronze dominates as a practical material, integral to everyday life. The only reference to silver being used in an active manner is the mention of its use for slaughtering goats, bulls and sheep (van Dijk 1953: A91-98). Unfortunately, this section is very fragmentary, but this line may be referencing the use of silver for sacrificial slaughter specifically; again, emphasising the use of silver in a symbolic manner, rather than in day-to-day activities.

This reflection of the role of copper versus silver is mirrored in the dataset utilised in this thesis. Silver is nearly exclusively used for jewellery and personal adornment (Figure 7.9). One exception, however, is a relatively high amount of needles. As silver is so soft, it is unlikely that it would have been the optimal choice for a needle. More likely is that these needles are either miscategorised as needles, or that they were made as needles with the sole intention of being used as grave goods rather than usable object. Similar patterns of contradicting composition choices and object types were found in the Early Dynastic material from the Royal Tombs of Ur, which included various objects such as chisels made of a composition too soft to be optimally functional.

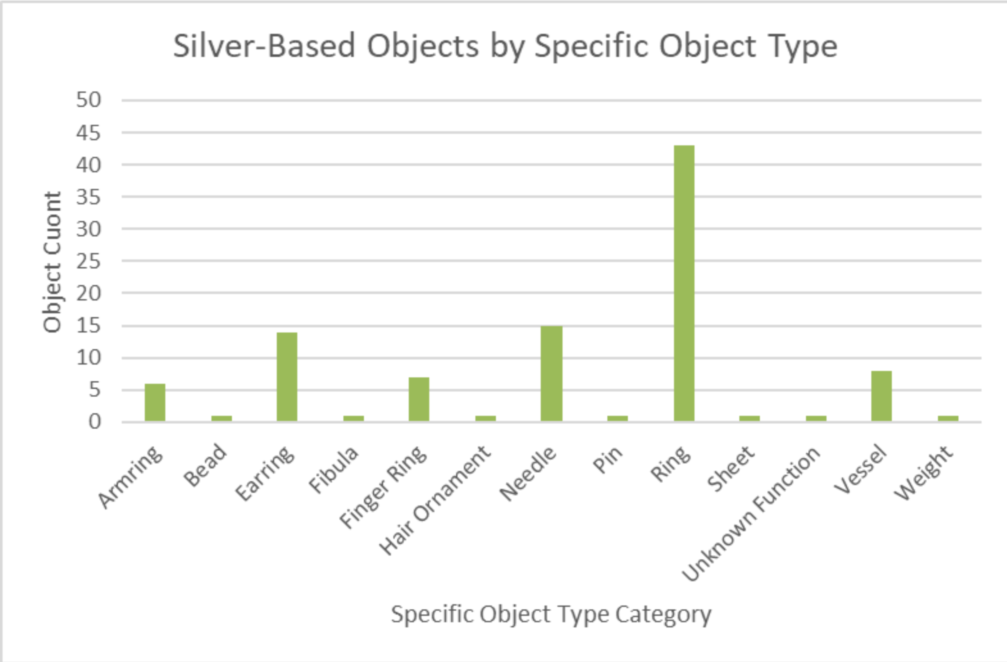

Figure 7.9: The count of silver-based objects that fell into each specific object type category, demonstrating a trend towards the use of silver for rings.

Although the emphasis of sacredness throughout the poem falls most heavily on Silver, strong links are also made between Copper and the gods. Copper is referred to as "the strong heir of Father Enlil" (van Dijk 1953: A99-128) and the "warrior of heaven" (van Dijk 1953: B15-18). The notion that processed metal appears to have held a deep connection to the divine, potentially somewhat irrelevant of whether it was a metal of higher or lower socioeconomic value, is examined in further depth in Chapter 8.

Throughout the poem, it is occasionally stated that Silver acts to "make lead shiny". Although it is not possible to know for sure, and the translation is not definitive, this may be referring to the intentional alloying of silver with lead in order to alter the final object's physical appearance. Alternatively, this may be a reference to the use of silver plating to cover lead statuary and other objects. We know that lead was often used to make statuary and we also know that silver was often used as plating, however, silver is typically used to cover materials such as wood (Moorey 1994: 238). Only five objects in the material utilised in this project are made predominantly of lead, but none of these five contain any silver.

Metal in the Near East appears to have already possessed a significant social and symbolic significance from it very earliest use. Frangipane (2017: 171) observes that the metalwork in use in the Near East in the 4th and early 3rd millenniums B.C. appears to nearly exclusively serve a 'prestigious' and not practical purpose; the only exceptions being some small tools such as awls. She also notes that the majority of this material was found from 'elite' contexts. Frangipane (2017: 171) argues that this is the case until the early to mid-2nd millennium, saying:

> "I believe that at least until 2600–2500 BCE metallurgy will not have been a fully-fledged, integral part of the production systems of Near Eastern societies and that the 'value' attributed to metal was mostly not 'use value' in economic terms but rather ostentatious and symbolic value, with a notable social function."

From the mid- to late 2nd millennium onwards, metalwork appeared to be used more widely, being used for a vast range of objects type, and the metal trade and metalworking industry expanded. Frangipane (2017: 172) argues that this was in part driven by the apparent advantages of using metal for weaponry, and in part driven by the greater introduction of tin.

As previously discussed in section 7.1, the exotic nature of metal presumably played a substantial role in shaping the social and/or symbolic significance of metal within southern Mesopotamia. Another potential influence that has yet to be discussed in depth this thesis relates to the metalworking process itself. A notable element in textual evidence, and one discussed in section 7.2, is the way in which metalworkers and metalworking is described; a way which clearly emphasises the respect and awe inspired by metalworkers and this transformative process. In his seminal publication on the concept of a 'technology of enchantment', anthropologist Alfred Gell (1992: 44) argues:

> "The power of art objects stems from the technological processes they objectively embody: the *technology of enchantment* is founded on the *enchantment of technology*. The enchantment of technology is the power that technical processes have of casting a spell over us so that we see the real world in an enchanted form."

Metalwork itself embodies the transformative, and often even perceived as magical, technological processes of metalworking. In section 7.2, this quote was originally introduced:

> "…the goldsmith shall puff and blow on you with his breath. You shall be shaped by him to form a matrix for his creations. People shall place the first fruits of the gods on you at the time of the new moon."
> Ninurta's exploits: a šir-sud (?) to Ninurta: c.1.6.2 (Black 1992)

This description of a metalworker as essentially possessing magical abilities of transformation would feed directly into the interpretation of the technology of enchantment; so, too, does the immediate reference afterwards to metal's use in a religious event. As will be discussed in much greater depth in Chapter 8, textual evidence demonstrates a clear connection between metal and the divine; while that portion of discussion focuses predominantly on shine, it is important to highlight the potential influence of the actual technology used in metalworking in potentially imbuing metal with symbolic importance.

7.4 Recycling and Deposition

Finally, this section explores some of the key aspects relating to the stages of reuse, recycling and, ultimately, the deposition of metalwork. As previously noted, reuse and recycling is typically a crucial aspect of metal use anywhere, but is particularly prominent in regions without any natural ores such as Mesopotamia. Due to the heavy dominance of objects from grave contexts in extant southern Mesopotamian collections, exploration of depositional practices and material from depositional contexts outside of burials occupy an important role in progressing current understanding.

Recently, the Oxford System and its use in the FLAME (Flow of Ancient Metal across Eurasia) project run by the University of Oxford, has made significant progress in the use of compositional data to investigate reuse and recycling. The Oxford System, which began with Peter Bray's 2009 Ph.D. thesis, is a method of interpreting chemical and isotopic data from copper alloy objects. While the Oxford System used by the FLAME project is a highly valuable and insightful tool, it has not been employed in this project with this dataset as the material currently available from southern Mesopotamia is ill-suited to the application of such a methodology. Firstly, the system requires extreme precision of trace elements. Although the results used in this project are highly accurate, the bulk of the readings are legacy data readings which, as discussed in Chapter 4, pose numerous challenges due to not having access to the exact methodology that was used. Secondly, while the application of this tool to Mesopotamian metalwork would no doubt produce highly interesting and valuable results, the time and space required to apply this tool to the dataset used in this project would be far more sizable than the degree to which it could achieve the fundamental aims of this project. Utilisation of this method for this thesis would require re-focusing a large amount of the thesis and the thesis' research questions on re-use specifically. Nevertheless, this would be a good direction for future research and would possibly feed into the results in this thesis.

Recycling has already featured as a topic of discussion in Chapters 5 and 6, predominantly due to the high variation found in the examined material. As discussed, 'recipe' texts exist from southern Mesopotamia, detailing specific ratios used, particularly in the creation of tin bronze. These textual sources provide an insight into southern Mesopotamian metalworking, but it is an extremely specific insight; one which rests largely on palatial contexts, and on initial creation rather than recycling. It is also important to acknowledge that these texts would not have been written by the metalworkers themselves, and may be partially to do with tracking and assigning commodities as much as actual metalworking. Throughout Chapter 5, it was made clear that actual compositional ranges of tin bronzes extended substantially either side of the ratios in these recipes. As discussed in Chapter 5, the initial, or 'first generation', alloying of a tin bronze may have fit the ideal composition written in these recipe texts, but subsequent generations of recycling probably diluted this original ratio. Where objects do fit into these ideal rations, therefore, these may represent objects manufactured by smiths with access to raw metal resources, such as palace smiths, or objects without many stages of reuse. Large amounts of variation found at smaller sites may also indicate manufacturing occurring in a far less strict manner if it was outside of a palatial context. Ultimately, with such high degrees of recycling present, it is challenging to determine original compositions. More recent work outside of the realm of Mesopotamian archaeology has begun to address metalworking from a perspective that is perhaps more useful in its ability to shed light on metalworking decisions and practices based on more realistic factors than exact ratios. Kuijpers (2017, 2018), for example, provides a framework which centres perception instead of exact percentages; this is an approach explored and utilised in Chapter 8.

Although yet to be examined in depth, the theme of deposition has frequently already risen to the surface of discussion at various points throughout the thesis in the form of considering grave goods and the large degree to which southern Mesopotamian metalwork currently comes from burial contexts. As discussed in Chapter 2, traditional approaches to excavation have prioritised relatively complete, well preserved objects which can be typed and which appeal to museums for their collections. Most of the material which would fit these specifications would most likely be grave goods. Most objects which were simply discarded or constituted metalworking waste, scraps or broken objects are precisely the types of objects that would most likely not have been collected in traditional excavation. As a result, the available body of material from southern Mesopotamia is currently dramatically skewed in favour of this type of context and form of deposition.

Metal found in burial contexts carries a specific type of meaning as these were objects which were being intentionally taken out of circulation. In a country with no natural ores, and throughout which metal was regularly repaired, reused and recycled, the action of taking some metal permanently out of circulation would most likely carry great significance (Frangipane 2017: 181). As discussed in Chapter 5, southern Mesopotamian grave goods regularly consisted of metal vessels and jewellery, both in male and female burials (Barrett 2007: 12). While some objects were of notable luxury, utilitarian objects were also highly common. This included objects such as pots and tools (Barrett 2007: 15). As such, these objects are, at least, likely to be somewhat representative of some of the objects in regular circulation; particularly if the composition of the objects fits its intended utilitarian use. Where objects possess a composition that appears to be at odds with its apparent intended use, such as the silver needles discussed in section 7.3, it is far more likely that these were intentionally created as grave goods. With regard to interpretations concerning the intentions behind including grave goods in burials, current interpretations of southern Mesopotamian grave goods tend to emphasise the possibility of preparing the deceased for the afterlife; particularly if the objects are utilitarian in nature. We should not, however, rule out the possibility that they were selected due to their connection to the deceased and therefore as a representation of key aspects of their identity (Ucko 1969: 265).

While a small number of the objects from Tell Khaiber do originate from burial contexts, the vast majority of the objects do not; something which is drastically different to previous assemblages. As mentioned previously, the use of a total collection strategy at the site meant that pieces of metal from a range of different contexts and positions along the lifecycle were collected, recorded and analysed. While previous assemblages provide material predominantly relating to deposition as grave good, the assemblage from Tell Khaiber offers material covering a wide scope of potential situations. For example, some objects may have been intentionally deposited with the intention to retrieve at a later date and, for whatever reason, the objects were never collected. A potential example of this could be the adze and bowl found together. While unlikely to be a cache, the slight possibility should be highlighted.

Another context of deposition potentially included in the Tell Khaiber assemblage is that of broken objects, or those intended to be used for recycling but which never were. The high number of highly fragmentary objects from Tell Khaiber make it highly likely that there were a number of broken objects that had either been discarded or intended for reuse. Finally, as presented in Chapter 6, metalworking waste was uncovered at the site, and is missing dramatically from extant assemblages.

This wide range of different potential contexts means that the Tell Khaiber material is likely to be far more representative of general compositions of everyday objects regularly in circulation. Unfortunately, as the only known body of metal of known Sealand date, it is difficult to assess the degree to which substantial differences in composition – most notably the low tin bronze and arsenic bronze presence – is the result of a much more representative sample, or of different political situations. With the future generation of new assemblages using a total collection strategy, however, this should become clearer.

7.5 Chapter Conclusions

The wide-ranging structure of this chapter has covered various different topics, all of which are important to the study of southern Mesopotamian metalwork. Consideration of differing and changing composition types at different sites has emphasised high levels of variation between sites, underlining the importance of moving beyond an extreme focus on Ur due to its overwhelming presence in extant datasets. The new material from Tell Khaiber has demonstrated key differences in metalwork at a site of the Sealand region in comparison to more northerly, potentially contemporary sites. It has also, however, thrown into question many of the traditional assumptions concerning smaller-scale, rural sites, their relationship with central sites, and their access and activities in relation to craft and manufacturing. Discussion has also advanced further to consider the potential influence of metal's exoticism on its perceived significance, and the possible role of metal in political power.

Focused discussion concerning metalworking and metalworkers has directly drawn into focus the humans behind the objects in question, and explored potential social attitudes towards them and their profession. While far more material relating to metalworking activities is needed through fieldwork, examination of textual sources clearly offers important further insight and should be exploited further. The influence of metalworkers and metalworking on the symbolic significance of metal has further been discussed in light of Gell's theories on the technology of enchantment, and topics of a similar vein are explored further in Chapter 8.

This chapter has by no means been a comprehensive exploration of the entire lifecycle of metal and all of the aspects that it would involve. Instead, the aim of this chapter was to draw out several key aspects, topics and themes at different points along that lifecycle and to use a holistic combination of archaeological, compositional, and textual evidence – including crucial new material contributed as part of this thesis – to investigate Mesopotamian metalwork in a fuller, more complete manner than has typically been seen in previous research. This chapter has also acted to highlight essential parts of the lifecycle of Mesopotamian metal that are severely lacking in sufficient evidence, and therefore highlighting these areas as important considerations in future excavation projects.

Through the inclusion of textual material alongside archaeological information and data, we can begin to create a broader and deeper understanding of metal's social, symbolic and socioeconomic significance. The utilisation of a more holistic approach can aid in solidifying or disproving interpretations reached using one source of information alone. With the current extant body of southern Mesopotamian metalwork and its current substantial issues, it is difficult to assess this further through archaeological material alone. While unfortunate, this does further act to reiterate a key argument of this thesis that future excavation in Mesopotamian archaeology must improve how it handles metalwork.

Chapter 8

Materiality and Sensory Perception

The previous chapter focused on exploring the lifecycle of metal in southern Mesopotamia. This chapter continues the aim of examining southern Mesopotamian metalwork from different, holistic perspectives, but focuses instead on materiality and sensory perception. The concept of materiality, both within and beyond archaeological theory, has been defined in various ways over the years. At its most basic level, the materiality of an object can simply be described as its material properties, but materiality as a concept also seeks to encapsulate the complex relationship between objects and humans; the 'intricate cultural nexus between artifacts and persons' (Taylor 2009: 299*)*. Through theories of materiality, archaeologists can understand how materials are shaped and given agency by humans through human interaction, and the way in which materials shape humans and human behaviour in turn. As Knappett (2014: 4700) observes, the embedded nature of materiality in our everyday lives makes it something so familiar that it essentially vanishes; something so present and so fundamental to our existence that we rarely consciously think about it. Yet, materiality is an integral part of both being and becoming human, and therefore it is an essential part of archaeological study (Knappett 2014: 4701).

As introduced in Chapter 3, materiality has been a growing field of exploration within archaeology more generally over the last few decades (for example, Gosden 2004; Jones 2004; Hurcombe 2007; Meskell 2008; Miller 2005), but a crucial part of the study of materiality that has yet to be discussed in depth in this thesis is the consideration of sensory perception. Sensory perception is an integral part of how humans experience material, yet it has not occupied a particularly strong position within previous archaeological research. Much of previous modern research has tended to adopt an approach which emphasises understanding archaeological material from a strongly scientific perspective. Research tends to use definitions, categories and interpretations of data based on modern scientific understanding, despite the fact that the fundamental knowledge and technology required for these definitions, categories and interpretations did not exist in the archaeological period to which the material in question belongs (Kuijpers 2017: 22; Pollard 2018: 115). Most forms of scientific analysis also investigate sensory material properties beyond the abilities of human perception (such as X-ray and infrared images), which fundamentally alters its ability to investigate how people of the past would actually have perceived the material in question (Edwards 2001; Hurcombe 2008: 534-5). Furthermore, research projects and aspects of material selected for examination and analysis are typically driven by research trends and scholars' research interests rather than topics and aspects most likely to have mattered to past interactors with the material. For example, compositional categories of metal are typically based on precise compositional percentages and tend to focus on the *properties* of the metal, yet primary research conducted with metalworkers emphasises the importance of sensorial factors such as colour in knowing whether a desired composition has been reached, emphasising instead the *qualities* of the metal (Kuijpers 2017: 29; 2018: 865). In other work, these qualities are also referred to as affordances (see Gibson 1979; Knappett 2004). Past metalworkers would not have had the ability to measure the exact percentages of their alloys to precise accuracy, therefore sensory perception would have been an integral guide to assess composition, particularly when recycling. As Kuijpers (2018: 864) argues, "every move craftspeople make, turning their idea into practice, happens in response to their material". Subsequently, it is less a case of mixing metals according to incredibly specific percentages, and more a case of observing and reacting to the material itself, resulting instead in a degree of approximation. Many previous studies have used metal categories that rely on incredibly specific compositional percentages. A 2010 study by Merkl, for example, uses statistical analysis to create 19 distinct metal groups for bell beakers copperwork based on trace elements (Merkl 2010). The differences between many of these categories, however, would not have been perceptible to the human eye. Categories such as these are created from the perspective and technological capabilities of modern-day researchers and are therefore arguably flawed in their ability to categorise metal in ways which are meaningful in relation to those who made the objects. These approaches undoubtedly play a vital role in progressing understanding of ancient metalwork, but their use in research which centres on human perception and experience of metal can be less beneficial.

Drawing consideration of sensory perception more firmly into view can aid the use of a more bottom-up approach to analysing and understanding archaeological material. Although academic focus on sensory perception within the field of archaeology remains limited, it has increased in recent years (see Cummings 2002; Dawson *et al.* 2007; Lazzari 2003; MacGregor 1999), and similar research has also occurred in subjects adjacent to archaeology which also feature a significant degree of material culture study (see Clarke 2005; Hofmann-de Keijzer *et al.* 2005; Lazzari 2005; Renfrew 1998; Seremetakis 1996;

Stahl 2002). There have been highly valuable and successful studies that have clearly demonstrated the ability to utilise scientific method, technology, and approaches alongside theories of materiality and focus on sensory perception. An excellent example of this is the work by Dorothy Hosler (1994, 1995) in historic West Mexico. In her work, investigation of the colour, luminosity, sound and cosmology of metal is investigated in a holistic manner which provides insight into the connection between sensory perception and worldview. Similarly, the recent work of Kuijpers (2017; 2018) on metalworking and skill offers another excellent example of approaching metalwork from a sensory perspective in combination with scientific analysis. Recognising the traditional division in previous studies of ancient metallurgy between a material framework and a social framework, Kuijpers proposes a third framework which he terms the 'psychophysical framework'; a framework which takes into account 'prehistoric skill, cognition and the senses' (Kuijpers 2017: 864). His proposed methodology utilises a sensory reading of material, through which Kuijpers creates 'perceptive categories' prioritising the qualities, behaviour and performance of material that could be recognised and appreciated by past craftspeople.

Both textual and archaeological evidence from Mesopotamia has demonstrated that the material from which objects are created possess social and symbolic significance beyond simply their economic value (Benzel 2015: 89). However, previous research within the area of Mesopotamian studies utilising approaches informed by theories of materiality has been highly minimal prior to an increase in the last ten years (such as Balke & Tsouparopoulou 2016; Benzel 2015; Feldt 2015; Tsouparopoulou 2016). Research focusing on sensory perception and topics central to sensory perception has occurred to varying degrees over the modern history of the discipline but has generally been relatively limited. It has, however, gathered considerably more momentum in recent years alongside greater emphasis on these themes in the wider discipline. Several Mesopotamia-focused chapters have appeared in key edited volumes on sensory archaeology, both on the Near East and more broadly (for example, McMahon 2019; Schmidt 2021; Steinert 2021). Research using a sensorial approach spans a wide range of different methods and topics. In publications by McMahon (2013), Shepperson (2017) and Neumann (2018), for example, sensorial approaches are utilised in the study of Mesopotamian architecture, while other research has applied these approaches to the examination of topics such as Mesopotamian religion (for example, Laneri 2011; Pongratz-Leisten 2022). Further key examples of relevant studies and publications relating to colour, shine and sonority more specifically are discussed at the start of each subsection throughout this chapter. Use of materiality-based approaches and/or sensorial perspectives within Mesopotamian archaeometallurgy specifically are highly limited but, as discussed later in the chapter, there are several important contributions from within the wider area of Mesopotamian studies that are paving the way towards a more sensory-informed understanding of metalwork.

A key challenge when researching sensory perception is that the sensory perception of materials by past societies acquired its meaning through contemporary individual and cultural experiences, and yet the archaeologists analysing and interpreting archaeological material possess a very different set of experiences. There are, of course, several potential problems posed by this, one of which being that the areas on which archaeologists choose to focus their investigation are not always the ones that would have mattered most to the people who originally engaged with the material in question. In answer to this, Hurcombe (2007: 539) proposes an "archaeology of attention", observing that:

> "If material culture gives expression to a sensory order (Classen and Howes 2006: 212, 218) then, although cultural outsiders cannot experience the material culture as originally intended, it is still possible to think through what features would draw attention by considering the material culture of past societies holistically."

In the case of metalwork, this could relate to the way in which metal caught and reflected light, its shine and luminosity, its colour, its heat after being used to cook with or after time spent in the sun, the sound of different metals either when struck or when hitting against other materials. Regarding metalworking this could relate to the sounds involved with working the metal, the smells, the changing colours of the flame, the glowing visual appearance of molten metal.

The lack of previous research into southern Mesopotamian metalwork using a materiality-based approach leaves important potential within the metalwork and data available to explore relationships to metalwork and metallurgy using such a perspective. This potential is further expanded if we consider simultaneously utilising textual evidence. Within Assyriology there has been greater exploration of the themes of materiality and sensory perception, as contemporary southern Mesopotamian textual sources provide a significant body of highly insightful references. These textual sources demonstrate a fundamental connection between metal and sensory perception in southern Mesopotamian culture throughout the Bronze Age. Therefore, to analyse and interpret southern Mesopotamian metalwork without consideration of sensory perception would be to create a substantially inadequate understanding of metal's role in society. By combining textual sources with the available metal material, there is scope to investigate these themes further from an archaeological perspective. In this chapter, the role played by factors relating to the materiality of metal in southern Mesopotamian metalwork is discussed in light of the analysis and study of the material utilised in this thesis, as well as through the examination of contemporary textual sources.

This chapter is divided into four, interlinking sections that explore key elements of the sensory perception and materiality of southern Mesopotamian metalwork. Section 8.1 explores the topic of colour, initially discussing the material more broadly and loosely, and then focusing, in subsection 8.1.1, on the application of Kuijper's (2017, 2018) 'perceptive categories'. Section 8.2 continues exploration from a visual perspective, but considers the symbolic significance of specific and intentional material combinations. In section 8.3, focus shifts to centre on the qualities of shine, brilliance and reflection, discussing fundamental connections in southern Mesopotamian thought between metal, light and the divine. Finally, in section 8.4, the sonorous nature of metals and specific metal compositions is considered.

8.1 Shades of Meaning: Exploring Colour

In recent years, there has been a growing body of archaeological research into colour in the archaeological record, and the shaping of an 'archaeology of colour' (such as Boivin 2004; Chapman 2003; Hardin & Maffi 1997; Jones & MacGregor 2002). Such research has highlighted the complex social, socioeconomic and symbolic significance of colour, and the power of aesthetic systems, within which colour occupies a crucial position, in meaning-making. As an extension of this, colour is a fundamental aspect of how people perceived, and interacted with, metal (see Chapman 2007; Juleff & Bray 2007; Kienlin 2008; Ottaway 2001; Stevens 2008). This applies not only to interactions with finished objects but also to metallurgy and the metalworking process. Various previous studies in archaeometallurgy and ethnography have demonstrated the importance of investigating colour in relation to archaeological metal (for example Jones 2004; Hosler 1994, 1995; Villegas & Martinón-Torres 2012).

Landsberger, with a 1967 paper on Mesopotamian colour, did much to ignite further discussion of colour within the realm of Mesopotamian archaeology and Assyriology specifically. Previous research has included focus on pigments (for example Chiriu *et al.* 2017), textiles (such as Waetzoldt 2010) and sculpture and polychromy (for example Hägele 2013; Nunn & Piening 2020). More pertinent to this paper, however, is the crucial work of Thavapalan which has shed considerable further light on the topics of colour and shine with Mesopotamia; most notably in her seminal 2019 publication on the words and expressions for colours in the Akkadian language, but also several other publications (see 2018; also Thavapalan *et al.* 2016; Thavapalan & Warburton 2019). Thavapalan not only delves into the relationships between colour, perception, meaning and language, but crucially also emphasises how we define and categorise colour is not universal, emphasising the way in which these elements vary between cultures. Sinclair (2012) also contribute valuable research relating to colour and particularly colour symbolism within Mesopotamia.

The subject of colour has featured in previous literature on Mesopotamian metalwork specifically, although infrequent and typically only to a limited extent and depth. Discussion has tended to focus on textual references to colour or provide general observations on colour difference between compositions (such as Cuénod 2015; Moorey 1985, 1994). The more recent work of Hauptmann *et al.* (2018) on gold and silver from Ur provides a much more in-depth study of colour in metal, incorporating an examination of colour variation based on composition. Hauptmann *et al.* include a particularly effective use of ternary phase diagrams to illustrate colour variation and include some discussion of relevant textual sources. As Hauptmann *et al.* were able to study the objects included in their study in person, they were also better position to examine colour specifically. Furthermore, their emphasis on objects of high gold and silver content means that many of these objects would have had less of their colour fundamentally obscured by corrosion; a key issue with copper-based objects. Their approach is one of strong emphasis on scientific methods, however, and does not particularly interact with wider material of a social theoretical basis. In a 2015 paper, Benzel also examines silver and gold from Mesopotamia, but her emphasis on materiality and the divine contributes a much-needed, holistic examination of Mesopotamian metalwork and colour from a position rooted in social theory. While both studies mentioned here are highly beneficial papers, their emphasis on gold and silver neglects the overwhelming majority of metalwork from

Mesopotamian which was copper-based. Within this section, a holistic approach is utilised which incorporates archaeological, metallurgical, textual and anthropological approaches to the examination of colour in the thesis' dataset, focusing on copper and its alloys first and foremost.

As has previously introduced in Chapter 2, and discussed in a plethora of previous work (for example Frangipane 2017; Hansen 2017; Helwing (undated)), there exists a significant variation in colour among copper-based alloys depending on the alloying material and the ratios used. The two most prominent categories of copper-based alloys are those of arsenic bronze and tin bronze. With the addition of arsenic, copper takes on a silvery appearance of increased brilliance (Frangipane 2017: 171; Hansen 2017: 140; Hosier 1995). High-arsenic bronzes have therefore often been used in various different region's jewellery and personal adornment. Hosler's (1988, 1994) work in west Mexico, for example, demonstrated the intentional use of high-arsenic bronzes for hair ornaments and bells.

Of the copper-based objects with the highest arsenic content, the majority were tools. As discussed in Chapter 5, a general pattern of preference towards the use of arsenic bronze for tools was observed across all of the analytical period groupings studied. This pattern is somewhat surprising given the greater strength of tin bronze and the greater ease with which it can be cast. As discussed in Chapter 2, there exists continued debate concerning the intentionality of arsenic bronze and the degree to which it is entirely the result of using arsenic-rich ores. If, however, arsenic bronze was intentionally created, there are several different factors which could potentially have influenced its selection over tin bronze. These include limited access to tin, the high value of tin, or the continuation of traditional practices, but another prominent potential influencing factor could have been that of colour and shine. The addition of arsenic to copper causes the metal to take on a silvery appearance, and one of increased brilliance (Frangipane 2017: 171; Hansen 2017: 140; Hosier 1995). Due to the high economic and socio-symbolic value of silver during this time, it is possible that the visual qualities created by the addition of arsenic to copper were specifically desirable, even in utilitarian tools.

Alternatively, due to the overwhelming majority of extant material deriving from burial contexts, it is difficult to assess how many of these tools were created with the intention of being used, and how many were created with the intention of being grave goods. In some instances, the composition of an object demonstrates clearly that it could not have been created with the intention for it to be functional. For example, an axe from the Royal Cemetery of Ur dating to the Early Dynastic period has been found which is made nearly entirely of silver. While this would be a grave good that few people could have afforded, it is not impossible that far more affordable copper objects, including tools, were being alloyed to intentionally possess a reminiscent silvery appearance and increased brilliance.

The addition of tin to copper produces a metal that possesses more of a golden hue; this is one of the key fundamental differences between tin bronze and arsenic bronze (Hansen 2017: 140). As discussed in Chapter 5, a general pattern of preference towards the use of tin bronze for vessels was observed across all of the analytical period groupings studied. Vessels in the dataset are occasionally made of silver, but none are made from gold. Of course, gold is by far the most commonly looted metal, so it is highly likely that the majority of gold in circulation at the time has not made it into current collections. As above, however, gold vessels have been discovered from the Royal Cemetery of Ur dating to the Early Dynastic period (Gansell 2007: 41). As such, high-tin bronzes with a golden hue may have been intentionally created to echo golden vessels.

Copper was occasionally added to silver to improve its strength and durability, but its addition also had a significant impact on the colour of the object (Moorey 1999: 236). As discussed by Helwing (no date: 244), alloys of silver and copper appear to have been used predominantly for jewellery. In Chapter 5, a strong pattern of silver used for jewellery is observed in the dataset. It is therefore not surprising that a silver-copper composition would also be utilised for the same type of objects. In some instances, this addition may have been made to improve the durability of these items of jewellery or personal adornment. The two pins from Tell Khaiber, found from the double pot burial of a woman and previously discussed in Chapter 6, are examples of this compositional practice. Based on the categories proposed by Kuijpers (2018), these pins would fall into Metal Type V: White Coppers. This type of copper has a distinctive silver-white appearance. In the burial, these were positioned at the pectoral region on the remains and would presumably have been worn in the same location. As they are not made purely of silver, these would have been less expensive. If we assume that they were made on-site, the smaller amount of silver required may have been more accessible, particularly at a small-sized site like Tell Khaiber. Due to the composition of these pins rendering an appearance similar to silver, they may have been created to intentionally mimic silver. Alternatively, as items of dress, this composition may have been chosen due to its improved durability over pure silver.

Figure 8.1: The two silver-copper pins from Tell Khaiber, found in the double-pot burial.

Substantial levels of added alloying metal are required to effect colour changes in native gold that are significant to the eye (Moorey 1994: 218). The addition of substantial levels of copper to gold would give gold a red colouring (Moorey 1994: 218). Alloying of copper with gold is referenced in a text from Ur regarding the making of earrings (Limet 1960: 43-5; Legrain 1947: no. 452). Notably, in contemporary textual sources, 'red gold' is described in the texts as being twice as expensive as 'bright gold' (Powell 1996: 230). There is still debate, however, concerning exactly what types of composition this relates to.

8.1.1 Exploring Mesopotamian Metalwork Through Perceptive Categories

The perceptive groups proposed by Kuijpers (2018) provide copper categories useful for the study of various aspects of ancient metalworking related to varying copper alloy composition from both craft and sensory perspectives. These categories are used by Kuijpers in his work to study the skill of past metalworkers. Metalworkers would have often been working with recycled material and impure ingots, so knowledge of colour and how it relates to differing composition allows the metalworker to make decisions about how the material can most effectively be worked (Kuijpers 2017: 868). As emphasised by

Kuijpers' work, it is important to note that we cannot assume that colour was always an intentional choice. In many instances, it may have been a by-product of attention to other qualities such as hardness and workability. As demonstrated by Kuijpers (Figure 8.2), however, there is a clear visible difference in colour across the different perceptive categories, and this could certainly have been used selectively and with intentionality when making particular compositions into objects. Although not dramatic, this difference in colour would also have been perceivable to non-craftspeople. As Hurcombe (2007: 540) argues:

> "…because colour is so often used to give strong patterning in our society, subtle tonal patterns such as natural differences in shade in two similar plants or subtle textural differences such as slight changes in the weave would not to our eyes be as strong a pattern as might have been intended and perceived in a society where strongly coloured material culture was rare"

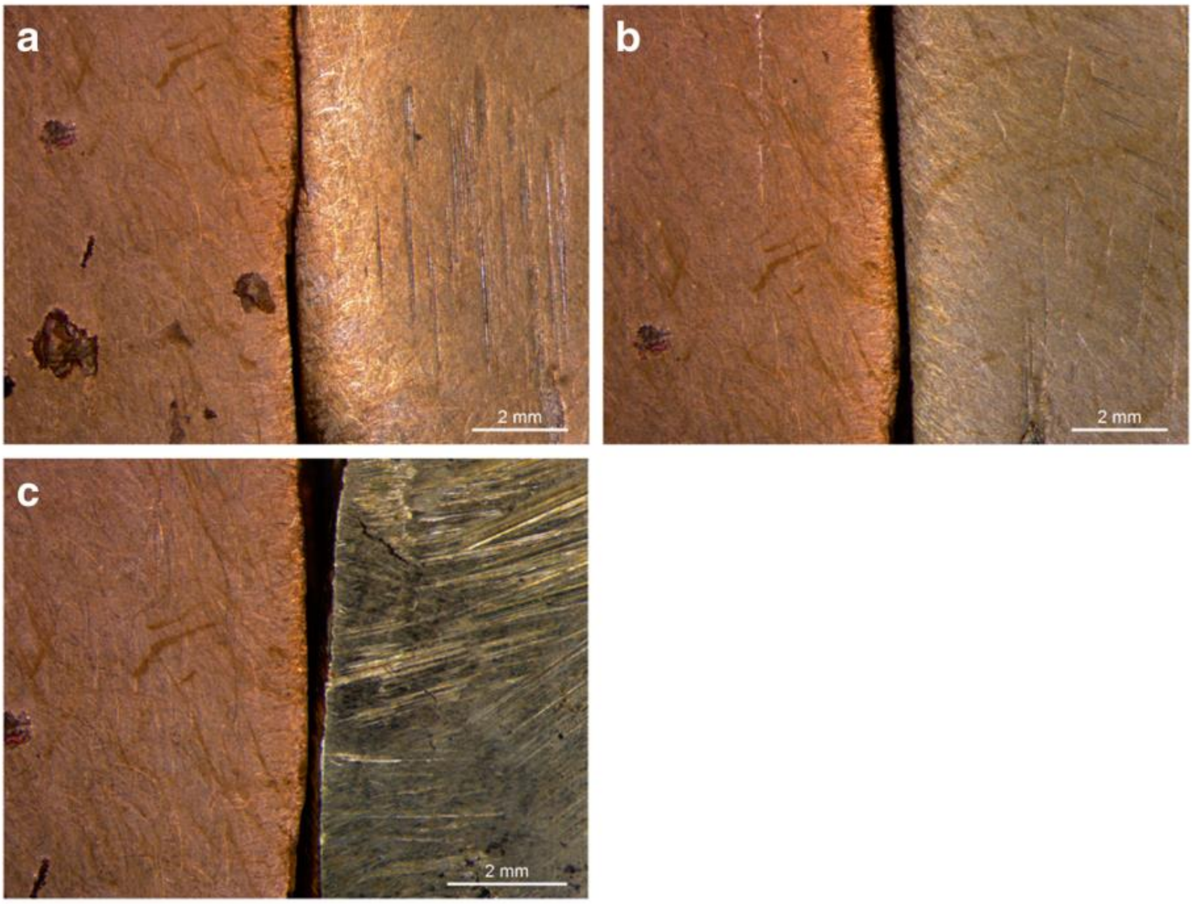

Figure 8.2: Sample from three different perspective categories, each compared to Type I red copper. Image A demonstrates Type II orange copper, image B demonstrate Type V white copper and image C demonstrate Type III yellow copper (Kuijpers 2018: 876).

While Kuijpers' categories are still fundamentally modern creations through which we are attempting to better understand material of the past, their grounding in craft practice and emphasis on sensory perception provides a much better-suited framework through which to investigate sensory engagement with ancient metal from the perspective of those who actually worked with it. Through exploration of the compositional data from Mesopotamian metalwork used in this thesis using Kuijper's perceptive categories, it is possible to achieve an understanding of the material from a perspective closer to that of the metalworkers who worked with the material. It is also a way for us to bridge the gap between materiality theory and archaeological science (Kuijpers 2017). Within this subsection, therefore, these perceptive categories are applied to the dataset utilised in this thesis.

Kuijpers (2018) outlines six key copper groups based on composition: Red Coppers (Type I), Orange Coppers (Type II), Yellow Coppers (Type III), Gold Coppers (Type IV), White Coppers (Type V) and Silver Coppers (Type VI). These categories encompass both perceptive categories such as colour and sonority and physical properties such as strength and workability. The compositional readings for all of the copper-based objects present in the material used in this study were examined using these categories. Patterns were examined between composition category and object type, period and site type.

Of the 1,522 analysed objects, 831 (64%) fell into the category of Type I (red coppers) (Figure 8.3). Type I objects can be defined in two different ways: having a composition of less than 3% arsenic, antimony, nickel and/or silver when combined (IA), or having a composition of less than 5% tin (IB). Where these conditions are both met, 'IAIB' is used. Their colour varies from red to red-orange-brown, but remains close to the colour of pure copper (Kuijpers 2018: 873). From a sensory perspective, therefore, Type I coppers are extremely similar to pure copper. It has previously been argued that an addition of as low as 2% tin is enough to alter the hardness of copper (Stech 1999: 62), therefore some scholars would classify some of the Type I coppers as tin bronzes. Kuijpers (2018: 873) has argued that, from the perspective of a metalworker, Type I metal behaves like copper, and that this low amount of tin would have been difficult even for a skilled metalworker to notice during working. To everyday people using and experiencing metal objects, this difference would have been even less noticeable.

Over half of the objects with an IAIB or IA composition are tools, and this corresponds to patterns already explored in Chapter 5. The objects of an IB composition, however, demonstrate a markedly different split: 31% are vessels and 29% are tools. Use of IAIB composition for vessels falls much lower, and even lower still for IA compositions. In Chapter 5, it was observed that tin bronze appears to have been preferred for vessels over arsenic bronze or "pure" copper, and this pattern is similarly reflected here. As Kuijpers (2018: 873) argues that an IB would not be distinguishable to even a highly trained metalworker, it is most probable that this composition was being intentionally created for these vessels, and that it was not simply a case of metalworkers making these objects out of recycled metal; unless, of course, they were being recycled from previous objects of known tin bronze composition. Use of Type IB metal is also far more prevalent for jewellery than either IAIB or IA, the latter of which was not found for any jewellery. If we are to use Kuijpers' findings that this amount of tin would not visibly change the colour of the metal, then the purposeful use of tin bronze for jewellery was most likely due to either the improved properties of tin bronze or the socioeconomic status of tin. In the latter case, this would presume that it was not necessary for it to be visible, however. Delving further into specific jewellery types, all of the jewellery objects that have been made of IB composition were types of rings (Table 8.1). This suggests a possible need to revisit our current approach to categorising rings and armrings as jewellery, or emphasises the need for rings that were worn to be movable for adjustment, or it relates to the way in which rings specifically were manufactured.

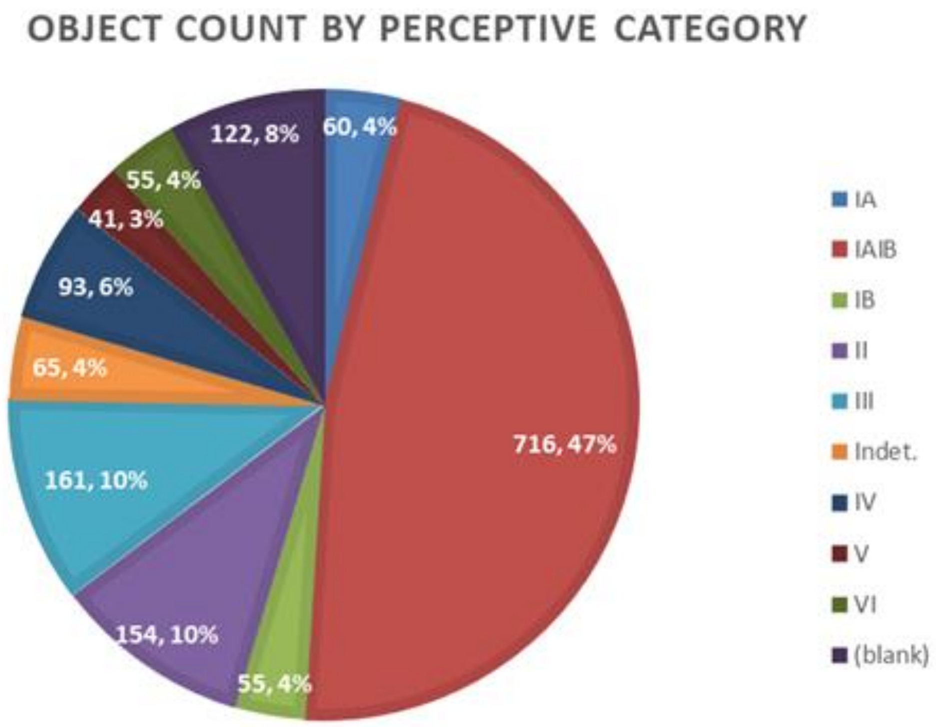

Figure 8.3: The spread of objects across each of the perceptive categories, with nearly half of all objects falling into Type I.

Table 8.1: Objects with Type IB composition categorised by specific object type.

Object Type	Object Count
Armring	2
Bracelet	1
Earring	1
Finger Ring	1
Ring	3
Total	**8**

Types II (orange coppers) and III (yellow coppers) were equally (10%) the next most common metal type. Type II has between 3-7% silver, nickel, arsenic and/or antimony in total, and the physical and visual properties of this metal can vary significantly depending on the amounts of each element present (Kuijpers 2018: 875). With regard to colour, however, all metal within this category appears as some shade of orange. Type II is also generally harder than Type I, and easier to cast. Type III metal contains 5-12% tin, and is what is traditionally thought of as tin bronze. Depending on the tin content, the colour of this metal varies between orange-yellow to yellow-gold (Kuijpers 2018: 875). It is significantly harder than pure copper, and possesses good casting properties.

As above, the same patterns can be found here regarding greater use of tin bronze for vessels, as significantly more vessels are made with Type III metal (31%) than Type II (6%). Type II is used more extensively for tools (58%) than Type III (30%), demonstrating the same patterns previously observed concerning greater use of arsenic bronze for weaponry than tin bronze despite the improved strength of tin bronze. As there is a perceivable difference between Types II and III, it is even more likely that this reflects intentional decisions both in terms of originally alloyed metal and potentially also recycling. Interestingly, the prevalence of Type II for weaponry is essentially the same as that for Type III, suggesting perhaps that the use of arsenic bronze for tools was the result of something more than strength. Finally, the tin bronze of Type III is more commonly used for jewellery than Type II, continuing the above pattern (Table 8.2). At this stage, tin-content would have been more visibly perceivable – both to metalworkers and consumers/users of the metal objects. Once again, however, they are all types of ring.

Table 8.2: Objects with Type III composition categorised by specific object type.

Object Type	Object Count
Anklet	1
Armring	7
Bracelet	2
Ring	5
Toe Ring	3
Total	**18**

The objects that fell into the category of Type IV, termed gold coppers, constitute 6% of the material. These are copper-based objects with 12-20% tin. In colour, Type IV is similar to Type III. It is, however, harder and has increased fluidity, making it easier to cast with. Although this metal type can also become brittle and therefore has a greater tendency to crack (Kuijpers 2018: 877). The largest proportion of Type IV objects (34%) fall into the category of vessel and vessel accessories and by far the most common object Type is a hemispherical bowl (35%), termed a Kalottenschalen by Hauptmanna and Pernicka (2004) and in Helwing's accompanying typology (Figure 8.5). Of secondary prominence among these objects are cups (19%). The rest of the objects fall into various, much smaller object categories. Notably, this is similar to the patterns observed in the Type III copper in which tools equate to 30% and vessels equate to 31%. As these two categories have significantly different composition types but possess a similar colour, this similarity in use may be the result of an intentional choice of golden hue for these particular objects.

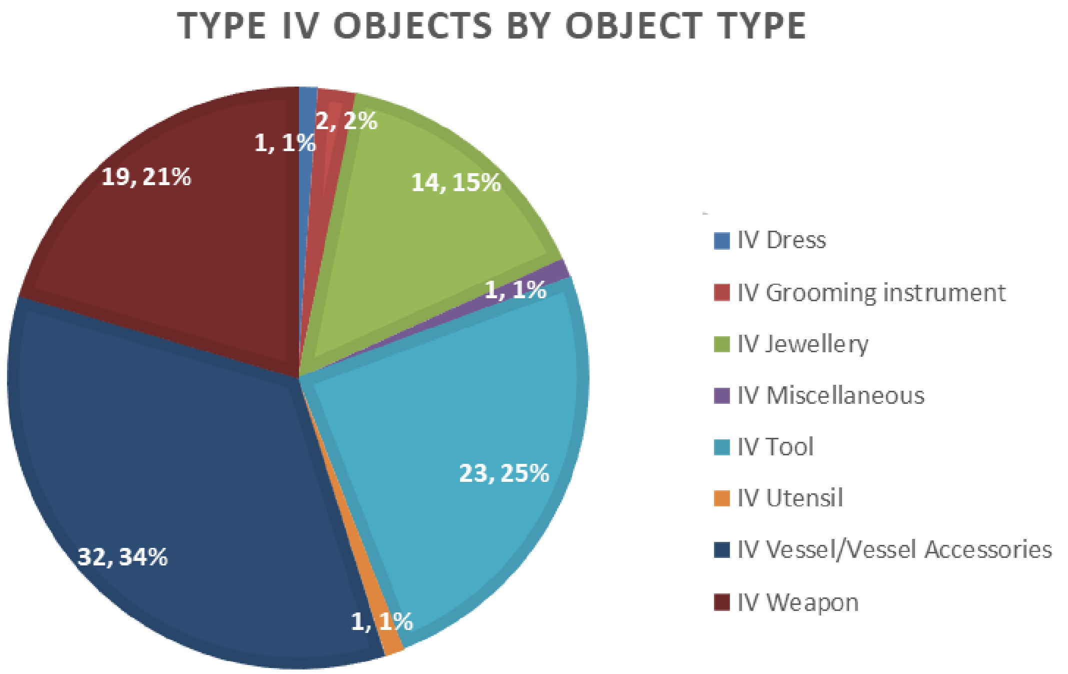

Figure 8.4: Objects with Type IV composition categorised by broad object type.

The objects that fell into the category of Type VI metal, silver copper, constitute 4% of the material, and 3% fell into Type V metal, otherwise termed white copper (Figure 8.5). Type VI metal has more than, or equal to, 20% tin, producing a yellow-white to white-silver colouring (Kuijpers 2018: 878). This metal is highly challenging to work with due to its brittle nature. It does, however, possess a sonorous quality that makes it well-suited to objects such as bells. Due to the brittle nature of this composition, it is perhaps more likely that objects – even seemingly utilitarian objects such as tools and weapons – were being made with this composition due to its colour. As mentioned previously, if this was the case, it may indicate that these objects were created with the intention of being used as grave goods rather than actually used as weaponry or tools.

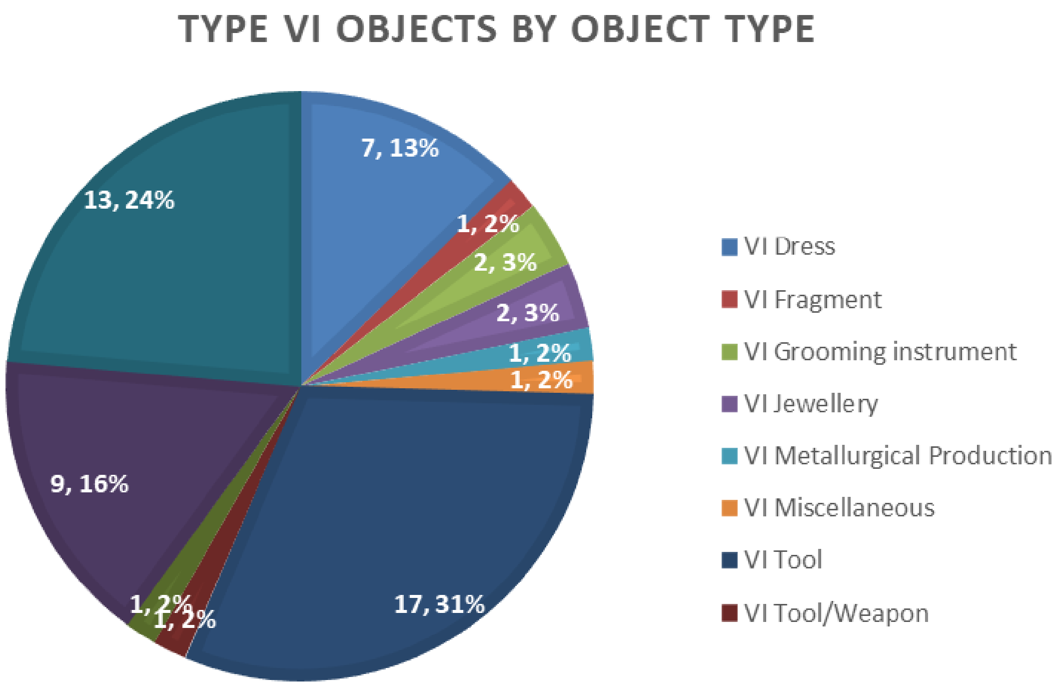

Figure 8.5: Objects with Type VI composition categorised by broad object type.

Type V metal has more than, or equal to, 7% silver, nickel, arsenic and/or antimony combined. The high amounts of arsenic and/or nickel provide a distinctive silver-white colour (Kuijpers 2018: 877). The high amount of arsenic and/or antimony results in this metal being particularly difficult to work with, as it tends to be very brittle. This would explain why this composition is so uncommon among the objects and is most likely to have been the result of recycling rather than an intentional choice (Figure 8.6).

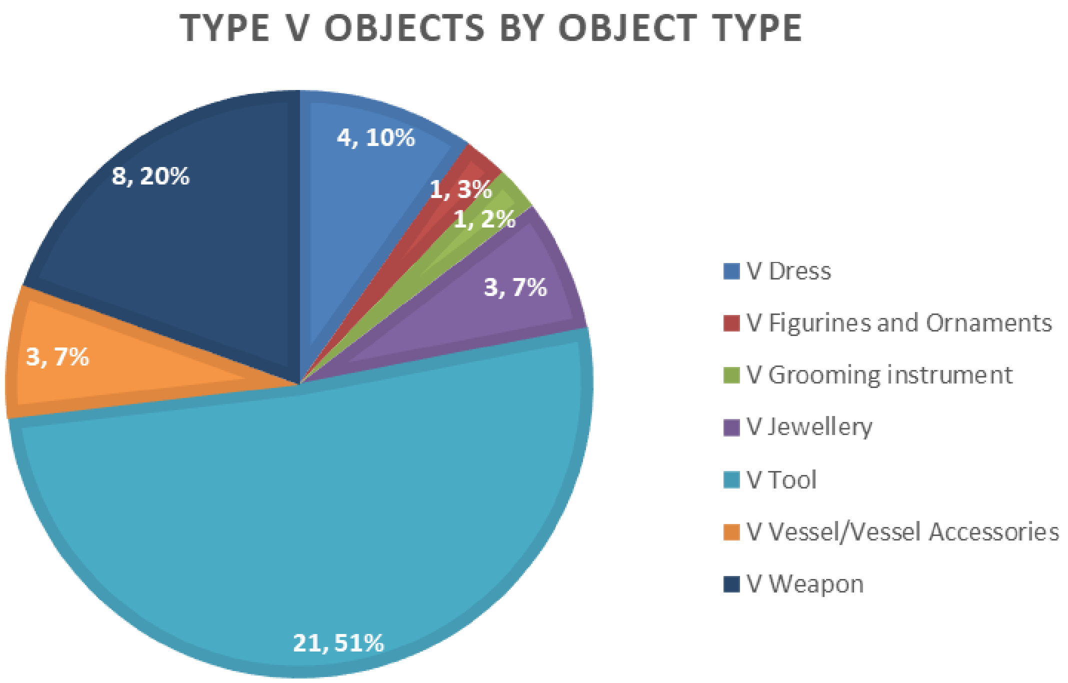

Figure 8.6: Objects with Type V composition categorised by broad object type.

Viewing these patterns generally, they broadly match up with the compositional patterns presented and discussed in Chapter 5. The largest perceptive category among the material is that of Type I copper which correlates to the more traditional categories of high-copper, low-tin bronze and arsenic bronze. With regard to object types, this compositional group spans essentially all object type groups. As Kuijpers' (2017: 109) highlights, however, Type I copper is soft and difficult to cast, making it a challenging material to work with. That this metal Type is so ubiquitous and used for such a wide range of object types suggests limited procurement access to other metals; particularly tin. As discussed previously, textual sources indicate that tin occupied a somewhat exotic and high-status role for at least part of the Bronze Age in southern Mesopotamia, therefore these general patterns correlate well with the textual evidence. Investigation concerning specific object types, however, can begin to shed light on patterns that cannot be so easily picked up using traditional approaches such as those utilised in Chapter 5.

Among tools and weapons, there is a much more consistent preference for Type I copper. While other coppers are represented, Type I is consistently the most common composition type by a significant amount. Among the jewellery, however, there is a much higher variation in composition, and a more prominent use of coppers with a silver or golden hue.

The utilitarian nature of tools and weapons of course require greater focus on the properties of the metal being used to make them, therefore, as an extension, the non-utilitarian nature of jewellery may simply lead to less purposeful control over composition. In a similar vein, production of weaponry in particular may have been more tightly controlled, or a much greater proportion of weaponry may have been made by palace smiths. Alternatively, or possibly simultaneously, the strong visual aspect of jewellery may have resulted in greater emphasis on selecting metal type by colour.

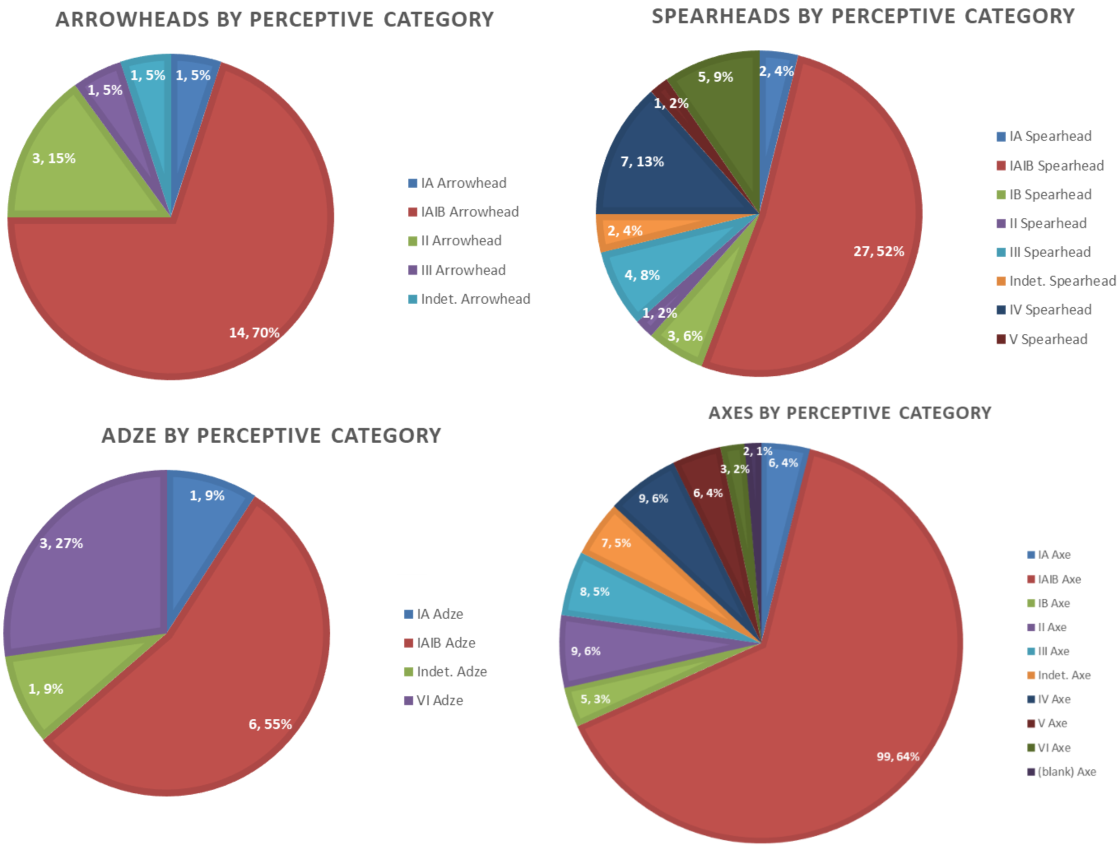

Figure 8.7: Types of tools and weapons categorised by their perceptive category.

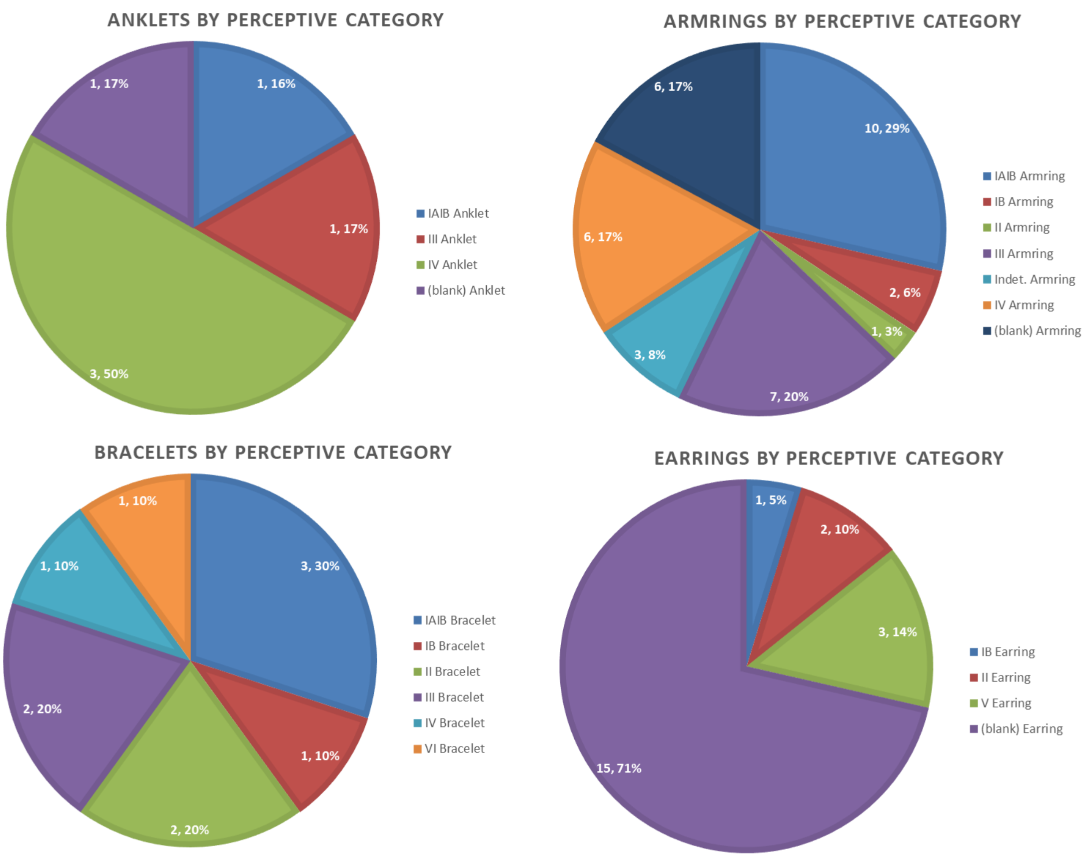

Figure 8.8: Types of jewellery categorised by their perceptive category.

An interesting pattern that was teased out in Chapter 5, was the reoccurring use of a specific copper alloy with both tin and arsenic. This composition was not a particularly common one, so it would be unlikely for it to be a coincidence that it was repeatedly used for armrings across multiple periods. Based on Kuijpers' perceptive categories, however, these armrings would fall into the category of Type I copper and the levels of tin and arsenic would have been unperceivable. If this is the case, it is perhaps more likely that a specific recipe or ratio was being followed for these objects, rather than purely using the colour of the metal to determine composition.

Overall, the application of these perceptive categories provides a new angle through which to view the patterns explored in Chapter 5, and help to draw out new potential avenues of more concentrated future examination. Notably, however, while there are some instances where potential patterns shown in the traditional approaches are not supported when studied through Kuijper's perceptive categories, it should be stressed that this proves neither approach to be fundamentally wrong. This is a necessary part of the process in working towards a more accurate and well-rounded understanding of past metal use, and it emphasises the importance of utilising different approaches along that journey.

8.2 Symbolism in Material Combinations

Another key visual aspect that can be investigated in the archaeological record is that of contrasts of patterns between different colours, textures and materials. One material combination seen extensively in Mesopotamian material culture is that of gold and lapis lazuli; particularly in high-status objects such as the material found at the Royal Tombs of Ur. Throughout the textual sources from Mesopotamia, many of the mentions of metal, particularly precious metals, are accompanied by references to lapis lazuli. For example:

> "She dwelt …… the eršema (?), of precious metal and lapis lazuli, of the goldsmith" (A song of Inana and Dumuzid (Dumuzid-Inana J): c.4.08.10 (Alster 1985)

> "Temple, built from precious metal and lapis lazuli"
> Enki's journey to Nibru: c.1.1.4 (Al-Fouadi 1969)

> "He built the temple from precious metal, decorated it with lapis lazuli, and covered it abundantly with gold"
> Enki's journey to Nibru: c.1.1.4. (Al-Fouadi 1969)

Although both gold and lapis lazuli were considered high-status materials and, therefore, it is not surprising that they would be used with one another, the frequency with which they are used together is significant enough to have warranted particular consideration. It has been suggested (Maxwell-Hyslop 1977: 85), that it may be a result of gold and lapis lazuli originating from the same source zone and/or being transported along the same trade routes. This is potentially seen referenced in textual sources, where not only is lapis lazuli mentioned next to metal with regard to objects but also in terms of mining and acquisition:

> "to break up its soil like the soil of mountains where precious metals are mined, to splinter it like the lapis lazuli mountain"
> The cursing of Agade: c.2.1.5. (Attinger 1984)

There may be a symbolic link between which materials were used together. Like metal, lapis lazuli possessed a deeply symbolic and aesthetic value within Mesopotamian society.

As emphasised by Winter (1999: 46), this is at least in part due to its lustre and ability to shine – much like metal. The way in which lapis lazuli features in language and texts is also highly similar to metal. Regarding lexical similarities, the Pennsylvania Sumerian Dictionary defines the word *zagin* to mean 'lapis lazuli; shining', demonstrating a similar lexical connection between the material and the property of shininess as discussed above with regard to metal. Throughout the texts, lapis lazuli is often used as a metaphor to express radiance and is explicitly linked to the divine, often used in descriptions of deities and of divine creatures such as the Bull of Heaven (Winter 1999: 47). In a paper on colour symbolism in Mesopotamia, Sinclair (2012: 9) discusses that, when referring to the colour blue, the word for lapis lazuli (*zagin*) was used. Later in the paper (2012: 13), it is also stated that the colour blue was associated with divinely sanctioned power. If metal was viewed with the ability to imbue divine power as discussed above, perhaps the inclusion of lapis lazuli in objects was partially done with the intent of reinforcing the notion of divine sanction and support. Lapis lazuli is also, just like metal, used to describe temples and their interiors; Winter (1999: 46) mentions a reference to the temple of Nisaba in Eres as "sparkling with lapis", whilst elsewhere, Winter (2000: 23) has highlighted the description of the Eanna Temple precinct at Uruk as having "wall[s] that gleam like copper".

There are no composite objects of gold or silver with lapis lazuli and other precious and semi-precious materials in the dataset; however, an example from the dataset which can be examined in light of material combinations are the silver-copper pins discovered in the double-pot burial of a woman alongside a necklace of 48 beads made of semi-precious stones including lapis lazuli (Figure 8.9). The burial was an intramural burial in the north corner of House 1 of the Private Houses. The necklace appears to have been well-worn prior to deposition, evidenced by significant wear described on the beads (Campbell at al. 2017: 14). Alongside lapis lazuli, the other beads were made of turquoise, carnelian and agate. The silver-copper pins were found at the pectoral area of the remains; presumably the location they would have been worn in life. While this example does not demonstrate a combination of silver and lapis lazuli in a composite object, it does demonstrate an intentional combination of them as grave goods and, most probably, were also worn at the same time by the individual in life.

Figure 8.9: The necklace found from the double-pot burial at Tell Khaiber.

8.3 Shine and Light, Metal and the Divine

When we consider the visual impact of a material, colour is often at the forefront of our mind, yet brilliance, shine, reflection and sparkle are also central to visual impact. As Thavapalan (2018) observes, while most modern European languages associate the meaning of colour with hue first and foremost, many speech communities define colour in ways which incorporate non-chromatic aspects. This can include luminosity and shine, transparency, patterns and contrasts, and even psycho-emotional values (Thavapalan 2018: VII-1). Over the last several decades, anthropological and ethnographic research has highlighted the myriad of ways in which the aesthetics of shine and brilliance carry social, cultural and symbolic significance. Archaeological research into brilliance, shine, reflection and sparkle remains highly limited, but where work has been conducted it has similarly demonstrated that this realm of aesthetics frequently held an important role in the value and meaning of materials throughout time and around the world. Archaeologist and anthropologist Nicholas J. Saunders, for example, has highlighted (1999; 2003) the key position occupied by shine in pan-Amerindian culture in embodying cosmic energy and signifying beauty, wealth, and power, touching on a vast range of different materials including metal, but also pearl, iridescent feather, polished wood and burnished pottery among others. Gaydarska and Chapman (2008) have demonstrated the importance of brilliant materials in social practices in the Balkan early farming period and later the Climax Balkan Copper Age. The shine of metal more specifically has been explored by Keates (2002) with regard to bronze swords in North Italian Copper Age society, the enmeshment between materiality and social practice, and its role in the ontological construction of cosmology.

In relation to both colour and luminosity in a recent paper discussing radiance in Mesopotamia, Thavapalan (2018: VII-1) argues that:

> "Realising that the origins of colours in ancient Mesopotamia are found in the idea of brightness is essential, it is argued here, for understanding religious thought and also for appreciating for colour as an aesthetic and rhetorical feature of the literature, art and architecture produced by this culture"

Not only is the study of shine and luminosity an important topic to investigate regarding metal due to the material's innate reflective properties, but it is also an integral aspect of colour and visual perception more broadly within Mesopotamia (Benzel 2015). By far the most prominent scholar of previous research relating to light, shine and radiance – alongside other interconnected aesthetic values – within Mesopotamia is Winter (e.g. 1994, 1999, 2000, 2002, 2008) who utilises a predominantly art historical approach. Also of significant importance is the work of Thavapalan (2018) that has previously been discussed in light of colour. Generally, however, shine in Mesopotamia is a highly limited research area; shine with regard to Mesopotamian metalwork is even sparser still, and usually included only briefly as part of wider discussions. A key exception to this is Benzel's 2015 paper on Mesopotamian gold and silver.

A fundamental challenge to the study of brilliance and shine in the archaeological record, particularly when involving base metals which require surface treatment to create or enhance brilliance, is the typical impermanence of these treatments. Due to the impact of corrosion, and other forms of deterioration and damage affecting the preservation of metal, this surface treatment is typically not retained. This is less of an issue concerning silver and gold, as both are two of the least chemically reactive elements. Both gold and silver do tarnish over time, however, reducing their shine and lustre. To maintain or revive the brilliance of archaeological metals where possible, requires surface treatment with the intentional aim of enhancing shine; something which is fundamentally at odds with modern conservation practices. Therefore, this crucial aspect of the draw, appeal and intentionality metal artefacts and their use is lost in favour of better preserving the material.

One way in which the archaeological study of shine can be bolstered is through utilisation of contemporary textual sources if and where available. Shine, and particularly the shine of metal, is a dominant theme in Mesopotamian texts, and although the study of this particular theme in Assyriological research is not extensive (Winter 2000: 23), some highly valuable work has been contributed (for example, Brüschweiler 1987; Winter 1994, 2000, 2002, 2010; Thavapalan 2018, 2019).

The inherent connection between metal and the quality of shine can be detected through semasiological study. Several of the words used to mean metal also possess meanings related to the quality of being shiny or bright; for example, defined by the University of Pennsylvania Assyrian Dictionary, the word *kug* means "metal, silver; (to be) bright, shiny", and *zabar* means "(to be) bright, pure; arrowhead; weapon; metal mirror; (to be) shiny; measuring vessel made of bronze; a metal bowl; bronze". Shine therefore appears to be intrinsically connected to metal as a material, linked deeply enough as to influence the Assyrian lexicon.

Shine is, of course, the bouncing of light off a reflective surface and, as such, the aesthetic of brilliance is intimately bound up with light. The fundamental relationship between light and shine is a reoccurring theme throughout much of the anthropological, ethnographic and archaeological research concerning shine. As light is also frequently connected with cosmic and/or spiritual power within the cultures featured in these studies, a connection between brilliance and divine power is also seen repeatedly. As discussed by Saunders (2003: 21) with regard to the pan-Amerindian cultures that he studies, "Making shiny objects was an act of transformative creation, trapping and converting ... the fertilising energy of light into brilliant solid forms". Similar themes and connections appear strongly in southern Mesopotamian textual sources. Throughout both Sumerian and Akkadian texts, light and radiance are predominantly used as positive attributes, whether from an astral body such as the sun and moon, light emitted or reflected by the elements such as fire and water, or, most pertinent here, the shine exuded by materials such as metal (Winter 1994: 123). As discussed by both Brüschweiler (1987: 187-9) and Winter (2002: 13; 2008 85), there is a strong connection between properties of radiance and sacredness in Mesopotamia. Shepperson (2017: 51) suggests that the basis for this appears to be the belief that deities were a source of light, seen through their frequent description as being radiant and in the connection between deities and celestial light sources. Winter (2002: 13) proposes that "if radiance is an attribute of the divine, then that which shines has been touched *by* the divine".

Luminosity is used throughout the textual record as a literary metaphor to signify that places, people and objects were either divine or in contact with the divine. These metaphors occasionally consist of comparisons to metal, therefore, references to metal are often found alongside themes of power, religion and divinity.

> "Like Nanna he is …… in heaven and earth. He holds in his hand a sceptre of shining precious metal, and the true crown of An is placed on his head. Like Utu he comes forth over the cypresses; like Nanna he stands over the high mountains."
> A šir-gida to Ninurta (Ninurta A): c.4.27.01 (Sjöberg 1974)

> "He made the metal tops of its standards twinkle as the horns of the holy stags of the abzu"
> The building of Ninĝirsu's temple (Gudea, cylinders A and B): c.2.1.7 (Edzard 1997)

The entire text from which the first passage is taken is religious in nature. The quote describes Ninurta and seeks to communicate his immense divine power. While this is done in several ways, one is through his possession of a "sceptre of shining precious metal" and his adornment with a crown. In some texts, the quality of radiance and shininess is more directly linked to the divine as seen in the second quote, where the shininess of the metal is compared to the radiance of the horns of the holy stags of the Abzu.

Although less common, there are also examples of individuals being referred to as metal:

> "Their ruler (i.e. Enmerkar), riding on a storm, Utu's son, the good bright metal, stepped down from heaven to the great earth. His head shines with brilliance, the barbed arrows flash past him like lightning; at his side the bronze pointed axe of his emblem shines for him, he strides forward keenly with the pointed axe, like a dog set on consuming a corpse."
> Lugalbanda in the mountain cave: c.1.8.2.1 (Black 1998)

Here, not only is the presence of metal and its purposeful description as being shiny lending to the power being illustrated for Enmerkar, but the divine power understood to be held by metal is also being extended to Enmerkar by portraying him as a personification of metal: ‘the good bright metal’, ‘head shines with brilliance’.

As illustrated in these excerpts, metal – and particularly shiny metal – was deeply entwined with sacredness and socio-symbolic power and authority. To delve into this further, it is necessary to consider the role played by sensorial experience. Part of the inherent power of light and radiance, and undoubtedly part of the reason that light features so prominently alongside divinity and power in a vast range of places and periods, is its strong impact on the senses. Winter (2000: 23) observes that within the textual sources the audience is explicitly urged to see and experience that which is being described. For example, instructions are given such as “look at its walls that gleam like copper(?)!” (Winter 2000: 23). Further, Winter (2000: 24) has highlighted the advanced Mesopotamian vocabulary regarding the actions of seeing and looking. It is clear, therefore, that there was an emphasis on the experiential aspect of sight and visual experience which undoubtedly fed into the significance of light, radiance, reflection and shine. Winter (2002: 13) has noted that temples’ interiors are described as being “endowed with gold and silver” to indicate divine presence. The experiential impact of this must have been awe-inspiring; not only due to the perceived connection between metal and divinity as discussed above, but also due to the powerful visual effect of light reflecting off the metal and around the temple.

Light occupies a central role in Mesopotamian religion, largely due to its highly visual nature which has been explored at length by Winter (1994; 2000; 2002; 2010). Sunlight, moonlight and starlight feature heavily in Mesopotamian magic and, as argued by Shepperson (2017: 53) (also Reiner 1995: 48-52), these seemed to be instrumental in giving power to medicine; in other words, the light from these celestial bodies imbues power onto the medicine. Considering the frequency with which figures are depicted holding or wearing shiny metal objects when described in a powerful manner, as demonstrated in the quotes at the beginning of this section, light may have similarly been understood to imbue metal with power, or the wearing and holding of metal may have been understood to imbue the wearer with power.

Although the concepts of light and radiance are predominantly visual, the role of heat is undoubtedly also bound up in the experiential nature of light and reflection. While light can possess intangibility, particularly when the focus rests solely on its visual nature, Shepperson (2017: 52-3) has highlighted the ability of heat to act as a tangible aspect of the power held by light. Although any objects left in the sun will heat up, a key quality of metal is its ability to conduct heat to a much higher temperature, and heat up far quicker, than most other materials commonly found in nature and that would have been in regular use in Bronze Age Mesopotamia. While heat is not a clear feature in the texts when referring to metal, it is possible that part of metal's perceived power may have come not only from its reflective quality but also from its intense ability to hold and radiate heat. Furthermore, this heat would affect the surrounding area, perhaps feeding further into the concept of light – visually and physically – imbuing power to its surroundings and/or whatever it touches (Shepperson 2017: 52-3).

The possession of a radiant quality by rulers to demonstrate divinity is a recurring visual feature in Buddhist and Christian art; for example, the use of halos or a nimbus (Winter 2008: 84). In contrast, there is no set way in which it is shown in Mesopotamian iconography (Winter 2008: 84). Occasionally, it is depicted as rays radiating from the shoulders of astral deities (Winter 2008: 84). Notably, this depiction often occurs when a ruler is shown within a military situation, suggesting that, in this particular case, the ruler has the support of the gods (Winter 2008: 84). If metal was, indeed, perceived as having the ability to imbue power, perhaps this would further the symbolic significance of metal weapons. The overwhelming majority of metal objects referenced in Mesopotamian literature are weapons. To some degree, this is due to the overriding themes of conflict and overcoming obstacles. As highlighted by Vidal (2011: 247), weapons have been a worldwide symbol of power throughout time and, subsequently, they have often been associated with deities. Many Mesopotamian deities were typically depicted holding a weapon; for example, Nergal often holds a lion-sickle, a lion-mace or both (Stone 1993: 87). The combination of divinity explored above with the clear power of metal as a strong, durable and sharp material undoubtedly furthers the notion of metal as a powerful material.

Another key value in utilising shine in weaponry is the powerful visual impact that it can have even over long distances. The 'flash' of metal in the sun in the run-up to conflict or during conflict would have been particularly impactful. In this sense, the objects are actors playing part in a performance (Gaydarska & Chapman 2008: 65). As an extension of the above-discussed connection between shine and divine power, the shine of weaponry during battle could further be intended and/or interpreted is a display of divine support.

The value placed on shine in contemporary textual sources can also indicate certain behaviours with regard to metal objects that we cannot gain through archaeological study alone. The fundamental value inherent in brilliance and shine, and the emphasis on metal weapons and objects which shine, indicate that these objects were not only treated and polished initially, but also that they were likely to have been continuously polished and cleaned in order to maintain their shine. This speaks to an ongoing relationship between the metal object and its owner. While we know that metal objects would likely have been regularly repaired, this aspect of upkeep is one that is between owner and object rather than smith and object. The ongoing upkeep and maintenance of metal objects in order to preserve this shine can create a connection and bond.

8.4 Metal's Voice: Considerations of Sonority

Sonority has featured even less prominently than shine in previous studies of southern Mesopotamian metalwork, although there are some examples of papers combining consideration of both sonority and sensory experience (such as Schellenberg & Krüger 2019). Archaeological consideration of metalwork and composition from southern Mesopotamia in light of sound specifically, aside from small mentions in wider studies, is missing from the existing body of academic work. Previous archaeological and Assyriological work has been undertaken regarding musical instruments used in Mesopotamia more broadly, however, some of which were made of metal.

Of all of the objects included in this project, only two have been typed as possible musical instruments; both of these are taken from the 2004 publication by Hauptmann and Pernicka. One of these objects is typed as a cymbal, while the other is typed as a chime bar or possible 'clapper'. The bar is from Kish and has not been given a date (Figure 8.10). It appears to be broken at one end as well as broken in the middle with a section missing. The object has a composition of 96% copper and falls into the category of potential arsenic bronze due to an arsenic content of 1.06%. Using Kuijper's perceptive categories, this object would fall into Type IAIB. This object does not, therefore, possess a composition that provides particularly unique sonorous qualities. Use of objects such as these as musical instruments appears to be depicted in iconographic sources (Helwing, no date: 141-2). In an Early Dynastic cylinder seal from the Royal Cemetery of Ur, figures are depicted in the lower of two registers clapping with two long, curved objects (Figure 8.11).

In the same register is a figure playing a lyre, suggesting the depiction of a musical scene and therefore adding weight to the interpretation of these curved objects as instruments (Marian van Dijk 2013: 10). Similar flat, horn-like metal objects to those depicted, and that that found from Kish, have been found from the sites of Shuruppak (Martin 1988: 63) and Ur (Woolley 1934:126-28) (Figure 8.12).

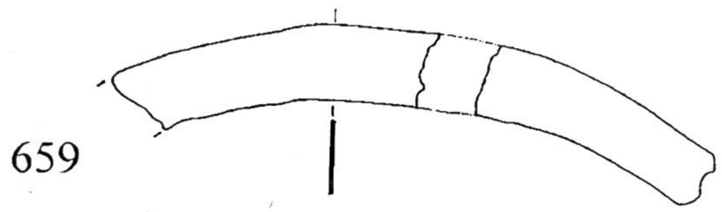

Figure 8.10: 'Chime bar' or 'clapper' from Kish (Hauptmann & Pernicka 2004: Plate 39).

Figure 8.11: Seal from Ur depicting the possible use of 'clappers' as musical instruments (Woolley 1934:127).

FIG. 21. Scale $\frac{1}{5}$.

Figure 8.12: Similar ‘clapper’ from Ur (Woolley 1934:127).

The cymbal is from Tello and similarly has not been given a date (Figure 8.13). The centre of the cymbal appears intact, but the outside edge appears to be broken on all sides. The cymbal has a composition of 92.5% copper and 5.5% tin, placing it into the category of likely tin bronze. Notably, it does also contain 1.1% arsenic. Using Kuijper’s perceptive categories, this object would fall into Type III. The use of cymbals in Mesopotamian has been evidenced by both textual and iconographic sources such as the Babylonian plaque held in the British Museum described by Duchesne-Guillemin (1981: 289). Unfortunately, with such little information available, and without particularly notable compositions, there is not much further insight to be drawn from these two objects.

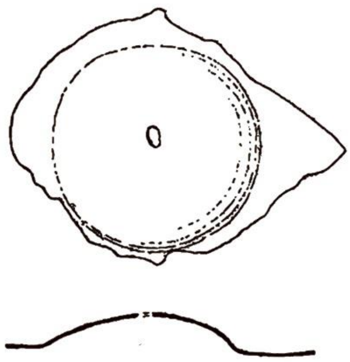

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Figure 8.13: Cymbal from Tello (Hauptmann & Pernicka 2004: Plate 153).

In Kuijpers’ perceptive categories, Type VI, which has more than, or equal to, 20% tin, producing a yellow-white to white-silver colouring, is described as being extremely brittle and therefore highly challenging to work with but also as possessing a sonorous quality that makes it well-suited to objects such as bells (Kuijpers 2018: 878). It has also been noted that this type of copper composition is capable of a notably high polish (Hiorns 1912: 215). As discussed above, of the 1,522 objects included in this project, 55 fall into the category of Type IV copper. The most common object type within this perceptive category is that of tools followed by weaponry (see Figure 8.14). Among these objects, it therefore does not appear that there is a general pattern between this composition use and its sonorous quality.

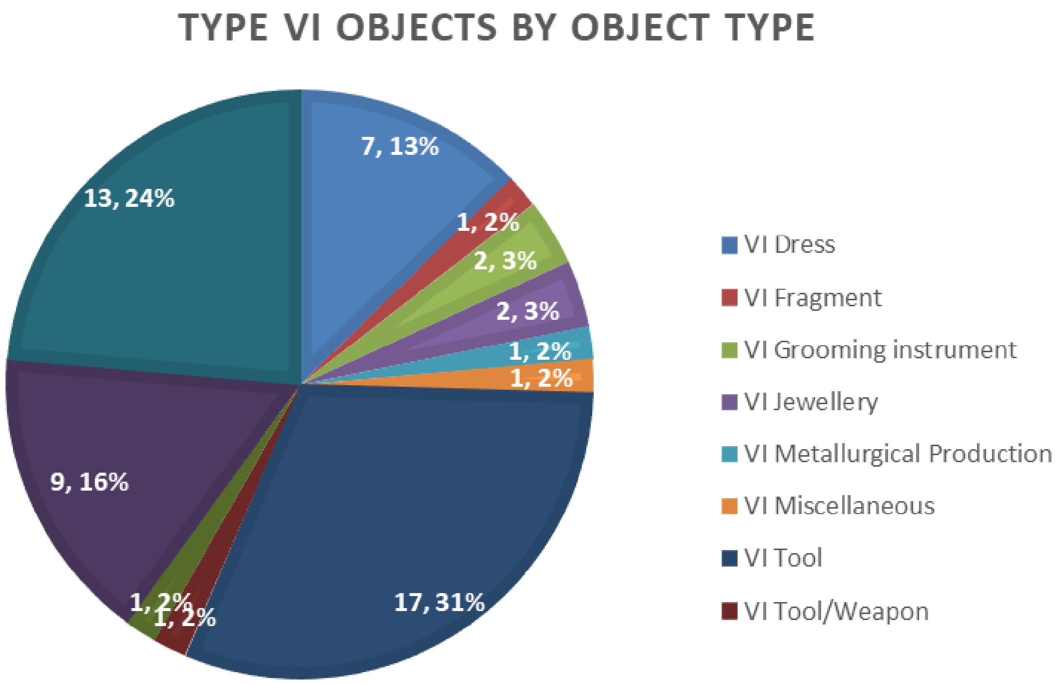

Figure 8.14: Objects with Type IV composition categorised by specific object type.

There are textual references found in 2nd and 1st millennium B.C. texts to ‘mighty copper’, apparently in reference to a bell, or, as Sánchez Muñoz *et al.* (2022: 15-17) argue, to a category encompassing both bells and gongs. These references can be found in (‘Evil Demons’) exorcistic incantations, wherein a priest uses a musical instrument to produce a noise capable of expelling evil (Rendu Loisel 2015). Rendu Loisel (2015) argues that this instrument referred to as ‘mighty copper’ should be viewed as an “autonomous agent”; both an animated and supernatural entity which possesses its own degree of divinity. The priest is described as accompanying mighty copper, rather than bringing it. This divine agency appears not only to relate to its sound, but also its appearance. Mighty copper is described as having its own *melammu*, explained by Rendu Loisel (2015: 218) as an ““awe-inspiring radiance”, a quality from the divine world”. This maps onto earlier discussion of the way in which light was understood to imbue metal with divine power, demonstrated through its subsequent radiance and shine. As mentioned above, one particular type of copper composition which possess both a unique sonorous ability and the ability to be polished to a very high shine is that of high-tin copper alloy where tin is $\geq$ 20% tin. Until objects that we know to that which is referred to as mighty copper are uncovered and analysed, it is not possible to test this hypothesis; but, currently, this type of composition does appear to match the textual evidence best.

8.5 Chapter Conclusions

Throughout this chapter, the dataset utilised in this project has been explored concerning key elements of sensory experience and interaction in order to tease out further patterns, connections, possibilities and future opportunities. Despite the myriad of limitations posed by the majority of extant assemblages from southern Mesopotamia, this chapter has demonstrated that there still exists important potential with regard to exploration from a materiality- and sensory-based perspective. The inclusion of textual evidence has clearly highlighted the fundamental connection between metalwork and the senses in southern Mesopotamian society. While previous research has tended to emphasise function, this chapter has instead helped to show the importance of progressed further into considerations of materiality, sensory perception, symbolism and ideology, and how all three can interconnect; for example, the major role of metalwork in symbolising and embodying divinity.

This chapter has focused predominantly on visual perception, with some discussion of sound and inclusion of aspects such as heat to lesser degrees where directly relevant; there are, however, multiple other directions in which future research could progress further. For example, further exploration of weaponry in relation to sound and shine during conflict could help to further elucidate important aspects of metal use and decisions relating to object type and composition, particularly in light of their potential connection to symbolic or ideological meaning. Alternatively, rather than focusing specifically on metal use, a materiality-based approach could be applied to more fully understand metalworking, the engagement of metalworkers with their material, the training of apprentices, or the sensory experiences of non-metalworkers observing metalworking taking place, and how that influences the social and cultural positions of metalworkers.

Ultimately, this avenue of interpretation and exploration offers a wealth of potential, both within and beyond southern Mesopotamian metalwork, that will only increase alongside the generation of new material using improved strategies. Through the use of a perspective fundamentally rooted in human engagement, perception, interaction and experience, a much more comprehensive reconstruction of past society can be reached.

Part III

Conclusions and Future Directions

Chapter Nine
Conclusion

In Chapter 1, three primary aims were laid out for this project:

4. To expand the existing body of compositional data and information relating to extant collections of Mesopotamian metalwork.
5. To address fundamental issues in previous approaches to the collection, recording and analysis of Mesopotamian metalwork and demonstrate, through the use of new material, the benefits of utilising approaches which vary from those traditionally employed.
6. To expand and develop current understanding of southern Mesopotamian metalwork by contributing interpretations that progress beyond traditional approaches to new holistic understandings of metal's social, symbolic and socioeconomic significance.

The first aim has been met both through the contribution of new analyses of the metalwork collections held at Manchester Museum, the Ashmolean Museum and Birmingham Museum and Art Gallery, and the contribution of examination and analysis of the Tell Khaiber assemblage. While the bodies of material in the three museum collections are victim to the same temporal, geographical and contextual issues as the rest of the material analysed in the legacy datasets utilised, the contribution of these new analyses has expanded the current body of data available. Secondarily, the reanalysis of select items previously published by Hauptmann and Pernicka (2004) has demonstrated that, despite these analyses being conducted in the 1990s, they are highly comparable to modern readings conducted using high-quality pXRF equipment, supporting their continued use in future research. The contribution of these new analyses not only facilitates the examination, analysis and discussion presented in this thesis which, in line with aim number three, expands and develops current understanding of southern Mesopotamian metalwork, but it also expands the dataset available for future research alongside the generation of new material and the application of different theoretical and interpretative frameworks.

Unfortunately, analysis of more UK-based collections of southern Mesopotamian metalwork beyond the three included in this thesis was made impossible due to the impact of COVID-19. While this has reduced the size of the new dataset produced by this project, it enabled me to place more focus on the critique of the museum corpus of metalwork and to seek more creative ways of approaching and interpreting it rather than concentrating solely on compositional technology. Nonetheless, future analysis of other, unanalysed UK-based collections of southern Mesopotamian metalwork, as well as other unanalysed, non-UK-based collections, would further bolster the available body of data with which to work.

The contribution of examination, analysis and discussion of the metal assemblage from Tell Khaiber has made various important contributions. Firstly, in line with aim number three, it has furthered understanding concerning metal use and metallurgy at sites of the Sealand Dynasty, and how this material compares with other, potentially contemporary assemblages. Therefore, this works to expand current knowledge of both southern Mesopotamian metal use and metallurgy, as well as southern Mesopotamia during the Sealand Dynasty. The drastic difference in the nature of the Tell Khaiber assemblage in comparison to other extant bodies of material has led to further key contributions of the examination in this thesis being a much-needed counteraction in material coverage, and valuable insight into metal use and metalworking on various levels and from different contexts than have typically existed in previous research. As a small-scale site of rural administration, the analysis of this metalwork has provided a unique view of metalwork outside of large urban centres. The inclusion of various highly fragmentary and scrappy pieces of metal, as well as pieces of metalworking waste, has allowed the examination in this thesis to explore southern Mesopotamian metalwork at various points along its lifecycle. Finally, in line with aim number two, the analysis of this material in this thesis has demonstrated the vital importance of excavating smaller-scale sites and utilising a total-collection strategy. Overall, the examination of the body of metal from Tell Khaiber in this thesis provides important insights into a period and context of metal use and metalworking that is nearly entirely missing from previous literature. While the highly fragmentary nature of the assemblage limits analysis in some ways, it expands the breadth of our examination of southern Mesopotamian metal use in others.

The third aim has been met through the examination and discussion of both the legacy and the new data utilised in this thesis and presented in Chapters 5, 6, 7 and 8. Section 9.1 explores the main results drawn out in these chapters, providing a synthesis of the key interpretative conclusions of this thesis. The second aim has been met through the critical analysis and discussion throughout this thesis concerning previous research, excavation and recording strategies, and extant collections. Section 9.2 discusses the main conclusions to be drawn from this discussion, the wider implications and subsequent future directions.

9.1 Summary of Analysis and Interpretative Conclusions

During the initial overview of both the legacy data and the new data from Manchester Museum, the Ashmolean Museum and Birmingham Museum and Art Gallery in Chapter 5, general patterns concerning metal use were highlighted. In the legacy data, a clear preference for high-copper and arsenic bronze compositions is detected across the analytical periods of Akkadian, Ur III and Isin-Larsa. While tin bronze use is represented, it is less common than arsenic bronze. Tin bronze appears to have been used predominantly for vessels while arsenic bronze is preferred for tools and weaponry. These patterns alter slightly from the Old Babylonian period onwards, during which tin bronze use increased. By the Kassite period, all of the material is tin bronze, but this body is extremely small and therefore barely representative. The patterns found in the legacy data have provided a general backdrop against which to explore the new analyses and information from the three UK museums and the Tell Khaiber excavations. Far more importantly, however, interpretative discussion then progressed beyond these basics and into consideration of metal's lifecycle and the application of a materiality-based approach.

9.1.1 Museum Collections

In many ways, the material from the collections held at Manchester Museum, the Ashmolean Museum, and Birmingham Museum and Art Gallery fit well into the general patterns highlighted in the legacy data; this is unsurprising given so much of this material originates from Ur and comes from very similar contexts to those that dominate the legacy data. The object types fit within general object types found across 3^{rd} and 2^{nd} millennium B.C. southern Mesopotamia. Across each of the three collections there was a high prevalence of high-copper and arsenic bronze objects.

Variation was found, however, in the broad object types present in the collections. In the Manchester Museum collection, for example, the largest broad object category is that of jewellery. The Birmingham Museum and Art Gallery collection contained far more vessels than the other museum collections and far more than is found in the legacy data by proportion. There were also some compositional differences. There was also far less tin bronze found in the Manchester Museum collection than would be expected based on the legacy data. However, most of the Manchester Museum data is undated, and if it is in fact of Early Dynastic date, this level of tin bronze would fit those found across the Early Dynastic legacy data published by Hauptmann and Pernicka (2004).

Ultimately, while further analysis and examination of these collections significantly further current understanding about them, they also clearly demonstrate the selectivity and/or unrepresentative coverage of museum collections. Furthermore, these results emphasise that these smaller collections lend themselves more usefully to concentrated study and consideration of individual objects rather than examination of broad patterns. This approach was therefore utilised more fully in Chapters 7 and 8.

9.1.2 Tell Khaiber

The analysis and examination of the metalwork assemblage from Tell Khaiber and the accompanying relevant textual evidence have shed considerable light on metal use and metallurgical practices as a small-scale site of Sealand date. Exploration of these results demonstrates elements of significant continuity with the legacy data, but also key aspects of difference.

While the majority of the assemblage is too fragmentary to typologically evaluate, the more complete objects can be typed and do appear to fit broadly into the types commonly found across southern Mesopotamia. Indeed, some specific objects bear a particularly close resemblance to objects from other, potentially contemporary sites such as Ur, Larsa, Tell Harmal, Haradum and Failaka. It, therefore, appears that, despite these sites falling under different political control, there remains an apparent continuity in the metalwork types being used.

Compositionally there are more significant differences. In general, the high prevalence of high-copper composition fits with 2nd millennium B.C. Mesopotamian metalwork more generally, as demonstrated in Chapter 5. There is, however, a dramatically lower prevalence of arsenic bronze and tin bronze. This indicates that Tell Khaiber may have had far more limited access to tin, or at least that tin at this point was not being transported out to smaller sites as commonly. The low amount of arsenic bronze suggests that the copper being used at Tell Khaiber may have been from ores that are less rich in arsenic, or that arsenic-rich minerals were not being intentionally added. There is also more iron present at Tell Khaiber than at any of the other sites included in this thesis. While it is clear that the iron anklet post-dates the occupation of the Fortified Building, the other iron found at the site indicates that iron may have been experimented with at the site. The iron slag from a Kassite context at Tell Khaiber 2 further supports the presence of iron working in the region during the Bronze Age. Finally, the use of a silver-copper alloy for pins used as burial goods is reminiscent of the copper-gold-silver alloys uncovered from graves at Ur (Hauptmann *et al.* 2018), and of various other copper-gold-silver alloys previously explored in the legacy data.

It is clear that metalworking was taking place at Tell Khaiber, evidenced by the presence of chief smiths in the texts from Tell Khaiber, the metal slag found and the mould fragment. Although this is not evidence of large-scale metalworking, it is evidence that, despite its small size, Tell Khaiber was responsible for producing some metalwork, beyond simple repairs. This is particularly important in light of advancing current understanding of smaller-scale and more rural sites, particularly in terms of economic structure, relationship with larger sites, and local craft activities. The discovery of three pieces of metal which may be *matte* also indicates that metal was being transported in a semi-processed form.

Despite its small size, the metal assemblage from Tell Khaiber provides a multi-faceted and valuable insight into southern Mesopotamian metalwork in the mid-2nd millennium. If a more traditional collection strategy has been used at the site, the vast majority of this assemblage would never have been collected, recorded or analysed. Not only are these findings highly important in terms of progressing understanding, but they are also vital in illustrating the importance of a total collection strategy.

9.1.3 Alternative Approaches to Southern Mesopotamian Metalwork

Throughout Chapter 7 and 8, the body of material utilised in this thesis was explored using approaches that advance beyond a traditional focus on function and, instead, seek to interpret the available data in a more socially-focused and holistic way. As previous research into southern Mesopotamian metalwork has largely focused on very specific parts of the lifecycle of metal, in Chapter 7 I sought to explore the available material – archaeological, chemical and textual – across various key points along the full range of metal's lifecycle; from procurement to deposition. Despite the overwhelming majority of metal objects currently excavated from southern Mesopotamia deriving from burial contexts at Ur, the chapter still managed to delve into a variety of key topics through the adoption of a holistic approach to evidence usage. Perhaps most crucially, throughout this chapter, the evidence from Tell Khaiber was explored in greater depth in relation to the lifecycle of metal, and the results not only shed further light on metal use and metalworking at the site, but also clearly demonstrated the value in using a total collection excavation strategy.

While Chapter 7 strove to explore various elements of the wider context of southern Mesopotamian metalwork, delving into topics such as the social and symbolic value of different metal types and craft practices at different site types and potential aspects of autonomy in metalworking, Chapter 8 progressed further into consideration of wider social context by considering materiality-based, sensory and experiential aspects of metal-use and metalworking. Through the incorporation of textual sources and the application of interpretative approaches based on material qualities beyond function, key connections between colour and value, shine and divinity, and sound and power were explored and discussed.

Both Chapter 7 and Chapter 8 made clear metal's interweaving social, technological and cultural role, and the subsequent ability of the holistic study of metalwork and metallurgy to further elucidate a plethora of wider social, technological and cultural networks. In the introduction of this thesis, I quoted Philip *et al.* (1995: 119), who argue that without an adequate understanding of Mesopotamian metallurgical processes, assessment of the degree of interrelationship between patterns of production and distribution in the wider region is fundamentally hindered. I hope that this thesis emphasises the truth of this statement; not just due to the interconnecting economic and political connections of the ancient Near East, but because of the multi-faceted roles occupied by metal and metallurgy.

9.2 Directions for Future Research

A key aim of this thesis was to address fundamental issues with the extant material from southern Mesopotamia, and with traditional approaches to the collection, recording and analysis of southern Mesopotamian metalwork. The motivation behind this aim is to help inform future work, as changes in traditional approaches are imperative to the pursuit of a more advanced comprehension of southern Mesopotamian metallurgy and metal use. Important directions for future work that have been highlighted throughout this thesis and deserve further, direct discussion here can be divided into two key areas: strategies employed in the collection, retention and analysis of material, and theoretical and interpretative frameworks employed in the study of material.

9.2.1 Excavation Strategies

As outlined in Chapter 3 and demonstrated in more depth in Chapter 5, extant bodies of southern Mesopotamian metalwork are heavily skewed by the urban-bias and highly-selective collection and retention strategies traditionally employed in excavation. There is certainly further research to be done on extant metalwork collections from southern Mesopotamia, but it is vital that new material is generated to begin counteracting the skewed nature of previous assemblages. Throughout this thesis, I have sought to demonstrate the crucial limitations caused by the many flaws of extant bodies of metalwork; however, through the inclusion of the Tell Khaiber assemblage, I have also sought to highlight how different strategies to excavation can work to rebalance the skewed nature of extant collections and dramatically diversify metalwork assemblages, allowing them to represent a far wider range of different contexts of use.

The first major way in which future excavation can begin generating new material to counteract current issues is through the excavation of a more varied range of site types, including smaller-scale sites and sites of varying degrees of rurality. While previous urban-centric approaches have consistently positioned cities as central to the state and to understanding society, and designated smaller-scale rural sites with a passive political role, more recent research has emphasised instead the vital importance of better understanding these sites (see Banning 1996; Curvers & Schwartz 1990; Falconer & Savage 1995; Liverani 1996; Richardson 2005; 2009; 2010). In Chapter 7, the material from Tell

Khaiber was discussed in relation to previous concepts of core-periphery, and it was demonstrated that previous assumptions, particularly relating to the movement of materials and manufacturing of objects, are not supported by the evidence from the site. Instead, despite its small size, and non-central positioning, metalwork was taking place at Tell Khaiber. Texts from the site even evidence the presence of two chief smiths. Although this is only one example, it demonstrates that traditional core-peripheral models can be reductionist in their interpretation of inter-site networks and non-central craft activities. Rather than relying on central urban sites for manufactured goods, Tell Khaiber was responsible for at least some of their own. Not only will a greater focus on sites outside of urban centres help to rectify issues with extant metalwork collections, but it will also substantially improve our understanding of social, political, and economic networks beyond urban centres, and the true breadth and complexity of these networks within Mesopotamia as a whole (Richardson 2005: 282; Stein 2002: 901).

Another vital change necessary in future excavation relates to the types and extent of material that is collected, recorded, analysed and retained. Traditionally, the types of metal objects collected were reasonably well-preserved objects, typically of complete or near-complete condition. Objects that could not be typed and/or would not be of interest to museums for their collections were often not collected at all. As demonstrated in Chapter 6, the use of a strategy of total collection at Tell Khaiber produced an assemblage that encompassed a large amount of fragmentary, scrappy objects, and even metalworking waste, as well as the more typically collected near-complete or complete objects. Subsequently, the assemblage spans a range of different contexts of use and deposition; a drastic difference from the grave-good heavy contexts of previous metalwork assemblages. These highly fragmentary and scrappy pieces of metal are perhaps more representative of the types of composition most commonly in circulation than the objects from grave contexts. The collection and analysis of apparent waste products from metalworking also allow for further information to be gathered concerning metalworking at southern Mesopotamian sites.

It has previously been highlighted in Chapter 3 that another key issue is the lack of archaeometallurgical expertise on excavations, or utilised through consultation following excavation. Commonly, metalwork is traditionally recorded by small-finds specialists rather than an archaeometallurgist during Mesopotamian excavations. Similarly, in excavation reports and other subsequent publications, sections on the metal evidence are typically written by directors or small-find specialists rather than metalwork specialists. The lack of archaeometallurgical specialism on excavations undoubtedly influences what material is deemed useful and important, and what is not. It also significantly impacts the way in which material is recorded. As the metalwork unearthed cannot generally be taken outside of Iraq, and only a proportion of it will be retained in Iraqi museums, the lack of archaeometallurgical expertise on-site working hands-on with material undoubtedly influences how in-depth and nuanced understanding of the material can be. While it may not be possible for all future Mesopotamian excavations to include an archaeometallurgist on their team, the use of a total collection strategy would, at least, result in a much wider body of material collected and documented; the records for which can then be sent for specialist archaeometallurgical study.

Finally, also highlighted in this project, is the value of portable forms of compositional analysis such as pXRF that allow for rapid analysis of material on-site. The use of this technology during excavation in Iraq allows for the analysis of material which, of course, cannot be taken out of the country. While much of the material unearthed, including metalwork, is retained by the Iraq Museum, not all metalwork and metalworking-related evidence is and can be. By ensuring all material is collected, fully recorded, photographed and, ideally, analysed, it is still possible for a rich body of data to be acquired regardless of the inability to retain all material.

Ultimately, while these suggestions for future changes in approaches to excavation and strategies employed will improve the diversity and quantity of material, as well as its ability to more adequately represent everyday use patterns and compositions, each of these is also vital to improving overall understanding of various other material types, and southern Mesopotamia more broadly.

9.2.1 Theoretical and Interpretative Frameworks

The second important direction for future work relates to the theoretical and interpretative frameworks employed in the study of material. As outlined in Chapter 3, previous research into southern Mesopotamian metalwork has long adopted traditional approaches rooted in processual theoretical frameworks that have emphasised function, typology and broader economic patterns. Subsequently, previous work has severely lacked examination of metalwork within its social context, and with more nuanced consideration of the human role in metallurgy and metal use.

Within this thesis, more traditional approaches to data interpretation and metal-type categorisation were utilised in Chapter 5. As demonstrated, these more conventional methods and approaches, which typically focus on larger-scale patterns, divisions of material by period, and categorisation of metals by traditional compositional ratios can provide an informative examination of the material; however, through their use, it also becomes clear that they are flawed in their ability to draw out more specific, smaller-scale patterns, to explore individual artefacts in a meaningful way, and to provide an understanding of metal usage and metalworking that is not heavily influenced by top-down interpretations built on modern understandings. Subsequently, in Chapters 7 and 8, alternative methods of approaching the material were explored. As discussed above, examination of the material utilised in this thesis in light of frameworks concerning object lifecycles and materiality has facilitated discussion of more nuanced, socially-focused, bottom-up interpretations. Nevertheless, there remains significant opportunity to delve into both extant and future bodies of southern Mesopotamian metalwork using a similar vein of interpretative approaches.

In addition to theoretical and interpretative frameworks, it is also crucial to emphasise the importance of future work utilising a holistic approach to the study of southern Mesopotamian metalwork; an approach which I hope this thesis has demonstrated to be of particular value and opportunity. The holistic approach utilised in this thesis exists on various planes. In line with recent theoretical and methodological developments in the realm of archaeometallurgy more broadly, this thesis has employed an approach which combines scientific analysis, archaeological interpretation and anthropological theory (Thornton 2012: 175). It is important that the subject of southern Mesopotamian archaeometallurgy, and, indeed, Mesopotamian archaeology more generally, more actively engages with recent theoretical and methodological developments. Future archaeometallurgical work must seek to advance beyond a strong focus on data generation, and strive more fully towards combining scientific analysis with archaeological interpretation and social theory.

The interpretative frameworks utilised in this thesis also strive towards a more holistic understanding. In Chapter 7, the framework of objects' lifecycles was explored as means of pursuing a more holistic understanding of the southern Mesopotamian metallurgical industry and the social role of metalwork that, rather than focusing entirely on finished objects, considers the wide scope of metallurgical processes and metal use. In Chapter 8, exploration utilising a materiality-based approach was conducted in pursuit of providing an understanding of metalwork from an experiential perspective; a vital aspect of archaeometallurgical study.

Finally, this thesis has adopted a holistic approach to evidence type, utilising not only archaeological and scientific evidence but also including textual evidence. There needs to be a greater emphasis in future work on integrating textual sources in the study of Mesopotamian metalwork beyond simply investigating source zones and manufacturing recipes. More work needs to be focused on the social and symbolic attitudes towards metal. There also needs to be a greater exploration of metalworkers in the texts. That there is likely to be limited data available should not mean that this avenue of research is dismissed; small amounts of information are necessary to build slowly towards a greater understanding further down the line. With up to 90% of the cuneiform tablets available still unanalysed, there inevitably remains a vast amount of potential new information on Mesopotamian metal and metallurgy to discover and ultimately utilise alongside archaeological evidence (Chen 2021: 193). Despite this, there is still a great deal of valuable content relating to metal in analysed texts but it has yet to be more extensively integrated into archaeological research.

Ultimately, while this thesis has contributed an expansion of available material and compositional data and its further examination and interpretation in light of interpretative frameworks inspired my recent broader theoretical developments, this project is also valuable in its role as an important and necessary stepping-stone, seeking to move and progress the study of southern Mesopotamian metalwork by offering a critical evaluation of current practices and approaches, identifying vital ways in which these need to be adjusted, and demonstrating how successful application of different approaches can be highly fruitful. With greater and more conscious consideration of metalwork and key changes to excavation strategies and interpretative frameworks, the field of southern Mesopotamian metalwork stands to be considerably reinvigorated, providing it with the ability to finally achieve a much more comprehensive, socially-informed understanding of metal use and metallurgy.

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Appendices

Appendix A

https://figshare.com/s/727e5f92f2124ea0758e

Appendix B

https://figshare.com/s/fe3201770a3fa4422189

Appendix C

https://figshare.com/s/a70670cec772b850a7a1

Appendix D

https://figshare.com/s/28abeead45ab62e85a81