University of Sheffield

Early Medieval Copper Alloys Dress Accessories in the Kingdom of Lindsey

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Abstract

Copper alloy objects are some of the most prominent material remains from the Early Medieval period in England, and are most frequently found through metal detecting. However, due to the decontextualised nature of their discovery, metal detected objects are often overlooked by analytical academic studies. This research addresses this imbalance, and demonstrates the potential of metal artefacts recorded by the Portable Antiquities Scheme in further scientific analysis. This thesis establishes a chronology for Early Medieval object types within the the former Kingdom of Lindsey, a region that traditionally has been largely understudied archaeologically.

Focusing primarily on objects recovered through metal detecting, but also supplemented by those found on selected excavations, this thesis presents a pXRF survey of 293 Early Medieval copper alloy items of personal display as well as some additional material, ranging in date from the Early Saxon period to the Second Viking Age (c. 450-1100 AD). This survey is the first detailed scientific study of its kind, and the only one to focus on metal detected finds from Lincolnshire.

The thesis establishes both a chronological overview of the broad changes occurring within copper alloy compositions and explores whether these changes were connected to concurrent Early Medieval socio-political developments. Questions are raised relating to metal supply, recycling, and cultural influence on production. In particular, the analysis has highlighted a significant decrease in the use tin within the alloys, whilst the inclusion of lead increased over the course of the study period. This thesis explores the possible circumstances surrounding production traditions in Lindsey that may have resulted in such a change, whilst highlighting the role that the Portable Antiquities Scheme can play in future scientific analysis of archaeological metals.

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In addition to the staff at my university a special thanks to those who assisted me in acquiring finds to scan and detectorists willing to lend me their treasures. Specific thanks to Adam Daubney (formerly PAS), Rose Nicholson (North Lincolnshire Museum) and Lisa Brundle (PAS). Additionally, many thanks are owed to the detectorists who loaned me material, in particular Tim who detects around Osbournby and contributed about 1/3 of the overall dataset! The detectorist Yoda also deserves recognition for teaching me detecting practices and little tricks of the trade that are unknown to many archaeologists.

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Chapter 1. Introduction

Jewellery is, above all things, a mirror to life itself. It reflects the sense and beliefs, the skill, the leisure and material comfort and the aesthetic taste of its makers and owners and helps us to place them in their proper perspective in the general historic scene. It is moreover an exact and particular guide to the state of trade and commerce, to the spread of ideas and the trend of fashion, a criterion even of the nature and extent of folk movement and of the survival of ancient cultures. Its distribution and use may mark, still more, the incidence of peace and war. It is, with truth, a footnote to history.
(Jessup, 1974, 17)

1.1. Project Outline

Copper alloy artefacts, particularly dress accessories, have been a focus of study for scholars of the Early Medieval period for the past several decades and even centuries (Kershaw 2013; Thomas 2000; Martin 2011, 2015; Williams 1997, 2007; Bayley 1991, 1992, 2008; Mortimer 1991, 1993, 1996; Ross 1991). To date, research into dress accessories has often taken the form of site-specific (Mortimer 1993) or single-object type studies (Wilthew 1984). Very few have attempted to look at large-scale change over the entire Early Medieval period, or even between different object types. Nonetheless, extensive research from other periods demonstrates it is possible to achieve significant results from a more holistic study (e.g. Dungworth 1995).

This thesis is an archaeometallurgical and stylistic study of Early Medieval copper alloy artefacts. At its core are the interpretations of compositional analyses, and the correlation between object types, styles and their associated social groups. The research examines metalwork from Early Medieval Lincolnshire, principally dress accessories and other personal effects along with a limited range of production evidence, to provide new insights into copper alloy production, design and its impact on Early Medieval society and economy.

Over the last 20 years, metal-detected finds reported to the Portable Antiquities Scheme have transformed archaeologists' understanding of Early Medieval England, as thousands of metalwork items (including coins, jewellery, dress accessories, ingots) have been recovered and recorded. In particular, a significant quantity of items have been reported that reveal evidence of Scandinavian interaction (Kershaw 2013, 8). This influence is especially prevalent in areas of eastern England, where the Scandinavian contact and settlement was densest and where agricultural practices render metal detecting a particularly popular undertaking. This is significant, as an identifiable Scandinavian presence is often absent archaeologically in England, in stark contrast to the abundance of the metal-detected evidence. Therefore, the addition of these recently found metal-detected items allows for a complete chronological picture of the Early Medieval period, whereas previously most Early Medieval dress accessories came from excavated Early Saxon cemeteries and Mid-Saxon production sites (Thomas 2011, 3–8). This new material creates an excellent opportunity for new research on material derived from a broader range of contexts.

In addition to these past discrepancies in the excavated record, there are similar research inconsistencies regarding object types that have been the traditional focus of study. While coinage and ingots have been extensively studied as representative of manufacturing processes, economic activity, and political ambition (see Blackburn 2002, Williams 2016, Graham-Campbell and Williams 2007, Archibald and Cook 2001), the insights to be gained from the analysis of dress accessories and jewellery have been less extensively explored, especially production (Fleming 2012; Mortimer 1990; Oddy 1983). Some exceptions have been the work of Gabor Thomas (2000), Kevin Leahy and Caroline Paterson (2001) and Jane Kershaw (2010), who have all commented on aspects of social identity based on the stylistic attributes of this metalwork.

1.2. Aims and Objectives

This thesis is an analytical study of Early Medieval dress accessories from the Kingdom of Lindsey. Using both stylistic and portable X-ray fluorescence (pXRF) analysis, it explores the complex and evolving relationship between object compositions, forms, styles and cultural groups, from the later 5th to the 9th century AD. In total, 293 dress accessories from both metal-detected and excavated sources have been studied to provide stylistic and semi-quantitative compositional data that is then used to discuss the items in their broader cultural context. Further questions related to metal use, recycling, production and cultural variation are also explored.

The thesis has two key aims. The first is to establish a basic compositional chronology for Early Medieval Lindsey. This is a region comparatively understudied when compared to other nearby areas such as Yorkshire and Norfolk, yet rich in material evidence, making it an ideal focus for a case study. Additionally, an overview such as this has yet to be done for either the Early Medieval period or for Lindsey. This basic overview of compositions will allow for further study into copper alloys during the Early Medieval period and enable research such as that of the second aim. The second aim is to answer whether changes in metalwork (both compositional and stylistic) are connected to socio-political changes in Early Medieval Lindsey.

To achieve the aims above the 293 Early Medieval copper alloy dress accessories and objects of display were analysed using the pXRF. As objects were analysed records were kept of the Early Medieval subperiod as well as the object type and style (working within pre-established stylistic frameworks). Compositional analysis focused on studying the variation in tin, zinc, and lead and their roles as alloying materials in copper alloys throughout Early Medieval Lindsey. These typological and compositional data were then cross referenced to establish a timeline of compositional changes over the Early Medieval period. Following a comprehensive overview of the compositional changes in Lindsey, they are compared to other known Early Medieval compositional trends, where possible. These changes are then discussed in conjunction with significant shifts in the socio-political and economic situation within Lindsey to gauge the level of impact on the copper alloy production process.

The outcomes of this research are first to establish the compositional changes that occurred to copper alloys during the Early Medieval period; this is primarily seen as a decrease in tin content and increase in lead content within the objects. By looking at these changes the impact of external socio-political factors is explored. An additional outcome is the placement of Lindsey in the larger context of Early Medieval production, showing Lindsey as possibly disconnected from the rest of the North East.

1.3. Thesis Format

The results obtained for this thesis are presented over four appendices. The analytical results in their cleaned up form can be found in Appendix One. The scaled factor and supplementary data, such as style and ascribed cultures, can be found in Appendix Two, and the data of the standards used can be found in Appendix Three. Lastly, Appendix Four contains the raw unedited data and can be found in a separate file.

Chapter Two focuses on the metallurgical background and covers the archaeological evidence for copper alloy production in the Early Medieval period, as well as previous compositional studies. From there it moves on to aspects of metallurgy, such as metal structure and corrosion, before concluding with the production process.

Chapter Three focuses on the issues of metal recycling and alloy resources, building on the previous chapter. The evidence for the production and acquisition of materials is discussed before outlining the specific metallurgical requirements for successfully alloying the relevant materials. Following that, theories of remelting thermodynamics are discussed, leading to the proposed model of understanding recycling patterns.

Chapter Four provides an overview of the specific methodology employed in this research including the semi-qualitative pXRF parameters and development of the methodology, as well as the working procedure of the data collection process.

Chapter Five discusses important background theoretical aspects, including identity, migration and craft production and consumption, necessary for interpreting the data and forming discussions based upon the results.

Chapter Six consists of a stylistic and typological overview of material from the Early Medieval period to contextualise the results.

Chapter Seven explores the compositional data, first by providing an explanation of the sampling procedure and the material analysed, before dividing the data based on its composition of tin, zinc and lead.

Chapter Eight outlines the key results drawn from the data in the previous chapter. This chapter divides the material chronologically, and then by object, to study each sub-period in more detail.

Chapter Nine explores the new dataset presented in this study and compares it to wider Early Medieval copper alloy data, how the results it yielded provide new interpretations of the material as well as the fresh questions surrounding copper alloy use, reuse and variation across objects, time and cultural groups within Lindsey.

Finally, Chapter Ten discusses the implications of this new research and data within the Early Medieval copper alloy corpus and how this can further be used to explore new areas of research.

1.4. Historical Context

The East of England underwent significant political and economic changes throughout the Early Medieval period. This thesis argues that these rapid and monumental changes had major repercussions on non-ferrous metal production and stylistic design of materials. The region transitioned from a decentralised economy in the late 5th–6th centuries to one that became increasingly centralised in the 7th century as a result of political developments and the rise of ecclesiastical power. This was followed by further social and economic upheaval with the arrival of the Vikings and the influence of a bullion economy. This section will explore those shifting political boundaries and their potential economic repercussions to better illustrate how these changes could have affected the composition of non-ferrous copper alloy production. This discussion will begin with Late Roman Lincolnshire to ensure understanding of the effects of the Roman withdrawal in England on Lindsey. This will then be followed by a discussion on Anglo-Saxon Lindsey, exploring the numerous political boundary changes and the spread of Christianity, before discussing Lindsey as part of the Danelaw.

Figure 1-1 Map showing location of Lindsey, edited from Foot 1993, 138

1.4.1. Late Roman Lindsey

Lincolnshire was a northern part of the Roman *Civita Corieltavorum,* with Leicester serving as its capital. Lincolnshire itself contained numerous settlements and forts (Figure 1-2), the biggest of which was modern-day Lincoln or *Lindum Colonia*. A Roman *Colonia* was a city that was primarily established as a colony for retired soldiers. *Coloniae* were associated with high status and prestige occupation, and by the end of the Roman period *Lindum Colonia* was one of only four Bishop's seats in the province, being occupied by Bishop Adelphius in the 4th century (Green 2019, 25). During the 4th century, many Roman towns experienced a decline in prominence, but *Lindum Colonia* was still at its peak; excavations have revealed continuous occupation through the 4th century, including the large-scale dumping of butchered animal bone. However, by the last quarter of the 4th century there is the first substantial evidence of population decline, with buildings decreasing in scale. This pattern continued into the 5th century and likely coincided with the end of coinage and official support from Rome around c. 410 AD (Green 2019, 27).

There is evidence suggesting that the Roman utilisation of the low-lying areas of Lincolnshire consisted of heavy exploitation of natural resources, with the exception of areas within the Eastern Wolds (Green 2019, 27). This is based upon the concentration and distribution of Romano-British material found spread throughout the rural areas that surrounded *Lindum Colonia,* which included not only portable material culture such as potsherds, but also structural evidence of a Roman presence such as villas (Green 2019, 27). Roman material is also found concentrated in the limestone uplands in both northern and southern Lindsey. Evidence of occupation in both rural settings, and in the *Lindum Colonia,* significantly declines in the 5th century. Green (2019, 27–28) suggested that evidence of occupation may be eluding archaeologists primarily due to a lack of datable materials, especially if no contemporary coinage was in circulation, which has long been used to assist in establishing typologies for other materials (Green 2019, 28).

Economy and Copper Alloy Production in Roman Britain

Recent scholarship (Gerrard 2016) has seen late Roman Britain to be a predominately agricultural economy. Evidence from the Kingdom of Lindsey is rare, so it is necessary to look elsewhere in Britain for evidence, such as to Castagore, Somerset, where the finds assemblage comprised coins, agricultural tools and faunal and floral remains, establishing the settlement as a farming community – a pattern reflected at similar excavated settlement sites across lowland Britain (Gerrard 2016, 854). While copper alloy objects recovered in Roman Britain are plentiful, the evidence for copper alloy production within Britain is sparse. Evidence mainly consists of moulds, crucibles and casting debris (Dungworth 1995, 63). It is worth noting that known workshops are limited to Verulamium (Frere 1972), Catterick (Wilson 2002a, 2002b), York (Ramm 1976), Heronbridge (Hartley 1954) and Caerleon (Zienkiewicz 1993).

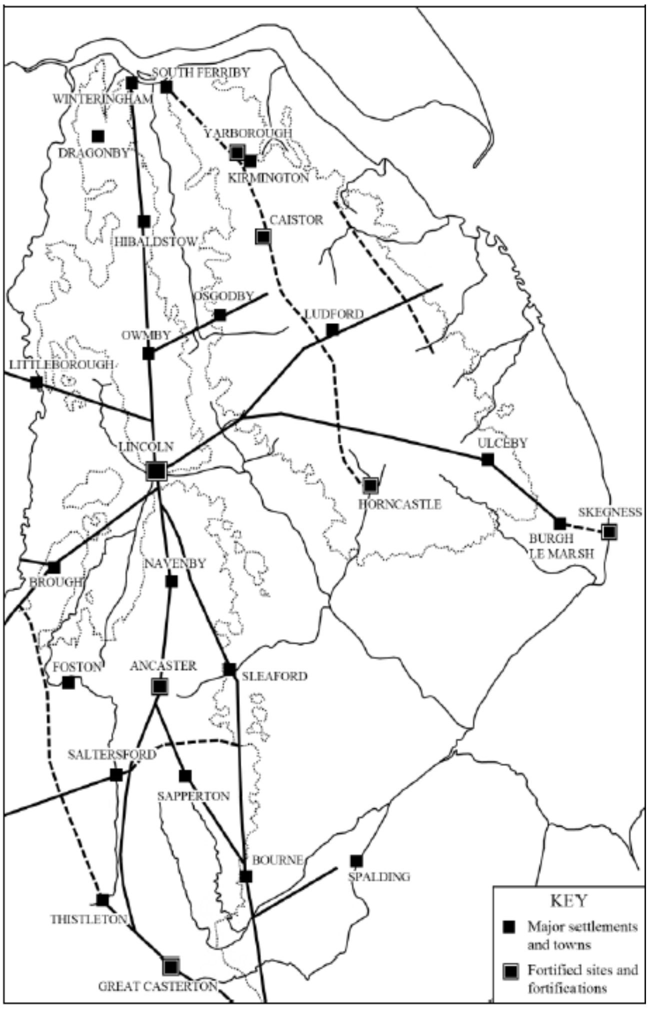

Figure 1-2 Roman Lincolnshire, showing the major settlements and road-routes in the region against the modern coastline. From Green 2019, 31

Continued Impact of Roman Infrastructure

As part of Roman Britain, Lincolnshire was a prosperous region, containing fortified towns, such as Caistor, and both a provincial capital and a bishop's seat in Lincoln. Additionally, the surrounding landscape was densely settled by villas and farmsteads and was heavily exploited for natural resources (Green 2019, 32–33). Excavation has revealed signs of abandonment in the buildings in Lincoln following the Roman withdrawal from Britain, and similar patterns can be seen across the region (Green 2019, 34). However, there is evidence for continued activity in settlements across Lincolnshire, at locations such as Deepdale, South Ferriby and Kirmington (Green 2019, 34). What seems to have occurred with the withdrawal of the Roman army is the collapse of the established market economy, taking with it the mass production of many material goods, which in turn led to the adoption of localised production (Green 2019, 36). The new scaled-down production often renders settlements archaeologically 'invisible' due to the drop in material remains, especially pottery and metalwork (Green 2019, 36–37).

The continued impact of the Romans on the later political geography of the East of England is still largely debated. The prime method for establishing the extent of the Roman legacy is through the distribution patterns of material culture (Figure 1-3). Using such observable patterns, Green (2019, 93) has suggested that the boundaries of former Roman provinces were still in use as political units and shaping the formation of 5th century Anglo-Saxon settlements. Therefore, by the later 5th century, two main points can be taken from the impact of the Romans. First, there was a relocation of industry from urban centres or villas to localised craft workshops, which operated on a much smaller scale. Second, the political boundaries established by the Romans continued to be used, or at least respected to some degree, in the century following the Roman withdrawal. Perhaps most important of these points was the shift of centralised production away from urban centres to more dispersed settlements, one which can be expected to have caused changes in the copper production process and resulting metal compositions between the Late Roman and Early Saxon periods.

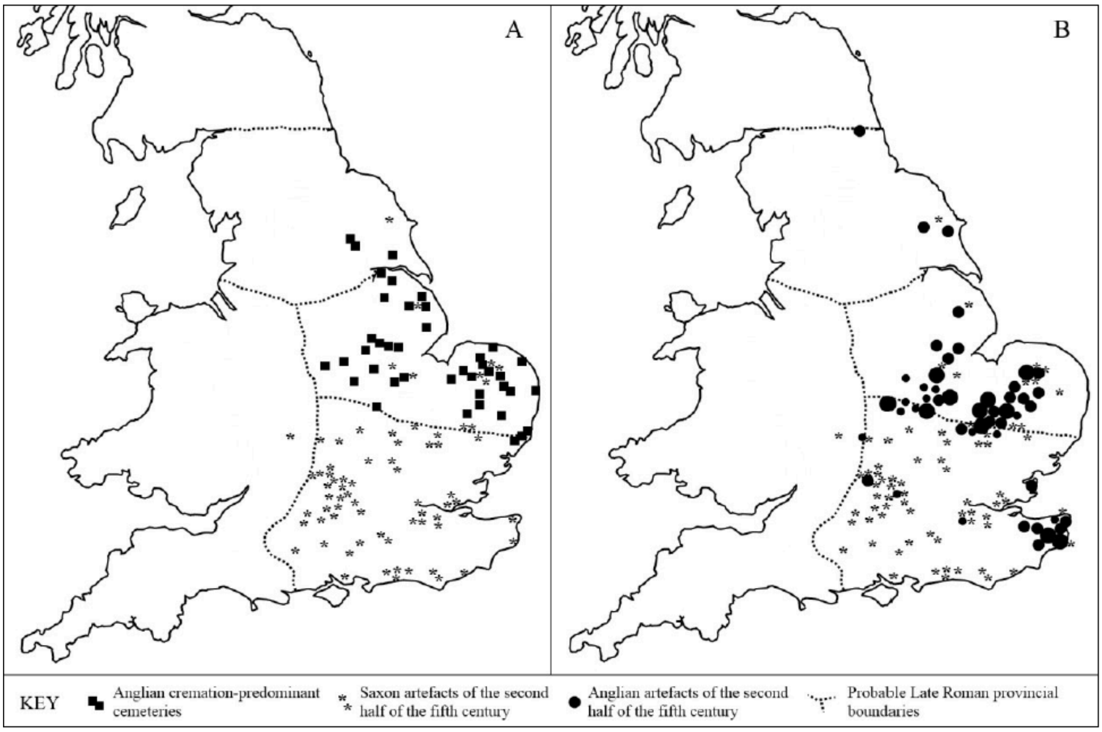

Figure 1-3 The distribution of Anglian archaeology plotted against the probable Late Roman provincial boundaries. The maps plot, respectively, Anglian cremation-predominant cemeteries and Anglian artefacts of the second half of the 5th century against Saxon artefacts of the same period. From Green 2019, 94–95

1.4.2. Anglo-Saxon England

The period following the Roman withdrawal in Britain was one that saw the migration, both peaceful and otherwise, of Germanic people throughout the 5th century. Both the size of this immigration and the potential displacement of the Britons are widely debated (Lucy 2000, 177; Dark 1994, 217). By the 6th century, dress accessories show that the Anglo-Saxon style of dress had been adopted across central and eastern England (Hines 1994, 50). It has been argued that the Anglo-Saxon lifestyle was particularly suited to the post-Roman landscape, as it filled the need for self-sustaining agricultural practices (Baker 2013, 5). In this new post-Roman world, long-distance trade also slowed and the focus was on local and regional trade, which likely would have significantly impacted access to copper, tin, zinc and lead. Many of the new styles of artefacts are believed to reflect the influence of migration rather than trade (Lucy 2000, 15), but by the 6th century there is evidence of the minting of silver coins, suggesting that trade was starting to increase and expand once again (Kelleher 2013, 251). Fleming (2012, 29) highlights the desire for 'exotic commodities' in the Early Saxon market that would then be expressed through personal dress and display.

During the 6th century, seven main kingdoms began to coalesce: Kent, the East, South and West Saxons, the East Angles, Mercia, and Northumbria; see Figure 1-4 (Arnold 1997, 208). These rising powers occupied contiguous zones and often competed for land and resources, leading to larger kingdoms annexing smaller ones (Arnold 1997, 209–211). Royal genealogies

Figure 1-4 Post-Roman Britain in the 7th century, showing both the British and Anglo-Saxon kingdoms. From Green 2019, 39

are often used to trace the pattern of kingships and their kingdoms from the Early to the Mid-Saxon periods. Many of the elites of these areas established lineages that dated back to the Germanic migrations from Northern Germany, Denmark and Holland that occurred almost immediately after the end of Roman Britain. However, they must be viewed critically as they could also be evidence of kings attempting to establish legitimacy through invented historical narratives (Green 2019, 38).

At the same time, there was an increase in the occurrence of weapon deposition in male burials, which is often seen as evidence of the high social status of warriors in Early Saxon society (Higham and Ryan 2013, 128). However, not all individuals buried with weapons were warriors, but instead used weapons as status symbols, highlighting the importance of metalwork (Higham and Ryan 2013, 128). By the 7th century, there was a general decline in in the widespread use of grave goods, with the exception of occasional 'princely' or 'Final Phase' burials, which have been considered as signs of the early stages of conversion to Christianity. It is entirely possible that the overall decline in the use of grave goods would result in objects, and therefore styles, staying in circulation for longer than previously seen (Higham and Ryan 2013, 129).

The earliest record of conversion to Christianity is King Æthelberht of Kent by Augustine in 597 AD; however, after both of their deaths missionary work struggled in England. The next prominent conversion is that of King Edwin of Northumbria in the 620s AD by Paulinus, and again after Edwin's death the Roman mission slowed. In the mid-630s AD, King Oswald introduced the Insular Irish tradition of Christianity to Northumbria after being in exile at

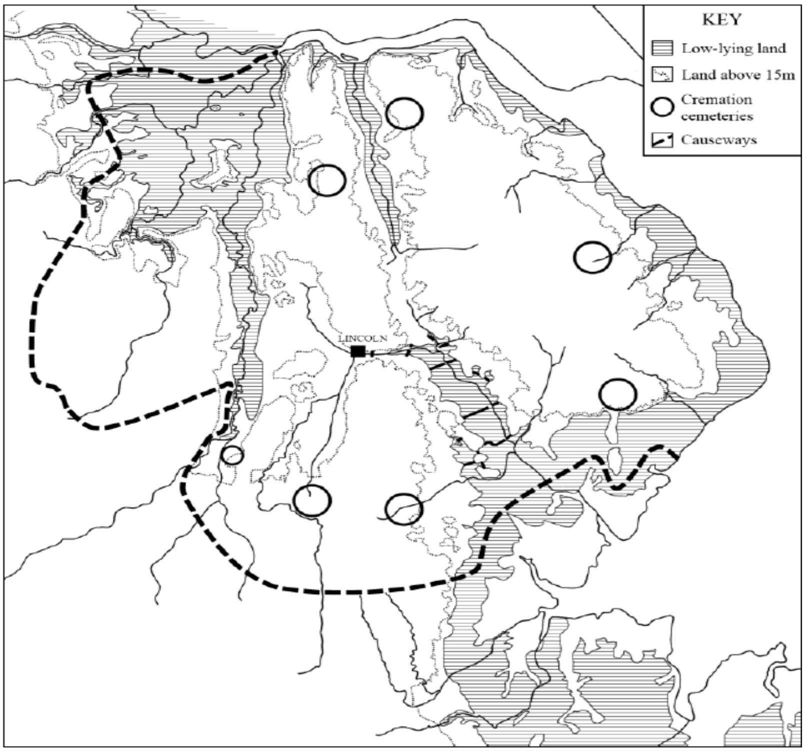

Figure 1-5 The suggested boundaries of the Anglo-Saxon kingdom of Lindissi, on the basis of Green's argument (2019, 128–36). Also shown are the major cremation cemeteries of Anglo-Saxon Lincolnshire and the causeways across the Witham valley. From Green 2019, 137

the monastery of Iona. This divide between the two traditions of Christian practice would continue for much of the Early Medieval period (Higham and Ryan 2013, 153). Conversion to Christianity is often framed as being advantageous to the Anglo-Saxon kings, allowing them to encode laws and raise taxes due to the literacy that accompanied the religious, while also providing new alliances and stratified relationships within the elite (Higham and Ryan 2013, 156–157). During the 7th century, many kings were 'reinventing themselves' along Roman political lines and establishing dioceses in subordinate kingdoms, creating ecclesiastical centres and new power foci for royal control. Furthermore, centralisation of the church and royal power likely resulted in production also becoming more centralised (Higham and Ryan 2013, 158).

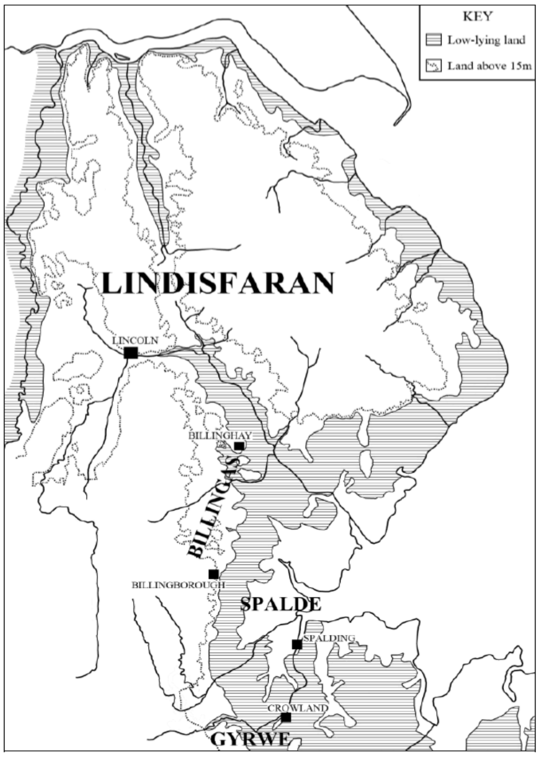

Figure 1-6 Map from Green (2019, 42) showing population groups in Lincolnshire

In the 8th century, there was an increase in the power of the Kingdom of Mercia, most notably under Æthelbald and Offa, due to their ability to control the changing economy and focus on the importance of long-distance international trade (Higham and Ryan 2013, 182). By the end of Offa's reign (757 AD), Mercia stretched from the Midlands to the southeast coast; indeed he had considerable influence beyond the boundaries of the kingdom (Higham and Ryan 2013, 187). In the early 9th century, Mercian dominance started to wane as both Kent and East Anglia gained independence, the Kingdom of Wessex grew in power, and Viking raids soon began (Higham and Ryan 2013, 192). To provide further insight, details of Anglo-Saxon Lindsey will now be outlined in the context of this wider political landscape.

Anglo-Saxon Lindsey

The southern border of Lindsey was likely located at The Wash and extended up to the Humber Estuary; see Figure 1-5 (Green 2019, 137). However, as Lindsey was consistently absorbed by larger kingdoms, this boundary was not fixed. Eventually, the southern regions of Kesteven and Holland were integrated into Mercia, and much of the northern area became part of Northumbria (Foot 1993, 133–136).

The documented lineages provide a genealogy for the kings of Lindissi (Lindsey), suggesting that it was an independent kingdom and not under the control of its larger neighbour, the Kingdom of Mercia, up until the late 7th century at least (Foot 1993, 129–133 and Green 2019, 130). This suggestion is further supported by the record of Lindsey having its own bishop (Foot 1993, 136–137). Bede, writing in the 730s AD, describes Lindsey as an independent kingdom and uses the term Lindisfaran to describe the people inhabiting Lindsey, as distinct from the surrounding kingdoms. In addition to the Lindisfaran, there were three other population groups mentioned by name that inhabited the study region; see Figure 1-6. The Billingas occupied the area of modern-day North Kesteven, the Spalde were located in the Fens at Holland and the Gyrwe lived in modern-day southern Lincolnshire and northern Cambridgeshire. The 7th century saw a re-emergence of densely populated landscapes and high levels of regionally distinct material culture, perhaps aligning with these different groups (Green 2019, 40–42).

Further evidence shows that Lindsey underwent constant political turmoil during the Early Medieval period. As stated above, Lindsey was an independent kingdom until the start of the 7th century (Foot 1993, 129–133, 136–137). However, according to *The Anglo-Saxon Chronicle*, by 620 AD Lindsey had been absorbed into the Kingdom of Northumbria, until 642 AD when Northumbria split into the kingdoms of Deira and Bernicia (Foot 1993, 129–133, 136–137).

Following the division of the Kingdom of Northumbria, the territory of Lindsey appears to have been annexed by King Penda of Mercia, taking advantage of the political situation (Savage 1983, 65). When Penda died in 655 AD, King Oswiu of Deria was able to take advantage of the ensuing power vacuum and take over the southern kingdoms, although shortly after becoming part of the Kingdom of Deira, the southern parts of Lindsey returned to Mercian control. It is unclear how this land transfer occurred, but Bede, writing in the *Historia Ecclesiastica*, stated that in 669 AD Wulfhere of Mercia granted land to Bishop Chad at the monastery 'æt Bearuwe', which is widely accepted as Barrow-upon-Humber (Colgrave and Mynors 1992, IV, 3).

By the 670s AD, there is some evidence that Lindsey went back to being under the control of Northumbria. However, this was short lived, as in 679 AD Æthelred retook Lindsey for Mercia, and Lindsey remained under Mercian control until it was absorbed into the Danelaw (Savage 1983, 111–115). During the 8th century, Mercia experienced relative peace due to the stability established by kings with longer reigns, such as Ethelbald (716–757 AD) and Offa (757–796 AD) (Nelson 1997, 39). However, upon Offa's death Mercian dominance in the region began to falter. There is also further evidence that Kesteven and Holland were likely consistently part of Mercia during this constant border change, so it was not the entire territory of Lindsey that was constantly being disputed (Foot 1993, 133–136).

As a result of this constant political turmoil, Lindsey is often overlooked as being a distinct kingdom (Buckberry 2004, 53). Furthermore, new research is beginning to show that there is significant regionality within Lindsey itself, a key reason the territory was selected for this thesis. There is consistent written evidence that, even though Lindsey was under the control of either Mercia or Northumbria from the early 7th century, it was still considered a distinct entity throughout this time. The early-8th-century 'Life of Gregory', the mid-8th-century 'Acts of the Council of Clofesho', and Asser's 'Life of King Alfred' in the 9th century all mention Lindsey (Green 2019, 58). Throughout the political turmoil, Lindsey continued to be a prominent location for ecclesiastical powers with a continuous line of bishops, perhaps the most significant of which, Cyneberht c. 729–731, built a cathedral in Lincoln (Colgraves and Mynors 1992, V, XXIII).

The movement towards greater political and ecclesiastical centralisation during the 8th and 9th centuries affected craft production. The excavated royal and monastic complexes, such as Tamworth, Hereford, Hoddom, Higham Ferrer, Droitwich and Ramsbury (Hinton 1990, 44; Lowe 2006; Hardy et al. 2007; Haslam et al. 1980) provide new evidence for production and inform the discussion around Early Medieval craft production. There is evidence for numerous centres such as these in Lindsey, yet few have been excavated; see Figure 1-7. Where excavation has taken place at such complexes, these have revealed an increase in infrastructure and centralisation of production and a variety of technologies. The increase in political centralisation and craft production saw a substantial increase in the standardisation of dress accessories and styles, as opposed to the very regional styles seen in the previous centuries, and it might be expected that similar patterns would appear in the copper alloy metallurgy (Thomas 2011, 412).

According to the Anglo-Saxon Chronicle, the first Scandinavian attack on Lindsey occurred in 841 AD as part of multiple raids going as far south as Kent (Savage 1983, 92). There was an apparent pause in raiding on the English coast until the arrival of the Great Viking Army in 865 AD, led by Ivar the Boneless (Keynes 1997, 54). In 869 AD, East Anglia fell to the

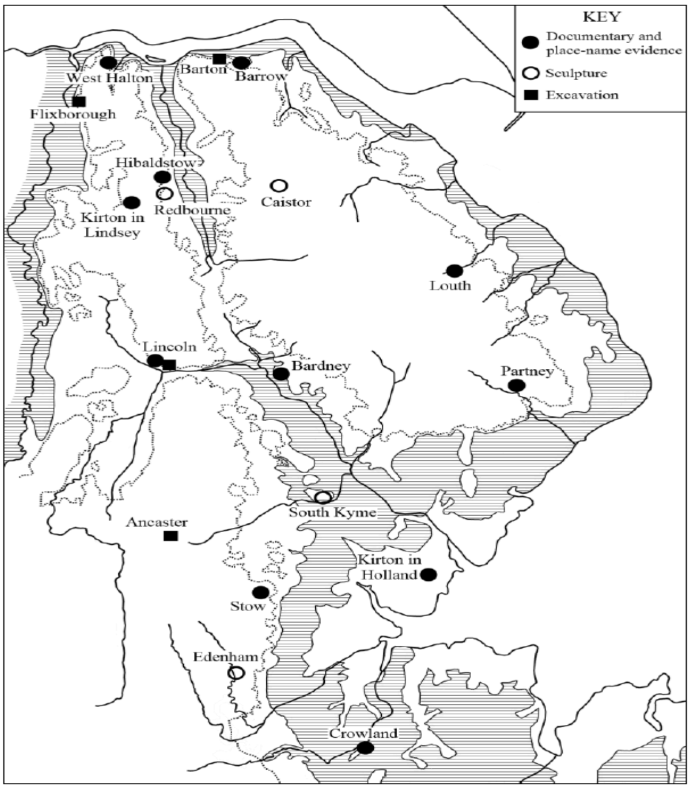

Figure 1-7 Evidence for pre-Viking ecclesiastical centres in Lincolnshire. From Green 2019, 47

Great Viking Army when they moved north. The Great Viking Army marks a shift in the Viking campaigns from raiding to establishing settlements. This began as 'wintering over' and is well recorded at the Viking Camps of Torksey and Repton (Savage 1983, 57). The Great Viking Army regrouped under Guthrum, who was able to unite the Scandinavian 'kingdoms' of York and East Anglia, and continued to push southwest, only to be defeated by Alfred at the Battle of Edington (White and Notestein 1915, 2). This defeat led to the Treaty of Wedmore in 878 AD, followed by the later formal Treaty of Alfred and Guthrum, which divided up the kingdoms in England between Wessex and the Danelaw, firmly placing Lindsey under Scandinavian control (Keynes and Lapidge 1983, 171; Keynes 1997, 58).

1.4.3. Historical Context to the Danelaw

In the years that followed the Great Viking Army's arrival, the force moved across eastern and northern England battling with Anglo-Saxon kingdoms, not only acquiring land and resources, but also bringing new dress accessory styles with them. This marked the shift from Scandinavian raiders to settlers (McLeod 2006, 146–147). There are accounts in the *Anglo-Saxon Chronicle* in 876 AD that part of the Great Viking Army partitioned out the land acquired in Northumbria and began to plough and settle, with a similar account from Mercia recorded in 877 AD (Whitelock 1961, 48). In 878 AD, under Alfred, the West Saxons defeated Guthrum and the Great Viking Army at the Battle of Edington, leading to the Treaty of Wedmore. The treaty required the baptism of Guthrum and thirty of his men and established borders between the Kingdom of Wessex and what would become the Danelaw (roughly described as drawing a line from London to Chester). The treaty also established rules for those within their boundaries, including legal disputes, trade and movement between the two territories (Blackburn 2005; Kershaw 2010).

The size and makeup of the Great Viking Army are widely debated. Sawyer (1962) argued that the army was much smaller than the *Anglo-Saxon Chronicle* has led us to believe, stating the quantity of ships was exaggerated, along with an incorrect translation of the Old English word '*here*' as army; in fact the word '*here*' meant a group of men consisting of more than thirty-five (Sawyer 1962, 120, 126). Brooks (1989, 7) disputed Sawyer, stating that the *Chronicle* often underestimated the number of ships, pointing out that Frankish, Irish and Spanish Muslim sources all have ship numbers around 300 or more. Brooks further asserted that the Great Viking Army likely made use of previously established Anglo-Saxon strongholds and thus left little archaeological presence (Brooks 1989, 7). More recently, McLeod (2011, 351) has made the case for greater numbers of women arriving with the Great Viking Army. Drawing on archaeological and written source evidence he showed that women arrived as early as the 860s AD and were likely left in locations where Scandinavians established control, showing that settlement was always a primary goal of the Great Viking Army (discussed in more detail in section 9.3.1).

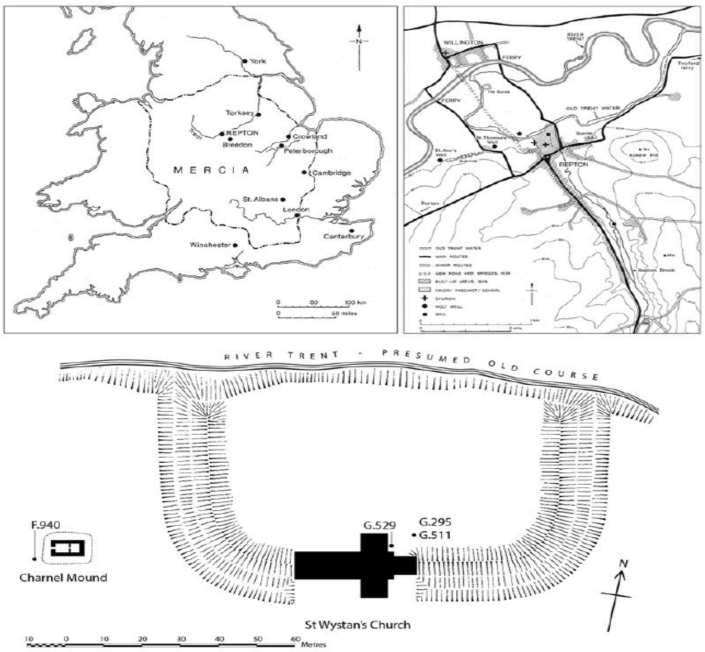

Figure 1-8 Location and site plan of Repton. From Jarman et al. 2018, 184

Two archaeological excavations that contribute to a greater understanding of the Great Viking Army have taken place at Repton and Torksey. Initial work at Repton consisted of excavations and geophysical surveys by Martin Biddle and Birthe Kjølbye-Biddle from 1974 to 1993. These revealed a small D-shaped enclosure 0.4 hectares in size; see Figure 1-8 (Biddle and Kjølbye-Biddle 1992, 40; Hadley and Richards 2016, 26). Additionally, four furnished graves and one mass grave containing at least 264 individuals were excavated and are closely associated with the Great Viking Army over-wintering, with radiocarbon dating placing these burials no later than the late 9th century (Biddle and Kjølbye-Biddle 2001, 60–81; Jarman et al. 2018, 196–197).

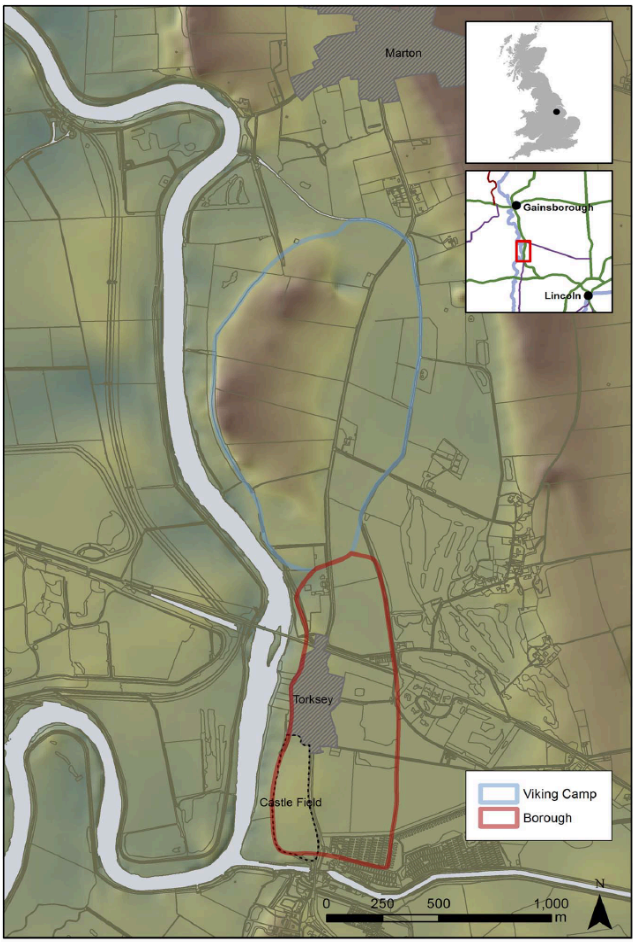

Figure 1-9 Location of Torksey site. Ordnance Survey/EDINA supplied from Hadley and Richards (2016, 28)

Torksey, Figure 1-9, another likely winter camp of the Great Viking Army, was initially discovered through metal detecting (Blackburn 2002; Hadley and Richards 2016, 29). Continued study of the site included geophysical surveys, field walking, metal detecting, test trenching and petrography. Items recovered from Torksey, such as hack silver, weights and gaming pieces, are believed to be clear evidence of the Great Viking Army because of their bullion economy (Hadley and Richards 2016, 27). The metal-detected items have been plotted for distributions across the sites, with no seeming distinction between object types, leading to the conclusion of 'undifferentiated activities' (Hadley and Richards 2016, 40). Repton and Torksey show clear evidence of Scandinavian activity, specifically dating to the mid-9th century, providing insight into the early movement of the Great Viking Army. Further Scandinavian sites in England, such as Aldwark, have since been identified using the artefact patterns from Torksey and Repton (Hadley and Richards 2016, 27, 43, 46, 58).

The Treaty of Wedmore marked the point where the Scandinavian presence changed from a force pushing into England to them settling and establishing the territory of the Danelaw, consisting of 'the Five Boroughs'. These were the main towns of the Danelaw, comprising Leicester, Derby, Nottingham, Stamford and Lincoln; see Figure 1-10. As demonstrated by Torksey, Lindsey likely had Scandinavian influence before the establishment of the Danelaw, and the historical record shows a strong Scandinavian presence. However, the size of the Scandinavian population in Lindsey is still a debated topic (Leahy 2010; Kershaw 2013), as discussed below in section 1.3.3.

Lindsey within the Danelaw

Using written sources to interpret this period can be challenging, as they were primarily produced by Anglo-Saxon monks and offer a skewed perspective on the incoming Scandinavians. However, they do provide a well-dated timeline for political change. According to the *Anglo-Saxon Chronicle*, the Anglo-Saxons are believed to have retaken the city of Lincoln by 918–920 AD, approximately forty years after the Treaty of Alfred and Guthrum. However, there was a continued Scandinavian presence, or identity, in Lindsey, even though the region was again under Anglo-Saxon rule. This is well surmised in retellings of the Battle of Maldon, which occurred in 991 AD against the Norwegian King Olaf Tryggvason. In the accounts, Florence of Worcester blames the Anglo-Saxon loss on the poor performance of the soldiers from Lindsey, claiming they fought with half-heartedness and calling them 'Danes of their father's side' (Thorpe 1849, 149). When, only twenty years later,

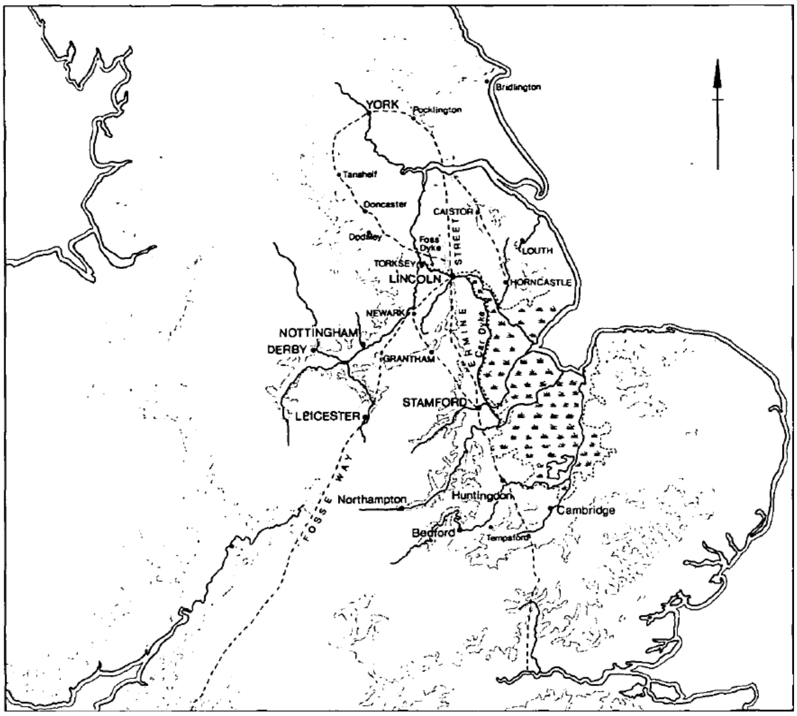

Figure 1-10 Five Boroughs of the Danelaw and other contemporary sites in Eastern England. From Hall (2008, 151)

in 1013 AD, Lindsey was invaded by Svein Forkbeard, the *Anglo-Saxon Chronicle* stated that all the people in Lindsey submitted to him, perhaps again due to their perceived Danish heritage (Savage 1983, 156).

Place-name evidence is one of the largest bodies of evidence supporting a Scandinavian presence in eastern England. Within the Danelaw there is a large quantity of Danish place names, especially those with Danish suffixes of *-by* and *-thorpe;* see Figure 1-11. There are 217 place names ending in *-by* and 66 ending in *-thorp,* which respectively comprise 28.8% and 8.9% of the vills recorded in the Domesday Book (Leahy and Paterson 2001, 182). However, a key issue with place names is that they are difficult to date and could very well postdate the Viking Ages (Leahy and Paterson 2001, 182–183). Fellows-Jensen specifically notes that the distribution of Scandinavian place names in Lincolnshire reflects distinct land partitions – see Figure 1-10 – particularly in the fenlands of south-east Lincolnshire, which had relatively few settlements overall. He also notes that this pattern is common with Scandinavian place names, in that there is an environmental explanation for areas without names (Fellows-Jensen 1989, 77–78).

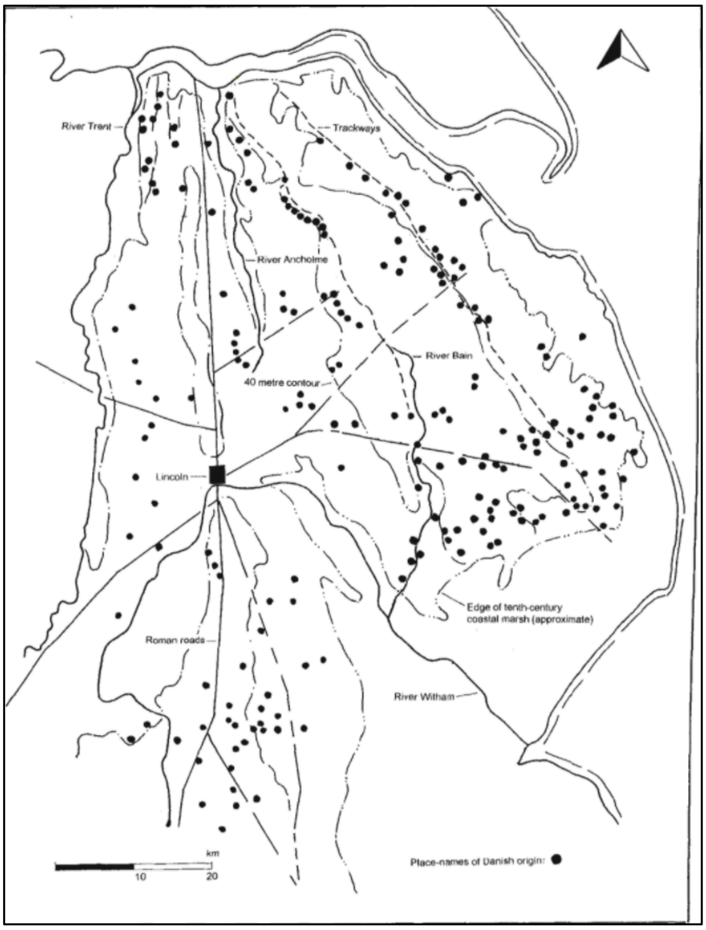

Figure 1-11 Distribution of Danish place names (Leahy and Paterson 2001, 184)

Recently, archaeological evidence has begun to support the historical and place-name research, largely due to the increase in metal detecting (Leahy and Paterson 2001, 186). For example, metal detecting has shown that there are high amounts of Scandinavian metalwork concentrated around some settlements with Scandinavian place names, such as South Ferriby (Leahy and Paterson 2001, 189). While excavations within the city of Lincoln revealed clear Viking phases throughout the city, Early Viking Age topography is restricted to the central part of the lower city, north of the Witham (Vince 2016, 163). Excavations in the central lower city at Flaxengate in Lincoln revealed a locally produced pottery, Lincoln Gritty ware, which is synonymous with Scandinavian activity and has a short date range of late 9th century to the early 10th (Vince 2016, 161). Further sherds have been found at Wigford, a modern suburb, suggesting it was part of the original settlement in the late 9th century (Vince 2016, 162).

Later in the Viking Age, this Scandinavian influence extended to areas south of the river and the surrounding pasture, at which point the southern suburb was drained (Vince 2016, 163). There is also secondary growth in the lower city with evidence for the appearance of markets (Vince 2016, 167), coupled with 9th- to 11th-century evidence for non-ferrous metalworking and major artefactual assemblages on the sites of Flaxengate and St Paul-in-the-Bail (Vince 2016, 171). The impacts of constant and frequent political upheaval at this time would likely have significantly impacted not only systems of production but possibly fashions in dress accessories, thus leaving significant evidence in the material in this dataset, the identification of which is a key objective of this thesis.

Economy, Craft Production and the Status of the Smith in the Danelaw and Lindsey

The main evidence for craftworking in Lindsey under the Danelaw comes from Lincoln and Torksey, and is focused on pottery production, specifically the Torksey and the Lincoln Gritty wares (Vince 2016, 171). There is also evidence of non-ferrous metalworking across multiple sites in Lincoln – see Figure 1-12 and Table 1-1 – and for silver and copper alloy production in particular, which discussed in further detail in section 2.3.

The 10th and 11th centuries were a period of great political upheaval in the British Isles, leading to changes in production and trade. However, perhaps the most significant change to craft production, sometimes referred to as England's first industrial revolution, was the move from a countryside economy based in itinerancy and household production to an urban environment with larger scales of production and the beginning of guild formation (Hodges 1989, 150–186). During this time, important technological changes can be seen, and the move to an urban sphere marked the end of the era of itinerant artisans (Thomas 2011, 414). Furthermore, written records, in the form of charters and wills, show the possibility of smiths acquiring great wealth and being quite high-status members of society during the Viking Age (Thomas 2011, 414).

During the Viking Age, Lindsey's position in wider trade networks is difficult to determine. This is alluded to by the presence of imported items, such as a headdress made from cloth from Coppergate, York, a few items of imported soapstone, a Danish and a Norwegian coin and whetstones of Blue Phyllite and Norwegian Rag, none of which are local (Vince 2016, 172). These items are very rare and are often attributed to being the belongings of travellers or migrants (Vince 2016, 172). Archaeological attempts to look at the riverfronts in Lincoln to detect the presence of river trade or ports were unsuccessful, and excavations have showed no evidence of Lincoln having significant river traffic. There is, however, evidence for a ferry link between North and South Ferriby across the Humber Estuary. Lincoln and Lindsey did have overland trade connections in the Roman period that may have continued to be used, as evidenced by Ermine Street running through Lincoln, but none appear to be long-distance trading routes (Vince 2016, 173).

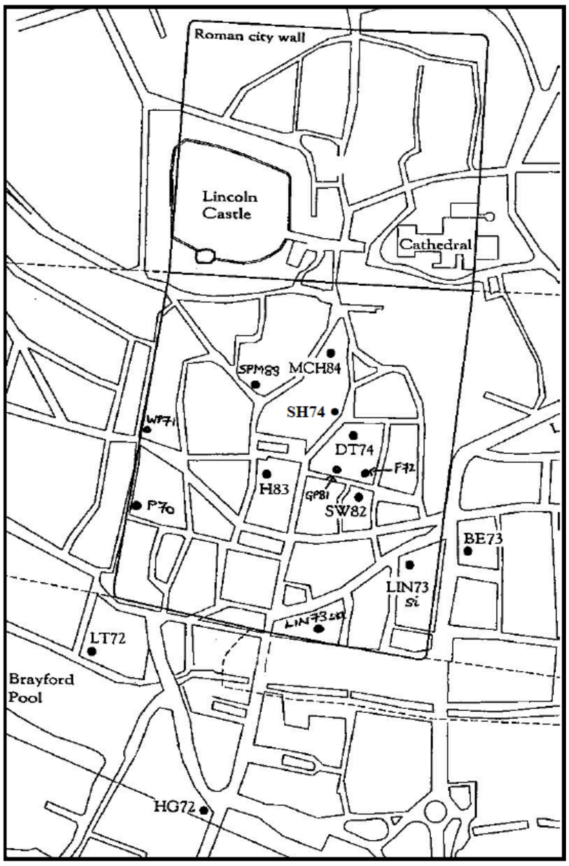

Figure 1-12 Viking Age metalworking sites in Lincoln, name key on Table 1-1. From Bayley (2008,

Table 1-1 Table showing site codes from Figure 1-12, adapted from Bayley (2008, 1)

Site Name	Site Code
Flaxengate	F72
Danes Terrace I	DT74i
Danes Terrace II	DT74ii
Grantham Place	GP8 I
Swan Street	SW82
Hungate	H83
Silver Street LIN A	LIN73si
Silver Street LIN B	LIN73si
Silver Street LIN C	LIN73si
Saltergate Lin D	LIN73sa
Saltergate LIN E	LIN73sa
Saltergate LIN F	LIN73sa
Broadgate East	BE73
Chestnut House, Michaelgate	MCH84
Spring Hill/Michaelgate	SPM83
Steep Hill	SH74
West Parade	WP71
The Park	P70
Lucy Tower	LT72
Holmes Grain	HG72

Pottery distributions have demonstrated the relative lack of connection between Lincoln and its wider hinterland. Lincoln Gritty ware is seldom found outside of Lincoln and its surrounding area, while local shell-tempered ware is only found in north Lindsey (Vince 2016, 174). Imported pottery is also relatively rare in Lincoln, and when found is mostly Stamford ware, although after 1000 AD Torksey ware also starts to appear. There are a few continental items from Northern France, Belgium and the Middle Rhine, but the quantities are too small to indicate regular trade (Vince 2016, 175). This apparent lack of trade reveals Lincoln and the surrounding area to be relatively isolated, even within the Danelaw; Lincoln's isolation is a key factor when studying its copper alloy production and resulting compositions.

Danelaw as a Bullion Economy

Kershaw's (2017) study of metal-detected material shows strong evidence of the Danelaw functioning as a bullion economy between 865 AD and 940 AD, employing standardised weights and hack silver. Hack silver is pieces of bent and cut silver that were used for currency by weight. In a bullion economy, weighted metal, such as this hack silver, was used instead of coinage. Furthermore, during the period of Scandinavia rule, Anglo-Saxon coinage continued to be minted, suggesting that a dual economy may have been in operation (Kershaw 2017, 173). Crucial to this study is the fact that a bullion economy leads to unique signatures on metal objects, such as ingots that are cut or have nicks to check the material, as well as hack silver of both dress accessories and foreign coin, usually dirhams (Kershaw 2017, 176). Kershaw highlights that the two different economies could have potentially divided trading communities and market exchanges if Scandinavians rejected coin and Anglo-Saxons rejected bullion; it is possible that both were used, with each having a specific function and appropriate setting (Kershaw 2017, 185). Kershaw introduces an intriguing perspective on how a bullion economy would function within a society that already had established minting, the impact of which would have had a notable effect on craft production.

The section has provided a brief overview of the historical context necessary to contextualise this research. It has provided an overview of the Late Roman through the to the Viking Age periods and has focused on the shifting political boundaries and the trading and industry practices in Lindsey. These external factors undoubtedly impacted copper production at the time through control over production as well as access to resources. These specific considerations will be revisited throughout the thesis, particularly in Chapter Nine.

Chapter 2. Metallurgical Background

2.1. Introduction

The primary aim of this chapter is to provide a comprehensive overview of copper alloy production and composition in Early Medieval England. This will help contextualise the data and discussion that follows in the later chapters of the thesis. The chapter begins with an examination of the different evidence for copper alloy production, utilising both written and archaeological sources. The discussion then continues to consider the metallurgical properties of the different metals on which this thesis focuses.

2.2. Important Definitions

In order to ensure clarity and consistency during the discussion, some crucial terms are defined in this section. The alloying terms are defined below and the exact proportion of each alloy type will be discussed in section 5.5.1. Alloys can be classed as

- Binary alloys: the combination of two main metals
- Ternary alloys: the combination of three metals
- Quaternary alloys: a combination of four metals; these have relatively few types.

The three key binary alloy types that are present in this study are

- Bronze: a combination of copper and tin
- Brass: a combination of copper and zinc
- Leaded copper: copper combined with lead.

The ternary alloys relevant to this study include

- Leaded bronze: copper, tin, and lead
- Leaded brass: copper, zinc, and lead
- Gunmetal: copper, zinc, and tin.

The only quaternary alloy in this study is

- Leaded gunmetal: a combination of copper, tin, zinc, and lead.

2.3. The Evidence for Copper Alloy Production in Early Medieval England

2.3.1. The Evidence for Production Methods

Archaeological evidence for Early Medieval metalworking is quite sparse, especially when compared to the Roman period and the Later Middle Ages. Therefore, in this thesis, discussion of copper alloy production is based upon both primary written sources and the archaeological material. Evidence from the Early Saxon period (c. 400–700) is especially rare as there is no evidence for workshops – furthering the notion of itinerant craft workers – or for the sources of raw materials (Caple 1986; Mortimer 1990; Bayley 1991). Given this lack of evidence, most conclusions drawn about Early Medieval metalworking are derived from archaeological evidence dating from the 9th to the 11th centuries (Bayley 1991). Primary written sources discussing metalworking are also lacking in the Early Medieval period, and technological discussions draw from both Classical and Later Medieval texts. The following section begins by discussing the written sources before moving to the archaeological evidence.

Primary Written Sources

The principal source of written evidence of early metallurgy is Pliny's *Natural History,* begun in 77 AD, with the remainder published posthumously. This text, containing ten volumes and thirty-seven books, serves as an encyclopaedia covering topics ranging from anthropology to mineralogy to painting. Pliny himself said that the purpose of text was to record all learning and art with their connections with nature (Stanley Smith and Hawthorne 1974). In this text, Pliny demonstrates that the Romans had the vocabulary to differentiate between copper alloys and it contains recipes for each alloy type, with some of these recipes including recycled metal. The inclusion of recycled material in recipes suggests that scrap was separated and grouped, at least in the Roman period.

By the 9th century, there was a re-emergence of metalworking manuals, and even though these were written in continental Europe, the information gathered from these sources is invaluable in a British context. The *Mappae Clavicula*, a late-9th-century text, is a recipe and instruction book for a variety of crafts, mainly metalworking and pigments recipes, with some miscellaneous chapters on topics such as alchemy (Stanley Smith and Hawthorne 1974, 15). A few of the techniques discussed in the *Mappae Clavicula* clearly refer back to classical sources such as Dioscorides and Pliny, among others. However, much of the information appears to be independently gathered, with some manuscripts containing copied text with new additions included at the end, and no changes made to the earlier text. These new additions occasionally contradict previous statements or result in incomplete recipes (Stanley Smith and Hawthorn, 1974, 15–17).

The *Mappae Clavicula* predominately focuses on the materials used rather than details of the techniques required. Furthermore, it included information on sourcing materials, but according to Stanley Smith and Hawthorn (1974), these locations appear to be outdated for the Early Medieval period. They surmised that this information is likely to have been copied from classical texts without being updated. The focus of these recipes tends to be on gold working and decorative elements such as niello and tinning, but the text also gives recipes for 'white copper' and soldering (Stanley Smith and Hawthorn 1974; 18). Some of the *Mappae Clavicula* does discuss production techniques and contains specific recipes (Stanley Smith and Hawthorn, 1974).

Another key medieval source is from the 12th-century *De Diversis Artibus* written by Theophilus, who was believed to be the Benedictine monk Roger of Helmsmarshausen. *De Diversis Artibus* provides a more comprehensive description of craft production, especially metalworking, including chapters on how to organise a workshop. It also discusses metalworking tools, and how to produce and use them. There are subsequent chapters on refining and producing copper alloys, including cementation, and precious metals as well as in-depth descriptions of crucial methods like the lost wax casting methods (Hawthorn and Smith 1979, 167). Due to the more comprehensive nature of the *De Diversis Artibus*, it is believed to have been the product of a single author, compared to the collaborative writing and updating seen in the *Mappae Clavicula*. It is without question that both the *Mappae Clavicula* and the *De Diversis Artibus* are important resources for studying the history and archaeology of craft production. However, it is uncertain how widespread this knowledge was during the Early Medieval period; was this information common knowledge amongst copper workers or are these documents the result of scholarly pursuits of individuals in the later church? Despite this uncertainty, these texts demonstrate a long-lasting metalworking tradition that continued from the Roman period within continental Europe. England, however, seems to have experienced greater differences between the Roman and Early Medieval metalworking traditions.

Written primary sources such as the *Mappa Clavicula* and *De Diversis Artibus* can provide key information that is frequently lost within the archaeological record, such as recipes used and known areas to source materials. Equally importantly they raise some interesting questions and thoughts for consideration; the existence of recipes implies that there were recognised target amounts of additives in various copper alloys. Furthermore, these recipes often included recycled material, indicating that this material could be sorted, likely by colour. The next step is to explore the archaeological evidence for this metalworking tradition and establish how these two streams of evidence can work together.

The Archaeological Evidence

Archaeological evidence for copper alloy production dating to the Early Medieval period is rare and varies throughout the period and across the British Isles. The primary sources of evidence, besides the completed objects, are moulds, models, crucibles and ingots. However, such material is rarely found archaeologically, likely due to the itinerant nature of copper smithing throughout the Early Saxon period. Within the region of Lindsey, it is even less frequently found, with evidence chiefly from Flixborough and the city of Lincoln, and then dating to the Middle Saxon period or later. This absence of evidence is also in part a reflection of the number and range of Anglo-Saxon sites that have been excavated. Few Early Saxon settlements have thus far been identified in Lindsey, the majority of recognised settlements dating to the Middle or indeed Late Saxon periods. Furthermore, many of these Late Saxon sites, such as Coppergate, York and Flaxengate, Lincoln, are in modern urban environments, which limits the possibility of archaeological investigation. Metalworking was not exclusively an urban industry in the later Saxon period, but it is still rarely found on rural settlements throughout the Early Middle Ages. Perhaps the higher visibility of urban craft centres is a result of their larger size and the fact they would have created more waste and occupied a greater area than their rural counterparts in order to meet their higher production demands (Bayley 1991, 122).

Crucibles are the most abundant form of evidence for non-ferrous metalworking, coming in a variety of forms, and often analysis can be performed on slag layers inside the crucibles to identify the alloys being melted (Bayley 1991, 116). Early Saxon crucibles tend to be small, with a capacity of around 20 ml, and were handmade. Crucibles dating prior to c. 700 AD are half-pear shaped and have knobbed lids (Bayley 1991, 117). Only a few examples have been found in England, for example at Church Close, Hartlepool (Figure 2-1) and analysis shows these were used to melt silver (Bayley 1991, 117). Further evidence dating before 700 AD includes a few crucibles and a square-headed brooch mould from Mucking, Essex (Jones 1977, 117), whilst there is also a crucible fragment from Spong Hill, Norfolk (Bayley 1991, 122), and two crucibles from Glastonbury Tor, Somerset (Rahtz 1970, 54). The most significant evidence is from the Tattershall Thorpe grave, the location of which can be seen in Figure 2-2, and is dated to c. 660–670 (Hinton 2017, 102). The individual was interred with a smith’s tool kit such as hammer heads, tongs, punches and lead models, all with varying degrees of use (Hinton 2017, 16–123). The tool kit was incomplete as it did not contain material such as moulds and crucibles, but it remains a prime indirect example of metalworking by containing a wide range of tools associated with the craft that have otherwise not been found in Lindsey.

Figure 2-1 Map showing significant Anglo-Saxon sites with non-ferrous metalworking evidence. From Bayley (1991, 116)

Evidence of non-ferrous metalworking dating to the Middle Saxon period is also rare, with notable finds being a few crucible fragments from Wharram Percy in Yorkshire, as well as a significant amount of crucible sherds from Hamwic (Southampton). Analysis of the Hamwic material showed that the crucibles were used for various copper alloys, as well as silver. The more intact vessels were small thumb pots, with a capacity of 10–15 ml and no pouring lips (Addyman and Hill 1969, 66; Bayley 1986). When using stylistic dating Late Saxon material often overlaps with the Viking Age, and it shows that there was a significant expansion in production; sites such as Coppergate and Winchester from the late 9th century onwards have produced assemblages containing several hundred sherds of crucibles. At this time, and across all sites, there is a growth in crucible capacity with the average size now between 50 and 100 mm in diameter (Bayley 1991, 117). The production methods of these crucibles vary,

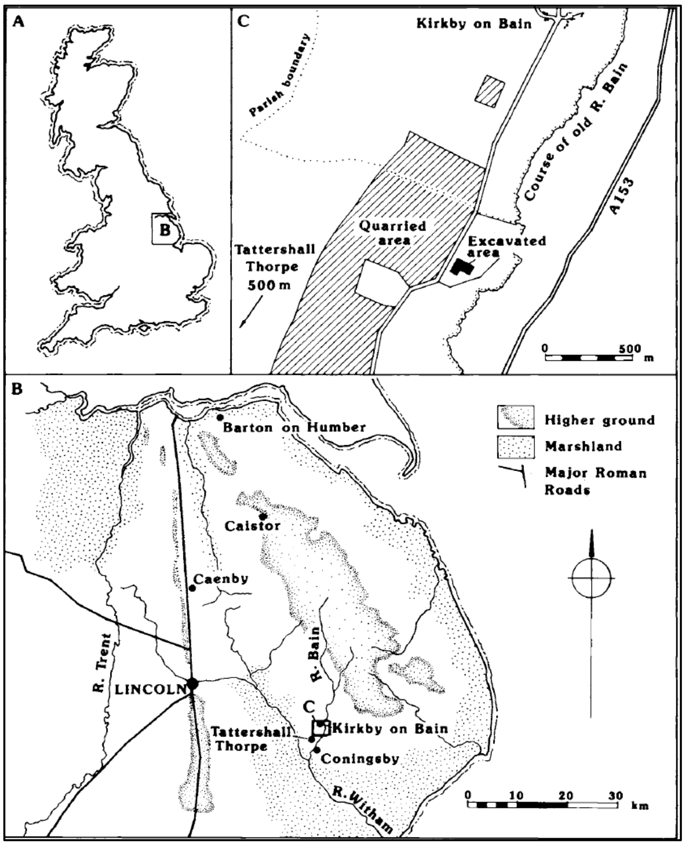

Figure 2-2 Location of Tattershall Thorpe grave. From Hinton (2017, 2)

with examples from Winchester being handmade (Bayley and Barclay 1990, 177), while sherds recovered from Flaxengate in Lincoln (Gilmour 1988, 70) and Coppergate in York (Mainman 1990, 469) were mostly the wheel-thrown Stamford ware. At some locations, such as Northampton (Bayley et al. 1981, 126), Thetford (Bayley 1984, 107) and London (Bayley 1987), a mix of manufacturing methods was found. Further Late Saxon and Viking Age evidence includes waste, such as slag and scrap metal, recovered from Flaxengate, Lincoln (Roesdahl et al. 1981, 101), and site 2S in Thetford, Norfolk (Rogerson et al. 1984: 69), as well as cupels (formerly called heating trays) used for precious metal refining at Winchester (Bayley 1991, 120).

The archaeological evidence for specifically Scandinavian and Anglo-Scandinavian production is also rare. There is a clay mould for a trefoil brooch in the English Winchester style recovered from the Blake Street excavations in York (Kershaw 2013, 263–264). There are also a few dies used for creating mounts and pendants – one from Ketsby, Lincolnshire (Leahy 2007, fig. 71.6) and another from Swinhope, Lincolnshire (NLM-690F57), as well as the die stamp from this study (DS.001) recovered at Osbournby (discussed in section 9.2.3). Furthermore, there are a few miscast and incomplete Anglo-Scandinavian items, such as a Jellinge brooch from 16–22 Coppergate, and two similar lead alloy disc brooches also from

York (Kershaw 2013, 135). Kershaw (2013) analysed the distribution of Anglo-Scandinavian brooches and discovered clusters around towns within the Danelaw; she concluded that production was likely occurring at these urban centres because of their close associations, and the similarity of types within the clusters (Kershaw 2013, 137). For example, she specifically mentions Norwich as having a large cluster of lozenge brooches with unusually elongated terminals, and they are possibly produced from a model within a single workshop in the town (Kershaw 2013, 139). However, Kershaw also acknowledges that the area surrounding Norwich is a popular metal-detecting locale, which could be skewing the clustering of material (Kershaw 2013, 140–141).

2.3.2. Previous Compositional Studies

There are a range of established analytical studies of Early Medieval copper alloys that can directly inform this current study. A common theme is that most such studies are either site-specific, such as at Castledyke (Mortimer 1998) and Cleatham (Leahy 2007), or look at multiple sites in just one city (Bayley 2008). Analyses that make wider cross-site comparisons are far less common, although there have been exceptions (e.g. Baker 2013). This section provides an of overview some of the most relevant analytical studies and discusses them chronologically. Whilst the focus is on Great Britain, some comparative work on materials for Scandinavia are also considered, given their relevance to the material found in Lindsey.

Anglo-Saxon Alloys

Much of the published analysis available has been undertaken on Early Anglo-Saxon grave goods. This is largely due to the fact that the largest amount of metalwork prior to the First Viking Age comes from cemetery contexts. A leading Figure 1n this archaeometallurgical work is Catherine Mortimer, who has produced a vast amount of Anglo-Saxon compositional data. Mortimer employed XRF (X-ray fluorescence) and EDXRF (energy-dispersive X-ray spectroscopy) analyses on a range of Anglo-Saxon sites, in particular focusing on Castledyke and Cleatham in Lincolnshire, as well as Thetford, Norfolk (Rogerson et al. 1984). These analytical techniques differ from those used in this research, but the compositional data obtained are comparable. Mortimer's compositional analysis was usually undertaken as a technical specialist within a broader excavation report, and she grouped items into broad stylistic categories, for example separating the key brooch forms, whilst combining all pin or wire type items (Mortimer 1998). These categories were then compared against the XRF or EDXRF data, as shown in the Castledyke analysis focusing on the primary alloy produced on site (Mortimer 1991). Additionally, she compiled data from 360 cruciform brooches in order to establish a typology of metal types for the Early Medieval period (Mortimer 1991). This is a rare example of an inter-site comparison and is an excellent precursor to the research undertaken for this thesis. Mortimer's study transformed the way compositional studies can be undertaken and demonstrated the great potential of inter-site comparison.

From this extensive analysis, Mortimer identified a number of key trends. From the assemblage recovered from Castledyke, she analysed ten cruciform brooches. Of these brooches, four were brass, four bronze, and two gunmetal (Mortimer 1998, 254), showing high levels of zinc within cruciform brooches at Castledyke. Mortimer found similar to results from Fonaby, another Lincolnshire site. Her Lincolnshire results are starkly different when compared to her analysis in East Anglia, such as the material she analysed from Cleatham. Of the eight brooches Mortimer analysed from Cleatham, six were bronze and two gunmetal (Mortimer 1993, 4). She hypothesised this regional divide could be due to brooch availability, as some earlier types analysed were not present in southern sites,[1] and stated that analysis on a large scale was needed (Mortimer 1993, 4).

A similar analytical approach has been undertaken by Wilthew (1984), who examined Middle Saxon copper alloy pins from Southampton and discussed their metal compositions according to the pin type and decoration. Wilthew's analysis showed the majority of pins were bronze or leaded bronze, but there was still a strong presence of brass and gunmetal. In his discussion, Wilthew suggests that specific pin types had similar compositions, and more significantly, had trace element profiles that might suggest production occurred at a single site or within a limited range of sites, and that copper smiths deliberately controlled alloy composition. Wilthew's strongest conclusion was that if materials were arbitrarily selected or produced at a large range of sites then the compositions would be drastically different (Wilthew 1984, 10). However, Wilthew's theory of trace elements determining provenance is still much debated (Pollard 2018), because there is still the possibility of trace elements being introduced to the material through residues remaining in items such as crucibles, and this could lead to contamination and skewed results.

More recently, Jocelyn Baker (2013) in her PhD examined early Anglo-Saxon dress accessories, using XRF analysis to explore the relationship between the composition of artefacts and their colour. Baker focused on a selection of excavated sites shown on Figure 2-3: Broughton Lodge (Nottingham), Fonaby (Lincolnshire), Castledyke South (North Lincolnshire) Cleatham (North Lincolnshire), Sewerby (North Yorkshire), and West

[1] These earlier brooches are G135 and G156 from Castledyke

Heslerton (North Yorkshire). In this study, Baker examined the potential aesthetics of early Anglo-Saxon metalworking, and discussed the lack of availability of materials to the Anglo-Saxon metalworker (Baker 2013, 426). Baker's analysis revealed a low zinc content across her sites, with a range of 1–5%, and low but variable lead content. Even with high tin content the materials are primarily classified as ternary alloys, as displayed in Figure 2-4. Baker

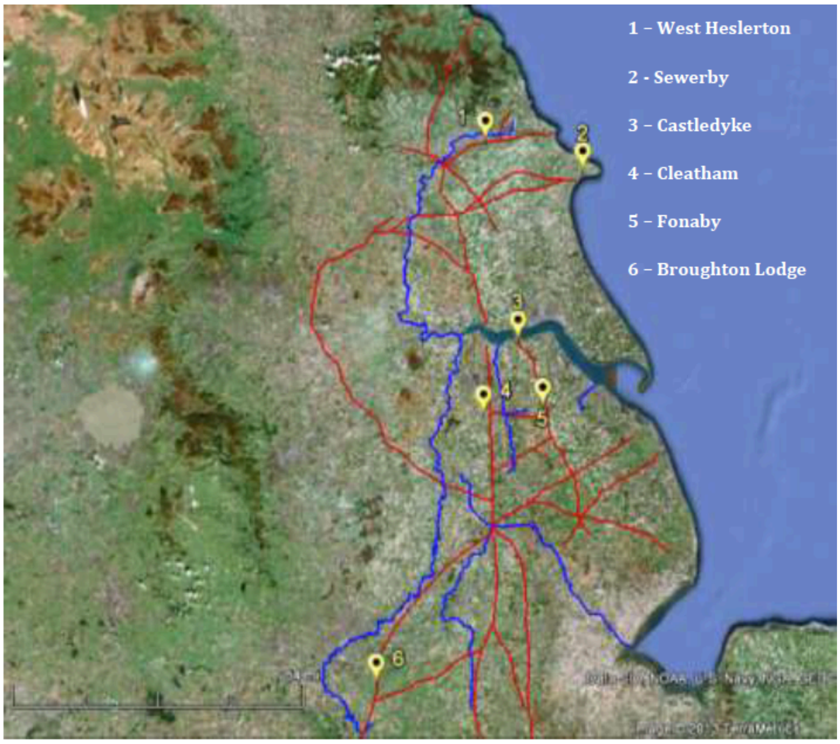

Figure 2-3 Sites used in Baker's (2013) study (Baker 2013, 278)

attributes the variation in metal compositions in her study material to changing availability of resources and a shift in recycling practices throughout the Saxon period (Baker 2013, 432–5).

Viking Age Alloys

Viking Age alloys have in some cases received more attention than their Anglo-Saxon counterparts, and in this section past work on Viking Age alloys will be discussed, focusing on studies from Great Britain and Scandinavia. It is important to study both the datasets from the UK and Scandinavia as manufacturing traditions could have travelled between the populations with the Scandinavian settlement of the British Isles.

Viking Age Alloys in Great Britain

Justine Bayley has been responsible for much of the pXRF and XRF analysis focusing on Viking Age assemblages, generating substantial amounts of data, such as her multi-site technology report looking at metalworking evidence from the different Early Medieval sites across the city of Lincoln during the First and Second Viking Ages (AD 793–1066) (Bayley 2008). This study, like much of her other research, takes the form of a technical report and contains little detail on stylistic patterns within the assemblages studied. There are of course a few exceptions, a notable example being her analysis of a near-complete thimble-shaped crucible found on Parliament Street in York, a rare find in England but the prevalent crucible type found in Scandinavian Viking Age contexts, such as at Ribe (Bayley 1991, 117). This led Bayley to conclude this item is likely to be an import from Scandinavia.

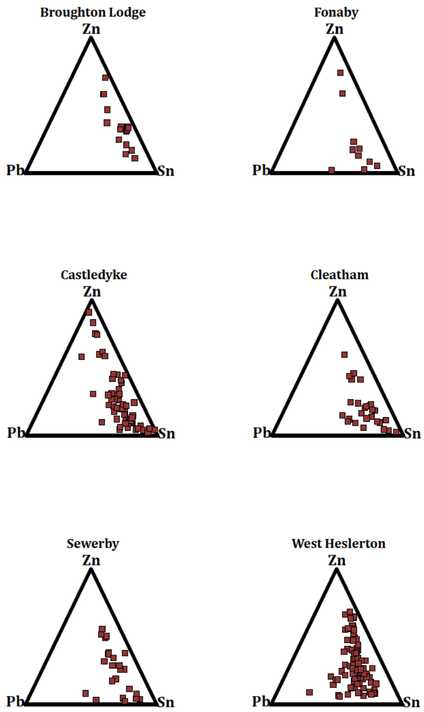

Figure 2-4 Ternary graph showing Baker's results (Baker 2013, 283)

Multiple metalworking sites within the city of Lincoln were excavated and analysed, all of which have been compiled into a comprehensive report by Bayley (2008). This report includes some of Bayley's own XRF analysis as well as a reinterpretation of Blades' (1995) work – Bayley refined the data to be in line with more modern standards of practice, by eliminating any of Blades' results where the total composition value was under 90% or above 110%. The materials analysed include crucibles, moulds and waste which Bayley determined to be too corroded to reconstruct the composition, as well as scrap, ingots and incomplete items, and also precious metal refining items and materials associated with lead working.

Of the crucibles analysed, Bayley found that approximately 40% were used for melting copper alloys, and the vast majority of these (85%) were zinc-rich, with there being very few instances of tin or lead (Bayley 2008, 10). The piece moulds recovered mostly only had very low readings of copper, zinc and lead, levels that were too low to draw any definitive conclusions. The data from analysis of the sites across Lincoln will be investigated more closely in Chapter Nine.

The 16-22 Coppergate excavations in York, undertaken between 1976 and 1983, revealed evidence for the manufacture of a wide variety of copper alloys through finds of metal refining, crucibles, ingot moulds, object moulds, scrap and waste metal, and metalworking tools. There are a wide range of copper alloys found at Coppergate, as well as the strong suggestion that significant recycling was occurring, rather than production using fresh materials (Bayley 1992a, 807). The most significant pattern, according to Bayley, was the emergence of leaded brass in the 4B period (c. 930 - c. 975), and one of the phases associated with the Danelaw. This contrasted with the earlier 4A period (late 9th–early 10th centuries) where leaded brasses were absent. Additionally, XRF data showed high amounts of brass as well as smaller amounts of bronze, gunmetal and leaded bronze in the Coppergate material (Bayley 1992a, 808-809). Bayley states that the results from Coppergate are similar to those from Lincoln, Dublin and Hedeby, possibly fitting into a more extensive Viking Age network of copper working (Bayley 1992a, 809).

The excavation of the burial of a Scandinavian woman at Adwick-le-Street is a significant archaeological find for this study, as to date it is the only female burial in England that shows clear ties to a Scandinavian homeland in both the material culture and the skeletal remains. Her birth and early life in Scandinavia were determined through isotope analysis (Speed and Walton-Rogers 2004, 63), and she was interred with a pair of almost identical 9th-century Scandinavian oval brooches and an Anglo-Saxon-style bowl. There is a high amount of use wear and damage on both brooches that occurred before burial, with one showing signs of repair (Speed and Walton-Rogers 2004, 72–73). All the copper alloy material was studied with EDXRF by Phil Clogg at Durham University. The bowl was leaded bronze, while both brooches were brass with tin-lead alloy plating on the flange that was either decorative or remains of the solder for attachments (Speed and Walton-Rogers 2004, 73). These results, comprising of multiple alloys but with significant zinc and lead content, are somewhat similar to the overall results from Coppergate.

The Viking Age dataset in Scotland is drastically different to than in England, as far more Viking Age materials from excavated contexts have been found there (see Graham-Campbell and Batey 1998 for an introduction). As a result, more of the Scottish material can be dated stratigraphically, which directly contrasts with the dependence on metal detecting to recover much of the First and Second Viking Age material in England. This crucial difference allows greater opportunities for contextual analysis of the material in Scotland, when compared to England, and is reflected in the studies that have been undertaken.

The study by Katherine Eremin (et al. 2002) is an excellent example of the application of XRF in Early Medieval research. In her research, Eremin focused on several cemeteries that had high concentrations of both ‘Insular' and ‘Norse' style material. She compared broad alloy types with the items' stylistic forms, from dress and non-dress artefacts found in both Norse and Insular graves across Scotland. She found the Scandinavian-style artefacts consisted of brass with a high zinc content, whereas the majority of the Insular artefacts were of bronze (Eremin et al. 2002). Furthermore, when Insular artefacts consisted of brass, they had a significantly lower zinc content than their Scandinavian counterparts. Eremin concluded by contributing to theories of the ‘Roman Zinc Decline', stating that zinc content was relatively rare in the British Isles during the Late Roman and Early Medieval periods. This discussion of the Roman Zinc Decline is a prevalent theme in copper alloy studies in the UK (see section 3.2.2 and Bayley 1992a, 803–10). Eremin, based on her results, suggests that the use of zinc indicated continued contact with Scandinavia or the European mainland after settlers had reached Scotland, or that the recycling of Roman materials that had high zinc content was taking place. Ultimate, Eremin's study highlights the benefits of integrating compositional data with typological information (Eremin et al. 2002).

A further relevant study focusing on material recovered in Scotland is the compositional analysis of the trefoil mounts from Jarlshof, Shetland[2] (Paterson and Eremin 1997). These ‘Jarlshof mounts' have direct parallels elsewhere: one from the North Lincolnshire Museum, one from Yorkshire recovered through metal detecting, as well as a single example from Denmark and two from Iceland (Paterson and Eremin 1997).[3] These trefoil mounts are often confused with, and were first classified as, brooches (Paterson and Eremin 1997, 654), because of they are nearly identical in form to Scandinavian trefoil brooches, and some have evidence of being repurposed into brooches (Paterson and Eremin 1997, 655).

To analyse the composition of the mounts, Eremin undertook EDXRF on the Jarlshof mount and the two equivalent mounts from Yorkshire and Lincolnshire. The results indicated that all three mounts were composed of leaded brass, with copper and zinc deletion due to corrosion (Paterson and Eremin 1997, 654). Eremin concluded by stating that the reintroduction of brasses after a long period of predominantly bronze and gunmetal could be on account of interaction with the Scandinavian mainland. However, more analyses of

[2] Accession number NMS: HSA 859
[3] The accession numbers of these comparative finds were not included in the original publication

Viking Age copper alloys within Scandinavia and the British Isles is necessary to establish definitive copper alloy patterns within the Early Medieval period (Paterson and Eremin 1997, 654–655). Bayley (1992a) and Eremin et al. (2002) using Coppergate and Scottish Insular artefacts, respectively, have concluded that Scandinavian-style material is composed of brass, and Insular- and Saxon-manufactured goods were made in bronze and gunmetal, but testing this theory on a broader scale is necessary.

In a Viking burial on the Kneep headland, Uig, on the Isle of Lewis (Figure 2-5), two oval brooches were found accompanied by glass beads, a ringed pin, a knife, a whetstone, a needle case, a sickle, and a matching buckle and strap end. The entire assemblage was dated, based upon the dress accessories, to the 10th century (Welander et al. 1987, 149). The oval brooches are not an identical pair, with slightly different Borre animal designs, but XRF analysis showed that both were bronze with iron pins (Welander et al. 1987 154). On the brooches, raised panels and the stylised animal heads have a tinned or silvered appearance yet the XRF analysis on those areas did not detect a higher amount of tin than the rest of the brooch or any traces of silver. It is hypothesised that these surfaces were acid-etched to remove the copper from the surface and then polished, leaving a tin-rich surface with a white metal finish (Welander et al. 1987, 160). Additionally, applied bosses on the brooches were shown to be comprised of a lead tin alloy, similar to applied bosses found at Oronsay, Argyll and Reay (Welander et al. 1987, 160). The ringed pin, belt buckle and strap end were all also comprised of bronze (Welander et al. 1987, 159). The Kneep brooches show the complex materiality of Early Medieval production and the multiple compositions that can be found on a single object.

Viking Age Alloys in Scandinavia

A wide range of Viking Age settlement excavations took place across Scandinavia during the 20th century, the most significant being those at Birka, Fyrkat and Kaupang (Ambrosiani and Erikson 1993; Olsen 1961; Skre 2007). These three sites significantly transformed the way archaeologists viewed the Viking Age in Scandinavia, as they uncovered a wealth of material including large amounts of metalwork and metalworking production materials. However, with the exception of Kaupang, compositional analysis has rarely been undertaken or has not been published.

Kaupang was a Viking Age urban centre surrounded by major cemeteries and was identified through Charlotte Blindheim's 1956–1974 excavations. Further excavations occurred 1998–2003, highlighting Kaupang's role as a significant trading centre – because of the high number of imported items found – that was occupied all year round (Pedersen 2016, 13).

Kaupang has evidence for both trade and craft production starting as early as 800 AD and lasting into the 10th century (Pedersen 2016, 13–14). In her volume *Into the Melting Pot,* Pedersen (2016) discusses the non-ferrous metalworking materials, including production materials, finished items and scrap metal, with a selection of the objects undergoing archaeometallurgical analysis. Of these, forty-seven crucible sherds were analysed in which silver was the element most well represented, being present on twelve sherds both as metal particles and silver sulphide. In one instance, the silver occurred alongside considerable amounts of lead and copper. Copper was identified in twelve sherds, but in more varying quantities than silver. Copper was primarily found as an oxide, with only five sherds having metal particles. The analysis of the sherds showed strong evidence of copper alloys, with particles of zinc, tin, and tin/lead all being found alongside the copper (Pedersen 2016, 122). There was also evidence for gunmetals, containing both tin and zinc, being produced (Pedersen 2016, 123). Gold was found in four separate crucible sherds, two sherds in combination with minor quantities of zinc and copper, and another with traces of silver (Pedersen 2016, 122).

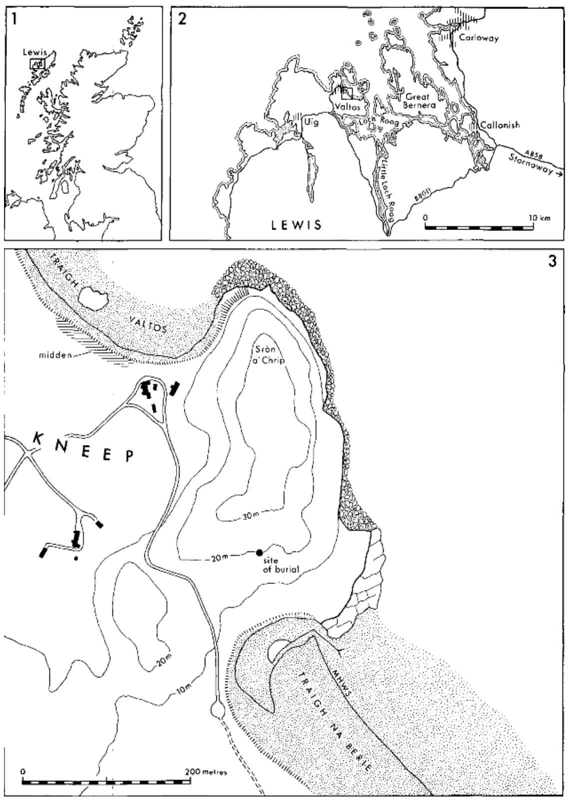

Figure 2-5 Map showing location of Kneep burial excavation. From Welander et al. (1987, 150)

Ingots are often considered a medium of exchange (Rygh 1885, 484; Hårdh 2011; Sindbæk 2001, 2003, 52–69) and an important part of the production process, making production and transportation of alloy and materials easier. The excavations at Kaupang also uncovered 208 ingots, of which eleven were complete and eighty-one were fragmented copper alloy examples (Pedersen 2016, 147). Twenty-two copper alloy ingots were selected for archaeometallurgical analyses; eighteen of these proved to be brass, three were gunmetal, and the remaining one a high-zinc brass containing 28.8% zinc. Four of the brass ingots also had high zinc contents ranging from 23.1 to 24.2%; three of these also had a slight lead content ranging from 0.6% to 1.5% and the fourth ingot contained 5.6% lead (Pedersen 2016, 154–155). The three gunmetal ingots are especially compelling finds as gunmetals have long been viewed as the result of haphazard mixing during smelting; however, these ingots showed that perhaps gunmetal production was far more intentional (Pedersen 2016, 158). One hundred lead ingots were also excavated, 86 of which are fragments, potentially indicating that lead was used an alloying material rather than the primary object material (Pedersen 2016, 147-8).

Figure 2-6 Map showing locations of Kaupang, Ribe, Hedeby. From Pedersen (2016, 14)

Twenty-one pieces of copper alloy casting waste were selected for archaeometallurgical analyses, fourteen of which were casting sprues and seven were melted drops, and the majority of these were brass ranging from zinc content of less than 5% up to 20% (Pedersen 2016, 168-169). The results from Kaupang correspond well with the few other archaeometallurgical analyses from other Viking-period sites, which also contain high zinc brasses with a low tin content (Pedersen 2016, 171).

2.3.3. Contemporary Continental Composition Studies

Contemporary copper alloy material recovered in continental Northern Europe has also been the focus for compositional analysis. A primary example is the large number of continental and Scandinavian cruciform brooches analysed by Mortimer (1990). The results were not unlike those uncovered in England; the majority, 72%, of German cruciform brooches were bronze with the region between Germany and Holland showing examples with a higher tin content and an overall low zinc content (Mortimer 1990, 392). This is quite different to those brooches analysed from Frisia, which have a high zinc content and are similar to those found in in Kent. This might suggest that the Rhineland had established trade contacts with Cornwall to access tin, whilst the Meuse region and Merovingia had access to calamine ore to produce fresh brass (Baker 2013, 51–52).

Werner (1967) analysed twenty copper alloy bowls from Haillot and other Belgian sites dating from the 4th to 5th centuries. These bowls were all leaded bronze with a much higher lead content (12–20%) compared to other early medieval compositions from the continent (.02–5%), with no traces of zinc (Werner 1967, 314). The strictly controlled composition found throughout this group indicated access to either fresh metal resources or regulated scrap metal input (Baker 2013, 52).

Ninety Viking Age mounts recovered from Domburg, Walcheren, a North Sea coastal town in The Netherlands (Figure 2-7), were analysed with pXRF (Roxburgh et al. 2018, 1). Their results were primarily brass, leaded brass, some leaded copper, with some leaded gunmetal (Roxburgh et al. 2018, 17), as shown on Figure 2-8.

Viking Age brass ingots or bars have been recovered in hoards and trading centres in the Baltic (Sindbæk 2003, 49–60). Roxburgh references the ingots recovered as well because the mounts analysed were hypothesised to have been cut, hammered and shaped from such bars; however, the mounts were quite high in lead in contrast to the bars analysed, which contained no lead (Roxburgh et al. 2018, 25; Sindbæk 2003, 55). This led to the proposition that the zinc could have been acquired from the reopening of the Roman zinc mines near Aachen, Germany.

In summary, compositional studies of contemporary continental material have been relatively sparse when compared to analyses from the British Isles, but these are still helpful, providing a richer picture of copper alloy content in the Early Medieval period. Furthermore, these studies help to highlight trade routes with the British Isles and possible resources acquisition.

Figure 2-7 Map showing Domburg and the Norfolk coastline. From Roxburgh and Van Os (2018, 308)

Previous Composition Studies Summary

Previous analytical studies have provided a unique understanding of production of copper alloy objects in the Early Medieval period, and previous compositional analyses highlight the variation and similarities throughout Northern Europe in copper compositions. These earlier works also provide an established framework of metal compositions, upon which this thesis builds. With this overview of previous studies complete, an examination of the benefits and potential issues of producing copper can be undertaken.

2.4. Metal Structure, Colour, Tarnish

This section outlines the necessary terminology and background concerning archaeological copper alloys that will be used throughout this thesis. Traditionally, archaeological copper alloys are divided in two groups: bronze and brass, and the specifics of what will be considered brass and bronze in this thesis are further discussed in section 5.5.1. Bronze has been produced since around the late 4th to early 3rd millennium BC, whereas brass did not become widely produced until the Roman period (Yener and Vandiver 1993, 208; Craddock 1975; Bayley et al. 2008).

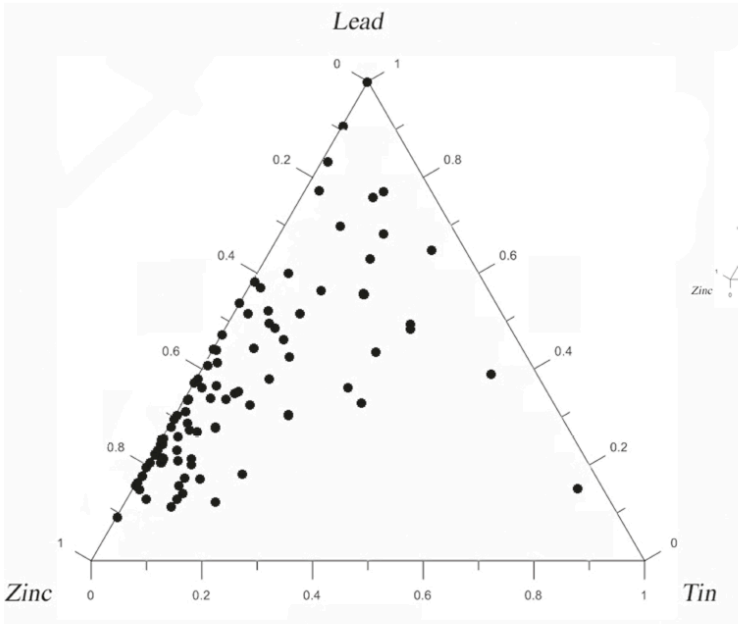

Figure 2-8 Roxburgh et al. Compositional Results (Roxburgh et al. 2018, 17).

2.4.1. Copper

Given the corpus of archaeological work examining ancient copper alloys, surprisingly little is known about their production during the Early Medieval period, and about the sourcing of raw materials in particular. While there is evidence of prehistoric, Roman, late and post-Medieval copper extraction in the British Isles, this is not the case for the 5th to 11th centuries. There are numerous naturally occurring copper deposits in Britain, within North Wales in particular, with evidence for Roman mines at Llanymynech and Machynlleth. There are also deposits in Shropshire, at Coniston in Cumbria and in south-west Scotland, and malachite deposits at Alderley Edge in Cheshire (Bayley et al. 2008). However, there is no evidence for Early Medieval mining occurring at any of these locations. This implies that copper extraction either only took place through surface collection, that only scrap copper was used, or that copper was imported (Bayley et al. 2008). While there is currently a study ongoing using isotopes to provenance raw materials, mostly focusing upon lead (Pollard 2018), at the time of this research, determining provenance for metals in this dataset has not been possible.

Current understanding concerning Early Medieval copper working is based mainly around the scientific principles required to achieve workable copper. Copper has quite a high melting point of 1,084.62 °C, and therefore the ideal pouring temperature for a copper alloy is between 1000° C to 1,200 °C (American Society of Metals 1977). Copper also has the lowest vapour pressure of all the elements being studied here, meaning it would experience the least amount of material lost through volatilisation.

2.4.2. Bronze

Tin has a melting point of 232 °C, and after smelting does not require further refining (Blades 1995, 25). Much like copper, tin was purified by selective oxidation since it has a low affinity for oxygen (Cottrell 1975). Selective oxidation through smelting was achieved by melting the tin to a liquid state then blowing air over the molten metal; this resulted in the impurities oxidising and rising to the surface where they could be scraped off. Bronzes usually have a tin content of approximately 7–12% but this can be as high as 18% and as low as 3% of tin in the alloy, and ranges that are considered a true bronze in the context of this study are further discussed in section 5.5.1. Bronze with a tin content of over 18%, considered a high-tin bronze, is relatively uncommon in the Early Medieval period and can lead to the bronze having different properties. For example, bronze with a tin content of 15% or more results in a paler colour and metal that is harder and more brittle, thus making it very difficult to work (Smythe 1937, 383; Oddy 1983; Tottle 1984). Consequently, low-tin bronzes would have been, and still are, more popular as they are easier to work and yield better results (Oddy 1983; Smythe 1937, 383; Tottle 1984). Bronze can be worked by both wrought working and casting; wrought alloys are found to generally have a lower tin content while cast alloys tend to have a high tin content; adding tin to a copper alloy can aid in reducing the melting temperature which aids in casting (Baker 2013, 14).

2.4.3. Brass

The melting point of zinc, 907 °C, is significantly lower than copper (American Society of Metals 1977). Zinc has a high vapour pressure and low boiling point (918 °C), and this high vapour pressure means that if zinc ore and charcoal were reduced, zinc would be a highly reactive vapour (American Society of Metals 1977). Because of this reaction, zinc sulphide ore had to be used to produce brasses before the 18th century. Furthermore, experimental projects by Musty (1975, 409) demonstrated that, prior to the 18th century, brass needed to undergo a cementation process, as pure elemental zinc had not been isolated in Europe.

Cementation enabled the zinc ore to react directly with copper (Blades 1995). This was achieved by roasting copper, zinc ore and charcoal in a sealed vessel; the container was then heated to 900–1000 °C, hot enough to cause the zinc to vaporise but not hot enough to melt the copper. The zinc vapour, trapped in the container, would then diffuse into the copper, before the batch was reheated to a temperature high enough to melt the copper and therefore homogenise the material. Musty (1975, 411) concluded that the maximum zinc content theoretically achievable through the cementation process was c. 28%. The proportion of zinc found in archaeological brasses is usually in the range of 17–20% (Werner, 1970), which shows holding archaeological material to modern manufacturing standards could result in skewed results.

Brasses tend to contain twice as much zinc as there is tin in bronzes, typically defined as having 6–30% zinc content (Bayley 1998, 8). Prior to the 18th century, European brass was also made using the cementation process (Bayley et al. 2008, 47; Craddock 1998, v). Zinc quickly volatilises and is lost when heated well below what is necessary for molten copper. The cementation process involves co-smelting calamine ore containing zinc along with copper in a closed crucible, so much of the zinc vapour diffuses into the copper in solid state (Bayley 1998, 9; Bayley et al. 2008, 47). This process has a maximum absorption level of around 28%, although recent experiments have increased this amount to 33% (Newbury et al. 2005). In practice, the maximum was not necessarily always attained, and in Anglo-Saxon England the cementation methods may have been lost (Bayley et al. 2008, 50; Baker 2013, 15). The colour of brass makes it highly appealing for dress accessories and display objects, and also suitable for wire and wrought purposes as it is very ductile, and 'springier' than bronze (Tottle 1984, xxvi-xl; Smythe 1937, 386).

2.4.4. Gunmetals

Very few samples for Early Medieval England are binary alloys as ternary alloys are much more common; however, the microstructural interactions of copper with tin and zinc have been less extensively studied when compared to bronze and brass. Baker (2013) explored the colour variants caused by the different ratios of tin and zinc in copper alloys, which she concluded had significant inconsistencies that were beyond the scope of her project. However, some helpful conclusions she could draw included the fact that small amounts of tin can have a whitening effect, which can make an item appear 'brassier' than it actually is. Additionally, she noted that certain levels of zinc inclusions occasionally caused more yellowness (Baker 2013, 238–242). Baker's (2013) work highlights the lack of information about both the appearance and workability of gunmetals. This is in part due to gunmetals not having as strict a definition as bronze or brass; for example, gunmetals can be high tin and low zinc or high zinc and low tin. Therefore, because of such variability in gunmetals it is an ongoing challenge to study their properties.

2.4.5. Leaded Copper

The addition of lead can be beneficial to the production of a copper alloy, when used in the correct amount; for example, copper with a 5% to 8% lead content allows the molten metal to flow more smoothly. It is therefore a useful addition when casting, particularly into large and complex moulds (Bayley and Butcher 2004, 15). A copper alloy with a lead content of less than 5% can still prove to have advantages, and even a 2% lead content improves workability. However, a lead content above 8% could lead to object failure as at this level lead forms small globules between the copper crystals, rather than becoming part of the copper metallic phase (Bayley and Butcher 2004, 15). Because of these potential issues, wrought alloys tend to have very low lead contents compared to cast alloys (Baker 2013, 16). Finally, the presence of lead in copper alloys can result in the alloy acquiring a bluish, whitish, or dull appearance, with a higher lead content resulting in a duller colour (Baker 2013, 242–243).

Lead has a melting point quite close to tin, at 327 °C; making an alloy with the two of them is thus relatively straight forward. Based upon the archaeological evidence, lead production resulted in very pure lead, usually around 99% purity. Unlike other ores, metallic lead's ore, sulphide galena, does not need to be roasted and smelted separately. Instead, galena is roasted into an oxide, which then reacts with the remaining unroasted galena and lead in a double decomposition reaction. The resulting metallic lead then sinks to the bottom of the fire, where it can be collected. Oxygen is the reducing agent during this process, as when sufficiently heated the lead is reduced to a metallic state while the sulphur is oxidised (Blades 1995, 25). However, since lead and silver are both found in galena, a process called cupellation is almost always implemented to reserve the silver.

Cupellation is a selective oxidation process in which the lead is heated in a cupel hearth and oxidised to a litharge (Blades 1995, 25). The top layer can then be scraped off, volatilised, or becomes absorbed into the hearth lining, and this litharge could be remelted to recover any lead lost in the process. It would leave a portion of unoxidised silver, frequently with very low lead levels, remaining.

Lead is frequently regarded as a by-product of silver extraction (see Blanchard 1992); however, given lead's prominence in the dataset coupled with the frequent lead mining in the 9th century in Wirksworth, Derbyshire (Ford and Rieuwerts 2000, 18) the argument can be made that the production of lead was the primary goal here. This insight is interesting, as many of the objects in the current study's dataset contain lead levels in excess of 8%. As steps were taken to ensure that lead pockets did not result in misleading lead amounts during the pXRF analysis, that is not likely to be the cause of these high lead values.

2.4.6. Iron in Copper Alloys

Iron found in copper alloys is often seen as an impurity or more typically as an indicator of corrosion and the inclusion of soil components in archaeological composition data. (Baker 2013, 247). This is because iron is difficult to integrate into copper as it is not soluble in copper above a few per cent, and only at high melting temperatures (Baker 2013, 247). Therefore, iron levels in the data can be seen as signs of corrosion rather than intentional additions to the object.

2.4.7. Surface Treatments and Coatings

Surface treatments and coatings were commonplace on dress accessories in the Early Medieval period to improve the aesthetics of an item. It is crucial to be aware of these different surface treatments as pXRF provides surface readings, so any residue left from these treatments will likely be prominent in the data.

Fire gilding was used to apply a fine gilt layer that increased the aesthetics of an item. Fire gilding, also known as mercury gilding, was achieved through grinding flakes of gold and dissolving them in mercury. This mixture was then spread over the surface of an object and then heated, which resulted in evaporating most of the mercury and leaving behind a very thin layer of gold (Northover and Anheuser 2000; Oddy 1983, 1977). Silver plating was often done in conjunction with gilding and would result in a bichrome effect on the object (Baker 2013, 17). Silvering also occurs but is far less common than plating (Vlachou-Mogire et al. 2007).

Tinning is another method that produces a silver-like surface appearance. The object is heated and then rubbed with tin. Since tin has a lower melting point than copper it melts when in contact with the heated copper alloy and can be spread across the base metal surface (Meeks 1993; Oddy 1977). Tinning as a process first occurred in the late Bronze Age and continued through the Roman period. It is an important example of a continuous metalworking tradition (Oddy 1977, 129).

2.5. Metalworking Processes

The following section outlines the production evidence, resources, methods and requirements for the manufacture of copper alloy materials during the Early Medieval period. The production of alloys was, and continues to be, constrained by certain factors first outlined by Caple (1986) and then modified by Baker (2013, 7–90). While every stage of the metalworking process does not directly impact the end composition each will still be discussed in the following sections. This is to ensure a complete understanding of the process and the specialism within it, particularly those that impact compositions.

Factors affecting metalworking can be divided into two categories: metallurgical constraints and human ones. Metallurgical constraints are those that are dictated by the metal itself, such as restricting alloying amounts so that an object does not break, or technological limitations (Baker, 2013: 87). The human constraints are:

1. Economic, such as costs and supplies
2. Technical, such as assigning certain alloys to specific purposes
3. Aesthetic, such as creating a visually appealing item for a cultural group
4. Tradition, in terms of continuing taught practices. These are the most difficult to determine, but likely play an important role.

a. Superstition – part of tradition and again impossible to definitively determine, but likely to influence how metallurgy is taught within the community. Superstition is very intertwined with tradition; tradition is solely the taught practice, whereas superstition is the potential driving factor behind some of those traditions (Baker 2013; 87–88).

With those constraints in mind, it is possible to begin to examine the evidence, resources and production methods for Early Medieval copper alloys and see how these constraints play a role in every aspect of production.

2.5.1. Raw Material Sources

There is little evidence for the acquisition of raw materials for metal production in the Early Medieval period (Brown 1986). Many of the theories surrounding their acquisition concern importation; McCormick's (2001) shipwreck evidence has demonstrated that, up to the 6th century, ready-made ingots came to Britain from the Mediterranean. Furthermore, in continental Europe, the Merovingians continued to operate many earlier Roman production sites, so it is possible that resources were imported from Francia; however, there is no definite evidence for raw material trading, as there is with finished products (Oddy 1983; Mortimer 1990). There is some documented evidence for the extraction of materials; in 835

AD the Abbess of Repton leased out multiple lead mines in Wirksworth, Derbyshire (Ford and Rieuwerts 2000, 18), highlighting evidence of ongoing mining in Early Medieval England.

Raw material extraction of non-ferrous metals, and especially tin, was primarily found in south-west England at this time. Tin had been heavily exploited during the Roman period; however, around 400 AD tin extraction decreased rapidly, resuming around 600 AD, before dropping off again around 905 AD. Even though tin production decreased after this time, the decline is much more gradual than the previous decline around 400 AD. This demonstrates that tin extraction was still occurring, although on a much smaller scale, during the Late Saxon period until the Second Viking Age. Consequently, while evidence for ore extraction is rare in the Early Medieval period, there is enough to suggest that it was happening particularly with tin, albeit on a very small scale. Two main sources of material acquisition, importing ores and extraction within Great Britain, were explored in this section. Both extraction and importation are equally likely to be the main sources for raw materials, although given zinc is not naturally occurring in Great Britain this ore would need to be imported. The final, most relevant and likely resource is scrap metal; all of these resources were used in the copper alloy production process.

Raw material sources have a significant impact on the end product's composition, the full impact of which is discussed in the following chapter when recycling is specifically investigated. Understanding possible sources for raw materials is crucial in understanding any changes that copper alloy compositions underwent, as they are likely to be a direct result of these resources and their changing availability.

2.5.2. Copper Alloy Production

Introduction

Metal alloys could be produced through a variety of methods: by melting down scrap metal to add to a smelt, mixing pure metals in measured amounts, or co-smelting two or more ores. This section discusses the different archaeometallurgical approaches to identifying the methods of production of alloys that are within the present dataset. Issues relating to production overall will be considered first, before discussing each element individually to understand the guidelines and protocols for manufacturing copper, zinc, tin and lead. This discussion will begin by going through the entire copper alloy production process including a chronological overview of Early Medieval metallurgical practice. This will be followed by a brief technical description of the main alloying metals being studied.

Roman copper alloy production has been extensively studied (Caley 1955; Craddock 1975; Dungworth 1995). These works have determined that bronze was the most common and widely used copper alloy, with leaded bronze being particularly favoured for cast objects, as were ternary and quaternary alloys. Roman production seems to have reserved brass for specific items, in particular coins and certain brooches. The zinc content increased from the 1st century onwards. By the 4th century, it has been estimated by Bayley (1998) that 30–40% of copper alloy objects were brass, although Gliozzo et al. (2011) believe this is an overestimate, since dress accessories were commonly made with brass and are more frequently analysed than other objects. Nevertheless, the increased zinc content demonstrates large-scale brass manufacture during the Roman period, until its subsequent decline by the 5th century (Caley 1955). This decline was likely caused by the repeated remelting of these brass objects and resulting loss of zinc through volatilisation.

During the later 5th and early 6th centuries, there seems to have been a shift from urban workshops to itinerant craft workers or, as Baker (2013) has observed, from central places to central workers. Despite this change of focus, it is unlikely that the earlier methods employed in copper alloy production were lost to Early Medieval coppersmiths, as demonstrated by the survival of later texts that freely reference the Classical sources (section 2.3.1). With these strands of evidence in mind the chain of production can be outlined.

These many stages of metal production highlight the likelihood of multiple agents in the metal production process (Hinton 2011). This theory is especially likely if we accept itineracy as a model for Early Medieval distribution. It is doubtful that the same individuals were mining ore, collecting clay or making crucibles, and then smelting the ores. These are all distinct skill sets, and it is far more likely that different individuals who were proficient in those fields undertook each stage (Ashby 2015, 11).

Metal Production

The metal production process, as displayed in Figure 2-9 is complex but has five key stages: smelting, refining, alloying, casting, and then smithing and decorating. This production model is further complicated by the cyclical use of the objects, often resulting in repair, repurposing or even recycling. Figure 2-9 stresses these points while also highlighting the types of evidence associated with the copper working process. The stages outlined below are those that will have the most significant impact on the final compositions of the objects being studied in this thesis.

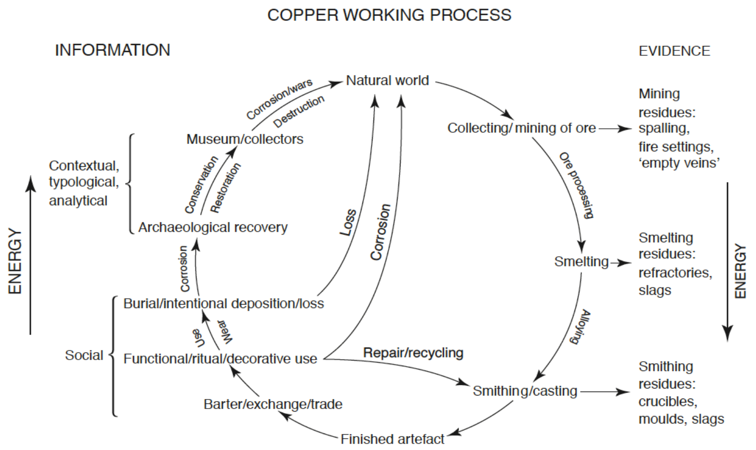

Figure 2-9 Cycle of copper production and working (Ottaway 2001, 88)

Smelting

The process of smelting is the application of heat to ores with the goal of extracting a base metal. During smelting heat is combined with a reducing agent, usually charcoal in the Early Medieval period, to separate the base metal from impurities within the ore. The reducing agent serves as a chemical reactant which removes any oxygen from the ore. This process is twofold, first with carbon combusting oxygen and producing carbon monoxide. The carbon monoxide will then react with the ore, which will lose an oxygen atom and release carbon dioxide. This will remove all oxygen in the ore and leave the base metal.

The furnace needed to be preheated using wood and charcoal; the charcoal insulated the furnace more than if only wood was used. Bellows were then inserted into the *tuyère*, a pipe through which air is blown into the furnace, towards its base. Forced air was required to keep the furnace at a high enough temperature, and as copper has a melting temperature of 1,084.62 °C it would likely take a few hours to melt down to a liquid, before with added heat and pressure it could be smelted. Everything, from the position of the tuyère, the type and frequency of fuel, to the timing of the addition of the ores, could impact the final product and potentially lead to failure (Ottaway 1994, 95).

Additional stages can impact both the smelt and composition of the copper alloy, such as beneficiation and roasting. Beneficiation is the process of removing the gangue minerals from the ore and thereby improving the quality of the ore. Beneficiation is done by crushing the copper-rich minerals and then either hand sorting to select the coloured and heavier minerals, or in later periods, water or wind would be used to sort the material (Ottaway

2001, 92). Experimental work has shown that beneficiation can greatly impact both the final product and the remaining smelting process. Merkel (1990) demonstrated that the level of detail employed during beneficiation can impact the minor and trace element patterning of the final object. Furthermore, Doonan (1994) showed that when beneficiation is done less fuel is used during the smelt. It is clear that the level of attention paid during beneficiation can greatly impact the smelt and the final product as well as waste (slag) from the process (Ottaway 2001, 92).

The goal behind roasting was to remove any unnecessary carbon and sulphur and leave only the oxide, which could then be reduced more easily. Roasting was carried out in shallow pits likely using wood as the fuel (Ottaway 2001, 97). Within copper production malachite was often roasted at a temperature between 250 °C and 350 °C. During roasting, carbon dioxide and water were discharged resulting in copper (II) oxide. Copper (II) oxide can be reduced into copper. Both beneficiation and roasting allowed for base metals to be more easily extracted.

Reduction is done at a very high temperature to aid removal of any remaining oxygen from the base metal, turning an oxide into elemental metal. This is done by creating an incomplete combustion. Modern experiments often use hydrogen, but natural gas can be used, although it will be slower. It is unclear how this would have been done in the Early Medieval period.

All in all, smelting is the key stage that can greatly impact the compositions being studied in this thesis. Changes in smelting practices, such as the introduction of the cementation method for production of brass, can directly result in composition changes. Smelting is a clear case for a high level of specialisation, but not necessarily a producer's full-time job. There was probably a sole chief smelter, and apprentices who all knew parts of the process.

Refining

The product of the smelting process would sometimes need to be further refined in order to be usable. Refining was necessary if the product of the initial smelt was copper prill –a small globule of copper; black copper – copper contaminated with iron; or matte – copper sulphide mixed with iron (Ottaway 2001, 97). Refining would heat the metal again with the goal of separating out impurities and leaving a purer base metal. Refining should be done in a crucible covered with charcoal to prevent the copper from oxidising while providing reducing conditions; finding the balance of these conditions would require highly specialised knowledge (Ottaway 2001, 97).

Alloying

Alloying is the process of mixing two or more metals and/or metalloid elements with the goal of increasing or establishing specific properties for the final product. Alloying allowed the producer to impart and choose the most desirable characteristic for the final object, such as colour, ease of molten flow, ability to transmit sound, and whether it would be better suited for cast or wrought working (Ottaway 2001, 98). Alloying to meet specific goals and requirements would have required specialised techniques that were likely only known to a leading individual (Ottaway 2001, 99). The possible benefits of the different alloying metals were outlined in section 2.4. The compositions of objects are likely formed during this stage of production. During alloying workers make intentional additions to their smelts to achieve a specific composition for the final object. It is this intentional variation and inclusion that this thesis will be studying further.

Alloying is achieved by heating the base metal past its melting point and then adding in the alloying elements, which are dissolved into the molten metal. Alloying additions need to be soluble in the base metal for the process to work, for example iron is not soluble in copper. Additionally, there is also a saturation point for each alloy and base metal, and when reached no more of the alloying element can be added. Saturation points being exceeded can be seen when lead globules form within copper alloy objects instead of the lead being intergraded in the copper. If done correctly, the differences in the size of the atom of the base metal and alloying metal will form internal stresses in the metallic crystal lattice, which often strengthen and improve its properties, such as those discussed in section 2.4.

Casting

The penultimate stage in production was usually casting (although some objects were wrought, such as annular brooches). The majority of cast copper alloy objects in the Early Medieval period used either the lost wax method or a two-piece mould (Mortimer 1990, 87). The lost wax method involved creating a positive or negative model carved in wax or clay. From the model a two-piece mould is created and then the wax is melted out and the mould is fired. Following the firing of the mould the shell is filled with the molten metal. Once the metal has cooled the shell of the mould is broken off. As production increased, lead models were made and used to produce numerous two-piece moulds instead of repeatedly carving new wax models.

Following the final casting extra elements were added such as fittings and further decoration. Archaeological remains of casting in Anglo-Saxon England are very sparse. The excavations at Mucking, Essex uncovered two fragments of a two-piece mould for a square-headed brooch, and in Winterton, Lincolnshire, a miscast small-long brooch was found (Leahy 2003, 141). Another square head brooch from Dalem, Norway, when viewed from the back, is shown to consist of five different cast pieces assembled to look like one piece from the front (Pedersen and Kristoffersen 2018, 220–221).

Smithing and Decorating

Smithing involves the hammering, grinding, polishing, and adding any final decorations and gilding to the object using a variety of tools (sandstone, water, sand, fleece). The goals of this process were to remove any seams or marks created by the moulds and decorate the object (Ottaway 1994, 100–101). Decorating an object in the Early Medieval period consisted of further incising the relief on the object and employing a variety of punches.

Additionally, higher valued objects were also fire gilded using mercury. As pXRF is a surface technique, the remains of gilding can skew results and is an important factor to consider when studying compositional data, particularly when looking at tin, gold, silver and mercury levels. The object then needed to be polished and smoothed. Fire gilding works better with bronze alloys than with brasses and gunmetals (Hinton 2011, 428).

Repair and Maintenance

Many of the copper alloy items show signs of repair, whilst others show signs of repurposing. A high amount of repair on items suggests that they were not made for specific occasions, such as burial, but had been worn and handled daily (Martin 2015, 132). Methods of repairing items included soldering, riveting (usually with iron but copper alloy was also used), and reattaching with yarn. Martin also found evidence for replacement side knobs on cruciform brooches because the knobs did not always match each other (Martin 2015, 135). The high level of repair found can also suggest a limited availability of resources as well as curation and heirlooms.

2.6. Summary

This chapter has covered a wide breadth of information regarding metal production and its associated research. The first half of the chapter covered past research and the evidence available for studying metal – specifically copper alloy – production. This provided a basis for which the research in this thesis builds upon. This section looked at the research being undertaken across Northern Europe for the Early Medieval period as these regions were interacting and likely trading. With the context of previous research laid out, it was possible to discuss the production process and properties of copper alloys, much of which is known through past research outlined in the earlier sections. The section on production provides necessary background for understanding the complexities that occur when producing copper alloys and how such variation in production methods can impact the overall composition of objects. Most of the production discussed in this chapter was of new copper alloys, yet production was likely mostly recycling of copper alloys rather than freshly made alloys as described in Section 2.5.2. Methods of studying the recycling of copper alloys can now be discussed in Chapter Three with the information from this chapter in mind.

Chapter 3. Recycling Copper Alloys: Supply, Theories and Modelling

3.1. Introduction

The recycling of copper alloys is easy to accomplish, and they have been subject to reuse since the Bronze Age (Needham et al. 1997). Due to the nature of metal recycling, the trace element and isotope source ores are combined, making the tracing of metal supply a difficult task for metallurgists. This is further complicated from the 1st century BC onwards, when brasses began to be produced, expanding the potential range of recycled compositions that might be encountered (Baker 2013, 71).

Processes of copper alloy recycling during the Roman period provide an important context for the practices that may have taken place during the Early Medieval period, which is less well understood. Given this, issues such as volatilisation during the re-melting process, as well as metal resources, will be discussed in the following sections. The goal is to provide adequate context for section 3.2, where the recycling models used in archaeometallurgical studies are outlined and discussed. An understanding of how recycled compositions appear at different stages of recycling can help when interpreting the data studied in this thesis.

3.2. Roman Recycling Practices

During the Roman period, metal production was highly controlled by the state in most aspects and at all stages of production (Fleming 2012, 6). The change from the high level of control of the Roman period to the Early Saxon mode of production that lacked such structured authority (Thomas 2011) raises the question of whether such developments would be reflected in object compositions. Previous theories on the residual impact of Roman infrastructure on metal production in Early Medieval England have relied on an assumption that Early Saxon production would have been focused upon the recycling of Roman copper alloy (Fleming 2012). In this section, these theories about the influence of the Roman infrastructure and production practices upon Anglo-Saxon manufacturing traditions will be discussed and evaluated.

The following sections will provide evidence that challenges the hypothesis that the Anglo-Saxons would have *had* to recycle Roman material because they were not able to produce copper alloys on their own (Fleming 2012, 15). Despite the withdrawal of Roman state support in 410 AD, it is now accepted that there was not a significant loss of population and, therefore, individuals with smelting knowledge would still have been present in the 5th century (Green 2019, 27). What did change, and would have had an impact on the production of fresh copper alloys, was the infrastructure that allowed for large-scale mining and extraction of ores.

It could also be argued that production through recycling actually required more expertise than that using raw materials; producers had the challenging task of needing to account for the unknown material properties when remelting old objects. Furthermore, there is extensive evidence of Roman material being repurposed during the Early Medieval period without being melted down, showing that not all material was being recycled (White 1988, Annable et al. 2010; Costello and Williams 2019, for in-depth discussion). A final complicating factor is that physical evidence for recycling is difficult to identify archaeologically; as a result, arguments focusing on this often borrow from written primary sources and experimental archaeology.

While many aspects of copper alloy production are difficult to trace between the withdrawal of the Romans and the Anglo-Saxon period, a major continued repercussion of the Roman withdrawal that is extensively studied is the proposed theory of the Roman Zinc Decline. The theory proposed that a decline of zinc in Roman brass coins was a significant sign of repeatedly recycling brass. This theory raises significant technological questions that do need to be addressed, such as how prevalent the decline in zinc was and how accurate its presumed continuation into the Early Medieval period is.

3.2.1. Re-examining the Roman Zinc Decline

The theory of a Roman Zinc Decline originated in Caley's (1964) study of 24 Roman brass coins. In this study, Caley noticed that the early coins had the highest zinc levels while the later coins contained decreasing proportions of zinc (Caley 1964). Caley concluded that the production of brass began at the end of the 1st century BC but stopped soon after, and that by the late 1st century AD coins were being produced from recycled brass, which due to zinc's volatility, led to a decline in the quantity of zinc with each occurrence of remelting (Caley 1964, 83). Caley also concluded that by c. 50 AD the methods for manufacturing brass were lost, but provided no evidence to support this statement (Caley 1964).

Since Caley's initial study, compositional studies on Roman coins have increased dramatically, such as those by Riederer (1974), Cope (1974), Carradice and Cowell (1987), Carter (1966), Carter and Buttrey (1977), and Etienne and Rachet (1984), the last discussing the River Garonne hoard, which also showed a decline in zinc levels over time (Etienne and Rachet 1984). However, as demonstrated by Dungworth, the rates of zinc decline do not match the gradient of zinc volatility (Dungworth 1995, 139). Instead, Dungworth hypothesises that if the zinc decline were due to the recycling of brass, that initial decrease would be almost immediate. However, the zinc loss in the late 1st century is very slight and only becomes a dramatic decline in the late 2nd and early 3rd centuries (Dungworth 1995, 140). Dungworth suggests that the initial slight decrease in zinc was as a result of combining fresh brass with a fresh leaded bronze, with less brass being added intentionally over time; the decline was due to deliberate alloying and not an accident due to recycling (Dungworth 1995, 141).

There are some crucial flaws in all the theories surrounding the Roman Zinc Decline as outlined above. The primary issue begins with Caley (1964) stating that the technology of zinc production had been lost by c.50 AD. Craddock (1975) directly argues against Caley's point, assessing that other artefacts from the Roman period continue to have high zinc levels. Another significant issue is Dungworth's argument that the alloying shift was deliberate, not due to recycling, without explaining why he does not consider recycling to be a 'deliberate' alloying practice. Dungworth is likely correct that the compositions of coins and other artefacts were carefully constructed, but why that negates ideas of recycling is unclear. Even with Dungworth's (1995) and Craddock's (1975) conclusions disagreeing with the notion of a Roman Zinc Decline, that narrative still continued, as evidenced by Bayley (2008). She agreed with the theories of the zinc decline and proposes its continuation into the Early Medieval period, only ending with a possible re-emergence of zinc coinciding with the migration of Scandinavians into Northern England.

Although Dungworth (1995) does not class recycling as a deliberate action, he is still likely correct that the use of zinc was deliberate and intended for the production of selected items. As previously stated in section 2.4, brass would have been particularly appealing for use in dress accessories because of its colour, while its ductile and springy nature would have made it ideal for wire and wrought working. Therefore, as Dungworth suggests, it is highly likely that zinc use was specifically prioritised by the metalworkers, an aspect further explored in section 9.2.3.

While there is a significant amount of research and evidence suggesting there was a genuine decline in the use of zinc in the Late Roman period, comparatively little consideration has been given to its continuation into the Early Medieval period. For the most part, the continuation of a zinc decline into the Early Medieval period was promulgated by Caley's

(1964) assertion that the technology of brass production was lost in the British Isles. This loss of technology has been shown to be not as extreme as once thought, owing to the continued presence of zinc in the material culture of the Early Medieval period (see Mortimer 1998, Castledyke data), often through recycling. So, while zinc content declined in the Roman period, whether due to recycling (Caley 1964) or intentional exclusion (Dungworth 1995), it is evident that the decline did not continue into later periods to the same degree. Therefore, this suggests there was access to materials, most likely previously made brasses, and a technological understanding of the production of brass.

3.3. The Recycling of Copper Alloys

The following section will provide an introduction to the previous studies of copper alloy recycling. These have tended to be based upon experimental work, using such methods to create models of recycling practices to better understand aspects such as volatilisation and determine specific recipes for copper alloys found. This work is discussed below and will aid in the interpretation of the thesis data presented in Chapters Seven and Eight.

Pollard (2018) with his FLAME project is making major advances in the study of recycling as well as the associated theoretical concepts. Pollard stresses focusing on the metal "flowing" through time and society and being altered by human intervention and therefore impacting the compositions and isotopes rather than focusing on individual objects (Pollard 2018, 42-43). Interventions that can impact objects produced from the copper alloy flow include: missing ore and/or smelted copper from multiple mining sources; intentionally alloying copper with a higher quantity of an additionally metal (like tin or lead) to deliberately create a new material; and reworking an object into a new object such as through recycling or re-alloying (Pollard 2018, 43). With these interventions Pollard captures the complex nature of studying and tracing copper alloy compositions.

From the theoretical side, Pollard (2018, 52) developed the "Oxford System" consisting of three separate but connected tools that can be used to study the copper alloy flow through time. The Oxford system includes: first, trace element composition, focuses on information primarily from the ore source(s) but can be altered by human inference; second, alloy composition, this is the intentional action of craftworkers of adding metals to alter the characteristics of the copper alloy, continuous changes and recycling to the compositions will may or may not move the copper alloy further from its original compositions; lastly, lead isotope composition which can give information about the source of copper or any added lead but can also be altered due to interference (Pollard 2018, 52). Pollard acknowledges the rarity of having access to data for each part of the Oxford System but stresses its value in highlighting difference perspectives of human behaviour (Pollard 2018, 52). The research that will be presented in Chapters Seven and Eight will focus on the second pillar of the Oxford System, alloy composition, but first will be an overview of remelting and recycling to better contextualise those compositions.

3.3.1. Theories of Remelting Thermodynamics

Theories of thermodynamics are a crucial aspect in the understanding of recycling, especially as it pertains to archaeological metals. By understanding the thermodynamics that occurred during the copper alloy production process, it is possible to work from the known composition quantities established with the pXRF to better understand the levels of recycling and metal working processes undertaken. This process of working back from known compositions would include aspects of determining zinc and tin loss through volatilisation and the rate at which this occurred. This section will discuss these theories of oxidation and volatilisation, which are particularly relevant, and provide a brief overview of experimental work that has been undertaken on this area in order to contextualise the recycling practices that are potentially visible within the current study's dataset.

The energy required to perform chemical changes is known as Gibb's Free Energy, and equations for Gibb's Free Energy can be used to estimate the probability of such chemical transformations (Dungworth 1995, 131). Understanding the principle of Gibb's Free Energy assists archaeometallurgists by allowing them to potentially work backwards from a known variable of the archaeological material to an unknown quantity (Dungworth 1995, 131). Temperature significantly impacts the level of energy needed for a chemical transformation and can be readily displayed on Ellingham diagrams. Figure 3-1 lays out the Gibb's Free Energy for the formation of the metal oxides required to produce several copper alloys: copper, lead, tin, and zinc. From the data in Figure 3-1, it is apparent that lead, tin, and zinc all oxidise more efficiently than copper does, with zinc being the most easily oxidised.

Studying the effects of temperature on Gibb's Free Energy is a crucial first step to understand the process of producing metal oxides. However, there are multiple additional factors to consider when attempting to recreate the conditions in the Early Medieval crucible. First and foremost, the Gibb's Free Energy levels are based on pure alloys (Dungworth 1995, 132) and therefore are not directly representative of the remelting process that this thesis is trying to address. In addition, oxidation will also be impacted by CO_2 and O_2 pressures (Dungworth 1995, 132), and these factors are harder to measure in quantifiable levels. In summary, even considering these factors, the relative oxidation levels likely remain intact, with zinc being the easiest to oxidise and copper being the most difficult (Dungworth 1995, 132).

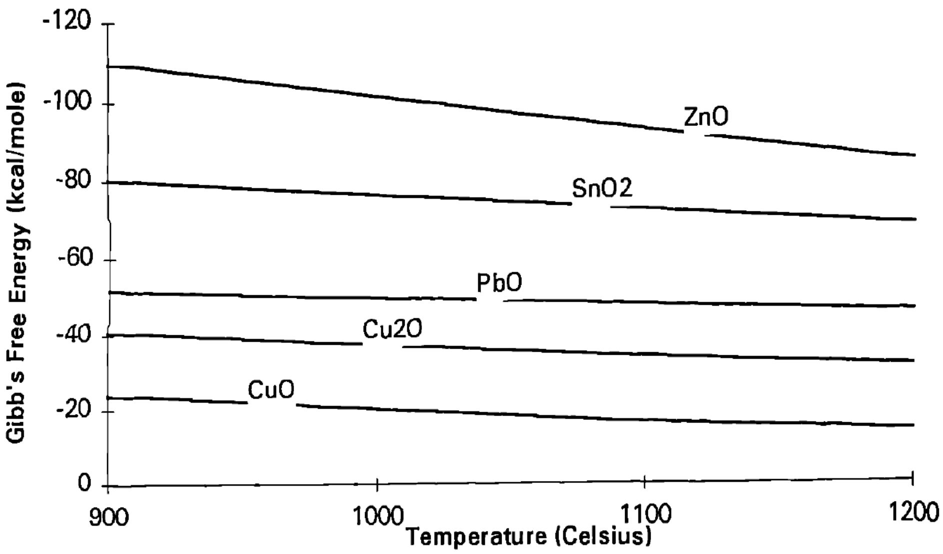

Figure 3-1 Ellingham diagram representing Gibb's Free Energy levels for the formation of metal oxides, from Dungworth (1995) using data from Reed (1971) and Kubaschewski and Alcock (1979) (Dungworth 1995, 131)

The variation in vapour pressure compared to temperature can be plotted and represented in a similar manner as the Gibb's Free Energy. While Gibb's Free Energy showed rates of oxidation, vapour pressure diagrams (e.g. Figure 3-2) display rates of volatilisation, again for pure alloys, which will directly lead to metal loss in the finished item (Dungworth 1995, 132). Figure 3-2 presents the data of vapour pressure for copper, tin, lead and zinc, in which it is clear that zinc, lead and tin are all more volatile than copper at the pouring temperatures established earlier in section 2.4.1. Similar to its oxidisation, zinc is again the most susceptible to volatilisation by quite a significant margin. At the same time, tin and lead levels are quite similar to one another, and only slightly above that for copper. Modern smelting practices recognise the high zinc volatilisation rates; the American Society of Metals (1970, 422) estimates that from less than 0.5% up to 12% of zinc is lost during smelting and that an additional 4% to 5% zinc needs to be introduced to compensate for losses. Their estimations for tin and lead loss are quite small, at less than 1%.

To further investigate how specific conditions affect oxidation levels and volatilisation, both archaeometallurgists and modern material scientists have performed experiments to test a variety of factors to see how they impact the remelting process. One such study by Yazawa and Azakami (1969) set out to determine the ease of purifying elements out of copper alloys based around oxidation levels. To accomplish this goal, they divided elements into three groups based on their oxidation level in relation to copper; the first group comprised elements that oxidise at similar rates to copper. The next group consisted of elements that are slightly easier or require slightly less energy to oxidise and included tin and lead. The final group comprised elements that oxidise with significantly less energy than copper; this group included zinc (Yazawa and Azakami 1969). Their experiment concluded that elements in the final group, such as zinc, were comparatively easy to purify out of copper while the second group proved far more difficult. Merkel (1990) recreated their experiment and yielded similar results. Yazawa and Azakami's (1969) research aimed to contribute to large-scale modern manufacture of copper alloys, and they do not comment on volatilisation. Nevertheless, the results of their study remain helpful and are used by archaeometallurgists.

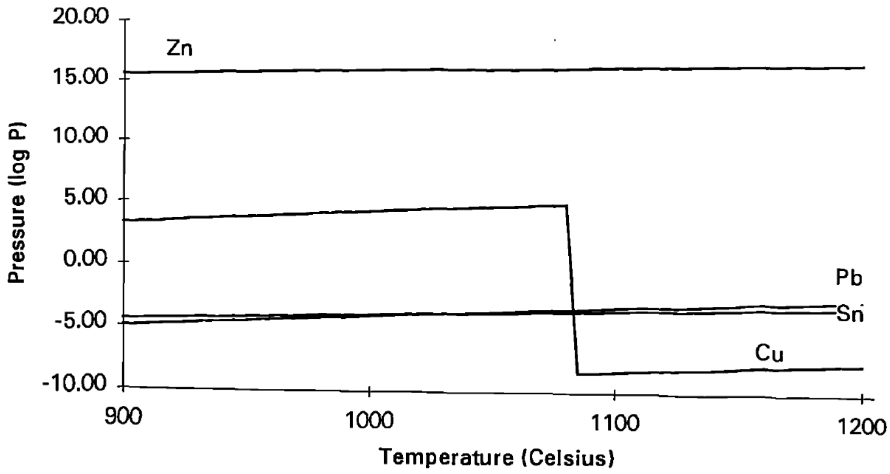

Figure 3-2 Vapour pressure diagram from Dungworth (1995) using data from Kubaschewski and Alcock (1979) (Dungworth 1995, 132)

Other experiments undertaken by archaeometallurgists tend to focus on zinc levels and rates of volatilisation. For example, Dungworth (1995) aimed to test the correlation between time, temperature and zinc loss; his results can be seen in Figure 3-3. Dungworth tested three different temperatures within the range of acceptable pouring temperatures over incremental lengths of time. He concluded, as is displayed in Figure 3-3, that zinc loss is quite high and tends to increase over time; however, the results are variable and somewhat inconsistent. Dungworth's experiment confirms the established view that zinc loss is likely high when remelting brasses, but also complicates the picture by displaying high amounts of variation even within a controlled environment.

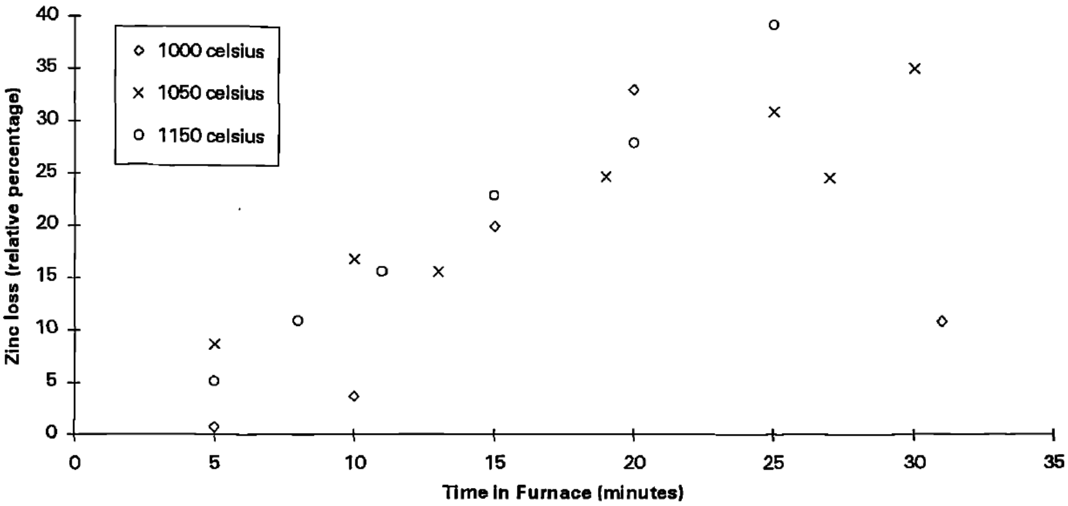

Figure 3-3 Relative zinc loss during remelting experiments (Dungworth 1995, 133)

Bayley's (1988) and Barnes's (nd) experiments examined zinc levels in metalworking refractory materials and compared these to the zinc levels in objects they were used to make. Bayley found that zinc residue in the crucible fabric was consistently high, while the object had low zinc levels (Bayley 1988). Likewise, the moulds used also had at least 1% zinc residue in the fabric, even though moulds were used for a relatively small proportion of the whole metalworking process (Barnes nd). Furthermore, zinc-free bronzes were melted in the zinc-heavy crucibles and tested afterwards. Both bronze samples tested showed an increase in zinc; the first sample (started at 0% zinc) after the first case of remelting rose to 0.47% and after a second remelting rose again to 0.57%. Similarly, the second sample, which also started at 0% zinc, had 0.49% zinc after the first remelting, and 0.59% after the second instance (Barnes nd). Given these results, the conclusion was reached that trace amounts of zinc could be coming from the reused crucibles that had previously contained the element.

By exploring thermodynamics theory, modern standards, and experimental metallurgical work, it has been possible to demonstrate the variability of alloy composition due to remelting practices. Caple (1986) has hypothesised that the composition of a recycled object would contain the average of the scrap used to make it based on his XRF analysis of post-Roman pins. However, since Caple's initial work, it has been made clear that a range of different factors still make the end result of recycling uncertain, in terms of alterations to the alloy's composition. However, the different threads of evidence lead to the determination of metallurgical constraints, and it is within these constraints that large bodies of alloy data must be studied while looking at different archaeological factors. With those constraints, factors, and variability in mind, it is possible to proceed to discuss the ways recycling will be studied with this dataset. The theories of thermodynamics discussed above have provided the foundation for archaeometallurgists to establish models for determining recycling in archaeological assemblages, some of which will be discussed in section 3.4.

3.3.2. The Sorting of Alloys for Recycling

A significant aspect of the recycling process would have been the sorting of metal scrap. Metal scrap would be a necessity if no fresh metal supply was available or if fresh sources were scarce. It is important to recognise that 'bronze' and 'brass' are modern terms and would not have been the way that distinctions were made in the Early Medieval period. Yet, recognising how scrap would have been sorted is important for an understanding of how and why Early Medieval metal smiths were producing the compositions found within the archaeometallurgical data. It is highly likely that in the Early Medieval period the sorting of scrap would have been done based on the colour of the items (Baker 2013, 74), and indeed it is also likely the way the Roman metal smiths divided their scrap, which led to the shortage of tin brass and zinc bronze towards the end of the 4th century (Blades 1995, 34).

Baker (2013) and Caple (2010) both highlight the potential possibilities of sorting scrap by colour. Their discussion focuses on the production of paired objects and the smith's desire for the colour of both items to match, which would thus require careful selection of the alloys being used to make the two objects (Baker 2013, 74–75). Caple (2010) discusses a pair of Saxon saucer brooches that have a similar zinc content, which he suggests would have had the same brass or high-zinc 'ancestor artefact' that was melted down to a form the two brooches. These brooches were gilded, so similar colouring is unlikely to have been the primary goal of having similar compositions. Caple further discusses the social motivations behind these activities alongside the practical reasons for dividing scrap. Caple also concludes that the general practice may have been to combine zinc-rich scrap with fresh sources when available, leading to a yellow colour and beneficial working properties (Caple 2010, 314). Another potential possible for sorting is by object type which could result in similar compositions for object type rather than across the period.

Practices outlined by Caple (2010) would explain a prevalence of high-zinc bronzes and gunmetals within an Early Medieval dataset and would mean careful selection of scrap would not be as important for items that would be gilded or tinned. Building upon Caple (2010), Baker (2013) also suggests that scrap of unknown compositions was mixed with fresh bronze to ensure it was appropriate for casting (Baker 2013, 75), as both methods would maximise the metal supply and maintain object quality when combining a variety of unknown scrap pieces.

3.3.3. Production Issues of Zinc Alloys

The specialisation and centralisation of cementation brass production alongside the location of calamine ore sources could all contribute to lower zinc levels and lack of fresh brass being produced in Britain after the Roman period (Gliozzo et al. 2011, 283). Anglo-Saxon metal smiths likely followed similar recycling practices to those in the Roman period, and this continued practice would result in a high proportion of gunmetals. If these practices continued with no fresh brass to add into the production chain, after a few occurrences of recycling, coupled with zinc's high volatilisation rates, the zinc content would steadily decrease (Baker 2013, 76). As will be discussed in section 7.4 this is not the case in the sample analysed in this thesis. Therefore, zinc must have been available to Anglo-Saxon metal smiths, either in the form of fresh brasses or as previously unrecycled scrap.

Experiments have shown that volatile impurities such as zinc could remain in the finalised copper alloy composition. For example, experiments by Tylecote et al. using sulphide ores with an initial 4% ZnO resulted in a smelted alloy with 1.2–2% zinc (Tylecote et al. 1977, 306–307). The retention of such volatile impurities is especially true for oxide ores, as they were more likely to have a high zinc content and they required less processing to result in the low zinc content found in Early Medieval bronzes (Baker 2013, 77). Furthermore, zinc at low levels could have entered copper through the reuse of crucibles, potentially at a rate of 1–2% (Barnes nd). Therefore, low levels of zinc found in some objects could be due to impurities rather than intentional additions of zinc. Zinc is a relatively frequent occurrence in the dataset presented in Chapters Seven and Eight and it is important to be aware of all the possible causes for zinc inclusion, both intentional and accidental.

3.3.4. Fresh Metal Supply and Ready-Made Alloys

While it seems highly likely that scrap was the primary resource for Early Medieval metal smiths, Caple (1986, 559) states that there must have always been a fresh metal source because without one the compositions would change drastically over a short period of time; compositions would become increasingly homogeneous and this has not been observed, as demonstrated in Figure 3-4 (Caple 1986, 559). Building on Caple's work, Dungworth (1995) stated that changes in compositions reflected changes in the fresh metal supply or how metal was being recycled (Dungworth 1995, 125). As will be shown in Section 7.4, the compositions observed in this study undergo significant changes over time and therefore an alteration to, or limitation of, supply along with a shift in recycling practices were the likely causes for the observed changes.

Past studies have suggested the possibility of a readily available supply of fresh metal for when scrap was low (Caple 1986, 549; Mortimer 1990, 328). The ready-made alloys, as discussed in Section 2.3.2, could then be used on their own or combined with scrap (Caple 1986, 549; Mortimer 1990, 328). Using 'ready-made' alloys would have been a practical and economic method of metalworking in the Early Medieval period. A pre-made alloy would be practical to transport and likely reduce metal waste – important considerations especially during the Early Saxon period, during which, as discussed in Section 2.4, artisans were itinerant. There is evidence for ready-made alloys from Kaupang as highlighted in section

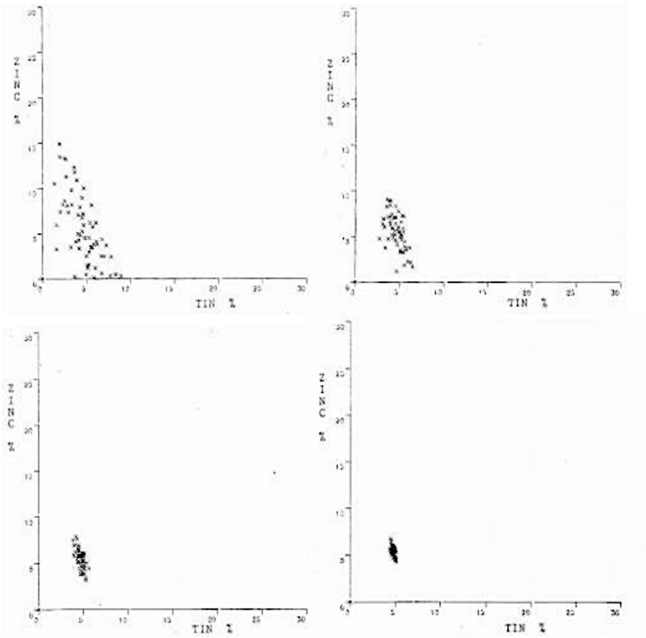

Figure 3-4 Homogenisation of copper alloys by tin and zinc content without addition of fresh metal. Top left shows compositions after one instance of recycling, top right after two, bottom left after three, and bottom right after four (Caple 1986, 559–564)

2.3.2.2.2. Ready-made alloys, such as the ingots from Kaupang, would ensure that smiths would not need to seek out additional alloying elements such as tin to create a workable copper alloy (Baker 2013, 81).

3.3.5. The Control of Alloys as Reflected in Their Compositions

The Early Medieval period has been characterised as one of a 'metallurgy of survival', during which all copper alloys were remelted together regardless of their compositions, and that the 'metal mixing and re-melting is largely intractable even with careful typological and archaeological consideration' (Mortimer 1990, 446). However, it seems that even from the Early Saxon period metalworkers were producing alloys that were suitable for object use. This was likely possible through control over both the scrap to be recycled and fresh alloys, based upon necessity for specific compositions.

This has been demonstrated by Baker (2013, 82–85), who divided her Early Saxon dataset into small cast objects, large cast objects and sheet-wrought objects in order to explore how technical necessities impacted the copper alloy content of each object group. She found that the small cast objects had the greater range of alloy types, and that bronze, zinc-rich bronze, and gunmetals were represented equally. This showed that they were easily available and that lead was more commonly found in high-tin copper alloys rather than high-zinc copper alloys. In large cast objects, she found high lead contents across all the alloy types present, as well as low zinc levels. Since zinc is a deoxidant, low zinc levels would help reduce the appearance of pinholes made by escaping gases, whilst the addition of lead would increase the viscosity of the molten metal.

Both attributes would be beneficial when pouring into larger and complex moulds. In contrast, wrought objects were primarily gunmetal and had a very low lead content; this is logical as increased levels of lead could make copper alloys brittle and would make the sheet more difficult to work. Wrought objects also had a higher zinc content (Baker 2013, 82–85). The Early Medieval period sees less evidence for sheet metal, especially when compared to the Roman period, during which sheet metal, as in Baker's dataset, was comprised of higher-zinc alloys (Mortimer 1990, 356). Therefore, a lack of brass and zinc may not be due to the technological loss of the cementation method, but instead a decline in the use of sheet copper alloys (Blades 1995, 139). Given this, and based on Baker's results, it seems that there was more control over alloy content and production than previously thought during the Early Saxon period.

3.3.6. Further Factors Affecting Composition

While recycling is a key factor in the final composition of an object, there are other circumstances that can impact the composition both during and after production. One such example is whether beneficiation was undertaken and to what degree, as discussed in section 2.5.2. Beneficiation has been proven by experimental work to greatly impact both the final product and the remaining smelting process. Merkel (1990) demonstrated that the level of detail employed during beneficiation could affect the minor and trace element patterning of the final object. The extent of this impact is based on the choice of ore quality and level of sorting undertaken during the beneficiation process. Similarly, the roasting of ores would also impact composition by reducing sulphur levels before smelting (Ottaway 2001, 96). Beneficiation and roasting are both stages in the production process that are not strictly necessary but have an impact on the quality and the composition of the final object. Additionally, there is variation in the melting process between simple and complex alloys that could impact the final composition. Furthermore, as discussed in section 3.3.1, composition could be impacted by remnants on the crucibles mixing into the smelt (Barnes nd). Finally, the soil in which the object was deposited can increase the speed and type of corrosion; both the intensity of corrosion and type of corrosion can alter the object's structure, making establishing the original composition a challenge (Roxburgh et al. 2019, 28). This is discussed further during methodology chapter in sections 5.4.2 and 5.5.4.

3.4. Modelling Copper Alloy Recycling

Caple (1986) attempted to model the possible metal sources in use throughout the Early Medieval period using the compositions of Roman scrap metal alongside fresh brass and fresh leaded bronze containing 8% lead. Caple's modelling had mixed results, and he concluded that the lead content likely dropped to 4% compared to the 8% he started with, but this does not account for the large quantity of unleaded material (Caple 1986, 528–565). Overall, he concluded that fresh metal had to be consistently and continuously entering the production chain, or the compositions would become very homogeneous, as discussed in section 3.3.4 (Caple 1986, 559). Dungworth, (1995) continuing to use experimental archaeology to attempt to model recycling practices, discussed factors not in Caple's (1986) experiment, such as the impact of zinc volatilisation and the possible uptake of zinc from a reused crucible (Dungworth 1995, 132–134). Baker (2013, 89–90) continued to build on Caple's and Dungworth's recycling models and developed a ten-point model for understanding recycling and the copper alloy supply in the Early Saxon England, as follows:

1. 'An estimate of 10% zinc is lost from volatilisation from the alloy each time it is remelted.
2. 1% tin is also lost from the alloy during each remelting act.
3. As fresh brass could not be locally produced brass is not in great supply and high-zinc alloys will therefore be uncommon.
4. Tin and lead are not necessarily present in Anglo-Saxon England as pure, independent metals; although of course at some point they would have been derived from ingots, tin and lead in Anglo-Saxon alloys need not have been added directly to pure copper prior to casting, but may have entered the system in an earlier stage of alloying. Tin and lead content can always be accounted for by a pre-existing alloy similar to Roman averages, and bronze may enter the Anglo-Saxon system as a pre-mixed ingot. Potential exceptions and rarer high-tin and high-lead alloys are accounted for in the model thusly:
    a. High-tin bronze derives from Roman scrap, and is therefore rare.

    b. Leaded alloys are primarily a result of recycling Roman leaded bronze, which has a low tin content.
5. 1–2% zinc may be absorbed into a copper alloy if it is melted in a reused crucible, which may account for the frequency of low zinc contents.
6. In terms of simplicity of testing the system only one fresh metal supply is assumed, and given the unreliability of trade in the period (factors discussed above) this fresh metal is most likely pre-alloyed bronze.
7. Alloys made from fewer remelting acts will be more frequent. Or rather, the simplest method of reaching an alloy is the most likely way, where several possible recipes can explain an alloy; these simpler recipes (with fewer remelting acts) will be more frequent unless other restrictions apply.
8. Alloys with fewer necessary source ingredients will be more frequent (e.g. an alloy requiring bronze + brass will be more likely than one requiring bronze + brass + copper + leaded bronze).
9. Alloys with source components more readily available or economically practical will be more frequent. Thus, if source alloy X is cheaper and more readily available, it will be a more frequent addition to copper alloys if other restrictions do not apply.
10. In terms of proportions of metals used, in many instances an alloy requiring two remelting stages to reach its composition, where A + B is then added in equal proportion to more of A (e.g. 3A + B is the recipe for the alloy), can usually be done directly in a single stage (with some exceptions, primarily those with high zinc content which is then significantly reduced upon remelting a second time).' (Baker 2013, 89-90).

Baker's model has been used to aid in the understanding of this dataset, and it employs eight source metals which will be discussed below; see Table 3-1.

3.4.1. Source Alloys Within the Production Chain

Table 3-1 outlines the eight different possible source alloys for the Early Saxon period (Baker 2013, 92); for the most part these are applicable to this dataset and will be presented in Chapter Seven. The concept behind studying the source alloys is to look at compositions present in the given object and to work backward to see what alloys would have been needed to form the end compositions seen. Baker (2013) concluded that the alloys in her own Early Saxon dataset could have been produced by combining two or more of the alloys present in Table 3-1. Determining the source alloys metalworkers would have been utilising is a crucial first step in discussing and understanding recycling practices.

Table 3-1 Source alloys in the recycling model, adapted from Baker (2013, 92)

SOURCE ALLOY	***% Zn***	***Sn***	***Cu***	***Pb***
BRASS A (ROMAN OR IMPORTED, FRESH)	28.0	0.0	72.0	0.0
BRASS B (3 REMELTS OF A)	20.0	0.0	80.0	0.0
LEADED BRONZE (ROMAN SCRAP)	0.5	6.5	73.0	20.0
COPPER (ROMAN SCRAP)	0.1	1.2	96.7	2.0
LEADED HIGH-TIN BRONZE	0.0	26.0	64.0	10.0
BRONZE A (MAIN)	1.8	10.0	85.5	2.7
BRONZE B (MINOR)	0.2	12.4	85.8	1.7
BRONZE C (REMELT OF EITHER BRONZE A OR B)	1.2	8.3	87.8	3.0

Baker's source alloys provide an excellent starting point for discussing recycling in this thesis's dataset, which will be presented in Chapter Seven, as it begins with the Early Saxon period. Baker's own Early Saxon dataset showed that approximately 96% contained Bronze A, so fresh alloys were a very common inclusion. Furthermore, she saw an increase in zinc in the late 6th century that she concluded resulted from a possible shift in recycling practices (Baker 2013, 108–109). It seems likely then, based on the composition of items in the earliest period of this current research's dataset, that the same source alloys that Baker outlines would have been utilised (Baker 2013, 92).

Baker modelled her compositions based on combinations of source alloys listed in Table 3-1 coupled with rates of zinc and tin loss; source alloys were combined in ratios of 1:1, 2:1, and 3:1. Her results also then created second- and third-generation alloys from those compositions; these alloy divisions can be found in Figure 3-5. From this model and tracing through remelting stages, she was then able to calculate recipes. For example, if Brass A and Bronze B (Table 3-1) are combined, alloy 10 (Figure 3-5) is the resulting composition (Baker 2013, 95–97). As Baker's modelling also included instances of remelting, she was also able to reveal a correlation between fewer remelting stages and the most frequent alloys found within her dataset, as well as with few source metals and higher frequency of occurrence (Baker 2013, 99).

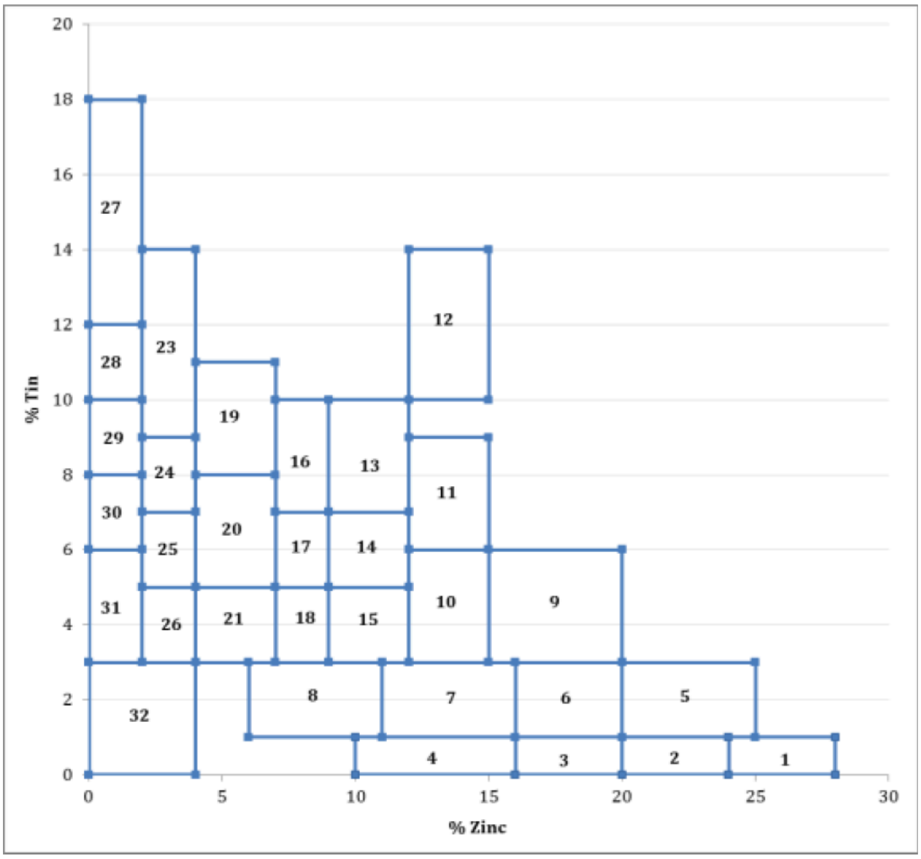

Figure 3-5 Unleaded alloy divisions used in Baker's 2013 recycling model (Baker 2013, 97)

Overall, Baker concludes that since there are numerous possible recipes for the alloys found during the Early Saxon period, alongside the frequency of Bronze A being used, the amount of fresh metal entering the production system cannot be accurately estimated (Baker 2013, 108). Furthermore, she also concludes that there was likely a break from Roman recycling practices, which involved adding a maximum of 1/3 scrap metal. There was a change in the frequency of alloy types between the Roman and the Early Saxon periods, leading to the conclusion that within the 'metallurgy of survival' mentality all scrap would be utilised to the best of the smith's capabilities, likely through combining a known and reliable scrap with the surplus of intermediary alloys.

As already stated, Baker's (2013) research focused on the Early Saxon compositions and worked backwards to Roman compositions to determine the recycling that occurred, and which Roman material was being utilised. Baker's (2013) research was possible because of the wealth of research focusing on Roman compositions, which provided a strong foundation for source materials, so we have a very clear sense of the material and compositions that Early Saxons would have been recycling. However, there is not that same level of compositional data for the Early Medieval period. Therefore, recycling practices for the Mid-and Late Saxon period as well as the First and Second Viking Ages cannot be established with the same confidence, as the body of compositional data presented in Chapters Seven and Eight is the first of its size to look at these later periods.

3.5. Summary

Past research on recycling provides an excellent framework for ways to think about the compositional data that will be presented in Chapter Seven and considered in the subsequent chapters, alongside further discussion of the recycling present. The models and source alloy information outlined here continuously informs the analysis and discussion of the data throughout this thesis. Key elements of this chapter discussed the theories behind studying recycling, such as thermodynamics, as well as other factors that can impact compositions. Additionally, a large portion of this chapter focused on the transition between the Roman and Early Saxon periods, and the recycling of scrap in particular. This allows for the Early Saxon period to have well-identified source materials when creating recycling models and evaluating the extent of Early Saxon recycling. Unfortunately, this dataset does not continue in the remainder of the Early Medieval period, which will make establishing recycling patterns in these later centuries a challenge. Nonetheless, the chapter has established a firm grounding of recycling theories and methods to better frame the interpretation of the data presented in Chapters Seven and Eight, as well as the development of the methodology presented in Chapter Five.

Chapter 4. Identity, Migration and the Theories of Craft Production

4.1. Introduction

This chapter will provide a brief overview to the relevant theoretical discussions surrounding key points in this research. It starts with an overview of identity and migration theory before moving on to discussions of production, technology and the consumption of material culture, leading to a summation of how these theoretical perspectives can aid in the interpretation of this research. Consequently, this chapter will aid in the contextualisation of key debates during discussion of the results and the primary dataset in this research as they pertain to the research outlined in Chapters Seven and Eight and discussed in Chapter Nine. This section does not seek to inform the wider debates surrounding these theories, instead using them to provide context and a lens to study the data presented in this PhD thesis.

4.2. Identity Theory and Migration Theory

4.2.1. Identity Theory

Approaches and methodologies applied to the study of identity in archaeology are complex and diverse (Maldonado and Russell 2016, 2). Studying identity within archaeology is useful in the attempt to gain insight into 'the generation of self' at multiple levels – within people's community, as themselves, in public and in private (Insoll 2007, 14). Therefore, recognising the multifaceted nature of studying identity is often fundamental to its success, as well as recognising the danger in associating past identities with modern definitions (Insoll 2007, 14).

Definitions of identity often get separated into categories such as culture and gender, and while understanding these separately is important, they cannot be separated so easily as they often impact and influence one another (Maldonado and Russell 2016, 3). For example, a cultural group identity is experienced differently based on other aspects of one's identity such as age, sex, gender and social status (Lucy 2005, 100). To touch on how these different identities can be studied separately, the theory surrounding each will be discussed before coming together in section 4.2.1 for an overview on identity and dress.

Gender and Sex

Gender as a lens for cultural study did not emerge in academia until the 1960s and was not applied archaeologically until the 1980s. This application enabled women to be viewed as active agents in the past with their own social realities (Gilchrist 1991; Hodder 1991; Díaz-Andreu 2005, 13). Many works from this early movement in gender identity focused on the oppression of women and actively trying to 'find' women in the archaeological record, while passing over the complex nature of gender alongside other identity markers such as age and social status (Meskell 2007, 41). By the end of the 1990s it became obvious that these other factors needed to be taken into consideration, as the experience of any gender varies greatly within and between cultures (Meskell 2007, 42). While the experiences of gender are not universal, they are still relevant and the theory surrounding them continues to be developed (Meskell 2007, 42).

Gender is a significant cultural variable in every society and it is culturally created, so its implications are historically and culturally specific and should not be held to modern definitions or standards (Díaz-Andreu 2005, 14, 17). Material culture, such as the dress accessories studied in this research, plays a major role in how gender identities are structured, particularly in terms of how identity is displayed utilising culturally acceptable material items. Additionally, involvement in production could have provided an amount of financial independence for a particular gender, while the shared technological skill could have formed group solidarity among those who identified with that gender within a society (Díaz-Andreu 2005, 31).

Methodological developments applied to studying gender in archaeology have drawn attention to the variation in 'gender relevant data' to increase the focus on ensuring inclusion of the discussion of all genders, and to avoid ethnographic or historic analogy when studying gender (Brumfiel 2007, 1). Much of this methodological development has been adapted from the theoretical output of other key aspects of identity, such as age and social status (Brumfiel 2007, 2). A key methodological point to highlight here (as will be stressed in Chapter Nine) is to ensure that discussion of all genders is included. By discussing the role of each gender together it allows archaeologists to see contributions of the different genders and the variation in gender roles rather than seeing the experience of one gender identity in a vacuum (Brumfiel, 2007, 1).

The final key point regarding the study of gender to be discussed is the avoidance and acknowledgement of biases. This research, while on a western population, is still unlike modern western populations; the societies studied are both Christian and pre-Christian and underwent massive social transformations over the course of the study period. With this in mind, there should be restraint in applying modern biases and analogy to the gender identities of the past (Brumfiel 2007, 15).

Status

Social status is another key aspect of both group and self-identity. Many aspects of social status tend to focus on the economic element of status, but it is important to remember that other aspects of identity also impact an individual's status, such as gender, cultural identity, and profession. The study of social status in archaeology grew in popularity in the 1960s and early 1970s with the new approach emphasising 'systems thinking'. This classified cultures as having a set of interdependent subsystems, with a key component being the social system (Babić 2005, 71). This method for interpreting archaeological data was not without faults. Systems thinking led to a high degree of cross-cultural generalisation and a strongly quantitative relationship between data and the following interpretation (Babić 2005, 71). This method grew increasingly popular for determining social status, especially within the study of funerary practice.

The systems thinking framework outlined explicit markers in practice for determining social status, which was a sharp contrast to the implicit and assumptive methodologies that came before (Babić 2005, 72). Determining universal markers of status can create significant issues when establishing identity; primarily it ignores the unique way status functions with other aspects of an individual's identity, thus leading to an over-simplification of status. These are important points that will be further explored later in this chapter in section 4.4 and again in Chapter Nine, when looking at notions of curated identities. The practice of using material culture to help determine status within a community is common when analysing Anglo-Saxon burials and their associated grave goods.

Studying material culture and status is most notably done with 'warrior graves' or weapon burials. Such studies have been spearheaded by Heinrich Härke, who says that weapon sets in burials can be used to determine an individual's social status as well as establish patterns of social stratigraphy, particularly the status connecting to economic influence (Härke 1999, 23). Härke also makes the important distinction between weapons used as a social status markers and those indicative of actual warriors, by studying the skeletal data of weapons burials as well as taking an in-depth look at the weapons in graves; in one instance Härke determines that a shield grip was far too small for the hand of the individual buried with the shield (Härke 1999, 24, 35) In regard to the skeletal data, Härke concluded, based on age, disability and the presence of injury, that one did not have to be a warrior in life to be buried with weapons (Härke 1999, 36–37). Work such as Härke's highlights the nuance found when studying social status. The research presented in this thesis is not privy to the same level of detail about the individual as work such as Härke's, but it is important to recognise the nuance found within status; additionally, it is crucial to understand the other factors such as gender and cultural group's role in determining an individual status.

Cultural Group

Cultural group identity is a significant aspect discussed in this research, primarily when studying the difference between Anglo-Saxon and Scandinavian styles. Theorists have advocated the abandonment of the term 'ethnicity' as a term and quantifier, and therefore it will not be used here except for when using it as it was historically used. (For more on this discussion see Lucy 2005, 86–94.)

Cultural identity is frequently reduced to an 'insider' versus 'outsider' distinction, but this can lead to a limited self-definition of cultural groups, so while there are constraints to how cultural groups can be defined, they can also be expanded beyond this dichotomy (Lucy 2005, 96). The formation of cultural group identity is multifaceted, involving human agency and groupwide transitions as well as group preservation (Nagel 1994, 161).

The archaeological study of 'cultural identity' saw a rise in popularity in the late 1970s, largely with the work of Shennan (1978) and Hodder (1978). Their research led to the establishment of cultural identity being self-defined. For Hodder (1982), material culture, ranging from pottery to metalwork, was given a more active role in the formation of identity, specifically social relationships, and objects had context and meaning. Hodder's book often used modern cultural populations to aid in the interpretation of prehistoric ones (Hodder 1982, 1). Additionally, the idea was put forward that similarities in cultural groups and their associated artefacts would indicate the level of interaction between the different groups; ideas such as these are discussed further in section 4.2.2 when focusing on migration (Hodder 1982, 8–9). Hodder reaches the conclusion that these similarities can depend on the interacting groups and their intentions, as well as how the materials play into these interactions and how the subgroups (such as status, gender, and age) have to function in their identity roles (Hodder 1982, 185).

Interaction between groups is an important aspect of identity and often uses terms such as 'syncretism' and 'bricolage'. Syncretism is often reserved for religious transitions, while bricolage is specific to new cultural forms taken from aspects of diverse cultural practices. Incorporating both is useful, as notions such as adaptation and flexibility should be key in the study of archaeological identities (Insoll 2007, 14). Therefore, cultural group identity is fluid; 'reproduction' of cultural interaction leads to small shifts that create larger identity change over time (Lucy 2005, 96). This is an important aspect within this study, as it examines multiple waves of migrating populations, and these small changes that occur in the migrant populations will be different to the homeland populations, potentially leading to new hybrid cultures, such as is reflected in the Anglo-Scandinavian material found in the Early Medieval period and included in this research.

Assuming cultural group identity to be directly reflected in forms of material cultural used has major problems. Jones (1997, 106) divides her critiques of this approach into three categories: the straightforward relationship between archaeological cultures and 'ethnic groups'; second, material distributions as definitive evidence for specific populations; and third, the notion of 'ethnicity' as being tied to a particular homogeneous cultural group. These are important aspects to consider before section 4.2.1 on Identity and Dress. Often these objects of display in the Early Medieval period are used to identify small cultural groups within a larger population, such as with Kentish-style items in Northern England and Scandinavian-style items across England; however, they are not necessarily direct evidence of cultural group identity. The changes in theories surrounding cultural group identity play an important role in drawing conclusions from the material being studied. Primarily they highlight the importance of understanding flexibility within identity and that identity is not static, as well as marking an object's role in forming identity. These two key developments in identity theory are crucial for understanding how the objects studied in this research can and cannot represent an individual's identity.

Identity and Dress

The use of dress is a common way to articulate cultural differences within a culturally diverse group, but also status and gendered differences within a single cultural group (Lucy 2005, 96–97), as it is possible to hold various cultural group identities; material culture can both create and transform social relations based on these various identities (Lucy 2005, 97, 108). Additionally, as identity can often be performative, this can place significant importance on the part of material culture in that performance as it can be manipulated to achieve certain aims of the individual or the group (Johnson 2010, 140–141). The use of dress to display or create perceptions of specific identities will be further discussed in sections 4.4 and 8.4.

Even with this clear significance of dress forming a visible identity, the importance of items of dress is often overlooked and there is a general reluctance to include them beyond typological analysis (Martin and Weetch 2017, 3). This is not to say the typological analyses performed on these objects are not of significance; they are invaluable to studies of dress in every period, providing a starting point for further research into personal adornment, such as this research. Martin and Weetch attribute this lack of study beyond typologies to the minimisation of the role of women in archaeology and history, especially given that during the Early Medieval period women were the main wearers of the jewellery (Conkey and Gero 1991; Wylie 1992; Martin and Weetch 2017). Furthermore, personal adornment has tended to be classed as feminine, regardless of the actual gender of its user, and because of modern day attitudes towards dress, it is then perceived as 'trivial and frivolous' (Martin and Weetch 2017, 3). This prejudice is then further emphasised by that fact that the study of personal adornment is overwhelmingly undertaken by female researchers (Gilchrist 1991; Martin and Weetch 2017, 3).

As suggested above, the study of dress within archaeology is well positioned to include insights into groups largely excluded from many traditional narratives, not only women but also lower social classes and cultural minorities. The materiality of archaeological remains can work in conjunction with written records and pictorial evidence when available. Martin and Weetch (2017, 6) hope that the quantifiable and scientific approaches employed in dress studies in archaeology are able to contribute to the more established wider interdisciplinary research on dress.

Returning to dress and its relationship with identity, from the late 19th century dress was established by culture historians to be a direct reflection of the identity of the wearer, indicating a belonging to a cultural group, age and gender. However, more recent studies have taken a more nuanced approach to interpreting personal adornment and identity by considering the variation and the fluidity identity can take (Martin and Weetch 2017, 8). However, the recent emphasis on genetics as a determinant of identity, which is especially prevalent in studies of the Early Medieval period and of Anglo-Saxons, also struggles to capture the nuance of identity. Genetics makes identity a fixed construct in one's life rather than recognising the fluid nature identity can take. Dress, while a less fixed display of identity, is not without similar faults. Therefore, the application of multiple ways of studying identity can lead to a more holistic view of an individual's personhood.

There is the notion that dress will express information about the wearer (Lillethum 2011, 189), but the key aspects dress reflects about identity are the identity the wearer *wants* to reveal and likely what was deemed acceptable for them to wear by their community. This goes back to ideas of identity being somewhat performative and therefore able to be manipulated (Johnson 2010, 140–141). Many of the theories surrounding dress are based around the fact that they are like a text that can be read and decoded (Hodder 1982; Shanks and Tilley 1987; Tilley 1990, 1991; Berger 1992; Lele 2006). This approach does not acknowledge the role the object takes but solely the manipulation by the wearer. Gell (1998, 6) argued that objects, such as those of personal adornment, do not have a meaning but they change the world around them rather than encrypt it. Material culture such as dress can, therefore, maintain or change social reality or norms and this includes identities, shifting the conversation from what personal adornment means to what it does (Gell 1998, 6). Gell's approach is highly applicable to the present research, as will be further discussed in section 4.3 in regard to object biographies; understanding that the relationship between identity and the objects studied is cyclical rather than only going in one direction provides a more nuanced and detailed view of both identity and the objects. This approach is also applicable to this research's specific dataset, as it is primarily metal-detected, giving the objects importance even while they lack the traditionally crucial information provided by a context.

4.2.2. Introduction to Migration Theory and its Applicability to Early Medieval Studies

The study of migration in archaeology has a long and variated history over the last century. When reviewing how migration has been studied within archaeological theory it is evident that it is often challenged by autochthonous theoretical perspectives (Hakenbeck 2008, 9). Early discussions of migrations assumed that migrations were performed by defined ethnic groups, and prior to the 1970s the focus of migration studies was on large-scale population spread and expansion. However, these narratives of migration focused on 'grand narratives' rather than motivations behind migration or the process of migration (Hakenbeck 2008, 10). Ideas of cultural history were prevalent during this time of migration studies; migration was used to provide a clear, and easy, explanation for changes in material culture (Hakenbeck 2008, 13). The migration studies of Early Medieval Northern Europe are still largely defined by this framework, such as the use of the term Migration Period (Bierbrauer 1985, 1993).

During this cultural historical approach to migration, migration was considered to be the movement of clearly defined ethnic groups who moved over long distances for a distinct time period (Hakenbeck 2008, 13–14). This definition of migration also included a substantial disturbance and occasionally displacement of native populations, and these migrations were traced using known aspects of material culture believed to be ethnically diagnostic. Migration studies such as these were often used to frame nationalistic ideals and support narratives of national origin myths (Hakenbeck 2008, 14).

From the 1970s the spread of agriculture became the focus to explain migration (see Ammerman and Cavalli Sforza 1971, 1973). Their 'demic diffusion' model hypothesised that agriculture led to an increase in population and the slow spread of this population brought farming practices with them to new areas. Renfrew expanded on this model, pairing the spread of agriculture with the spread of Indo-European languages (Renfrew 1987, 1989, 1992). As well as Bellwood (1984 -1985, 1991), who applied Renfrew's model of language dispersal with language and agriculture in Austronesia (maritime Southeast Asia), Rouse (1986) expanded the model even further, looking at worldwide population movement and language. These theoretical approaches, particularly those of Renfrew, have been criticised for being a rebranded form of culture historical notions of migration and equating Indo-European languages with the first farmers and therefore Neolithic cultures (Hakenbeck 2008, 16; Zvelebil and Zvelebil 1988, 575). Since those critiques, Renfrew (2000) has expanded his approach to what has now been incorporated under the term 'archaeogenetics', to include not only linguistics but genetics, demographic modelling and archaeological evidence to map the spread of different populations. This theoretical approach has been used to study prehistoric population movement (see Hurles et al. 2005; Underhill et al. 2001) as well as historical documented migration (see Thomas et al. 2006; Wilson et al. 2001). These studies still focus on large-scale and large-group movement of entire population or ethnic groups with no significant reflection on the fact that language, genetic markers and 'diagnostic' material culture do not equate to ethnic groups (Pattison 2008). Furthermore, these studies often reduce complex migration to 'little more than arrows on maps', showing the focus has not progressed beyond the end result of migration rather than examining the motives behind the migration processes (Hakenbeck 2008, 16).

Post-processual archaeologists were the driving critics of these earlier narratives of migration, rejecting how general the grand narratives were and their lack of emphasis on individual agency. This critique led to a drastic shift away from using migration as an explanation for change, and changes were primarily explained with developments made within native populations and changes to their own identities; this has been thought to be an occurrence specific to British archaeology (Härke 1998, 20; Zvelebil 2000, 59). The 'immobilist' view of post-processualism has been addressed, most notably resulting in Anthony's (1990; 1992; 1997) work. He proposes a dynamic model that bridges the gap between the cultural historical point of view and the 'immobilist' one, focusing on the role that the transmission of information about routes and destinations can play and highlighting the complex nature of migration as well as the social aspects.

Similarly, in order to delve further into the complexities of migration, Burmeister looked into sociological and anthropological studies of modern migration, with his own caveat that the applicability is not yet clear (Burmeister 2000, 543). Similar to Anthony's early work, Burmeister looks at the networks between the start point and destination of migrations and how they can impact information exchanges as well as returns to the origin point. Burmeister also examines social identity – such as class, gender and age – and how that can impact migration. However, with both Anthony's and Burmeister's works, the theoretical concepts do not yield the development of discovering archaeological evidence of migration (Burmeister 2000; Hakenbeck 2008, 18). One truly revolutionary aspect of both Anthony's and Burmeister's work was studying migration as its own area of important research, as opposed to as an explanatory device of cultural change. And while we cannot impose modern migration narratives on to historic or prehistoric, we also cannot view migration as monolithic blocks of ethnic movement. Hakenbeck proposes utilising the term 'mobility' to replace migration as a more encompassing and less loaded term. This would allow specific forms of mobility to be considered within their own context rather than within a larger migration narrative (Hakenbeck 2008, 19). Hakenbeck continues, stating that the use of stable isotopes and a bottom-up approach is the way forward, by using scientific evidence of mobility and then expanding outward to avoid over-generalisation about migration (Hackenbeck 2008, 19–20).

With the history of the study of migration in mind, it is important to outline and define the types of migration scholars have previously put forward: exclusive, inclusive and colonisation (Adams et al. 1978; Chapman and Hamerow 1997; Burmeister 2000). Exclusive migration is usually limited to long-distance and permanent migration patterns (Adams et al. 1978), while inclusive refers to both short-term and short-distance migrations (Chapman and Hamerow 1997). Colonisation movements are a key type of migration, during which there is a large movement of people travelling with plans to make permanent or semi-permanent new homes. This often includes political dominance. By this definition, the Viking expansion into north-east England can be considered a colonising movement (McGuire 2009, 60).

Migration can take many forms, such as chain migrations. It may be part of a trade network, military expansion, seeking out employment, or general exploration. Often migration relies on scouts who pass information back to the homeland and it is also likely based in kinship relations (Anthony 1997, 26). A major discussion within migration theory, applicable to scholarship of the Viking Age and the earlier Germanic migration into the British Isles, focuses on the primary causes of migration. The first factor when studying the causes of migration is the weighing of the perceived benefits and risks associated with the journey and the destination (Anthony 1990, 899). The most common cause of migration is economic, but it can also be socially based, usually occurring as an attempt to improve the migrants' situation (Burmeister 2000, 286). The causes of migration can be either push or pull factors, which impacts the type of migration occurring; for example, people migrating in response to a push factor can often be considered refugees. Migration can take many forms and as it is selective, only a portion of a society will migrate (Burmeister 2000, 543). Often early migrants, especially for colonisation and long-distance migration, tend to be single males, with females migrating later or more commonly over short distances (Anthony 1990, 908). Additionally, primary migrants help later settlers by easing the obstacles they might face (Anthony 1990, 91).

The early Germanic and Viking migrations can be considered forms of colonialism. There are three key types of colonialism defined by Gosden (2004, 26–32): 'colonialism within a shared milieu, middle ground, and *terra nullius*.' *Terra nullius* is a colonisation in which the colonisers treat the new territory as empty and ignore or actively dismantle former ways of life there. Middle ground colonialism occurs when the settlers and local population work together to achieve common goals. Finally, there is colonialism with a shared cultural milieu. The defining characteristic of this type of colonialism is that the colonising population takes control of authority at the expense of the local population, impacting things such as settlement patterns, language and material culture. Both migrations discussed in this research can be considered colonialism with a shared cultural milieu.

Migration impacts the societal norms both of those migrating and of the local population – such as can be seen in the gender roles and overall identity. The discussions surrounding migration and gender roles are difficult to directly apply to Early Medieval populations because of the drastic differences between modern and historical gender norms and their associated roles. For example, in some early modern migrating populations, women have greater authority in the home as a result of needing to or being able to contribute financially through external employment (Foner 1997, 969). By contrast, Viking women enjoyed some freedoms compared to their contemporaries elsewhere in Early Medieval Europe. For example, while still considered subordinate to men in pre-Christian Scandinavia, there is evidence of women occasionally owning property and playing an active role in politics (Magnúsdóttir 2008, 40–41). Other migrant identities are often framed by acculturation or resistance, with there being little scholarship on the portrayal of such identities (McGuire 2009, 69).

4.3. Production, Technology, and the Consumption of Material Culture

The study of production and consumption of material culture has long been an important research theme within archaeology, particularly focusing on the questions of how and why certain choices are made during production. Often the first stage of understanding starts at the basic cultural historical approach of classification. For example, Rouse's (1960) work on analytic classification offered great consideration to the procedures in the process of production and artefact design; his classification can be used to recreate the process of production, or those relevant elements of it (Rouse 1960, fig. 1). The *chaîne opératoire* is a methodology that aims to reconstruct these systems or organisations of technology for an archaeological object, and to understand how the production process functions within a social context. The *chaîne opératoire* aims to understand every cultural transformation that an object undergoes from raw material to finished product. Traditionally the *chaîne opératoire* follows a chronological path, starting with the collection of raw materials to the discarding of the object (Sellet 1993, 106). However, as object biographies grew in popularity, the *chaîne* continued, to include aspects of post-deposition activity.

The notion of the *chaîne opératoire* was first established by André Leroi-Gourhan in 1966 as a method for interpreting prehistoric lithics and stone tools but has since been adapted for other modes of production and periods. Within the analysis of lithics, production is divided into five categories: raw material acquisition, production, use, maintenance and discard. The Early Medieval *chaîne opératoire* for metal production would involve more phases than necessary for lithic production, including pre-metal production (such as the construction of furnaces, moulds, etc.), and the different types of repurposing (heirlooms, loss, metal recycling). Where interpretations of the *chaîne opératoire* often seem to be lacking is through not including the potential technological issues that can occur during production, such as variations in flint fracturing or a copper alloy being too brittle to work properly. These production 'failures' can greatly impact final conclusions about production and are important to consider (Lucas 2000, 90).

Schiffer and Skibo (1997) attempted to remedy the lack of inclusion of production failure in theoretical models by including behavioural chains to reconstruct the actions of the life an object (Schiffer and Skibo 1997, 29). This theory had a major impact on the study of objects and production, particularly the idea that the technical decisions influence the production process and therefore impact the resulting functionality and characteristics of an object (Lucas 2000, 91). Schiffer and Skibo (1997) further acknowledge that specific constraints will impact the design of an object and therefore by identifying instances where decisions are made, the impact of social or cultural influence can be determined. An example of such work in action is van der Leeuw's (1993) study of pottery production, where he showed that while the technical necessities of potting may restrict the production process, there was still a large amount of variability present. He illustrated different ways of forming a pot, such as wheel throwing and coil-building, all of which achieved the same goal and were not employed because of the material properties of the clay, and therefore must be part of the social context of pottery production. Van der Leeuw traced this back to key elements, the first being the overall conceptualisation involved, such as shape, and then the types of tools used during the process, such as moulds, rotary supports and wheels (Lucas 2000, 91–92).

As post-processualism emerged the concept of object biographies began to gain popularity, first suggested by Gosden and Marshall (1999). Object biographies stress the agency objects have to influence change within the culture or society in which they operate, whereas in contrast the *chaîne opératoire* could be seen more in terms of the impact a culture might have upon the life of an object. Object biographies document the life history of an object at each stage, beginning at creation and often going up to the present day (Joy 2009, 542). For each stage of an object's life, questions are asked to carefully consider the potential shifting relationships of objects and people as the object moves in and out of social contexts. This often results in a linear narrative organised chronically with no stage prioritised over another (Appadurai 1986, 17). In this way it can be better understood whether objects are atemporal or multi-temporal and how their value can change or stay the same. Object biographies also aid in better understanding how objects can impact social and cultural contexts and individuals (Joy 2009, 542).

Object biographies frequently include questions of 'who' raised in early life stages, leading to the emergence of studying not just the consumer's identity through crafts and production but the producer's identity as well. It has been suggested that elements of the producer's identity could be included in objects from the production stage (Mullins 2011, 135). The role of human agency plays a significant role in an object biography; therefore, during the production of an item, it could become imbued with certain cultural traits, whether intentionally or not (Kopytoff 1986, 66). Object biographies will play an important role in the interpretation of the data presented in this research by highlighting the reciprocal role objects can play in the formation of identities.

Beyond the production of these items, consumption of material culture is an important aspect of this theoretical framework, aiding in the examination of how people and groups socialise material goods. Frameworks including consumption recognise the agency of the consumers, not just the producers. Consumption is often discussed in conjunction with identity. Mullins attributes consumption to a progression of defining self as well as collective identity, further explaining that through consumption of an object one can ‘confirm, display, accent, mask, and imagine who we are and who we wish to be’, showing how consumption does not always serve to be a clear reflection of one’s identity (Mullins 2011, 135). The intertwined nature of objects and identity is an aspect this research will examine during the discussion in Chapter Eight. By viewing consumption in this light, it will help to show the importance of these stages of the object’s life and how, when studying an object, production is only one key part, which it is necessary to look beyond.

4.4. Discussion and Summary

The theoretical perspectives outlined in this chapter affect the interpretation of the data that is presented in Chapters Seven and Eight. By combining these different theoretical perspectives, we can get closer to understanding the nuances found in the dataset. First and foremost, as Brumfiel (2007, 15) states, it is important to acknowledge that even though the populations being studied are a western population they will not function as a modern western population; furthermore the populations being studied are both pre-Christian and Christian societies, which will greatly impact changes in conceptions of identity over the Early Medieval period.

This changing nature of Early Medieval society highlights the importance of the *chaîne opératoire* in this research. A *chaîne opératoire* approach will aid in studying how the surrounding culture and society impacted the production and use of these objects, and how this impact shifted over time, while an object biography approach allows for studying the opposite, seeing how the object in turn impacted society and individuals with which it came into contact. This highlights the role objects can play in inciting change and not just the changes that impact objects. Using both *chaîne opératoire* and object biography approaches allows a closer look at the possible cyclical relationship between societies and the objects they create and use. These theories also tie in closely to ideas of consumption and its connection to identity; it is necessary to highlight the role consumption plays in the formation of identities, even if that identity is meant to be performative.

The role of material culture in reflecting identity is the most complex aspect discussed in this chapter. Section 4.2.1 highlighted many of the issues and nuances of determining the identity of an archaeological population as well as the pitfalls of using a formula for calculating social status, a common practice in the study of Early Medieval archaeology. Objects of personal adornment are better subjects for discussion points such as those Gell (1998, 6), highlights when asking what this material culture does to society rather than who exactly it is representing. This material is often already accepted to be performative and has been suggested to show an attempt by Anglo-Saxon populations to align themselves with the incoming Scandinavian populations (see Michelli 1993). The discussion presented in Chapter Nine will work through this lens of thinking, attempting to highlight the nuances in why such material culture was used and for what goals in terms of identity display and performance.

This chapter has provided a brief but necessary background to the theoretical components that are the key framework for this research. The discussion has focused on identity and migration theory, followed by a discussion of production and consumption of material culture. What is evident from these discussions is that notions of identity and material objects are interwoven, as roles of identity come to play in both the production and consumption of material goods.

Chapter 5. Research Design and Methodology

5.1. Introduction

The main aim in this thesis is to study changes in metalwork connected to socio-political changes, specifically in Early Medieval Lindsey, as well as to address the aims of founding a compositional chronology for the Kingdom of Lindsey and then establishing whether socio-political changes directly impacted those compositions. The methodological design of this research is to collect compositional data with the pXRF from across Early Medieval Lindsey and study the variation between the compositions over time. The pXRF was chosen for this study for numerous reasons. The instrument allows for sufficient readings to answer the study question, but the primary benefit of the pXRF is the portability of the instrument, allowing for ease of access to material, particularly detecting material. The portability of the instrument allowed it to be brought to the materials' locations rather than needing loans of material from detectorists' personal collections or from museums. A full discussion on the use of pXRF is in section 5.4. This chapter will cover the necessary information to contextualise the methodology, the potential and challenges of the dataset (5.2.1 and 5.3.1) and the use and further challenges of the pXRF (5.4). These sections will set the context for section 5.5, Practical Methodology, which will discuss the research design of the project, as well as the working procedure and the data interpretation strategy.

5.2. Development of Methodology

5.2.1. The Potential and Challenges of the Portable Antiquities Scheme

The United Kingdom's Department for Culture, Media, and Sport (DCMS) established the Portable Antiquities Scheme (PAS) in England and Wales to complement the Treasure Act of 1996, in order to encourage members of the public to report non-treasure artefacts (Gill, 2010). The initial purpose was to test whether the PAS would be able to function as a viable method for recording publicly found artefacts, with broader goals of advancing archaeological and historical knowledge (Bland 2009, 64). Museums were used as bases for the scheme and six Finds Liaison Officers (FLOs) appointed, one of which was in North Lincolnshire, and the whole scheme was funded and coordinated by the British Museum (Daubney 2015, 64). The database was published online by July 1999, and with an expansion of the scheme to cover all of England and Wales, a total of thirty-nine FLOs were funded

(Gill, 2010). The purpose of the FLO's job is to record and identify artefacts, and communication between them and detectorists is a significant aspect of the PAS' role in the heritage community. This communication is crucial, especially when considering the history of tension between detectorists and archaeologists (Robbins 2012, 5–12). Currently within the study area of Lincolnshire there are two FLOs, one based in the Lincolnshire HER and the other in the North Lincolnshire Museum (Daubney 2015, 65).

The previously strained relationship between detectorists and archaeologists has improved significantly since the beginning of the PAS, and many archaeologists now accept it for its decisive role in recording heritage, and detectorists are moving beyond their initial distrust of archaeologists (Clark 2008, 6). However, the system of metal detecting in England is still far from perfect; a questionnaire survey (Daubney 2015), of sixty-six Lincolnshire metal-detecting clubs revealed major issues in reporting practices by detectorists. Only five of twenty-one individuals stated that they always report to the PAS and five usually report ('usually' is defined as more than 50% of the time), and one individual stated that they never report to PAS (Daubney 2015, 66).

The PAS has provided invaluable information to archaeologists studying the Early Medieval period. However, it is still a body of data open to biases of its own, often different from the traditional biases affecting archaeology; almost all object recovery is made by individuals who are not archaeologists. A discussion of specific biases is necessary before this study can proceed, and these can be broadly classified as: area constraints, patterns of metal detecting, and recording bias.

Area constraints are defined as the parameters that impact the selection of a location for study. Area constraints for metal detecting vary significantly from those related to excavation, and it is important to discuss both in order to fully understand patterns in the material uncovered. These area constraints play a significant role in where metal detecting occurs and are often outside of detectorists' control. Restrictions include areas such as roads and urban areas where detecting is virtually impossible due to recent build-up above archaeological layers. They also include prohibited regions such as scheduled ancient monuments, military zones and land where landowners withhold permissions, where it could be possible to detect but legally it is prohibited. Area constraints are not to be confused with metal-detecting patterns, which also affect where detecting occurs but in which the detectorists are free to decide rather than being subject to issues of accessibility.

Robbins (2012), as part of her PhD thesis, attempted to understand site selection by detectorists, taking into account their comments on how elements such as distance from home, site type, and knowledge of an archaeological site impacted their choice of detecting. Perhaps unsurprisingly, site selection was most significantly impacted by landowner permission and detectorists picked sites solely based on access rather than specific material targeting (Robbins 2012, 88).

Furthermore, agricultural factors play a vital role in the recovery of artefacts; ploughing moves artefacts horizontally and vertically in the plough-soil (Worrell 2004, 318). Because of this, the PAS recommends detecting in ploughed land and it is also preferred by detectorists due to the continuous movement of artefacts. Detectorists potentially target sites where numerous artefacts have previously been recovered as opposed to where recovery has been scarce (Robbins 2012, 237). This focus on areas that historically have had numerous finds recovered can lead to detecting in the same field countless times. Detectorists will often try to walk in multiple directions across a field (such as across its length, width and diagonally) and during different weather conditions as these affect the readings on the instruments. For these reasons there are often variations in the number of artefacts recovered, not necessarily due to presence or absence of objects but because of metal-detecting practices.

The detecting techniques, site choices, sampling methods, visual indicators and an individual's interests when recovering artefacts all affect how archaeologists interpret the archaeological record based on the metal-detected data (Robbins 2012, 238). It is essential to consider these biases when discussing the prominence of specific materials across a landscape; an absence in the PAS record does not necessarily equal an absence in reality but instead could be a reflection of metal-detecting practices.

Detectorists play a significant role in how and what material FLO's record. Failure to report artefacts is primarily affected by the aims and intentions of metal detectorists. Unreported finds are difficult to track, but luckily, many detectorists and landowners increasingly see the value in the reported finds and are discouraging what might be seen as looting among their groups. Unreported finds are not necessarily mishandled because of malicious intent, but can be a result of the time available to detectorists to report their finds, or the potential loss of land and artefacts. However, 'nighthawking', which is the theft of artefacts from protected archaeological sites or where access has not been granted, is still a prominent issue in archaeology and metal detecting. The most recent data on this problem is from Oxford Archaeology's (2009) *The Nighthawking Survey*, which revealed that there are twelve known sites where nighthawking has occurred in Lincolnshire, including the training excavation at Sudbrooke Villa, where nighthawks dug approximately twenty holes into archaeological features (Oxford Archaeology 2009, 62). The report does not provide an estimate of unreported finds for Lincolnshire but estimates 20,000 metal objects in Norfolk, a county of similar size, go unreported each year.

Illegal metal detecting is not the only cause of unreported finds. A lack of knowledge about the find or issues with confidentiality of find-spots can factor into whether detectorists report their finds to FLOs. Many FLOs are attempting to improve accessibility for reporting finds. Due to aspects such as time constraints, they are holding open days where detectorists and members of the public can go and report their finds; these are become increasingly common and improve the accessibility of FLOs (Robbins 2012, 240). However, the most common reasons detectorists choose not to report finds stem from a historically strained relationship with archaeologists or FLOs (Robbins 2012, 240).

The PAS database is affected by factors other than those relating to metal detectorists. The FLOs carry their own biases that also affect the completed record of the artefacts. FLOs are primarily affected by the funding in an area as well as personal interest and training (Robbins 2012, 240). Funding for an area can significantly impact not just how FLOs record the finds but also the number of artefacts recorded. Better-funded areas can employ more FLOs and consequently record a higher number of finds and as well as have more time to meet with detectorists. Additionally, each county area is run independently, leading to a notable variation in the detail of recordings. This discrepancy is reflected in the allocation of time, and as a result, the detail allowed for each recording. For example, Norfolk has a very high level of detail, unlike Yorkshire, which usually does not provide a detailed written description of an object (with a few significant exceptions). Additionally, Yorkshire is divided into three regions with different FLOs and this leads to discrepancies across the county (Robbins 2012, 17–18).

Within the last twenty years the use of the PAS for further research has expanded, showing the database's full potential. This potential is evident, with studies ranging from landscape and distribution of finds (Daubney 2015) to specific material culture-based studies (Thomas 2000). Although its potential is being realised, like any data set, understanding its problems and how to confront them is an integral part of its use. It is essential to recognise that, unlike traditional archaeological surveying methods, metal-detected evidence often does not have the support of contextual evidence to assist FLOs, detectorists, or researchers in their interpretation. Therefore, using the data often leads to different questions than excavated material does. Remembering these differences and biases helps to inform the research being undertaken and ensure that it will extract the best information from the material.

5.3. Sampling

5.3.1. Potential Issues with Sampling

The majority of this dataset comes from metal detected resources across Lincolnshire (Figure 5-1 and 5-2) and the modern unitary authority areas of North Lincolnshire and North East Lincolnshire. Metal-detected objects have provided invaluable new information to archaeologists in recent years; however, they form an imperfect dataset. To combat the issue, attempts were made to have excavated material integrated into the dataset alongside the metal-detected items (with the sites of Scremby and Flixborough), but access was not granted for material excavated in Lincoln from the latter half of the Early Medieval period, such as that from Flaxengate. This section will discuss the potential challenges with using such a dataset, such as dating based on style and using a small dataset.

Metal-detected Finds

The first important consideration when using metal-detected data is to remember that the spread of finds is more likely to represent bias within the recovery of artefacts rather than Early Medieval activity. Daubney (2015, 348) discusses the importance of merging HER data with PAS data to improve on these biases, especially when using the PAS for landscape studies. This is being stressed here, even though this is not a study in landscape distribution of finds, because it is important to remember that patterns in the data could solely be the result of detecting bias. For example, the majority of Anglo-Saxon finds comes from the southern half of Lindsey, especially from the area around Osbournby, while many Scandinavian and Anglo-Scandinavian finds are around the Humber Estuary. No conclusions will be drawn based on this division because it is far more likely to be a sign of recovery and availability, especially with a relatively small dataset.

The other important consideration when using a detected dataset is that the location of production is largely unknown; material retrieved consists almost entirely of finished objects. Excavations of production sites are rare in the former Kingdom of Lindsey, thus it is difficult to tie the types of objects and manufacture to Lindsey itself and conclusions made about the production occurring in Lindsey will be more difficult to draw. As most of the finds in the dataset were metal-detected they are therefore dated based on style, as will be discussed in 5.3.1.2.

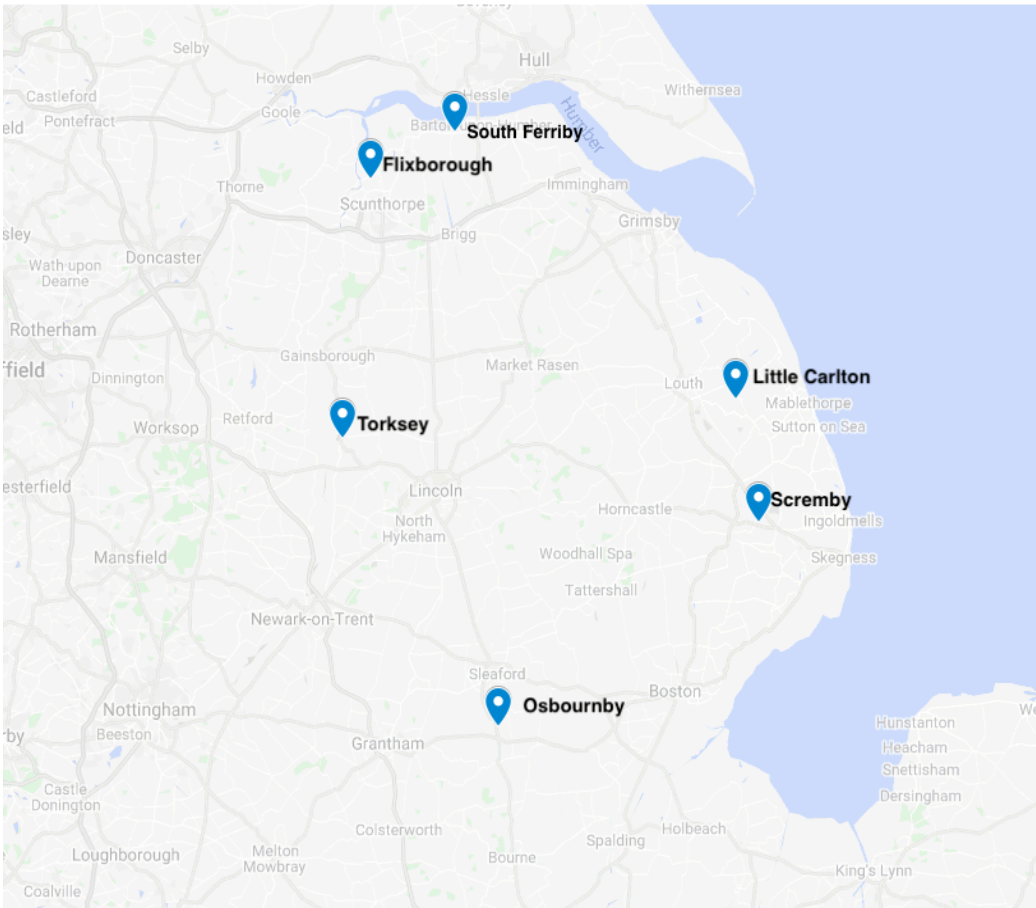

Figure 5-2 Map showing the locations of key find spots

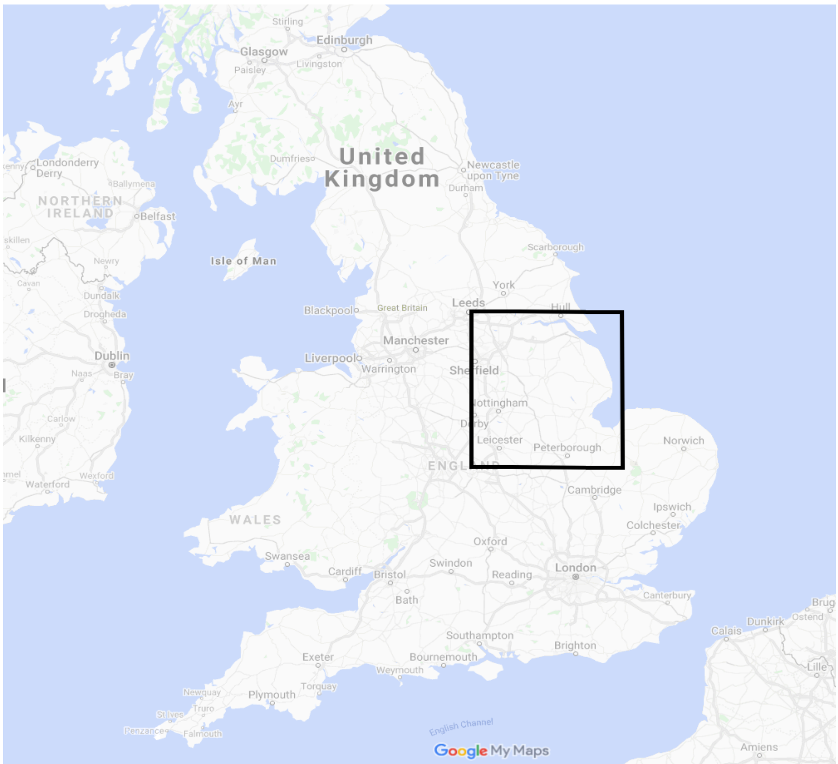

Figure 5-1 Map showing location of Figure 5-1

Employing Stylistic Dating

As the majority of the material is from metal-detected contexts, it is dated solely based on stylistic grounds and this was only possible because there are already well-established chronologies for Early Medieval styles. Solely using stylistic dating means the object date ranges will be not as refined as they would be if they were studied alongside stratigraphic data, or absolute dating methods, as they will normally encompass the date range for the entire style or object type. Additionally, objects dated entirely through stylistic methods results in other aspects, such as date of deposition, being unknown. So, the dates used here are based on when the style was being produced, but it will be unclear how long the object was actually in use for. Gifting objects, especially certain dress accessories, was a common practice in the Early Medieval period, and Anglo-Saxon burials show objects in older styles alongside new styles; therefore, it is possible to conclude that many of the objects in this study could have been in circulation beyond the dates provided by stylistic dating (see Härke 2014).

Working with a Small Dataset

Working with a small dataset in this project of 293 objects was inevitable because of the availability of material and limitations of access, and while this dataset still enabled significant results to be achieved, there are some limitations and specific approaches that should be discussed. First, with a smaller dataset individual outliers can have a disproportionate impact on the overall results, so within smaller datasets it is often recommended to remove outliers (Forman and Cohen 2004). Nonetheless, one helpful aspect of working with a smaller dataset is to choose simple statistical models to prevent a model from presenting non-existent patterns or over-complicating the dataset; analysis of the data should consist of as few parameters as possible (Forman and Cohen 2004). These principles were adopted, as when statistical analysis was attempted on the dataset it quickly became over-complicated. Therefore, as will be shown below, simple ternary diagrams were the best method for clearly recognising patterns within the data.

5.4. pXRF Introduction

Previous analytical studies of copper alloys have utilised a wide range of techniques, primarily EDXRF and XRF, whilst for this project, pXRF was the analytical instrument chosen. XRF and pXRF are commonly used techniques in archaeology for the examination of a wide range of materials; as a result there is a large amount of literature about analytical methods and techniques (Caple 1986; Craddock 1975; Dungworth 1995; Frahm and Doonan 2013; Pollard 2018). The analytical method presented below focuses on literature specific to pXRF to ensure the correct use of the instrument. The pXRF methodology is suitable for answering questions related to the determination of bulk chemical composition most appropriate for investigating alloys. The portability of the equipment also adds to the ease of accessing materials that otherwise could not be studied, as it allows the collection of data in the place where objects are housed rather than acquiring loans of the material. This ease becomes especially important with the inclusion of metal-detected material since detectorists usually retain ownership of the material.

For analysis, X-ray fluorescence can be produced by four different methods: first, using bombardment with a beam of high-energy electrons; second, using radioactive material that emits X-rays; third, from a synchrotron radiation source; and lastly, exposure with a beam of X-rays that creates a secondary beam of X-ray fluorescence. It is this fourth method that is used by XRF and pXRF (Skoog et al. 2017, 303). X-ray fluorescence is produced when the sample is bombarded with a focused beam of X-rays. The absorption of these X-ray beams causes electrons to become energised and then return to their ground state due to a redistribution of electrons at higher energy levels. This redistribution occurs since atoms have multiple electron orbitals (K, L and M shells). Since electrons cannot change the speed they move, they instead change the distance they travel to expel the extra energy. This distance travelled results in the electrons moving between the different shells with different intensities. Once the extra energy is expended, the electrons can return to their original orbital. This movement back creates a second beam that goes to the pXRF/XRF instrument. These varying intensity levels are represented in the spectrum, and a secondary X-ray beam reveals discrete energies that are element-specific; for example, copper emits X-rays at 8.04 KeV. The spectrum is a visual display of the energy peaks, which identifies the element to the user (Skoog et al. 2017, 309).

5.4.1. Semi-Quantitative pXRF Parameters

The model of pXRF used in this study is the Niton XL3t GOLDD+ XRF analyser, equipped with an Ag anode 50 kV and 200 μA tube operating at a voltage of 50kV with the main filter. Data output was calculated and normalised with Standard Thermo Scientific™ Niton Data Transfer software provided. Table 5-1 shows the elements sought by the pXRF. Machine standards were run prior to analysing the material as will be further discussed in 5.5.2.1.

Table 5-1 Elements sought by pXRF; those reported in bold

Copper	**Zinc**	**Tin**	**Lead**	**Iron**
Gold	**Silver**	**Arsenic**	**Nickel**	**Mercury**
Cadmium	Antimony	Palladium	Ruthenium	Molybdenum
Niobium	Zirconium	Bismuth	Selenium	Tungsten
Cobalt	Manganese	Chromium	Vanadium	Titanium
Aluminium	Rhenium	Tantalum	Hafnium	

5.4.2. Potential and Limitations in Using pXRF

The archaeological application of pXRF analysis has been the subject of significant debates and discussion. Shackley (2010, 17) stated that archaeology is not intellectually prepared for pXRF because its methodological and theoretical frameworks had not caught up with the technology in field analysis (Shackley 2010, 17). Much of the discussion has been met with scepticism because there is a perception of a 'lack of analytic rigour or understanding' (Grave et al. 2012, 1674). While being aware of the limitations of the pXRF is very important to ensure the use and resulting data are as accurate as possible, realising its potential is just as important:

as one can observe in the great successes of labXRF in archaeological research during the last fifty years, but such practice does not play to the obvious strengths of HHpXRF. HHpXRF cannot compete with the capabilities of labXRF within the lab-based paradigm but can be uniquely successful in novel applications. (Frahm and Doonan 2013, 1432)

The main and clearest potential for the pXRF is the convenience and portability of the machine. This allows for material to be analysed where it is housed or when it is uncovered in the field. Therefore, a wider range of material can be studied and added to the corpus of knowledge. Additionally, pXRF is cheaper and takes less time to perform analysis than laboratory-based XRF; this is because the pXRF is non-destructive and most samples do not undergo preparation such as drilling, as many do when in the laboratory. But as the above quote states, the use of pXRF and HHpXRF suitability varies from lab-based XRF. Primarily, it is still believed the pXRF provides less accurate results, and whilst this is less true than it used to be as the technology has advanced significantly, lab-based XRF is still superior in detecting trace elements compared to pXRF or HHpXRF. This makes pXRF more suitable for studying broad alloy changes rather than details of trace elemental analysis.

pXRF provides a surface analysis, analysing approximately 0.1 mm of the outer surface of an item, so surface corrosion or treatments can lead to deceptive results. Corrosion is the most significant issue to compensate for; the most recognisable Cu-based corrosion is the formation of a patina, which occurs when Cu alloys are in a damp oxygenated environment. The damp environment causes the Cu to dissolve along the grain boundaries and results in a red Cu_2O; furthermore the upper layers of the object can then react with the soil and form both carbonates and occasionally chlorides (Giumlia-Mair 2005, 36). There is also noble patina, which develops on Cu alloys in general, that consists of green malachite, a basic Cu(II) carbonate ($CuCO_3 \cdot Cu(OH)_2$). In drier environments, blue azurite, a different basic Cu(II) carbonate ($2CuCO_3 \cdot Cu(OH)_2$) can form, but it is far less common. The colour can become darker if sulphides of Cu and Pb are present, or lighter if there are Cu carbonates or cassiterite, Sn oxide (SnO_2). It is important to note that the type of patina that develops is dependent of the environment the object is deposited in rather than the composition of the object. However, patina compositions can vary, impacting their thickness, and some patinas can be up to 2 mm thick (Giumlia-Mair 2005, 36). Drilling into the object past the corrosion is a key way of minimising its effects, but this is not always an option as it is destructive. Additionally, ways of minimising the effects include simply avoiding areas of corrosion and understanding how to distinguish it in the data so it can be recognised during analysis and redone or eliminated when interpreting the data.

Interelement Interference

There are two types of spectral interferences that can impact the readings from the pXRF – background interferences and spectral overlap. Background interference occurs when the device picks up radiation from sources other than the item being analysed. Often background interference cannot be corrected during analysis and will need to be corrected after analysis. Spectral overlap can be corrected during or after analysis, the corrections for spectral overlap done in this thesis are discussed in section 5.5.2. Spectral overlap is increasingly common in complex samples. Spectral overlap occurs as the emission signal of an element is composed of a range of very narrow wavelengths, rather than one large wavelength, these wavelengths measures approximately 5pm; however, these measurements can shift by a factor of ten or more contingent on either object parameters, such as corrosion, or experimental parameters, such as temperature or pressure (Majidiv 2003, 765). This shift is measurement can result in spectra lines that are very close to lines of other elements pushing it to the wavelength of another metal, if these lines are not far enough apart the spectral overlap or inferences occurs (Majidi 2003, 767).

5.5. Methodological Approach to pXRF

5.5.1. Introduction

This section will provide an overview of the methodological procedure including sample preparation (5.5.2) and the working procedure (5.5.3). This will allow a clear understanding of how the methodology functions in this research project and how it will achieve its aims. Section 5.5.4 will be further explore how the pXRF data with the qualitative stylistic data allow for a multifaceted interpretation including aspects of identity, gender and technology.

5.5.2. Sample preparation

In order to ensure the most reliable and representative data possible, each pXRF session began by analysing with reference to a range of standards that most closely resembled the full range and the heterogeneous nature of the dataset being studied. These standards were chosen to reflect the range of archaeological material that is the focus of this study: copper, tin, zinc and lead. These standards include gunmetal, brass, leaded-bronze and tinned bronze, which sufficiently covered the range of archaeological material. It is essential to be aware of other elements that may be present, such as silver, gold, mercury and arsenic (standards: 364, 344, 207/2, 183/4). These different elements are often used as a surface enhancement or gilding or included intentionally or unintentionally as trace elements. Since pXRF is a method of surface analysis, as discussed in 5.4.2, surface treatments could return as a significant portion of the compositional results, but this would be a misleading result. Therefore, it is necessary to be aware of their potential influence on the overall composition determined and avoided when visible on the surface of the object, but since they are not what is being tested, they do not need a comparable standard as do the main elements studied.

The standards were measured three times at the beginning and end of each pXRF session to be able to establish precision and accuracy for each. The standards were also analysed three times after every ten samples. This frequency was necessary to uphold the accuracy or provide the ability to correct any errors that may have occurred during the session. Following the collection of the data, precision and accuracy were both determined, and the results of this are presented in Appendix Three. Precision is defined as how repeatable the results are, meaning if three samples are taken at the same point on an object, how similar or dissimilar the results are. Precision is calculated by taking the sample’s standard deviation and multiplying it by 100 and then dividing it by the sample's mean average, as shown below.

$$precision = \frac{sample's\ standard\ deviation * 100}{sample's\ mean}$$

Accuracy, on the other hand, is how close to the element's 'true' value the reading is. Accuracy is calculated as the relative error, so accepted values (of a standard) (xt) are subtracted from the average of a small set of certified samples taken (of a standard) (x1) then divided by the average (x1) and multiplied by 100, as shown below.

$$relative\ error = \frac{x^1 - x^t}{x^1} * 100$$

From here, it is possible to see whether there are extreme issues with the data, primarily whether the accuracy and precision is within the acceptable range or whether the material needs to be tested again or excluded from the study. Potential accuracy issues can be remedied by visually checking the spectra and not only relying on computer-generated results. One key, and relevant, example of this is dealing with lead and arsenic. These two elements have very close peaks and can result in peak overlap due to erosion. This peak overlap confuses the computer-generated information and causes, in some cases, arsenic values to be greatly exaggerated, instead of recognising them as lead peaks. The primary solution to this issue is to switch lead to a less sensitive peak and manually check the spectra.

Acceptable Accuracy and Precision

There is no straightforward answer to what is an acceptable accuracy and precision reading for this study. Using specific examples from the standards employed in this study, this section will break down the many factors that go into what would be considered acceptable or unacceptable values and how these values can sometimes be misleading. For this study the standards 364, 344, 207/2, and 183/4 were all used before, after, and throughout pXRF analysis and their values can be found in Table 5-2 and in Appendix Three.

Table 5-2 Standards used and their values

Standards	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
364	9.35	0	9.25	0.07	0	0.13	80.6	0.005
344	0	0	0	0	0	30.98	68.98	0
207/2	9.74	0	0.7	0.066	0	1.6	87.35	0.029
183/4	7.27	0	3.15	0.13	0	3.47	84.08	0.056

Acceptable Results

As stated, there is no generally acceptable result when testing standards; the overall goal for accuracy is to have the numbers as close to zero as possible. However, the distance acceptable from zero varies between standard and the element being tested; to aid in the explanation of these acceptable variations an example from Appendix Three can be found in Table 5-3. This example of standard 207/2 was used because the precision and accuracy would be acceptable; however, if just looking at the accuracy results that may not be apparent.

Table 5-3 Example of standard 207/2 test

SAMPLE		Sn	Pb	As	Zn	Cu	Fe
207/2		10.582	0.889	0	1.734	85.869	0.029
207/2		10.587	0.868	0.675	1.705	85.576	0.028
207/2		10.542	0.884	0	1.697	85.767	0.022
	Avg.	10.57	0.88	0	1.712	85.737	0.027
	Standard Deviation	0.02466441431	0.01096965511	0.3897114317	0.01946792233	0.1487357836	0.003785938897
	Precision	0.2333435602	1.246551718		1.137144996	0.1734791089	14.02199592
	Accuracy	7.852412488	20.45454545		6.542056075	-1.88133478	-7.407407407

This discussion will begin with an examination of the accuracy of lead within this sample. Accuracy calculations are proportional and therefore elements less prevalent in the object will have less 'accurate' results. The standard 207/2, as shown in Table 5-2, has a lead value of 0.7%; the pXRF readings averaged to be 0.88%. This difference of 0.18 is quite small, but when looking at Table 5-3 the accuracy for lead is high (20.45454545), making it the least accurate value from this sample. If this is compared to the accuracy of the copper reading, which is -1.88133478, the problem with relying on accuracy results alone becomes apparent. The amount of copper found in 207/2 is 87.35% but the average reading from our standard is 85.737 %, making a 1.613 difference. This total value difference is much bigger than that of lead, but the accuracy measurement is significantly smaller. In fact, the copper reading comes back as the most accurate but has the greatest difference in actual value compared to the value recorded by the pXRF. This highlights the need when looking at accuracy and precision to take the total value into consideration. Lead values can be considered inaccurate, based solely on the accuracy equation, while the copper value is simple due to the total value, because the total value of lead is so small the 0.18 difference between the average and the actual value seems to be much more significant that the 1.613 difference with copper. Therefore, it is important to consider both the total value and difference as well as the accuracy measurements, which is proportional when determining the usability of the compositional data.

Correcting for Interelement Interference

A common prevalent issue with pXRF is inter-element interferences this results in peak overlap and inflated values of specific elements, in this research's case, lead and arsenic. To combat this issue after the fact the average accuracy can be taken from the standards and used to correct those specific elements. The process of this can be seen starting in Appendix One, where the original lead values are next to an added column with the lead values that have been scaled-down in accordance with the standards data, this column is noted as Pb (scaled down). These scaled down values will be used going forward in this work, such as the values for lead found in Appendix Two and the data graphed in Chapters Seven and Eight. The data having undergone this process means that the data being presented is semi-quantitative and should be analysed and discussed as such. This means that it can be utilised for broad alloy change but not for detailed analysis of slight differences in element content.

5.5.3. Working Procedure

As a result of the potential and limitations of the pXRF, the methodology developed for this project had to fit around those parameters to ensure the best possible results. To begin, the pXRF was chosen for this analysis for a variety of reasons beyond access to the equipment. The primary reason was the portability of the machine; this research often involved needing to travel to where the material was housed rather than the material being able to come to the laboratories in Sheffield, so because of this portability a large portion of material that previously had not been able to be studied because of access were included in this research. Beyond portability, the pXRF was also considered adequate for this research as the primary goals of the study were to look for broad alloy changes rather than trace element analysis, therefore also working within the limitations of the pXRF while exploring its potential.

Sample selection was a crucial part of the analysis process. First, any items with significant visible corrosion were not included because of pXRF being a surface analysis method and not able to penetrate through the corrosion. Once items were selected based on visible corrosion levels, points for analysis were selected on the item. A minimum of three points were taken per object to ensure an average could be made to then equate standard deviation, accuracy and precision; with larger objects more points were taken. Flat objects, such as brooches and strap ends, had points taken on each side, and objects that were more cylindrical in nature, such as Norse bells, had points taken around the object. If objects had patches of obvious corrosion those were avoided when taking points, as were areas that had evidence of iron fittings, such as the pin fittings on brooches.

While analysis was underway, there was frequent rescanning of the standards to ensure the machine was still operating well. Occasionally there were some extreme readings and the machine was switched off, given time to cool down and then standards were analysed; if determined to be within an acceptable range analysis proceeded and items that were scanned when the machine was over heating were reanalysed. If compositional readings for an object totalled under 90% or above 110%, they would need to be removed from the dataset, but no readings were outside of this acceptable range. Additionally, preliminary checks of the data were made throughout the analysis, in order to check for markers of corrosion or the machine malfunctioning.

A clear sign of corrosion was caused by high levels of iron in the copper alloy; this is because high levels of iron cannot be smelted into copper and therefore must have occurred through corrosion. A common issue in this analysis were high arsenic readings, occasionally in the 40–50% range, which is not probable in a copper alloy. For instances such as these, items were reanalysed and after selecting new points arsenic levels were found to be much lower, and to further tackle this potential issue the spectra were also referred to. The spectra were an important tool here, as lead can often be mistaken for arsenic by the machine, but in the spectra it was possible tell them apart – lead being mistaken for arsenic has a bottleneck appearance in the graph as opposed to a clean peak as would be expected. A further significant issue was the pXRF detecting high lead levels at specific points, and this, unlike improbably high arsenic levels, is a common issue. Lead, if not properly melted into the copper, can result in lead pockets or bubbles throughout the object, highlighting the importance of multiple readings along an object. Readings at these high and unusual levels on objects that were subsequently rescanned can be seen in Appendix Four as that data was not manipulated in any way; however, those results were not included in the interpretation.

Following the analysis with the pXRF, the data was then cleaned up and normalised, which included eliminating elements from the pXRF analysis that were not included in the interpterion. This is because such elements were not available in the Early Medieval period, and any interpretation of them would be misleading. Such elements included tungsten and hafnium as shown earlier in Table 5-1. This data was then divided based on period, object type and ascribed culture, and interpreted through the theoretical framework outlined in the previous chapter. Additionally, the main alloying elements (zinc, tin and lead) were looked at individually by scale factoring them and graphing them to understand their proportions as well as their total value. Their proportions were used for graphing and examining broad changes, while their total values were used for classifying each object as bronze, brass, gunmetal and so forth. Once those steps were completed the data could then be interpreted.

5.5.4. Data Interpretation

Data interpretation initially established a timeline of compositional changes over the Early Medieval period as well as variation between object types. This allowed for ease of visualisation of the changes the occurred over time. Once a timeline was established it was possible to revisit the socio-political changes and population movements that occurred in Lindsey to see whether there was a correlation between those and the compositional changes. These changes over time were then able to be compared to other areas in the Early Medieval period. This allows for the placement of Lindsey within a wider context of Early Medieval Northern Europe, showing how Lindsey was similar or dissimilar to the surrounding kingdoms and regions. This also enables examination of how socio-political changes would have impacted Lindsey compared to the surrounding region, as discussed in section 9.02. These comparisons also place Lindsey into the modern discussion of changes in technology and metal production; see section 10.2.

Interpreting the data patterns between styles and compositions focused on how social groups and possible migrating populations into Lindsey employed different resources for copper alloy production. This was the most challenging aspect of data interpretation; as discussed in 4.2.1 and 4.2.2 these stylistic changes may not have been necessarily due to the movement of people. The theoretical frameworks discussed in section 4.2 formed the crux of the interpretation methods for discussing these objects, their compositions and the correlations with their styles. Owing to the use of these theoretical frameworks there is a careful consideration of the impact and issues surrounding hybridisation and acculturation as well as group identity and performative identity. These aspects of the theoretical framework resulted in a cautious approach to interpreting objects as means of identifying populations.

5.5.5. Compositional Data Classification System

A key aspect of understanding the pXRF data is classifying the total values into copper alloy types; therefore, these different alloy types must be defined and the classification system employed in this dissertation outlined.

There are many classification systems already in place for the study of archaeological alloys. The most often-cited example is Bayley and Butcher's (2004) classification of copper alloys. In this classification they categorise different copper alloys based on zinc to tin ratios alongside absolute values. This system, for the most part, disregards lead's role as a sole alloying possibility and considers it mainly as an additional element to brasses and bronzes. This system, like most others, also relies on both ratios of elements and their absolute values. As a result, brass is defined as needing 8% zinc, with the amount of zinc needing to be at least four times the amount of tin (Bayley and Butcher 2004, 14). The full classification system can be found below in Table 5-4.

Table 5-4 Copper alloy classification based on Bayley and Butcher (2004, 14).

Alloy	Zinc:Tin Ratio	Absolute Values
Brass	Zn > 4Sn	Zn = 8%
Brass/Gunmetal	2.5Sn < Zn < 4Sn	Zn = 8%/ Sn = 3%
Gunmetal	0.67Sn < Zn < 4Sn	Sn = 3%
Bronze/Gunmetal	0.33Sn < Zn < 0.67Sn	Sn =3%
Bronze	Sn = 3Zn	Sn = 3%
Copper	-	Zn < 3% and Sn < 3%
Copper/Brass	-	3%= Zn < 8% and Sn < 3%
Leaded Alloys	-	Pb > 8%
(Leaded) Alloys	-	8% = Pb = 4%

Pollard's (2018) system is a significant departure from these previous classifications. He simplified this new approach as a result of having a fundamental and 'philosophical' difference in belief regarding the study of archaeological copper alloy compositions (Pollard 2018, 699). The difference is an opposition to the core belief that assumes each alloy was produced with a specific composition as the goal and these are then measured using relatively modern specifications. Instead, Pollard states that researchers' own assumptions about metal compositions should not impact the determination of past metal production (Pollard 2018 699–700), and these practices could range from carefully designed recipes to relatively random compositions produced by frequent cycles of recycling and mixing. Consequently, this study focuses less on ratios and employs a simple 1% benchmark for alloys, as presented in Table 5-5. The selection of a 1% standard was chosen to achieve an absolute value that could illustrate alloys and eliminate any natural contributions to the compositions – for instance, from the copper ore or the ceramic materials such as crucibles.

Table 5-5 Copper alloy classification system based on Pollard (2018, 700).

Alloy Type	Definition
Leaded Copper	Pb > 1%; Sn & Zn both < 1%
Bronze	Sn > 1%; Zn & Pb both < 1%
Leaded Bronze	Sn & Pb both > 1%; Zn < 1%
Brass	Zn > 1%; Sn & Pb both <1%
Leaded Brass	Zn & Pb both > 1%; Sn <1%
Gunmetal	Sn & Zn both > 1%; Pb < 1%
Leaded Gunmetal	Sn, Zn, & Pb all > 1%

Both Bayley and Butcher's (2004) and Pollard's (2018) classification systems were employed separately to this study's dataset to establish alloy types. However, neither worked perfectly with this dataset. To begin with, the most prevalent conflict when employing Bayley and Butcher's system was their treatment of lead. As highlighted in Table 5-4, leaded copper is not an option within this system, resulting in 174 objects of the 293 total being considered either leaded or (unleaded) even if the lead amount was higher than the zinc or tin absolute value. Additionally, the high zinc levels required for brass by Bayley and Butcher's system was not feasible in this study. Prior to the 18th century, and substantial changes in zinc production, brass could not achieve a higher zinc content than 21% (Tylecote 1992, 152). Consequently, historic brasses should not be held to a modern standard of zinc. All things considered, Bayley and Butcher's system, in this dataset, would lead to a bias toward items being classified as leaded bronze.

In Pollard's (2018) system, as displayed in Table 5-5, the issues were the opposite of those in Bayley and Butcher's (2004) system. The benchmark of 1% is simply too low an absolute value to be functional for the dataset in this thesis. This issue is easily illustrated by the alloy divide that occurred when Pollard's system was used with this dataset; of the 293 objects in this study, 283 of them had more than 1% of lead. Additionally, 216 of the objects had more than 1% tin, and of these all but two also had lead levels of more than 1%.

Similarly, 213 objects had more than 1% of zinc, and of those objects 207 of them had more than 1% lead. Consequently, with Pollard's system, nearly half the objects (142) would be classified as leaded gunmetal and all but ten objects would be considered leaded. For these reasons, Pollard's benchmark of 1% was considered far too low for this dataset, as it seemingly eliminates the diversity of compositions found within the Early Medieval objects studied. Therefore, for the final analysis of compositions, a new system needed to be established.

Table 5-6 Copper alloy classifications used in this thesis

Alloy Type	Definition
Leaded Copper	Pb > 8%; Sn & Zn both < Pb
Bronze	Sn > 3%; Zn & Pb both < Sn
Leaded Bronze	Sn > 3%; Pb > 3% and ≤ Sn; Zn < .5Sn
Brass	Zn > 3%; Sn & Pb both <Zn
Leaded Brass	Zn > 3%; Pb > 3% and ≤ Zn; Sn < .5Zn
Gunmetal	Sn ≈ Zn and both > 3%; Pb < 1%
Leaded Gunmetal	Sn, Zn, & Pb all > 3%; none exceeding twice the others

The classification method established for this thesis, as laid out in Table 5-6, builds upon the two preceding systems discussed. Here Bayley and Butcher's use of ratios is adapted to ensure clear divisions between alloy types, especially those with heavily mixed compositions. Similar to Pollard's method, this system employs a standard benchmark, but this is raised from the level of 1% to 3%. This higher benchmark avoided accidental inclusions and attempted to only recognise the intentional production of specific alloys. The new 3% benchmark was highly influenced by Dungworth's (1995, 134) experiments in which he studies the mobility of zinc. He melts bronze in crucibles previously used for brass melting and found in his two samples and two separate melting occurrences that the zinc content rose from 0% to 0.57% and 0.59%, demonstrating quite a high mobility of zinc from the crucibles to the bronze Dungworth was producing. Consequently, for this study these amounts were likely to be too close to the benchmark of 1%. Furthermore, this slight increase to a 3% benchmark allowed for further separation and classification of objects with slightly mixed compositions. Moreover, Pollard's inclusion of leaded copper and leaded gunmetal are additional elements incorporated into this new classification system. As will become apparent, lead comprises a significant part of this dataset and classifying it solely as a tertiary additive and not as an alloying material in its own right would have been an erroneous approach. In short, while Bayley and Butcher's and Pollard's systems worked for their respective studies, a middle ground between them needed to be reached to create a productive and functional methodology for this study.

5.6. Summary

This chapter has presented the methodology of this thesis. The key focus was explaining the process that was employed to answer the fundamental thesis question: does socio-political change impact copper alloy production, and specifically in the Early Medieval kingdom of Lindsey? The methodology required consideration of pXRF practices as well as an understanding of utilising a metal-detected dataset. Furthermore, this chapter has discussed the potential problems that can occur when using pXRF and how to combat those issues. With this methodology in mind the discussion can now proceed to the necessary stylistic background (Chapter Six) required to contextualise the dataset (Chapter Seven) and compositional data (Chapter Eight).

Chapter 6. A Classification for Early Medieval Styles and Types

6.1. Introduction

The aim of this chapter is to categorise and provide an overview of the object types and styles addressed in this thesis, to ensure clarity during the discussion of the compositional data in Chapters Eight and Nine. Since a wide range of diverse objects are being considered, it should be no surprise that there is significant variety in the level of previous research undertaken on the different forms under consideration. It is not the purpose of this chapter to refine these established typologies or provide them for those objects lacking sufficient earlier analysis; rather the discussion exists within the constraints of these established typologies. As a result, this has inevitably led to some object types being discussed in more detail than others. Furthermore, this chapter will only include object types and styles that are present in the research, rather than presenting an overview of all Early Medieval types and styles.

6.2. Stylistic Overview

6.2.1. Anglo-Saxon Styles

Anglo-Saxon design underwent radical changes between the 5th and 11th centuries (Weetch 2014b). The styles that will be discussed here are Style I, Style II, Trewhiddle and Winchester. Brooch types and styles interplay with one another quite significantly, especially as displays of different cultures and identities. During the Viking Age, object types and styles begin to be combined in different ways, leading to significant developments in dress accessories but also highlighting the importance of understanding the object types and styles and how they relate to the compositional results.

The Anglo-Saxon styles that are discussed below are established styles within Anglo-Saxon art. However, they are not the only design elements found on objects during this period. Other design elements to be aware of include punched dots, triangles and crescent patterns, as well as incised lines, which are prevalent on annular brooches. The variation between the employment of each style can be considered to be clearly related to the intrinsic or perceived value of an object, both by archaeologists and an item's contemporary audience. These unclassified design elements are actually far more common on objects than the styles discussed below, but all are important to discuss.

Style I (Late 5th and 6th Centuries)

Style I is frequently described by scholars as abstract, jumbled, busy, and an 'animal salad' (Weetch 2014b). However, upon closer inspection it is not as unintelligible as it first seems. Square-headed brooches are often the prime medium for displaying Style I. The brooch in Figure 6-1 shows just how intricate the designs could be, this example involving twenty-four different animals, birds and human heads, one of which is believed to be the Germanic god Woden/Odin (Weetch 2014b). The Style I objects found in this dataset are not quite as lavish as this brooch. They are primarily cruciform brooches of Martin's type IV, along with some squared head fragments, as shown in Figure 6-2. Key features of this style are the surfeit of animals and the distinct sections or compartments, each with different scenes.

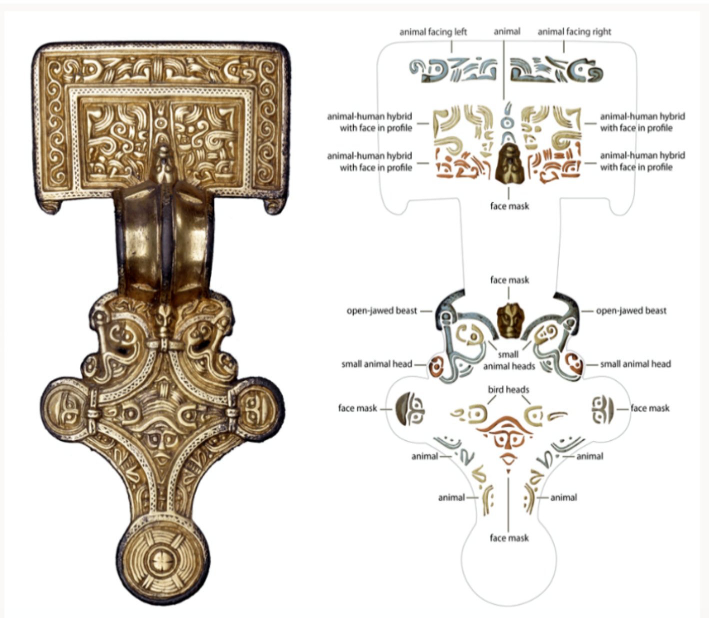

Figure 6-1 Brooch showing Style I features (Weetch 2017)

Figure 6-2 BR.90 showing Style I in the dataset

Style II (Late 6th Century)

Style II, which became dominant in the 6th century, is distinct from Style I in the design of its animals, which are long and graceful and now easily shaped into interlacing patterns over an entire object, rather than in confined compartments as in Style I. However, there are still some elements of separation within an object, as shown in Figure 6-3, a belt buckle from Sutton Hoo (Karkov 2011, 23–24). This composition now follows the borders and boundaries of an object. There are three continuous patterns: one on the plate of the buckle, one on the

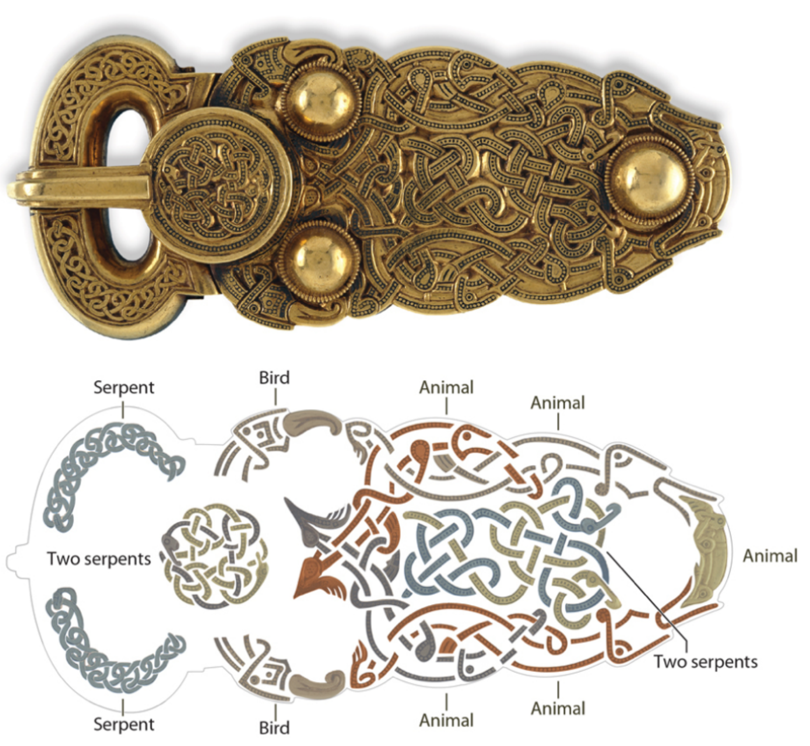

Figure 6-3 Sutton Hoo belt buckle showing Style II features (Weetch 2017)

tongue, and the last on the actual buckle. These three pieces also would have been produced separately and then assembled, so the separate scenes are necessary. Style II stresses the importance of the natural world in Anglo-Saxon culture and identity, and there are many theories that highlight the importance in the choice of animals selected for particular objects. Different animals were thought to hold specific properties, which the objects they decorated would then be imbued with – for example, snakes were believed to be shape shifters (Weetch 2014b). Those specific characteristics would then become an outward display for the wearer of such objects. After the conversion to Christianity, stylistic traits such as these become less animal focused and more humanistic (Weetch 2014b).

Trewhiddle (9th Century)

The Trewhiddle style is frequently found on 9th-century Anglo-Saxon disc brooches (Kershaw 2010, 33). Trewhiddle was named after a silver hoard found at Trewhiddle, Cornwall in 1744 (Karkov 2011, 189), and it grew out of an older Mercian animal style. However, it soon spread, becoming increasingly popular throughout southern England, as shown by manuscripts produced in Kent and Mercia, while also having prominence in the Danelaw. The style is lively with triangular or geometric animals each in self-contained fields with beaded frames (Webster 2012, 151, Karkov 2011, 189). An example of the Trewhiddle style as represented in dress accessories can be seen on the Fuller Brooch (Figure 6-4), which was part of a hoard found in Pentney, Norfolk, dated to the early 9th century. The brooches in the Pentney hoard were all made of silver, and this may mark a shift away from surface gilding most likely due to a lack of availability or aesthetic changes. However, artists took advantage of this by using the light/dark contrast that was possible with silver, creating a greater dimension to the brooches (Karkov 2011, 251). The Trewhiddle style is not extremely widespread within Lincolnshire, but instead it tends to present itself on items such as strap ends and hooked tags.

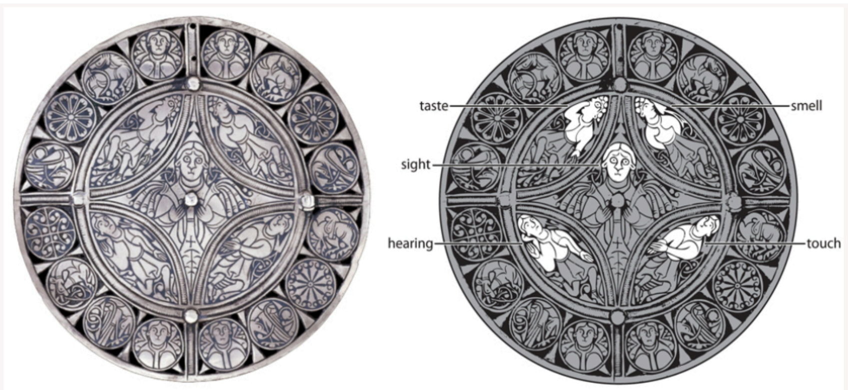

Figure 6-4 Trewhiddle style as shown of the Fuller Brooch (Weetch 2017)

Winchester (Late 10th to Mid-11th Century)

The Winchester style emerged in the later 10th century and remained popular until the 11th century (Kershaw 2010, 33). This style was prevalent throughout England and even expanded out to Northern Europe, likely through connections between monastic communities (Webster 2012, 174). The style returns to designs focused on plant ornament, with acanthus leaves being commonplace, while animals only appear occasionally. The Winchester style is a typical design found on metalwork, similar to the Trewhiddle style, and it is frequently found on masculine gendered strap ends as shown in Figure 6-5, yet very few examples have been found on female dress items (Kershaw, 2013; 33–34).

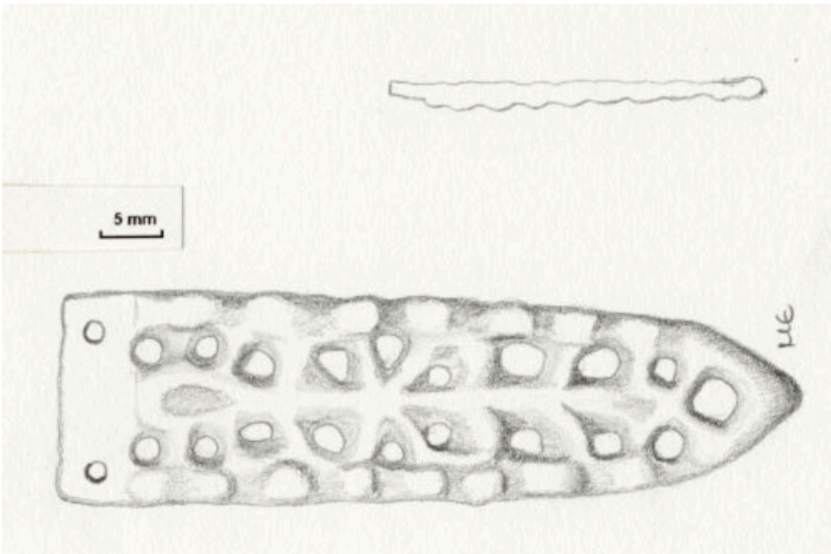

Figure 6-5 Drawing of Winchester strap end NLM4546. North Lincolnshire Museum

6.2.2. Scandinavian Styles

Only the relevant Scandinavian styles found in the British Isles are discussed here. These styles are grouped under the headings of Style E or Oseberg Style, Borre, and Jellinge, all of which are from the First Viking Age (793–850), followed by styles from the Second Viking Age (850–1066) including Mammen, Ringerike, and Urnes. There are stylistic and chronological overlaps between some of the trends; however, they are still varied enough to be placed in the following defined categories (Kershaw 2010, 1).

Borre (Mid-9th to Mid-10th Century)

Figure 6-6 Modern re-creation of Borre ring-chain (Markussen 2019)

Borre, named after discoveries in Borre, Vestfold, Norway, dates from the late 9th to the 10th centuries. Dendrochronology has confirmed this date range of use at sites such as Gokstad, Tune, Borre and Trelleborg (Bonde and Christiansen 1993; Graham-Campbell 2021, 63). The earliest example of Borre style is from Denmark from a hoard from Vester Vedsted, Ribe. The object is a gold mount with three Borre animals all with their heads facing towards the centre (Wilson and Klindt-Jensen 1966, 92–3; Graham-Campbell 2021, 63–64). Upon the Scandinavian arrival in the British Isles, the Borre style was initially favoured and is reflected by its prominence in finds throughout the Danelaw. Borre is seen in a variety of materials from stone to metalwork and seems to be longer lasting than other Scandinavian styles in the British Isles, persisting beyond its popularity in Scandinavia. However, this is difficult to say with much certainty as the majority of Borre-style metalwork in England has derived from metal detecting and thus cannot be tied to a context.

Borre style (Figures 6-6 to 6-9) is easily recognised by its repetitive patterns and geometric shapes. Just like preceding styles, Borre's interlacing is very tight with barely any visible background, employing double- and triple-strand ribbons. It is known for having curly loops and pretzel knots in the interlace patterns (Graham-Campbell 2021, 65). One of the most recognisable Borre motifs, and the one most commonly found in the British Isles, is the interlacing double ring-chain. The ring-chain (Figures 6-6 and 6-7) pattern primarily consists of a chain of interlocking circles that are then divided across by a broad line and then overlaid by repeating lozenges. A few items, such as strap ends, consist of the ring-chain ending with an animal head, but these are not very common.

Figure 6-7 BR.077 (LIN-9BB619) showing Borre ring chain in dataset

Figure 6-8 BR.087 showing Borre bear motif in dataset (author's own photo)

Borre also employs zoomorphic motifs alongside geometric patterning. The most common of these zoomorphic patterns, and especially prevalent in this study, is of a forward-facing bear. The Borre bear is easily recognised by large, rounded eyes and triangular face but with a rounded snout and large subrounded protruding ears. The bear's design makes it a clear addition for objects ending in a rounded point, as will be discussed later in the chapter. The other zoomorphic Borre design is of a gripping beast characterised by a pretzel-shaped body reminiscent of the ring-chain pattern, with gripping paws and a triangular face (Figures 6-8 and 6-9) (Graham-Campbell 2021, 65).

Traditional Borre motifs become slightly altered during their transition from Scandinavia to the British Isles. The ring-chain motif was modified to be a series of bowed triangles surrounded by cascading and interlocking loops. On recently found metalwork, the gripping beast motif has also occurred throughout the British Isles, along with less complicated zoomorphic designs such as isolated triangular faces and the gripping paws that are found in interlacing patterns. Additionally, recently hoards have been recovered with individual items containing a mix of both Borre and the later Jellinge style together, such as one in Vårby, Södermanland, Sweden and one in Gnezdovo, Russia (Hedenstierna-Jonson 2006, 314 . This common occurrence of the two styles combined into one item has led to the conclusion that they had a period of coexistence (Wilson and Klindt-Jensen 1966, 93; Graham-Campbell 2021, 81).

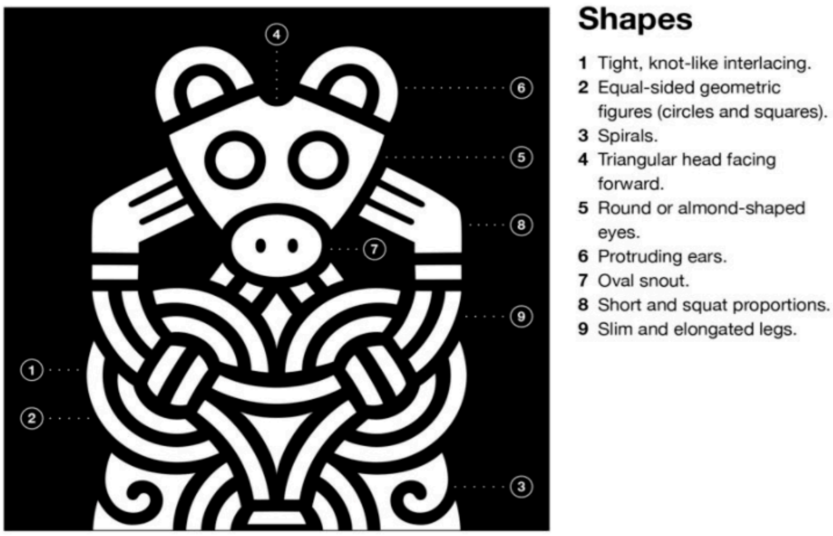

Figure 6-10 Modern re-creation of Borre shapes, particularly the Borre bear (Markussen 2019)

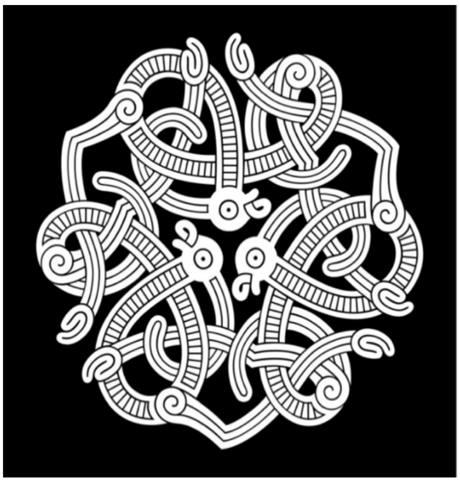

Figure 6-9 Modern re-creation of Jellinge animals in ring-chain (Markussen 2019)

Jellinge (10th Century)

The Jellinge style (Figures 6-10 to 6-12) is extraordinarily diverse and widely distributed. Therefore, it is often challenging to distinguish Jellinge from other styles (Wilson and Klindt-Jensen, 1966, 95). The name Jellinge is derived from a 10th-century silver cup with animal motifs running around the side found at the North Mound at Jelling, Denmark (Kershaw 2013, 28; Graham-Campbell 2021, 84, 86–89). This style is contemporary with the Borre style, and also dates to from the late 9th century to the 10th century (Wilson and Klindt-Jensen 1966, 96). The Jellinge style is not very common in metalwork, especially in isolation, but the combination of Borre and Jellinge styles became popular during the transition between the two styles. One example of this combination is a brooch from Östra Herrestad, Skåne, Sweden; on this brooch the animals are Jellinge style but arranged in a Borre ring-chain pattern (Figure 6-10) (Wilson and Klindt-Jensen 1966, 96–97). Wilson and Klindt-Jensen (1966) hypothesise that the Jellinge style developed alongside the Borre style until the late 10th century before it merged into the later Mammen style (Wilson and Klindt-Jensen 1966, 118).

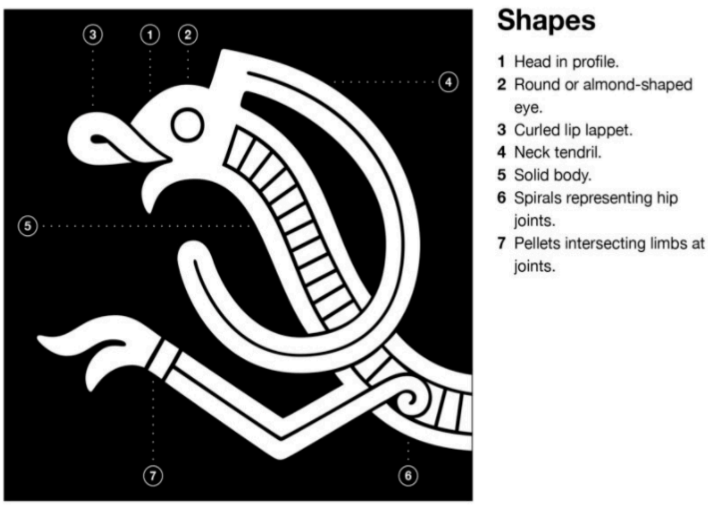

Figure 6-11 Modern re-creation of Jellinge-style animal (Markussen 2019)

The compositions found in Jellinge tend to be simple, focusing on overlapping and or mirrored S-shapes. Overlapping pretzel knots around a central circular point is an additional typical Jellinge composition. Jellinge has markedly less interlacing than older styles, with some visible background, and employs single- and double-strand ribbons. Jellinge motifs are primarily zoomorphic (Figure 6-11), and are in profile, having 'ribbon-like' bodies in the shape of an S with clawed feet. The neck or ear lappet is usually interlacing with spirals comprising the animal's limb joints; the mouth is often open and can have a tongue sticking out. In the Jellinge styles animals have round eyes (Wilson and Klindt-Jensen 1966, 95; Graham-Campbell 2021, 85–86). Another motif is a continuation of the Borre-style gripping beast, with the animal looking backwards with its tongue out extending beyond the creature's paw (Kershaw 2013, 29).

Figure 6-12 BR.067 showing Jellinge style in dataset (authors own photo)

Mammen (Mid-10th Century to Early 12th Century)

The Mammen style (Figures 6-13 and 6-14) is the first style that marks the end of the use of stylised animal motifs in Norse art forms and the introduction of semi-naturalistic animals and vegetal motifs (Kershaw 2013, 30; Graham-Campbell 2021, 99). The Mammen style is most commonly found in monumental stonework, such as rune stones and church architecture, and is quite rare in small, portable metal works (Wilson and Klindt-Jensen 1966, 119–121; Kershaw 2013, 30). Items in Mammen style are often stylistically closely related to its predecessor, Jellinge, or its successor, Ringerike (Wilson and Klindt-Jensen

1966, 133; Graham-Campbell 2021, 81), and consequently Mammen is seen as a bridging style between the two.

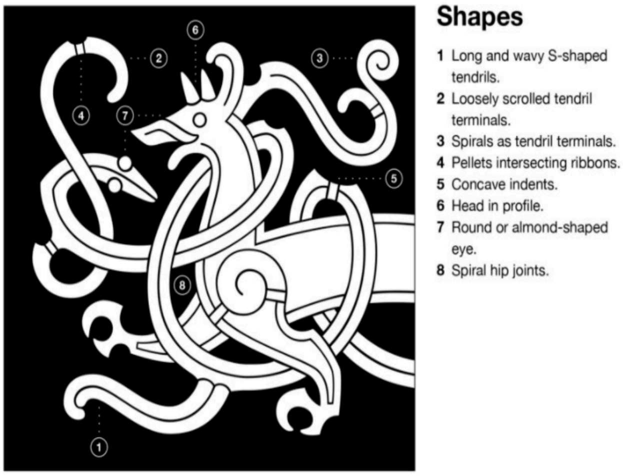

Figure 6-13 Modern re-creation demonstrating Mammen patterns and shapes (Markussen 2019)

Figure 6-14 M.001 (LIN-A64A26) showing Mammen style in this dataset

Objects decorated in Mammen styles tend to focus on a single motif with loosely flowing compositions employing curly loops, pretzel knots and S shapes, as a culmination of earlier styles. Patterns have loose interlacing, resulting in some visible background using single- and double-strand ribbons. A typical pattern of the Mammen style is of semi-naturalistic animals, such as lions, birds and snakes, that have been encircled by interlacing tendrils and scrolls (Kershaw 2013, 30–31; Graham-Campbell 2021, 98–99). Mammen animals are always in profile and can either have rounded or almond shaped eyes and spiral hip joints, as in Jellinge style.

Ringerike (Early 11th Century to Late 11th Century)

The Ringerike style (Figures 6-15 and 6-16) was named for a district a few miles north of Oslo, Norway (Wilson and Klindt-Jensen 1966, 134; Graham-Campbell 2021, 112). There, archaeologists uncovered various stone monuments with Ringerike tendril and animal motifs. Nevertheless, similar to the Mammen style, Ringerike is also far more common on stone carvings than on metalwork (Kershaw 2013, 31). Later examples of openwork brooches in the Ringerike style show the shift towards the newly emerging style, Urnes (Wilson and Klindt-Jensen 1966, 140).

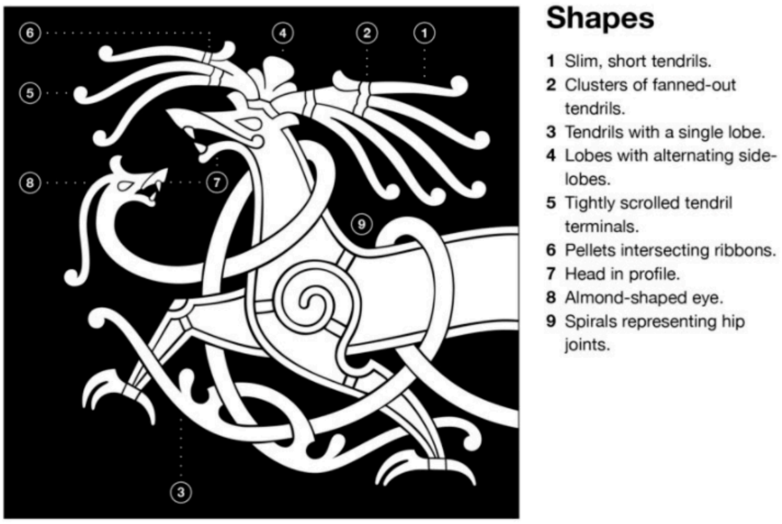

Figure 6-15 Modern re-creation demonstrating Ringerike patterns and shapes (Markussen 2019)

The Ringerike compositions tend to be far more balanced than those of their predecessor, Mammen. Ringerike still focuses on single motifs but employs more decorative elements, such as tendril clusters. The interlacing found in Ringerike is described as semi-tight and has some visible background. Ringerike employs single- and double-strand ribbons; however, they are now layered, leading to interlacing breaking ribbons. Ringerike also begins the flow of compositions in one direction and the use of figure-of-eight loops (Graham-Campbell 2021,112).

Figure 6-16 SF.001 (LIN-F29FC4) showing the use of Ringerike style in the dataset

Ringerike has three core motifs (Kershaw 2013, 31). The first is a quadruped that is a continuation of the earlier Mammen creature, with a snake, which is encompassing the whole scene; additionally, there are long tendrils that surround both animals (Fuglesang 1980, Wilson and Klindt-Jensen 1966, 136–138). Additional motifs are intertwining mammals, and large birds interlaced with snakes.

Urnes (Late 10th Century to Early 12th Century)

The Urnes style's name comes from woodcarving adornment from a small church in Urnes, Sogn, Norway (Wilson and Klindt-Jensen 1966, 147, Kershaw 2013, 32; Graham-Campbell 2021, 126). To create imbalanced, smooth looping patterns, the Urnes style (Figures 6-17 and 6-18) uses single-strand ribbons of varying widths, often forming figure-of-eight patterns (Kershaw 2013, 32; Graham-Campbell 2021, 126–127). Because of these unbroken flowing lines with undecorated backgrounds, many brooches in the Urnes style are openwork brooches (Kershaw 2013, 32; Graham-Campbell 2021, 127). The focus of the design is a large quadruped that has the swollen hips and lip-lappet of preceding styles, but it is elongated with tapered legs and feet (Wilson and Klindt-Jensen 1966, 147). The Urnes style is the last Scandinavian style to be discussed here, as later forms are no longer considered part of the Viking Age.

Figure 6-17 Modern re-creation demonstrating Urnes style (Markussen 2019)

Figure 6-18 BC.006 showing Urnes style on buckle from dataset (author's own photo)

6.3. Brooch Typology

6.3.1. Introduction

Brooches are the largest group of objects analysed in this thesis; they are also the most variable object type. Brooches were consistently popular through the entire Early Medieval period – a longevity of popularity, as will become evident, which is quite rare for most other object types. Because of this continued popularity, as well as high survival rates, there are numerous brooch types to become familiar with before proceeding with the discussions of compositional analyses. The typological discussion will start by discussing Anglo-Saxon brooch types, then Scandinavian brooch types, and finally brooches whose cultural origin is still debated, before moving on to the results from the dataset. This division allows for clarity when looking at the compositional data but also follows a relatively chronological path.

6.3.2. Anglo-Saxon Brooch Types

Cruciform Brooches

Cruciform brooches are one of the most common types found, both in this study and in Anglo-Saxon archaeology generally, as demonstrated in Martin (2011 and 2015). The name of the brooch can be somewhat misleading as the shape does not resemble a crucifix, nor is it related to the Christian idea of one. Cruciform brooches date from c. 420 AD to 570 AD, placing them firmly in the Early Saxon period. They are subdivided into four groups, which allow for the more precise dating of these brooches within the broader date range above. The fourth group is decorated in 'Style I', which was discussed early in 6.2.1.1.

Cruciform brooches, like the other long brooches that will be discussed, consist of three main components: the head, the bow and the foot, as displayed in Figure 6-19. The head of the brooch is comprised of a rectangular or square central panel with knobs on the two sides and the top. The level of decoration on the headplate of cruciform brooches varies based on cruciform type, quality and survival. Additionally, the attachment methods and decorations of the knobs changed over time (Martin 2015, 12–14). The knobs from cruciform brooches can either be fully rounded or have a flat back. They are frequently found on their own as they can become detached reasonably easily, and therefore single knobs form a large proportion of the examples of cruciform brooches in this study.

The bow is the connecting piece between the head and the foot of the brooch. The bow can be challenging to describe and classify as there is little uniform terminology. It is usually curved outwards, likely to allow the pin to run along the length of the brooch, and the depth of this curve varies greatly between brooches. The bow can also be decorated but, just like the headplate, the level of decoration can be a challenge to discern and is highly variable.

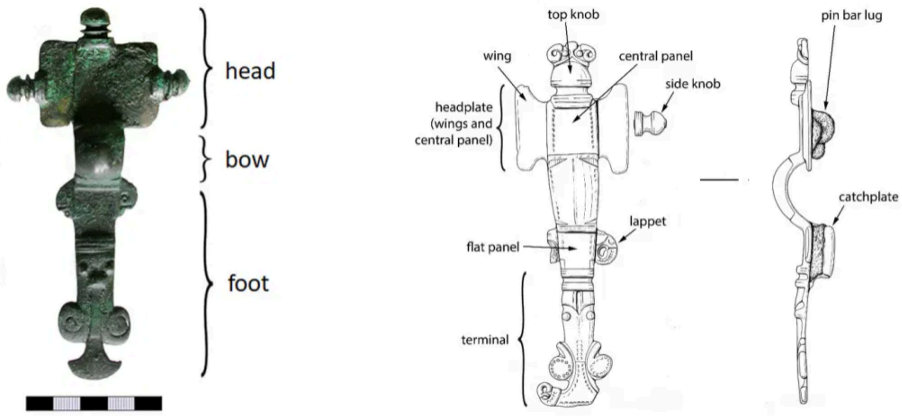

Figure 6-19 PAS image demonstrating parts of the cruciform brooch, showing NCL-248642 to the left and composite drawing of SF3889 and SF6475 to the right

The foot of a cruciform brooch can be divided further into three sections: a flat panel, lappets and a terminal. The flat panel is found directly below the bow. The face of the panel is usually undecorated, and on the reverse of the panel, the brooch's catchplate is placed, usually curling to the left (Penelope Walton Rogers pers. comm.). The lappets, which can be plain or decorated, are an optional inclusion and project out of the sides of the flat panel. The final element is the brooch terminal, and this is often the most characteristic element of a cruciform brooch. Earlier terminals are comprised of a long animal head, thought to be a horse, which tends to consist of eyes and nostrils in relief and sometimes with one portion extended between the nostrils, which is believed to be the horse's tongue (Martin 2015, 13). Later brooches display a greater variety of terminals, often appearing to be types of animal–human hybrid, and are squared off at the very bottom (Martin 2015, 21, 29, 39, 66).

Cruciform brooches have inevitably received a considerable amount of scholarly consideration. This started when Åberg (1926) first produced the first classification of them, and this continues to be used today. More recent studies include Reichstein (1975), Mortimer (1990) and most recently, Martin (2011 and 2015). Martin's work is now the primary classification type for cruciform brooches, dividing them into four main categories. Martin not only classified the brooches but also discussed distribution coinciding with PAS data, allowing us to see the regionality of these brooch subtypes (Martin 2015, Appendix Two). They are most common north and east of Felixstowe and Derby, and then north along the Pennines. The region is often considered to be part of the 'Anglian' cultural sphere rather than the 'Saxon' region of England at the time (Martin 2015, 88), which will become relevant when discussing cultural variations in Chapter Seven.

Square-Headed Brooches

Square-headed brooches (Figure 6-20) make up a relatively small portion of the dataset; however, they are probably considered to be the most recognisable Anglo-Saxon dress accessory (Hines 1997), because of their large size and the use of elaborate and intricate Style I relief patterns. They are associated with well-furnished female graves, and metal-detecting discoveries of complete examples often lead to full-scale excavations because of the strength of this association. The production of these brooches occurred over a relatively short time span of c.500 AD to c.570 AD. Square-headed brooches are the largest brooches produced in the Early Medieval period, measuring between 100 and 150 mm in length. Similar to the cruciform brooches, square-headed brooches are separated into three components: the head, the bow, and the foot (Hines 1997, 5).

The heads of square-headed brooches are actually very rarely square, tending to be more rectangular. The head is further divided into seven separate panels, which can be seen in Figure 6-20. These different panels often contain individual decorative elements existing in their own space rather than intertwining or interacting with each other. Below the headplate is the brooch bow. Unlike cruciform brooches, the bow of square-headed brooches is usually decorated too. A usual decoration is to have two bands of Style I relief going down along the bow, often separated by a raised ridge or deep groove in the centre. The bow occasionally has roundels or lappets attached to the sides. The foot of the brooch is also heavily decorated in Style I. The corners are often enlarged in order to add more decoration and emphasis to the brooch, before terminating in a lozenge shape. The catchplate is found on the reverse of the foot (Hines 1997, 5).

The distribution of square headed brooches is remarkably similar to the distribution of cruciform brooches. PAS distribution maps mark out Felixstowe and Derby again as a boundary along with the southernmost point and east of the Pennines (Portable Antiquities Scheme 2020). Therefore, square-headed brooches also fall into this 'Anglian' cultural sphere of Early Medieval England. Additionally, there is a brooch type called a small square-headed brooch, which is simply a smaller version (measuring 40 mm) of the square-headed brooch (Leigh 1980, 3, 11, 110). While no small square-headed brooches were found during the data collection for this study, it is still important to acknowledge their presence in the Early Medieval brooch canon.

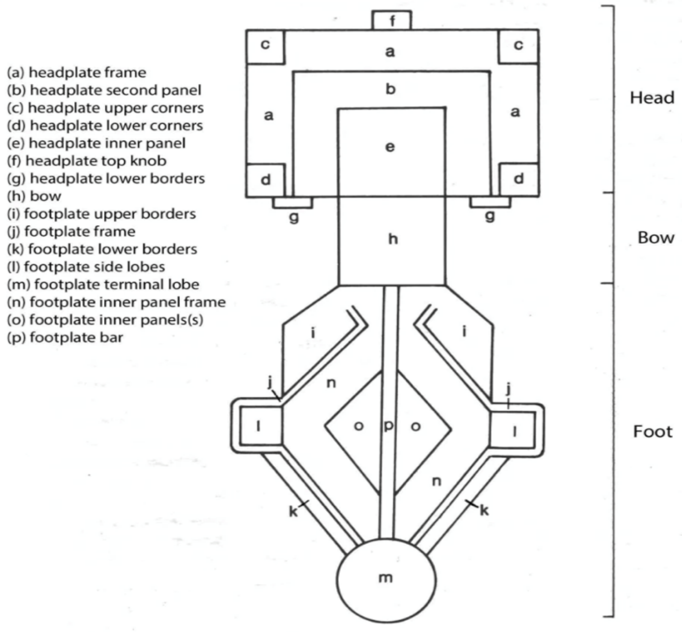

Figure 6-20 Parts of a square-headed brooch (Hines 1997)

Small Long Brooches

Small long brooches (Figure 6-21) are designed to be a small imitation of cruciform and square-headed brooches. They have similar a similar date range to the cruciform and square-headed brooches, ranging from c. 450 AD to c. 550 AD. They comprise the same three components as seen above: the head, the bow and the foot. Small long brooches have not yet been fully classified. However, Penn and Brugmann (2007) began this process and divided the brooches into three categories based solely on the headplate and the presence or absence of lappets.

The headplates of small long brooches are rectangular or square; the headplate is often embellished by making u-shaped cuts into the headplate or with flat panels projecting from the headplate. The headplates would have been cast as one piece, but the cut-outs or additions can give a similar effect to the knobs added to the cruciform brooches. Small long brooches had varying degrees of cut-outs and additives, making classification a challenging task. Just like the headplates, the bows of small long brooches are also quite prone to variation. For the most part, the bows follow the same outward curved pattern as other long brooches. However, there is the addition of large lappets, triangular facets at the top and bottom of the bow, and rectangular flat panels at the top and bottom. The small long brooch foot has significantly less variation than the headplate and bow. The most common foot type is a narrow flat panel and a flared terminal. The other foot type is a lozenge-shaped terminal that can be circular or flared. The distribution of small long brooches is, unsurprisingly, similar to cruciform and square-headed brooches. Small long brooches are concentrated in these ‘Anglian’ areas of modern-day England, but they are also found in small numbers in other areas such as Kent, the Isle of Wight and Hampshire (Portable Antiquities Scheme 2020).

Figure 6-21 PAS Image showing the four most common types of bow found on small long brooches. Left: BERK-59B2F7 (above) and NLM-86A1E2 (below). Right: KENT4742 (above) and BERK-0732F1 (below). From PAS

Equal-Arm Brooches

Equal-arm brooches become popular as early as the Roman period and continue throughout the Early Medieval period with slight variations. The brooches that will be discussed here are of the early Anglo-Saxon type, which has three variations: wide (c. 400–530 AD), Anglian (c. 500–570 AD) and long (c. 450–570 AD) (Figures 6-22 and 6-23). The Anglo-Saxon type is distinguished from other types by having triangular headplates and feet connected by a bow (Hines 1984, 253–9). Equal-arm brooches are frequently confused with Ansate brooches; however, they can be easily distinguished from each other based on their pin fittings. Equal-arm brooches have pin fittings set so the pin lug and catchplate run parallel with the edge of the brooch (Annable et al. 2010, 27), contrasting with Ansate brooches, which have pin lugs set transversely to the edge of the brooch. The significant of the pin fittings will be discussed later in section 6.3.4.

Figure 6-23 LANCUM-2322A4 Anglian type equal-arm brooch, from PAS

Figure 6-22 IOW-A1F47D Long type equal-arm brooch, from PAS

Annular and Quoit Brooches

Annular brooches (Figure 6-24) make up a large portion of the present dataset, yet scholarly research on them is somewhat lacking in comparison to other brooch types. While a formal typology has yet to be compiled, Leeds (1945) outlined a brief classification using letters ‘A’ to ‘G’, and this classification largely remains in use today. These brooches are quite different

Figure 6-24 Annular brooches of late 5th- to late 6th-century date, with pin constrictions (NCL-A29D44 above, LIN-92AFFA below), a pin hole blocked with iron corrosion (SF-74C243) and a pin slot (SF-F95D33). Note the gloss on NCL-A29D44. From PAS

from those previously discussed since they are not classed as long brooches. They consist of a closed ring with a pin that goes across the centre. Defining characteristics to distinguish annular brooches include whether the frame is flat and wide or has a D-shaped cross-section (Leeds 1945, 46–49). Alternatively, it can be defined as a Quoit brooch (Figure 6-25), which would have a notch on the inside edge of the frame to prevent the pin from falling through the brooch. Later annular brooches are defined by thick, ribbed frames and continue in popularity within East Yorkshire and Lincolnshire but are rare in other areas of England (Portable Antiquities Scheme 2020).

Figure 6-25 Quoit brooch example NARC-63FA58, from PAS

These brooches are often considered to be poorly made and decorated, which is not accurate. They may not be as elaborate as others discussed, but they are still found within richly furnished burials (Penn and Brugmann 2007). Additionally, many annular brooches have copper frames and iron pins, meaning that knowledge of working two very different metals would have been required to create these brooches. While the lack of research makes them challenging to interpret, these brooches may have had a more practical and enduring purpose than other brooches in the Early Saxon period.

Penannular Brooches

Penannular brooches (Figure 6-26) were a long-lived form, originating in the Iron Age and lasting until the 7th century, before returning again in the Later Medieval period, although they do become less prevalent as time goes on. Penannular brooches are quite easy to identify; they share many similarities with annular brooches, the critical difference being that the frame is not closed. Penannular brooches either have a gap in the frame or have overlapping ends. The main feature of some Early Medieval penannular brooches are zoomorphic terminals on the gap within the frame (Booth 2015, 116, 197–198).

Figure 6-26 Penannular brooch SWYOR-213050, from PAS

Saucer and Button Brooches

Saucer brooches (Figure 6-28) and button brooches (Figure 6-29) have numerous similarities, which is why they are discussed together here. Button brooches date between c. 480 AD and c. 550 AD (Suzuki, 2008). They are tiny, usually around 2 cm in diameter, circular brooches with an upturned rim. They are commonly decorated with a frontal human face (Avent and Evison 1982). They are quite robust and tend to survive quite well, and they are primarily concentrated in the south-east of England (Suzuki 2008). Button brooches are often mislabelled as small cast saucer brooches, but the distinguishing characteristic of a button brooch is the presence of a human face, something that wears away easily, making its absence an unreliable diagnostic.

Figure 6-27 Cast saucer brooch HAMP-005BE3, from PAS

Cast saucer brooches are one of the two types of saucer brooches, the other being applied saucer brooches. Cast saucer brooches are very similar to button brooches, as they are circular and have upturned rims. The crucial difference is their size; cast saucer brooches are between 25 mm and 50 mm in diameter and display a greater variation in decoration. The variable motifs are the primary method of dating cast saucer brooches, as outlined by Tania Dickinson (1993). Cast saucer and applied saucer brooches can be differentiated by their manufacturing methods. Applied saucer brooches are made from multiple pieces, usually thinner sheet metal, than their cast counterparts (MacGregor and Bolick 1993; Evison 1978).

Figure 6-28 Button brooch PUBLIC-61770D, from PAS

Because of this manufacturing method, applied saucer brooches are far more delicate than the cast types and therefore do not survive as well.

Disc Brooches

Disc brooches have quite an extended life in Early Medieval England. Disc brooches consist of a flat, round and somewhat thick single piece of metal with separately added pin lugs and catchplates. The earliest examples of disc brooches date between c. 450 AD and 550 AD and have stamped decoration on the face of the brooch. The most common stamp decoration is a dot at the centre point of the brooch with notches around the edges. Openwork disc brooches were also popular at this time; cut-outs included T, L and V shapes or a cross and swastika. In the late 6th and 7th centuries, disc brooches had inlays of gems or glass and are evidence of a significant improvement in technology. These jewelled disc brooches were comprised of many different pieces that were then assembled. As disc brooches continued to be manufactured during the Mid and Late Saxon period, their variety only increased. Weetch (2014a) divides Disc brooches into seventeen different categories, though this is primarily based on stylistic variations rather than changes in the structure and form of the brooches.

Bird and S-Shaped Brooches

Bird brooches (Figure 6-29), much like disc brooches, have a long temporal range in Anglo-Saxon England. Early bird brooches have quite a short time span of c. 500 AD to c. 550 AD but subsequently re-emerge in the mid-7th century. In contrast, S-shaped brooches date a little earlier to c. 450 AD and remained popular until c. 550 AD, after which their use ceased. S-shaped brooches resemble an S or a reversed S, and some appear as a figure-of-eight (Figure 6-30). They are often decorated with bird-head terminals and curved beaks. S-Shaped brooches are found across England but are still quite rare and seem to have lacked significant popularity in the British Isles. In contrast, they are common on the Continent, especially within Francia and Lombardy (Briscoe 1968).

Figure 6-29 Bird brooch SF-E28B03, from PAS

As already stated, bird brooches remerge in popularity both in the Middle Saxon period between c. 750 AD and c. 850 AD and then again in c. 1000 to c. 1100 AD. In the Early Saxon period, both predatory birds in a vertical position and other birds, possibly ducks or doves, in a horizontal position were popular. In the Mid and Late Saxon periods these patterns shifted; the birds are consistently horizontal and in profile. Later bird brooches will briefly be discussed again in the context of the many debates as to whether they are indeed Anglo-Saxon, Scandinavian or Continental in origin.

Figure 6-30 S-shaped brooch NLM-908608, from PAS

6.3.3. Scandinavian Brooch Types

Domed Brooches

Domed brooches (Figure 6-31), sometimes termed circular brooches, are a similar type to the Anglo-Saxon disc brooches discussed earlier. The crucial difference between a disc brooch and domed brooch is that disc brooches are flat, whereas domed brooches are convex and comprise two pieces: a solid bottom layer and decorated top layer. The convex portion of these brooches varies in diameter. Some of the brooches have a domed portion that comprises the majority of the brooch while with others it is just the centre of the brooch that

Figure 6-31 Domed brooch NMS-E84328, from PAS

protrudes outwards. These brooches appear in the British Isles around 850 AD and remain in fashion until c. 1000 AD. There are three different varieties of domed brooches, each with varying date ranges, within this broader chronology (Jansson 1984). These variations are primarily based on stylistic attributes rather than brooch type changes.

Trefoil Brooches

Trefoil brooches are one of the most common Scandinavian brooch types found in the British Isles. They begin to appear around 850 AD and remain in circulation until c. 950 AD. The centre of the brooch is typically a triangle with three elongated and rounded lobes projecting from each side of the triangle (Figure 6-32). Archaeologists believe that the inspiration for trefoil brooches stems from Carolingian harness mounts, and they are decorated with a wide range of styles, which is usually how dating and classification of these brooches are undertaken (Maixner 2005; Kershaw 2010, 212–233; 2013, 79–91). Trefoil brooches, like many other brooch types discussed, still have no standardised terminology used in their description. This lack of standardisation is highlighted well by the terms 'lobe' and 'arm' both being frequently used to describe the same portion of a brooch.

Figure 6-32 Trefoil brooch LIN-56D731, from PAS

However, the terminology is not the most challenging obstacle when working with trefoil brooches. Fragmented lobes of trefoil brooches are completely indistinguishable from Thomas Class E strap ends, which will be discussed later in this chapter. This resemblance has resulted in incorrect classification by some of the most qualified brooch researchers, such as the Kershaw type D trefoil brooch, which is now confirmed to be a strap end type (Thomas 2012, 509). Therefore, when studying fragments of trefoil brooches, it is essential to be vigilant and cautious in classification.

Some of the best evidence for production of trefoil brooches in the British Isles are the mould fragments found at Blake Street, York (Graham-Campbell 1980, 283). These mould fragments are especially interesting as the design is a pair of facing birds above a face-forward animal head, which is a typical Winchester-style motif showing a clear combination of Scandinavian and Anglo-Saxon styles (Richardson 1993, 62–4).

Openwork Lozenge Brooches

Openwork lozenge brooches (lozenge brooches), like trefoil brooches, were popular during the period c. 850 to c. 950 AD. These brooches are unique as they are only produced with Borre-style decoration, which will be discussed in depth later in this chapter. Lozenge brooches are diamond shaped with four holes in the centre arranged in a cross (Kershaw 2013, 43–9). Each corner of a lozenge brooch is decorated with a zoomorphic bear in the Borre style, the lines that form the cross in the centre are the bears' necks, which usually intertwine in knotwork (Figure 6-33). Dividing lozenge brooches into types has proved exceedingly difficult because of the high amount of wear on the face of the brooches found so far (Kershaw 2013, 43–9).

Figure 6-33 Openwork lozenge brooch NMS-9A5FA8, from PAS

6.3.4. Debated Brooch Types

Pin Fittings

A key area of debate (Kershaw 2013, 161–162; Walton-Rogers, pers. comm. 6/8/15) within the discussion of Early Medieval brooch types focuses on the pin fittings. Key distinctions that have been drawn between brooches of Anglo-Saxon and Scandinavian provenance are the type of pin fitting employed, the placement of the pin fitting, and finally the way the pin catch turns. With regard to the first two differences, the pin fitting type and its placement, Scandinavian brooches are suggested by Kershaw (2013, 160) to exclusively use a double H-shaped pin lug placed on the right and a hooked catchplate placed on the left, when viewed from the reverse, with the possible inclusion of a third loop on the brooch. The pin lug and catchplate placement would create a horizontal axis. An H-shaped pin lug would have functioned as a hinge; a bar would run across the pin lug which would attach to the pin. The pin lug and catchplate are then placed at a right angle to the edge of the brooch (Kershaw 2013, 160).

In comparison, Anglo-Saxon brooches employ a transverse pin lug on the left and C-shaped catchplate on the right. A transverse pin lug consisted of a single lug on the reverse of the brooch with a single perforation that the pin would be placed through and then bent around the lug to secure it. The transverse pin lug and C-shaped catchplates were both aligned vertically with the brooch edge. This placement would create either a horizontal or diagonal axis (Kershaw 2013, 161). Anglo-Scandinavian brooches are primarily found with the Anglo-Saxon style and placement of pin fitting; Kershaw (2013, 162) suggests that this occurrence could be connected to the women wearing the brooches using the ways of dressing with which they were familiar. Kershaw (2013, 162) also explains the Anglo-Scandinavian brooches with Scandinavian style catchplates as evidence of distinct workshop traditions forming around Anglo-Scandinavian manufacture, which would have been independent of both Anglo-Saxon and Scandinavian traditions.

The final crucial difference in pin fittings is the turn of the catch. To determine the turn of the catch, the pin of the brooch must be facing down. With the pin facing down, Scandinavian-manufactured catches would turn to the right while Anglo-Saxon-manufactured examples would turn to the left (Walton-Rogers, pers. comm. 6/8/15). This divide is believed to be more definitive than the other elements of pin fittings in determining whether a brooch was produced with Anglo-Saxon or Scandinavian methods. This level of detail on the study of pin fittings has led to a revolutionary way of helping to classify brooches. These methods have been included when making determinations in this dataset. They have proved invaluable and as the following sections will show, pin fittings often determine the cultural group to which a brooch is assigned.

Ansate Brooches and Later Equal-Arm Brooches

Ansate brooches, also called bow brooches, are a brooch type that spans from c. 550 AD to c. 1000 AD. They are divided into twelve basic types, which are used for dating the brooches. This typology is primarily based on the form of the brooch, rather than style as has previously been the case. These earlier brooches are definitively Anglo-Saxon, as they predate the Viking Age. However, as the form developed, they became a little more closely related to Scandinavian elements, such as H-shaped pin fittings, and quite closely resemble later equal-arm brooches (c. 900–1000 AD), which are definitively considered Scandinavian or Anglo-Scandinavian.

Figure 6-34 Ansate brooch Weetch's type XII.Ai NMS-CC8531 from PAS

Ansate brooches consist of a single piece with matching head and foot terminals (Figure 6-34), though whether the brooch was worn horizontally or vertically is challenging to say, with a curved bow connecting them. The shapes of the terminals tend to be what most visibly changes over time; the earlier brooches have rounded terminals whereas the late types are squared off or have little animals similar to lozenge brooches. The crucial difference between ansate brooches and later equal-arm brooches is that on the curved bow of the equal-arm brooches there tends to be a raised circular centre. There is an apparent similarity between these two types and continuous influence back and forth between the Anglo-Saxons and Scandinavians is highly reflected in these brooches.

Re-emergence of Bird Brooches

As suggested above, bird brooches are an item of considerable debate. This stems from both cultural groups having a version of this brooch type before extensive interaction between them. The classic examples of a Scandinavian type, illustrated by examples found in Denmark, are the clear precursors to some types found within Viking Age British Isles (Pedersen 2001). Because of this, each bird brooch has to be carefully evaluated to determine its most likely origin, and there is rarely a straightforward answer. The bird brooches dating to mid (750–850) and late periods (1000–1100) (Figure 6-35) have been divided into two to three main categories, depending on the scholarship (Weetch 2014a and Kershaw 2013). Of the two Weetch types, one subtype has parallels in Pedersen's typology, and the other does not. Therefore, it is easy to definitively say that bird brooches are a prime example of Anglo-Scandinavian style and manufacturing, where elements from both origins' styles are being combined and intertwined in numerous ways.

Figure 6-35 A later bird brooch NMS-556A43 from PAS

6.3.5. *Conclusion*

As may have become apparent, brooches are one of the more complicated object types included in this study. Brooches are also one of the few object types that remained very popular throughout the entire Early Medieval period as opposed to other items whose popularity occurred in waves, and this has led to brooches having the best representation in this study – nearly a third of the objects analysed are brooches. Brooches remain complex because of the variety of types and styles and the numerous way those can be combined; this study has attempted to include as much of this variety as possible. Those results, and the conclusions drawn about the types, styles and metal compositions, will now be discussed.

6.4. Buckle Typology

6.4.1. *Introduction*

Marzinzik (2003) has classified Anglo-Saxon buckles dated between the late 5th to the early 8th century. She divided them into two basic types: Type I has no buckle plate, and Type II does have a plate, hinged or integral. After the Early Saxon period buckles are less typologically distinct, and therefore there are significant challenges in classifying and dating them. During the Viking Age, buckle types are classified according to specific Scandinavian styles, which leads to fascinating results and interpretations surrounding the cultural groups of these objects.

6.4.2. Anglo-Saxon Buckle Types and Styles

Oval and D-Shaped Buckles

Oval and D-shaped buckles (Figure 6-36) fall into Marzinzik Type I, meaning they have no buckle plate. If buckles of these shapes exist with a plate, they are classified based on the plate, not the buckle frame. D-shaped buckles are commonly dated to the 7th century, but some earlier examples exist. These earlier types have a tendency to be slightly more substantial, and they are found in contexts as late as the Mid Saxon period, with examples found in 8th- and 9th-century settlements. They are a quite simple buckle type, consisting of a small oval or D-shaped frame, and there is little to no distinction between the tongue and the loop that attaches it to the frame. Most D-shaped buckles have an even thickness around the entire frame, but there are a few examples of the frame being thinner where the tongue attaches (Marzinzik Type 1.5). The tongues of buckles are sometimes decorated, known as 'shield-on-pin' form, in which a shield is present on the base of the tongue of the buckle; this style does not endure past the early 7th century (Marzinzik 2005).

Figure 6-36 example of D-Shape buckle, PAS finds number BH-3473A5

Other Buckle Shapes

There are other buckle frame types produced during the Early Saxon period, though the D-shaped frames are the most common. These other shapes include flat, rectangular frames; shaped as broad rectangles with the area where the tongue attaches significantly thinner and smaller than the rest of the buckle. Rectangular frames tend to have more decoration than their D-shaped counterparts, as there is a greater surface area to allow for increased decoration. There are also some unusual shapes, such as U-shaped buckles. These buckles are somewhat similar to the D-shaped frames, except they are flat and wide like the rectangular buckles (Marzinzik 2005).

Hinged Plate and Integral Plate Buckles

Hinged plate buckles fall into Marzinzik Type II (Figure 6-37) and come in square, triangular, and rectangular shapes. The square hinge plates are the most difficult to identify, as they share a form with belt mounts and seem to be converted from other objects. Square plates are made from the decorative panel being affixed to an underplate that has hinge loops or by adding hinge loops directly to the decorative panel. Square panels are often decorated in Style I, making them relatively straightforward to date once identified (Marzinzik 2005; Geake 1995, 76–77).

Figure 6-37 Early Anglo-Saxon buckle with integral plate. PAS finds number NLM-F3C144

Triangular plates are split further into two groups: large and small. The large type is easily identifiable, made from a thick and hollow plate with distinctive large rivets, two at the buckle frame edge and one at the tip of the triangle. These objects also seem to be gendered, only being found in male graves. The small triangular plates measure c. 30 mm long and were cast as one piece. They bear a strong resemblance to a Roman buckle type, and if they are undecorated, they can be very challenging to differentiate (Speed 2020).

The last type of hinged plate buckle is those with rectangular plates (Marzinzik Type II.16. 11.19, 11.24) and these are prevalent throughout the Early and Mid-Saxon periods. Therefore, dating rectangular plates relies upon their style and decoration. Typical decorations include repoussé dots (5th–6th centuries), and ring and dot, openwork or incised lines (7th centuries). There are also undecorated versions, but they are challenging to date (Marzinzik 2005).

Integral plate brooches have the same general shapes are their hinged plate counterparts. Small integral triangular plates can be dated to the 7th century, and unlike the hinged plate, triangular plates are found in graves of both sexes (Geake 1995). Similar to the hinged plate types, undecorated examples can be difficult to tell apart from Roman types; however, if the plate has perforated lugs, it is Anglo-Saxon, while riveted buckles are Roman (Speed 2020).

Mid- and Late Saxon Buckles

As mentioned in the introduction to this section, buckles from the Mid-Saxon period are rare, especially in excavated contexts. The sites of Hamwic and Flixborough (Hinton 1996b; Evans and Loveluck 2009) have yielded a very few buckle examples, but they are small and lacking in defining characteristics. As discussed with Early Saxon buckles, the dating of these objects can prove quite challenging; therefore, without examples from secure contexts, it is problematic to establish classifications and chronologies. There are two unique buckles from Fishergate in York, a site dated to the 8th to early 9th centuries, and both buckles are integral plates that have a rectangular outline. The decoration on one buckle is in the Trewhiddle style, and the other has a 'fan-shaped' motif that has also been found on 9th-century strap ends. Buckles do not seem to have a resurgence in popularity until the Viking Age. When they do return, they appear to follow Scandinavian styles, with no classified buckles in a distinct Anglo-Saxon style in the Viking Age (Hinton 1996b, 6–8; Rogers 2009, 22–25).

6.4.3. Scandinavian Buckle Types and Styles

Borre Buckles

Borre buckles are widespread and variable, and there are four possible distinct types. The simplest Borre buckle type seems to be a possible development from the D-shaped buckles of the Early Saxon period (Figure 6-38). These buckles are considered D-shaped or subtriangular with a bear's head at the single point of the triangle. This buckle is quite reminiscent of the Borre lozenge brooches as it is the same bear decoration, which is never in profile but instead frontal. Some examples of this buckle type have the sides of the buckle continue past the transverse bar for the buckle's tongue and have the same bear's head on each corner of the triangle (Portable Antiquities Scheme 2020).

Figure 6-38 Borre buckle (PAS finds number SWYOR- E29015)

Another Borre buckle is reminiscent of earlier D-shaped buckles, and this type has a broad, flat decorative outside edge while having a significantly smaller transverse bar for the buckle's tongue (Figure 6-39). The decoration on the broad outside edge is in typical Borre interlace. Thomas (2000, 281) has suggested that this specific buckle type has a companion strap end (Class E Type 4).

Figure 6-39 Borre buckle (PAS finds number NMS-60B8C7)

Two other Borre buckle types are less certain in their dating. Both of these buckle types have decorative animals that are similar to those seen in other Borre objects. Only one type of these buckles fits into the study's time frame. The type appears to form a pair with Thomas Class B Type 4 strap ends, which would include it in the Viking Age (Thomas 2000, 280). This type has an oval frame with an animal head emerging from the outside edge. The other edge has two rectangular arms with a transverse bar for the buckle's tongue, which is also sometimes decorated. A core reason these buckles are considered to be Borre styles is the representation of the animal not in profile, a distinct characteristic of Borre items that ends after the style dies out. The other buckle is composed similarly, but the waisted plate shape suggests a later date and therefore has not been included in this dataset.

Ringerike Buckles

As discussed in section 6.2.2, Ringerike-styled items have animals in profile rather than facing forward like in Borre style. This change is the crucial difference between the earlier Borre buckles and the Ringerike buckles. The most common Ringerike buckles, with a large concentration in Norfolk, are produced in a broad and flat D shape with a thinner transverse bar; see Figure 6-40. Higher-quality Ringerike buckles are in relief, with the animal head rising out of the flat buckle. Some Ringerike buckles have the animal facing the bar, its nose meeting the bar and its ear fanning out into scroll patterns that cover the remainder of the brooch (Griffith & De Haseth 2007). There is a less common version where the animal is facing towards the pin rest instead of the bar; this style is considered an English version of Ringerike (Hinton 1990). There are a large number of Ringerike buckles on which, because of wear, it is difficult to determine which way the animal is facing; therefore, tracing cultural determination between them is difficult.

Figure 6-40 Ringerike buckle (PAS finds number HAMP-E64375)

There are a minority of Ringerike buckles with integral plates. These plates tend to be narrower than the buckle frame; in this type, there can be multiple animals facing one another. There are also the same two groups as in the other Ringerike buckles of animals facing the bar versus facing the pin rest. The other uncommon type of Ringerike buckles is a clear development from the common triangular Borre type. The Ringerike type is also D-shaped with large three-dimensional animal heads serving as the buckle's pin rest and is produced both with and without an integral plate. Those with an integral plate are similar to Thomas Class B, and Type 6 strap ends from the 11th century (Thomas 2000, 105). Those without an integral plate can be challenging to differentiate from the Borre type. A key difference, as discussed with style determination in brooches, is the change in eye shape between Borre and late Scandinavian styles. Animals in the Borre style tend to have round eyes while animals in later styles have almond-shaped eyes. This distinction is very apparent in these buckles and a clear way to determine Borre or Ringerike.

Urnes Buckles

The last buckle type included in this study is the Urnes type. As discussed above, the Urnes style is the first Scandinavian style that does not have a symmetrical composition. The Urnes buckles, like earlier buckle types, are D-shaped but with broad and flat frames and a thinner transverse bar; see Figure 6-41. Similar to Urnes type brooches, the buckles can be openwork and have an animal with a wide body that curves around and loops over itself, usually with a single line. Urnes-style animals, instead of having the head in the centre, usually by the pin rest, tend to have the head to one side of the transverse bar, with the body comprising the bulk of the buckle frame and then the feet at the other end of the transverse bar. There are also a few Urnes buckles with an integral plate. The buckles with plates have the same decorative pattern as those without; the interlacing body of the animal continues down and around the plate, making is obvious it was created and cast as one piece (Owen 2001).

Figure 6-41 Urnes buckle (PAS finds number SF-1623C7)

6.4.4. Conclusion

Buckles are a somewhat complicated object type to classify. They go through significant rises and falls in popularity. In the Early Saxon period they are increasingly popular, before nearly disappearing in the Mid- and Late Saxon periods. However, as archaeologists are frequently taught, a lack of material does not equal a lack of existence. Mid- and Late Saxon buckles that are uncovered are remarkably similar to those that immediately predate them. It is equally possible that Early, Mid- and Late Saxon buckles do not change over time until a wave of new stylistic traits comes in with the Vikings. Following a significant decrease in popularity, buckles in the Viking Age are being produced with more variation than before, though this variation is primarily within Scandinavian styles and Anglicised versions of Scandinavian styles.

6.5. Strap End Typology

6.5.1. Introduction

Strap ends begin to grow in popularity during the Late Saxon period and continued into the First and Second Viking Ages. Strap ends are the second most common object type included in this thesis. This high quantity is somewhat surprising as they, unlike brooches, were not frequently produced throughout the entire Early Medieval period. Until fairly recently, strap ends had no official classification system, until Thomas (2000) surveyed 1,400 strap ends and divided them into types and subtypes while also discussing the manufacturing and regional distribution patterns of these objects (Thomas 2000). This classification is dependent on a few factors, such as the ratio of width to length of the strap end, the style of the terminal, and the overall strap end shape, while the subtypes were dependent on the stylistic patterns and motifs, most of which will be familiar from the discussion of stylistic background. Thomas's classification was used to group objects and assign styles and cultural groups in this study.

6.5.2. Late Saxon and Viking Age Strap Ends

Thomas Class A

Thomas Class A strap ends are the most common type, making up 63% of Thomas's database. Class A strap ends are defined as having a split end, convex form, and zoomorphic terminals with an average width–length ratio of 1:3.5; see Figure 6-42 (Thomas 2000, 69). This class is split into five different types based on stylistic design; type one is in Trewhiddle, two is geometric, three is anthropomorphic, four is enamelled, and five is silver wire. In Class A, these styles are solely on the face of the strap end and employed using a variety of techniques. Each type also has further regional subtypes illustrating the full range of trend within each class and type.

Figure 6-42 Thomas Class A strap end (PAS finds number LIN-809298)

Class A strap ends have been mainly dated based on coin-hoard evidence, which leads to a tight date range of approximately sixty years, starting in c. 850 AD and lasting until c. 905 AD. Of 141 Class A strap ends, only 15% have been found in excavated contexts, and therefore we are reliant on art-historical dating methods and the coin hoards. As previously stated, this class of strap end is the most common, and it also has the most extensive distribution, with examples being found from Cornwall to Orkney. There is a dense concentration in eastern England, which includes this study region of the former Kingdom of Lindsey (Thomas 2000, 224–47). Each type and subtype and more detailed dating and regional distributions is outlined in Thomas (2000).

Thomas Class B

Class B strap ends are defined as split-end with parallel-sided shafts and zoomorphic terminals, with an average ratio of width–length of 1:4.5. Class B (Figure 6-43) and Class A strap ends are quite similar; the crucial difference between them is that Class B strap ends are thinner and longer than their Class A counterparts and the zoomorphic terminals are more stylised. Class B strap ends have seven types: type one, Trewhiddle; type two, silver-wire scrollwork; type three, elaborate shafts; type four, multiheaded; type five, interlace; type six, profiled animal-head terminals; and type seven, hooked terminals (Thomas 2000, 99).

Figure 6-43 Thomas Class B strap end (PAS finds number NLM-46317)

Fortunately, many Class B strap ends have been excavated from securely stratified archaeological contexts and can, therefore, provide a date range of mid-8th to the 11th centuries. Archaeological sites containing Class B strap ends have a wide distribution, from the Middle Saxon site of Hamwic (Hinton 1996b) to Thwing in North Humberside, where a strap end is associated with a coin of King Earned of Northumbria (Thomas 2000, 244). Even though the number of Class B strap ends is significantly smaller than Class A, they share a similarly wide range of distribution, from Southern England to Orkney. Furthermore, similar to Class A, eastern England has the densest quantity of Class B strap ends (Thomas 2000, 243–6).

Thomas Class C

Class C strap ends are classified as having a split end; however, they are thin and have sub-circular section shafts, with an average width–length ratio exceeding 1:13; see Figure 6-44. Class C strap ends were produced with a range of terminal styles. Class C strap ends only have two types: type one, knobbed terminals and type two, other terminals (Thomas 2000, 106–7). Class C strap ends are, comparatively, quite plainly decorated; this prevents assigning a date based on style, so dating is therefore entirely dependent on well-dated archaeological contexts. These archaeological contexts have indicated that Class C strap end-use began in the mid-7th century and lasted until the 9th century. Class C strap ends are only found on seven archaeological sites, primarily in eastern England. Thomas (2000, 247) hypothesises that production of these strap ends occurred at Hamwic based on the relative popularity of the object on the site coupled with the extensive non-ferrous metalworking that occurred on site.

Figure 6-44 Thomas Class C strap end (Thomas 2000, 513)

Thomas Class D

Class D strap ends are also of a split-end type, and like Class C they employ a variety of terminals. The critical difference between Class D and other split-end strap ends is that the tongue is kite or leaf shaped; see Figure 6-45. Additionally, Class D has no subtypes. Class D strap ends are dated based on well-defined archaeological contexts, supported by art-historical dating. The combination of these two dating methods places Class D strap ends within the 8th to 10th centuries (Thomas 2000, 106). The distribution of Class D strap ends is much smaller than those previously discussed and is defined as within the Kingdom of Lindsey. There are only three outliers found outside the Kingdom's boundaries, and thus it is believed that the production of Class

Figure 6-45 Thomas Class D strap end (Thomas 2000, 513)

D strap ends occurred within the Kingdom of Lindsey (Thomas 2000, 248). Therefore, it is surprising that none could be found for inclusion in this study.

Thomas Class E

Class E strap ends are classified as being tongue-shaped with an average width–length ratio of 1:2. Class E is the second-largest class of strap end, comprising 16% of Thomas's dataset. Class E's most striking difference from the strap ends already discussed is that the attachment method is not a split strap but instead an integrally cast butt-end. This Class of strap end is divided into six types: type one is Winchester style; type two is anthropomorphic; type three is ribbed; type four is Borre style; type five is other Scandinavian motifs, and type six is Carolingian (Thomas 2000, 107–120).

Type six will be quickly explored since it is a motif/style that has yet to be discussed; see Figure 6-46. The decoration is in stylised foliage with a geometric appearance, divergent from the Winchester style, which employs a naturalistic foliage pattern. Though these styles are Carolingian, and the closest parallels are from metalwork on the Continent, they are thought to have transferred as a result of Scandinavian movement. Carolingian items are found in Viking Age graves in Scandinavia and other areas of Scandinavian contact. However, in the Early Saxon period, there is also evidence of continental influence coming up through Kent. So, the Scandinavian incomers may not be the sole explanation for the emergence of this style as there is no reason why this older chain of influence, from Kent, would have ceased to exist (Thomas 2000, 107–120).

Figure 6-46 Thomas Class E.6 strap end (Thomas 2000, 520)

Class E strap ends, likely many of the previous types, are dated through a combination of archaeological data and art-historical methods. These methods place Class E strap ends within the 10th and 11th centuries. This date range is further supported by the beginning of cultural connections with the European continent in the late 9th century and the emergence of a Carolingian style strap end. The distribution of Class E strap ends is more restricted than the other types with similarly high quantities. They tend to be found on the Irish Sea coast, except for Type E3, which has dense concentrations and likely production centres in eastern England, especially in Yorkshire and the Humber area, Lincolnshire and Norfolk (Thomas 2000, 248–253).

Thomas Class F

Figure 6-47 Thomas Class F strap end (Thomas 2000, 521)

Class F strap ends are unique because of their double-sided decoration. They also have split-end attachment methods and have decorative roundels and zoomorphic terminals; see Figure 6-47. The decoration on Class F strap ends is usually separated into two panels; this decoration can be Insular or Scandinavian in design. Class F strap ends are divided into two types: type one has perforated roundels, and type two is without perforated roundels. They, like many other strap end types, are dated by both archaeological evidence and art-historical data (Thomas 2000, 120–122). The archaeological contexts place Class F strap ends between the 9th and 11th centuries, with the region of production possibly providing more specific dating (Thomas 2000, 216). Class F, like Class E, has connections with the Irish Sea. Class F is believed to have origins in Ireland itself, and the style travelled likely with the Vikings as they expanded across the Irish Sea, establishing capital cities in Dublin and York and increasing the trade between the two cities. Findspots for Class F strap ends occur throughout the former Danelaw, especially in Yorkshire and Lincolnshire but also further south in Norfolk and Suffolk (Thomas 2000, 254).

Thomas Class G

Class G strap ends (Figure 6-48) are defined as having a split end with openwork Urnes-style shafts. This class is very closely related to Class E strap ends with the crucial difference being the openwork decoration of Urnes style (Thomas 2000, 122). Unfortunately, none of the Class G strap ends has been found in an archaeological context. Therefore, these strap ends are dated entirely on an art-historical basis. Given that they are all Urnes style, it does make art-historical dating of Class G strap ends relatively straightforward as the Urnes style in the British Isles begins in the mid-11th century and lasts until

Figure 6-48 Thomas Class G strap end (Thomas 2000, 522)

the mid-12th century. Class G strap ends are too few in number to establish a significant pattern of distribution; however, a cluster of them come from Lincolnshire and the South Humber area (Thomas 2000, 255).

Thomas Class H

Class H strap ends are the most difficult to work with, and are a class of unclassified Anglo-Scandinavian strap ends. They are derived from an evident Scandinavian influence, but they do not fit into the other classes. Class H strap ends are dated individually based entirely on art-historical comparison to the Scandinavian style (Thomas 2000, 123). Similar to Class G, Class H has too few finds over a wide distribution range to establish any definitive conclusions (Thomas 2000, 256).

Thomas Class I

Class I strap ends set themselves apart by being a composite object with a cast front plate with stylised zoomorphic terminals, and a sheet metal backplate; see Figure 6-49. Class I strap ends do not have any secure archaeological dating and are therefore dated entirely based on art-historical analysis (Thomas 2000, 124). Based on the predominance of Ringerike and Urnes styles in this class, they can frequently be dated to the latter half of the 11th century. Similar to Class G and Class H, Class I has too few finds to establish any definitive conclusions about distribution (Thomas 2000, 256).

Figure 6-49 Thomas Class I strap end (Thomas 2000, 522)

Thomas Class J

Figure 6-50 Thomas Class J strap end (Thomas 2000, 523)

Class J strap ends are categorised as folded-metal strap ends; see Figure 6-50. Thomas hypothesised that this type extended beyond the Late Saxon and Viking Age. He also divides them into two distinct types. Type one consists of strap ends with a wedge-shaped plate and circular attachment-ends, and type two comprises strap ends with rectangular-shaped plates. Class J strap ends are difficult to date with art-historical methods so we must rely entirely on excavated examples. Archaeological contexts with Class J strap ends have a long temporal range from the 7th century to the 11th century. Thomas stated that the J1 type might have a later date, starting in the mid-9th century and lasting until the late 11th century. An issue with Class J strap ends is that they are difficult to recognise; Thomas attributes the difficulty in interpreting the distribution of Class J strap ends to this (Thomas 2000, 124). Because of this identification issue, the distribution is focused solely on excavated material, the majority of which comes from Flixborough and is concentrated in eastern England.

Thomas Class K

Figure 6-51 Thomas class K strap end (Thomas 2000, 523)

Class K strap ends are split end with the tongues in the form of an animal viewed from above; see Figure 6-51. Class K and Class A strap ends are closely related to one another. Class K is not divided into types. Only one Class K strap end has been found in an archaeological context, dating between c. 950 and 1150 AD. However, this is believed to be a secondary context based on art-historic assessment of the animal heads of these strap ends, and the 9th century is often considered the acceptable date for Class K strap ends (Thomas 2000, 126). Like some of the other classes, there are not enough examples to establish clear distribution patterns.

Thomas Class L

Class L strap ends are the fourteen strap ends from Thomas's study that did not fit into any other category. It is essential to remember that while this classification is fundamental for categorising strap ends, there are still gaps within the system that need to be filled as more objects are uncovered. As Class L strap ends are not a uniform class but a group of unclassified objects, they each need to be dated individually and any distributional analysis of Class L strap ends needs to bear this in mind (Thomas 2000, 126).

6.5.3. Conclusion

As may have become apparent during the discussion of strap ends, there is a heavy concentration of this material in eastern England. It is important to consider that, as discussed in Chapter Two, this high proportion of material could be due to the significant amount of metal detecting that occurs in this region of the British Isles. Strap ends also reveal themselves to be an essential and easy indicator of cultural movement and interaction in the Early Medieval period. In the next section, we will discuss whether such variety is also visible in the metal compositions.

6.6. Hooked Tags Typology

6.6.1. Introduction

Hooked tags are a primarily Anglo-Saxon type of dress accessory (Read 2008). Hooked tags consist of a plate, lobe and hook. The lobe is at the top of the hooked tag and consists of one or two punctures where the item would have been sewn onto a garment, whilst the hook is at the opposite end of the lobe, usually considered the bottom of the object. The shape of the plate is the main typological feature of the hooked tag. Hooked tags are classified first based on the form of the plate, then the decoration, and lastly, whether lobes are present. Classification, therefore, is presented as: A1.b.iii (lobed), where A1 is the plate type and b.iii is the decoration (Read 2008).

6.6.2. Types

Type A hooked tags are defined as having a circular plate; see Figure 6-52. This type has three main subtypes. Type A1 can have a plate that is a 'perfect' circle, usually with a collar between the plate and the hook, or be tear shaped. The last A1 type is named 'coin'; they are

Figure 6-52 Type A hooked tags (Lewis and Naylor 2013, 2)

not made from coins but made to resemble them. Type A2 is classified as 'oval'. A2 hooked tags are slightly unusual in appearance compared to other types. They are quite long and narrow and often only have one perforation at the top, while the norm is two. Type A3 is 'multi-knopped'; these hooked tags consist of a central circular boss encircled by smaller circular knobs (Read 2008).

Type B hooked tags are those with a triangular plate and are divided into two subtypes; see Figure 6-53. B1 is the classic triangle shape, tending to be an isosceles triangle tapering directly to the hook with no collar. The tops of B1 hooked tags have right angles at the 'base' of their triangles. B2 hooked tags resemble shields; they are roughly triangular but have more rounded corners (Read 2008).

[1] triangle [2] shield *example of B1 (lobed)*

Figure 6-53 Type B hooked tags (Lewis and Naylor 2013, 2)

Type C hooked tags are quadrilateral. They are divided into two subtypes; see Figure 6-54. C1 hooked tags are square and frequently do not have a collar before the hook. C2 tags are classified as a lozenge and are primarily diamond-shaped with many collars above the hook. C2 tags come in a variety of sizes. The majority tend to have sides of equal length; however, there are also examples of quite long C2 tags with a very slight width increase toward the centre of the plate. The last hooked tag type is type D, irregular tags. This type is also split into two groups: D1 with plates shaped as fleur-de-lys and D2 with trefoil-shaped plates. Type D hooked tags tend to be the least common type found (Read 2008).

[1] square [2] lozenge *example of C2 (lobed)*

Figure 6-54 Type C hooked tags (Lewis and Naylor 2013, 2)

6.6.3. Decoration

Hooked tag decoration is divided into eight main groups, lettered a through g and x.[4] Groups a through e also have subtypes; here the overarching groups will be discussed. Group a is ring-and-dot decoration, which has been present in many other object types. This group has four different subtypes. Group b is hooked tags decorated with punched shapes, another common design motif. This group has three subtypes. Group c is hooked tags with linear decoration and has three subtypes. Group d is floriated decorations with two subgroups, and

[4] Hooked tag classification has the group letters for type capitalised and the group letters for decoration lower case.

group e is interlace with three subgroups. Group f is zoomorphic, group g is anthropomorphic, and group x is undecorated; these three have no subgroups (Read 2008).

6.6.4. Conclusion

Hooked tags are an elusive object; archaeologists are still not quite sure of their full purpose beyond functioning as some type of clothes fastener. Hooked tags had a surge in popularity during the Early and Mid-Saxon period, but by the Viking Age they seem to have lost all popularity before they return in the early modern period (Read 2008, 45–49; 137–8). Current scholarship of these objects has been quite brief likely due to their short time frame and delicate nature making survival difficult.

6.7. Sleeve Clasp Typology

6.7.1. Introduction

Sleeve or wrist clasps were used in the Early Saxon period predominantly in the Anglian sphere of influence and then quickly fell out of style. There have been no further distribution studies of the different styles of wrist clasps to determine stylistic popularity within the Anglian cultural sphere. Their purpose was to fasten the cuffs of women's clothing during this period. These objects were occasionally attached to a gusset plate, but this dataset has no examples of those. Even though sleeve clasps are quite short-lived in the Early Medieval period, they possess a substantial amount of variety in type and style. They have been classified by Hines (1993) with date corrections made by Penn and Brugmann (2007, 71). Hines divided sleeve clasps into three main classes with multiple subtypes, and this classification is adopted here.

6.7.2. Anglo-Saxon Types and Styles

Class B Clasps

Class B is the largest class of sleeve clasps, with twenty different subtypes, some of which have further subcategories. Class B sleeve clasps are rectangular, as a plate or bar, often with a slight curve to fit the form of a wrist; see Figure 6-55. These types can either can be produced from a sheet or can be cast. Class B sleeve clasps consist of the main plate, the front edge of the clasps, where the hook or catch would be, and the edge of the plate where sewing holes would be (Hines 1993).

Class B clasps are the most common and variable. There are specific subtypes that are more common than others. The two predominant subtypes are B12 and B20 and the least common are B2, B3, B4, B9 and B15 (PAS). The different subtypes were determined by aspects such as general form (for example, plate and buttons compared to plate and bar or plate only) or surface decoration (Hines 1993). A common issue with Class B clasps is the confusion between B18 and B20, where the crucial difference is the location of perforations on the clasp. The entire sleeve clasp dataset is comprised of Class B clasps, clearly showing the significantly higher popularity of this type (Hines 1993).

Figure 6-55 Type B20 sleeve clasp (PAS finds number NMS-54A8B4)

Class C Clasps

Class C clasps are defined as clasps that do not fit into either Class A or Class B groups. Hines (1993) still managed to create different groups within this class. There are five subtypes in Class C. The primary unifier between all the Class C subtypes is they are all decorated in Style I. The most common is C1, with the others being rare; C2 is only found in Scandinavia (Hines 1993). Recording guides recommend if a clasp is unknown then to record it as a Class C, since that is what the object is likely to be (Hines 1993, 69–73).

6.7.3. Conclusions

Sleeve clasps are delicate objects from the Early Saxon period that are divided into three class types. These items have a poor survival rate, often making further classification beyond the overarching class type difficult.

6.8. Pin Typology

6.8.1. Introduction

Early Medieval pins are challenging to date and classify if they do not come from a well-stratified context. A few different classification methods have been put forward, but none have been widely accepted. Determination of the date and type of pin is usually focused on the shape of the pinhead and the presence or lack of a collar. As will be discussed, pins did not become significantly popular until the Mid-Saxon period, and many of the styles established during this period remained in use through the rest of the Early Medieval period.

6.8.2. Early Saxon Pins

As stated above, pins were not especially popular during the Early Saxon period. Still, Ross (1991) attempted a classification of the types of pins found that dated between the 5th and 7th centuries. The pins did not have clear distinctive groups, like brooches and buckles, and many of the Group One pin types have only one recovered example. The most common and recognisable Early Saxon pin is Ross type LXVI; see Figure 6-56. This pin type has two inward-curling spirals on the pinhead and is marked as different from those with outward-curling spirals (Ross 1991).

Figure 6-56 Ross type LXVI (PAS finds number LEIC-709A97)

6.8.3. Mid-Saxon Pins

The Mid-Saxon period experienced a considerable rise in not only the number of pins but their variety as well, found both on excavated sites and through metal detecting. This surge in pin production is likely due to the expanded standardisation of production that happened in the Mid-Saxon period (Thomas 2011, 413). The first distinction necessary for Mid-Saxon pins is size. Typically, larger pins would have been used on substantial articles of clothing such as cloaks, whereas the smaller ones would have been used for hair or thinner garments (Ross 1991, Hinton 1996a).

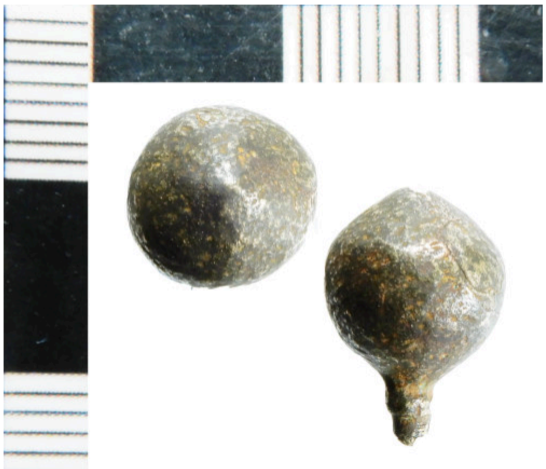

Figure 6-57 Example of globular, collared pin head (PAS finds number NLM-76E9C6)

The larger pins have three accepted types and are quite easy to differentiate. The first consists of a small pinhead with a distinct collar; the second has a flat head with distinct decoration; and the last type is referred to as a ball-headed pin because of the very round pinhead (Ross 1991). A separate large type of pin is a linked pin, which is occasionally misclassified as an Anglo-Saxon brooch. Linked pins consist of a large, flat pinhead with rivet holes for attaching the head to a separate pin shaft. The smaller types have more variation than the larger ones. They can also be easily confused with Roman pins, but the crucial difference is that the majority of Anglo-Saxon pins have a collar and Roman pins do not (Ross 1991). Therefore, the presence of a collar is definitively Anglo-Saxon, but a lack of collar could mean the pin is either Roman or Anglo-Saxon. The most common small pin types, again focusing on the pinheads, are globular head (see Figure 6-57), globular head with a flattened top, polyhedral, biconical, biconical with a median band, and flattened biconical. Pins fitting these descriptions are dated to the 8th and 9th century. The established dating of Mid-Saxon pins is primarily a result of excavations showing significant evidence of their manufacture, such as those at Flixborough (Evans and Loveluck 2009) which yielded an high number of Mid-Saxon pins. After this increase in pin production, they then seem to decline again in popularity (Hinton 1996).

6.8.4. *Late Saxon and Viking Age Pins*

Pins in the Late Saxon period and the Viking Age are far less common than in the Mid-Saxon period. Many of the pins from these periods are definitively believed to be Anglo-Scandinavian or have Irish origins (Mainman and Rogers 2000). Ringed pins (Figure 6-58) and kite-headed pins are the two most evident types, both of which have Irish origins. As their production begins to occur in northern England, the conclusion is drawn that they developed because of Scandinavian influence (Mainman and Rogers 2000). Haldenby and Richards (2009) put forward pin type chronologies based on the excavations in Cottam in the East Riding of Yorkshire. However, due to the methods of their study to establish Scandinavian settlement being solely metal-detecting based and there being no secure contextual dating associated with the pins (Haldenby and Richards 2009), it is difficult to draw definitive conclusions from their results.

Figure 6-58 Example of a ringed pin (PAS finds number NCL-03EE35)

6.8.5. *Conclusion*

Early Medieval pins continue to be a complicated object to classify. Ross's 1991 PhD thesis started the process, but little progress has been made since then. Therefore, the pins included in this study primarily come from the Mid-Saxon period, which has best established pin chronologies as a result of extensive excavations at large-scale production sites such as Flixborough. As more data becomes available for Late Saxon and Viking Age pins hopefully the chronologies can continue to be refined and further information can be learned about Early Medieval pins.

6.9. Horse Fittings Typology

6.9.1. *Introduction*

For the purposes of this study, all the different types of horse fittings will be discussed together. This discussion will also allow for a comparison between accessories for display used by individuals and those still used for display but in secondary ways such as display on a horse. The different types of horse fittings include stirrups and stirrup mounts as well as bridle fittings and cheekpieces. The different horse fittings have undergone different levels of classification. The focus of these classifications is primarily on the later material from the Late Saxon period and the Viking Age. The most comprehensive classification of horse fittings has been Williams's (1997) catalogue of Late Saxon stirrup-strap mounts and his classification of Anglo-Scandinavian harness fittings (Williams 2007). Unfortunately, the other time periods and horse fittings are less common and have not received the same attention from scholars, and this is reflected in the discussion of types and styles.

6.9.2. Late Saxon and Scandinavian Stirrups and Stirrup Mount Types and Styles

Introduction

Stirrup mounts are one of three decorative elements that formed stirrups in the Early Medieval period along with copper alloy mounts and terminals. Stirrup mounts, while decorative, also served a functional purpose. At the base, the mount was riveted to the iron stirrup. Through the back of the mount, the leather stirrup strap would have been woven through and attached with iron rivets.

Williams (1997) classified and outlined distributions for what he defines as Late Saxon stirrup-strap mounts but also included what are defined here as Anglo-Scandinavian and some Scandinavian examples. In his study, Williams divided stirrup mounts into three different classes: Class A, Class B and Class C. Classes A and B have types within the classes. These classes are determined first by form and then by style, leading to an in-depth and easy-to-understand classification.

Williams Class A

Class A mounts are the largest class of mount; out of the 500 mounts that Williams catalogued, 394 of them were Class A. The 394 mounts were divided into seventeen different types and then further into groups. All the Class A mounts are sub-triangular in form and have a right-angle flange at the base of the mount; see Figure 6-59. Just above this right angle are the lower fixing holes at the base of the triangle shape, where iron fittings or a strap would have been attached. At the apex of the triangle is the aptly named apex loop (Williams 1997). Class A mounts are commonly decorated in Ringerike and Urnes styles, making them overwhelmingly Scandinavian or Anglo-Scandinavian in origin. These styles also provide secure methods for dating the mounts to the 11th century, and they do not seem to have a long period of popularity, not being found in a context that postdates c. 1100 AD. Williams discusses distribution based on class and type.

Figure 6-59 Williams Class A stirrup mount (PAS finds number IOW-C908A5)

Williams Class B

Class B is sufficiently more challenging to identify and classify and, therefore, they are far less common than their Class A counterparts. Class B mounts are divided into four different types and then further divided into groups. Class B mounts are defined as being a trapezoidal shape with their flange at a slight angle instead of a right angle like Class A types; see Figure 6-60. The lower fixing holes are just above the base of the mount where the angle beings. At the top of the mount, there are three upper fixing holes, one on each top corner and one in the centre. The key stylistic difference of Class B mounts is that they are primarily openwork and zoomorphic, usually with a central beast head projecting out of the mount, occasionally with further heads flanking the central beast. The openwork style dates them within the same timeframe as Class A mounts; however, the forward-facing animal on many Class B mounts is reminiscent of the Borre style (Williams 1997).

Figure 6-60 Williams Class B stirrup mount (PAS finds number SOM-E11166)

Williams Class C

Class C is by far the smallest class of mount, comprising only seven mounts. The crucial difference between Class C and Classes A and B is the size of the mount. Class C mounts are significantly larger than those in the other two classes and have projecting flanges or side plates; see Figure 6-61. Class C mounts are divided into one group, with the rest being unclassified. Class C mounts employ styles from both Class A and Class B, likely also placing them within the 11th century (Williams 1997).

Figure 6-61 Williams Class C stirrup mount (PAS finds number WAW-1BA854)

6.9.3. Cheekpieces, Harness and Bit Links

Introduction

Cheekpieces, harness and bit links, similar to the mounts discussed earlier, are only discussed in depth for the Viking Ages. However, because of the lack of variation among each of these types and the limited scholarship focused on them, except for cheekpieces they have not been divided into subtype and or into categories but instead discussed together. Though cheekpieces have been subdivided, as will become evident, their types are significantly less detailed than those described for mounts (Williams 2007; Pedersen 1997).

Cheek Pieces

The study of cheek pieces has similar gaps in knowledge as other horse equipment types; the typologies that have been done are primarily Anglo-Scandinavian era and types; see Figure 6-62. Early Saxon cheek pieces are bars with loops through which a mouthpiece could connect (Fern 2005). A later cheek piece consists of a flat plate often with a projections to attach to a leather harness strap; these are usually in pairs on either side of the horse's face with the bit link attached between them. Williams has divided cheek pieces into three different types. Type One cheek pieces are the most common of the types found. This type is engraved with typical late-Scandinavian strip creatures in openwork style and with central knobs. This type has parallels found in Denmark identified by Pedersen (1997). Type Two is easily recognised for not having zoomorphic decoration or rounded terminals. Type Three is also easily distinguishable because it is the only type that is cast rather than engraved. It is decorated with inward-facing animals similar to those on Class B stirrup-strap mounts (Williams 2007, 3-4).

Figure 6-62 Ringerike style cheek piece (PAS finds number LIN-CB3329)

Bit Links

The only bit links found to date are undecorated and similarly designed. Their purpose was to attach the bit to the reins. Bit links are easy to identify as they consist of two somewhat circular terminals with a joining arm with a central knobbed boss; see Figure 6-63. Usually, one terminal appears to be diamond-shaped due to three knobbed points with a circular opening, similar to those found a harness links, particularly the four-way harness links. The other terminal is consistently an oval (Williams 2007).

Figure 6-63 example of harness or bit link (PAS finds number PUBLIC-10E345)

6.9.4. Conclusion

Horse fittings are one of many object types that have been overlooked in Early Medieval scholarship. These object types seem to have emerged substantially during the Second Viking Age, which will likely have a significant impact on the pXRF results that will soon follow. It will be interesting to see how much variation there is between the different objects made for a similar purpose, such as horse equipment.

6.10. Bell Typology

6.10.1. Introduction

While bells make up only a small portion of this dataset, they are a noteworthy object type. When bells from the Early Medieval period are discussed, there tends to be a focus on church and religious practice and the associated bells (Willmott and Daubney 2020). However, there are bell types that appear to have been intended for personal use and adornment, rather than for building or livestock use. Only one bell type is included as it is the only recovered type available used for personal adornment.

6.10.2. 'Norse Bells'

The only Early Medieval bell type included in this study is the aptly named 'Norse Bell'. These bells date from the late 9th to late 11th centuries. They have integral loops and have hexagonal cross-sections that are slightly concave and are frequently found with ring-and-dot decorations and sometimes with a scalloped edge; see Figure 6-64. The use and origin of these little bells are mostly unknown; however, they seem to emerge at the same time as Scandinavians begin to settle in Northern England and therefore have primarily been attributed to them, hence the name Norse Bells. However, they have seemingly no parallels from Early Medieval Scandinavia, although examples are known in Iceland, specifically from a disturbed burial from Brú uncovered in 1987 (Schoenfelder and Richards 2011; Batey 1988, 214). They are found across Great Britain in Freswick Links, Caithness; at Peel Castle in the Isle of Man, and another from the Isle of Man found in a pre-Christian grave of a child; the Holmes Grain Warehouse in Lincolnshire; and the Wirral site of Meols, to name a few examples. These bells are clear evidence for a connection between Iceland and Great Britain (Batey 1988, 213–215).

Figure 6-64 an example of a Norse bell (PAS finds number LIN-4509AB)

6.10.3. Conclusions

Norse Bells are a unique and exciting object to be included in this study. While they are a small portion of the dataset, they receive a significant amount of attention because so little is known about them. Moreover, by giving them some extra focus, this study and perhaps their composition can shed some light on their usage, purpose and origins.

6.11. Girdle Hangers Typology

6.11.1. Introduction

Girdle hangers are another object in this study that only exists for a small part of the overall study period. They are popular in Early Saxon female graves and are often associated with feminine power (Felder 2014). Girdle hangers are believed to represent symbolic latchlifters and keys and are often in assemblages all together, commonly found at a woman's hip (Felder 2014). This object seems to have popularity across social classes, being present in very lavish decorated graves but also occasionally they are the only grave object. There has been significantly less research focused on their typology, with the exception of that by Felder (2014), who recently divided girdle hangers into two typological groups. Felder used the terminals to determine their type. Girdle hangers consist of a long narrow shank with a horizontal terminal base. The base has two prongs on either end that fork upwards where the terminals are found.

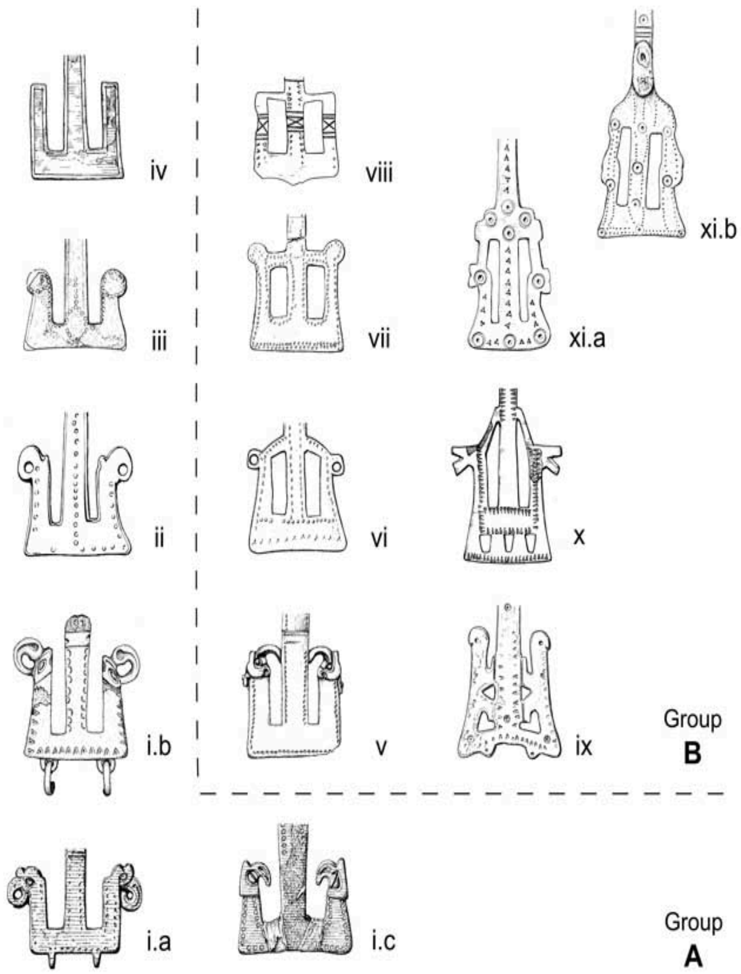

Figure 6-65 The distinction between Felder Group A And B (Felder 2014)

6.11.2. Typology

The critical difference between Group A and Group B is that Group A terminals are open terminals while Group B has closed terminals. There is some speculation that the Group A terminals are derived from the flared terminals of cruciform brooches. Group A bases range from being plain with no terminal decoration, to having simple lobes at the terminals, to having ornate bird heads as the terminals. Group B sees a similar variation in decoration. The terminals range from being closed by a simple plain bar to more lavish forms also decorated with bird heads. The variation within these can be seen in Figure 6-65.

6.11.3. Conclusion

Girdle hangers are a fascinating subject of Anglo-Saxon female identity, with research focused on their importance in the Early Saxon period (Felder 2014). They are also an object that sees frequent instances of repair and deposition in burial contexts.

6.12. Summary

The primary goal of this chapter was to lay a strong foundation for understanding the vast amount of variation between and within Early Medieval object styles and types. This goal was to ensure clarity when discussing the compositional results in relation to type and cultural groups in the subsequent chapters. This chapter also reveals the scholarship disparity between certain object types. These discrepancies are also important to keep in mind when analysing the details of the compositional results and the levels of the divisions and discussion for each object. This research employed the stylistic analysis previously undertaken by scholars to provide a framework for the dataset. This will allow a closer examination of the material including the basis for how the material included is dated and what cultural group the objects most closely relate to, as well as any other impact on the material.

Chapter 7. The Dataset

7.1. Introduction

This chapter sets out the analytical results for the 293 copper alloy objects from Lindsey. Each alloying element – tin, zinc and lead – is considered individually before bringing them together in a wider discussion. This data is then compared to other studies to contextualise it. The subsequent Chapters Eight and Nine will focus on the interpretation of this data with regards to recycling, object type, time period and cultural identity. Appendix Four contains the full details of the raw data that this chapter presents, using the item's PAS or museum accession number as their sample number. Appendix Three is a display of the scale factored data allowing the elements to be viewed as ratios rather than total values, this being the most suitable way to look at data such as pXRF compositional data that often has many issues with accuracy. Additionally, the Appendix Three catalogue contains the object reference numbers created for ease of discussion in this thesis, alongside their PAS or museum accession number and further object information.

Previous studies of Early Medieval copper alloys, because of the nature of reporting, as discussed in Chapter Five, have derived from either a limited object type or individual site. In order to gather a more representative picture of Early Medieval copper alloys in Lincolnshire, readings of all object types were taken. In total, 293 objects were analysed by the pXRF, 180 from metal-detected sources and 113 from excavations. The method of recovery does not impact compositional results, those excavated simply have better contextualising than metal detected material . As shown in Table 7-1, Early to Late Saxon finds came from both metal-detected sources and excavated sources, while the Viking Age material primarily comes from metal detecting. Metal detecting in and around the village of Osbournby provided the largest amount of material and is the only location that covered every time period. The second-largest source of material was the excavations at Scremby, resulting in 83 objects, all from the early Saxon period. The specific findspots could not be shared; however, a map showing the general location of finds can be seen in section 5.3.1.

7.1.1. Timeline Divide

Tables 7-1 and 7-2 also display how many objects from each time period were analysed. These time periods are Early Saxon, dated from the 5th to mid-7th centuries; Mid Saxon, dating from the mid-7th and 8th centuries; Late Saxon and First Viking Age, dating from the end of the 8th century to the mid-10th century; and then the Second Viking Age, dating from the mid-10th century to the mid-11th century. Because style is the predominant variable used to date objects in this study, they tend to have wide date ranges. This is one of the main reasons that the Late Saxon and First Viking Age are grouped as one. Many popular styles span both periods, making it difficult to divide them when solely dated stylistically.

Source	Early Saxon (410–660)	Mid Saxon (660–793)	Late Saxon & First Viking Age (793–865)	Second Viking Age (865–1066)	Total
MD – Osbournby	41	16	5	25	87
MD – South Ferriby	0	0	9	15	24
MD – Torksey	2	3	8	0	13
MD – Little Carlton	0	5	1	0	6
MD – Other Southern Lindsey	1	1	10	38	50
Ex – Little Carlton	0	16	0	0	16
Ex – Scremby	83	0	0	0	83
Ex - Flixborough	0	14	0	0	14
Total	127	55	33	78	293
MD = metal detected, Ex = excavation					

Table 7-1 Objects by source and time period

It was not always possible to have equal representation of different object categories and dates. The most significant bias is the 127 items from the Early Saxon period. This is due to the ease of access to the Scremby material, as the author took part in the excavation and was able to analyse material during its recovery. The remaining periods have similar amounts of objects analysed. While there is some variation, it is reflective of the available material and there are adequate numbers in all cases for interpretations to be well founded.

7.1.2. Object Types Included in the Dataset

The items analysed encompass a wide variety of objects (see Table 7-2) and as stated in the

	Early Saxon (410–660)	Mid Saxon (660–793)	Late Saxon & First Viking Age (793–865)	Second Viking Age (865–1066)	Total
Bell	0	0	0	5	5
Bridle Fitting	1	0	0	12	13
Brooch	64	2	5	20	91
Buckle	2	1	1	8	12
Chatelaine	1	0	0	0	1
Die	0	0	1	0	1
Flyer	1	0	0	0	1
Gaming Piece	0	0	1	0	1
Girdle Hanger	9	0	0	0	9
Hooked Tag	5	0	2	0	7
Ingot	0	0	1	0	1
Mount	1	0	3	10	14
Pendant	0	0	1	0	1
Pin	1	22	1	0	24
Sleeve Clasp	18	0	0	0	18
Spangle	2	0	0	0	2
Stirrup	0	0	0	7	7
Strap Distributor/ Fitting	0	0	0	2	2
Strap End	0	7	11	14	32
Sword Fitting	0	0	2	0	2
Tweezers	0	0	3	0	3
Undiagnostic	21	23	0	0	44
Vessel	1	0	0	0	1
Weight	0	0	1	0	1
Total	127	55	33	78	293

Table 7-2 Objects by type and time period

Introduction (section 1.02), establishing whether there is a pattern in compositions and object types is one aim of this study. Different compositions may have been utilised for different objects to aid in their production; for example, if a complex style was being used, lead would be beneficial to aid in the ease of the molten flow.

The frequency of each object type is significantly impacted by sampling and survival rates of objects, as well as what dress accessories and items of personal display were fashionable at a given time. This variability in popularity is clearly reflected in the periodisation of objects shown in Table 7-2. A prime example of this phenomenon is the continued popularity over time of brooches, leading to the inclusion of ninety-one brooches in this study. The high frequency is starkly different when compared to sleeve clasps and girdle hangers, both of which are popular during the Early Saxon period but fall out of style in the later periods, resulting in eighteen and nine objects respectively. This periodisation used in this study is determined by stylistic research outside of this thesis; see Chapter Six. With regard to sampling and survival rates, the impact of these can also clearly be seen in the number of brooches included. Brooches have a good survival rate and are relatively easy to sample, as even when fragmented they are easily identifiable. This has led to a significant inclusion of brooches in the dataset. Additionally, there is one category listed as undiagnostic. These are fragments of objects that were dated stratigraphically, but too fragmented to classify by object type. Therefore, these undiagnostic objects can only be used in the discussion of the time period and not in the discussion of object type. All in all, the importance behind dividing the object by type is to see whether there are any significant patterns between them and the possible intentionality behind their compositions and the choices producers were making.

7.1.3. Cultural Divide

Dividing the objects by 'cultural' group faced similar issues as the chronological divisions and therefore yielded similar results, as shown in Table 6-3. These groups include Anglo-Saxon, Scandinavian, Anglo-Scandinavian, and Irish. The one Irish style object is likely a result of increased trade with Dublin due to Viking expansion. These divisions are actually made based on the object's style rather than definitive cultural variation. This object classification was also adopted from the PAS to ensure that the discussion here would be consistent with similar discussions using this type of material. It is highly likely that any patterns between these groups will actually be a result of change over time as they reflect stylistic changes that were occurring within the Early Medieval period, as is reflect by studies looking at the styles during the Early Medieval (Kershaw 2013; Thomas 2000).

Table 7-3 Objects by cultural group and time period

	Early Saxon (410–660)	Mid Saxon (660–793)	Late Saxon & First Viking Age (793–865)	Second Viking Age (865–1066)	Total
Anglo-Saxon	127	55	21	2	205
Scandinavian	0	0	19	35	54
Anglo-Scandinavian	0	0	1	34	35
Irish	0	0	1	0	1
Total	127	55	33	78	293

Now that the overall object data has been laid out, the subsequent sections can focus on patterns found in subgroups of the compositional dataset. The simplest, most effective way of dividing the data is by cultural group: Anglo-Saxon, Scandinavian and Anglo-Scandinavian, as this division incorporates style and some of the timeline divide.

7.2. Compositional Data

7.2.1. Compositional Dataset

Using the new classification methods established in section 5.5 the pXRF compositional data were divided into their defined alloy types. The following section will establish the prominence of alloy types and the spread and diversity of compositions within the material. This initial examination will naturally raise questions and prompt further ways of studying the dataset. These questions will be revisited throughout the subsequent chapters of this thesis and the data compared to other classificatory categories by which individual objects can be grouped. With those objectives in mind, this chapter will explore the variability revealed by the pXRF data.

The most abundant alloy type is leaded bronze, represented by 99 objects out of the 293. Conversely, bronze was the smallest category, with only five objects. The second-largest category was leaded gunmetal, with 92objects. The compositional data are also shown plotted in Figure 7-1, where the prominence of leaded bronze and leaded gunmetal is clear. These results show quite a high diversity of compositions and marked variability in alloying materials. Similarly, the lead, both in content and frequency, was much higher than

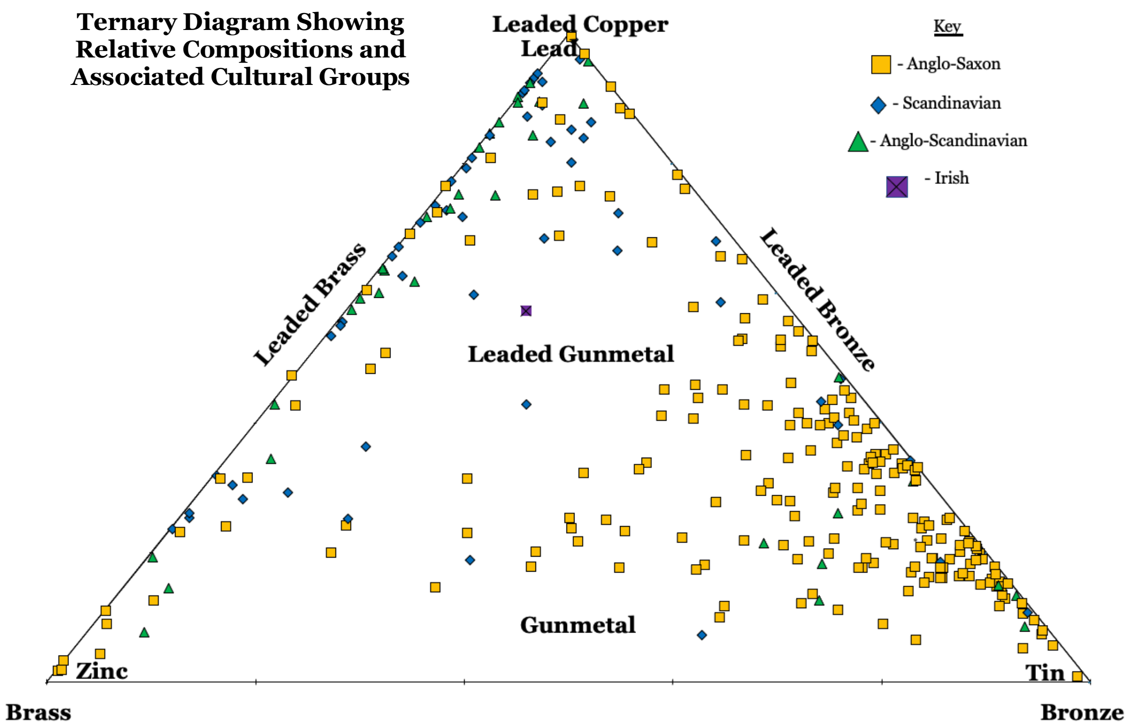

Figure 7-1 Ternary graph displaying compositions of entire dataset

expected, although the results plotted in Figure 7-1 do not show the prevalence of lead as clearly as Figure 7-4 does.

Table 7-4 Alloy type and frequency

Alloy Type	Frequency
Leaded Copper	37
Bronze	11
Leaded Bronze	99
Brass	19
Leaded Brass	19
Gunmetal	16
Leaded Gunmetal	92

Not only is leaded copper a relatively prominent alloy type, being the most abundant of those with only one alloying material, but in addition for each alloy type (brass, bronze, gunmetal) the leaded variation is more common than its unleaded counterpart, demonstrating lead's significance in the dataset. These results are noteworthy; as noted above, many past classification systems – see section 5.5 (Bayley and Butcher 2004; Pollard 2018) – have largely underrepresented lead. Furthermore, unleaded brass comprised twelve items and leaded brass twenty-six. These results show that unleaded brass is more than twice as common as unleaded bronze, showing that more brass was being produced than previously believed (Table 7-4).

Beyond the overview of the results, there are many ways that the data can be further interrogated to answer additional questions. These include aspects of compositional variation over time, between possible cultural groups, and based around object type. However, before those questions can be answered, there will be an individual discussion of each alloy type and material to ensure full comprehension of the data is achieved.

Copper Content and Iron as a Potential Corrosion

The copper content of the alloys will briefly be discussed along with iron content to contextualise the data and the results. Iron is the only additional element discussed, as others present are trace elements, and as previously outlined the pXRF is not suitable for trace element analysis. Additionally, copper and iron content are discussed together because, as mentioned in section 2.4.6, iron cannot be integrated into copper and therefore is a clear sign of corrosion; often in the data a higher iron content is coupled with a lower copper content. Furthermore, as pXRF is a surface analysis and the samples were not drilled, as in many other studies, being aware of this relationship between iron and copper is important when considering total copper values.

The copper content of the object encompassed quite a wide range with the top end being 97% for object UK.043, an undiagnostic Mid-Saxon object, which is the only object in the study that is considered pure copper. Below that the range for objects considered copper alloys is 90% (Ref. number BF 005). Objects with copper levels lower than 30% had to be looked at holistically to determine whether they should still be included. Factors taken into consideration included whether copper still formed the majority of the composition, the content of iron and the consistency of the readings. To illustrate this, the readings from object BR.022 will be examined, summarised below in Table 7-5. This object was chosen as it is an extreme example of the situations described above. BR.022 is an annular brooch; the brooch pin is iron, and the circular ring of the brooch is copper. Because of the iron pin, the object had high levels of obvious corrosion in the area immediately around the pin. Best practice was employed in an attempt to avoid those areas of corrosion, but as shown by the results this was not entirely successful.

Table 7-5 Cu and Fe readings for BR.022

	Cu	Fe
BR.022 reading one	56.363	14.234
BR.022 reading two	17.169	50.327
BR.022 reading three	15.5	38.57
Avg. of readings	29.677	34.377

The example of BR.022 shows both the potential inconsistency within the copper alloy readings as well as the lower copper readings directly corresponding with high iron levels, demonstrating why a low average of copper may require closer inspection before eliminating the object from the study. Additionally, this object, even with the low copper average, still had a higher proportion of copper than the alloying elements, with tin averaging at 26%, lead at 3% and zinc at 0.5%. That stated, this is an extreme example of the relationship between copper and iron in this dataset. Most of the objects analysed in the study had copper levels of between 50% and 70%, with high-copper items ranging from 70% to 93%. However, these were lower copper levels than found in other similar studies, perhaps due to the abilities of the pXRF compared to the drilling and sampling on XRF and EDXRF allowing for better avoidance of corrosion.

Tin Content

Tin-based alloys were the most common, with 110 objects in total. However, only eleven of these were not leaded bronzes; bronze is defined here as possessing tin levels above 3%, and leaded bronze comprising both tin and lead in excess of 3%, with lead levels not exceeding those of the tin. There is evidence for both high-tin and low-tin bronzes, as seen in Figure 7-2, with the majority of bronzes and leaded bronzes having a tin content of between 10% and

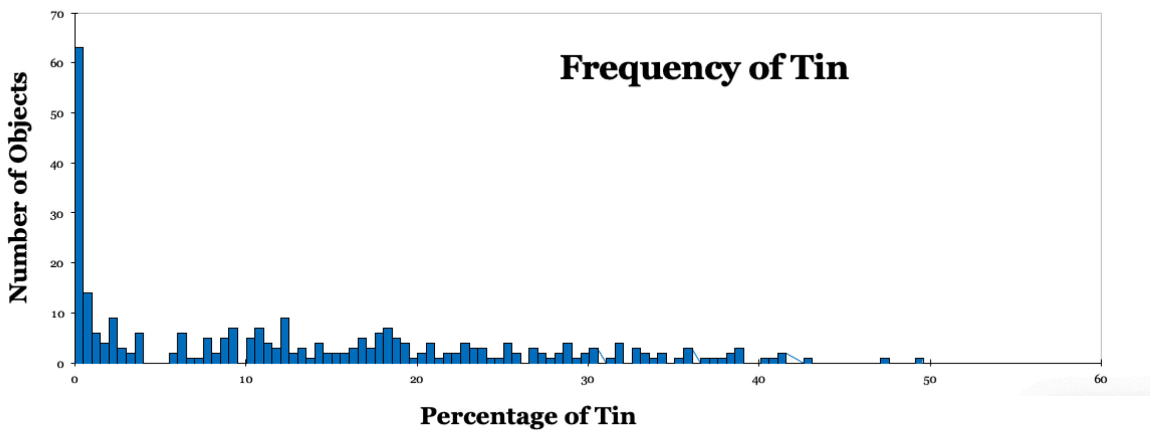

Figure 7-2 Frequency of tin in objects

20%. The wide range of tin content suggests that there was no target for tin content or that the acceptable amount of tin was a wide range. This tin content variation could also be indicative of recycling practices. This will become increasingly clear when objects are separated by time in Chapter Eight, to see whether this wide range exists through the entire period or varies over time.

Zinc Content

Zinc-based alloys are not very common in the study's dataset, with 38 brasses in total, and 19 of these being leaded. Brass here is defined as composing more than 3% zinc, and leaded brass more than 3% zinc and lead respectively, with the lead not surpassing the zinc. As displayed in Figure 7-3, there is a clear negative correlation between the percentage of zinc and the number of objects, showing the rarity of high-zinc brasses within this dataset. Furthermore, objects with a zinc content of 1–2% are most common. This shows that when zinc appears it is likely as an unintentional inclusion rather than being used to alloy copper.

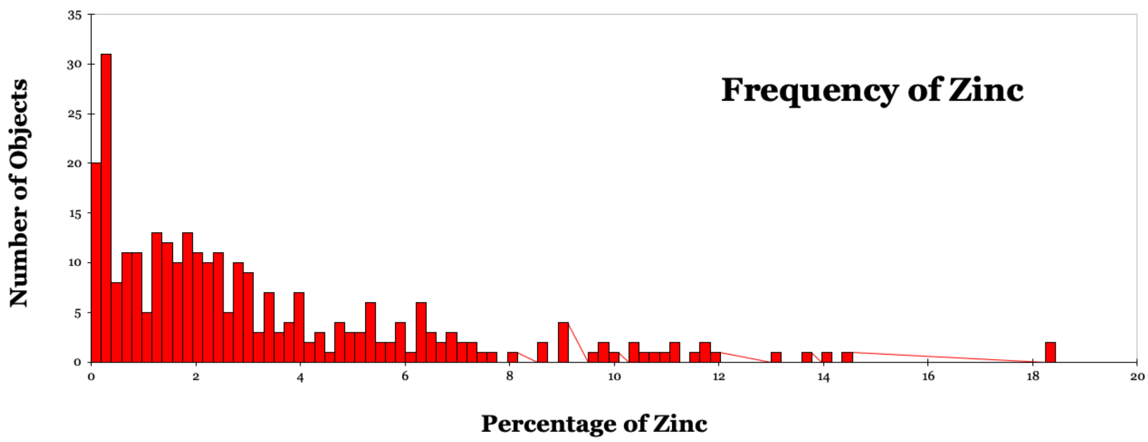

Figure 7-3 Frequency of zinc in objects

Lead Content

Lead is abundant in this dataset; there are 37 objects classified as leaded copper, defined as having lead proportions above 8% with zinc and tin levels both lower than the lead. The majority of objects that contain lead are actually leaded bronze, leaded brass and leaded gunmetals. This highlights leads role as not being the main alloy choice but likely a supplementary one.

As displayed in Figure 7-4, the lead percentage follows a negative trend, though with more peaks and troughs than seen in the zinc data. The negative trend takes shape following its highest point at 9%. These results are promising to explore, as lead levels in copper alloys are not often closely analysed. In summary, while lead frequency decreases after 9%, lead content is still quite abundant and present in the samples up to the level of 60%. Figure 7-4 demonstrates the high lead content occurring as both small quantities and as the primary alloying material in the Early Medieval period. There is likely a multitude of factors contributing to the treatment of lead in this period, all of which are explored in later chapters.

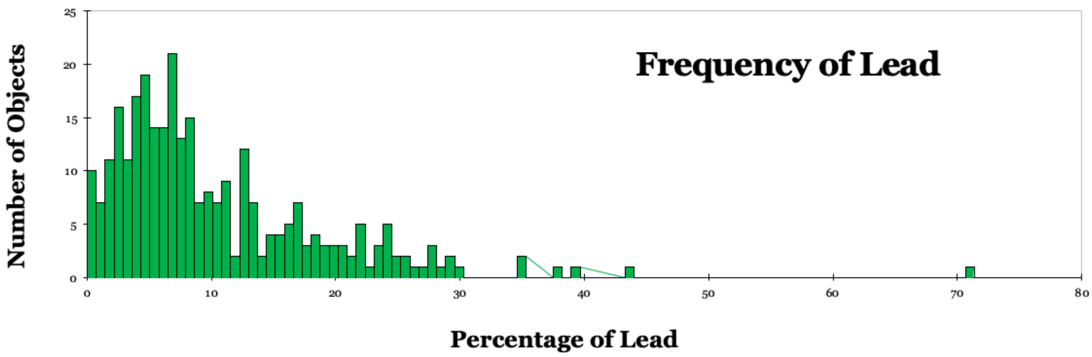

Figure 7-4 Frequency of lead in objects

7.3. Summary and Conclusion

This thesis aims to explore the range and potential variation of copper alloys throughout the Early Medieval period within the historical territory of Lindsey. These aims were met through a combination of stylistic analysis and pXRF chemical composition analysis. The goal is to understand whether there are broad alloy changes to copper alloys and how those changes correlate to stylistic patterns. The pXRF focuses on the deliberate addition of other significant elements, primarily tin, zinc and lead, which leads to the production of bronze, brass, gunmetals and leaded variations of those. A representative sample was taken of each object type, style and temporal phase of the Early Medieval period, in order to ensure future inter-site comparison. These compositional patterns will, in the following chapters, be related to the broader archaeology of the Early Medieval period and current questions in order to give such data relevance.

Chapter 8. Considerations of the Variations in Object Composition

This chapter will present the pXRF data from the material outlined in the previous chapter. The compositional changes that occur over time are the most notable patterns of variation explored in this study. Each of the subperiods has defining characteristics and represent aspects of the ever-changing political and cultural landscape of Lindsey. Because of this drastic temporal shift, the data are first divided by subperiod and then the associated styles and types are discussed. It is important to note that the bar graphs that are presented throughout the chapter are used to aid in visualising the approximate range of metal content rather than to be used to study small changes in content.

8.1. Early Saxon Data

8.1.1. Introduction

This section will discuss the data from the Early Saxon material,[5] beginning with an overview discussing the compositional data from these objects before moving into style and typologically specific compositions. There will then be a brief discussion about these data that will feed into larger discussions in Chapter Nine.

8.1.2. Overview

The Early Saxon copper alloys are primarily tin based, with a broad and reasonably even spread of bronze, leaded bronze and leaded gunmetal. Figure 8-1 clearly shows this wide spread of material, with the majority of objects having a high tin content and firmly within the category of bronze. The Early Saxon material has the highest quantity of leaded gunmetals compared to the other periods, and this will become more apparent as the later periods are discussed.

[5] Early Saxon reference numbers: BC.001, BC.003, BC.009,BF.003, BR.002, BR.003, BR.004, BR.005, BR.006, BR.007BR.008, BR.009, BR.010, BR.011, BR.012, BR.013, BR.015, BR.016, BR.017, BR.018, BR.019, BR.020, BR.021, BR.023, BR.024, BR.025, BR.026, BR.027, BR.028, BR.029, BR.031, BR.032, BR.033, BR.034, BR.035,BR.036, BR.037, BR.038, BR.039,BR.040,BR.041,BR.042,BR.043, BR.044, BR.045, BR.046,BR.047, BR.048, BR.049, BR.050, BR.051, BR.052, BR.053,BR.054, BR.055, BR.056, BR.057, BR.058, BR.059, BR.060, BR.062, BR.063, BR.064,BR.065, BR.074, BR.088, BR.090, CH.001, F.001, GH.001, GH.002, GH.003, GH.004, GH.005. GH.006,GH.007, GH.008, GH.009, HT.002, M.002, P.001, PN.010, R.001, SC.001, SC.002, SC.003, SC.004, SC.005, SC.006, SC.007, SC.008, SC.009, SC.010, SC.011, SC.012, SC.013, SC.014, SC.015, SC.016, SC.017, SC.018, SP.001, SP.002, TW.001, TW.002, UK.001, UK.005, UK.006, UK.012, UK.013, UK.015, UK.016, UK.017, UK.019, UK.020, UK.021, UK.022, UK.023, UK.025, UK.027, UK.028, UK.031, UK.037,UK.038, UK.039, UK.042, UK.044,V.001

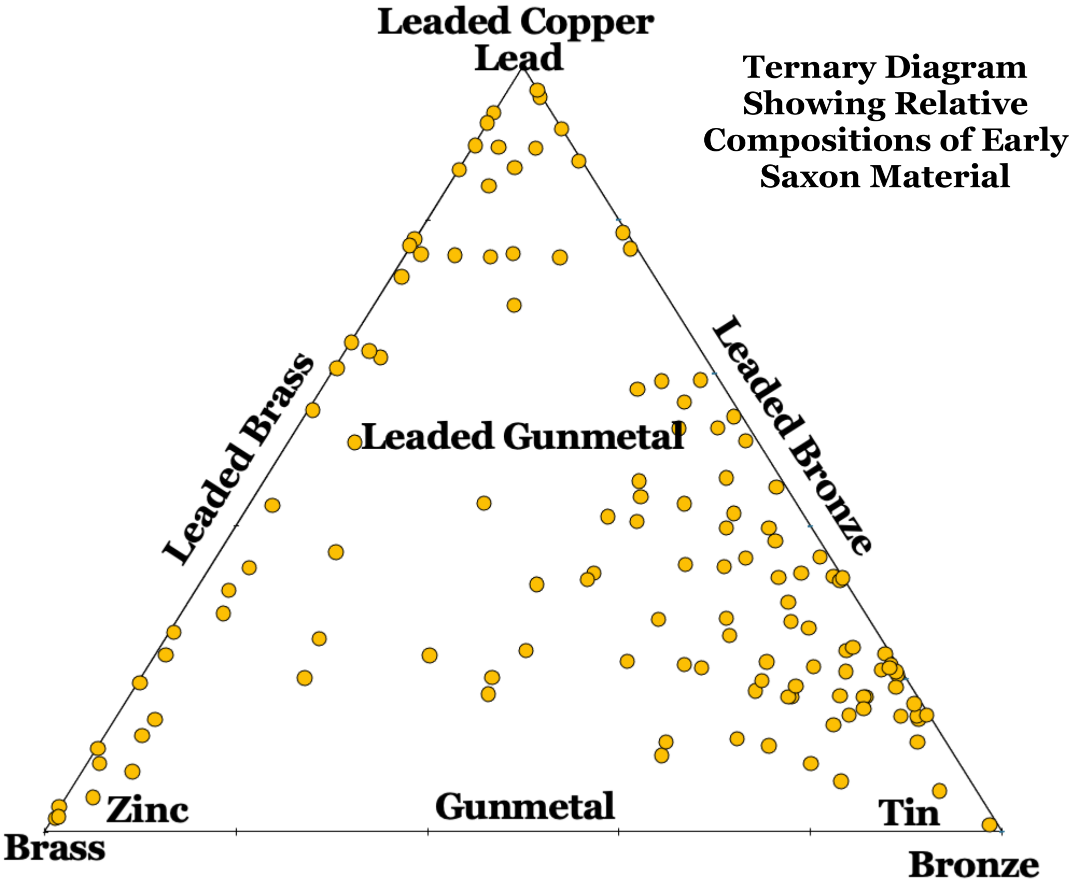

Figure 8-1 Ternary diagram showing the relative values of tin, zinc and lead for the Early Saxon material

Figure 8-2 shows that the Early Saxon objects have significantly high tin levels, as well as a large number of objects with high tin levels. In fact, only two Early Saxon objects do not contain any traces of tin (HT.007 and UK.044). The Early Saxon data, similar to the overall data outlined in Chapter Seven, show the most common percentages of tin in this period range between 10% and 20%. The frequency between 20% and 40% also remains relatively high, whilst objects with tin levels above 40% are very uncommon. As discussed in Chapter Two, such high tin levels can lead to a production failure. These items with high tin[6] are mostly brooches, as well as a Kentish buckle (BC.001). These are all object types that could have used tinning as a surface treatment, and as pXRF is a surface analysis this tinning could increase the measured tin levels to such high amounts; however, it is important to consider all possibilities for such high levels. The high levels of tin in the Early Saxon period are to be

[6] High-tin bronzes: BC.001, BR.002, BR.003, BR.004, BR.005, BR.006, BR.007, BR.008, BR.009, BR.010, BR.011, BR.012, BR.013, BR.015, BR.016, BR.017, CH.001, GH.001, HT.002, SC.001, SC.002, SC.003, SP.001, UK.005

expected given the high number of bronzes and leaded bronzes shown previously in Figure 8-1.

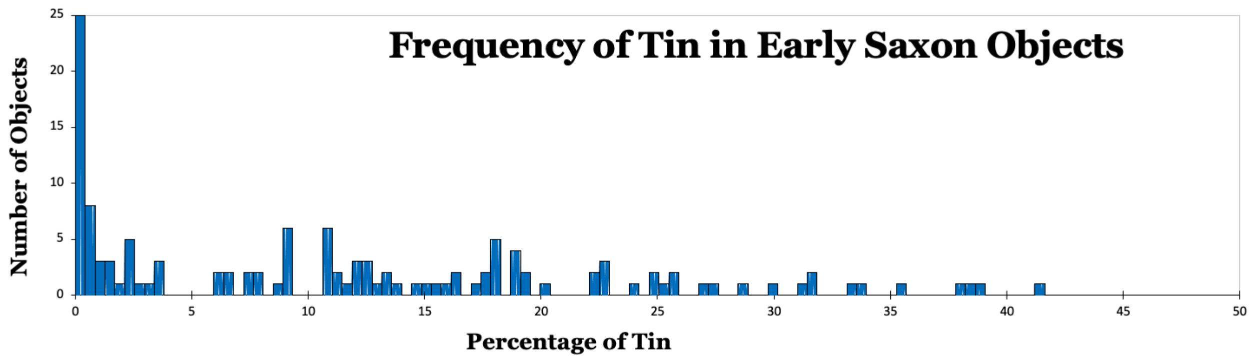

Figure 8-2 Frequency of tin levels in Early Saxon objects

Zinc content in the Early Saxon period is low, as shown on Figure 8-3, and is reflective of patterns from the entire Early Medieval period. Only a few items have high amounts of zinc.[7] This pattern shows us that zinc was likely continuing to dissipate due to volatilisation during the continued recycling of brass, and that zinc was infrequently imported and therefore not regularly available for use, either for the production of new brass objects or to compensate for zinc loss during the recycling. This pattern of low zinc content also continues into the Mid Saxon period.

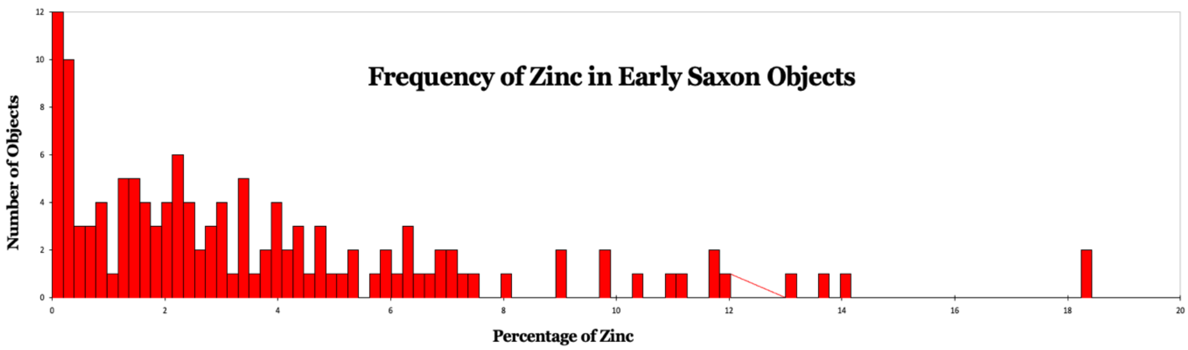

Figure 8-3 Frequency of zinc levels in Early Saxon objects

The Early Saxon period shows high levels of lead usage, shown by both high frequency and percentages of lead (Figure 8-4). Some of the most heavily leaded objects in the overall dataset come from this period. Upon seeing high lead presence in the overall data, it is intuitive to think that high lead quantities came in with the bullion economy of the Scandinavians during the Viking Age, as lead was commonly used for weights, but this does not appear to be the case. There is instead a high frequency of objects containing between 5%

[7] BR.028, BR.045, BR.049, BR.059, HT.006, SC.011, UK.023, UK.039, UK.042

and 15% lead during the Early Saxon period, making it a significant and clearly intentional addition to an item.

8.1.3. Compositions by Object Type

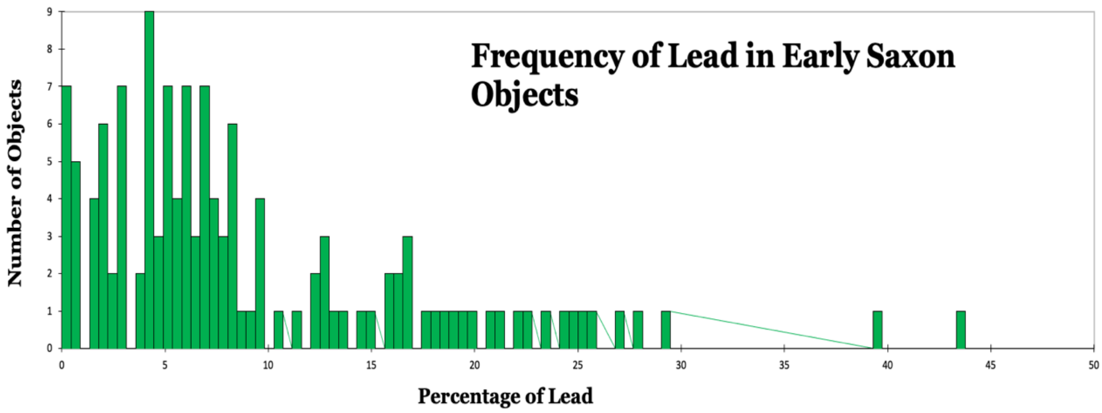

Figure 8-4 Frequency of lead in Early Saxon objects

The following section will be dividing the Early Saxon objects based on the object types discussed in Chapter Six. The goal is to see whether there is any patterning based on the different typological forms. Some objects that span more than one period are included here, such as annular brooches, because the majority of the examples recovered are from the Early Saxon period. These data will feed into a further discussion about specific object types in section 9.2.1, where these data are discussed alongside those from other periods.

Brooches

Annular Brooch Data

Annular brooches make up a significant portion of the brooch dataset, comprising twenty-two of the ninety-one total objects identified as brooches. They are also from predominantly excavated contexts, with only two found as a result of metal detecting – these coming from the area surrounding Osbournby.[8] The excavated material primarily comes from Scremby, with eighteen[9] of the twenty-two objects, and the final two objects come from the Little Carlton site.[10] All of the annular brooches analysed were Leeds Type G. The two metal-detected examples were fragmented but consisted of quite large fragments, and therefore could be assigned to types. The majority of these brooches did not have a surviving pin. Compositional variations are reflected in the different compositions of the Little Carlton

[8] Osbournby annular brooches: BR.039 and BR.088
[9] Scremby annular brooches: BR.011BR.017, BR.018, BR.019, BR.021, BR.023, BR.025, BR.028, BR.034, BR.038, BR.042, BR.045, BR.046, BR.047, BR.049, BR.054, BR.057, BR.060
[10] Little Carlton annular brooches: BR.014 and BR.022

material, with similar differences seen between the Scremby and Osbournby material, representing a pattern discussed throughout this chapter.

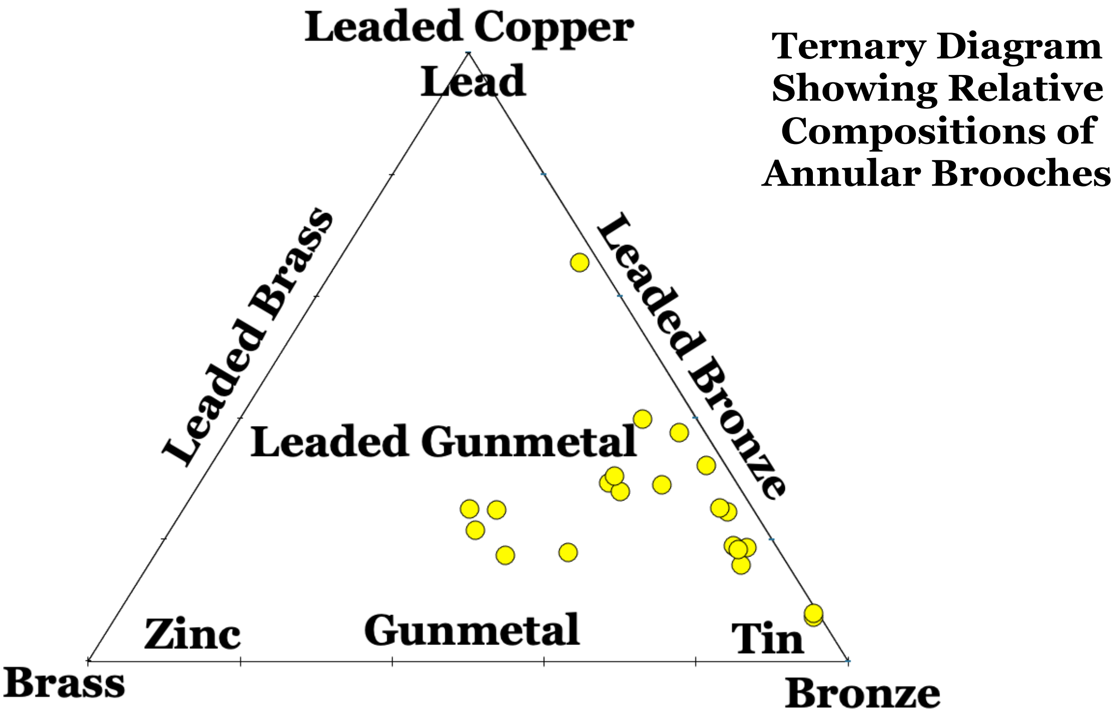

Figure 8-5 Ternary diagram showing the compositions of annular brooches

The two Little Carlton objects are the two 'purest' bronzes, as seen on Figure 8-5. The Scremby and Osbournby materials make up the rest. The two Little Carlton objects, being such a 'pure' bronze, suggest that a high level and quality of copper alloy production was occurring at that site, with the ability to acquire fresh material. This conclusion fits with the rest of the narrative of Little Carlton as a high-status site (Willmott and Wright 2021). The grouping in the centre of the graph, the gunmetals, comprises objects from Scremby, while those closer to bronze and leaded bronze are a mix of Scremby and Osbournby. This pattern is similar that in the square-headed brooches; Scremby seems to have higher amounts of material recycling than Osbournby. This result of high amounts of gunmetals brings us back to Mortimer's hypothesis of zinc coming from a Humberside production chain and process.

Nevertheless, again here at Scremby, there is a relatively high amount of zinc in their annular brooches. It is now essential to return to the question of recycling of Roman objects as a method for obtaining zinc. The levels of zinc suggest these annular brooches were made from recycling a high-zinc material, considering the high amount of zinc loss that occurs during recycling. This question is clearly one the requires further insight and investigation.

There is a possibility that it is coincidental that the Osbournby material compositions align so closely with the Scremby material. However, the absence of evidence does not necessarily mean recycling was not occurring. The two objects from Osbournby do show some signs of recycling, just not to the same extent as the central group from Scremby, while the slightly later material from Little Carlton could suggest refining of recycling practices over time.

Cruciform Brooch Data

Cruciform brooches are the second most abundant type of brooch included in the study, with twenty-three examples from the ninety-one total. They come from both excavated[11] and metal-detected sources;[12] the majority of the cruciform brooches from detected sources were heavily fragmented, while those from excavation were entire brooches. This difference between the two does not appear to have had any impact on compositional analysis, as deposition can impact degradation and therefore composition, as discussed in section 3.3.6. While the fragmented pieces were primarily the knobs of the brooches, which are cast separately and attached to the headplate of the brooch, it is interesting to note that compositionally, they are similar to complete brooches.

As can be seen in Figure 8-6, cruciform brooches present some clear patterns but also some clear outliers in their compositions. The two most significant groupings are in leaded bronze with a grouping of twelve objects,[13] and bronze with a grouping of seven objects.[14] These patterns fit into what we already know about metal production during this period. It is somewhat contrary to the data of Catherine Mortimer from the site of Castledyke, where cruciform brooches consisted of four brasses, four bronzes and two gunmetals, by both the definition used in this thesis and Mortimer's definition. Mortimer says that the high levels of zinc at Castledyke are surprising and unusual when compared to her data from sites in East Anglia (Mortimer 1998, 254). Her data from Cleatham, however, align very closely with the evidence found here, with cruciform brooches primarily being made of tin-based alloys.

These distinctions are quite significant. The cruciform brooches in this study come from quite far south within the Kingdom of Lindsey, specifically the area around Osbournby and the excavations at Scremby, both of which are close to the Kingdom's southern border. The site of Cleatham is further north but still close to the southern border. Castledyke, in

[11] Scremby cruciform brooches: BR.016, BR.029, BR.033BR.036, BR.051, BR.059
[12] Osbournby cruciform brooches BR.003, BR.004, BR.005, BR.008, BR.013, BR.020, BR.031, BR.032, BR.035, BR.041, BR.043, BR.048, BR.050, BR.056, BR.058, BR.065, BR.074
[13] Leaded bronze cruciform brooches BR.005, BR.013, BR.020BR.031, BR.032, BR.033, BR.035, BR.043, BR.050, BR.051, BR.056, BR.058
[14] Bronze cruciform brooches BR.003, BR.004, BR.008, BR.016, BR.029, BR.036, BR.041

contrast, is on the Humber Estuary, the Kingdom of Northumbria's southern border. Mortimer hypothesised, with her smaller sample size, that it is highly likely that communities along the Humber Estuary would have had a different supply chain or production system (Mortimer 1998, 252). The data acquired here seem to confirm that theory; this will be continually taken into consideration when studying other objects throughout this chapter, especially those from the Early Saxon period.

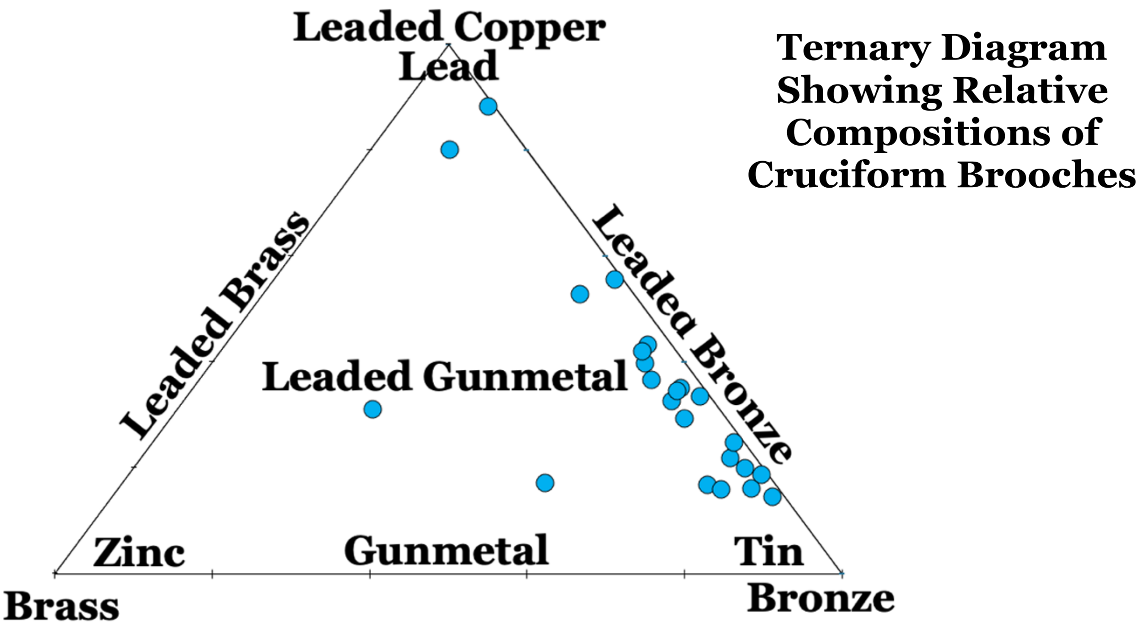

Figure 8-6 Ternary diagram showing the composition results of cruciform brooches

The remaining four cruciform brooches are significant outliers from the two clear groups presented in this data. Two of them are gunmetals[15] and the other two are leaded copper.[16] Given the high concentration of leaded bronze, the presence of leaded copper is not entirely surprising as many of the tin-based alloys were already heavily leaded. These two leaded copper items could be a result of recycled leaded bronzes that steadily lost tin, as discussed in section 3.2. The more unusual of the outliers are the two gunmetals. These are surprising because they are the only instances of zinc in the cruciform brooches.

Returning to the issue of the recycling of Roman material, it is believed (see section 3.2 and Fleming 2012) that Anglo-Saxons recycled Roman brass, which could lead to the formation of gunmetals. Therefore, the two gunmetal objects could be instances of recycling with a source alloy of brass A or B, as outlined in 3.2.2

[15] Gunmetal cruciform brooches BR.0048, BR.0059
[16] Leaded copper cruciform brooches BR.065, BR.074

Other Brooch Data

Square-headed brooches make up a relatively small portion of the brooches in this study, with only five brooches or brooch fragments being included. These samples are from the excavations at Scremby[17] and metal detecting in the area surrounding Osbournby[18]. The three brooch fragments from Osbournby are plotted along the right line of the graph (Figure 8-7) on account of their high tin content. The other brooches, with lower tin content, come from the site of Scremby and are characterised by higher zinc, albeit still a relatively small quantity.

Patterns with such a small number of objects cannot be interpreted further with confidence. The more surprising element of the square-headed brooch data is the apparent evidence of some recycling, such as the heavily mixed compositions in the brooches from Scremby, as they are considered a very high-status grave good. There is a possibility that these mixed

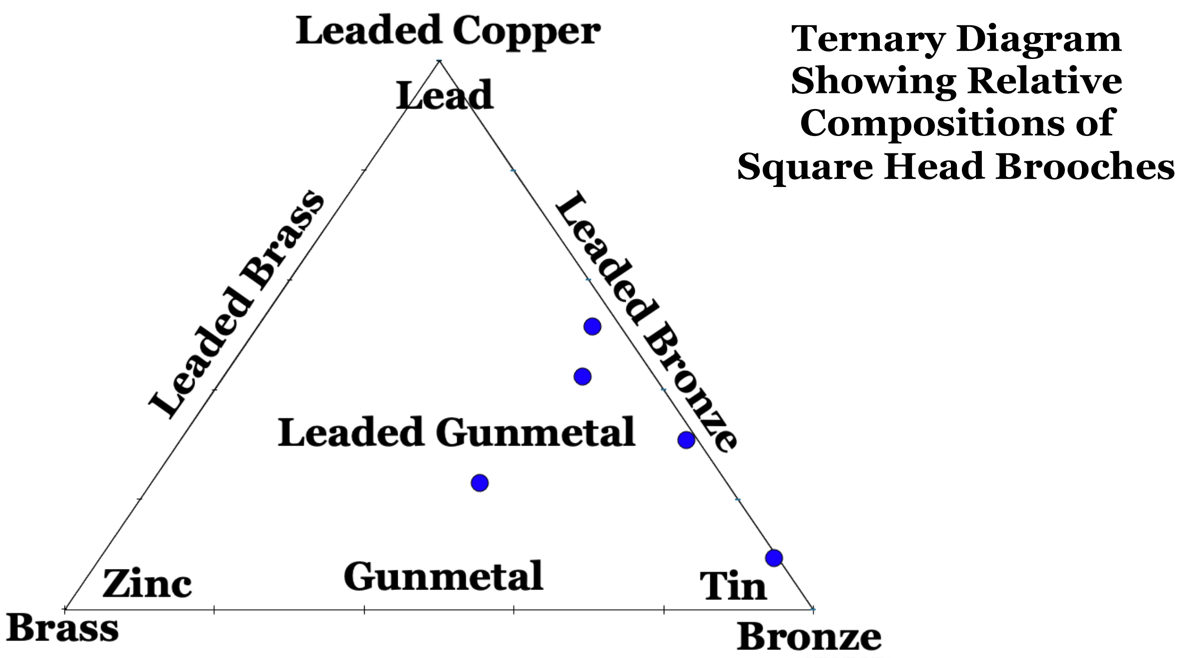

Figure 8-7 Ternary diagram showing the compositions of square-headed brooches

compositions could be due to the item being gilded. As Baker (2013, see section 2.4) discusses, heavily mixed compositions would have resulted in unknown colours, unlike producing a brass or bronze. Therefore, if the producer knew they would be covering the item in gold foil and the colour of the item would not be visible, then perhaps the final composition also mattered less (Baker 2013, 105, 207, 369, 422).

[17] Scremby square-headed brooches BR.053, BR.055
[18] Osbournby square headed-brooches BR.009, BR.040, BR.090

Eleven small long brooches from Scremby[19] and Osbournby[20] were analysed, derived from both excavations and metal-detected sources. They form two clear groupings, which are quite closely related. One grouping is a definite bronze,[21] consisting of five of the eleven brooches. The second grouping is on the edge of becoming a leaded bronze,[22] comprising six of the eleven brooches. It is not surprising that, with these brooches being from the same time period and locations as the cruciform brooches, they have similar composition patterns. It is interesting to note that there is little evidence for recycling in the small long brooches. This could be because this brooch type was not covered in gold foil or tinned, and therefore the colour of the item would have been on display, requiring closely controlled compositions by the producers.

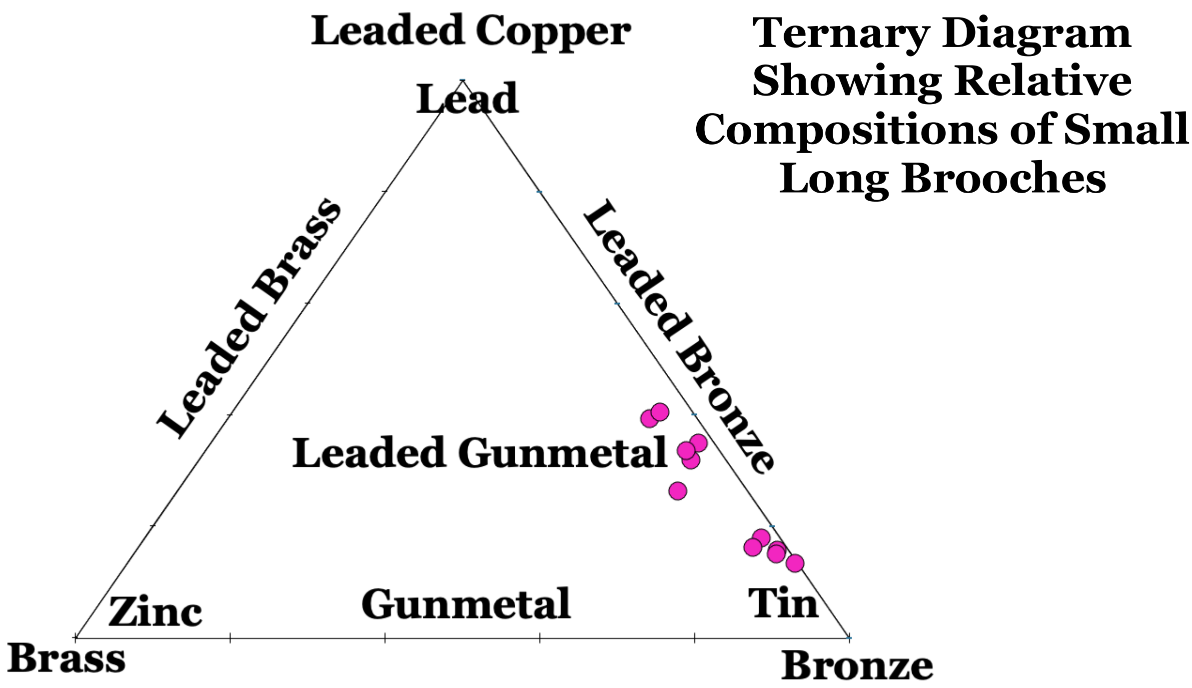

Figure 8-8 Ternary diagram showing the compositions of small long brooches

[19] Scremby small long brooches BR.026, BR.044, BR.052
[20] Osbournby small long brooches BR.002, BR.006, BR.010, BR.012, BR.015, BR.024, BR.027, BR.037
[21] Bronze small long brooches BR.006, BR.010, BR.015, BR.026, BR.052
[22] Leaded bronze small long brooches BR.002, BR.012, BR.024, BR.027, BR.037, BR.044

Girdle Hanger Data

Nine girdle hangers were analysed using the pXRF and included in this study. Of these objects, four were excavated from the site Scremby,[23] and the remaining five were metal-detected from the area around Osbournby.[24] Eight of the nine objects are bronze with the ninth being leaded bronze.[25] However, all the girdle hangers are somewhat leaded, although not enough to be considered a leaded bronze (as seen on Figure 8-9). As mentioned earlier, lead could be added to increase the strength of an object. Given that girdle hangers were frequently worn on the hip and functioned as latch lifters it is not surprising that they would need high material strength. There is possible evidence of small levels of recycling amongst the girdle hanger data, as the decrease in tin could represent steady levels of tin volatilisation.

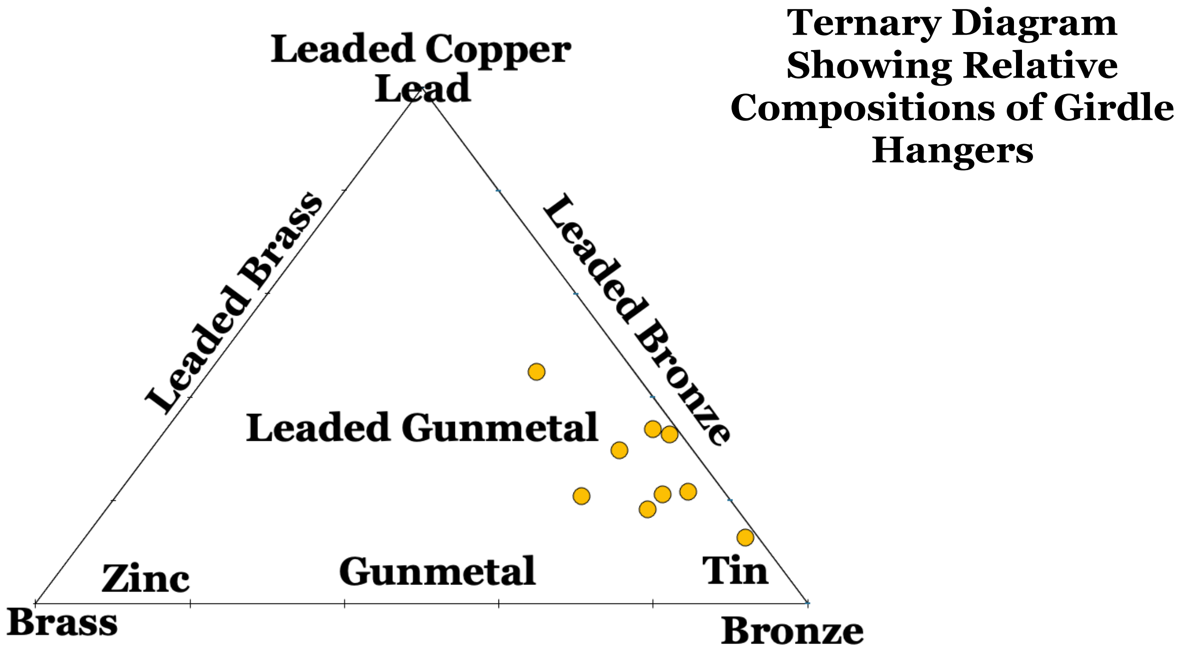

Figure 8-9 Ternary diagram showing the compositions of girdle hangers

Sleeve Clasp Data

All of the eighteen sleeve clasps analysed fall into the Hines B form. Three of these are unknown form B, seven are form B7,[26] three are form B12,[27] two are B13,[28]; there is one B18[29] and two are B20.[30] There is a wide range of compositions, primarily focused on tin levels.

[23] Scremby girdle hangers GH.003, GH.005, GH.006, GH.008
[24] Osbournby girdle hangers GH.001, GH.002, GH.004, GH.007, GH.009
[25] Leaded bronze girdle hanger GH.001
[26] B7 sleeve clasps SC.001, SC.003, SC.004, SC.005, SC.009, SC.012, SC.014
[27] B12 sleeve clasps SC.002, SC.011, SC.016
[28] B13 sleeve clasps SC.008, SC.010
[29] B18 sleeve clasps SC.015
[30] B20 sleeve clasps SC.017, SC.018

Compositions vary between bronze,[31],leaded bronze,[32] and gunmetal,[33] as can be seen on Figure 8-10. There do not appear to be any significant groupings based on the different b forms. It is highly likely that these items underwent high levels of recycling, which is more apparent in this object than in any other object type.

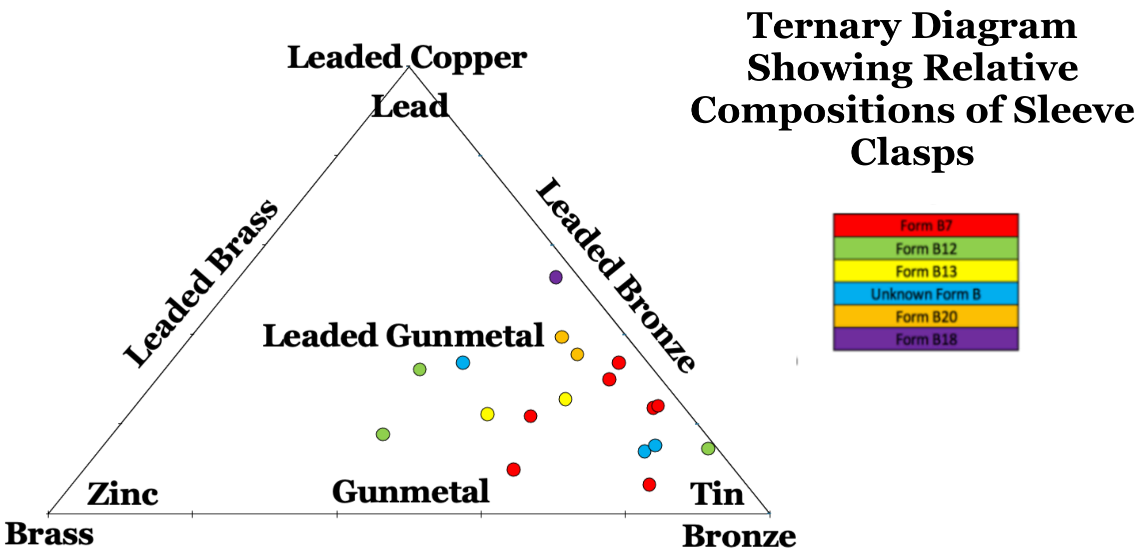

Figure 8-10 Ternary diagram showing the compositions of sleeve clasps

Hooked Tag Data

Nine hooked tags were analysed by the pXRF for this study. The majority of them are Type B, with five hooked tags;[34] additionally, there is one Type C,[35] one Type D[36] and two unknown[37] types. Given how few hooked tags were analysed there is a surprisingly wide variety of compositions represented (as shown on Figure 8-11). Compositions include bronze,[38] guntmetal,[39] leaded gunmetals,[40] leaded bronze,[41] leaded brass[42] and leaded copper.[43] These hooked tags show high levels of recycling with highly mixed compositions.

8.1.4. Early Saxon Data: Discussion and Summary

As previously discussed throughout Chapter Two and currently highlighted in Figure 8-2, tin content was very abundant in the Early Saxon period. These levels are starkly different from

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[31] Bronze sleeve clasps SC.001, SC.006, SC.007, SC.014
[32] Leaded bronze sleeve clasps SC.002, SC.003, SC.004, SC.005, SC.008, SC.009, SC.015, SC.017, SC.018
[33] Gunmetal sleeve clasps SC.010, SC.011, SC.012, SC.013, SC.016
[34] Type B hooked tags HT.001, HT.003, HT.004, HT.007, HT.008
[35] Type C hooked tag HT.005
[36] Type D hooked tag HT.002
[37] Unknown type hooked tags HT.006, HT.009
[38] Bronze hooked tags HT.002, HT.003, HT.009
[39] HT.005
[40] Leaded gunmetal hooked tags HT.008
[41] Leaded bronze hooked tags HT.001, HT.004
[42] Leaded brass hooked tag HT.006
[43] Leaded copper hooked tag HT.007

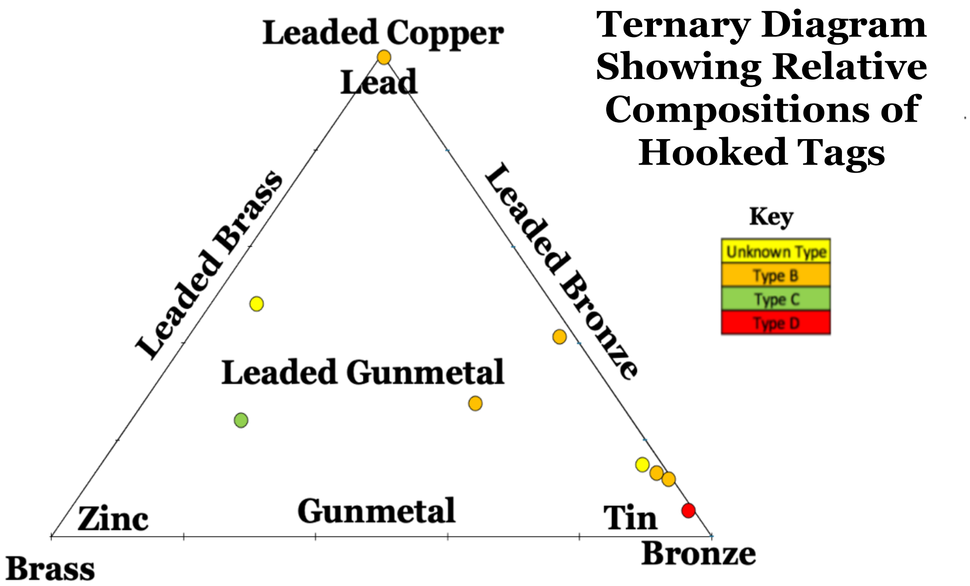

Figure 8-11 Ternary diagram showing the compositions of hooked tags

those of zinc and lead. The zinc data, displayed in Figure 8-3, show the relatively low levels present. The graph also displays the overall low frequency of objects with zinc traces, with a few apparent outliers. Lead, however, appears at a high frequency but in low amounts, as represented in Figure 8-4. These variations in alloy levels were anticipated at the beginning of this project for the Early Saxon period. However, the expectation was that there would be more ternary and quaternary compositions than there are, specifically in the form of gunmetals. This expectation originated from previous assumptions that the Early Saxon period was lacking in the alloying technology present during the Roman period. As a result, it was believed that the population was not producing fresh alloys but instead relying on recycling Roman material. This assumption is disproven when seeing how little the material in this period shows evidence of being recycled from brasses and how little zinc and lead, which had high levels of use in the Roman period, were actually present in the Early Saxon compositions. If Roman material was being extensively recycled, Early Saxon metalworkers were able to recycle like compositions with like – probably sorted based on colour – and therefore leaving little visible trace. Of course, there is some evidence for the recycling of Roman material, just not on the scale that was anticipated.

While the Early Saxon objects included in this study had minimal zinc content, other studies on similar material yielded different data that can be compared and contrasted with the data of this project. A comparison can made in order to combat the southern bias in this study's Early Saxon data. The Early Saxon data presented here does not exhibit significant distinctions based on location. It is possible to establish a distinction when comparing the southern sites represented here to Catherine Mortimer's North Lindsey sites (Mortimer 1998). As seen in Figures 8-1 and 8-3, there is very little evidence of zinc. The only zinc presence is in gunmetals, which suggests potential recycling of other brasses and the adding of tin to compensate for the zinc loss. To expand on Mortimer's work, she compared Castledyke with sites in East Anglia. Her EDX data from Castledyke showed that 60% of the brooches had at least moderate, if not high levels, of zinc, compared to the 16% of objects from East Anglia. This correlates with the data achieved with the materials in this study. There is a clear production difference between copper alloys from the Humberside region and Southern Lindsey that appears to end well before the start of the Viking Age (as will be shown in Chapter Nine), implying that the distinction was the result of other factors before the Scandinavian migration.

To better understand the variations in production between the different regions in Lindsey, further research is needed on material from Early Saxon Humberside. As Mortimer did not analyse all of the materials from Castledyke with EDX, this cemetery would be a logical place to begin any further research. Since additional questions surrounding compositional variation based on location became apparent during the analysis of the data, they could not be explored further.

8.2. Mid-Saxon Data

8.2.1. Introduction

This section will provide an overview of the metallurgical data of objects for the Mid-Saxon subperiod.[44] The Mid-Saxon data show a decline in stylistic variety but an increase in compositional variation. The reasons behind these will be briefly discussed here before contributing to broader debates in Chapter Nine.

8.2.2. Overview

The Mid-Saxon data initially appear to be significantly different to the Early Saxon data. The Mid-Saxon copper alloys primarily consist of bronzes and leaded bronzes, with rare and occasional gunmetals and leaded copper objects. The data shows more variability and less clustering than in the Early Saxon period, as shown in Figure 8-12; there is also a sharp decrease in gunmetals due to an overall decrease in zinc content and an increase in lead content.

[44] Mid-Saxon reference numbers PN.001, PN.002,PN.003, PN.004, PN.005, PN.006, PN.007, PN.009, PN.010, PN.011, PN.012, PN.013, PN.014, PN.015, PN.016, PN.017, PN.018, PN.019, PN.020, PN.021, PN.022,PN.023, PN.024, SE.001, SE.006, SE.008, SE.010, SE.012, SE.013, SE.019, SE.020, UK.014UK.026, UK.030, UK.033, UK.034, UK.035, UK.043

The Mid-Saxon period also sees a shift in regional variation within the compositional groups. There there is not the same distinction between the Mid-Saxon material from the northern sites[45] and those from southern areas[46]. Mortimer (1992, 4) proposes further study to see whether a regional divide continued throughout the Early Medieval period. However, in the Mid-Saxon period it would seem that the material from Humberside has overall more lead and less tin than in those materials from southern Lindsey.

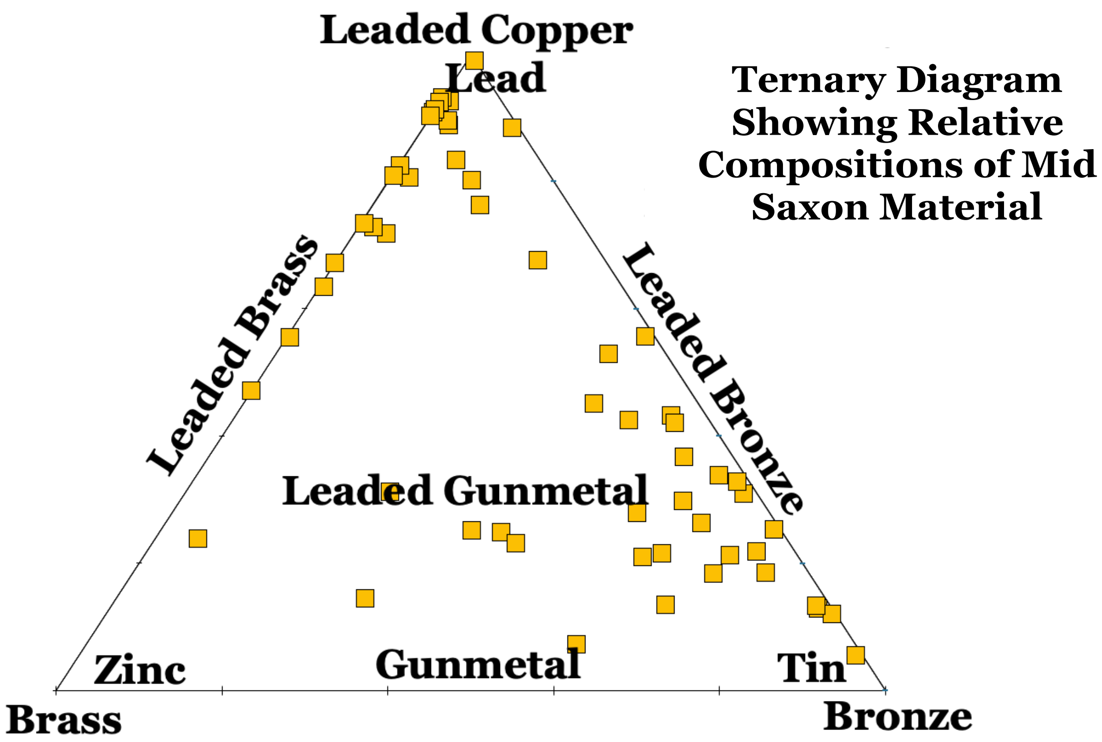

Figure 8-12 Ternary diagram showing the composition of Mid Saxon material

The Mid-Saxon period sees the same range of tin percentage but at much lower frequencies, as shown in Figure 8-13. Surprisingly, nine objects have no evidence of tin. The numbers are quite small and therefore not statistically significant. The tin content of Mid-Saxon objects reflects the patterns from Figure 8-13, showing primarily bronzes and leaded bronzes. Only a few objects have a tin content that would lead to unstable production, similar to the Early Saxon material.

[45] North Lindsey material PN.001, PN.002, PN.003,PN.004, PN.005, PN.006, PN.007, PN.009, PN.011, PN.012, PN.014, PN.015, PN.016,PN.017, PN.018, PN.019, PN.020, PN.022, SE.001, SE.006, SE.006, SE.008, SE.008, SE.008, SE.010, SE.010, SE.010, SE.012, SE.012, SE.012, SE.013, SE.013, SE.013,SE.019, SE.020 SE.020, SE.020, UK.014, UK.026, UK.030, UK.033, UK.034, UK.035, UK.043

[46] South Lindsey material PN.001, PN.002, PN.003, PN.004, PN.005, PN.006, PN.007, PN.008, PN.009, PN.010, PN.011, PN.012, PN.013, PN.014, PN.015, PN.016, PN.017, PN.018, PN.019, PN.020, PN.021, PN.022, PN.023, PN.024

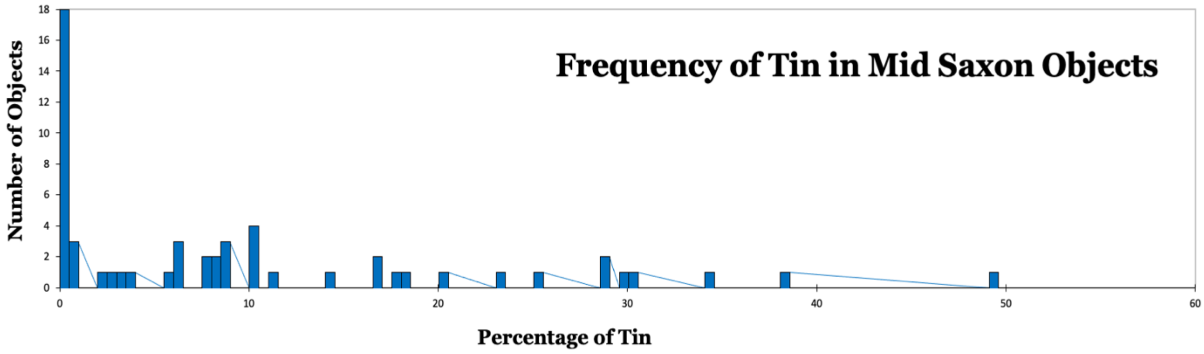

Figure 8-13 Frequency of tin in the Mid-Saxon material

Mid-Saxon objects reveal a drastic decrease in the zinc content examined (Figure 8-14). Fifty per cent of the objects from the Mid-Saxon period have no traces of zinc; there is one object with 1% zinc, and five objects with 2% zinc. After this, the percentage of zinc tapers off and is sporadic, with no objects exceeding 13%. The pattern of zinc content seen here is similar to that of the Early Saxon period and continues into the Mid-Saxon period. However, there is one key difference, represented in Figure 8-12; some of the high-zinc objects are binary alloys, resulting in what appears to be a fresh brass.

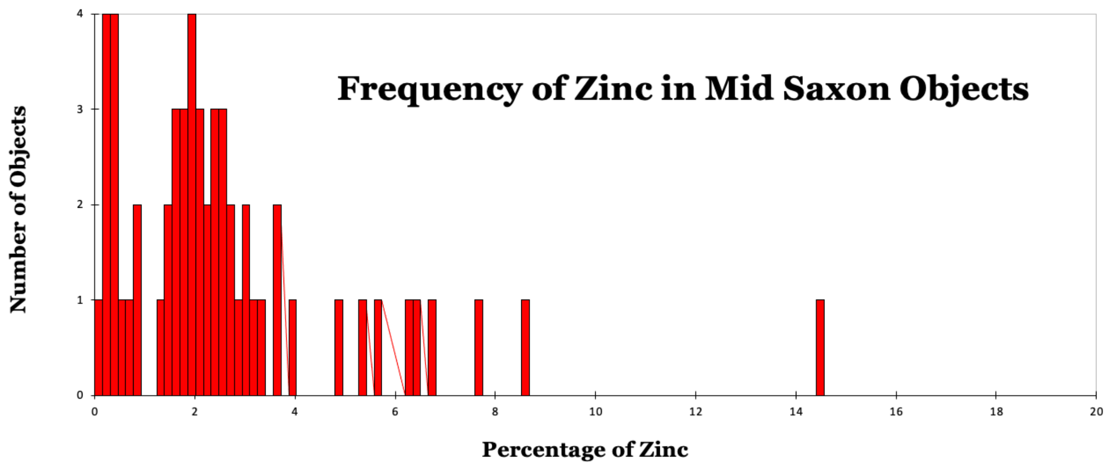

Figure 8-14 Frequency of zinc in the Mid-Saxon material

The Mid-Saxon period shows somewhat similar patterns to the Early Saxon period concerning lead content. The peak of lead content is between 1% and 13% with the frequency tapering off as the amount of lead increases (Figure 8-15). There is significant lead content in the Mid-Saxon period, as demonstrated by steady amounts of lead up to 35%. The most significant difference is that there are no objects without traces of lead. Noticeably, lead continues to be an essential alloying metal for copper alloys but the content increases between the Early and Mid-Saxon periods. This will be further explored in section 9.2 where temporal changes are studied more closely.

8.2.3. Objects

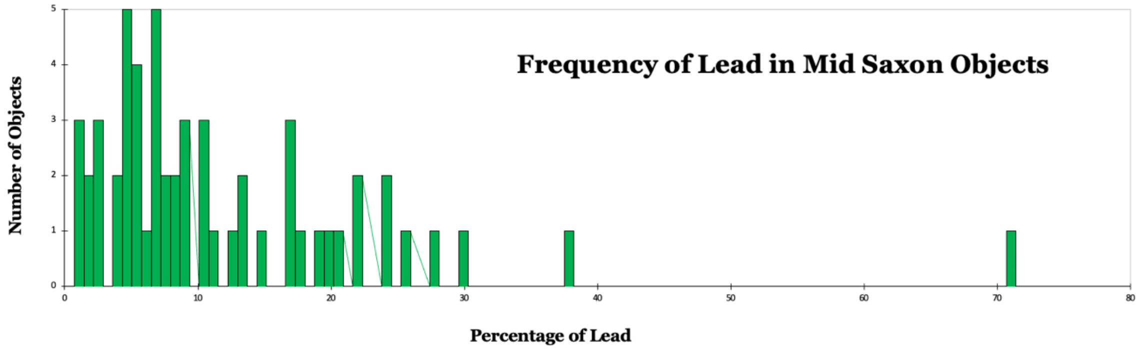

Figure 8-15 Frequency of lead in the Mid-Saxon material

The following section will divide the Mid-Saxon period by object type to discuss patterns within the compositional data, based on the object types outlined in Chapter Six. The Mid-Saxon period sees a decline in stylistic and typological variety, as is shown in the data. These data and the subsequent discussion will feed into a larger discussion in section 9.2 alongside the data from the other periods.

Pin Data

Twenty-four Early Medieval pins were analysed using pXRF. Of these, twenty-three are Mid-Saxon and the other is Early Saxon. The Early Saxon pin (PN.023) is the only one to have been excavated; the rest were recovered through metal detecting. The vast majority of pins consist of bronze or leaded bronze, as can be seen on Figure 8-16. There are a small number that have different compositions in comparison to the majority of the pins. Three biconical-headed pins are fairly pure brasses.[47] There are additionally two leaded brasses: one biconical-headed pin and one faceted cube head.[48] The last pin that does not contain tin is a biconical-headed pin comprised of leaded copper.[49] There is only one biconical-headed pin that contains tin. It is, therefore, a reasonable conclusion that biconical-headed pins were primarily produced in copper alloys other than bronze and that the sole bronze pin is the outlier.

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[47] Brass biconical-headed pins PN.013, PN.022, PN.024
[48] Leaded brass biconical-headed pin PN.023, faceted cube pin PN.012
[49] Leaded copper biconical-headed pin PN.021

The globular-headed pins, on the other hand, have very different compositions and can be divided into two clear groups. One with three pins comprises bronze,[50] while the second group has four pins and these are leaded bronze.[51] Other than those groups there does not appear to be any patterning between the different pinhead types. However, it remains overarchingly true that Early Medieval pins are consistently made of a type of bronze that is more often leaded than not. This makes sense when considering the purpose of this dress accessory, and they would need the strength provided by lead if they were needed to pin heavier items. Most of the pins do not show evidence of recycling. Bronze as the primary copper alloy type does align with other patterns from the same period, which will be explored further in Chapter Nine.

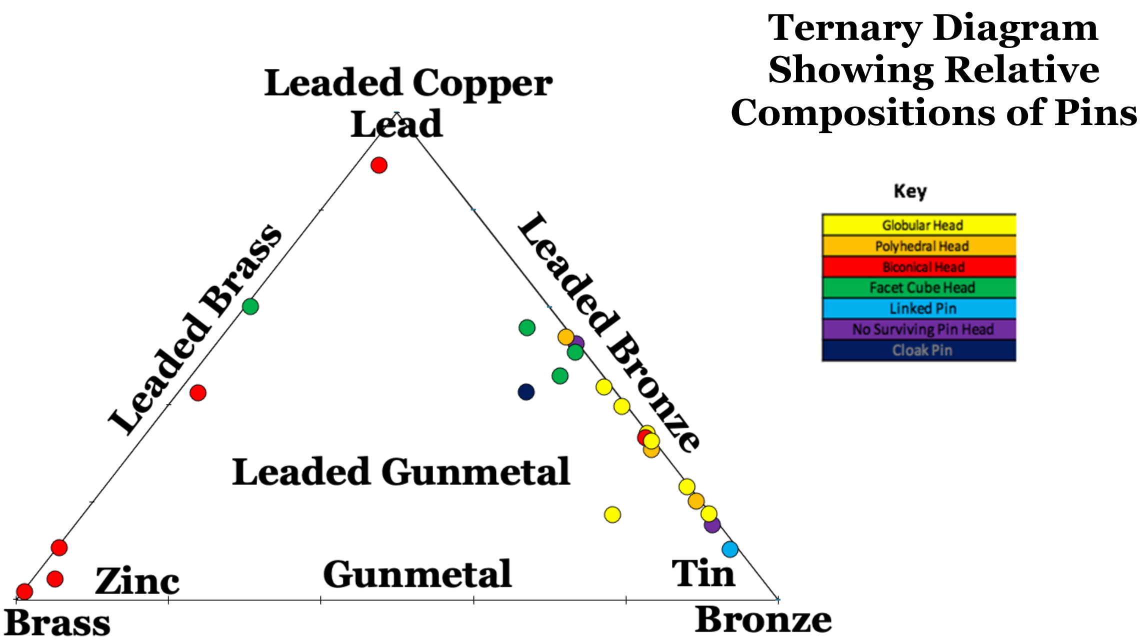

Figure 8-16 Ternary diagram showing the composition of Mid-Saxon pins

Strap Ends

The Mid-Saxon strap ends consist of eight different objects,[52] all coming from the excavations at Flixborough. These eight objects show a rather varied composition. Because of the site's significant output, the conclusion was reached that production was occurring on site (Evans and Loveluck 2009, 322, 335). Therefore, it is surprising that the compositions are so highly variable (as seen in Figure 8-17), so it is possible that not all production was occurring on site.

[50] Bronze globular-headed pins PN.003, PN.014, PN.015
[51] Leaded bronze globular-headed pins PN.001, PN. 005, PN.006, PN.016
[52] Mid-Saxon strap ends SE.001, SE.006, SE.008, SE.010, SE.012, SE.013, SE.019, SE.020

These items show significantly less tin content than other material from Flixborough. This could possibly suggest that recycling was done with intent and coppersmiths had ways of dividing scrap and prioritising particular scrap for specific items. These compositions are starkly different from the data of the other strap ends from the later periods.

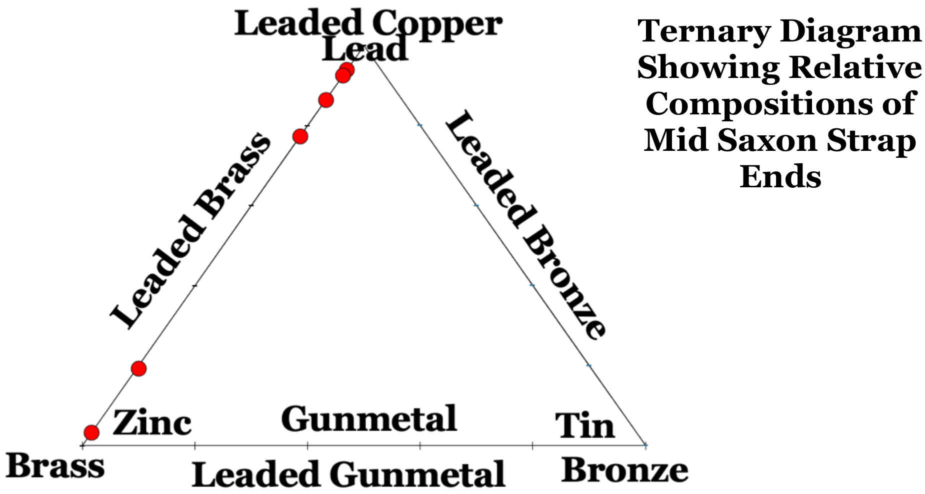

Figure 8-17 Ternary diagram showing the composition of Mid-Saxon strap ends

8.2.4. Mid-Saxon Data: Discussion and Summary

Some of the data from the Mid-Saxon period fit neatly into the already established narrative for Saxon copper alloy production; however, other conclusions drawn from this data are quite surprising and reveal a considerable departure from the metal production practices of the Early Saxon period. The similarities between the Mid-Saxon and the Early Saxon periods will be discussed first, and then the changes that have occurred will be addressed.

The most significant similarity between the two periods is the continued high tin content of the objects, as shown in Figures 8-12 and 8-14. In both periods, tin content is closely followed by lead, as demonstrated in Figure 8-6. This ratio is where the similarities between the two periods cease; the Mid-Saxon period makes a significant departure in metal production when compared to the Early Saxon period. The most apparent distinction between the two periods is the emergence and sharp increase of brasses and leaded gunmetals. While bronzes and leaded bronzes still make up the majority of Mid-Saxon metalwork, there are now significantly higher quantities of lead and zinc within the copper alloys than seen previously. There are a variety of reasons as to why this variation in metal compositions could be occurring; the two most likely options are an increase in recycling and reuse of copper alloys, or a shift in supply chains. Furthermore, during the Mid-Saxon period there appears to be enough access to zinc that fresh brass can be produced, or enough zinc is being added to recycled brasses to supplement loss from volatilisation. In addition, the recycling of copper alloy could lead to heavily mixed compositions, as is observed in the Mid-Saxon material, especially if the sorting of material was not prioritised.

The acquisition and collection of metal ores is a significant part of the production chain. If there was a change or disruption in the production chain, it could easily be reflected in the metal compositions. Production chains were already touched upon in section 8.1 when discussing the Early Saxon material, where the data from this study were compared to Catherine Mortimer's (1991; 1993) data. This comparison suggested the presence of two production chains within the Kingdom of Lindsey divided by the north and south regions of the kingdom, however by the Mid Saxon period this division has disappeared. In addition, the copper alloys have changed within this division from brass and bronze to being a mix of brass, bronze, gunmetals and leaded copper.

If either the northern or southern production chains were disturbed by external factors, metal producers would need to find an alternative source of alloying material. Producers could enter a new trade network to acquire fresh ores, or they could repurpose and recycle copper alloys that were out of use. It is also possible that increased interaction between the north and south of the Kingdom and merging of the production networks could be the cause of the muddled compositions with a lack of distinction between the two. During the Mid-Saxon period the power of the Church was growing and monasteries were gaining more control over numerous types of production (Blair 2005, 134, 181, 247); the potential effects of this will be discussed later in section 9.3.

8.3. Late Saxon and First Viking Age Data

8.3.1. Introduction

This section will discuss the data from the Late Saxon and First Viking Age material,[53] beginning with an overview of the compositional data from these objects before moving into style and typologically specific compositions. There will then be a brief discussion about these data that will feed into wider discussions that can be found in Chapter Nine.

[53] Late Saxon and First Viking Age reference numbers: BC.005, BR.030, BR.071, BR.072, BR.078, BR.084, DS.001, HT.001, HT.005, I.001, M.003, M.011, PN.008, SE.002, SE.003, SE.004, SE.005, SE.007, SE.014, SE.015, SE.020, SE.022, SE.024, SE.032, SW.001, SW.002, W.001

8.3.2. Chronological Overview

Many of the trends in the metal compositions that begin to emerge in the Late Saxon period and First Viking Age are the start of substantial changes to copper alloys that continue into the Second Viking Age. These changes seem to become commonplace for copper alloy compositions. As shown in Figure 8-18, the compositions in the Late Saxon period and First Viking Age share some resemblance to those in the Mid-Saxon period. The similarities are primarily that both periods have a broad range of compositions instead of significant clustering near one alloy type, as was seen in the Early Saxon period. What can be observed is the continued shifting of the primary alloying metal from tin to lead; however, this is yet to be as definitive as it becomes in the Second Viking Age.

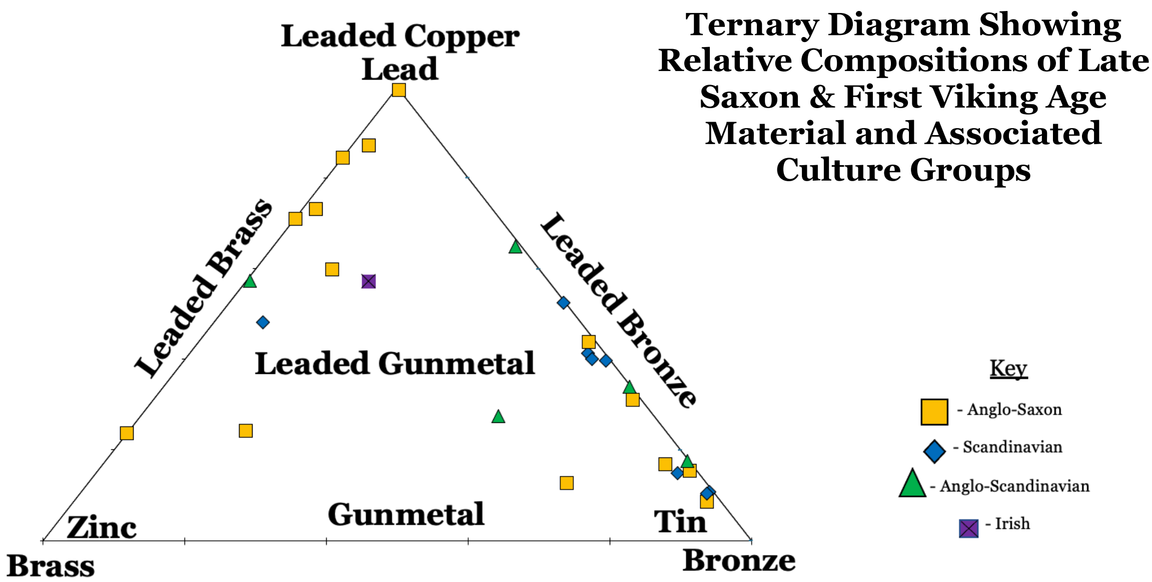

Figure 8-18 Ternary graph showing compositions of the Late Saxon and First Viking Age material

Additionally, there is a significant drop in the number of gunmetals from the Mid-Saxon period, and this decrease can suggest a refinement of the metal production process or a decrease in the recycling. This period also sees a slight distinction between different cultural groups and the metals their producers are using. These ideas will be touched on later in this chapter and also in more depth in Chapter Nine.

The Late Saxon period and First Viking Age show sharp decline in tin content when compared to the preceding periods, as seen in Figures 8-2 and 8-14. Figure 8-19 demonstrates that there is a high quantity of objects with no traces of tin. This level is drastically different from previous data where there was a high tin content. There is still some evidence of tin being used, so while the amounts significantly dropped it is clear that tin was still in circulation – just in much smaller quantities and in significantly fewer objects.

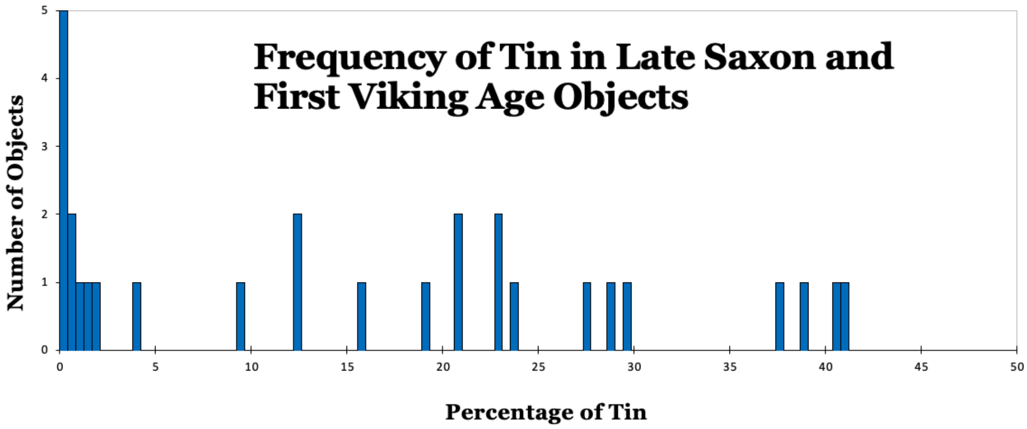

Figure 8-19 Bar graph showing the frequency of tin in the Late Saxon and First Viking Age

The zinc content, much like tin in this period, is different than that observed in earlier periods. In the Late Saxon period and First Viking Age zinc content has increased, as can be observed in Figure 8-20. However, the highest amount of zinc is 12%, which is very similar to the Mid-Saxon period.

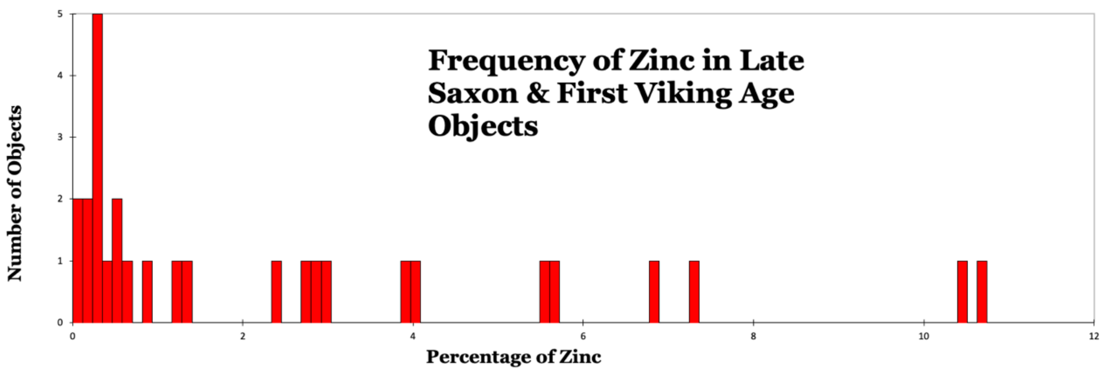

Figure 8-20 Frequency of zinc in the Late Saxon and First Viking Age

The lead content patterns in the Late Saxon period and First Viking Age (see Figure 8-21), had slight increase in both amount and frequency compared to the Mid Saxon. The Late Saxon period and First Viking Age have fewer items with no lead traces and more objects with low, medium, and high lead levels. This steady shift that is being observed from the Mid-Saxon period into the First Viking Age is a clear indication that lead is slowly becoming the primary alloying metal instead of tin. In the preceding periods, lead was used alongside tin and resulted in a high quantity of leaded bronze. However, what is starting to be witnessed here is lead being used on its own rather than in conjunction with another alloying metal.

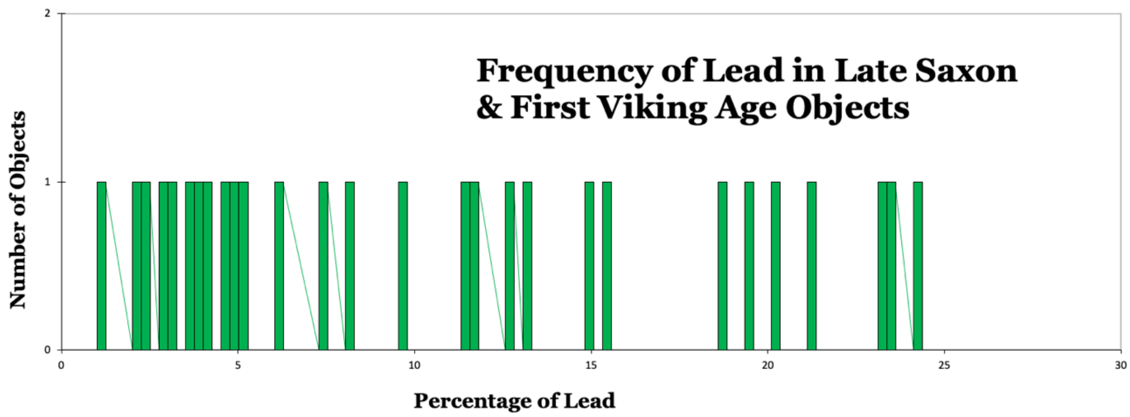

Figure 8-21 Frequency of lead in the Late Saxon period and First Viking Age

8.3.3. Objects

The Late Saxon and First Viking Age object data consist entirely of Thomas Type strap ends. This is because many of the other object types from the Late Saxon period and First Viking Age overlap with the Second Viking Age so they will be discussed in Section 8.4.2.

Strap End Compositions

Introduction

Strap ends are one of the larger typological groups presented in this study, with twenty-eight examples. The collected strap ends also provide a range of different types, as displayed in Figure 8-22. The majority come from metal-detecting sources from the areas of Osbournby, Torksey, South Ferriby and a few other undisclosed locations, the majority of which are along the Humber Estuary. Eight strap ends are from excavations at Flixborough, all of which are the Mid-Saxon type and have already been discussed above. All of the remaining twenty strap ends date to the Late Saxon period or Viking Age. The most common type included in the study is the Thomas Class A with eleven examples, followed by the Mid-

Saxon examples and the Thomas Class E strap ends with eight examples each. Since the type groups are relatively small, they will be primarily discussed as a whole. Seeing that the majority of these strap ends date to a similar time period, the majority of compositional variation could be easily attributed to any variation in type and style.

The overall compositional data reveal multiple groupings and patterns between and within the strap end classes. The strap ends show a variety of compositional range but with some clear groupings. Most of the strap ends do not have high levels of tin and are heavily leaded.

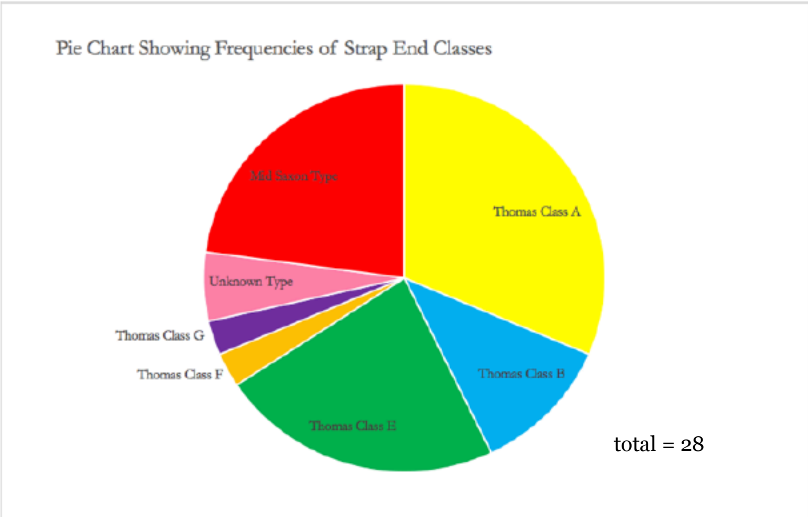

Figure 8-22 Frequency of strap end classes

Thomas Class A

The Thomas Class A strap ends are the most abundant class included in this study, and as a result it is not surprising that they have the greatest compositional variety. The Class A[54] strap ends have three primary groups and one possible outlier, as seen on Figure 8-23. These three groups are four strap ends in leaded bronze, four in leaded brass and two in brass, with one outlier in leaded copper. A closer investigation may reveal the cause of these groupings. The two brass strap ends[55] are both metal detected and come from different areas of the Kingdom of Lindsey. One is from the south of the kingdom in Osbournby and the other from the central-west region of Lindsey. They are both Class A2, which may be their connecting element, yet there are other Class A2 strap ends included in this study that are not brass. The leaded brass and leaded bronze groupings are also from a wide range of locations across the

[54] Thomas Class A strap ends: SE.003, SE.004, SE.005, SE.007, SE.009, SE.014, SE.015, SE.017, SE.019, SE.020, SE.024, SE.025, SE.032

[55] SE.02, SE.030

Kingdom of Lindsey. The lack of location patterns within this data can suggest that production chains during the Late Saxon period and Viking Ages are significantly more intertwined than in the Early and Mid-Saxon periods. This is a possibility that will be discussed further in 9.2.3.

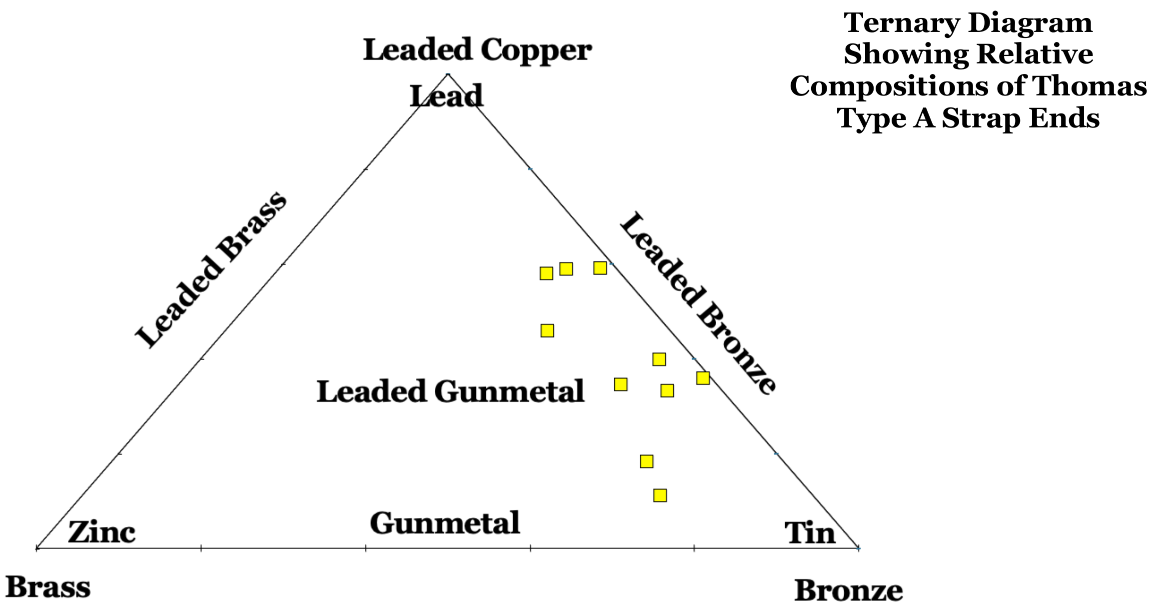

Figure 8-23 Ternary diagram showing the composition of Thomas Class A strap ends

Thomas Class B

The Thomas Class B[56] strap ends are one of the smaller groups included, with only four examples. Two of these are brass, one bronze and one leaded brass (Figure 8-24). The bronze strap end does have some signs of recycling, as it is not neatly in the corner of the graph but venturing towards higher amounts of lead and zinc. It is possible that this was due to the recycling of a bronze item, and the metal loss was supplemented with zinc and/or lead. These Class B strap ends follow similar patterns to the Class A ones included in this study, just with fewer examples.

Furthermore, there is no distinction amongst the Class B strap ends between their locations within the Kingdom of Lindsey. The only two from the same location (Osbournby) are the bronze and leaded brass strap ends. Overall, Class B strap ends fit within the patterns established by other objects from this period.

[56] Thomas class B strap ends SE.022, SE.026, SE.027

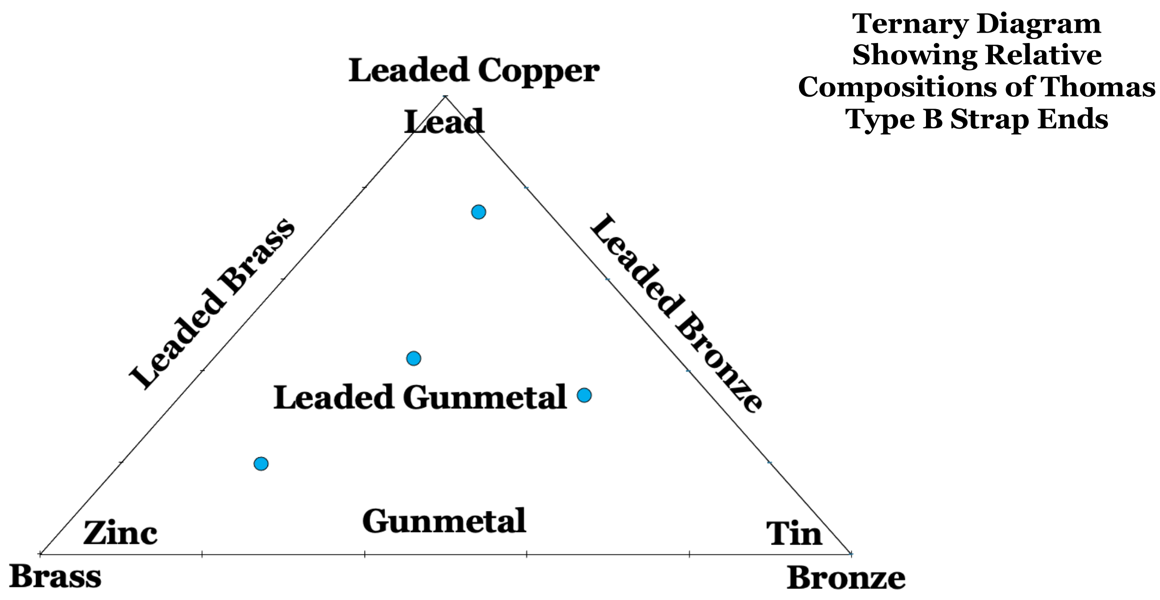

Figure 8-24 Ternary diagram showing the composition of Thomas Class B strap ends

Thomas Class E

Thomas Class E[57] strap ends are the second largest subtype of strap end included in this study. These strap ends also have the most consistent composition, with all but one strap end composed of leaded copper, as shown on Figure 8-25. All but one of these objects are from along the Humber Estuary; the other is from Osbournby. This divide is not reflected in the composition of these strap ends, as the only brass object is from along the Humber Estuary. The Class E strap ends are the most heavily leaded of the different strap end types. The high lead level is consistent with other Viking Age objects that have been discussed so far, and these trends will be discussed in more detail in Chapter Nine. There is no apparent reason why Class E strap ends would need to be more heavily leaded than other types; their design and production does not vary so significantly between classes that they would need more lead than their Class A counterparts. The significance in the composition may actually lie in their cultural origin. The majority of Class E strap ends are Scandinavian and Anglo-Scandinavian, while other classes included here are primarily Anglo-Saxon. The possible implications of this will be discussed in 9.2.1.

[57] Thomas class E strap ends SE.011, SE.016, SE.018, SE.021, SE.028, SE.029, SE.030, SE.031

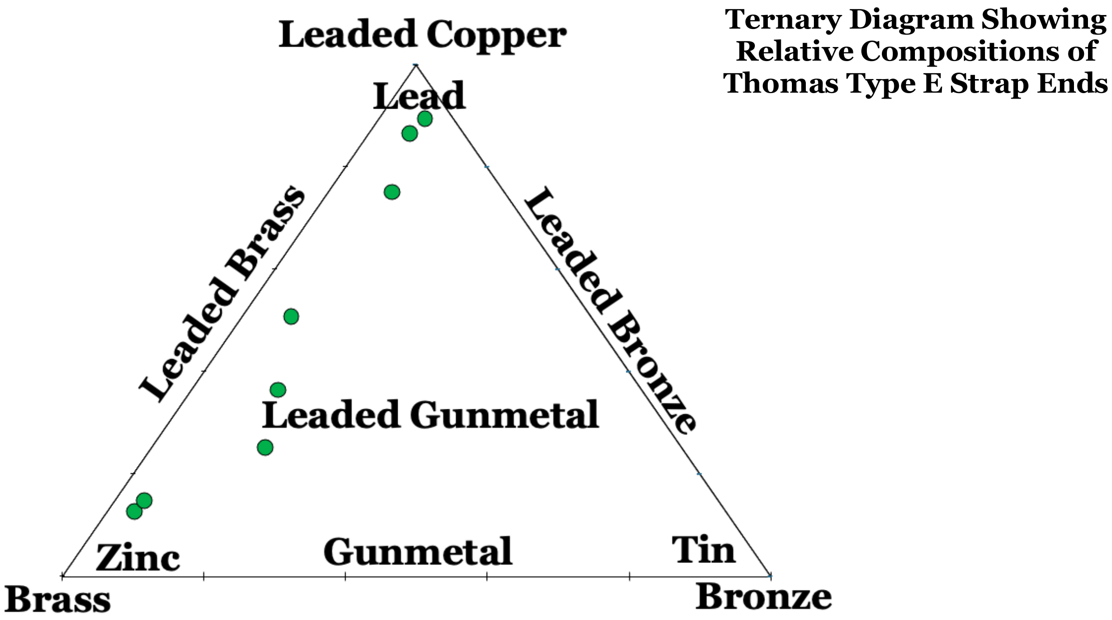

Figure 8-25 Ternary diagram showing the composition of Thomas Class E strap ends

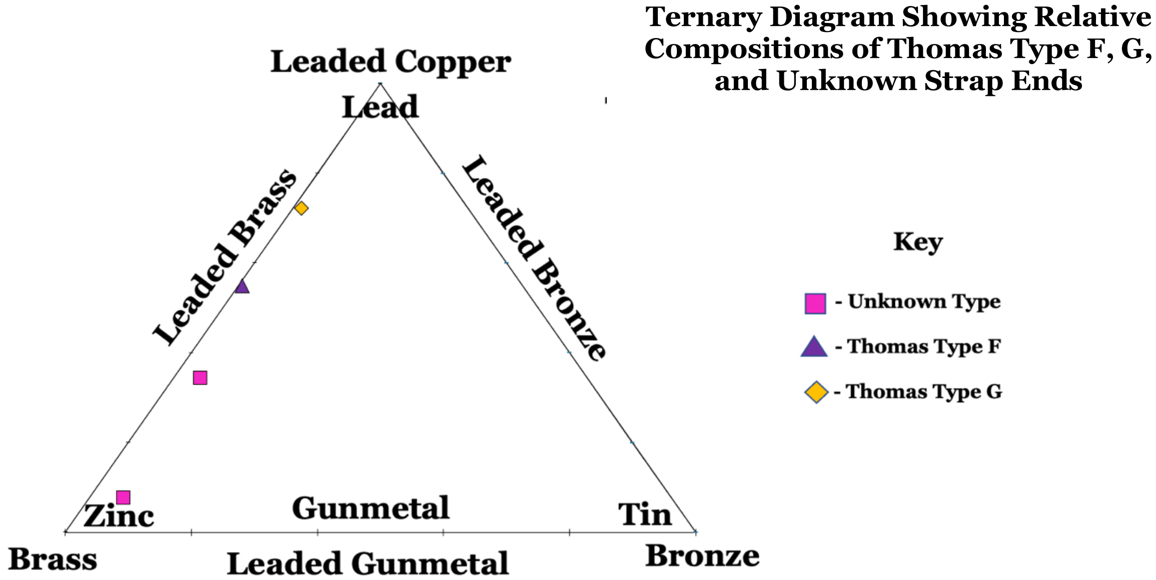

Figure 8-26 Ternary diagram showing the composition of Thomas Classes F, G, and unknown strap ends

Thomas Class F and Thomas Class G

Thomas Class F[58] and Class G[59] strap ends only have one example each. The Class F strap end is leaded gunmetal and the Class G is on the border between leaded brass and leaded copper (see Figure 8-26). These two strap ends could be primary examples of the small amount of recycling that was going on in the Viking Age; unfortunately, however, the small quantities of these classes means it is impossible to say whether they are typical compositions for their classes. This is most certainly one object type that would benefit from further research.

8.3.4. Late Saxon and First Viking Age Data: Discussion and Summary

The Late Saxon and First Viking Age pXRF data show a wide range of copper alloys. As discussed in Chapter One, this period was one of significant change. With this in mind, the fact that production reflects this large variation in culture and political disruption is not surprising. The Late Saxon period and First Viking Age saw some core changes to metal compositions. First and foremost is the continued decrease in the tin content, which began in the Mid-Saxon period and carries on throughout the Early Medieval period. While tin content is declining, zinc and lead content are both increasing, lead at a higher rate than zinc. However, even with increased levels of lead and zinc, there is a decrease in gunmetals and leaded gunmetals. Essentially, there is an increase in brasses and leaded copper and a decrease in bronzes.

As suggested in the discussion of the Mid-Saxon data, there is likely some disruption to tin acquisition in the Mid-Saxon period leading to the steady decline of its use that continues into the Late Saxon period and First Viking Age. Theories as to why this occurred will be presented later in section 9.2. It is important to remember that the tin loss is too great to be solely attributed to tin volatilisation during object recycling. Instead, it seems that the loss of access to tin sources was efficiently replaced by lead and zinc resources, countering the theories of zinc decline.

[58] Thomas class F strap ends SE.009
[59] Thomas class G strap ends SE.0023

These metal composition trends that begin in the Mid-Saxon period and start to become more defined in the Late Saxon period and First Viking Age truly take hold during the Second Viking Age. In conjunction with this, the stylistic trends that emerge during the Late Saxon period and First Viking Age also become more apparent in the Second Viking Age. Both of these continuations will now be explored.

8.4. Second Viking Age Data

8.4.1. Introduction

This section will discuss the data from the Late Saxon and First Viking Age material,[60] beginning with an overview discussing the compositional data from these objects before moving into stylistic and typologically specific compositions. There will then be a brief discussion about these data that will feed into the wider discussions in Chapter Nine.

8.4.2. Chronological Overview

Trends from the Late Saxon period and First Viking Age become more defined as the focus shifts to copper alloys from the Second Viking Age. As seen in Figure 8-27, the prominence

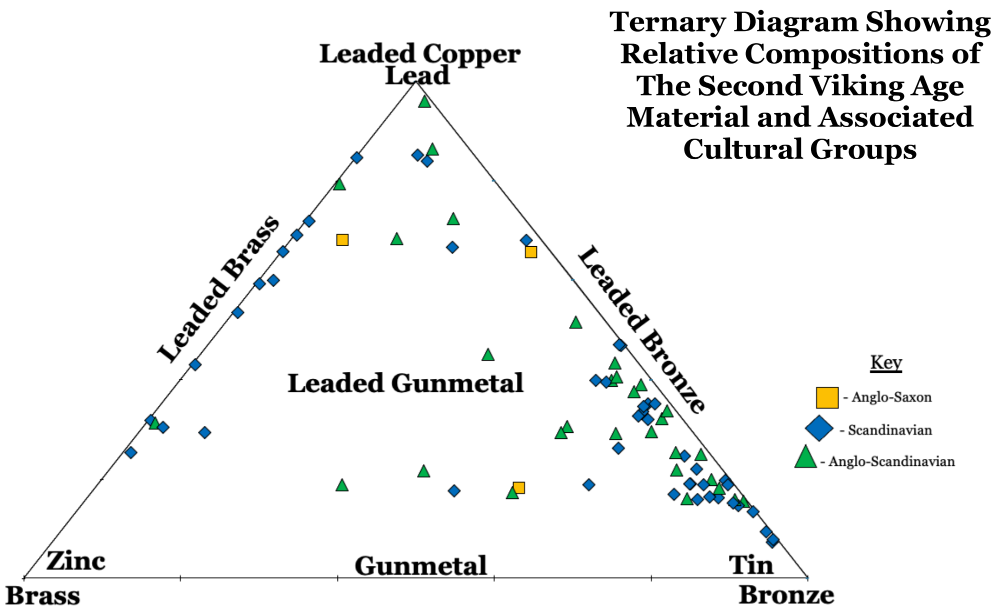

Figure 8-27 Ternary graph showing compositions of Second Viking Age material

[60] Second Viking Age reference numbers: BC.002, BC.004, BC.006, BC.007, BC.008, BC.010, BC.011, BC.012, BE.001, BE.002, BE.003, BE.004, BE.005, BF.001, BF.002, BF.004, BF.005, BF.006, BF.007, BF.008, BF.009, BF.010, BF.011, BF.012, BR.001, BR.061, BR.066, BR.067,BR.068, BR.069, BR.070, BR.073, BR.075, BR.076, BR.077, BR.079, BR.080, BR.081, BR.082, BR.083, BR.085, BR.086, BR.087, BR.089, M.001, M.004, M.005, M.006, M.007, M.008, M.009, M.010, SD.001, SE.009, SE.011, SE.016, SE.017, SE.018, SE.021, SE.023, SE.025, SE.026, SE.027, SE.028, SE.029, SE.030,SE.031, SF.001, SU.001 SU.002, SU.003, SU.004, SU.005, SU.006, SU.007, SU.008, SU.009, SU.010

that bronze had for most of the Early Medieval period has firmly ended. While the majority of the objects are composed of leaded copper, brasses still have some prominence, as do gunmetals. The number of gunmetals from the Late Saxon period and First Viking Age compared to the Second Viking Age has not varied greatly; this suggests that other than the removal of tin from the process, metal production has not significantly changed between the two periods.

Tin content in the Second Viking Age, as shown in Figure 8-28, has undergone the most significant and visible transition from the Early Saxon period. Tin content decreased and is not present in 70% of the Second Viking Age objects; the remaining 30% of objects range from having 1% tin to 19% tin. The highest frequency occurs at 1% with five objects. A simple conclusion to draw from this is that, likely due to numerous factors, tin consumption ceases in Second Viking Age Lindsey. While tin content was steadily declining in the previous periods, this drop is far more significant.

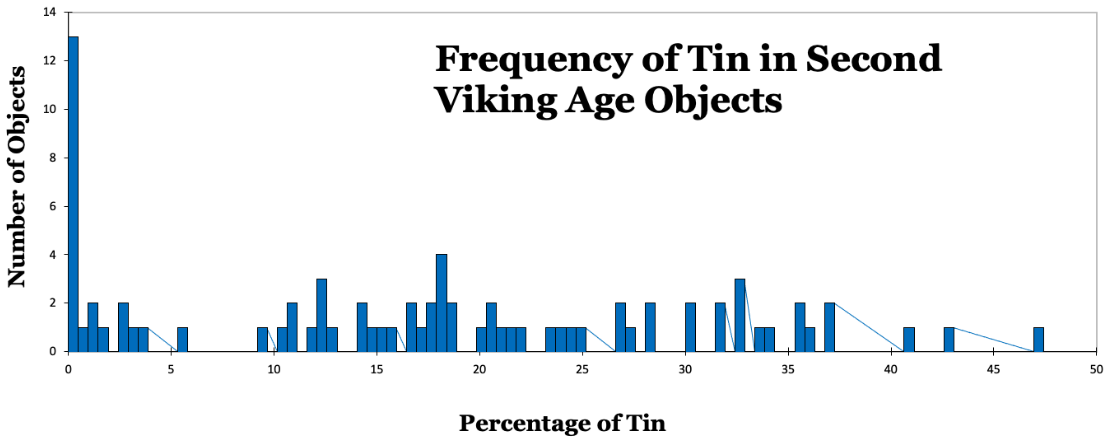

Figure 8-29 Frequency of tin in the Second Viking Age

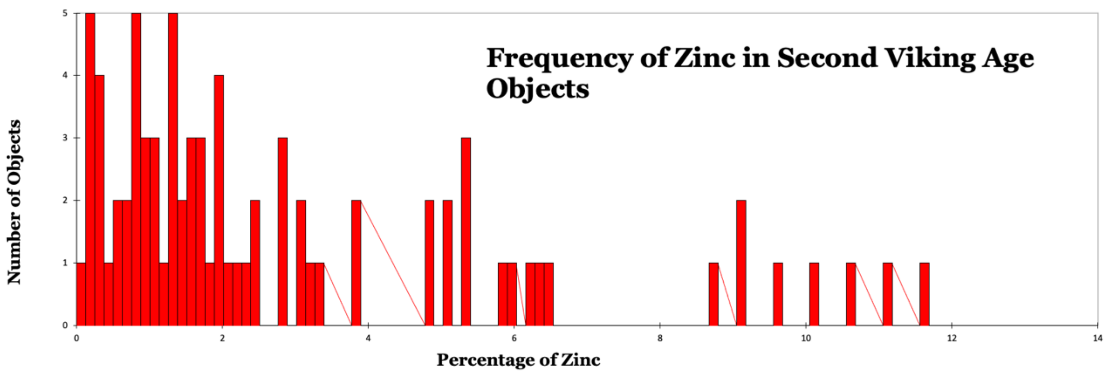

Figure 8-28 Bar graph showing the frequency of zinc in the Second Viking Age

The pattern of zinc content is relatively similar to the previous periods. There is a slight increase in the Second Viking Age in the amount and frequency of zinc from the Late Saxon period and First Viking Age. As shown in Figure 8-29, the peak in zinc content is between 2% and 6%, which is precisely the same as during the Late Saxon period and First Viking Age. However, the highest amount of zinc is only 19%, and the next highest is 12%. While zinc content is more prominent than tin, its relatively infrequent occurrence makes it highly unlikely that zinc is the primary or secondary alloy of the Second Viking Age. Additionally, when looking back at Figure 8-1, most of the brasses are leaded, possibly explaining why the percentages appear similar to those in the Late Saxon period and First Viking Age, although without the same high levels of zinc.

Lead content continues to increase into the Second Viking Age. Every object scanned for this study contained at least 2% lead. Lead content is reasonably steady and consistent up to 41% with only a few gaps, as shown in Figure 8-30. In Figure 8-30 it is apparent that there is a wide range in the percentage of lead content, but the frequency stays quite low. This relationship is starkly different from what was observed in the other alloying metals. What these lead levels could suggest is that while lead content was high it was not well measured during the production process, leading to highly variable amounts across these objects.

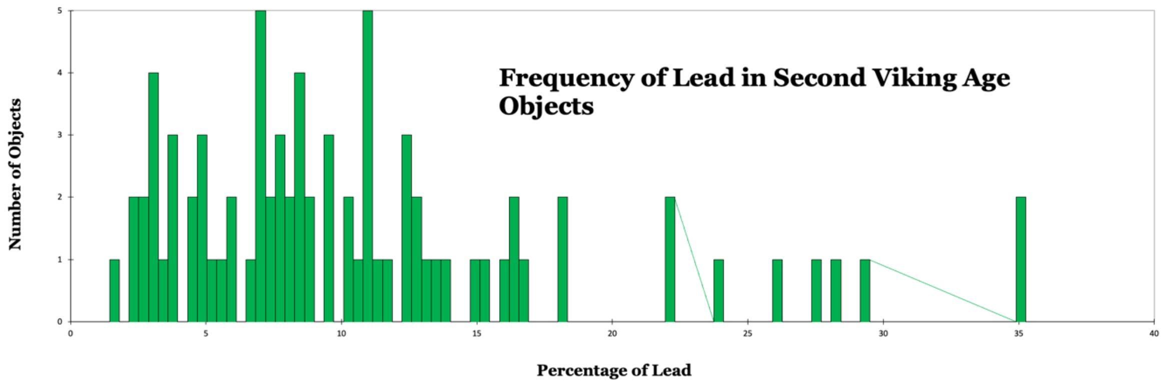

Figure 8-30 Frequency of lead in the Second Viking Age

8.4.3. Objects

The following sections will divide and discuss the compositional data of the items dating to the Second Viking Age. Some of the objects presented include examples that can be stylistically dated to both the First and Second Viking Ages. They were included in this section because the majority of the objects date to the Second Viking Age. The following sections discuss various brooch types, bells, different horse fittings and buckles.

Brooch Compositions

Disc Brooch Data

Disc brooches[61] make up a surprisingly small proportion of the dataset, with only five examples. All of these samples come from metal detecting, three from the area of Osbournby and two from the area near the Humber Estuary, more specifically near the village of South Ferriby. Four of the disc brooches are considered Anglo-Scandinavian and in the Borre styles; the remaining brooch is Anglo-Saxon and likely Trewhiddle style. Of the five brooches, four of them have the Anglo-Saxon-style pin fittings. There does not appear to be a distinction in composition based on pin fitting and stylistic division.

The compositions of disc brooches, as seen in Figure 8-31, are very heavily leaded. Two of the brooches are leaded copper, and the other three brooches are leaded brass. Of these latter three, two of the brooches are more heavily leaded than the remaining brooch. All of these brooches only have trace levels of tin. These compositions are drastically different from the brooches that have already been discussed in this thesis.

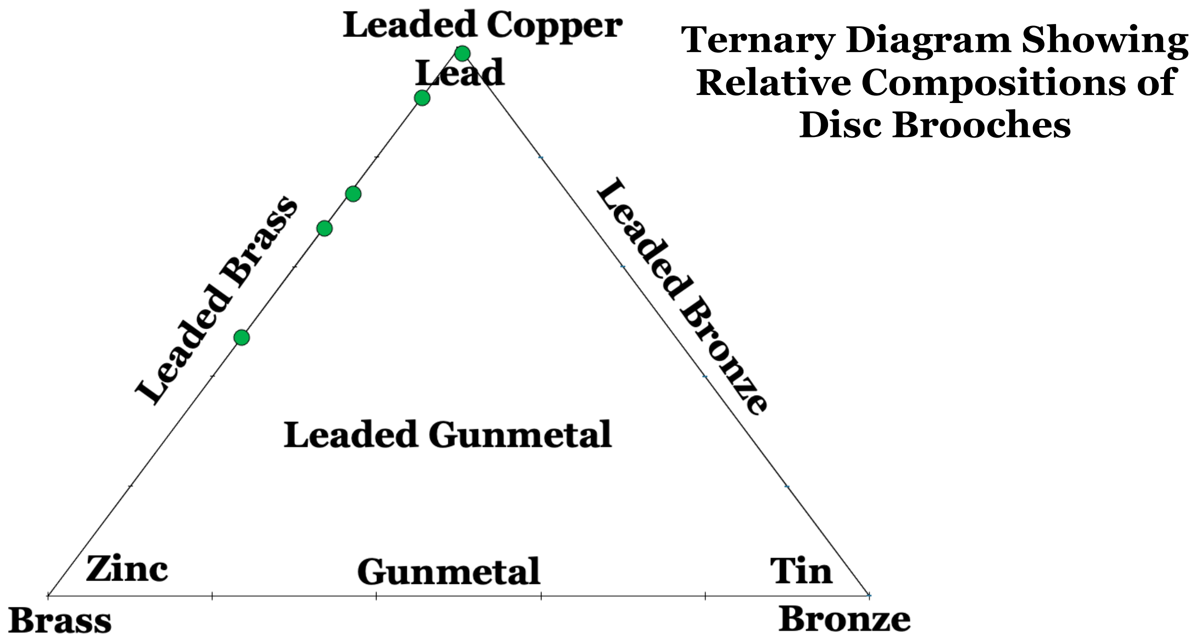

Figure 8-31 Ternary graph showing compositions of disc brooches

Domed Brooch Data

Domed brooches also comprise a relatively small proportion of the overall dataset, with seven brooches,[62] but they yield some distinctive data. All of the domed brooches come from metal-detecting sources along the Humber Estuary, primarily South Ferriby with four

[61] Disc brooch references numbers BR.077, BR.082, BR.086, BR.089

[62] Domed brooch reference numbers BR.068, BR.071, BR.073, BR.076, BR.079, BR.080, BR.081

brooches, but also other undisclosed locations within North Lincolnshire. All are diagnostically Scandinavian based on the type, style and pin fittings. There are three different styles across the seven brooches: one early zoomorphic brooch, four Borre and two Ringerike brooches. There are some possible composition trends based on these stylistic divisions.

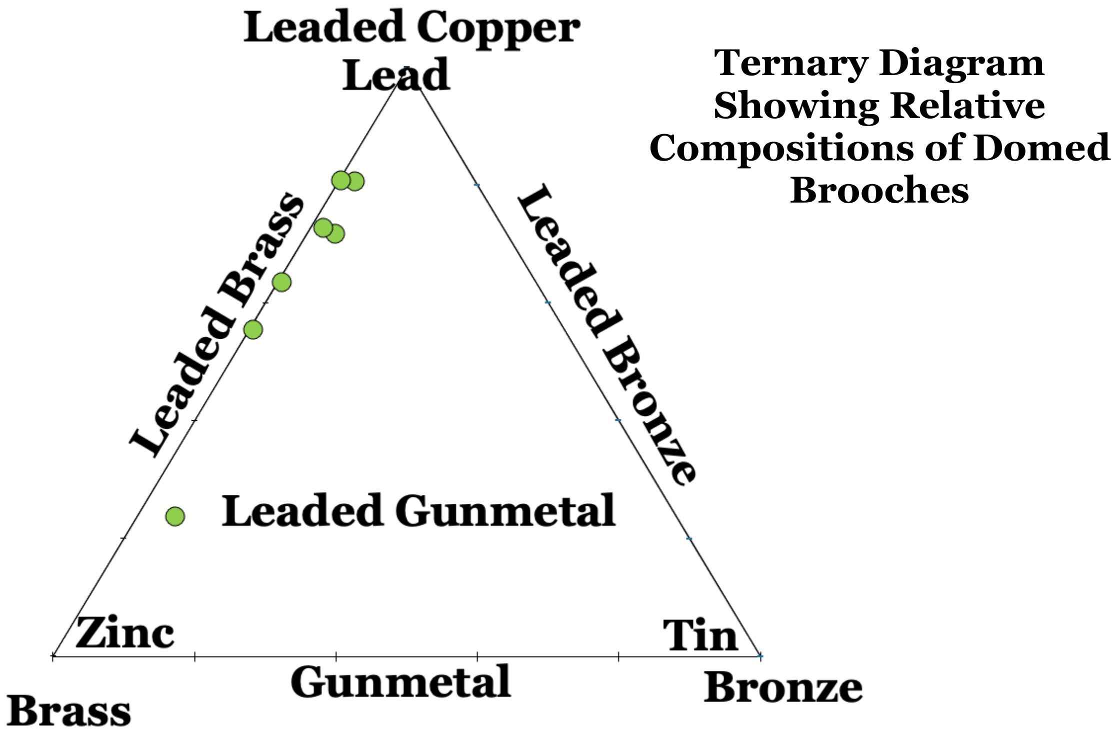

Figure 8-32 Ternary graph showing compositions of domed brooches

As seen in Figure 8-32, the domed brooches are, for the most part, very heavily leaded. Six of the seven brooches are categorised as leaded brass while the seventh brooch is just shy of being considered a leaded brass and is brass. As with disc brooches, there is only a trace amount of tin in all seven of these brooches, with none of them exceeding 0.5% tin.

Trefoil Brooch Data

Trefoil brooches[63] form the smallest sample size that will be discussed individually, consisting of only four brooches out of the ninety-one total. All four brooches were recovered through metal detecting from four different locations along the Humber Estuary. All of the brooches are considered Scandinavian based on type, style and pin fittings; of the four brooches, two are in Jellinge style, while the other two are plant ornamented style. Despite their small number, the trefoil brooches still reflect some interesting general trends.

[63] Trefoil brooch reference numbers BR.061, BR.066, BR.067, BR.085

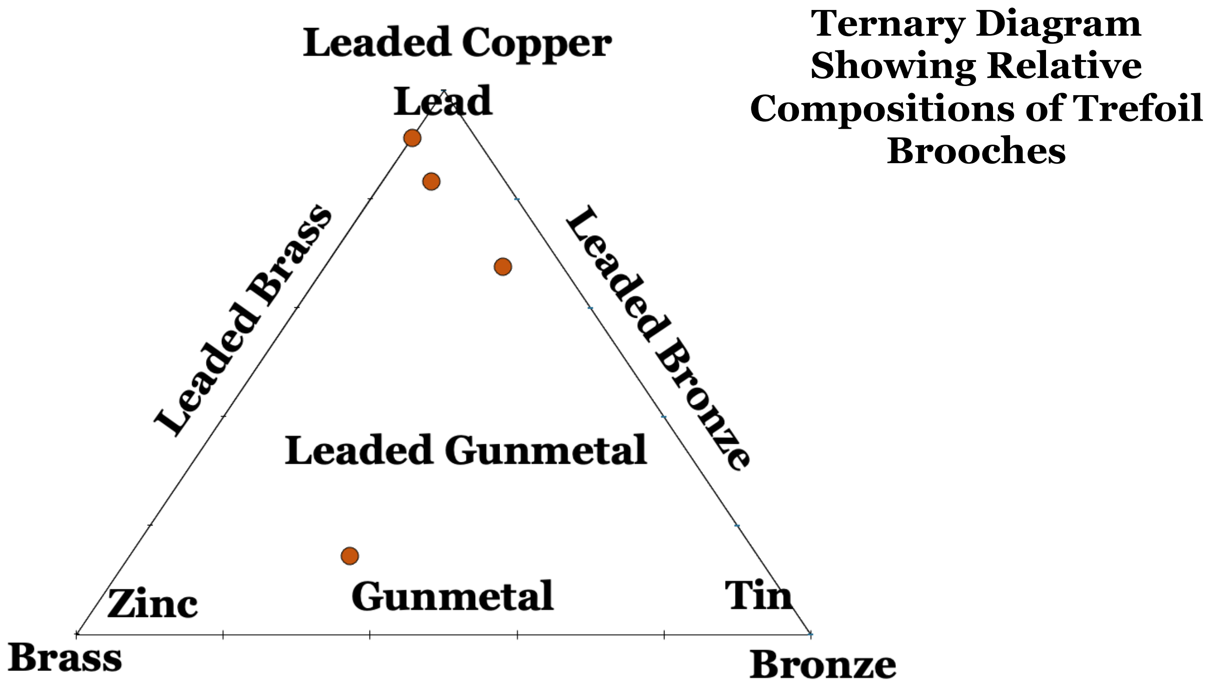

Figure 8-33 Ternary graph showing compositions of trefoil brooches

Two the of trefoil brooches are definitively leaded copper, one is leaded bronze, and one is gunmetal, as seen in Figure 8-33. There are two leaded copper brooches decorated in Jellinge style and two are the plant ornamented style. This directly contradicts the theory put forward when discussing the domed brooch data that lead quantity decreased over time. The Jellinge style post-dates the plant ornamented style and the Borre brooches from the domed data, yet they contain more lead than both of these styles. The presence of tin is also an exciting element in these brooches. All of the other Scandinavian brooches studied so far have had only minor traces of tin, whereas one of these trefoil brooches is a leaded bronze and another is gunmetal. The presence of gunmetal indicates evidence of recycling, which also has not been present in the other Scandinavian brooches. All of these brooches are from along the Humber Estuary. Overall, even though trefoil brooches comprise a small proportion of the overall brooch dataset, they have yielded data that differ from much of the data recovered from the other brooches.

Other Brooch Data

The final brooches to be discussed are the remaining four types that were not represented by many examples, so they will be discussed as a collection. This final section includes two lozenge brooches,[64] two equal-arm brooches,[65] one bird brooch,[66] one saucer brooch[67] and two ansate brooches.[68] Of these brooches, the lozenges and one equal-arm are classified as Scandinavian; the other equal-arm and the bird brooch are both Anglo-Scandinavian. The two ansate brooches and saucer brooch are Anglo-Saxon. The majority of these brooches come from metal detecting except for the saucer brooch, which was excavated at Scremby. The two ansate brooches were metal detected from the area around Osbournby, and the remaining brooches come from across North Lincolnshire.

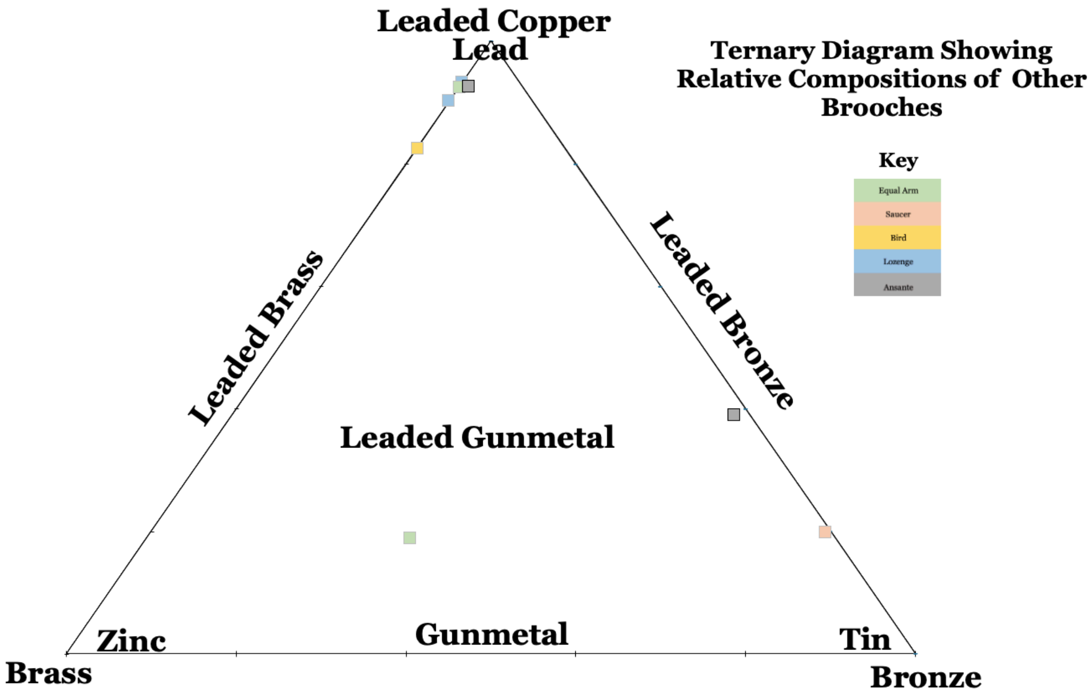

Figure 8-34 Ternary graph showing compositions of multiple brooch types

Of these brooches, the lozenge brooches are the only type to have similar compositions to one another, as shown in Figure 8-34. Both lozenge brooches are leaded copper, which is unsurprising given the composition of the other brooches of Scandinavian origin from North Lincolnshire. The bird brooch, one of the equal-arm brooches and one of the ansate brooches were also leaded copper. The other ansate brooch was leaded bronze and the remaining equal-arm brooch is composed of gunmetal. The single saucer brooch is bronze. For the most part, these brooches fit in with other trends established by the other brooches previously discussed. Since they do not have a large sample size based on typology, trends within the types cannot be established.

[64] Lozenge brooch reference numbers BR.083 and BR.087
[65] Equal-arm brooch reference numbers BR.001 and BR.084
[66] Bird brooch reference numbers BR.078
[67] Saucer brooch BR.007
[68] Ansate brooch reference numbers BR.030 and BR.072

Bell Data

Six Norse Bells were analysed by pXRF, but only five[69] were included in this study. This was because the sixth was discovered to be a lead alloy, not a copper alloy. The remaining five Norse Bells that could be included in the study were primarily leaded copper, leaded bronze and leaded gunmetal, as seen on Figure 8-36. Even though they span three different compositions, they are still quite similar. The high level of lead in these materials is rather surprising, as lead is not the best conductor of sound. This makes it an unusual alloying material for bells, perhaps alluding to their main purpose being decorative rather than musical. The bells do seem to be very representative of the general alloy trends in this time period, which will be explored further in Chapter 9, section 9.2.3.

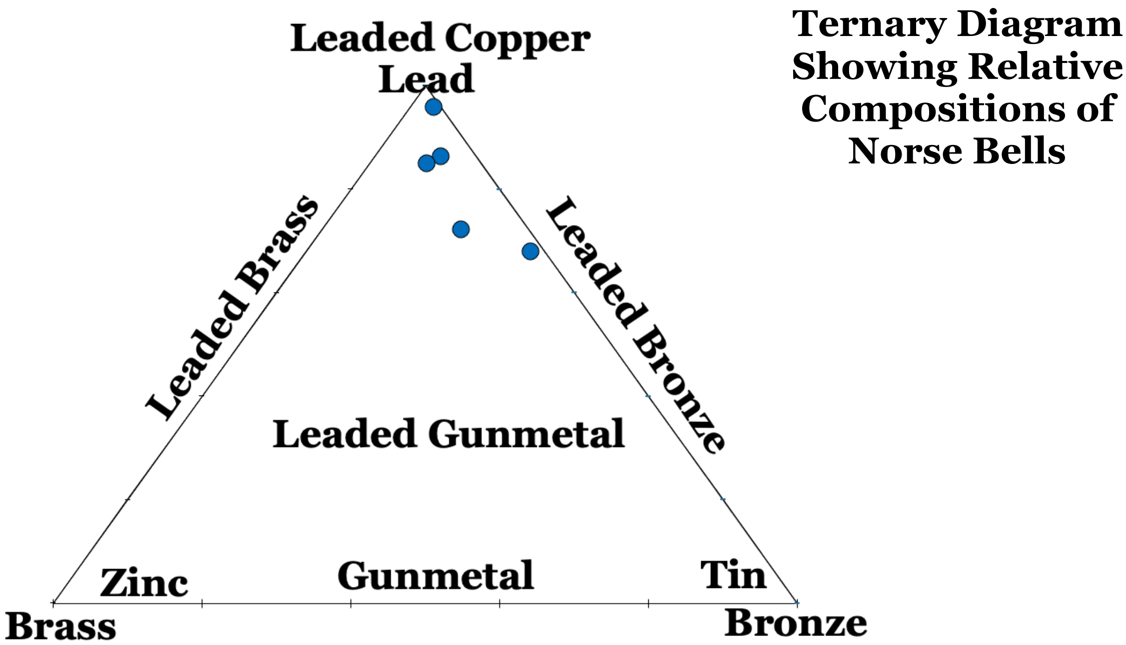

Figure 8-35 Ternary graph showing compositions of Norse bells

Horse Fittings Composition

As stated above, the horse fittings will be examined together instead of by each separate type. The horse fittings analysed for this study include twelve bridle fittings,[70] six mounts[71] and eight stirrup[72] accessories, including terminals and mounts. The majority of the objects are along the left side of Figure 8-36. They are primarily leaded brass and leaded copper with a few brasses, gunmetals, leaded gunmetals, leaded bronzes, and one bronze object. These objects do not show significant variation between type, perhaps suggesting that all horse accessories and materials were produced with the same manufacturing methods. It is

[69] Bell reference numbers BE.001, BE.002, BE.003, BE.004, BE.005
[70] Bridle fitting reference numbers BF.001–BF.0012
[71] Mount reference numbers M.001, M.003–M.011
[72] Stirrup reference numbers SU.001–SU.010

unsurprising that these objects are heavily leaded, as high material strength would be a requirement in order to survive and function as horse equipment. Similarly, this can also be attributed to the seemingly low rates of recycling present in this material. However, it is also possible that the high rates of lead are due to the Scandinavian production, as will be further discussed in section 9.2.2.

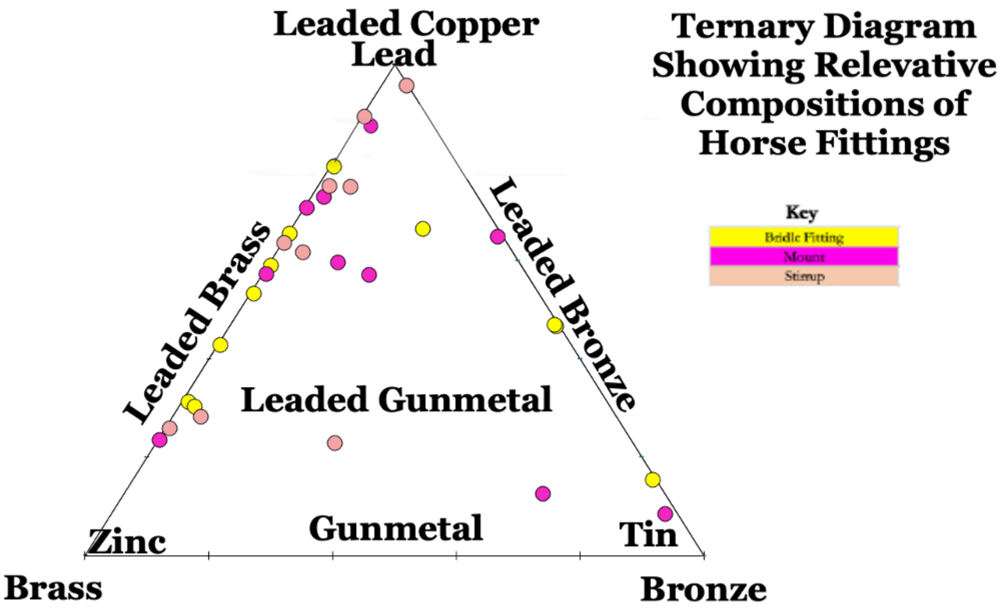

Figure 8-36 Ternary graph showing compositions of horse fittings

Buckle Compositions

Introduction

Buckles represent a small portion of the overall dataset (as stated in Chapter Seven) with only twelve buckles found and analysed by the pXRF for this study. Of these, seven were detected in locations along the Humber Estuary, two from the area surrounding Osbournby and one from an undisclosed location in Lincolnshire. The remaining two buckles were excavated from the site at Scremby. These buckles were primarily D-shaped, but there is a greater variety in the stylistic design of the buckles. This variation is clearly represented in Figure 8-37; in only twelve buckles there are seven different styles. Of these twelve, only three predate the Viking Age. This division is not unusual, considering the lack of popularity of buckles in the Mid- and Late Saxon periods. Since the sample size of buckles is comparatively small, they will be discussed as a whole, rather than subdivided by period like many of the other object types.

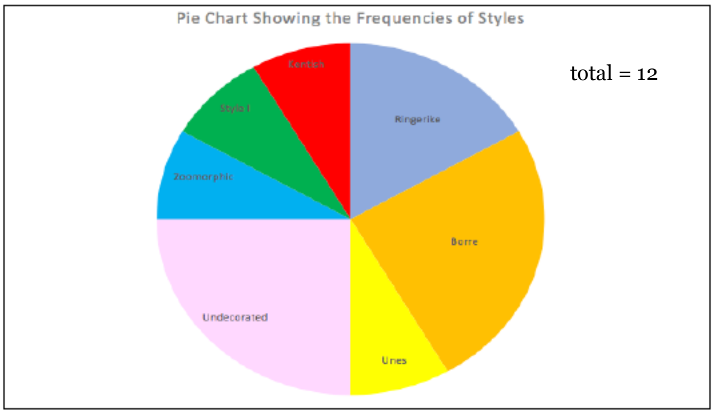

Figure 8-37 Frequency of buckle styles

Compositional data

The data from the pXRF analysis of buckles[73] are presented in Figure 8-38, a ternary diagram colour-coded to show the different styles present. This graph shows how varied the buckle compositions are. These data reflect variations in bronze,[74] brass,[75] leaded brass,[76] two leaded gunmetals[77]and one leaded copper buckle.[78]

The bronze buckles consist of three buckles of three different styles. One buckle is a Kentish shield buckle tongue, one has a Style 1 integral plate and the other is a Borre buckle. This is quite interesting as they comprise two different Anglo-Saxon-style buckles and a much later Scandinavian one. This is even more curious given that the Kentish type is likely to have been imported into the Kingdom of Lindsey from the South of England. All of the buckles in this group may have come from some slightly recycled material, as they all contain trace elements of both zinc and lead. It is interesting that in many other objects like brooches, there is a robust compositional divide based around the date of the object; that is not the case for these buckles.

The leaded brass buckles are Urnes style, zoomorphic style, and Ringerike style respectively. All three buckles are Scandinavian in style and, therefore, date within the Viking Ages; their compositions fit into patterns seen in the Scandinavian brooches discussed above. Consequently, these data are not as curious as the group of bronze buckles. As there are no other Urnes or zoomorphic buckles, it is difficult to determine whether this composition was

[73] Buckle reference numbers BC.001–BC.012
[74] Bronze buckles BC.001, BC.002, BC.003
[75] Brass buckles BC.007, BC.009, BC.012
[76] Leaded brass buckles BC.008, BC.010, BC.011
[77] Leaded gunmetal buckles BC.005 and BC.006
[78] Leaded copper buckle BC.004

typical for these buckle styles. The brass buckles consisted of one Ringerike buckle and two undecorated buckles.

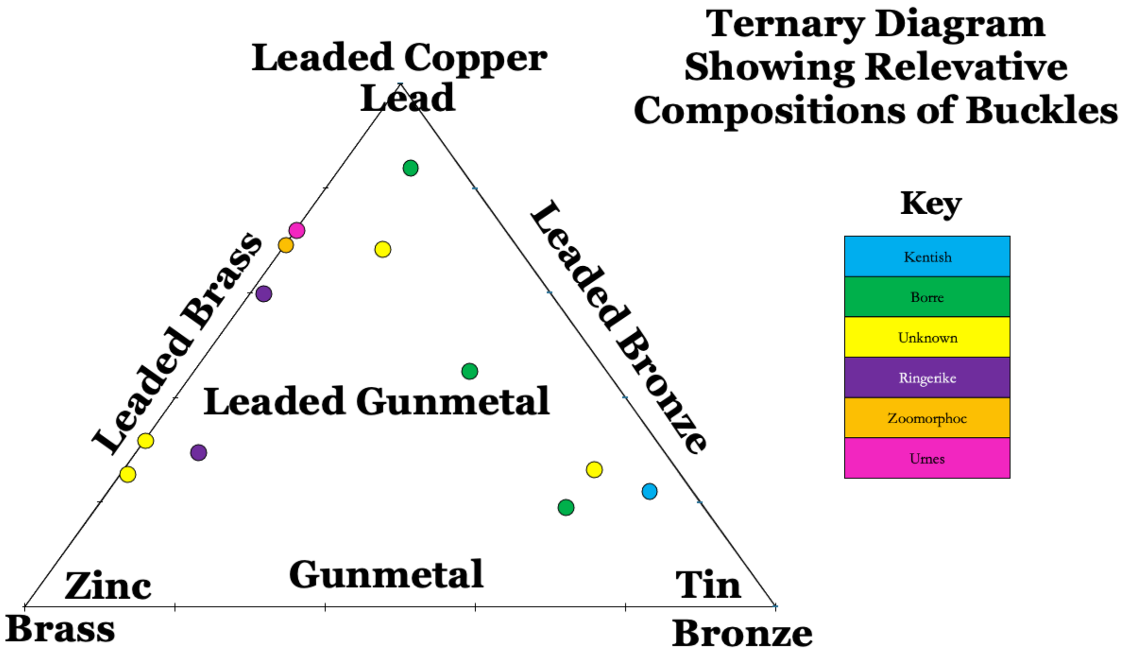

Figure 8-38 Ternary graph showing compositions of buckles

Discussion

Despite being a small dataset, the buckles showed far more variability within styles than that demonstrated for the brooches. There is a range of possible reasons for this; first and foremost, these buckles cross all the subperiods in this thesis. As has been discussed, the recycling of materials could lead to a final product that was difficult to work and manipulate. Perhaps this was not a primary concern for items such as buckles as it would have been for more complex and multipiece items. Alternatively, perhaps given the small sample size of buckles, these data are not representative of Early Medieval buckles. It is clear that this area would benefit from further analysis.

8.4.4. Second Viking Age: Discussion

The Second Viking Age metal composition data show the most significant clustering since the Early Saxon period. However, it varied from what was seen before, where the material was primarily bronze and leaded bronze. During the Second Viking Age the material was primarily composed of leaded copper with some leaded brasses.

When compared to the Late Saxon period and First Viking Age, there are some significant changes, some of which were beginning in the Mid-Saxon period. The most drastic of these is the reduction in tin content. Tin content had been steadily dropping since the Early Saxon period and, until the Second Viking Age, this decline was steady and slow. By the Second Viking Age, tin has nearly disappeared, as shown in Figure 8-28. Based on previous theories about composition in the Early Medieval period, it would be expected for zinc to replace tin as the primary alloying material instead of the high amounts of lead that were seen, possibly causing production failure (discussed in section 2.3) and Bayley's (1992a) data from Coppergate. However, this is not the case. Instead, tin was primarily replaced by lead. Even when zinc occurs, just as in the Late Saxon period and First Viking Age, it was usually accompanied by lead and resulted in a prominence of leaded brasses over brass.

In previous metallurgical studies (e.g. Bayley 1992a), drastic changes, such as those displayed in the data from the Second Viking Age, are often concluded to be the result of the migrating populations of Scandinavians into Northern England. However, while these shifts are most obviously seen in the Second Viking Age, they actually begin during the Mid-Saxon period and simply grow more apparent later on. While it is likely that migrating populations had an impact on copper alloy production, they are not the sole cause of this drastic shift. With this in mind, it is essential to investigate the possible causes of changes in the production chain, as they are likely multifaceted.

8.4.5. Conclusion

The main compositional shift observed in these data is the shift from using tin to using lead as the primary alloying metal. Over time there is evidence for the refinement of copper alloy production techniques, until a drastic shift in the Second Viking Age. The beginning of this transition is mostly shown in a greater variety of metal compositions, which could be due to several factors such as political and religious changes. This will be explored in the next chapter.

8.5. Summary of Copper Alloy Patterns in Early Medieval England

8.5.1. Recycling and Metal Supply Over Time

The main changes occurring in the metal compositions in this dataset over time are: first, a general fall in tin with sporadic exceptions of fresh tin being utilised; second, zinc use being varied and not drastically declining as scholars have previously hypothesised (Bayley 2008); and finally a significant increase in the use of lead in copper alloys.

The dataset, as outlined above, yielded highly mixed compositions. As previously discussed in section 3.4, there are two possible ways that recycling can present itself – as mixed compositions and as pure compositions. In this section, the data will be explored in detail to determine which of these has occurred, or if there even is recycling present in this dataset.

The overall dataset shows a wide variety of compositions, many of which are highly mixed, leaded bronzes and brasses in particular. There are also examples of gunmetals and leaded gunmetals, but they are far less frequent. At first glance, the comparatively low levels of gunmetals would suggest that there are low levels of recycling; however, the data are not so clear.

Due to the confusing nature of studying recycling compositions in the metallurgical data, this section will attempt to explore all theories that are a possibility, starting with tin-based alloys. One proposed concept about the level of recycling occurring in the tin-based alloys of this dataset is that if recycling is taking place, it is happening without being able to add additional tin to the mixture. This 'recipe' would result in and explain the high level of leaded bronzes and possibly gunmetals seen in the dataset, depending on the additional alloying element. That this process resulted in more leaded bronzes than gunmetals seems the most likely explanation; the reasoning behind this is twofold. First, zinc would need to be processed through cementation, so it being added into a bronze seems unlikely when this would have required extra work. If it was unknowingly added, the vapour loss would be very high, and it would only be present in very small quantities. Additionally, lead was a common additive in Roman material and could be sourced relatively close to the Kingdom of Lindsey. This process would explain the high levels of leaded bronze, especially compared to gunmetals, specifically in the Early Saxon period.

Another possible result of recycling tin-based alloys is that the recycling would actually result in a purer bronze. Coincidentally this explanation can also serve as a reasoning for the low levels of gunmetals. A purer bronze, tin-heavy gunmetals, or gunmetals could all have resulted from the intentional recycling of either high-zinc gunmetals or brasses without employing the cementation method. This practice would lead to higher rates of zinc volatility and therefore zinc loss, creating a purer bronze with a higher tin and lower zinc content. This would mean recycling would need to be occurring over a very long period of time to result in the bronzes seen in this dataset. However, only a few recycling instances would need to happen to move an item from a brass to a gunmetal. Here the idea being put forward suggests that the gunmetals seen in the dataset were the result of recycling.

Zinc-based alloys appear to be somewhat simpler than the tin-based alloys. This 'simplicity' may be the result of the cementation production method discussed earlier in section 3.3.3. The technique means that zinc levels could not exceed 28%; additionally, if zinc-based alloys were recycled without the cementation method, fresh zinc could not be added to the mixture. This production process would result in very few high-zinc brasses, which is the case in this dataset. Furthermore, and similar to tin-based alloys, there is a high number of zinc-based alloys that are heavily leaded. This result will again lead to the argument that when a material is being recycled lead is added instead of tin or zinc, perhaps due to the availability of materials.

By dividing the data temporally, it becomes apparent that there are clearly significant shifts in composition and therefore in Lindsey's metal supply. However, is this through mining, different materials being recycled, or a combination of the two? As discussed, determining recycling through compositions alone is difficult task, so a conclusion was not reached using this dataset.

In the Early Saxon material, which is mostly composed of leaded bronze objects, there is significantly less evidence for mixed composition recycling than expected. It is highly likely that in the Early Saxon period recycling would have occurred, but in the form of recycling like materials with other like materials, such as recycling items with the same leaded bronze composition all together. Therefore, such materials would have little evidence for recycling compared to fresh productions. Leaded bronze was the standard alloy type in the Roman period; it would, therefore, comprise the majority of objects available to be recycled. As a result, it would make sense that recycling cannot be clearly seen in the compositions, as a recycled composition and a freshly made leaded bronze could look quite similar.

The shift between the Early Saxon period into the Mid-Saxon period shows a higher proportion of mixed compositions. While it is difficult to say that this is evidence for recycling, it may be the clearest example of potential recycling observed in this dataset. There were mixed compositions in the Early Saxon period, but they were not the dominant composition type. In contrast, the Mid-Saxon period has a much more comprehensive range of compositional data than the Early Saxon period. The broader range of compositions is where this author believes the recycling becomes evident. What is apparent when comparing these two sets of data is that there is new material entering the production chain; whether it is fresh or scrap material is significantly harder to determine. While arguments could be made for either, there is a logical reason for an increase in scrapping material and therefore recycling during the Mid-Saxon period. An increase in scrap material could be due to a decrease in the prominent use of grave goods. Individuals were no longer reserving material to deposit in graves; items that would normally become grave goods could then instead be recycled.

The Mid-Saxon period also sees both a slight decrease in high-tin bronzes and a significant increase in high-zinc brasses. Both of these trends could be the outcome of either recycling or fresh production. As hypothesised, recycling materials could lead to a more refined alloy, given that the coppersmith was recycling like compositions with like. This production process could lead to the high-zinc brasses found during this period if brasses were being recycled together and with the proper cementation process, allowing other accidental additives to volatilise out of the mixture. Since there is no clear trade path that would bring zinc into the Kingdom of Lindsey, the recycling of older brass material makes the most sense given this data and its historical context. The slight shift in tin level in bronzes can also be easily attributed to recycling, as a slight decrease in tin levels can occur when recycling bronzes without adding any new tin – this can lead to a slight tin loss in the material. Tin would have been replaced with another alloying material such as zinc, most likely in the form of brass scrap, which would result in gunmetals (as discussed earlier). If not zinc, lead could be added as an alloying metal, which would result in the high amounts of leaded bronze found or leaded gunmetals, depending on the extent of recycling.

Many of the trends that are observed in the shift from the Early Saxon to the Mid-Saxon periods continued into the latter half of the Early Medieval period. The later periods saw a continued increase in lead content and a massive decrease in tin content. However, gunmetals did not continue to increase, as was observed between the Early Saxon and the Mid-Saxon periods. Instead, the quantity of gunmetals started to decrease and, therefore, in the Late Saxon period and First Viking Age there are very few gunmetals. Instead, the majority of the material is composed of leaded copper and leaded bronze. This result adds support to the theory proposed earlier, that bronze items were being recycled, but that there was no new tin to add to the mixture, so lead was being added instead. The Late Saxon period and First Viking Age also saw an increase in lower-zinc brasses, including leaded brasses. The same theory proposed for tin can be applied here; that the supply of zinc or brass scrap began to run out so other alloying material, such as lead, needed to be used instead.

As we move into the Second Viking Age, there seems to be a decrease in mixed compositions and tin content is almost entirely absent. There is a drastic shift in the metal resources that occurs throughout the Early Medieval period that cannot be solely attributed to recycling. The data from the Second Viking Age suggest there was less recycling overall and, if there was recycling, the primary alloying material was lead. While a definitive conclusion about the level of recycling occurring in the Second Viking Age is difficult to reach, what is clear is that new mining resources emerged throughout the Early Medieval period and over time there were fewer tin-based scrap resources; this drastic drop in the percentage of tin cannot be solely attributed to tin volatilising. It is possible that after the Danelaw was established the access to tin from Cornwall decreased or ended altogether, leading to the drastic drop that is seen across Early Medieval Lindsey.

Studying metallurgical recycling practices in the past continues to prove itself a problematic area of investigation. This is primarily due to the multiple ways that recycling can present itself in the metallurgical compositions (see Pollard 2018, Chapter Two) Throughout this chapter, it became clear that the quantity of recycling occurring is not necessarily the most significant aspect to be studied, but rather how compositions and therefore recycling practices and metal supplies changed between periods. Considering the material through this lens and being open to the possibility that each recycling theory has its fundamental components will lead to a multifaceted and logical conclusion surrounding the recycling practices within this dataset.

Aligning primarily with Caple's (1986) theories, the conclusions have been drawn that the recycling of Roman material in the Early Saxon period leads to high amounts of leaded bronze, due to the significant Roman production of leaded bronze. This recycling is difficult to trace because of the consistent recycling of like material with other like materials, perhaps as the amount of Roman material suitable for recycling or other scrap copper alloys decreased and coppersmiths were required to find other sources of copper, tin, zinc and lead. The consistent metal source that was around during the Early Saxon period has shifted to utilising multiple metal sources in the Mid-Saxon and the Late Saxon periods, as well as into the First Viking Age. By the Second Viking Age, the metal source has once again become more singular as compositions are now more significantly clustered around leaded copper.

This raises interesting questions about the use of alloying metals in the Early Medieval period, such as were metal producers aware of the potential issues with high lead and high tin levels, which are present throughout this dataset, and what methods were used to combat any potential production failures? Alternatively, it could be that other alloying materials were so rare that they needed to use lead even knowing the risk of failure; or perhaps they were an accident of overcompensation for tin loss during recycling. The examination of recycling practices throughout this chapter has led to more questions than answers about Early Medieval metalworking practices; these questions provide exciting new routes of study within Early Medieval metallurgy and will inform further discussions as this study progresses.

8.5.2. Significant Object Variation

The compositional data when divided by object type yielded some noteworthy data. Patterns found seem to align with known patterns within their styles and distributions. For example, the compositional data for Mid-Saxon pins were highly clustered and consistent, which aligns with theories about the centralisation of production in that time and with the marked homogeneity seen in pin styles and production (Wilthew 1984). However, this is not true across all the Mid-Saxon material analysed, as Thomas Class A strap ends showed the most marked compositional variation. This variation can indicate a high amount of variation within Mid-Saxon copper alloy production.

The composition of brooches is varied and seems to be based on chronology rather than brooch type. A surprising conclusion is that objects considered to be indicative of high status, such as square-headed brooches, had heavily mixed compositions. This implies recycling and also that they were possibly produced with the risk of failure if the scrap content was unknown. However, if scrap content was able to be sorted, this mixed alloy content may have been the producer's goal. An interesting aspect to consider when looking at compositions, established in Early Medieval metalwork by Baker (2013), is the role of colour goals in selecting a composition. Baker (2013, 422–424) hypothesises that items that were intended to be gilded, even though considered higher status, would have had more heavily mixed compositions as the final colour of the item mattered less. This is because heavily mixed compositions resulted in unpredictable colours as opposed to brasses, bronzes and leaded coppers. Baker's hypothesis directly aligns with compositional data found in this study, particularly in the Early Saxon period, such as with the square-headed brooches and some of the cruciform brooches, as well as the sleeve clasps and hooked tags.

8.6. Conclusion

This chapter outlined the data from the compositional analysis and was followed by a brief discussion covering the key points from this data. The compositions of copper alloys changed greatly over time and showed variation between objects, while there are issues with the lead values once corrected they remain significant even as semi quantitive values. The key changes seen across the period were a decrease in tin content in objects and an increase in lead content. This chapter also discussed the potential differences in composition and object type; these variations in composition are primarily connected to the function of the objects, as with girdle hangers. There are many factors that could have led to these changes and the development of copper alloy practices and the use of styles in the Early Medieval period.

Chapter 9. Discussion

9.1. Introduction

The following chapter aims to discuss the key themes that were highlighted when working through the data and results in Chapters Seven and Eight. The biggest pattern of note within the data is the variation in composition that occurred chronologically, and this can be examined within the context of the change from Anglo-Saxon to Scandinavian political control. However, it was also possibly impacted by a range of other factors, primarily the influence of the Church. Additionally, this dataset can be discussed with considerations to these objects' role in identity and their associated displays, as well as part of continued traditions.

9.2. The Transition from Anglo-Saxon to Scandinavian Political Control

During the course of transition from the Early Saxon to the Mid-Saxon periods, compositional variability can be seen to be increasing, yet at the same time styles become highly standardised and uniform. This standardisation of style has been determined to be the result of the centralisation of manufacturing at agricultural estates, which would increase production capacity (Thomas 2011, 412). While the cause of the stylistic changes that materials underwent during the Mid-Saxon period can be attributed to the shift towards centralised estates, it presents the question of why centralisation made one aspect of copper alloy production uniform and another aspect hugely varied.

At first glance, there appears to be little change in composition between the Mid-Saxon period, the Late Saxon period and the First Viking Age. These periods have a wide range of compositions with few examples of clustering in the data. However, closer inspection reveals that something significant changed between the Mid-Saxon period and the Late Saxon period and First Viking Age. In the Mid-Saxon period, there is still a prevalence of bronze and leaded bronze compositions. In the Late Saxon and First Viking Age, this pattern is shifting towards leaded copper, as bronze compositions become increasingly sparse. The cause of this change could be due to a political shift; while Lindsey's borders primarily remained the same as in the Mid-Saxon period, political control moved from Northumbria to Mercia (Savage 1983, 111-115) The crucial compositional changes are appearing to occur at the same time as Viking raiding begins, but the decrease in tin actually began earlier in the Mid-Saxon period. This decrease means the Viking raids were not spurring change in the composition of copper alloys; instead, it seems the raiding may highlight and exaggerate changes that were already ongoing.

In the Second Viking Age, the slow shift away from using tin that was beginning in the Mid-Saxon period becomes far more drastic. Tin content became minimal, and lead was established as the primary alloying material. Since the decrease in tin content was already ongoing, can the sudden dramatic occurrence of this change solely be attributed to the political turnover from Anglo-Saxon to the Scandinavian control? A significant theory that will now be put forward is that Scandinavian influence on production and access to primary alloying materials caused lead content to be increased so dramatically.

However, this theory argues that the decline in tin was not due to a cultural difference but born from pragmatics. When the Scandinavians arrived and subsequently settled in Northern England, tin was already declining; the theories around why this occurred will follow in the subsequent section. A possible explanation is that the increase in lead content was due to the prominence of a bullion economy among the Scandinavian migrants. Lead weights and gaming pieces are often considered to be highly indicative of a Scandinavian presence (Hadley and Richards 2016). This theory is not considered entirely valid by the author, considering high levels of these items at Mid-Saxon monastic complexes, such as the assemblage recovered from Little Carlton (Willmott and Wright 2021).

However, it remains that Scandinavians in Lindsey were also using items such as lead weights and gaming pieces in significant quantities. The Scandinavian economy in the Early Medieval period is also known for utilising hack metal and having a high amount of ongoing recycling (Kershaw 2017). Therefore, it is possible if Scandinavian raiders and then settlers were recycling copper alloys or even smelting fresh copper, that due to inaccessibility of other alloying options such as tin and zin, lead would be the most accessible alloying material on their sites, which resulted in high lead content in the copper alloys produced. The access to lead and a lack of access to tin will be explored in the following section when discussing the site comparison of compositions in the Early Medieval period, as well as the impact of the Church on the alloying elements put to use.

9.2.1. Lindsey Compositions in the Wider Context of Early Saxon England

The data presented in Chapter Seven will be compared to those outlined in 2.2.2.1, which were from analyses undertaken by Mortimer (1991; 1993; 1998) and Baker (2013). The results from these studies are compiled to establish how the results presented from Lindsey in Chapters Seven and Eight compare and contrast with those from Anglo-Saxon England as a whole. To begin, comparisons will look at other results from Lindsey before looking to analyses that have been done elsewhere in Anglo-Saxon England.

Sites within the study region of Lindsey analysed in earlier studies include Castledyke South (Mortimer 1991; Baker 2013), Cleatham (Mortimer 1993; Baker 2013), and Fonaby (Baker 2013); specifically those from Baker (2013) can be seen on Figure 9-1.[79] Castledyke is a particularly relevant comparison as much of the material recovered is stylistically similar to those excavated and subsequently analysed from Scremby. Additionally, Baker's data from her Lindsey sites are somewhat similar to those presented in Chapters Seven and Eight. For example, the lead levels are variable (Baker 2013, 432–5), similar to the present Lindsey data. Additionally, her results from Castledyke and Cleatham align with those from Mortimer from the same sites (1991; 1993, 4; 1998, 254). The analysed materials from Castledyke are primarily composed of bronze and leaded bronze, with significant quantities of zinc reflected in the presence of gunmetals and a few brasses (Mortimer 1998, 254; Baker 2013, 283). Baker's results from Cleatham are primarily bronze and leaded bronze, with significantly less zinc (Mortimer 1993, 4; Baker 2013, 254).

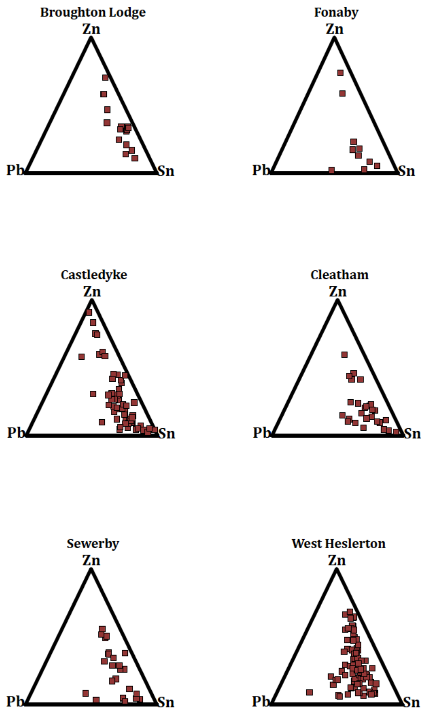

Figure 9-1 Ternary graph showing Baker's results (Baker 2013, 283)

79 Please note Baker's graphs have zinc at the top and lead to the left of the graph, which is different from other graphs presented in this study

Baker's Fonaby results consist of primarily leaded bronze and two gunmetals. The sole difference between the results in Figure 9-1 and those presented in Chapter Eight is the variation in zinc. Those presented in Chapter Eight show far lower zinc levels than Baker's and Mortimer's results. This difference, as Mortimer (1993, 4) has hypothesised, could be that there is a regional divide in Lindsey during the Early Saxon period, with material from the northern part of the kingdom near the Humber Estuary having higher zinc content than that from the southern part of the kingdom, closer to East Anglia. This is supported by the results presented here, as most of the material analysed and outlined in Chapter Eight is from the southern half of the kingdom, while Baker's northern Lindsey material from Castledyke is the furthest north and contains the most zinc. Both Cleatham and Fonaby, however, are towards the middle of the kingdom and have some appreciable levels of zinc present.

However, this theory of regional divide becomes complicated as the scope is expanded outside of Lindsey; one would expect Baker's results from the sites of Sewerby and West Heslerton, in East and North Yorkshire respectively, to have high levels of zinc, and Broughton Lodge, in Nottinghamshire, to have less (Baker 2013, 283). While West Heslerton does have higher zinc levels than most other sites, with most of the objects being gunmetal, comparatively Sewerby zinc levels are low while Broughton Lodge's are high (Baker 2013, 283). This suggests that if this regional divide does exist it is separating North and South Lindsey, not all of Anglo-Saxon England.

9.2.2. Impact of the Church

As the shift from the Early Saxon into the Mid-Saxon period occurs, the methods of production also transform. Primarily, production goes from local travelling artisans to growing centralised production chains (Hinton 2011, 430). This drastic shift is spurred mainly by the influence of the Church and the formation of secular estate centres. Ecclesiastical centres and secular power centres became highly intertwined as conversion spread throughout modern-day England (Webster 2011, 484). Evidence for the centralisation of production is multi-faceted and spans across multiple craft types. Archaeologists and historians (e.g. Crabtree 2010) have concluded that not only did production become centralised under church control but that it was highly controlled and regulated by the ecclesiastical powers as well. However, these notions are not universally accepted, as the status of certain sites, whether they be monastic or secular high status, is still contested, as Loveluck (2001) has argued is the case with Flixborough. This centralisation phenomenon is coupled with an economic boom that occurs in during the Mid-Saxon period, impacting both style and composition of copper alloys (Ross 1991).

The ecclesiastical control of production presents itself in multiple ways. There is substantial evidence of monastic control over multiple different production chains, from water milling at Tamworth, Derbyshire (Rahtz and Meeson 1992) to salt working at Droitwich, Worcestershire (Woodiwiss 1992); Barking (Essex) has preserved pre-Viking charters discussing a glass furnace, as well as archaeological evidence of a glass furnace in the early 10th century, and housed a community in the 940s (Blair 2005, 318). The furnace has recently been redated to the 8th to early 9th century (Willmott forthcoming).

The new infrastructure developed because of centralisation under probable ecclesiastical control, or secular estates would have allowed for a greater level of extraction and production. Evidence of monastic ownership of the land for metal production in the Early Medieval period is relatively sparse, but examples are known, such as the Abbess of Repton in AD 835 lending out lead mines at Wirksworth Derbyshire (Ford and Rieuwerts 2000, 18). It is difficult to determine the specific areas of control within the production chain that the Church had.

Debate Over 'Monastic Sites'

Before moving further into the theories of how the ecclesiastical structure of the Early Medieval period would have impacted production it is important to briefly touch on the debate over whether some of these production sites were in fact monastic. Some scholars, such as Blair (2005, 211) believe these sites to be monastic, largely due to the presence of styli, stating: 'on present knowledge it seems fair to say that the sites which were most highly developed, lasted longest, and yield the widest and richest assemblages of finds bear a strongly monastic stamp. Or, to put it another way: if Northampton, Brandon, Flixborough, and at least some others were not themselves minsters, they were secular establishments influenced to a quite extraordinary degree by the morphological and cultural attributes of monasticism' (Blair 2005, 211). However, many scholars no longer view the discovery of styli on a site to equate a monastic property (Loveluck 2001; Pestell and Ulmschneider 2003; Naylor 2004; Willmott and Wright 2021). This debate is still ongoing, but what still remains certain is that the Church would have been both a major landowner and landlord, so even if they did not directly control production, they still would have had influence as consumers or through trade. It is likely they could have acted as secular lord in the expansion of trading and market centres. Where it can be definitely concluded, there is evidence of many types of production, such as textile working and metalworking, on both secular and ecclesiastical estates (Coatsworth 2012, 190–191).

Style Standardisation

The increasing standardisation beginning in the Mid-Saxon period is an important consideration, especially in the context of Church and secular estate centralisation. This stylistic standardisation is seen in the mass popularity and uniformity of pins (Ross 1991), strap ends (Thomas 2000) and hooked tags (Graham-Campbell 1982). Additionally, by the 9th century, the rise of Trewhiddle styles as well as a marked increase in the use of niello and engraving techniques occurred not only across Lindsey, but across England and parts of Scotland (Thomas 2000). Furthermore, the styles after initial conversion to Christianity reflect new ideals set by the Church. These trends change once there is Scandinavian influence, and animals on dress accessories again become popular. So, while object styles and typologies can be seen as direct evidence of production centralisation possibly occurring due to monastic or secular estate control, the compositional change does not shift in the same manner. The standardisation of objects begins in the Mid-Saxon and continues into the Late Saxon period and First Viking Age, and yet those two periods have significantly higher compositional variation than the Early Saxon and the Second Viking Age.

The Church, Distribution, and Compositional Variation

The potential for the Church's control extended beyond material acquisition and production and into the control of markets and distribution of goods, both raw material and finished products. In eastern and southern England metal detecting is frequently used to study trading sites and production sites, primarily focusing on object distributions (Ulmschneider 2000, 59-63). The sites, such as Flixborough and Riby Cross Roads (Ulmschneider 2000, 60), are vastly different in nature, revealing a significant variety in site types ranging from large monastic sites to simple coin scatters (Blair 2005, 260). Most of the sites are well positioned for trade, either being near a waterway, road, or both. The finds on these sites included pottery, small-finds, and coins, indicating variable sizes (Blair 2005, 260). Ulmschneider's study of Lincolnshire and Hampshire debates that the key centres of consumption and trade are primarily monastic and that early 8th century site expansion was pushed forward by ecclesiastical organisation, production capability, increasing need, and perhaps trading privileges provided by or with minsters (Ulmschneider 2000, 95–99; 105, Blair 2005, 260).

At present, archaeological work indicates the monastic sites played a major role in both regional and local distribution of materials. It is important to note that these markets were much less extensive than those that emerged by the 10th century. Blair (2005) stresses that the ecclesiastical role at this time was largely that of consumption more than anything else (Blair 2005, 260–261). However, as the material in the study is largely not ecclesiastical in nature, seeing the residual impact that may have been due to their consumption is significant.

In section 3.1.5 the theory of ready-made alloys was introduced; these ready-made alloys would have been a profitable and relatively easy way for ecclesiastical centres to influence or control metal production. Yet, looking at the composition shift from the Early Saxon to the Mid-Saxon and then the Late Saxon period, the compositions are more scattered, implying more recycling and likely without intensive sorting. However, dividing the material provided better insight. Pins, for example, were primarily composed of bronze or leaded bronze, with a few outliers; this is directly contrasted with strap ends, which had highly varied compositions; see sections 8.2.3 The results from the pins in this dataset are consistent with those reported by Wilthew (1984). Wilthew concluded, based on his results from Southampton, Hampshire, that each pin type would have been a carefully controlled production at a specific site or limited range of sites, continuing that if a larger range of sites were used or they were produced using 'arbitrarily selected scrap material' there would be a wider range of compositions among the objects (Wilthew 1984, 10). If Wilthew's theories are applied to the Mid-Saxon material analysis in this research similar conclusions can be drawn about the pins produced in the Mid-Saxon presented in Chapter Eight. Wilthew's compositional results also had outliers, similar to the data presented here; he hypothesises the objects with a wider range of compositions would have been produced in multiple, more local settings and on a smaller scale (Wilthew 1984, 10). This seems likely to be occurring in Lindsey as well, where the majority of production was centralised or starting to be centralised.

It should be noted that at the time of this research, Flixborough and Little Carlton are the only 'productive' sites excavated in the study region. There are other settlements that have been excavated, such as Riby Cross Roads (Steedman et al. 1994) and Quarrington (Taylor et al. 2003), but the region (Lincolnshire and North Lincolnshire) lacks major excavated sites, which limits interpretation (Ulmschneider 2000, 53), especially since Blair states that Lindsey did support significant amounts of small monastic sites (Blair 2005, 212). A large quantity of small monastic sites would make sense with the variation of compositions seen in the current Mid-Saxon data, especially if it is coupled with an increase in recycling as

Christianity became more widespread and significant grave goods, such as in Early Saxon pagan burials, were no longer considered acceptable by the Church; this author proposes that recycling dress accessories could increase as they were not being deposited for ritualistic purposes and could instead re-enter the production cycle. While centralisation of production continued for the remainder of the Early Medieval period, there is evidence that control over product shifted.

The Church, its Loss of Control and Conclusions

As the Scandinavian presence moved into the region and gained greater control there is also a shift in control over production. Workshops that previously showed evidence of working for and with a monastic market shifted to producing more secular material. This is largely seen through the sculpture, which had an increase in production and had more secular themes and depictions such as heavily armed warriors, groups of horsemen, and hunting (Blair 2005, 321). As Richard Bailey observes, such themes were uncommon in pre-Viking sculpture: 'the change in patronage has removed that conventional taboo and given us access to the manner in which this society thought it most appropriate to express its ideals and achievements, through the symbolism of the hunt and warfare' (Bailey 1996, 84–85). The scenes from Scandinavian mythology such as those on the Gosforth Cross (Figure 9-2) and found elsewhere are frequently used to argue for a continuing pagan tradition, but as Bailey (1996, 84–85) and Blair (2005) argue, could represent an assimilation of secular cultural imagery with Christian iconography: 'a folkloric manifestation of successful conversion' (Blair 2005, 322).

The impact of the centralisation of production, either through the Church or secular estates, on copper alloy dress accessories can be measured in many ways, yet due to the lack of evidence in Lindsey definitive conclusions are difficult to reach. The conclusions that can be reached from this dataset coupled with the historical context and other relevant studies are still significant. First is that the Church likely gained control over some aspects of production during the Mid Saxon period – a likely stage is the acquisition of raw materials and possible production of ready-made alloys that would then be exchanged with coppersmiths. The Church's most significant role was as a consumer and thus a facilitator of markets and exchange of goods, therefore expanding the market and easing material acquisitions for coppersmiths. Second, this control in the region of Lindsey was probably more centralised than seen in the Early Saxon period but not as centralised as other contemporary regions because of Lindsey's abundance of small monastic centres. This is building on Wilthew's (1984) study and is reflected in this dataset's wide range of clustered compositional results, perhaps showing many smaller centralised production centres, as Blair believes to be the pattern of monastic sites in Lindsey (Blair 2005, 212). Lastly, the decline of the Church's impact can also be marked from the shift away from the Church to the control by a Scandinavian political elite over production. This is seen through the change in stylistic expression but also the change in compositions moves from small variable clusters to having less variation, showing a more central urban manufacturing, in the city of Lincoln, compared to multiple small monastic sites across Lindsey (see Hadley and Richards 2021, Chapter 10).

Figure 9-2 Sigyn protected the bound Loki; engraving on the Gosforth Cross (Jónsson 1913, 95).

9.2.3. Lindsey Compositions within the Viking Diaspora

The Viking Age material analysed from Lindsey is significantly compositionally different from both the earlier material and from contemporary material analysed from Viking Age excavations, both within the Danelaw and abroad. However, the majority of the items previously available for analysis in England from past research were not completed objects; with a few exceptions, the more commonly analysed material is non-ferrous metalwork waste and equipment. Because of the nature of this material, conclusions about overall production will need to be drawn to provide comparisons. This section will delve into those differences and potential similarities between the compositional results acquired from Viking Age Lindsey to those from elsewhere in the Viking diaspora.

Lindsey within the Danelaw

This discussion begins by looking to analysis carried out within Lindsey at the multiple metalworking sites found within the city of Lincoln (see Figure 9-3 and Table 9-1), all of which have been compiled into a comprehensive report by Bayley (2008). This report includes some of Bayley's own XRF analysis as well as a reinterpretation of Blades' (1995) work, where Bayley brings the level of the data up to a more modern standard of practice, such as by eliminating any of Blades' results where the total was under 90% or above 110%. The materials analysed include crucibles, moulds, waste, the latter Bayley determines to be too corroded to reconstruct the composition, scrap, ingots and incomplete items, as well as precious metal refining items and materials associated with lead working.

Across the sites in Lincoln the primary metalworking occurring was melting silver and copper; there is occasional evidence for casting copper objects at Flaxengate, and ingots at Holmes Grain, as well as smithing copper at Flaxengate (Bayley 2008, 44). The data acquired from the analysis of the metalworking materials, and especially the crucibles, have a tendency to overrepresent certain elements such as zinc, which diffuses easily into the fabric of the material due to its high vapour pressure (see section 3.1.2 for further discussion), while silver and tin tend to be underrepresented in crucible fabric as those elements more often appear as metal droplets. Additionally, the metal deposits on crucibles are not evenly distributed across the fabric (Bayley 2008, 10). With those potential pitfalls highlighted, this Lincoln data can now be introduced. Of the crucibles analysed, Bayley found that approximately 40% of them were used for melting copper alloys, and the vast majority of those (85%) were zinc-rich and there were very few instances of tin or lead (Bayley 2008, 10). Here Bayley highlights that these sites were more likely to be producing wrought objects rather than cast; this can partially explain the absence of lead, as wrought objects suffer when lead is included (Bayley 2008, 10).

Though these sites tend to be producing more wrought objects, some moulds were recovered. The piece moulds recovered mostly only had very low readings of copper, zinc and lead – too low to draw any definitive conclusions. This is with the exception of the stone mould fragment F72 M85 (Figure 9-4); the readings of this mould had positively identified lead (Bayley 2008, 17). Ingot moulds were also found throughout the sites in Lincoln; from the XRF analysis the ingot moulds from the site of Flaxengate were likely casting silver with accidental impurities or debasing elements of copper, zinc, and lead (Bayley 2008, 19). An additional ingot mould that is significant, but not for its XRF readings, is LIN73 D1 62 2690 (Figure 9-5), which was recovered from Saltergate. This mould is made from a repurposed soapstone vessel; soapstone was imported to England from Norway either directly or through the Shetland Islands (Bayley 1992b, 7) and indicates continued trade connections or Scandinavian craftworkers using familiar materials (Bayley 2008, 20)

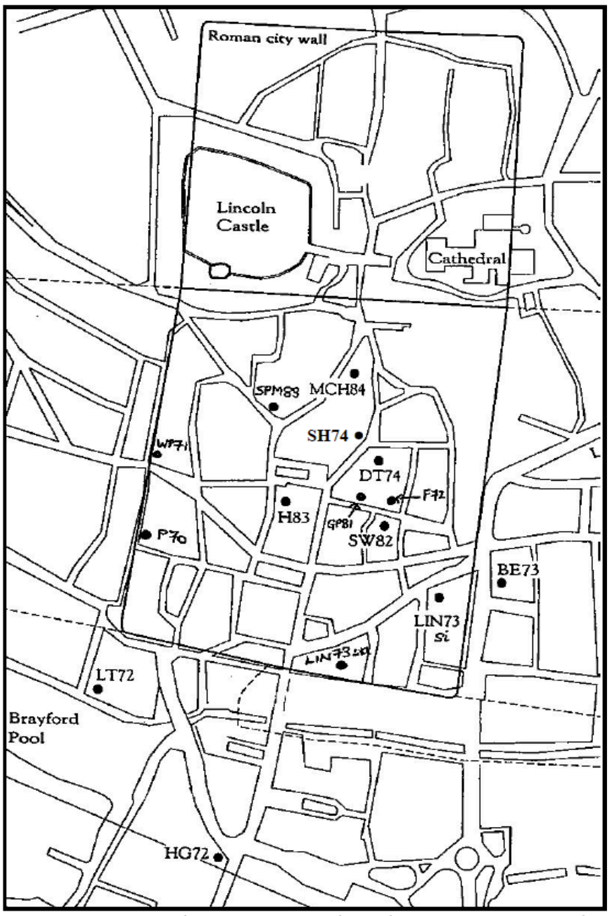

Figure 9-3 Viking Age metalworking sites in Lincoln; name key on Table 9-1 (Bayley 2008, 3).

Table 9-1 Site codes from Figure 9-3, adapted from Bayley (2008, 1)

Site Name	Site Code
Flaxengate	F72
Danes Terrace I	DT74i
Danes Terrace II	DT74ii
Grantham Place	GP8 I
Swan Street	SW82
Hungate	H83
Silver Street LIN A	LIN73si
Silver Street LIN B	LIN73si
Silver Street LIN C	LIN73si
Saltergate Lin D	LIN73sa
Saltergate LIN E	LIN73sa
Saltergate LIN F	LIN73sa
Broadgate East	BE73
Chestnut House, Michaelgate	MCH84
Spring Hill/Michaelgate	SOM83
Steep Hill	SH74
West Parade	WP71
The Park	P70
Lucy Tower	LT72
Holmes Grain	HG72

Figure 9-4 Two sides of stone mould F72 M85 (Bayley 2008, 17)

Figure 9-5 Soapstone vessel sherd repurposed as ingot mould LIN73 D1 62 2690 (Bayley 2008, 20)

The copper alloy scrap and ingots were originally analysed by Blades (1995); however, Bayley's (2008) revised analyses will be used here. The ingots and scrap were mostly brass and leaded brass (see Figure 9-6) with relatively low lead levels. Less than 25% of the objects analysed contained over 5% lead and four objects had more than 10% lead (Bayley 2008, 25). Furthermore, this data shows a much greater presence of tin than the metalworking materials described above.

The compositional data from Lincoln have observable similarities and differences to those outlined in Chapters Seven and Eight. The tin levels

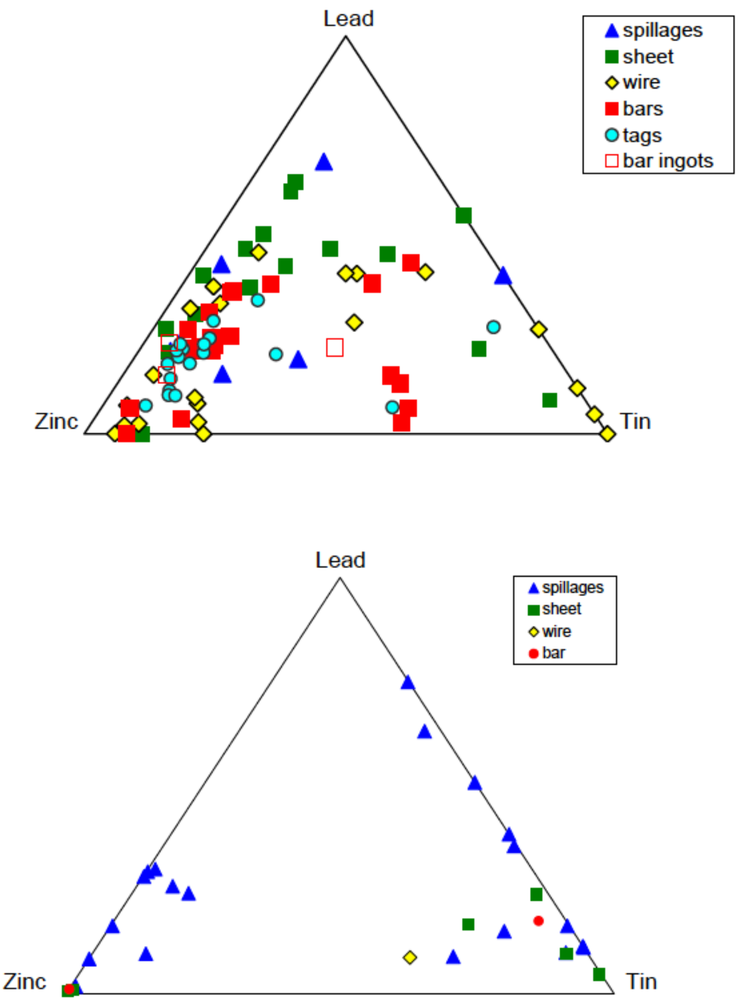

Figure 9-6 Flaxengate compositional data from copper alloy scrap and waste (Bayley 2008, 25)

found throughout Lincoln are relatively comparable to those found in this analysis, especially during the First Viking Age where more tin is seen in the objects. The zinc levels found throughout Lincoln are actually comparable and just a little higher to those found within this study's dataset, with the zinc content in this dataset ranging from 1% to 12%, and seven objects with no zinc in the First Viking Age, and 1%–18% in the Second Viking Age and six objects without traces of zinc. The sites across Lincoln have a similar range but also have high-zinc brasses with content over 20%; however, the majority of the objects have levels between 5% and 10% (see Bayley 2008, tables 31–37, pp. 127–138). The key difference in the composition between these objects, which includes the production material, scrap, and finished objects, is the products analysed for this study are far more heavily leaded than both the production waste and other material from Lincoln. This is an interesting result and potentially suggests that coppersmiths working in rural industries in Lindsey had access to zinc but were still alloying significantly with lead, the implications of which will be discussed at the end of the section.

York

By way of comparison, analyses of production debris from Coppergate and the objects from the furnished burial at Adwick-le-Street will be briefly discussed, as many of the results are remarkably similar to those found throughout Lincoln. As discussed in Section 2.2.2 the Adwick-le-Street burial is to date the only female burial in England that shows clear ties to a Scandinavian homeland in both the material culture and skeletal remains. Isotope analysis done on the teeth indicate she has origins in either Norway or North-East Scotland (Speed and Walton-Rogers 2004, 63). Furthermore, she was interred with a pair of almost identical ninth century Scandinavian oval brooches (Figure 9-7) and an Anglo-Saxon style bowl. The bowl is a leaded bronze, while both brooches were brass with tin-lead alloy plating on the flange that is either decorative or remains of the solder for attachments (Speed and Walton-Rogers 2004, 73).

Figure 9-7 Oval brooches from Adwick-le-Street (Speed and Walton-Rogers 2004, 64).

These results comprising of multiple alloys but with significant zinc and lead content are similar to the overall results from Coppergate. The Coppergate excavations yielded crucibles, ingot moulds, bell moulds, cupels, parting vessels, litharge, haematite, motif pieces, part manufactures, and coin dies (Bayley 1992a). Other sites in York also recovered crucibles, ingot moulds, moulds, and motif-pieces (Bayley 1991, 127). The crucible fragments associated with copper working revealed similar compositional data as those in Lincoln, and that those associated with copper working were primarily used for the melting of brasses. However, leaded brass is more common from the early 10th century in Coppergate when compared to the sites in Lincoln (Bayley 1992a, 808–809). Curiously, the ingot moulds recovered appear to have primarily been used for silver, even though the crucibles had significant copper alloy evidence and there were finds of fully formed ingots consisting of bronze, gunmetal and brass, suggesting that copper production in Coppergate was importing ready-made ingots and remelting to produce finished objects (Bayley 1992a, 832–833). Other significant finds from York such as the Blake Street mould (Kershaw 2013, 263–264) and the Parliament Street (Bayley 1991, 119) thimble crucible have, unfortunately, not had any compositional analysis performed.

Discussion

Upon closer examination of the dataset analysis in this research, alongside those from sites across Lincoln and at Coppergate, York, the results appeared to be more aligned than previously thought. The biggest difference is the cast objects studied in the dataset contain more lead than the metalworking material previously analysed by Bayley (1992a, 2008) and Blades (1995). This is especially true for material from the Second Viking Age. There are a few possible reasons why this disparity might be occurring.

The clearest reasoning is that, as Bayley (2008,10) hypothesised, these sites show more evidence of wrought copper alloy working than copper alloy casting. As discussed in section 2.3.5 lead can be poorly integrated into copper and result in lead globules; this creates more issues when working with wrought copper compared to cast copper. Lead in copper also improves the flow when pouring copper alloys, aiding in casting copper. Therefore, it is a logical conclusion when comparing cast objects to wrought production items that the cast objects would have a higher lead content. However, the cast objects have a lead content that is unexpectedly high, as over 8% lead in copper can lead to object failure in cast objects, yet this dataset contains numerous objects successfully cast with a lead content over 10%.

What continues to be interesting about these comparisons is that when looking at the amounts of zinc in all the data, it does not appear lead is replacing zinc as an alloying material as zinc levels are relatively similar across the cast objects analysed and the manufacturing material. Instead, it seems lead may be added in place of copper; this conclusion was drawn due to the disparity in copper levels between the datasets – the cast objects analysed here primarily had copper content between 70% and 80%, with some variations outside this range. In contrast, the material from Lincoln and Coppergate was closer to 80%–90%, again with some exceptions. This suggests that when supplies were low lead was being used to compensate for low amounts of copper to produce these cast objects, rather than zinc or tin. Following this theory, that could indicate copper was a more valuable commodity or in higher demand than zinc. The prioritisation of materials was likely a significant factor in production; as lead could not be used for wrought working, it was likely a conscious decision by copperworkers to preserve copper for wrought materials. With these theories in place, the scope can now be expanded to see how this mode of copper alloy production in parts of the Danelaw fits in the larger Viking diaspora – specifically, the Scandinavian 'homeland'.

Comparison with 'Homeland' Material

By looking at the compositions from the Late Saxon period to the First and Second Viking Ages and comparing the results of material from Lindsey to those from Scandinavia, a method for determining whether compositional changes were due to the incoming Scandinavian population or whether a more general, temporal change was already underway can be established. Of course, compositions cannot determine provenance, but what could be determined is whether metalworkers had access to similar amounts of alloying materials for the items found in Scandinavia and Lindsey. Therefore, the goal of this method would be to focus on determining whether objects are likely to be from the same production chain and not to focus on the exact location of ore and manufacture. The Scandinavian results available during this research are limited due to availability; some objects can still be examined to see whether any conclusions can be drawn from them about the Scandinavian material recovered from Lindsey. Additionally, like with comparisons from the Danelaw, there is no perfect comparison material available

The first site to be discussed is the data and results for the excavations and subsequent analysis that occurred at Kaupang in Norway. The range of objects analysed at Kaupang is similar to those from the Lincoln sites and Coppergate, such as ingots, metal production materials and waste. Sixty crucibles were initially analysed from Kaupang, but only twelve contained copper traces and the vast majority were used for precious metals. Of these twelve, only five contained identifiable metal particles while the other seven were copper oxide, which makes identification less certain. Yet there is still suitable evidence for the production of brass, bronze and leaded bronze (Pedersen 2016, 122). During an additional round of analysis thirteen more crucibles were tested; again the primary metal found was silver with small traces of copper, but with higher amounts of zinc (Pedersen 2016, 124). Similarly to the crucibles, casting waste of sprues and melted drops were both found to be overwhelmingly brass, with the majority having a zinc content of 14%–16% and only one of the twenty-one waste pieces analysed is a gunmetal (Pedersen 2016, 168–170).

Twenty-two copper alloy ingots were also selected for compositional analysis. Eighteen of these ingots were brass, four of which have some of the highest zinc readings from the Viking Age, three were gunmetal, and one was bronze. Two of the brass ingots contained lead, one with 0.6%–1.5% and another with 5.2%. Pedersen notes that five of the brass ingots have remarkably similar compositions to each other, with zinc levels between 20.3% and 20.8% (Pedersen 2016, 154–155). Additionally, the gunmetal ingots also have tin and zinc content consistent across the three; this is very significant because there is a perception that gunmetals were a result of poor recycling practices, but it seems that they were a far more intentional production (Pedersen 2016, 158). Additionally, two cast objects were selected for analysis, a Borre pendant (C52519/15915) and a fragment of a penannular brooch (C52517/2518); see Figure 9-8. these two objects are leaded gunmetals, a common alloy type found in the data presented in Chapter Seven.

Kaupang also has a significant quantity of lead finds, which sets it apart from many other Viking Age towns in Scandinavia. Pedersen attributes the lead to connections to the British Isles, specifically Dublin and York, especially as lead production sees an upturn in the 9th century (Pedersen 2016, 197). This is an interesting conclusion drawn by Pedersen, as lead in the dataset presented here is aligning with the start of the Viking Age. The implications of this will be discussed at the end of the section.

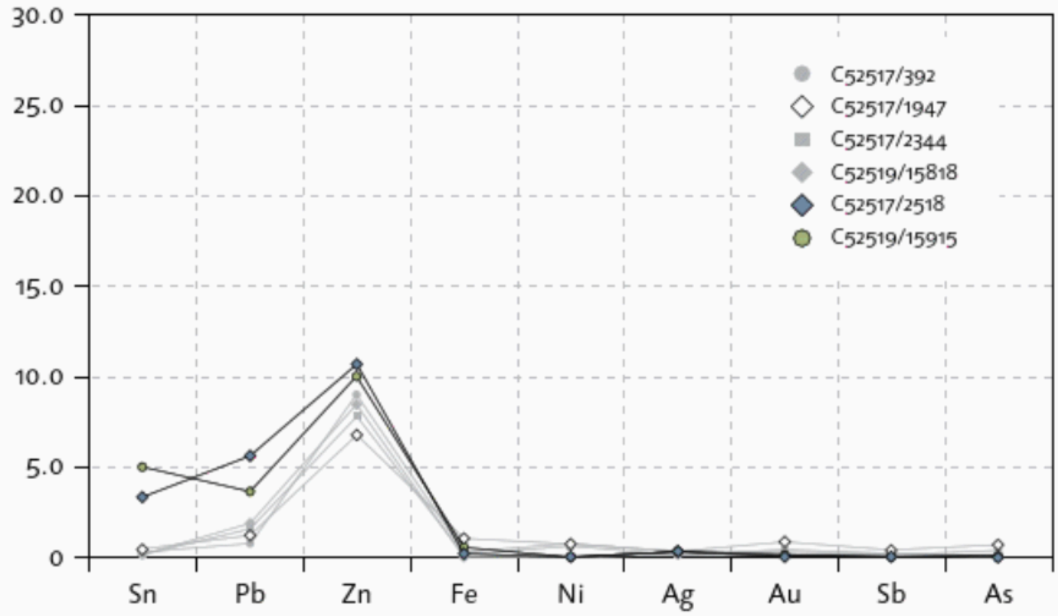

Figure 9-8 Compositional results from two cast objects and ingots found at Kaupang from Pedersen (2016, 179).

The 1995–2003 excavations of a Viking Age settle around Lake Tissø, Denmark, revealed a complex that includes three large halls and numerous other small buildings, interpreted as a cult site because of the lake's named association with Tyr, the Viking god of war. From the lake, archaeologists recovered multiple pieces of jewellery, including a number of brooches (Table 9-2), all of which predate Denmark's conversion to Christianity. These items are believed to be offerings to Tyr, a common practice in the Viking Age (Androshchuk 2010, 263–264; Jørgensen 2014). Additionally, a smithing complex was found nearby with numerous tools, suggesting that production was occurring near the site. Therefore, Lake Tissø, with its multiple examples of metalworking finds and evidence for production, can provide a good homeland comparison for the Scandinavian material found in Lindsey. However, the comparison is not perfect; as Lake Tissø is largely regarded as a ritual site it is highly possible that the types of copper alloy production occurring were specialised for ritual practice, which could influence the elements selected for production.

Table 9-2 Compositional results of Viking Age brooches from Denmark; adapted from Kershaw (2013, 258)

Item	Sn	Zn	Pb	Alloy
Trefoil Brooch, Lake Tissø, Denmark	5.92%	3.83%	3.40%	Gunmetal
Trefoil Brooch, Lake Tissø, Denmark	1.33%	7.99%	9.81%	High Zinc Leaded Copper
Trefoil Brooch, Lake Tissø, Denmark	3.07%	1.42%	7.41%	Leaded Copper

The results displayed in Table 9-2 show similarities with the results from the dataset discussed above; when looking at the overall alloy type, there is a high prominence of lead within the material. However, what is somewhat surprising is that even though the items are not bronze, they still contain high amounts of tin. As seen in the dataset presented in Chapters Seven and Eight, and as has previously been hypothesised, tin in Early Medieval England is often thought to be indicative of Anglo-Saxon production, and yet these brooches from Denmark have generally higher levels of tin than zinc and much higher levels of tin when compared to the Scandinavian items in the dataset recovered from Lindsey.

Additionally, a few copper alloy objects from Hrísbrú in Iceland were analysed with XRF; all but four of these objects had to be eliminated because of their heavily corroded nature. Interestingly, the four objects were all determined to be bronze with about a 2% lead content (Wärmländer et al. 2010, 2287–2288). This small but informative dataset allows us to draw some interesting conclusions about the production of Viking Age material. The first to be discussed is the hypothesis of whether the Scandinavian materials found in the UK are imports or whether they are locally produced. Many scholars (Richards 2011; Kershaw 2013) concluded that because these items have no Anglo-Saxon influence in the design or style they must be imports.

Discussion

The finds from Kaupang align almost perfectly with the Viking Age material found in Lindsey, while Lake Tissø and Hrísbrú suggest quite the opposite for the majority of the material in this dataset. The results from Kaupang reveal similar compositions to those in this dataset; they show high zinc use in copper alloys alongside high lead production and the very small dataset of cast objects shows them to be leaded gunmetals. The analysis of ingots and completed objects at Kaupang revealed that gunmetals were being intentionally produced and perhaps used and mixed with lead to improve to molten flow of the alloy to produce cast dress accessories.

Pedersen (2016) attributes the high lead values in Kaupang to connections with England, and it is significant that in England during the Viking Age there is also an increase in lead use. One theory for why this could be occurring is an improvement of trade networks across the North of England, in part due to the presence of Scandinavian settlements. There is a close connection between Kaupang and Viking settlements in England and there are clear sources of lead in the nearby Peak District that Vikings in England would have had access to (Sidebottom 2010, 28-33).

There are a few items in the Lindsey dataset that are Scandinavian styled materials with high tin content; these items could be argued to be imports. This is a surprising conclusion to draw, as Scandinavia has no naturally occurring tin deposits, so tin would likely need to be imported from the south-west of England or Central Europe. In regard to the Lake Tissø material, as it comes from a ritual site, perhaps the addition of imported tin added to the value of the object, making it ideal for deposition there, or perhaps Lindsey was not part of a trade network that allowed access to tin.

The high-tin materials in the Lindsey dataset do not seem to have any significant patterning to them, which implies various object types do not have different manufacturing traditions. They include a wide variety of object types such as bells, strap ends, brooches, buckles, and horse equipment. While there is not a correlation between high tin and object type there is one between high tin and decoration. The majority of the materials are decorated with the earlier Viking styles of plant ornamented, Borre and Jellinge, with no examples of the later styles. This could suggest objects being imported during the first wave of Scandinavian migration. Two high-tin object types in particular are important to discuss individually: the Norse bells and the die stamp, whose compositions can be seen in Table 9-3.

Table 9-3 Compositions of selected objects

Sample	Object Type	Sn	Pb	Zn
BE.001	Bell	12.24	27.65	0.77
BE.002	Bell	5.73	22.30	2.79
BE.003	Bell	2.48	24.11	1.31
DS.001	Die Stamp	2.98	17.57	2.46

The die stamp, Figure 9-9, is an important object and used to create pressed appliqué and filigree pendants, usually of silver or gold. They tend to be specific to a Viking means of production and are found throughout the Viking diaspora although they are most commonly found in hoards in southern Scandinavia dating from the late 10th to early 11th century (Skovmand 1942, 53; Armbruster 2004; 109–123). This specific die stamp is of the Hiddensee-Rügen type and has a terminal of Thor's hammer, a popular pre-Christian motif (Armbruster 2004; 109–24).

The die stamp is a significant find within Lindsey for two reasons. First, it is evidence that even though workshop evidence is scant, production of Scandinavian-style material was occurring in Lindsey, particularly in rural Lindsey. Furthermore, it was not just any type of production, but high-quality precious metal production was occurring. The second reason is that the die stamp demonstrates the spread of *producers* into Lindsey. If the theory of tin levels and importation holds true, that means that this item would have been made in Scandinavia and then brought to the Danelaw. Therefore, not only did the craft workers come from Scandinavia, but also materials, equipment, and methods of production. Their presence in the Danelaw and beyond is a promising route for further study.

A complication to the suggestion that high-tin objects represent imported items are the Norse bells found in Lindsey. Three of these have a high tin content, which could imply that they are imported. Norse bells are synonymous with a Scandinavian or Irish presence in England and Scotland (Schoenfelder and Richards 2011). There are parallels to those in this study from Freswick Links, Caithness; Peel Castle and West Nappin, Isle of Man; Iona; and the Wirral site of Meols (Batey 1988, 215). There are also parallels from Iceland, in a double burial at Brú and from Kornsá (Batey 1988, 215). However, Norse bells are unknown form in Scandinavian or Irish archaeological contexts, the single exception being a bell recovered from Christ Church Place, Dublin; however, it is of a notably different form (Batey 1988, 215). Given this, it is hard to imagine that an object would be produced in Scandinavia seemingly only for exportation, since there is no evidence of the bells being used there.

Additionally, the material from Lake Tissø and Hrísbrú further suggests that the dramatic shift away from tin in Lindsey was not the direct result of Viking settlement there. Therefore, the lack of tin is likely a result of the scarcity of tin resources and possibly limited trade with the south-west of England and Wales starting in the Late Saxon period and First Viking Age and into the Second Viking Age.

Figure 9-9 Die stamp DS.001 or LIN-1A1F1C, from Portable Antiquities Scheme

9.2.4. Conclusions

The Early Saxon period is the best research subperiod within the study region; multiple Early Saxon cemeteries have been excavated and their material subsequently analysed for compositional data. This allows for a relatively clear picture of the Early Saxon period and the typical compositions of bronze and leaded bronze occurring within Lindsey, with an increase of zinc in the northern half of the kingdom. The conclusions from the Mid-Saxon period are somewhat less definitive; it is highly likely there were small local production centres across Lindsey leading to a variation in compositions depending on access to raw materials.

The Church likely played a role in the process of centralisation of production; however, whether that role was one of direct control, influencing as consumers, or some combination thereof, remains to be determined. It is likely that this production remained in place as Scandinavia took political control over the region and production just functioned under different patronage than before. Furthermore, as this research is the only occurrence of compositional analysis for completed dress accessories in Lindsey from the Mid-Saxon period to the Viking Age, it is difficult to draw conclusions solely from this dataset, and it is necessary to expand the scope until more research is done. This is significant as much of the compositional analysis of the Viking Age Danelaw has been done on metalworking equipment of sites that likely produced wrought copper rather than cast; this difference in production would naturally lead to a difference a composition between materials.

9.3. Curated Identities in the Early Medieval Period and the Role of Dress Accessories

Previous studies of Early Medieval copper alloys have tended to focus on the metallurgical results or the stylistic data (Bayley 1992a; Thomas 2000). This study seeks to determine whether the compositional data and stylistic data can be used in conjunction to answer these complex theoretical questions. As the dataset presented in Chapters Seven and Eight is a smaller dataset, for the following discussions the data will be viewed in conjunction with other studies and data, positioning itself as part of a larger body of research rather than on its own. It is evident that before the immigration of Scandinavian populations, there was already a strong regional identity within the Anglo-Saxons population. Subsequently, as discussed, there were three significant shifts in composition away from high tin content to the high variability of compositions, and then another shift to significant lead content. These results do not support past hypotheses (Bayley 1992a) that Scandinavian immigration and settlement resulted in a rise of zinc content, at least within the former Kingdom of Lindsey. The move to high lead content, as discussed in the previous section, does correspond with the increased prevalence of Scandinavian and Anglo-Scandinavian objects in circulation during the First and Second Viking Ages, found across research on the Viking Age Danelaw (e.g. Kershaw 2013). The following subsections will explore a range of themes discussing curated identities, which will build on the previous section in order to explore how identity was displayed in this region and the Early Medieval period as a whole. These sections rely heavily on the stylistic data, the compositional data will enter the discussion when determining whether these identities went so far as to impact the metal alloy producers and metalworkers in Lindsey.

9.3.1. Status, Identity, and Material Culture

This section tackles multiple complex issues surrounding identity that are commonplace within archaeological research. The following data and discussions will explore the divisions, changes, and potential similarities between the three possible stylistic groups: Anglo-Saxon, Scandinavian and Anglo-Scandinavian, from the Early Medieval period. Early Medieval Lindsey had constant immigration and border changes, making it a complicated place to study identity. Many of the objects and cultural groups studied here are the results of hybridisation, assimilation and acculturation (Hutnyk 2005, 80–81; Bergstøl 2004, 8; Eriksen 1994, 11–21). The Early Medieval Period sees continuous immigration starting with Germanic groups moving in after the Roman withdrawal and then a few hundred years later there is another uptick in immigration, with incoming Scandinavian populations.

These movements can be understood as colonisation, during which hybridisation and acculturation occur because the political interests, economic desires and social identities of colonisers quickly and drastically change compared to those of their homeland populations; this, therefore, leads to the creation of entirely new identities (Stein 2005, 28). Hybridisation has some issues because it assumes that the original cultures are not hybrids, a notion with which this author disagrees. The primary acculturation this research sets out to study is that which is occurring between the Anglo-Saxons and the Scandinavians, or really the similarities seen in compositions between the groups.

There are a few crucial ways Scandinavian and Anglo-Saxon material can be differentiated: by item type, item style, and for some items, manufacturing technique. This thesis explores the actual differences in methods between the two cultural groups. Chapter Six contains further discussion of these specific styles, types and techniques. These distinct differences clearly set Anglo-Saxon and Scandinavian material apart from one another. However, what begins to occur during the Viking Age is a hybridisation of material that has aptly been named Anglo-Scandinavian; a commonly found example of Anglo-Scandinavian material is a disc brooch, an Anglo-Saxon object, with a Borre ring chain, Scandinavian style, on the face of the brooch.

There are theories in which every Scandinavian or Anglo-Scandinavian item has been argued to be evidence for Viking settlements (e.g. Kershaw 2013). As discussed in Chapter One, these defining terms do not equate to populations, but rather to a taught method of copper alloy production that is most closely associated with a specific cultural group. By using definitions associated with those known ways of producing and designing copper alloys, the conclusion is reached that an Anglo-Scandinavian object can be defined as any object with a combination of Scandinavian and Anglo-Saxon stylistic elements.

These stylistic combinations may have occurred for numerous reasons. The most prominent theory is that Anglo-Saxon producers were making dress accessories for the incoming Scandinavian settlers (Kershaw 2013, 40, 129, 143). This theory has also been applied for the Viking Age in other areas settled by the Viking diaspora, such as Ireland (Michelli 1993). The approach this study follows is the premise that the interaction between the two groups was quite high, leading to the transition and exchange of technological practices that would, consequently, begin to blur the lines between the two groups in terms of their technology. Additionally, since Scandinavians were the group in political dominance, Anglo-Saxons native to the Kingdom of Lindsey wearing items in a Scandinavian style would have tried to align themselves with that political group (Johansen 1973, 114, Kershaw 2010, 243-248; Michelli 1993, 183). A big market would have developed for Scandinavian styles and object types; Anglo-Saxon producers would have been likely to seize this opportunity to sell in Scandinavian circles, but also within the native population groups with political aspirations (Michelli 1993, 183).

However, just like the theories of hybridisation, that initial question was formed around the assumption that the Anglo-Saxons had a cohesive identity, which is not the case. Additionally, there was an initial division between those remaining in the Kingdom of Lindsey and the incoming Germanic populations from the 5th century. These ideas, while not new, raise multiple questions concerning how the Anglo-Saxon population self-identified. Brooks (1989) states that individuals most likely identified with a local leader or as a specific religion – so did our study population then identify as being from Lindsey or were there further divisions, and how would that identity change as the political boundaries shifted? Furthermore, did their identity become more unified when a new 'other' (in this instance the Scandinavians) began settling in Lindsey?

Some of the Early Medieval regional identities have been touched upon when discussing object types; the local varieties demonstrate the variation in object types, especially those seen dating to the Early Saxon period. Early Saxon objects are frequently classified as being Anglian or Jutish, Kentish and Frankish, such as cruciform brooches being divided into Anglian or Kentish types (Martin 2015, 113). These clear group identities within the material culture of Anglo-Saxon England begin to show how dress accessories are commonly used as significant indicators of status, identity and political allegiances in the Early Medieval period in the British Isles. These indicators are not just the physical materials, but the traditions associated with their use, deposition and, of course, their production (Sharples 2003, 161–162).

A significant question that remains throughout this research is whether Scandinavian objects indicate a Scandinavian presence and identity. Dress accessories are largely considered to be displays of identity (Thomas 2000). However, displays of identity can be different than actual identity; in short, display does not always equal identity. Shanks and Tilley best summarise these ideas:

Material culture is assumed to passively reflect individual or [cultural] identities. It is quite possible that precisely the contrary situation may take place, in which style is actively manipulated to invert, disguise, and misrepresent social practices. Furthermore, style cannot be held simply to mirror social strategies and practices but can also mediate and therefore serve to actively reorient these strategies (Shanks and Tilley 1987, 142).

So, then we have to return to that initial question; can we actually conclude that 'Scandinavian' objects were being worn by Scandinavians? To add to the debate surrounding this question other types of evidence and their prevalence can be addressed. Other evidence, such as place names with Scandinavian roots, are abundant throughout Lindsey, while other forms are lacking completely, such as 'Scandinavian' style burials.

The lack of Scandinavian burial evidence in this region has been a significant topic of discussion. Hadley and Buckberry (2005, 138-139), as an explanation for the lack of Scandinavian burials in Lincolnshire, suggested that Lindsey had such a high level of overt Scandinavian displays of identity, such as through dress accessories, that the same displays would not be necessary for burial practice. However, in other areas settled by the Viking diaspora, burials are a primary focus of research and often reveal complex and multifaceted displays of identity (e.g. McGuire 2009).

These potential discrepancies in displays of identity and perhaps a lack of overall understanding of what this identity looks like bring us back to the introductory discussion of hybridisation. Hybridisation comes with many issues in itself, primarily disregarding other factors that accompany migration like displacement and the changes that will inevitably lead to new identities as time goes on. These ideas and their impact are explored by Espolin Norstein (2014), who shows the development and indisputable change that occurs in 'Norse' burials in Scotland. While a different study region and material of study, Norstein's conclusions are significant and highly relevant to this dataset. One of her conclusions is that certain aspects of Norse identity may have grown more significant because this group of migrants that previously did not view themselves as one cohesive group now did (Norstein 2014, 45). She also shows that there is a significant quantity of Norse-type burial practices in Northern Scotland and, therefore, clear displays of this identity harking back to their homeland traditions (Norstein 2014, 75).

Similar theories were proposed by McGuire (2009, 268–269), who compares grave goods and isotope analysis of the skeletons. McGuire found a strong correlation between significantly masculine grave goods and males born in Iceland and theorises that displaying masculine identities grew more important over time in Iceland, or that 'it is also plausible that the second and third generation immigrants were using burial ritual more than their parents/grandparents for the purposes of (re)negotiating their place in society.' (McGuire

2009, 269). McGuire also discusses two female graves in Scotland that have local-fashion grave goods as well as Scandinavian. This display could either be local women adopting the incoming styles or Norse women embracing a local fashion. Overall, McGuire concludes that displays such as these could be a Scandinavian population establishing themselves as an elite group, but that they could also be used to mark individuals in the native population who were considered elite (McGuire 2009, 268). Similar patterns of Scandinavian and local grave goods can be seen with the Adwick-le-Street burials, in which a Scandinavian woman was interred with oval brooches and an Anglo-Saxon-style bowl (Speed and Walton-Rogers 2004, 64). If these boundaries of identity can be easily crossed in contexts such as burial, it is likely they are also being crossed through the use of everyday dress accessories.

Social Status Displays and Association with Political Elites

A common discussion surrounding the use of Scandinavian-styled material within the British Isles is the association of the material with the political elite (Michilli 1993). This point of discussion is convincing, as Scandinavians quickly became the leading political power in north-east England with the establishment of the Danelaw. The use of material culture to align with a specific group and those in political power is a well-established phenomenon in the archaeological and historical literature, frequently referred to as instrumental ethnicity (Foot 2002, 58).

The quality and composition of the material in this dataset suggest that these items were not produced for elites. The heavily recycled and heavily leaded compositions would have been at high risk of failure, as previously discussed in Chapter Four, and they have limited traces of precious metals such as silver and gold; it is highly likely that many of the dress accessories found by detectorists were mass-produced (Richards 2005, 66). Nevertheless, there is evidence that high-quality dress accessories were being made with the die stamp (DS.001) in this dataset. In addition, there are metal-detected items that serve as evidence that have not been included here as they are both silver not copper alloys, such as the Odin Pendant (NLM-7F954A) and Thor's Hammer (NLM-1A6811), both in North Lincolnshire Museum.

The majority of Scandinavian and Anglo-Scandinavian dress accessories uncovered are of lower-quality material. However, they closely mimic precious metal elite styles and forms, specifically brooches, strap ends, and equestrian equipment. It is unclear whether this desire to emulate these higher-quality styles would originate from those within the elite or not. It is highly likely that this production was initially controlled by elites to establish and continue their own ideas and political dominance. These ideas have been explored throughout studies of the Viking diaspora, primarily by Michilli (1993) in her study of Hiberno-Norse penannular bossed brooches. She trialled a methodology to trace how decoration was applied and how the craftworker was taught to construct patterns (Michilli 1993, 182).From this Michilli is able to see patterns that suggest Scandinavian craftworkers, as the laying out of patterns of the Hiberno-Norse brooches have comparatives in Scandinavian material but not early Insular art forms (Michelli 1993, 185–186). Michilli began her (1993) study as she saw an issue with the assumption that craftworkers in Ireland would simply accept the new methods and ways of production. It is essential to consider that production at this point may have already been under the control of a political or religious elite. Therefore, it is not inconceivable to assume that craftworkers would have been more than able to deal with the political change and new methods and styles of production.

Theories that argue material culture was used to assert political dominance are supported by the presence of high concentrations of Scandinavian material in locations that bear Scandinavian place-names (Richards 2011). One such example is South Ferriby, which contributes a high number of items in this dataset. The use of place-names in archaeological studies is an ongoing debate. Many place-name scholars have found a relationship between place-names and the borders of Scandinavian settlements (Fellows-Jensen 1989, 1990; Richards 2005, 64–66). However, Scandinavian place-names are difficult to date as many are only first officially recorded in the Domesday book, 200 years after initial Scandinavian migrations began (Richards 2005, 66). Fellows-Jensen has been able to narrow the timeframe in which these place-names would have been established by observing the distribution of the suffix -*by*. She observes that -*by* is not found in the area Scandinavians lost control of in the first half of the 10th century, such as the North-West (Fellows-Jensen 1989, 79, 81–82; 1990, 16-17). Therefore, it can be argued the occurrence of such place-names aligns with general areas of Scandinavian settlement that continued past the early 10th century (Fellows-Jensen 1989, 82).

There is evidence that Old Norse and Old English would have been somewhat understandable between the two groups of speakers. This is best demonstrated by the Old English poem the Battle of Maldon; in this poem a Scandinavian leader, Olaf, addresses the Saxons directly, and the dialect of the poem shifts slightly when Olaf speaks compared to the Old English speakers (Pons-Sanz 2008, 421). This marks his language out as different, but the ongoing conversation is understood by both the groups; this comprehension extends to the characters in poem and the poem's audience, and shows that Olaf, when speaking in Old Norse, would have been understood by all (Pons-Sanz 2008). Given this, the hybridisation and loan words seen between the two languages in the Second Viking Age is not surprising

(Richards 2005, 65). Therefore, it is crucial to consider that the role of Old Norse place-names was a further attempt to assert dominance by the new incoming population.

However, once the Scandinavian rulers of the Danelaw had firmly asserted their political dominance, it is possible that then the general population would have accepted new object styles as the new norm and adapted them in their own ways. As Scandinavians continued to establish political dominance, it is unsurprising that, even without any elite pressure, the popularity of the items would increase. Some of these items would be exact copies or made by incoming Scandinavians, as would be later classified as Scandinavian, and others would be a mix of Scandinavian and Anglo-Saxon styles and types. Regardless of being Scandinavian or Anglo-Scandinavian, the outward display sent a clear message aligning oneself with the new political elite of Lindsey.

Gender Displays

The sex ratio of the Great Viking Army and the migrating Scandinavian populations has long been a point of academic study and has undergone many paradigm shifts. This is now far more complex than what was once thought of as 'a demobbed Norse army seeking Anglo-Saxon wives' (Mcleod 2011, 352). Mcleod (2011) provides an overview of all the relevant evidence both for and against the presence of women in the initial wave of the Great Viking Army, the period immediately after, and the settlement period, from which he concludes many relevant points such as women and children likely accompanied the Great Viking Army in the campaigns in the 860s and 870s, showing that winning homeland could have always been the intention of the raiding parties. Additionally, in the 890s, women and child were likely left in Norse-controlled areas with an Anglo-Saxon client king as the Army progressed (Mcleod 2011, 351). Lastly, Mcleod concludes that intermarriage was probably less common that previously thought, and accompanying women were likely wives of the members of the Great Viking Army (Mcleod 2011, 352). The presence of women with the Great Viking Army primarily indicates the Viking Age styles described in Chapter Six were likely brought to eastern England by individuals wearing them rather than trade. Furthermore, Anglo-Saxon producers would have likely made objects now frequently referred to as Anglo-Scandinavian for these Norse women remaining in client kingdoms, but also potentially Anglo-Saxon women as these styles grew in popularity. These displays of gender and cultural identity can be examined more closely.

Gender displays are reflected in both Scandinavian and Anglo-Scandinavian objects during the latter Early Medieval period. To continue with this discussion, it is important to determine which objects are associated with which genders. While there is some fluidity within these gender groups, the archaeological evidence suggests that dress accessory objects did not transcend these gender displays. In contrast, other items displaying profession or status did (Price et al. 2019; Hedenstierna-Jonson et al. 2017; Hadley 2008). This dataset has evidence of both masculine and feminine accessories with Scandinavian and Anglo-Scandinavian styles. This evidence continues to undermine the traditional narratives of the Viking raids and subsequent settlements simply being the actions of men; while this narrative has steadily been disproven over the last 30 or so years (van Houts 1999; Kershaw 2013), it is still an important ongoing discussion and deserves to be considered here.

The vast majority of the Scandinavian material recovered for this dataset consists of brooches, a form that also comprises the second most abundant Anglo-Scandinavian object type. Kershaw (2013) has extensively proved, based on clothing style, fit, and pin fittings, that brooches were almost exclusively a feminine dress accessory as the shape and pin length of these brooches would not work with the style of clothing worn by men in Scandinavia and the British Isles in the Early Medieval period, such as tight-fitting shirts with round or square necks or heavy cloaks that secured at the shoulder (Kershaw 2013, 171). The only exception to this patterning is highlighted by Maixner (2005), who uncovered trefoil brooches with diagonal fastening in six male graves, worn at the hip or shoulder. This use is primarily attributed to the trefoil brooch's development from Carolingian mounts (Maixner 2005, 205–6). Maixner concludes that this male use of trefoil brooches appears to be short-lived and soon became exclusively feminine (Maixner 2005, 213–4).

Van Houts (1999) has argued that in medieval societies, women were frequently considered as bearers of cultural tradition. This practice is undertaken through many performative actions; the most relevant to this study, and one that can be easily seen even before the establishment of a Scandinavian presence in Lindsey, is the association made because of visible dress accessories, as well as with practices of passing down of artefacts, specifically jewellery, for generations (van Houts 1999; Kershaw 2013). Therefore, the high number of feminine dress accessories can be, to a degree, attributed to women's roles as keepers of traditions and their homeland styles and practices, even generations later. These ideas also feed into notions raised during this study's discussion of social status display, and how these cultural ties may have actually grown over time. Marriage is often discussed as leading to new kinship and possibly new identities for women and would likely play a significant role in Early Medieval gender politics (Magnúsdóttir 2008, 42). However, the notion of mixed identities seems quite well accepted in Early Medieval Lindsey, with displays on metalwork, and personal names (Richards 2005). The Domesday Book, while postdating the study period, shows this trend well. In Cheshire, 50% of recorded names are of Scandinavian origin. In the north and east of England the personal names of Scandinavian origin are different than those recorded in Scandinavia and reflect compound names between Old Norse and Old English (Richards 2011, 49–50). Therefore, even as assimilation continued, displays of homeland identity would likely remain significant for women.

In comparison, the frequency of male Scandinavian-style dress accessories is quite low in this dataset, as well as in other studies (e.g. Kershaw 2013). This is partially due to the fact that many other accessories recovered from the Viking Ages, such as strap ends and buckles, were not restricted to masculine uses, as shown by their recovery from both male and female graves (Petersen 1928; Fanning 1994; Graham-Campbell and Batey 1998; Leahy and Paterson 2001). One explanation for the smaller amount of male associated finds is that their way of dressing simply involved fewer pieces of metalwork (Kershaw 2013, 175). Further theories are formed from a visible shift in this established ratio of feminine to masculine items.

The Late Viking Age Ringerike and Urnes styles have become more exclusively associated with masculine items in the British Isles (Kershaw 2013, 175). This shift is notable due to the large amount of equestrian equipment in these styles and the relatively low number of brooches of the same decoration. This shift in ratio is also directly reflected in this dataset; of the Scandinavian and Anglo-Scandinavian brooches, only two are in a later style, Ringerike, while nearly all of the horse equipment is in the Ringerike, Mammen and Urnes styles. This apparent reversal of gendered displays raises interesting questions about the displays of Scandinavian and Anglo-Scandinavian identity. The riding equipment is believed to have originated in Denmark before being exported, either as items or ideas, to England (Pedersen 2001, 51–4; Bill and Roesdahl 2007, 22). The cavalry and its accompanying material are usually associated with King Cnut and his unification of the Scandinavian kingdoms and subsequent military hegemony in England (Graham-Campbell 1992, 88). This new focus of unified military dominance likely shifts and lessens the need for women to be the bearers of visible Scandinavian traditions (Kershaw 2013, 177) and perhaps marked the change from assimilation to political dominance.

The gender displays associated with cultural groups through dress accessories can show not only the importance of identity displays, but also the overall fluctuation in receptions of cultures and other ways of curating their identities. The gender displays associated with the Scandinavian styles undergo their own transformation. They, therefore, reflect a change occurring within the display of cultural and gender identity in the Early Medieval period.

Conclusions

Scandinavian and Anglo-Scandinavian material culture has frequently been used to confirm theories of Scandinavian migration and movement throughout the British Isles (Richards 2005). However, while the significant migration into Lindsey and across the Danelaw impacted dress accessories, their use as symbols of identity, as has been demonstrated above, is far more nuanced. During these discussions, it is evidenced that cultural identity in the Early Medieval period was not a stagnant concept but was constantly evolving. It was a malleable concept that could be used to mould and shift a community and individuals (Geary 1983, 16). These ideas are supported by Espolin Norstein's (2014) and Thomas's (2000) data showing a visible increase in Scandinavian identity as time progressed, to enable later generations to remember the 'homeland'. These ideas are not directly reflected in this dataset, but instead, we see a shift in the way that Scandinavian and Anglo-Scandinavian identities are being represented, and they have a close connection to gender displays.

The discussions surrounding the power dynamic represented in the styles of the Early Medieval period led to the conclusion that it is likely to be a combination of cultural identities, with individuals wearing these items either as a conscious or unconscious attempt to align themselves with the political elite or as a way to show remembrance to an ancestral or kinship heritage and continue those traditions. The potential for items to be gifted down ancestral or kinship lines works with the seemingly longer popularity of earlier Scandinavian styles in the British Isles (Williams 2006, 15).

During the First and Second Viking Ages there were no strong patterns between the compositions and cultural groups; this likely reflects a lack of division in material production. However, as the data obtained for this study is the only instance of Viking Age compositional analysis of finished copper alloy objects, aside from ingots, in the region, these theories put forward need further research to be strengthened. With that in mind, there is a potential for future research along these lines and following the work of Jocelyn Baker (2013). Baker (2013) looked at the compositions of Early Saxon objects and their resulting colours to discuss the implication of colour use and aesthetics during this period. Similar principles could be applied to material from the latter half of the Early Medieval period to establish whether there are patterns agreeing with the other theories of identity display for the Viking Ages.

9.4. Summary

The compositional changes over time experience significant fluctuations. This ambiguity allowed multiple routes and theories to be explored to see how and whether they would impact compositions of metalwork. It also highlights where there are excellent opportunities for further study especially regarding trade practices and the impacts of conversion. Both discussions required looking beyond Lindsey to the remainder of Anglo-Saxon England. Additionally, conversion and political boundaries had to be discussed in overarching ways. These discussions could greatly benefit from a narrower focus solely on them and how these major historical events were affecting the everyday.

The materials studied as part of this dataset add to the established theoretical notion that dress was, and continues to be, a way to include and segregate different populations and social groups by merely making them look different. However, as we have discussed, outward displays of identity were heavily curated – from outward cultural displays to social status and gender through the use of dress accessories. Therefore, Anglian and Scandinavian objects may not reflect actual Angles or Scandinavians but instead populations that were heavily influenced by new ways of dress, with evidence of an increase in the desire to display Norse identity as time passed, as a way of remembering their homeland identity.

Craftworkers, whether under elite control or not, were able to market this opportunity as many of these items were probably made locally and not imported, as demonstrated by the compositional results and the possibility of accessible materials. Furthermore, integration between cultural groups likely resulted in conflicting gender and cultural identity displays, leading to the question, would individuals choose to display their original identity or that of their new kin?

The exploration into this dataset uncovered some of the questions put forward in Chapter One. From this data, it can be definitively concluded that any disparities in compositions during the latter half of the Early Medieval period are not due to active cultural differences but instead represent a lack of materials, specifically tin and zinc, coming into the former Kingdom of Lindsey. The compositions suggest that by the Second Viking Age the production of Scandinavian, Anglo-Scandinavian, and Anglo-Saxon items was probably occurring alongside one another.

Chapter 10. Conclusion

This chapter provides a synthesis of the conclusions drawn from this research. The aims of this research were to first establish a basic compositional chronology for metalwork compositions in Early Medieval Lindsey as well as to discover whether compositional changes in metalwork are connected to socio-political developments in Early Medieval Lindsey. This chapter will discuss the success of these aims as well as explore the implications of this new research within the previously established Early Medieval copper alloy corpus, while providing the first picture of the copper alloy compositions across Early Medieval Lindsey. Further, the integration of materials not traditionally sourced for scientific analysis attempted to remedy the lack of visibility of Early Medieval Lindsey in the archaeological record and has resulted in the conclusions presented here.

10.1. Summary of Primary Results

10.1.1. Patterns in Alloy Use

The material analysed revealed that copper alloy composition varied greatly across the Early Medieval period in Lindsey. While there were issues with the lead content as discussed in 5.5.4 there results are still significant. The Early Saxon period saw high levels of tin content, moderate lead content and low zinc levels. This result can be attributed to recycling of the large quantities of leaded bronze material left from the Roman period and the production of brasses and gunmetals without proper cementation methods. As there is little evidence for ore extraction during this time, along with these compositions it is a likely conclusion to draw that most material was produced from recycled Roman scrap. Recycling was not as haphazardly done as previously thought (Dungworth 1995; Baker 2013) but was instead done with intentionality. This is best illustrated by the composition of square-headed brooches (section 8.1.3), which have a heavily mixed composition of gunmetal and would have been gilded.

These patterns in alloy use are relevant thanks to Baker (2013), who concluded that gunmetals would produce inconsistent colouring, and reusing scrap for objects that were later gilded shows knowledge and intentionality of the process. The inconsistent colouring caused by gunmetals would have been covered by the gilding, allowing metalworkers to reserve other scrap for objects that would not be gilded, but still produce an 'ideal' colour. Other key variations between objects largely tend to be due to chronological shift rather than solely based on the object being produced.

By the Mid-Saxon period there is a shift to a higher variation in the ratios of tin, zinc and lead but with some clustering of similar compositions. This is likely due to the centralisation of production in Lindsey being small and still relatively localised, leading to many small points of production. These compositional trends continue into the Late Saxon period and First Viking Age, likely as the Scandinavian elite moved in and took control of those production centres.

By the Second Viking Age, there is far less variation in compositions, as tin is rarely found in the copper alloys and the majority are leaded copper or leaded brass. The prevalence of zinc is found across the Viking diaspora; however, these lead levels are unusually high, even with the error corrections done. A key reason for the high lead level and low zinc level could be the difference in manufacturing. Studies of Viking Age copper alloys, such as that by Bayley (2008), primarily examined wrought copper alloys while this research's dataset consisted of cast copper alloys. Lead would improve the molten flow of the copper alloys and would therefore be better suited for cast copper, while zinc can improve the malleability and therefore aid in producing wrought copper alloys.

While the dataset was overall too small to delve closely into local variation within Lindsey, some basic conclusions can be drawn. The compositional data from this research, particularly from the Early Saxon period, agrees with Mortimer's (1990) research about the compositional differences between North and South Lindsey. However, for later periods, it is unclear whether there is minimal local variation or whether the small dataset made it impossible to continue to discern local differences.

This research primarily focused on rural material, as is often the case with metal-detected material, while past research on Early Medieval copper alloy composition comes from urban environments, specifically for the Viking Age. It is a natural inclination to compare the different compositions as rural and urban industries; the material from the urban excavations of York and Lincoln show objects have a much higher zinc content and lower lead content than the rural material, but this comparison is quite misleading. The majority of the material recovered from York and Lincoln is wrought copper alloy while the material in this dataset is cast copper alloy. As discussed in section 9.2.3, zinc is more suitable for producing wrought copper alloys while lead is more suitable for cast copper alloys. This is likely to be the cause of differences between the urban and rural compositions rather than location of industry. The recovery of material also plays a major role here but will be further explored in section 10.1.3 when discussing the positives and negatives when working with metal-detected material.

10.1.2. Analyses of a Range of Copper Alloy Material from Early Medieval Lindsey

This aim was the first to be accomplished. There were some continued access issues for some material, but a suitable range of material was able to be analysed to adequately represent each subperiod of the Early Medieval period in Lindsey. This range of analysis is the first done within the region and the first relying primarily on metal-detected material, which is what allowed this representative analysis to be accomplished. While these results are semi-quantitative, they still provide an overview of broad alloy change. The changes observed are a decrease in tin and an increase in lead. From these changes new questions about copper alloy compositions from the Early Medieval period can be raised and discussed.

10.1.3. Working with PAS and pXRF

One principal aim for this dissertation was to explore the applicability of metal-detected datasets within archaeological science methodologies. This goal is one that goes beyond the parameters of copper alloy composition or Early Medieval studies. Metal-detected items are often neglected because of their lack of context, when in reality they provide a wealth of information; this thesis has demonstrated the utility of these collections for such research. As so many objects in this study came from metal detected sources, the assumption was that access to materials would be the greatest challenge; however, upon hearing their objects could be used for further research, detectorists were overwhelmingly excited to share their objects. Furthermore, most of the objects collected for analysis were in a suitable condition, in regard to corrosion, for pXRF analysis. Additionally, while pXRF still does not provide the same level of detail and precision as XRF, the portability of the machine allows for the additional of valuable information, even if semi-quantitive. Therefore, the argument can be made that further steps should be taken to integrate the PAS and metal-detected finds into continued scientific analysis.

While working with the PAS was a surprisingly positive experience, using it as a primary source of data in conjunction with the pXRF also revealed many cons. Since, at the time of the research, further scientific analysis had not been previously undertaken, there was no set methodology to rely upon for potential issues and any solutions needed to be determined as issues arose. Corrosion was expected to be a major issue when using pXRF, but there was no significant difference found between the metal-detected items and the museum items. This is very circumstantial, however; each detectorist worked with over the course this project kept their items well packaged and cared for – this may not be the case is other areas.

One key aspect of using metal-detected material is the difference in recovery compared to excavated material. The most prevalent issue that occurred with using PAS material was often that if items were returned to the detectorists, they were not kept in the PAS labelled bags; because of this seemingly small issue, a lot of time was spent finding the correct PAS numbers for multiple items to ensure the correct object was being recorded. While many detectorists are quite knowledgeable about the material they recover, as they are not archaeologists working on an excavation their recovery and retention processes are quite different than many researchers might be used to. This is all to say that material without discernible features or with clear indication of item type or period could be disregarded by detectorists or not reported to the PAS. Furthermore, even if reported to the PAS, if the item does not have a stylistic attribute, it cannot be connected it to a time period – a known issue for material without context. This is relevant when discussing the divide between urban and rural material and the recovery between wrought and cast copper objects. Wrought copper is less likely to be decorated and identifiable to a specific period so detectorists likely disregard this material, whereas if recovered from excavations it is easier to date. Therefore, this difference in recovery methodology could be the cause of the difference between urban and rural compositions, and it highlights a key issue in the recovery of metal-detected materials.

10.1.4. Copper Alloy Compositions within Lindsey and the Wider Early Medieval Context

Copper alloy production and consumption within the Kingdom of Lindsey appears to be distinct from the surrounding kingdoms and to be varied even within the region itself, firmly placing these results as a significant part of the story of Early Medieval copper alloy production. Lindsey seems to have not been as well connected as other areas of both Anglo-Saxon England and the Danelaw, as shown by the lack of trade occurring within the region throughout the Early Medieval period, and this disconnect is reflected in the compositions. Additionally, by placing Lindsey in the wider context, it is demonstrated that the theories about an increase of zinc in copper alloy production, especially in the Viking Age, are based primarily on wrought copper alloy production, which would yield different compositions to cast copper alloy production.

10.2. Future Research

As with many projects of this scale, while some questions are answered, many new questions are raised. Some of these questions led to unexpected routes of research and productive discussion within this text. However, many others were not in the scope of this research. On a broader scale, relatively little is known about Lindsey and how Lindsey fitted into the wider landscape throughout the Early Medieval period. More research into the region would further contextualise data (such as those presented in earlier chapters) – for example, information crucial to illustrating a full picture of copper alloy production, such as trade within and beyond the region.

Similarly, refining some object typologies that have largely been overlooked, such as belt buckles and annular brooches, would allow for more precise dating. More accurate dating of metal-detected items would allow a closer examination of specific fluctuations in compositions for this period.

Many aspects of compositional study would further expand knowledge of copper alloy production. For example, gunmetals are comparatively understudied as they are often assumed to be the result of haphazard recycling; however, recent studies (Pedersen 2016) have shown that this is not necessarily the case. Therefore, it would be beneficial to further understand the properties of such mixed compositions and the possible benefits of casting copper with them, particularly examining the irregular corrosion of ternary and quaternary alloys. Moreover, further refinement of recycling models could also improve understanding; experiments such as rates of zinc volatilisation between covered and uncovered crucibles could help us understand methods taken by smiths to retain zinc and improve their compositions. Improvements in understanding recycling practices could also help further knowledge about trade, but this would need to be in conjunction with typological refinement.

The application of pXRF to metal-detected material can be applied to other cultural and chronological objects, ideally increasing the amount of data for compositions overall. While this research has opened up many new questions it also provides a starting point for mapping Early Medieval copper alloy compositions across the entire period.

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Appendix One

Appendix One contains the cleaned up data from Appendix Four as well as both the Museum Reference Number and the reference numbers used throughout the thesis. This Appendix also displays both the original lead values as well as the lead values that have been appropriately scaled down in accordance with the standards displayed in Appendix Three. After Appendix Two only the scaled down lead values and new reference numbers will be displayed

Table 4 Simplified pXRF Data

REF NUM	***SAMPLE***	***Sb***	***Sn***	***Cd***	***Pd***	***Ag***	***Ru***	***Mo***	***Nb***	***Zr***	***Bi***	***Pb***	***Pb (scaled down)***	***Hg***	***Se***	***As***	***Au***	***W***	***Zn***	***Cu***	***Ni***	***Co***	***Fe***	***Mn***	***Cr***	***V***	***Ti***	***Al***
BC.001	SF000.5007	0.23	34.14	0.00	0.00	0.32	0.00	0.00	0.00	0.01	0.03	13.07	9.47	0.00	0.00	0.00	0.00	0.00	3.11	47.37	0.04	0.00	1.29	0.00	0.00	0.00	0.40	0.00
BC.001	SF000.5007	0.22	32.94	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.06	16.28	11.80	0.00	0.00	2.34	0.00	0.00	2.98	43.37	0.03	0.00	1.25	0.00	0.00	0.00	0.23	0.00
BC.001	SF000.5007	0.28	40.56	0.00	0.00	0.32	0.00	0.00	0.00	0.01	0.05	15.53	11.25	0.00	0.00	0.00	0.00	0.00	2.54	39.23	0.00	0.00	1.12	0.00	0.00	0.00	0.36	0.00
BC.001	average	0.24	35.88	0.00	0.00	0.31	0.00	0.00	0.00	0.01	0.05	14.96	10.84	0.00	0.00	0.00	0.00	0.00	2.88	43.32	0.00	0.00	1.22	0.00	0.00	0.00	0.33	0.00
BC.002	gyxx 1	0.15	15.42	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.06	6.93	5.02	0.00	0.00	0.00	0.00	0.00	6.00	67.76	0.00	0.00	3.19	0.00	0.00	0.00	0.19	0.00
BC.002	gyxx 1	0.18	19.76	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.06	7.51	5.44	0.00	0.00	0.00	0.00	0.00	5.58	63.25	0.00	0.00	3.18	0.00	0.00	0.00	0.18	0.00
BC.002	gyxx 1	0.13	13.10	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.04	5.77	4.18	0.00	0.00	0.00	0.00	0.00	5.56	72.43	0.00	0.00	2.60	0.00	0.00	0.00	0.14	0.00
BC.002	average	0.15	16.10	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.05	6.74	4.88	0.00	0.00	0.00	0.00	0.00	5.71	67.81	0.00	0.00	2.99	0.00	0.00	0.00	0.17	0.00
BC.002	gyxx 1	0.13	15.71	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.06	6.54	4.74	0.00	0.00	0.00	0.00	0.00	5.67	68.17	0.00	0.00	3.32	0.00	0.00	0.00	0.16	0.00
BC.002	gyxx 1	0.17	18.77	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.08	7.70	5.58	0.00	0.00	0.00	0.00	0.00	5.41	63.49	0.00	0.00	3.86	0.00	0.00	0.00	0.27	0.00
BC.002	gyxx 1	0.19	19.95	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.06	8.36	6.06	0.00	0.00	0.00	0.00	0.00	5.00	62.44	0.00	0.00	3.58	0.00	0.00	0.00	0.15	0.00
BC.002	average	0.16	18.14	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.07	7.53	5.46	0.00	0.00	0.00	0.00	0.00	5.36	64.70	0.00	0.00	3.59	0.00	0.00	0.00	0.20	0.00
BC.003	SF041.008	0.04	2.41	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	8.16	5.91	0.00	0.00	0.00	0.00	0.00	0.66	75.10	0.00	0.00	13.59	0.00	0.00	0.00	0.00	0.00
BC.003	SF041.008	0.08	15.91	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.03	5.28	3.83	0.00	0.00	0.00	0.00	0.00	2.57	72.18	0.00	0.00	3.51	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BC.003	SF041.008	0.03	13.74	0.00	0.00	0.32	0.00	0.00	0.00	0.03	0.04	4.96	3.59	0.00	0.00	0.00	0.00	0.00	2.43	72.24	0.00	0.00	6.18	0.00	0.00	0.00	0.00	0.00
BC.003	average	0.05	10.69	0.00	0.00	0.25	0.00	0.00	0.00	0.02	0.03	6.13	4.44	0.00	0.00	0.00	0.00	0.00	1.89	73.17	0.00	0.00	7.76	0.00	0.00	0.00	0.00	0.00
BC.004	tf 46717 68672	0.16	8.63	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	16.50	11.95	0.00	0.00	0.00	0.00	0.00	5.84	63.66	0.00	0.00	4.80	0.03	0.00	0.00	0.25	0.00
BC.004	tf 46717 68672	0.19	8.98	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	17.42	12.62	0.00	0.00	8.03	0.00	0.00	5.20	56.06	0.00	0.00	3.68	0.00	0.00	0.00	0.27	0.00
BC.004	tf 46717 68672	0.25	13.20	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	18.12	13.12	0.00	0.00	2.75	0.00	0.00	4.28	57.45	0.00	0.00	3.46	0.00	0.00	0.00	0.30	0.00
BC.004	average	0.20	10.27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.15	17.34	12.57	0.00	0.00	3.59	0.00	0.00	5.11	59.06	0.00	0.00	3.98	0.00	0.00	0.00	0.27	0.00
BC.005	CAAA 4	0.12	2.76	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.00	29.18	21.14	0.00	0.00	0.00	0.00	0.00	2.63	48.31	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00
BC.005	CAAA 4	0.16	3.14	0.00	0.00	0.31	0.00	0.00	0.00	0.02	0.00	33.87	24.54	0.00	0.00	0.00	0.00	0.00	2.37	49.03	0.00	0.00	11.11	0.00	0.00	0.00	0.00	0.00
BC.005	CAAA 4	0.20	2.87	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	44.59	32.31	0.00	0.02	14.62	0.00	0.00	1.13	33.95	0.00	0.00	2.28	0.00	0.00	0.00	0.00	0.00
BC.005	average	0.16	2.93	0.00	0.00	0.20	0.00	0.00	0.00	0.01	0.10	35.88	26.00	0.00	0.00	4.88	0.00	0.00	2.04	43.76	0.00	0.00	10.02	0.00	0.00	0.00	0.00	0.00
BC.005	CAAA 4	0.17	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	38.66	28.01	0.00	0.04	28.75	0.00	0.00	1.10	26.50	0.02	0.00	2.13	0.00	0.00	0.05	0.15	0.00
BC.005	CAAA 4	0.18	3.25	0.00	0.00	0.32	0.00	0.00	0.00	0.01	0.28	37.44	27.12	0.00	0.03	18.83	0.00	0.00	1.83	36.54	0.00	0.00	1.19	0.00	0.00	0.00	0.11	0.00
BC.005	CAAA 4	0.19	3.31	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.28	39.07	28.31	0.00	0.03	19.22	0.00	0.00	1.75	34.10	0.00	0.00	1.66	0.00	0.00	0.00	0.00	0.00
BC.005	average	0.18	2.85	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.32	38.39	27.81	0.00	0.03	22.27	0.00	0.00	1.56	32.38	0.00	0.00	1.66	0.00	0.00	0.00	0.11	0.00
BC.006	sfwh 13	0.12	2.63	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	18.81	13.62	0.00	0.00	0.00	0.00	0.00	3.11	72.73	0.00	0.00	2.30	0.04	0.00	0.00	0.19	0.00
BC.006	sfwh 13	0.12	2.85	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	21.85	15.83	0.00	0.00	0.00	0.00	0.00	3.07	69.17	0.00	0.00	2.63	0.02	0.00	0.00	0.22	0.00
BC.006	sfwh 13	0.10	2.29	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	18.32	13.27	0.00	0.00	0.00	0.00	0.00	2.95	74.34	0.00	0.00	1.73	0.03	0.00	0.00	0.14	0.00
BC.006	sfwh 13	0.13	3.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.11	19.88	14.40	0.00	0.00	0.00	0.00	0.00	3.70	69.93	0.00	0.00	2.91	0.03	0.00	0.00	0.25	0.00
BC.006	sfwh 13	0.09	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	13.08	9.48	0.00	0.00	0.00	0.00	0.00	3.60	79.86	0.00	0.00	1.27	0.00	0.00	0.00	0.12	0.00
BC.006	sfwh 13	0.10	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	11.96	8.66	0.00	0.00	0.00	0.00	0.00	3.63	81.33	0.00	0.00	0.74	0.00	0.00	0.00	0.06	0.00
BC.006	average	0.11	2.47	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	17.31	12.54	0.00	0.00	0.00	0.00	0.00	3.34	74.56	0.00	0.00	1.93	0.02	0.00	0.00	0.16	0.00
BC.007	lin-2dcd46	0.22	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.03	2.92	0.00	0.00	3.62	0.00	0.00	6.03	83.24	0.02	0.00	0.17	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.24	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	3.66	2.65	0.00	0.00	3.80	0.00	0.00	5.61	85.81	0.02	0.00	0.15	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.23	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	3.82	2.77	0.00	0.00	4.82	0.00	0.00	6.08	83.35	0.02	0.01	0.16	0.00	0.00	0.00	0.00	0.00
BC.007	average	0.23	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	3.83	2.78	0.00	0.00	4.08	0.00	0.00	5.91	84.13	0.02	0.00	0.16	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.24	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.33	3.14	0.00	0.00	3.72	0.00	0.00	6.48	82.79	0.03	0.01	0.20	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BC.007	lin-2dcd46	0.23	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	3.70	2.68	0.00	0.00	4.24	0.00	0.00	5.86	84.77	0.02	0.01	0.15	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.24	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.76	3.45	0.00	0.00	3.30	0.00	0.00	6.13	82.54	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00
BC.007	average	0.24	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.26	3.09	0.00	0.00	3.75	0.00	0.00	6.15	83.37	0.02	0.00	0.19	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.22	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.03	2.92	0.00	0.00	3.62	0.00	0.00	6.03	83.24	0.02	0.00	0.17	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.24	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	3.66	2.65	0.00	0.00	3.80	0.00	0.00	5.61	85.81	0.02	0.00	0.15	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.23	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	3.82	2.77	0.00	0.00	4.82	0.00	0.00	6.08	83.35	0.02	0.01	0.16	0.00	0.00	0.00	0.00	0.00
BC.007	average	0.23	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	3.83	2.78	0.00	0.00	4.08	0.00	0.00	5.91	84.13	0.02	0.00	0.16	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.24	1.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.33	3.14	0.00	0.00	3.72	0.00	0.00	6.48	82.79	0.03	0.01	0.20	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.23	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	3.70	2.68	0.00	0.00	4.24	0.00	0.00	5.86	84.77	0.02	0.01	0.15	0.00	0.00	0.00	0.00	0.00
BC.007	lin-2dcd46	0.24	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.76	3.45	0.00	0.00	3.30	0.00	0.00	6.13	82.54	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00
BC.007	average	0.24	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	4.26	3.09	0.00	0.00	3.75	0.00	0.00	6.15	83.37	0.02	0.00	0.19	0.00	0.00	0.00	0.00	0.00
BC.008	wbyaa	0.28	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.21	13.72	9.94	0.00	0.00	6.30	0.00	0.00	6.15	69.69	0.00	0.00	3.13	0.03	0.00	0.00	0.20	0.00
BC.008	wbyaa	0.26	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	19.07	13.82	0.00	0.00	15.25	0.00	0.00	5.93	53.64	0.00	0.00	4.99	0.03	0.00	0.00	0.23	0.00
BC.008	wbyaa	0.26	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.18	14.30	10.36	0.00	0.00	8.49	0.00	0.00	5.96	67.55	0.00	0.00	2.73	0.02	0.00	0.00	0.23	0.00
BC.008	average	0.27	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.23	15.70	11.37	0.00	0.00	10.02	0.00	0.00	6.01	63.63	0.00	0.00	3.62	0.03	0.00	0.00	0.22	0.00
BC.008	wbyaa	0.24	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	11.15	8.08	0.00	0.00	15.81	0.00	0.00	5.23	64.47	0.00	0.00	2.50	0.00	0.00	0.00	0.10	0.00
BC.008	wbyaa	0.25	0.26	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.29	12.84	9.30	0.00	0.00	18.14	0.00	0.00	5.08	60.11	0.00	0.00	2.84	0.00	0.00	0.00	0.13	0.00
BC.008	wbyaa	0.27	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.21	10.50	7.61	0.00	0.00	8.98	0.00	0.00	5.60	71.68	0.00	0.00	2.32	0.00	0.00	0.00	0.19	0.00
BC.008	average	0.25	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	11.49	8.33	0.00	0.00	14.31	0.00	0.00	5.30	65.42	0.00	0.00	2.55	0.00	0.00	0.00	0.14	0.00
BC.009	lin-df9b77	0.04	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	4.27	3.09	0.00	0.00	7.03	0.00	0.00	7.95	73.60	0.02	0.00	6.71	0.06	0.00	0.03	0.10	0.00
BC.009	lin-df9b77	0.03	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	3.16	2.29	0.00	0.00	4.93	0.00	0.00	10.81	74.21	0.03	0.00	6.45	0.07	0.00	0.04	0.12	0.00
BC.009	lin-df9b77	0.04	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	4.86	3.52	0.00	0.00	7.70	0.00	0.00	7.44	72.63	0.02	0.00	6.89	0.05	0.00	0.04	0.11	0.00
BC.009	lin-df9b77	0.03	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	3.85	2.79	0.00	0.00	6.37	0.00	0.00	9.15	73.58	0.02	0.00	6.58	0.08	0.00	0.03	0.12	0.00
BC.009	lin-df9b77	0.04	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	4.29	3.11	0.00	0.00	8.54	0.00	0.00	8.83	73.37	0.04	0.00	4.63	0.03	0.00	0.00	0.05	0.00
BC.009	lin-df9b77	0.04	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	4.23	3.07	0.00	0.00	7.46	0.00	0.00	7.99	73.17	0.02	0.00	6.67	0.03	0.00	0.03	0.15	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BC.009	average	0.04	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	4.11	2.98	0.00	0.00	7.01	0.00	0.00	8.69	73.43	0.03	0.00	6.32	0.05	0.00	0.03	0.11	0.00
BC.010	sfwq20	0.34	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.09	16.41	11.89	0.00	0.00	6.58	0.00	0.00	6.04	68.80	0.00	0.00	1.41	0.00	0.00	0.00	0.15	0.00
BC.010	sfwq20	0.35	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	12.56	9.10	0.00	0.00	10.80	0.00	0.00	5.11	69.33	0.00	0.00	1.54	0.00	0.00	0.00	0.13	0.00
BC.010	sfwq20	0.35	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.12	16.68	12.09	0.00	0.00	11.73	0.00	0.00	3.53	65.96	0.00	0.00	1.39	0.00	0.00	0.00	0.08	0.00
BC.010	average	0.35	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.11	15.22	11.02	0.00	0.00	9.70	0.00	0.00	4.89	68.03	0.00	0.00	1.45	0.00	0.00	0.00	0.12	0.00
BC.010	sfwq20	0.54	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.22	20.95	15.18	0.00	0.00	26.77	0.00	0.00	4.20	45.44	0.00	0.00	1.62	0.00	0.00	0.00	0.12	0.00
BC.010	sfwq20	0.33	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12	16.14	11.69	0.00	0.00	17.18	0.00	0.00	5.03	59.72	0.00	0.00	1.31	0.00	0.00	0.00	0.09	0.00
BC.010	sfwq20	0.29	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.13	15.50	11.23	0.00	0.00	16.15	0.00	0.12	5.13	60.95	0.00	0.00	1.46	0.03	0.00	0.00	0.16	0.00
BC.010	sfwq20	0.31	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	12.16	8.81	0.00	0.00	17.28	0.00	0.00	3.73	64.94	0.03	0.00	1.26	0.00	0.00	0.00	0.08	0.00
BC.010	sfwq20	0.32	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	10.61	7.68	0.00	0.00	15.71	0.00	0.00	3.03	68.70	0.00	0.00	1.33	0.00	0.00	0.00	0.10	0.00
BC.010	sfwq20	0.31	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.15	14.89	10.78	0.00	0.00	18.31	0.00	0.00	2.65	62.02	0.00	0.00	1.38	0.02	0.00	0.00	0.18	0.00
BC.010	average	0.35	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14	15.04	10.90	0.00	0.00	18.57	0.00	0.00	3.96	60.30	0.00	0.00	1.39	0.02	0.00	0.00	0.12	0.00
BC.011	bkaf 3	0.30	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	7.54	5.46	0.00	0.00	11.43	0.00	0.00	1.60	78.75	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
BC.011	bkaf 3	0.29	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	6.38	4.63	0.00	0.00	7.57	0.00	0.00	2.39	83.07	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00
BC.011	bkaf 3	0.31	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	7.25	5.25	0.00	0.00	12.25	0.00	0.00	1.94	77.84	0.00	0.00	0.23	0.00	0.00	0.00	0.05	0.00
BC.011	average	0.30	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	7.06	5.11	0.00	0.00	10.42	0.00	0.00	1.98	79.89	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00
BC.012	1994.103	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	5.05	3.66	0.00	0.00	7.80	0.00	0.00	6.54	79.92	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00
BC.012	1994.103	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	3.66	2.65	0.00	0.00	5.81	0.00	0.00	6.66	83.24	0.02	0.00	0.36	0.00	0.00	0.00	0.00	0.00
BC.012	1994.103	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	3.93	2.85	0.00	0.00	7.18	0.00	0.00	6.37	81.55	0.02	0.00	0.68	0.00	0.00	0.00	0.00	0.00
BC.012	average	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	4.21	3.05	0.00	0.00	6.93	0.00	0.00	6.52	81.57	0.02	0.00	0.48	0.00	0.00	0.00	0.00	0.00
BE.001	ayxx 2	0.32	12.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	36.35	26.33	0.00	0.00	0.00	0.00	0.00	0.82	30.38	0.00	0.00	19.78	0.00	0.00	0.00	0.19	0.00
BE.001	ayxx 2	0.32	12.84	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	41.06	29.75	0.00	0.00	0.00	0.00	0.00	0.68	26.06	0.00	0.00	18.92	0.00	0.00	0.00	0.00	0.00
BE.001	ayxx 2	0.31	11.84	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	37.08	26.86	0.00	0.00	0.00	0.00	0.00	0.81	31.73	0.00	0.00	17.94	0.00	0.00	0.00	0.19	0.00
BE.001	average	0.32	12.25	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.08	38.16	27.65	0.00	0.00	0.00	0.00	0.00	0.77	29.39	0.00	0.00	18.88	0.00	0.00	0.00	0.00	0.00
BE.002	sfn002	0.17	5.29	0.00	0.00	0.52	0.00	0.00	0.00	0.01	0.22	32.04	23.21	0.00	0.00	21.57	0.00	0.00	3.14	34.97	0.00	0.00	1.74	0.00	0.00	0.00	0.27	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BE.002	sfn002	0.18	6.30	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.21	34.00	24.64	0.00	0.00	16.79	0.00	0.00	2.66	35.97	0.00	0.00	2.94	0.04	0.00	0.00	0.26	0.00
BE.002	sfn002	0.17	5.63	0.00	0.00	0.53	0.00	0.00	0.00	0.01	0.19	26.29	19.05	0.00	0.00	18.30	0.00	0.00	2.58	44.32	0.00	0.00	1.71	0.00	0.00	0.00	0.22	0.00
BE.002	average	0.18	5.74	0.00	0.00	0.54	0.00	0.00	0.00	0.01	0.21	30.78	22.30	0.00	0.00	18.88	0.00	0.00	2.79	38.42	0.00	0.00	2.13	0.00	0.00	0.00	0.25	0.00
BE.003	sfn003	0.07	2.51	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.28	35.49	25.71	0.00	0.03	25.26	0.00	0.00	1.27	33.67	0.00	0.00	1.09	0.00	0.00	0.05	0.21	0.00
BE.003	sfn003	0.07	2.37	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	31.53	22.84	0.00	0.03	25.13	0.00	0.00	1.24	37.23	0.00	0.00	1.84	0.00	0.00	0.06	0.22	0.00
BE.003	sfn003	0.06	2.58	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	32.81	23.77	0.00	0.03	19.35	0.00	0.00	1.42	41.88	0.00	0.00	1.39	0.00	0.00	0.05	0.18	0.00
BE.003	average	0.07	2.49	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	33.28	24.11	0.00	0.03	23.25	0.00	0.00	1.31	37.59	0.00	0.00	1.44	0.00	0.00	0.05	0.20	0.00
BE.004	sfn001	0.02	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	18.56	13.45	0.00	0.02	14.48	0.00	0.00	1.11	64.07	0.00	0.00	0.40	0.00	0.00	0.00	0.10	0.00
BE.004	sfn001	0.01	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	17.11	12.40	0.00	0.02	12.33	0.00	0.00	1.07	67.85	0.00	0.00	0.31	0.00	0.00	0.00	0.07	0.00
BE.004	sfn001	0.02	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	17.17	12.44	0.00	0.02	11.54	0.00	0.00	1.07	68.55	0.00	0.00	0.31	0.00	0.00	0.00	0.08	0.00
BE.004	average	0.02	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	17.62	12.76	0.00	0.02	12.78	0.00	0.00	1.08	66.82	0.00	0.00	0.34	0.00	0.00	0.00	0.08	0.00
BE.005	lin 4db330	0.09	1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.63	56.00	40.57	0.00	0.07	28.94	0.00	0.00	0.40	9.95	0.04	0.00	2.18	0.00	0.00	0.07	0.22	0.00
BE.005	lin 4db330	0.09	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.71	56.43	40.89	0.00	0.06	32.59	0.00	0.00	0.39	6.40	0.02	0.00	1.58	0.00	0.04	0.08	0.23	0.00
BE.005	lin 4db330	0.09	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.59	63.00	45.64	0.00	0.06	24.40	0.00	0.00	0.52	6.99	0.04	0.00	2.32	0.00	0.00	0.08	0.24	0.00
BE.005	average	0.09	1.45	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.64	58.48	42.37	0.00	0.06	28.64	0.00	0.00	0.44	7.78	0.03	0.00	2.03	0.00	0.00	0.08	0.23	0.00
BE.005	lin-4db330	0.09	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	51.15	37.06	0.00	0.07	35.85	0.00	0.00	0.35	8.68	0.03	0.00	1.65	0.00	0.05	0.08	0.25	0.00
BE.005	lin-4db330	0.08	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	45.81	33.19	0.00	0.06	32.76	0.00	0.00	0.32	8.03	0.02	0.00	1.51	0.00	0.04	0.09	0.20	1.42
BE.005	lin-4db330	0.08	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	45.42	32.91	0.00	0.06	32.69	0.00	0.00	0.36	9.07	0.03	0.00	1.32	0.00	0.03	0.08	0.24	1.27
BE.005	lin-4db330	0.07	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	49.96	36.20	0.00	0.07	30.71	0.00	0.00	0.37	6.35	0.00	0.00	1.33	0.00	0.04	0.07	0.24	1.39
BE.005	lin-4db330	0.08	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.43	51.93	37.62	0.00	0.07	26.36	0.00	0.00	0.34	5.99	0.03	0.00	1.61	0.00	0.00	0.10	0.19	2.22
BE.005	lin-4db330	0.08	1.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.48	45.44	32.92	0.00	0.07	33.78	0.00	0.00	0.35	6.98	0.03	0.00	1.22	0.00	0.05	0.10	0.23	2.09
BE.005	average	0.08	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	48.29	34.98	0.00	0.07	32.03	0.00	0.00	0.35	7.52	0.02	0.00	1.44	0.00	0.04	0.09	0.23	0.00
BF.001	23	0.32	16.53	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	21.53	15.60	0.00	0.00	0.00	0.00	0.00	0.19	25.10	0.00	0.00	36.09	0.00	0.00	0.00	0.18	0.00
BF.001	23	0.36	19.70	0.00	0.00	0.20	0.00	0.00	0.00	0.02	0.05	20.0 8	14.55	0.00	0.00	0.00	0.00	0.00	0.16	18.42	0.00	0.00	40.82	0.00	0.00	0.00	0.20	0.00
BF.001	23	0.35	18.67	0.00	0.00	0.23	0.00	0.00	0.00	0.02	0.00	25.58	18.53	0.00	0.00	0.00	0.00	0.00	0.15	26.86	0.00	0.00	27.97	0.00	0.00	0.00	0.15	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BF.001	average	0.34	18.30	0.00	0.00	0.14	0.00	0.00	0.00	0.02	0.00	22.40	16.23	0.00	0.00	0.00	0.00	0.00	0.17	23.46	0.00	0.00	34.96	0.00	0.00	0.00	0.18	0.00
BF.002	7 big	0.38	18.50	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.04	22.41	16.24	0.00	0.00	0.00	0.00	0.00	0.20	21.28	0.00	0.00	36.74	0.00	0.00	0.00	0.20	0.00
BF.002	7 big	0.34	17.27	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.04	22.50	16.30	0.00	0.00	0.00	0.00	0.00	0.20	26.16	0.00	0.00	33.13	0.00	0.00	0.00	0.13	0.00
BF.002	7 big	0.36	17.68	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.04	21.35	15.47	0.00	0.00	0.00	0.00	0.00	0.23	21.52	0.00	0.00	38.34	0.00	0.00	0.00	0.25	0.00
BF.002	average	0.36	17.81	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.04	22.09	16.00	0.00	0.00	0.00	0.00	0.00	0.21	22.99	0.00	0.00	36.07	0.00	0.00	0.00	0.19	0.00
BF.002	7 small	0.17	16.27	0.06	0.03	4.39	0.00	0.00	0.00	0.00	0.04	1.96	1.42	10.64	0.05	1.17	8.93	0.00	0.28	36.91	0.03	0.00	18.28	0.04	0.07	0.17	0.51	0.00
BF.002	7 small	0.04	3.85	0.01	0.01	1.32	0.00	0.00	0.00	0.00	0.00	0.98	0.71	3.49	0.05	0.00	2.88	0.00	0.29	32.17	0.00	0.00	54.70	0.05	0.00	0.04	0.11	0.00
BF.002	7 small	0.18	17.19	0.07	0.04	5.22	0.00	0.00	0.00	0.00	0.05	1.99	1.44	11.45	0.07	1.35	10.38	0.00	0.26	33.35	0.05	0.00	17.46	0.07	0.10	0.19	0.57	0.00
BF.002	average	0.13	12.44	0.05	0.03	3.64	0.00	0.00	0.00	0.00	0.03	1.64	1.19	8.53	0.06	0.84	7.40	0.00	0.28	34.14	0.03	0.00	30.15	0.05	0.06	0.13	0.40	0.00
BF.003	lin-74c576	0.36	18.50	0.11	0.06	0.00	0.00	0.00	0.00	0.01	0.09	4.70	3.41	13.67	0.00	3.37	17.07	0.00	0.12	21.44	0.10	0.00	1.85	0.09	0.15	0.32	1.06	5.65
BF.003	lin-74c576	0.45	16.87	0.15	0.08	2.97	0.00	0.00	0.00	0.01	0.10	3.96	2.87	17.35	0.00	2.37	19.49	0.00	0.09	16.82	0.09	0.00	1.68	0.09	0.20	0.44	1.28	5.09
BF.003	lin-74c576	0.42	14.69	0.14	0.08	3.19	0.00	0.00	0.00	0.01	0.09	4.09	2.96	16.64	0.00	2.45	20.14	0.00	0.09	14.91	0.08	0.00	2.51	0.11	0.18	0.40	1.44	5.50
BF.003	average	0.41	16.69	0.13	0.08	2.06	0.00	0.00	0.00	0.01	0.09	4.25	3.08	15.89	0.00	2.73	18.90	0.00	0.10	17.72	0.09	0.00	2.01	0.10	0.18	0.39	1.26	5.42
BF.003	lin-74c576 back	0.23	39.33	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.07	13.09	9.48	0.00	0.00	0.00	0.00	0.00	0.19	36.45	0.19	0.00	0.97	0.00	0.00	0.00	0.00	2.49
BF.003	lin-74c576 back	0.24	39.57	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.06	12.20	8.84	0.00	0.00	0.00	0.00	0.00	0.17	37.40	0.18	0.00	0.85	0.00	0.00	0.00	0.27	2.43
BF.003	lin-74c576 back	0.24	39.02	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.07	12.35	8.95	0.00	0.00	0.00	0.00	0.00	0.17	37.71	0.22	0.00	0.85	0.00	0.00	0.00	0.35	2.44
BF.003	average	0.24	39.31	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.07	12.55	9.09	0.00	0.00	0.00	0.00	0.00	0.18	37.19	0.20	0.00	0.89	0.00	0.00	0.00	0.27	2.46
BF.003	lin-74c576	0.36	18.50	0.11	0.06	0.00	0.00	0.00	0.00	0.01	0.09	4.70	3.41	13.67	0.00	3.37	17.07	0.00	0.12	21.44	0.10	0.00	1.85	0.09	0.15	0.32	1.06	5.65
BF.003	lin-74c576	0.45	16.87	0.15	0.08	2.97	0.00	0.00	0.00	0.01	0.10	3.96	2.87	17.35	0.00	2.37	19.49	0.00	0.09	16.82	0.09	0.00	1.68	0.09	0.20	0.44	1.28	5.09
BF.003	lin-74c576	0.42	14.69	0.14	0.08	3.19	0.00	0.00	0.00	0.01	0.09	4.09	2.96	16.64	0.00	2.45	20.14	0.00	0.09	14.91	0.08	0.00	2.51	0.11	0.18	0.40	1.44	5.50
BF.003	average	0.41	16.69	0.13	0.08	2.06	0.00	0.00	0.00	0.01	0.09	4.25	3.08	15.89	0.00	2.73	18.90	0.00	0.10	17.72	0.09	0.00	2.01	0.10	0.18	0.39	1.26	5.42
BF.003	lin-74c576 back	0.23	39.33	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.07	13.09	9.48	0.00	0.00	0.00	0.00	0.00	0.19	36.45	0.19	0.00	0.97	0.00	0.00	0.00	0.00	2.49
BF.003	lin-74c576 back	0.24	39.57	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.06	12.20	8.84	0.00	0.00	0.00	0.00	0.00	0.17	37.40	0.18	0.00	0.85	0.00	0.00	0.00	0.27	2.43
BF.003	lin-74c576 back	0.24	39.02	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.07	12.35	8.95	0.00	0.00	0.00	0.00	0.00	0.17	37.71	0.22	0.00	0.85	0.00	0.00	0.00	0.35	2.44
BF.003	average	0.24	39.31	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.07	12.55	9.09	0.00	0.00	0.00	0.00	0.00	0.18	37.19	0.20	0.00	0.89	0.00	0.00	0.00	0.27	2.46

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BF.004	sfcl	0.18	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	5.53	4.01	0.00	0.00	0.00	0.00	0.00	9.76	83.78	0.00	0.00	0.41	0.00	0.00	0.00	0.05	0.00
BF.004	sfcl	0.22	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	6.53	4.73	0.00	0.00	0.00	0.00	0.00	8.43	84.02	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
BF.004	sfcl	0.18	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	6.74	4.88	0.00	0.00	0.00	0.00	0.00	9.91	82.19	0.00	0.00	0.58	0.00	0.00	0.00	0.05	0.00
BF.004	sfcl	0.17	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	5.86	4.25	0.00	0.00	0.00	0.00	0.00	9.02	84.23	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00
BF.004	sfcl	0.16	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	6.45	4.67	0.00	0.00	0.00	0.00	0.00	11.05	81.62	0.00	0.00	0.38	0.00	0.00	0.00	0.05	0.00
BF.004	sfcl	0.17	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	5.94	4.30	0.00	0.00	0.00	0.00	0.00	9.85	83.44	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
BF.004	average	0.18	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	6.18	4.47	0.00	0.00	0.00	0.00	0.00	9.67	83.21	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
BF.005	lin-e07f16	0.537	0.125	0	0	0	0	0	0	0	0.271	1.903	0	0	0.872	0	0	3.945	91.826	0	0	0.478	0	0	0	0	0	
BF.005	lin-e07f16	0.681	0.189	0	0	0.211	0	0	0	0.011	0.456	3.684	0	0	1.416	0	0	3.624	87.959	0	0	1.613	0	0	0	0.137	0	
BF.005	lin-e07f16	0.546	0.123	0	0	0	0	0	0	0	0.237	1.699	0	0	0	0	0	4.063	93.114	0	0	0.1	0	0	0	0.107	0	
BF.005	average	0.588	0.146	0	0	0.07	0	0	0	0.004	0.321	2.429	0	0	0	0	0	3.878	90.967	0	0	0.731	0	0	0	0.092	0	
BF.006	kswy 6	0.47	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	20.98	15.20	0.00	0.00	0.00	0.00	0.00	8.89	67.72	0.00	0.00	1.69	0.00	0.00	0.00	0.00	0.00
BF.006	kswy 6	0.40	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.15	18.52	13.42	0.00	0.00	3.92	0.00	0.00	8.07	66.97	0.00	0.00	1.81	0.00	0.00	0.00	0.00	0.00
BF.006	kswy 6	0.38	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.19	15.44	11.19	0.00	0.00	0.00	0.00	0.00	10.24	70.26	0.00	0.00	2.96	0.00	0.00	0.00	0.40	0.00
BF.006	average	0.42	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.16	18.31	13.27	0.00	0.00	0.00	0.00	0.00	9.06	68.32	0.00	0.00	2.15	0.00	0.00	0.00	0.14	0.00
BF.007	ayxx4	0.37	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.24	30.38	22.01	0.00	0.00	10.79	0.00	0.00	14.18	39.71	0.02	0.00	3.91	0.12	0.00	0.00	0.10	0.00
BF.007	ayxx4	0.40	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.32	29.02	21.02	0.00	0.00	22.43	0.00	0.00	10.97	33.58	0.00	0.00	3.07	0.06	0.00	0.00	0.07	0.00
BF.007	ayxx4	0.42	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.31	32.83	23.78	0.00	0.00	21.93	0.00	0.00	9.54	31.14	0.02	0.00	3.49	0.09	0.00	0.00	0.14	0.00
BF.007	average	0.40	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	30.74	22.27	0.00	0.00	18.38	0.00	0.00	11.56	34.81	0.00	0.00	3.49	0.09	0.00	0.00	0.10	0.00
BF.007	ayxx4	0.36	34.38	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	19.26	13.96	0.00	0.00	0.00	0.00	0.00	8.03	32.69	0.00	0.00	4.54	0.10	0.00	0.00	0.50	0.00
BF.007	ayxx4	0.41	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.32	30.88	22.37	0.00	0.00	21.50	0.00	0.00	11.25	31.25	0.00	0.00	3.71	0.11	0.00	0.00	0.14	0.00
BF.007	ayxx4	0.40	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.30	29.98	21.72	0.00	0.00	16.98	0.00	0.00	11.91	34.85	0.00	0.00	4.88	0.13	0.00	0.00	0.14	0.00
BF.007	average	0.39	11.71	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24	26.71	19.35	0.00	0.00	12.83	0.00	0.00	10.40	32.93	0.00	0.00	4.38	0.11	0.00	0.00	0.26	0.00
BF.007	lin-e07f16	0.54	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	1.90	1.38	0.00	0.00	0.87	0.00	0.00	3.95	91.83	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00
BF.007	lin-e07f16	0.68	0.19	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.46	3.68	2.67	0.00	0.00	1.42	0.00	0.00	3.62	87.96	0.00	0.00	1.61	0.00	0.00	0.00	0.14	0.00
BF.007	lin-e07f16	0.55	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	1.70	1.23	0.00	0.00	0.00	0.00	0.00	4.06	93.11	0.00	0.00	0.10	0.00	0.00	0.00	0.11	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BF.007	average	0.59	0.15	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.32	2.43	1.76	0.00	0.00	0.00	0.00	0.00	3.88	90.97	0.00	0.00	0.73	0.00	0.00	0.00	0.09	0.00
BF.008	lin-eb7763	0.20	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	12.36	8.95	0.00	0.00	10.78	0.00	0.00	3.82	71.52	0.02	0.00	0.90	0.00	0.00	0.00	0.08	0.00
BF.008	lin-eb7763	0.21	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	10.76	7.80	0.00	0.00	8.50	0.00	0.00	3.13	76.22	0.00	0.00	0.78	0.00	0.00	0.00	0.06	0.00
BF.008	lin-eb7763	0.22	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	15.38	11.15	0.00	0.00	5.90	0.00	0.00	2.95	73.94	0.00	0.00	1.18	0.00	0.00	0.00	0.07	0.00
BF.008	lin-eb7763	0.21	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	11.57	8.38	0.00	0.00	4.84	0.00	0.00	3.03	79.12	0.00	0.00	0.87	0.00	0.00	0.00	0.05	0.00
BF.008	lin-eb7763	0.20	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	9.08	6.58	0.00	0.00	11.00	0.00	0.00	2.42	76.44	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00
BF.008	lin-eb7763	0.20	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	15.65	11.34	0.00	0.00	0.00	0.00	0.00	3.11	79.59	0.02	0.00	1.09	0.00	0.00	0.00	0.07	0.00
BF.008	average	0.21	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	12.47	9.03	0.00	0.00	6.84	0.00	0.00	3.08	76.14	0.00	0.00	0.89	0.00	0.00	0.00	0.06	0.00
BF.008	lin-eb7763	0.22	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	16.51	11.96	0.00	0.00	13.54	0.00	0.00	2.62	65.59	0.00	0.00	1.10	0.00	0.00	0.00	0.06	0.00
BF.008	lin-eb7763	0.22	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.16	16.98	12.30	0.00	0.00	0.00	0.00	0.00	3.13	78.28	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00
BF.008	lin-eb7763	0.23	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24	15.09	10.93	0.00	0.00	10.70	0.00	0.00	2.67	69.89	0.03	0.00	0.96	0.00	0.00	0.00	0.07	0.00
BF.008	lin-eb7763	0.20	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	9.04	6.55	0.00	0.00	9.81	0.00	0.00	2.54	77.55	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00
BF.008	lin-eb7763	0.21	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	10.03	7.27	0.00	0.00	5.01	0.00	0.00	3.37	80.26	0.00	0.00	0.78	0.00	0.00	0.00	0.05	0.00
BF.008	lin-eb7763	0.21	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	22.57	16.35	0.00	0.00	11.44	0.00	0.00	2.30	61.33	0.00	0.00	1.73	0.00	0.00	0.00	0.15	0.00
BF.008	average	0.21	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	15.04	10.89	0.00	0.00	8.42	0.00	0.00	2.77	72.15	0.00	0.00	1.03	0.00	0.00	0.00	0.07	0.00
BF.009	lin-2e2710	0.24	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.33	9.33	6.76	0.00	0.00	12.60	0.00	0.00	8.00	67.49	0.00	0.00	1.81	0.00	0.00	0.00	0.12	0.00
BF.009	lin-2e2710	0.26	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.33	10.74	7.78	0.00	0.00	9.36	0.00	0.00	8.53	68.49	0.00	0.00	2.04	0.00	0.00	0.00	0.15	0.00
BF.009	lin-2e2710	0.24	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.30	9.84	7.13	0.00	0.00	9.90	0.00	0.00	8.90	68.82	0.02	0.00	1.79	0.00	0.00	0.00	0.11	0.00
BF.009	lin-2e2710	0.21	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	9.31	6.75	0.00	0.00	11.01	0.00	0.00	8.80	67.74	0.00	0.00	2.43	0.00	0.00	0.00	0.19	0.00
BF.009	lin-2e2710	0.24	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	9.82	7.11	0.00	0.00	12.17	0.00	0.00	9.17	66.09	0.02	0.00	1.98	0.00	0.00	0.00	0.15	0.00
BF.009	lin-2e2710	0.21	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.30	10.63	7.70	0.00	0.00	12.88	0.00	0.00	8.38	64.85	0.03	0.00	2.43	0.00	0.00	0.00	0.21	0.00
BF.009	average	0.23	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	9.94	7.20	0.00	0.00	11.32	0.00	0.00	8.63	67.25	0.02	0.00	2.08	0.00	0.00	0.00	0.15	0.00
BF.009	lin-2e2710	0.19	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	9.14	6.62	0.00	0.00	9.67	0.00	0.00	9.07	69.48	0.00	0.00	1.96	0.00	0.00	0.00	0.12	0.00
BF.009	lin-2e2710	0.23	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	8.99	6.51	0.00	0.00	11.10	0.00	0.00	8.74	68.93	0.00	0.00	1.58	0.00	0.00	0.00	0.09	0.00
BF.009	lin-2e2710	0.24	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	9.46	6.85	0.00	0.00	12.24	0.00	0.00	8.95	67.40	0.00	0.00	1.24	0.00	0.00	0.00	0.08	0.00
BF.009	lin-2e2710	0.21	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.21	9.34	6.76	0.00	0.00	10.60	0.00	0.00	8.93	67.90	0.00	0.00	2.55	0.00	0.00	0.00	0.18	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BF.009	lin-2e2710	0.25	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.32	9.16	6.64	0.00	0.00	7.98	0.00	0.00	9.91	68.80	0.02	0.00	3.25	0.00	0.00	0.00	0.23	0.00
BF.009	lin-2e2710	0.22	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.32	10.77	7.80	0.00	0.00	14.64	0.00	0.00	8.89	61.87	0.02	0.00	2.97	0.00	0.00	0.00	0.24	0.00
BF.009	average	0.22	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.28	9.48	6.86	0.00	0.00	11.04	0.00	0.00	9.08	67.40	0.00	0.00	2.26	0.00	0.00	0.00	0.16	0.00
BF.010	mhaa	0.32	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.40	38.73	28.06	0.00	0.00	12.76	0.00	0.00	5.23	30.90	0.00	0.00	11.26	0.00	0.00	0.00	0.28	0.00
BF.010	mhaa	0.38	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.44	41.66	30.18	0.00	0.00	13.11	0.00	0.00	4.55	31.38	0.00	0.00	8.17	0.00	0.00	0.00	0.24	0.00
BF.010	mhaa	0.35	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.29	44.06	31.92	0.00	0.00	0.00	0.00	0.00	5.12	42.24	0.00	0.00	7.48	0.00	0.00	0.00	0.32	0.00
BF.010	average	0.35	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.38	41.48	30.05	0.00	0.00	8.62	0.00	0.00	4.97	34.84	0.00	0.00	8.97	0.00	0.00	0.00	0.28	0.00
BF.010	mhaa	0.34	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.43	39.49	28.61	0.00	0.00	19.90	0.00	0.00	4.86	28.39	0.02	0.00	6.22	0.00	0.00	0.06	0.21	0.00
BF.010	mhaa	0.36	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.41	36.25	26.27	0.00	0.00	19.74	0.00	0.00	5.05	32.35	0.00	0.00	5.40	0.00	0.00	0.06	0.26	0.00
BF.010	mhaa	0.38	0.05	0.00	0.00	0.20	0.00	0.00	0.00	0.03	0.25	41.80	30.28	0.00	0.00	0.00	0.00	0.00	5.47	46.13	0.00	0.00	5.52	0.00	0.00	0.00	0.17	0.00
BF.010	average	0.36	0.05	0.00	0.00	0.07	0.00	0.00	0.00	0.03	0.36	39.18	28.39	0.00	0.00	13.21	0.00	0.00	5.13	35.62	0.00	0.00	5.71	0.00	0.00	0.00	0.21	0.00
BF.011	1989-379-77	0.70	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	7.00	5.07	0.00	0.00	6.37	0.00	0.00	2.72	82.35	0.02	0.00	0.50	0.00	0.00	0.00	0.07	0.00
BF.011	1989-379-77	0.67	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	6.21	4.50	0.00	0.00	6.44	0.00	0.00	3.08	82.74	0.00	0.00	0.55	0.00	0.00	0.00	0.06	0.00
BF.011	1989-379-77	0.65	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	4.86	3.52	0.00	0.00	6.92	0.00	0.00	3.10	83.86	0.00	0.00	0.30	0.00	0.00	0.00	0.05	0.00
BF.011	average	0.67	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	6.02	4.36	0.00	0.00	6.58	0.00	0.00	2.96	82.98	0.00	0.00	0.45	0.00	0.00	0.00	0.06	0.00
BF.011	1989-379-77	0.64	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	5.10	3.70	0.00	0.00	4.78	0.00	0.00	3.48	85.48	0.00	0.00	0.21	0.00	0.00	0.00	0.05	0.00
BF.011	1989-379-77	0.68	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	4.76	3.45	0.00	0.00	6.03	0.00	0.00	2.95	85.15	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
BF.011	1989-379-77	0.68	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	5.23	3.79	0.00	0.00	5.37	0.00	0.00	3.00	85.31	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
BF.011	average	0.67	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	5.03	3.64	0.00	0.00	5.39	0.00	0.00	3.14	85.31	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00
BF.012	uncm 63	0.11	11.36	0.00	0.01	0.28	0.00	0.00	0.00	0.00	0.00	39.06	28.30	0.00	0.00	0.00	0.00	0.00	6.84	38.76	0.00	0.00	3.36	0.00	0.00	0.00	0.20	0.00
BF.012	uncm 63	0.08	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	39.26	28.44	0.00	0.00	16.10	0.00	0.00	4.12	30.15	0.00	0.00	2.93	0.00	0.00	0.00	0.00	0.00
BF.012	uncm 63	0.10	10.86	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	32.86	23.81	0.00	0.00	3.78	0.00	0.00	6.02	43.17	0.00	0.00	2.73	0.00	0.00	0.00	0.19	0.00
BF.012	uncm 63	0.06	8.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	32.86	23.81	0.00	0.00	0.00	0.00	0.00	5.42	48.82	0.00	0.00	4.52	0.00	0.00	0.00	0.27	0.00
BF.012	uncm 63	0.11	9.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	49.56	35.91	0.00	0.00	0.00	0.00	0.00	4.70	32.11	0.06	0.00	3.40	0.00	0.00	0.00	0.00	0.00
BF.012	uncm 63	0.12	9.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	49.34	35.74	0.00	0.00	3.21	0.00	0.00	5.03	29.75	0.00	0.00	2.67	0.00	0.00	0.00	0.26	0.00
BF.012	average	0.10	9.44	0.00	0.00	0.09	0.00	0.00	0.00	0.01	0.00	40.49	29.34	0.00	0.00	3.85	0.00	0.00	5.35	37.13	0.00	0.00	3.27	0.00	0.00	0.00	0.19	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.001	auac 2	0.03	14.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.34	2.42	0.00	0.00	0.00	0.00	0.00	5.51	71.38	0.00	0.00	3.46	0.03	0.00	0.00	0.24	0.00
BR.001	auac 2	0.06	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	1.20	0.00	0.00	0.00	0.00	0.00	5.39	91.12	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.00
BR.001	auac 2	0.06	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	1.91	0.00	0.00	1.21	0.00	0.00	6.66	86.68	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00
BR.001	auac 2	0.07	1.59	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	3.94	2.86	0.00	0.00	0.00	0.00	0.00	5.96	87.16	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
BR.001	auac 2	0.07	1.42	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	3.62	2.62	0.00	0.00	1.54	0.00	0.00	5.37	86.87	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00
BR.001	auac 2	0.07	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.02	2.19	0.00	0.00	1.86	0.00	0.00	6.31	86.49	0.02	0.00	1.20	0.00	0.00	0.00	0.00	0.00
BR.001	average	0.06	3.65	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	3.04	2.20	0.00	0.00	0.00	0.00	0.00	5.87	84.95	0.00	0.00	1.34	0.00	0.00	0.00	0.00	0.00
BR.002	27	0.10	45.45	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.06	10.50	7.61	0.00	0.00	0.00	0.00	0.00	0.22	34.65	0.00	0.00	8.29	0.00	0.00	0.00	0.32	0.00
BR.002	27	0.10	46.35	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.05	10.11	7.32	0.00	0.00	0.00	0.00	0.00	0.21	32.67	0.00	0.00	9.82	0.00	0.00	0.00	0.27	0.00
BR.002	27	0.12	50.33	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.05	9.70	7.03	0.00	0.00	0.00	0.00	0.00	0.19	28.30	0.00	0.00	10.61	0.00	0.00	0.00	0.00	0.00
BR.002	average	0.11	47.38	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.06	10.10	7.32	0.00	0.00	0.00	0.00	0.00	0.21	31.87	0.00	0.00	9.57	0.00	0.00	0.00	0.28	0.00
BR.003	lin-7249f2	0.12	42.58	0.00	0.00	0.29	0.00	0.00	0.00	0.01	0.00	16.10	11.66	0.00	0.00	0.00	0.00	0.00	1.80	34.13	0.00	0.00	4.97	0.00	0.00	0.00	0.00	0.00
BR.003	lin-7249f2	0.11	44.62	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.04	11.00	7.97	0.00	0.00	0.00	0.00	0.00	1.67	35.26	0.00	0.00	6.86	0.00	0.00	0.00	0.00	0.00
BR.003	lin-7249f2	0.09	39.86	0.00	0.00	0.29	0.00	0.00	0.00	0.01	0.03	9.70	7.03	0.00	0.00	0.00	0.00	0.00	1.66	40.84	0.00	0.00	7.17	0.00	0.00	0.00	0.35	0.00
BR.003	lin-7249f2	0.10	40.39	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	13.45	9.75	0.00	0.00	0.00	0.00	0.00	1.58	40.20	0.00	0.00	3.82	0.00	0.00	0.00	0.22	0.00
BR.003	lin-7249f2	0.09	41.09	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.00	9.24	6.70	0.00	0.00	0.00	0.00	0.00	2.02	42.02	0.00	0.00	4.86	0.00	0.00	0.00	0.40	0.00
BR.003	lin-7249f2	0.12	47.12	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	11.41	8.27	0.00	0.00	0.00	0.00	0.00	2.00	33.74	0.00	0.00	5.04	0.00	0.00	0.00	0.24	0.00
BR.003	average	0.10	42.61	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.00	11.82	8.56	0.00	0.00	0.00	0.00	0.00	1.79	37.70	0.00	0.00	5.45	0.00	0.00	0.00	0.23	0.00
BR.004	lin-00d320	0.26	42.92	0.00	0.01	0.54	0.00	0.00	0.00	0.01	0.03	9.93	7.19	0.00	0.00	0.00	0.00	0.00	0.79	26.77	0.00	0.00	18.72	0.00	0.00	0.00	0.00	0.00
BR.004	lin-00d320	0.25	42.99	0.00	0.00	0.54	0.00	0.00	0.00	0.01	0.03	9.95	7.21	0.00	0.00	0.00	0.00	0.00	0.76	26.79	0.00	0.00	18.67	0.00	0.00	0.00	0.00	0.00
BR.004	lin-00d320	0.20	37.44	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.04	9.79	7.09	0.00	0.00	0.00	0.00	0.00	0.75	33.69	0.00	0.00	17.39	0.00	0.00	0.00	0.23	0.00
BR.004	average	0.24	41.11	0.00	0.00	0.52	0.00	0.00	0.00	0.01	0.04	9.89	7.16	0.00	0.00	0.00	0.00	0.00	0.77	29.08	0.00	0.00	18.26	0.00	0.00	0.00	0.00	0.00
BR.005	lin-4db330	0.09	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52	51.15	37.06	0.00	0.07	35.85	0.00	0.00	0.35	8.68	0.03	0.00	1.65	0.00	0.05	0.08	0.25	0.00
BR.005	lin-18e954	0.40	40.45	0.00	0.00	1.77	0.00	0.00	0.00	0.01	0.07	16.38	11.87	0.00	0.00	0.00	0.00	0.00	1.60	32.56	0.10	0.00	6.48	0.00	0.00	0.00	0.00	0.00
BR.005	lin-18e954	0.31	40.47	0.00	0.00	1.47	0.00	0.00	0.00	0.01	0.07	14.51	10.51	0.00	0.00	0.00	0.00	0.00	1.71	34.14	0.00	0.00	6.96	0.00	0.00	0.00	0.34	0.00
BR.005	lin-18e954	0.24	30.67	0.00	0.00	1.34	0.00	0.00	0.00	0.04	0.06	14.28	10.35	0.00	0.00	0.00	0.00	0.00	1.54	42.29	0.00	0.00	8.75	0.00	0.00	0.00	0.75	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.005	average	0.32	37.19	0.00	0.00	1.53	0.00	0.00	0.00	0.02	0.07	15.06	10.91	0.00	0.00	0.00	0.00	0.00	1.61	36.33	0.04	0.00	7.40	0.00	0.00	0.00	0.42	0.00
BR.006	lin-4db330	0.08	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	45.81	33.19	0.00	0.06	32.76	0.00	0.00	0.32	8.03	0.02	0.00	1.51	0.00	0.04	0.09	0.20	1.42
BR.006	lin-00e711	0.22	39.16	0.00	0.00	0.66	0.00	0.00	0.00	0.01	0.03	9.56	6.92	0.00	0.00	0.00	0.00	0.00	0.41	36.24	0.00	0.00	4.23	0.00	0.00	0.00	0.21	2.19
BR.006	lin-00e711	0.19	41.81	0.00	0.00	0.82	0.00	0.00	0.00	0.01	0.00	10.34	7.49	0.00	0.00	0.00	0.00	0.00	0.55	35.74	0.00	0.00	4.71	0.00	0.00	0.00	0.00	0.00
BR.006	lin-00e711	0.19	39.56	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.00	8.95	6.48	0.00	0.00	0.00	0.00	0.00	0.60	39.77	0.00	0.00	4.62	0.00	0.00	0.00	0.00	0.00
BR.006	average	0.20	40.18	0.00	0.00	0.72	0.00	0.00	0.00	0.01	0.00	9.62	6.97	0.00	0.00	0.00	0.00	0.00	0.52	37.25	0.00	0.00	4.52	0.00	0.00	0.00	0.00	0.00
BR.006	lin-00e711 back	0.20	37.99	0.00	0.00	0.68	0.00	0.00	0.00	0.01	0.00	9.91	7.18	0.00	0.00	0.00	0.00	0.00	0.70	32.83	0.00	0.00	7.02	0.00	0.00	0.00	0.27	2.21
BR.006	lin-00e711 back	0.16	37.77	0.00	0.00	0.66	0.00	0.00	0.00	0.01	0.00	9.57	6.93	0.00	0.00	0.00	0.00	0.00	0.54	39.86	0.00	0.00	5.52	0.00	0.00	0.00	0.00	0.00
BR.006	lin-00e711 back	0.18	34.58	0.00	0.00	0.60	0.00	0.00	0.00	0.01	0.00	9.59	6.95	0.00	0.00	0.00	0.00	0.00	0.63	39.45	0.00	0.00	6.10	0.06	0.00	0.00	0.00	2.06
BR.006	average	0.18	36.78	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.00	9.69	7.02	0.00	0.00	0.00	0.00	0.00	0.62	37.38	0.00	0.00	6.21	0.00	0.00	0.00	0.00	0.00
BR.006	lin-00e711	0.22	39.16	0.00	0.00	0.66	0.00	0.00	0.00	0.01	0.03	9.56	6.92	0.00	0.00	0.00	0.00	0.00	0.41	36.24	0.00	0.00	4.23	0.00	0.00	0.00	0.21	2.19
BR.006	lin-00e711	0.19	41.81	0.00	0.00	0.82	0.00	0.00	0.00	0.01	0.00	10.34	7.49	0.00	0.00	0.00	0.00	0.00	0.55	35.74	0.00	0.00	4.71	0.00	0.00	0.00	0.00	0.00
BR.006	lin-00e711	0.19	39.56	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.00	8.95	6.48	0.00	0.00	0.00	0.00	0.00	0.60	39.77	0.00	0.00	4.62	0.00	0.00	0.00	0.00	0.00
BR.006	average	0.20	40.18	0.00	0.00	0.72	0.00	0.00	0.00	0.01	0.00	9.62	6.97	0.00	0.00	0.00	0.00	0.00	0.52	37.25	0.00	0.00	4.52	0.00	0.00	0.00	0.00	0.00
BR.006	lin-00e711 back	0.20	37.99	0.00	0.00	0.68	0.00	0.00	0.00	0.01	0.00	9.91	7.18	0.00	0.00	0.00	0.00	0.00	0.70	32.83	0.00	0.00	7.02	0.00	0.00	0.00	0.27	2.21
BR.006	lin-00e711 back	0.16	37.77	0.00	0.00	0.66	0.00	0.00	0.00	0.01	0.00	9.57	6.93	0.00	0.00	0.00	0.00	0.00	0.54	39.86	0.00	0.00	5.52	0.00	0.00	0.00	0.00	0.00
BR.006	lin-00e711 back	0.18	34.58	0.00	0.00	0.60	0.00	0.00	0.00	0.01	0.00	9.59	6.95	0.00	0.00	0.00	0.00	0.00	0.63	39.45	0.00	0.00	6.10	0.06	0.00	0.00	0.00	2.06
BR.006	average	0.18	36.78	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.00	9.69	7.02	0.00	0.00	0.00	0.00	0.00	0.62	37.38	0.00	0.00	6.21	0.00	0.00	0.00	0.00	0.00
BR.007	lin-4db330	0.08	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	45.42	32.91	0.00	0.06	32.69	0.00	0.00	0.36	9.07	0.03	0.00	1.32	0.00	0.03	0.08	0.24	1.27
BR.007	SF035.018	0.16	29.94	0.00	0.00	0.69	0.00	0.00	0.00	0.01	0.04	10.34	7.49	0.00	0.00	0.00	0.00	0.00	2.71	48.89	0.05	0.00	6.86	0.00	0.00	0.00	0.28	0.00
BR.007	SF035.018	0.10	33.38	0.00	0.00	0.67	0.00	0.00	0.00	0.03	0.00	10.45	7.57	0.00	0.00	0.00	0.00	0.00	1.29	41.56	0.00	0.00	12.46	0.00	0.00	0.00	0.00	0.00
BR.007	SF035.018	0.14	26.93	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.05	10.53	7.63	0.00	0.00	3.68	0.00	0.00	2.68	50.17	0.05	0.00	4.80	0.00	0.00	0.00	0.34	0.00
BR.007	average	0.13	30.08	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.00	10.44	7.56	0.00	0.00	0.00	0.00	0.00	2.23	46.87	0.00	0.00	8.04	0.00	0.00	0.00	0.00	0.00
BR.007	lin-a6943e side b	0.08	13.46	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3.74	2.71	0.00	0.00	0.00	0.02	0.00	0.22	62.33	0.00	0.04	19.10	0.00	0.00	0.00	0.00	0.00
BR.007	lin-a6943e side b	0.10	14.89	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	3.76	2.73	0.00	0.00	0.00	0.03	0.00	0.15	79.35	0.00	0.00	1.63	0.00	0.00	0.00	0.00	0.00
BR.007	lin-a6943e side b	0.12	19.79	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	5.40	3.91	0.00	0.00	2.68	0.03	0.00	0.36	70.52	0.04	0.00	0.85	0.00	0.00	0.00	0.12	0.00

REF NUM	***SAMPLE***	***Sb***	***Sn***	***Cd***	***Pd***	***Ag***	***Ru***	***Mo***	***Nb***	***Zr***	***Bi***	***Pb***	***Pb (scaled down)***	***Hg***	***Se***	***As***	***Au***	***W***	***Zn***	***Cu***	***Ni***	***Co***	***Fe***	***Mn***	***Cr***	***V***	***Ti***	***Al***
BR.007	average	0.03	5.69	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	2.06	1.49	0.00	0.00	0.00	0.00	0.00	0.14	37.12	0.00	0.12	54.83	0.00	0.00	0.00	0.00	0.00
BR.007	lin-a6943e side a	0.11	35.71	0.00	0.00	0.32	0.00	0.00	0.00	0.01	0.09	12.20	8.84	0.00	0.00	7.74	0.06	0.00	0.30	41.86	0.00	0.00	1.11	0.00	0.00	0.00	0.44	0.00
BR.007	lin-a6943e side a	0.11	30.26	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.17	18.27	13.24	0.00	0.02	18.00	0.00	0.00	0.25	31.61	0.00	0.00	0.60	0.00	0.00	0.00	0.48	0.00
BR.007	lin-a6943e side a	0.08	48.27	0.00	0.00	0.31	0.00	0.00	0.00	0.01	0.07	11.60	8.40	0.00	0.00	2.88	0.00	0.00	0.27	34.03	0.00	0.00	1.98	0.00	0.00	0.00	0.45	0.00
BR.007	average	0.13	28.61	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.04	6.72	4.87	0.10	0.00	2.34	0.19	0.00	0.37	59.94	0.00	0.00	0.74	0.00	0.00	0.00	0.40	0.00
BR.008	lin-4db330	0.07	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	49.96	36.20	0.00	0.07	30.71	0.00	0.00	0.37	6.35	0.00	0.00	1.33	0.00	0.04	0.07	0.24	1.39
BR.008	lin-00bea6	0.26	42.41	0.03	0.01	0.56	0.00	0.00	0.00	0.01	0.04	12.63	9.15	0.00	0.00	0.00	0.00	0.00	0.36	27.24	0.05	0.00	16.41	0.00	0.00	0.00	0.00	0.00
BR.008	lin-00bea6	0.11	22.79	0.00	0.00	0.32	0.00	0.00	0.00	0.03	0.02	8.71	6.31	0.00	0.00	0.00	0.00	0.00	0.41	25.57	0.00	0.00	41.75	0.00	0.00	0.00	0.28	0.00
BR.008	lin-00bea6	0.26	41.57	0.03	0.01	0.55	0.00	0.00	0.00	0.01	0.05	13.12	9.50	0.00	0.00	0.00	0.00	0.00	0.36	27.71	0.00	0.00	16.30	0.00	0.00	0.00	0.00	0.00
BR.008	average	0.21	35.59	0.02	0.01	0.47	0.00	0.00	0.00	0.02	0.04	11.48	8.32	0.00	0.00	0.00	0.00	0.00	0.38	26.84	0.00	0.00	24.82	0.00	0.00	0.00	0.00	0.00
BR.009	lin-b05d6d	0.07	32.88	0.00	0.00	0.24	0.00	0.00	0.00	0.02	0.03	5.00	3.62	0.00	0.00	0.00	0.00	0.00	0.24	47.26	0.00	0.00	13.68	0.08	0.00	0.00	0.49	0.00
BR.009	lin-b05d6d	0.10	42.47	0.00	0.00	0.32	0.00	0.00	0.00	0.01	0.04	5.60	4.05	0.00	0.00	0.00	0.00	0.00	0.24	41.57	0.00	0.00	9.24	0.00	0.00	0.00	0.30	0.00
BR.009	lin-b05d6d	0.07	27.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	4.16	3.02	0.00	0.00	0.00	0.00	0.00	0.23	44.78	0.00	0.00	23.23	0.09	0.00	0.00	0.41	0.00
BR.009	average	0.08	34.12	0.00	0.00	0.18	0.00	0.00	0.00	0.01	0.03	4.92	3.56	0.00	0.00	0.00	0.00	0.00	0.24	44.54	0.00	0.00	15.38	0.07	0.00	0.00	0.40	0.00
BR.009	lin-4db330	0.08	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.43	51.93	37.62	0.00	0.07	26.36	0.00	0.00	0.34	5.99	0.03	0.00	1.61	0.00	0.00	0.10	0.19	2.22
BR.010	lin-4db330	0.08	1.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.48	45.44	32.92	0.00	0.07	33.78	0.00	0.00	0.35	6.98	0.03	0.00	1.22	0.00	0.05	0.10	0.23	2.09
BR.010	lin-93c4e2	0.20	35.95	0.00	0.00	0.53	0.00	0.00	0.00	0.01	0.08	9.19	6.66	0.00	0.00	3.12	0.00	0.00	0.84	34.75	0.00	0.00	8.62	0.00	0.00	0.00	0.34	0.00
BR.010	lin-93c4e2	0.18	31.88	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.10	8.78	6.36	0.00	0.00	4.59	0.00	0.00	0.75	33.48	0.00	0.00	10.32	0.00	0.00	0.00	0.42	0.00
BR.010	lin-93c4e2	0.19	35.88	0.00	0.01	0.56	0.00	0.00	0.00	0.00	0.08	7.36	5.33	0.00	0.00	1.85	0.00	0.00	1.00	34.13	0.00	0.00	6.71	0.00	0.00	0.00	0.49	2.10
BR.010	average	0.19	34.57	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.09	8.44	6.12	0.00	0.00	3.18	0.00	0.00	0.86	34.12	0.00	0.00	8.55	0.00	0.00	0.00	0.42	0.00
BR.010	lin-93c4e2	0.14	30.88	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.05	8.25	5.98	0.00	0.00	2.04	0.00	0.00	0.80	32.79	0.00	0.00	6.14	0.00	0.00	0.00	0.49	4.73
BR.010	lin-93c4e2	0.16	34.99	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.07	8.35	6.05	0.00	0.00	3.69	0.00	0.00	0.80	35.96	0.00	0.00	7.04	0.00	0.00	0.00	0.49	0.00
BR.010	lin-93c4e2	0.17	34.44	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.08	8.66	6.27	0.00	0.00	4.12	0.00	0.00	0.76	34.06	0.00	0.00	6.41	0.00	0.00	0.00	0.55	1.87
BR.010	average	0.16	33.43	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.07	8.42	6.10	0.00	0.00	3.28	0.00	0.00	0.79	34.27	0.00	0.00	6.53	0.00	0.00	0.00	0.51	2.64
BR.010	lin-93c4e2	0.20	35.95	0.00	0.00	0.53	0.00	0.00	0.00	0.01	0.08	9.19	6.66	0.00	0.00	3.12	0.00	0.00	0.84	34.75	0.00	0.00	8.62	0.00	0.00	0.00	0.34	0.00
BR.010	lin-93c4e2	0.18	31.88	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.10	8.78	6.36	0.00	0.00	4.59	0.00	0.00	0.75	33.48	0.00	0.00	10.32	0.00	0.00	0.00	0.42	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.010	lin-93c4e2	0.19	35.88	0.00	0.01	0.56	0.00	0.00	0.00	0.00	0.08	7.36	5.33	0.00	0.00	1.85	0.00	0.00	1.00	34.13	0.00	0.00	6.71	0.00	0.00	0.00	0.49	2.10
BR.010	average	0.19	34.57	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.09	8.44	6.12	0.00	0.00	3.18	0.00	0.00	0.86	34.12	0.00	0.00	8.55	0.00	0.00	0.00	0.42	0.00
BR.010	lin-93c4e2	0.14	30.88	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.05	8.25	5.98	0.00	0.00	2.04	0.00	0.00	0.80	32.79	0.00	0.00	6.14	0.00	0.00	0.00	0.49	4.73
BR.010	lin-93c4e2	0.16	34.99	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.07	8.35	6.05	0.00	0.00	3.69	0.00	0.00	0.80	35.96	0.00	0.00	7.04	0.00	0.00	0.00	0.49	0.00
BR.010	lin-93c4e2	0.17	34.44	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.08	8.66	6.27	0.00	0.00	4.12	0.00	0.00	0.76	34.06	0.00	0.00	6.41	0.00	0.00	0.00	0.55	1.87
BR.010	average	0.16	33.43	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.07	8.42	6.10	0.00	0.00	3.28	0.00	0.00	0.79	34.27	0.00	0.00	6.53	0.00	0.00	0.00	0.51	2.64
BR.011	average	0.08	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	48.29	34.98	0.00	0.07	32.03	0.00	0.00	0.35	7.52	0.02	0.00	1.44	0.00	0.04	0.09	0.23	0.00
BR.011	SF035.023	0.11	33.18	0.00	0.00	0.89	0.00	0.00	0.00	0.01	0.06	11.77	8.53	0.00	0.00	7.31	0.00	0.00	2.52	38.50	0.00	0.00	5.35	0.00	0.00	0.00	0.31	0.00
BR.011	SF035.023	0.13	28.36	0.00	0.00	0.76	0.00	0.00	0.00	0.01	0.08	10.93	7.92	0.00	0.00	6.83	0.00	0.00	2.43	37.19	0.04	0.00	12.92	0.00	0.00	0.00	0.28	0.00
BR.011	SF035.023	0.13	37.10	0.00	0.00	1.02	0.00	0.00	0.00	0.01	0.06	11.35	8.22	0.00	0.00	4.49	0.00	0.00	2.27	38.01	0.00	0.00	5.18	0.00	0.00	0.00	0.40	0.00
BR.011	average	0.12	32.88	0.00	0.00	0.89	0.00	0.00	0.00	0.01	0.06	11.35	8.22	0.00	0.00	6.21	0.00	0.00	2.41	37.90	0.00	0.00	7.81	0.00	0.00	0.00	0.33	0.00
BR.012	lin-509ee0	0.23	32.73	0.00	0.00	0.43	0.00	0.00	0.00	0.01	0.00	21.93	15.89	0.00	0.00	0.00	0.00	0.00	2.39	34.43	0.00	0.00	5.91	0.07	0.00	0.00	0.26	0.00
BR.012	lin-509ee0	0.26	32.56	0.00	0.00	0.43	0.00	0.00	0.00	0.01	0.00	21.93	15.89	0.00	0.00	0.00	0.00	0.00	2.39	33.32	0.00	0.00	8.75	0.08	0.00	0.00	0.24	0.00
BR.012	lin-509ee0	0.26	32.84	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.00	24.25	17.57	0.00	0.00	2.31	0.00	0.00	2.11	33.37	0.00	0.00	4.14	0.00	0.00	0.00	0.26	0.00
BR.012	average	0.25	32.71	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.00	22.71	16.45	0.00	0.00	0.00	0.00	0.00	2.29	33.71	0.00	0.00	6.27	0.05	0.00	0.00	0.25	0.00
BR.013	lin-0e02d6	0.32	35.03	0.00	0.00	0.61	0.00	0.00	0.00	0.01	0.05	16.54	11.98	0.00	0.00	0.00	0.00	0.00	0.54	37.19	0.00	0.00	9.57	0.00	0.00	0.00	0.00	0.00
BR.013	lin-0e02d6	0.31	34.43	0.00	0.00	0.60	0.00	0.00	0.00	0.01	0.05	14.83	10.75	0.00	0.00	0.00	0.00	0.00	0.53	40.37	0.00	0.00	8.74	0.00	0.00	0.00	0.00	0.00
BR.013	lin-0e02d6	0.34	33.62	0.00	0.00	0.57	0.00	0.00	0.00	0.01	0.04	15.57	11.28	0.00	0.00	0.00	0.00	0.00	0.53	37.95	0.00	0.00	11.08	0.00	0.00	0.00	0.28	0.00
BR.013	lin-0e02d6	0.28	30.58	0.00	0.00	0.54	0.00	0.00	0.00	0.01	0.00	14.42	10.45	0.00	0.00	0.00	0.00	0.00	0.62	45.91	0.00	0.00	7.35	0.00	0.00	0.00	0.25	0.00
BR.013	lin-0e02d6	0.29	30.32	0.00	0.00	0.54	0.00	0.00	0.00	0.01	0.04	14.18	10.27	0.00	0.00	0.00	0.00	0.00	0.54	48.47	0.00	0.00	5.38	0.00	0.00	0.00	0.23	0.00
BR.013	lin-0e02d6	0.31	31.51	0.00	0.00	0.55	0.00	0.00	0.00	0.01	0.00	15.36	11.13	0.00	0.00	0.00	0.00	0.00	0.55	43.42	0.00	0.00	8.09	0.00	0.00	0.00	0.17	0.00
BR.013	average	0.31	32.58	0.00	0.00	0.57	0.00	0.00	0.00	0.01	0.04	15.15	10.98	0.00	0.00	0.00	0.00	0.00	0.55	42.22	0.00	0.00	8.37	0.00	0.00	0.00	0.20	0.00
BR.014	LIN A3C689	0.00	26.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.16	2.29	0.00	0.00	2.60	0.00	0.00	0.37	58.88	0.05	0.00	7.97	0.00	0.00	0.00	0.52	0.00
BR.014	LIN A3C689	0.00	26.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.26	2.36	0.00	0.00	2.75	0.00	0.00	0.35	57.81	0.00	0.00	8.36	0.00	0.00	0.00	0.44	0.00
BR.014	LIN A3C689	0.00	42.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.05	2.93	0.00	0.00	1.33	0.00	0.00	0.25	35.07	0.00	0.00	16.73	0.00	0.00	0.00	0.39	0.00
BR.014	average	0.00	31.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.49	2.53	0.00	0.00	2.22	0.00	0.00	0.32	50.59	0.00	0.00	11.02	0.00	0.00	0.00	0.45	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.015	lin-869ef5	0.13	26.69	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	10.89	7.89	0.00	0.00	0.00	0.04	0.00	0.76	55.40	0.00	0.00	0.97	0.00	0.00	0.00	0.15	0.00
BR.015	lin-869ef5	0.14	28.91	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.03	9.81	7.11	0.00	0.00	2.46	0.04	0.00	1.05	49.28	0.00	0.00	1.27	0.00	0.00	0.00	0.34	1.43
BR.015	lin-869ef5	0.24	39.15	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.03	8.88	6.43	0.00	0.00	0.00	0.03	0.00	0.99	36.47	0.00	0.00	1.61	0.00	0.00	0.00	0.36	3.58
BR.015	average	0.17	31.58	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	9.86	7.14	0.00	0.00	0.00	0.04	0.00	0.94	47.05	0.00	0.00	1.28	0.00	0.00	0.00	0.28	2.11
BR.016	lin-92e72a side b	0.08	22.05	0.00	0.00	0.14	0.00	0.00	0.00	0.01	0.03	7.32	5.30	0.00	0.00	0.00	0.00	0.00	0.55	41.60	0.00	0.00	28.10	0.00	0.00	0.00	0.00	0.00
BR.016	lin-92e72a side b	0.05	14.52	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	4.74	3.44	0.00	0.00	0.00	0.02	0.00	0.60	46.58	0.00	0.00	33.35	0.00	0.00	0.00	0.11	0.00
BR.016	lin-92e72a side b	0.04	9.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	2.01	0.00	0.00	0.00	0.00	0.00	0.34	37.94	0.00	0.00	49.51	0.00	0.00	0.00	0.00	0.00
BR.016	average	0.15	42.24	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.08	14.44	10.46	0.00	0.00	0.00	0.00	0.00	0.71	40.27	0.00	0.00	1.45	0.00	0.00	0.00	0.22	0.00
BR.016	lin-92e72a side a	0.12	30.39	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.05	10.75	7.79	0.00	0.00	2.31	0.07	0.00	0.94	50.31	0.00	0.00	4.39	0.00	0.00	0.00	0.28	0.00
BR.016	lin-92e72a side a	0.12	25.97	0.00	0.00	0.34	0.00	0.00	0.00	0.01	0.05	9.19	6.66	0.00	0.00	3.63	0.08	0.00	1.01	52.53	0.00	0.00	6.78	0.00	0.00	0.00	0.29	0.00
BR.016	lin-92e72a side a	0.11	26.21	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.05	9.59	6.95	0.00	0.00	3.30	0.09	0.00	1.01	53.58	0.00	0.00	5.46	0.00	0.00	0.00	0.26	0.00
BR.016	average	0.15	39.01	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.05	13.48	9.77	0.00	0.00	0.00	0.05	0.00	0.81	44.82	0.00	0.00	0.92	0.00	0.00	0.00	0.30	0.00
BR.017	SF035.018	0.16	29.94	0.00	0.00	0.69	0.00	0.00	0.00	0.01	0.04	10.34	0.00	0.00	0.00	0.00	0.00	2.71	48.89	0.05	0.00	6.86	0.00	0.00	0.00	0.28	0.00	
BR.017	SF035.018	0.10	33.38	0.00	0.00	0.67	0.00	0.00	0.00	0.03	0.00	10.45	0.00	0.00	0.00	0.00	0.00	1.29	41.56	0.00	0.00	12.46	0.00	0.00	0.00	0.00	0.00	
BR.017	SF035.018	0.14	26.93	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.05	10.53	0.00	0.00	3.68	0.00	0.00	2.68	50.17	0.05	0.00	4.80	0.00	0.00	0.00	0.34	0.00	
BR.017	SF035.018	0.13	30.08	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.00	10.44	0.00	0.00	0.00	0.00	0.00	2.23	46.87	0.00	0.00	8.04	0.00	0.00	0.00	0.00	0.00	
BR.018	lin-90ef99 side b	0.23	28.36	0.00	0.00	0.52	0.00	0.00	0.00	0.01	0.09	13.36	9.68	0.00	0.00	0.00	0.01	0.00	1.41	50.43	0.00	0.00	5.38	0.00	0.00	0.00	0.19	0.00
BR.018	lin-90ef99 side b	0.22	25.96	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.08	12.67	9.18	0.00	0.00	0.00	0.03	0.00	0.58	53.78	0.00	0.00	6.03	0.00	0.00	0.00	0.19	0.00
BR.018	lin-90ef99 side b	0.25	32.60	0.00	0.00	0.66	0.00	0.00	0.00	0.01	0.10	14.72	10.66	0.00	0.00	0.00	0.00	0.00	3.03	44.88	0.04	0.00	3.47	0.00	0.00	0.00	0.25	0.00
BR.018	average	0.22	26.53	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.08	12.68	9.19	0.00	0.00	0.00	0.00	0.00	0.61	52.62	0.00	0.00	6.66	0.00	0.00	0.00	0.00	0.00
BR.018	lin-90ef99 side a	0.12	20.66	0.00	0.00	0.37	0.00	0.01	0.00	0.01	0.06	15.44	11.18	0.00	0.00	0.00	0.03	0.00	0.91	38.66	0.00	0.10	23.50	0.00	0.00	0.00	0.00	0.00
BR.018	lin-90ef99 side a	0.17	26.46	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.05	13.77	9.98	0.00	0.00	0.00	0.09	0.00	0.71	54.74	0.00	0.00	3.42	0.00	0.00	0.00	0.00	0.00
BR.018	lin-90ef99 side a	0.05	4.37	0.02	0.02	0.00	0.00	0.02	0.00	0.01	0.00	3.09	2.24	0.00	0.00	0.00	0.00	0.00	0.51	27.62	0.00	0.29	63.82	0.03	0.00	0.05	0.11	0.00
BR.018	average	0.14	31.16	0.00	0.00	0.54	0.00	0.00	0.00	0.03	0.13	29.45	21.34	0.00	0.00	0.00	0.00	0.00	1.51	33.61	0.00	0.00	3.25	0.00	0.00	0.00	0.00	0.00
BR.019	lin-92affa side b	0.21	28.93	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.31		0.00		0.00	0.00	0.03	0.84			0.08	0.00	17.07	0.00	0.00	0.10	0.33	0.00
BR.019	lin-92affa side b	0.26	36.30	0.05	0.00	1.10	0.00	0.00	0.00	0.00	0.45		0.00		0.00	0.00	0.00	1.45			0.11	0.00	7.73	0.00	0.11	0.25	0.55	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.019	lin-92affa side b	0.23	36.46	0.00	0.00	1.07	0.00	0.00	0.00	0.01	0.09	12.63	9.15	0.00	0.00	0.00	0.09	0.00	2.25	38.75	0.00	0.00	8.16	0.00	0.00	0.00	0.24	0.00
BR.019	average	0.13	14.02	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.40		0.00		0.00	0.00	0.00	1.06			0.10	0.00	35.31	0.04	0.04	0.06	0.21	0.00
BR.019	lin-92affa side a	0.18	28.20	0.00	0.00	0.85	0.00	0.00	0.00	0.01	0.06	9.47	6.86	0.00	0.00	0.00	0.06	0.00	1.44	40.85	0.00	0.00	18.70	0.00	0.00	0.00	0.16	0.00
BR.019	lin-92affa side a	0.24	36.17	0.00	0.00	1.11	0.00	0.00	0.00	0.01	0.08	11.82	8.57	0.00	0.00	0.00	0.09	0.00	1.73	39.95	0.00	0.00	8.50	0.00	0.00	0.00	0.29	0.00
BR.019	lin-92affa side a	0.24	36.09	0.00	0.00	1.03	0.00	0.00	0.00	0.01	0.09	10.90	7.90	0.00	0.00	0.00	0.09	0.00	1.57	42.04	0.00	0.00	7.72	0.00	0.00	0.00	0.20	0.00
BR.019	average	0.07	12.34	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.00	5.69	4.12	0.00	0.00	0.00	0.00	0.00	1.03	40.57	0.00	0.00	39.89	0.00	0.00	0.00	0.00	0.00
BR.020	lin-32d770	0.47	57.32	0.00	0.01	1.02	0.00	0.00	0.00	0.01	0.05	17.98	13.03	0.00	0.00	0.00	0.00	0.00	0.80	17.24	0.00	0.00	4.77	0.00	0.00	0.00	0.00	0.00
BR.020	lin-32d770	0.40	46.31	0.00	0.00	0.49	0.00	0.01	0.00	0.01	0.00	24.98	18.10	0.00	0.00	0.00	0.00	0.00	0.54	22.71	0.00	0.00	4.38	0.00	0.00	0.00	0.00	0.00
BR.020	lin-32d770	0.46	58.27	0.05	0.00	0.79	0.00	0.00	0.00	0.01	0.05	18.99	13.76	0.00	0.00	0.00	0.00	0.00	0.58	15.17	0.23	0.00	5.40	0.00	0.00	0.00	0.00	0.00
BR.020	average	0.44	53.97	0.00	0.00	0.77	0.00	0.00	0.00	0.01	0.04	20.65	14.96	0.00	0.00	0.00	0.00	0.00	0.64	18.37	0.09	0.00	4.85	0.00	0.00	0.00	0.00	0.00
BR.020	lin-32d770	0.27	32.11	0.03	0.00	0.66	0.00	0.00	0.00	0.02	0.00	21.31	15.44	0.00	0.00	0.00	0.00	0.00	1.11	32.80	0.16	0.00	11.31	0.00	0.00	0.00	0.00	0.00
BR.020	lin-32d770	0.17	24.80	0.00	0.01	0.52	0.00	0.00	0.00	0.02	0.04	21.08	15.27	0.00	0.00	0.00	0.00	0.00	1.45	39.66	0.00	0.00	11.85	0.00	0.00	0.00	0.39	0.00
BR.020	lin-32d770	0.19	24.74	0.00	0.01	0.59	0.00	0.00	0.00	0.01	0.04	21.30	15.43	0.00	0.00	0.00	0.00	0.00	1.30	43.75	0.00	0.00	7.76	0.00	0.00	0.00	0.30	0.00
BR.020	average	0.21	27.22	0.00	0.01	0.59	0.00	0.00	0.00	0.01	0.00	21.23	15.38	0.00	0.00	0.00	0.00	0.00	1.29	38.74	0.06	0.00	10.31	0.00	0.00	0.00	0.29	0.00
BR.021	SF041.015	0.23	32.14	0.00	0.00	1.02	0.00	0.00	0.00	0.01	0.05	13.86	10.04	0.00	0.00	0.00	0.00	0.00	1.90	45.22	0.00	0.00	5.42	0.00	0.00	0.00	0.00	0.00
BR.021	SF041.015	0.21	29.18	0.00	0.00	0.98	0.00	0.00	0.00	0.01	0.05	14.58	10.56	0.00	0.00	0.00	0.05	0.00	1.98	48.98	0.00	0.00	3.83	0.00	0.00	0.00	0.17	0.00
BR.021	SF041.015	0.14	19.29	0.00	0.00	0.73	0.00	0.00	0.00	0.01	0.04	11.38	8.25	0.00	0.00	0.00	0.00	0.00	1.04	41.38	0.00	0.00	25.99	0.00	0.00	0.00	0.00	0.00
BR.021	average	0.20	26.87	0.00	0.00	0.91	0.00	0.00	0.00	0.01	0.05	13.27	9.62	0.00	0.00	0.00	0.00	0.00	1.64	45.19	0.00	0.00	11.74	0.00	0.00	0.00	0.00	0.00
BR.022	LIN A3AF71	0.00	25.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.53	0.00	0.00	2.14	0.00	0.00	0.27	56.36	0.09	0.00	14.23	0.00	0.00	0.00	0.54	0.00
BR.022	LIN A3AF71	0.00	13.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.44	3.21	0.00	0.00	6.89	0.00	5.52	0.00	17.17	0.00	0.00	50.33	0.00	0.00	0.00	1.26	0.00
BR.022	LIN A3AF71	0.15	40.50	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.02	4.32	3.13	0.00	0.00	0.00	0.08	0.00	0.24	15.50	0.00	0.00	38.57	0.00	0.00	0.00	0.25	0.00
BR.022	average	0.00	26.70	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	3.16	2.29	0.00	0.00	3.01	0.03	1.84	0.17	29.68	0.00	0.00	34.38	0.00	0.00	0.00	0.68	0.00
BR.023	lin-90d7fb small frag side b	0.22	25.12	0.00	0.00	0.80	0.00	0.00	0.00	0.01	0.09	17.08	12.37	0.00	0.00	0.00	0.02	0.00	1.00	54.98	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00
BR.023	lin-90d7fb small frag side b	0.22	25.12	0.00	0.00	0.80	0.00	0.00	0.00	0.01	0.09	17.08	12.37	0.00	0.00	0.00	0.00	0.00	1.00	54.90	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00
BR.023	lin-90d7fb small frag side b	0.22	25.13	0.00	0.00	0.79	0.00	0.00	0.00	0.01	0.09	17.08	12.37	0.00	0.00	0.00	0.04	0.00	0.99	55.02	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.023	average	0.21	25.10	0.00	0.00	0.80	0.00	0.00	0.00	0.01	0.09	17.09	12.38	0.00	0.00	0.00	0.00	0.00	1.01	55.02	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00
BR.023	lin-90d7fb small frag side a	0.23	24.75	0.00	0.00	0.83	0.00	0.00	0.00	0.02	0.09	21.26	15.40	0.00	0.00	0.00	0.09	0.00	2.23	49.40	0.05	0.00	0.86	0.00	0.00	0.00	0.21	0.00
BR.023	lin-90d7fb small frag side a	0.23	24.73	0.00	0.00	0.82	0.00	0.00	0.00	0.02	0.09	21.25	15.39	0.00	0.00	0.00	0.08	0.00	2.23	49.44	0.05	0.00	0.87	0.00	0.00	0.00	0.19	0.00
BR.023	lin-90d7fb small frag side a	0.23	24.73	0.00	0.00	0.84	0.00	0.00	0.00	0.02	0.09	21.23	15.38	0.00	0.00	0.00	0.10	0.00	2.23	49.39	0.06	0.00	0.86	0.00	0.00	0.00	0.24	0.00
BR.023	average	0.22	24.79	0.00	0.00	0.83	0.00	0.00	0.00	0.01	0.09	21.29	15.43	0.00	0.00	0.00	0.08	0.00	2.21	49.36	0.05	0.00	0.86	0.00	0.00	0.00	0.20	0.00
BR.023	lin-90d7fb larger frag side b	0.26	23.73	0.00	0.00	0.77	0.00	0.00	0.00	0.01	0.33	9.95	7.21	0.00	0.00	0.00	0.10	0.00	0.76	33.91	0.04	0.00	6.25	0.00	0.00	0.00	0.17	0.00
BR.023	lin-90d7fb larger frag side b	0.21	22.35	0.00	0.00	0.72	0.00	0.00	0.00	0.01	0.06	12.26	8.88	0.00	0.00	0.00	0.00	0.00	0.90	55.58	0.00	0.00	7.88	0.00	0.00	0.00	0.00	0.00
BR.023	lin-90d7fb larger frag side b	0.24	24.72	0.00	0.00	0.76	0.00	0.00	0.00	0.02	0.07	17.58	12.74	0.00	0.00	0.00	0.00	0.00	1.37	46.15	0.00	0.00	9.08	0.00	0.00	0.00	0.00	0.00
BR.023	average	0.31	24.13	0.03	0.01	0.83	0.00	0.00	0.00	0.00	0.88		0.00		0.00	0.00	0.26	0.00			0.11	0.00	1.78	0.05	0.10	0.15	0.50	0.00
BR.023	lin-9007fb larger frag side a	0.21	23.99	0.00	0.00	0.81	0.00	0.00	0.00	0.01	0.07	14.08	10.20	0.00	0.00	0.00	0.00	0.00	1.23	52.99	0.00	0.00	6.54	0.00	0.00	0.00	0.00	0.00
BR.023	lin-9007fb larger frag side a	0.17	18.50	0.00	0.00	0.62	0.00	0.00	0.00	0.01	0.05	12.35	8.95	0.00	0.00	0.00	0.00	0.00	1.20	55.30	0.00	0.00	11.77	0.00	0.00	0.00	0.00	0.00
BR.023	lin-9007fb larger frag side a	0.22	25.58	0.00	0.00	0.87	0.00	0.00	0.00	0.01	0.08	15.27	11.06	0.00	0.00	0.00	0.00	0.00	1.17	51.08	0.00	0.00	5.74	0.00	0.00	0.00	0.00	0.00
BR.023	average	0.23	27.89	0.00	0.00	0.93	0.00	0.00	0.00	0.01	0.08	14.61	10.58	0.00	0.00	0.00	0.05	0.00	1.31	52.59	0.00	0.00	2.11	0.00	0.00	0.00	0.18	0.00
BR.024	lin-a588c1	0.31	23.16	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	32.47	23.52	0.00	0.00	8.65	0.00	0.00	0.91	17.06	0.00	0.00	5.29	0.00	0.00	0.00	0.00	2.15
BR.024	lin-a588c1	0.25	31.50	0.00	0.00	1.00	0.00	0.00	0.00	0.01	0.00	26.29	19.04	0.00	0.00	0.00	0.00	0.00	1.70	26.80	0.00	0.00	4.78	0.00	0.00	0.00	0.00	0.00
BR.024	lin-a588c1	0.26	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	34.62	25.08	0.00	0.00	0.00	0.00	0.00	1.18	23.20	0.00	0.00	5.67	0.00	0.00	0.00	0.00	1.85
BR.024	average	0.27	25.52	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.00	31.13	22.55	0.00	0.00	2.88	0.00	0.00	1.27	22.35	0.00	0.00	5.24	0.00	0.00	0.00	0.00	0.00
BR.024	lin-a588c1	0.26	30.56	0.00	0.00	1.00	0.00	0.00	0.00	0.01	0.00	22.10	16.01	0.00	0.00	0.00	0.00	0.00	1.58	26.71	0.00	0.00	5.66	0.00	0.00	0.00	0.00	0.00
BR.024	lin-a588c1	0.25	20.80	0.03	0.00	0.63	0.00	0.00	0.00	0.01	0.78		0.00		0.03	52.67	0.00	0.26			0.05	0.00	2.04	0.07	0.08	0.15	0.48	3.53
BR.024	lin-a588c1	0.28	21.22	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	33.65	24.38	0.00	0.00	0.00	0.00	0.00	0.71	19.08	0.04	0.00	7.70	0.00	0.00	0.00	0.00	3.97
BR.024	average	0.26	24.19	0.02	0.00	0.54	0.00	0.00	0.00	0.01	0.27	18.59	13.46	0.00	0.01	17.56	0.00	0.09	0.76	15.26	0.03	0.00	5.13	0.00	0.00	0.00	0.16	3.12
BR.025	lin-909046 side b	0.20	23.97	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.13	24.87	18.02	0.00	0.00	4.19	0.03	0.00	3.25	39.90	0.04	0.00	2.70	0.00	0.00	0.00	0.25	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.025	lin-909046 side b	0.19	21.85	0.00	0.00	0.42	0.00	0.00	0.00	0.02	0.16	28.25	20.47	0.00	0.00	7.68	0.06	0.00	3.18	35.01	0.03	0.00	2.91	0.00	0.00	0.00	0.24	0.00
BR.025	lin-909046 side b	0.21	23.57	0.00	0.00	0.46	0.00	0.00	0.00	0.02	0.14	28.05	20.32	0.00	0.00	4.89	0.00	0.00	2.52	37.62	0.04	0.00	2.27	0.00	0.00	0.00	0.20	0.00
BR.025	average	0.21	26.49	0.00	0.00	0.52	0.00	0.00	0.00	0.01	0.08	18.30	13.26	0.00	0.00	0.00	0.00	0.00	4.03	47.06	0.05	0.00	2.93	0.00	0.00	0.00	0.30	0.00
BR.025	lin-909046 side a	0.25	29.48	0.00	0.00	0.43	0.00	0.00	0.00	0.03	0.12	32.58	23.60	0.00	0.00	0.00	0.05	0.00	3.51	30.16	0.05	0.00	3.31	0.00	0.00	0.00	0.00	0.00
BR.025	lin-909046 side a	0.21	21.69	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.11	41.62	30.15	0.00	0.00	0.00	0.00	0.00	3.00	28.60	0.00	0.00	4.68	0.00	0.00	0.00	0.00	0.00
BR.025	lin-909046 side a	0.26	32.77	0.00	0.00	0.60	0.00	0.00	0.00	0.02	0.12	25.74	18.65	0.00	0.00	0.00	0.00	0.00	3.03	34.76	0.05	0.00	2.62	0.00	0.00	0.00	0.00	0.00
BR.025	average	0.27	33.96	0.00	0.00	0.69	0.00	0.00	0.00	0.03	0.14	30.37	22.00	0.00	0.00	0.00	0.07	0.00	4.50	27.13	0.08	0.00	2.62	0.00	0.00	0.00	0.00	0.00
BR.026	lin-93123a side b	0.23	31.77	0.00	0.00	0.91	0.00	0.00	0.00	0.01	0.07	10.32	7.48	0.00	0.00	0.00	0.09	0.00	1.24	54.46	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00
BR.026	lin-93123a side b	0.22	32.92	0.00	0.00	1.00	0.00	0.00	0.00	0.01	0.06	10.66	7.72	0.00	0.00	0.00	0.12	0.00	1.62	52.53	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00
BR.026	lin-93123a side b	0.29	32.45	0.00	0.00	0.90	0.00	0.00	0.00	0.01	0.07	10.34	7.49	0.00	0.00	0.00	0.06	0.00	0.95	53.93	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
BR.026	average	0.20	29.94	0.00	0.00	0.84	0.00	0.00	0.00	0.01	0.08	9.97	7.22	0.00	0.00	0.00	0.10	0.00	1.15	56.92	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00
BR.026	lin-93123a a	0.16	23.36	0.00	0.00	0.64	0.00	0.00	0.00	0.01	0.04	6.61	4.79	0.00	0.00	0.00	0.03	0.00	1.29	41.07	0.00	0.00	26.56	0.00	0.00	0.00	0.00	0.00
BR.026	lin-93123a a	0.02	4.85	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	1.76	1.27	0.00	0.00	0.00	0.00	0.00	0.70	18.80	0.00	0.15	73.67	0.00	0.00	0.00	0.00	0.00
BR.026	lin-93123a a	0.22	30.99	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	8.33	6.03	0.00	0.00	0.00	0.00	0.33	1.57	52.74	0.00	0.00	4.84	0.00	0.00	0.00	0.00	0.00
BR.026	average	0.24	34.23	0.00	0.00	1.01	0.00	0.00	0.00	0.01	0.06	9.73	7.05	0.00	0.00	0.00	0.10	0.00	1.60	51.67	0.00	0.00	1.18	0.00	0.00	0.00	0.00	0.00
BR.027	lin-724271	0.16	19.17	0.00	0.00	0.30	0.00	0.00	0.00	0.06	0.00	14.25	10.33	0.00	0.00	0.00	0.00	0.00	1.60	54.40	0.00	0.00	9.76	0.05	0.00	0.00	0.25	0.00
BR.027	lin-724271	0.18	20.56	0.00	0.00	0.36	0.00	0.01	0.00	0.03	0.00	14.85	10.76	0.00	0.00	0.00	0.00	0.00	2.11	52.40	0.00	0.00	9.18	0.00	0.00	0.07	0.23	0.00
BR.027	lin-724271	0.15	23.17	0.00	0.00	0.60	0.00	0.00	0.00	0.05	0.00	17.90	12.97	0.00	0.00	0.00	0.00	0.00	1.56	45.81	0.00	0.00	10.60	0.00	0.00	0.00	0.00	0.00
BR.027	lin-724271	0.12	17.15	0.00	0.00	0.36	0.00	0.00	0.00	0.07	0.00	16.72	12.11	0.00	0.00	0.00	0.00	0.00	0.99	55.06	0.00	0.00	9.02	0.00	0.00	0.00	0.49	0.00
BR.027	lin-724271	0.16	20.12	0.00	0.00	0.43	0.00	0.00	0.00	0.03	0.00	17.26	12.51	0.00	0.00	0.00	0.00	0.00	1.45	50.30	0.00	0.00	9.89	0.00	0.00	0.00	0.28	0.00
BR.027	lin-724271	0.24	30.79	0.00	0.00	0.78	0.00	0.00	0.00	0.05	0.00	16.70	12.10	0.00	0.00	0.00	0.00	0.00	1.40	40.97	0.00	0.00	8.84	0.00	0.00	0.00	0.21	0.00
BR.027	average	0.17	21.83	0.00	0.00	0.47	0.00	0.00	0.00	0.05	0.00	16.28	11.79	0.00	0.00	0.00	0.00	0.00	1.52	49.82	0.00	0.00	9.55	0.00	0.00	0.00	0.26	0.00
BR.028	SF038.015	0.19	19.03	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.06	11.82	8.56	0.00	0.00	4.44	0.00	0.00	10.62	50.72	0.06	0.00	2.38	0.00	0.00	0.00	0.16	0.00
BR.028	SF038.015	0.33	32.95	0.00	0.00	0.90	0.00	0.00	0.00	0.01	0.10	11.23	8.14	0.00	0.00	0.00	0.00	0.00	12.25	35.71	0.00	0.00	6.43	0.07	0.00	0.00	0.00	0.00
BR.028	SF038.015	0.16	13.03	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.05	6.78	4.92	0.00	0.00	0.00	0.00	0.39	10.54	63.32	0.05	0.00	5.23	0.00	0.00	0.00	0.00	0.00
BR.028	average	0.23	21.67	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.07	9.95	7.21	0.00	0.00	0.00	0.00	0.00	11.14	49.92	0.05	0.00	4.68	0.00	0.00	0.00	0.00	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.029	lin-d1e451 side b	0.18	21.07	0.04	0.00	0.55	0.00	0.00	0.00	0.01	0.04	6.57	4.76	0.00	0.00	0.00	0.00	0.00	2.46	57.91	0.16	0.00	11.01	0.00	0.00	0.00	0.00	0.00
BR.029	lin-d1e451 side b	0.11	14.07	0.00	0.01	0.40	0.00	0.00	0.00	0.01	0.03	6.23	4.51	0.00	0.00	0.00	0.00	0.00	2.71	55.92	0.00	0.00	20.46	0.00	0.00	0.00	0.00	0.00
BR.029	lin-d1e451 side b	0.15	19.11	0.00	0.00	0.56	0.00	0.00	0.00	0.01	0.04	6.76	4.90	0.00	0.00	0.00	0.00	0.00	2.44	66.86	0.00	0.00	4.09	0.00	0.00	0.00	0.00	0.00
BR.029	average	0.27	30.04	0.11	0.02	0.69	0.00	0.00	0.00	0.00	0.00	6.72	4.87	0.00	0.00	0.00	0.00	0.00	2.24	50.95	0.45	0.00	8.47	0.00	0.00	0.00	0.00	0.00
BR.029	lin-d1e451 side a	0.02	5.70	0.00	0.00	0.07	0.00	0.01	0.00	0.02	0.00	2.89	2.09	0.00	0.00	0.00	0.00	0.00	1.19	22.26	0.00	0.00	67.55	0.00	0.00	0.00	0.00	0.00
BR.029	lin-d1e451 side a	0.05	6.87	0.00	0.00	0.20	0.00	0.01	0.00	0.01	0.00	4.14	3.00	0.00	0.00	0.00	0.00	0.00	1.53	19.63	0.00	0.00	67.56	0.00	0.00	0.00	0.00	0.00
BR.029	lin-d1e451 side a	0.00	3.26	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	1.42	1.03	0.00	0.00	0.57	0.00	0.00	0.99	20.49	0.00	0.19	72.98	0.00	0.00	0.00	0.04	0.00
BR.029	average	0.00	6.96	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	3.10	2.24	0.00	0.00	0.00	0.00	0.00	1.06	26.66	0.00	0.00	62.12	0.05	0.00	0.00	0.00	0.00
BR.030	lin-18ec20	0.40	26.38	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.12	20.98	15.20	0.00	0.00	14.56	0.00	0.00	0.67	30.27	0.03	0.00	6.11	0.00	0.00	0.00	0.19	0.00
BR.030	lin-18ec20	0.30	20.23	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	20.24	14.66	0.00	0.00	14.67	0.00	0.00	0.61	36.00	0.00	0.00	7.69	0.00	0.00	0.00	0.16	0.00
BR.030	lin-18ec20	0.25	15.74	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	15.41	11.16	0.00	0.00	17.57	0.00	0.00	0.62	37.16	0.00	0.00	12.99	0.00	0.00	0.00	0.14	0.00
BR.030	average	0.31	20.78	0.00	0.00	0.09	0.00	0.00	0.00	0.01	0.11	18.88	13.67	0.00	0.00	15.60	0.00	0.00	0.63	34.48	0.00	0.00	8.93	0.00	0.00	0.00	0.16	0.00
BR.031	lin-6eba65	0.48	18.48	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.34	20.64	14.95	0.00	0.00	0.00	0.00	0.00	2.07	39.32	0.00	0.00	8.92	0.08	0.00	0.00	0.00	0.00
BR.031	lin-6eba65	0.56	20.83	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.43	19.18	13.90	0.00	0.00	0.00	0.00	0.00	1.75	35.04	0.00	0.00	9.27	0.00	0.00	0.00	0.00	3.15
BR.031	lin-6eba65	0.60	22.64	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.46	21.95	15.90	0.00	0.00	0.00	0.00	0.00	1.97	32.68	0.00	0.00	7.96	0.00	0.00	0.00	0.00	2.54
BR.031	average	0.55	20.65	0.00	0.00	0.14	0.00	0.00	0.00	0.01	0.41	20.59	14.92	0.00	0.00	0.00	0.00	0.00	1.93	35.68	0.00	0.00	8.72	0.05	0.00	0.00	0.00	2.37
BR.031	lin-6eba65	0.60	22.99	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.44	16.33	11.83	0.00	0.00	0.00	0.00	0.00	1.83	39.16	0.00	0.00	4.84	0.00	0.00	0.00	0.00	3.07
BR.031	lin-6eba65	0.54	21.40	0.00	0.00	0.20	0.00	0.00	0.00	0.01	0.38	20.89	15.13	0.00	0.00	0.00	0.00	0.00	1.96	34.42	0.00	0.00	9.61	0.06	0.00	0.00	0.00	2.30
BR.031	lin-6eba65	0.64	24.40	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.43	19.42	14.07	0.00	0.00	0.00	0.00	0.00	2.19	28.93	0.00	0.00	9.33	0.06	0.00	0.00	0.00	4.05
BR.031	average	0.60	22.93	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.42	18.88	13.68	0.00	0.00	0.00	0.00	0.00	1.99	34.17	0.00	0.00	7.93	0.05	0.00	0.00	0.00	3.14
BR.032	lin-494afa	0.32	17.57	0.00	0.00	2.17	0.00	0.00	0.00	0.01	0.00	13.78	9.98	0.00	0.00	0.00	0.08	0.00	1.77	60.96	0.00	0.00	3.06	0.06	0.00	0.00	0.20	0.00
BR.032	lin-494afa	0.36	19.58	0.00	0.00	2.29	0.00	0.00	0.00	0.01	0.00	13.07	9.47	0.00	0.00	2.61	0.11	0.00	1.82	57.45	0.03	0.00	2.39	0.03	0.00	0.00	0.24	0.00
BR.032	lin-494afa	0.40	22.81	0.00	0.00	2.61	0.00	0.00	0.00	0.01	0.11	16.70	12.10	0.00	0.00	14.83	0.10	0.00	1.50	38.04	0.03	0.00	2.50	0.04	0.00	0.00	0.35	0.00
BR.032	average	0.36	19.99	0.00	0.00	2.36	0.00	0.00	0.00	0.01	0.04	14.51	10.52	0.00	0.00	5.81	0.09	0.00	1.70	52.15	0.03	0.00	2.65	0.04	0.00	0.00	0.26	0.00
BR.033	SF026.039	0.11	17.59	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.00	13.58	9.84	0.00	0.00	0.00	0.00	0.00	2.35	64.18	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00
BR.033	SF026.039	0.11	18.36	0.00	0.00	0.25	0.00	0.00	0.00	0.03	0.00	10.37	7.51	0.00	0.00	0.00	0.00	0.00	0.77	63.25	0.00	0.00	6.80	0.05	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.033	SF026.039	0.11	20.35	0.00	0.00	0.28	0.00	0.00	0.00	0.02	0.00	11.09	8.04	0.00	0.00	0.00	0.00	0.00	1.48	60.49	0.00	0.00	6.08	0.06	0.00	0.00	0.00	0.00
BR.033	average	0.11	18.77	0.00	0.00	0.27	0.00	0.00	0.00	0.02	0.00	11.68	8.46	0.00	0.00	0.00	0.00	0.00	1.53	62.64	0.00	0.00	4.88	0.05	0.00	0.00	0.00	0.00
BR.034	SF037.005	0.11	13.42	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	13.70	9.92	0.00	0.00	0.00	0.00	0.00	2.28	68.13	0.00	0.00	2.31	0.00	0.00	0.00	0.00	0.00
BR.034	SF037.005	0.16	20.78	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	9.88	7.16	0.00	0.00	0.00	0.00	0.00	3.60	55.70	0.04	0.00	9.78	0.00	0.00	0.00	0.00	0.00
BR.034	SF037.005	0.16	22.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	13.53	9.81	0.00	0.00	0.00	0.00	0.00	3.39	58.42	0.00	0.00	2.28	0.04	0.00	0.00	0.00	0.00
BR.034	average	0.14	18.77	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05	12.37	8.96	0.00	0.00	0.00	0.00	0.00	3.09	60.75	0.00	0.00	4.79	0.03	0.00	0.00	0.00	0.00
BR.035	nlm972	0.10	10.18	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00	18.43	13.36	0.00	0.00	0.00	0.00	0.00	0.95	42.42	0.00	0.00	27.66	0.05	0.00	0.00	0.09	0.00
BR.035	nlm972	0.33	34.59	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.05	15.88	11.51	0.00	0.00	0.00	0.00	0.00	1.57	38.74	0.08	0.00	6.52	0.00	0.00	0.00	0.46	0.00
BR.035	nlm972	0.10	10.07	0.00	0.01	0.00	0.00	0.01	0.00	0.02	0.00	8.08	5.85	0.00	0.00	0.00	0.00	0.00	0.74	38.96	0.00	0.14	41.67	0.04	0.00	0.00	0.17	0.00
BR.035	average	0.18	18.28	0.00	0.01	0.15	0.00	0.00	0.00	0.01	0.00	14.13	10.24	0.00	0.00	0.00	0.00	0.00	1.09	40.04	0.03	0.06	25.29	0.04	0.00	0.00	0.24	0.00
BR.036	SF041.005	0.19	19.67	0.00	0.00	1.39	0.00	0.00	0.00	0.02	0.09	6.02	4.36	7.74	0.11	0.00	11.20	0.00	1.35	44.43	0.00	0.00	7.30	0.08	0.00	0.00	0.37	0.00
BR.036	SF041.005	0.09	17.28	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	4.50	3.26	0.00	0.00	0.00	0.00	0.00	2.52	71.63	0.00	0.00	3.36	0.00	0.00	0.00	0.00	0.00
BR.036	SF041.005	0.19	17.50	0.00	0.00	1.26	0.00	0.00	0.01	0.02	0.09	5.17	3.75	7.45	0.00	0.00	10.84	0.00	1.39	49.86	0.00	0.00	5.91	0.06	0.00	0.00	0.00	0.00
BR.036	average	0.16	18.15	0.00	0.00	1.09	0.00	0.00	0.01	0.01	0.06	5.23	3.79	5.06	0.04	0.00	7.35	0.00	1.75	55.31	0.00	0.00	5.52	0.00	0.00	0.00	0.00	0.00
BR.037	lin-7223a1	0.18	13.86	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.08	17.58	12.73	0.00	0.00	11.21	0.00	0.00	2.07	42.30	0.00	0.00	4.79	0.00	0.00	0.00	0.27	0.00
BR.037	lin-7223a1	0.19	17.13	0.00	0.00	0.48	0.00	0.00	0.00	0.01	0.00	16.73	12.12	0.00	0.00	0.00	0.00	0.00	2.05	43.56	0.03	0.00	7.21	0.00	0.00	0.00	0.14	3.07
BR.037	lin-7223a1	0.25	21.40	0.00	0.01	0.66	0.00	0.00	0.00	0.01	0.00	17.98	13.03	0.00	0.00	0.00	0.00	0.00	1.71	42.00	0.00	0.00	4.82	0.00	0.00	0.00	0.17	0.00
BR.037	average	0.21	17.46	0.00	0.00	0.53	0.00	0.00	0.00	0.01	0.00	17.43	12.63	0.00	0.00	3.74	0.00	0.00	1.94	42.62	0.00	0.00	5.61	0.00	0.00	0.00	0.19	2.23
BR.037	lin-7223a1	0.07	6.59	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.00	7.38	5.35	0.00	0.00	0.00	0.00	0.00	1.06	22.92	0.00	0.00	42.79	0.03	0.00	0.00	0.08	4.96
BR.037	lin-7223a1	0.24	24.68	0.00	0.00	0.81	0.00	0.00	0.00	0.02	0.00	20.24	14.66	0.00	0.00	0.00	0.00	0.00	2.09	38.82	0.00	0.00	7.91	0.00	0.00	0.00	0.00	0.00
BR.037	lin-7223a1	0.20	21.22	0.00	0.00	0.69	0.00	0.00	0.00	0.01	0.00	19.92	14.43	0.00	0.00	0.00	0.00	0.00	2.11	40.24	0.00	0.00	8.35	0.00	0.00	0.00	0.00	0.00
BR.037	average	0.17	17.49	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.00	15.84	11.48	0.00	0.00	0.00	0.00	0.00	1.75	33.99	0.00	0.00	19.69	0.00	0.00	0.00	0.00	0.00
BR.038	SF036.006	0.13	19.66	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	53.91	39.06	0.00	0.00	0.00	0.00	0.00	1.65	19.87	0.00	0.00	4.68	0.00	0.00	0.00	0.00	0.00
BR.038	SF036.006	0.16	17.42	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	44.60	32.31	0.00	0.00	0.00	0.00	0.00	1.35	31.12	0.00	0.00	5.32	0.00	0.00	0.00	0.00	0.00
BR.038	SF036.006	0.10	14.02	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	46.27	33.52	0.00	0.00	0.00	0.00	0.00	1.04	32.16	0.00	0.00	6.29	0.09	0.00	0.00	0.00	0.00
BR.038	average	0.13	17.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	48.26	34.97	0.00	0.00	0.00	0.00	0.00	1.35	27.72	0.00	0.00	5.43	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.039	lin-135196	0.16	16.16	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.13	12.22	8.85	0.00	0.00	12.47	0.00	0.00	4.83	36.83	0.18	0.00	3.67	0.04	0.00	0.00	0.37	3.06
BR.039	lin-135196	0.17	16.67	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.13	14.38	10.42	0.00	0.00	14.25	0.00	0.00	4.72	38.24	0.19	0.00	3.15	0.04	0.00	0.00	0.26	0.00
BR.039	lin-135196	0.17	17.92	0.00	0.00	0.29	0.00	0.00	0.00	0.01	0.13	12.88	9.33	0.00	0.00	10.93	0.00	0.00	5.00	36.07	0.20	0.00	4.15	0.04	0.00	0.00	0.31	2.78
BR.039	average	0.16	16.92	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.13	13.16	9.53	0.00	0.00	12.55	0.00	0.00	4.85	37.05	0.19	0.00	3.66	0.04	0.00	0.00	0.31	0.00
BR.039	lin-135196	0.16	16.28	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.11	13.40	9.71	0.00	0.00	11.19	0.00	0.00	4.32	38.91	0.17	0.00	3.66	0.00	0.00	0.00	0.31	2.83
BR.039	lin-135196	0.17	16.55	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.14	14.87	10.77	0.00	0.00	14.53	0.00	0.00	4.56	33.42	0.17	0.00	3.71	0.03	0.00	0.00	0.30	2.68
BR.039	lin-135196	0.19	17.66	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.13	13.80	10.00	0.00	0.00	12.83	0.00	0.00	4.00	34.75	0.16	0.00	3.50	0.00	0.00	0.00	0.25	2.91
BR.039	average	0.17	16.83	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.13	14.03	10.16	0.00	0.00	12.85	0.00	0.00	4.29	35.69	0.17	0.00	3.62	0.00	0.00	0.00	0.29	2.81
BR.040	not in pas marked as33	0.52	19.70	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.51	20.22	14.65	0.00	0.00	10.86	0.00	0.00	2.29	31.50	0.00	0.00	5.71	0.04	0.00	0.00	0.16	0.00
BR.040	not in pas marked as33	0.44	14.52	0.00	0.00	0.19	0.00	0.00	0.00	0.01	0.47	25.14	18.22	0.00	0.00	20.15	0.00	0.00	1.59	27.62	0.00	0.00	2.94	0.00	0.00	0.00	0.20	1.76
BR.040	not in pas marked as33	0.43	15.40	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.28	24.13	17.48	0.00	0.00	0.00	0.00	0.00	1.69	33.04	0.00	0.00	5.46	0.00	0.00	0.00	0.20	5.04
BR.040	average	0.46	16.54	0.00	0.00	0.14	0.00	0.00	0.00	0.01	0.42	23.16	16.78	0.00	0.00	10.34	0.00	0.00	1.86	30.72	0.00	0.00	4.70	0.00	0.00	0.00	0.19	3.04
BR.040	not in pas marked as33	0.41	14.21	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.16	21.32	15.44	0.00	0.00	0.00	0.00	0.00	1.16	42.21	0.00	0.00	10.29	0.04	0.00	0.00	0.00	1.99
BR.040	not in pas marked as33	0.31	11.49	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	35.35	25.61	0.00	0.00	0.00	0.00	0.00	1.10	31.84	0.00	0.00	8.42	0.00	0.00	0.00	0.00	3.19
BR.040	not in pas marked as33	0.60	21.89	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.41	19.23	13.93	0.00	0.00	0.00	0.00	0.00	1.78	33.33	0.00	0.00	11.88	0.09	0.00	0.00	0.14	2.06
BR.040	average	0.44	15.86	0.00	0.00	0.08	0.00	0.00	0.00	0.02	0.22	25.30	18.33	0.00	0.00	0.00	0.00	0.00	1.35	35.79	0.00	0.00	10.20	0.04	0.00	0.00	0.00	2.41
BR.041	lin-91e233	0.10	27.61	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.00	15.04	10.90	0.00	0.00	0.00	0.00	0.00	0.33	35.55	0.00	0.00	4.03	0.00	0.00	0.00	0.28	5.18
BR.041	lin-91e233	0.13	31.14	0.00	0.00	0.64	0.00	0.00	0.00	0.01	0.00	19.71	14.28	0.00	0.00	0.00	0.00	0.00	0.37	30.07	0.00	0.00	4.29	0.00	0.00	0.00	0.22	3.71
BR.041	lin-91e233	0.13	29.31	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.00	22.11	16.02	0.00	0.00	0.00	0.00	0.00	0.33	30.20	0.00	0.00	3.50	0.00	0.00	0.00	0.00	4.83
BR.041	average	0.12	29.35	0.00	0.00	0.56	0.00	0.00	0.00	0.01	0.00	18.96	13.73	0.00	0.00	0.00	0.00	0.00	0.34	31.94	0.00	0.00	3.94	0.00	0.00	0.00	0.20	4.57
BR.041	lin-91e233	0.04	11.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.43	6.83	0.00	0.00	0.00	0.00	0.00	0.24	63.63	0.00	0.00	1.73	0.00	0.00	0.00	0.00	4.93
BR.041	lin-91e233	0.06	15.42	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.00	13.41	9.72	0.00	0.00	0.00	0.00	0.00	0.29	55.26	0.00	0.00	2.26	0.00	0.00	0.00	0.00	4.50
BR.041	lin-91e233	0.08	18.97	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	10.04	7.27	0.00	0.00	0.00	0.00	0.00	0.32	53.23	0.00	0.00	2.16	0.00	0.00	0.00	0.00	4.93
BR.041	average	0.06	15.42	0.00	0.00	0.19	0.00	0.00	0.00	0.01	0.00	10.96	7.94	0.00	0.00	0.00	0.00	0.00	0.28	57.37	0.00	0.00	2.05	0.00	0.00	0.00	0.00	4.79
BR.042	lin-90cofd sideb	0.07	13.75	0.00	0.01	0.32	0.00	0.00	0.00	0.01	0.04	4.60	3.33	0.00	0.00	0.00	0.00	0.00	1.56	45.80	0.07	0.12	33.27	0.05	0.00	0.00	0.00	0.00
BR.042	lin-90cofd sideb	0.02	0.10	0.02	0.03	0.00	0.00	0.00	0.00	0.01	0.00	0.19	0.14	0.00	0.00	0.75	0.00	0.00	0.22	7.18	0.08	0.36	90.78	0.09	0.00	0.00	0.13	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.042	lin-90c0fd sideb	0.11	19.24	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.05	6.35	4.60	0.00	0.00	0.00	0.00	0.00	1.79	70.25	0.05	0.00	1.71	0.00	0.00	0.00	0.00	0.00
BR.042	average	0.09	21.90	0.00	0.00	0.53	0.00	0.00	0.00	0.01	0.06	7.26	5.26	0.00	0.00	0.00	0.00	0.00	2.69	59.97	0.09	0.00	7.30	0.00	0.00	0.00	0.00	0.00
BR.042	lin-90c0fd side a	0.07	14.86	0.00	0.01	0.34	0.00	0.00	0.00	0.01	0.03	4.19	3.03	0.00	0.00	0.00	0.00	0.00	1.18	46.97	0.00	0.15	31.73	0.07	0.00	0.00	0.00	0.00
BR.042	lin-90c0fd side a	0.12	23.36	0.00	0.00	0.55	0.00	0.00	0.00	0.01	0.06	5.98	4.33	0.00	0.00	0.00	0.00	0.00	1.46	66.64	0.00	0.00	1.76	0.04	0.00	0.00	0.00	0.00
BR.042	lin-90c0fd side a	0.00	0.20	0.02	0.04	0.00	0.00	0.00	0.00	0.03	0.00	0.22	0.16	0.00	0.00	0.89	0.00	0.00	0.33	5.81	0.00	0.45	91.66	0.15	0.00	0.00	0.18	0.00
BR.042	average	0.11	21.00	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.05	6.35	4.60	0.00	0.00	0.00	0.00	0.00	1.74	68.45	0.05	0.00	1.76	0.00	0.00	0.00	0.00	0.00
BR.043	lin-88a451	0.14	12.14	0.00	0.00	0.43	0.00	0.00	0.00	0.01	0.10	15.99	11.58	0.00	0.00	9.01	5.72	0.00	0.68	48.79	0.02	0.00	6.58	0.08	0.00	0.00	0.32	0.00
BR.043	lin-88a451	0.12	11.02	0.00	0.00	0.39	0.00	0.00	0.00	0.01	0.04	19.89	14.41	0.00	0.00	0.00	3.67	0.00	0.83	55.58	0.03	0.00	7.99	0.06	0.00	0.00	0.36	0.00
BR.043	lin-88a451	0.21	19.18	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.06	11.26	8.16	0.00	0.00	7.41	0.10	0.00	0.82	57.74	0.03	0.00	2.44	0.00	0.00	0.00	0.30	0.00
BR.043	average	0.15	14.12	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.07	15.71	11.38	0.00	0.00	5.48	3.16	0.00	0.78	54.04	0.03	0.00	5.67	0.05	0.00	0.00	0.33	0.00
BR.044	SF026.002	0.11	11.53	0.00	0.00	1.13	0.00	0.00	0.00	0.01	0.00	13.51	9.79	0.00	0.00	0.00	0.00	0.00	0.82	70.31	0.00	0.00	2.54	0.02	0.00	0.00	0.00	0.00
BR.044	SF026.002	0.11	17.19	0.00	0.00	1.97	0.00	0.00	0.00	0.01	0.00	14.23	10.31	0.00	0.00	0.00	0.05	0.00	1.39	63.11	0.00	0.00	1.91	0.00	0.00	0.00	0.00	0.00
BR.044	SF026.002	0.11	13.59	0.00	0.00	1.44	0.00	0.00	0.00	0.02	0.00	15.14	10.97	0.00	0.00	0.00	0.00	0.00	0.99	56.74	0.00	0.00	11.97	0.00	0.00	0.00	0.00	0.00
BR.044	average	0.11	14.10	0.00	0.00	1.51	0.00	0.00	0.00	0.01	0.00	14.29	10.35	0.00	0.00	0.00	0.00	0.00	1.07	63.39	0.00	0.00	5.47	0.00	0.00	0.00	0.00	0.00
BR.045	SF036.047	0.08	14.29	0.00	0.00	0.58	0.00	0.00	0.01	0.04	0.03	6.31	4.57	0.00	0.00	0.00	0.00	0.00	10.82	59.21	0.10	0.00	8.41	0.14	0.00	0.00	0.00	0.00
BR.045	SF036.047	0.10	11.26	0.00	0.00	0.51	0.00	0.00	0.00	0.02	0.03	5.63	4.08	0.00	0.00	0.00	0.00	0.00	10.21	68.70	0.09	0.00	3.40	0.04	0.00	0.00	0.00	0.00
BR.045	SF036.047	0.11	12.81	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.05	8.15	5.90	0.00	0.00	0.00	0.00	0.00	9.18	65.65	0.11	0.00	3.40	0.04	0.00	0.00	0.00	0.00
BR.045	average	0.09	12.79	0.00	0.00	0.53	0.00	0.00	0.00	0.02	0.04	6.70	4.85	0.00	0.00	0.00	0.00	0.00	10.07	64.52	0.10	0.00	5.07	0.07	0.00	0.00	0.00	0.00
BR.046	lin-90b047 side b	0.15	12.20	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.10	9.16	6.63	0.00	0.00	7.31	0.00	0.00	3.82	38.68	0.05	0.11	27.85	0.00	0.00	0.00	0.13	0.00
BR.046	lin-90b047 side b	0.24	19.33	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.16	13.91	10.07	0.00	0.00	10.76	0.00	0.00	5.47	46.84	0.07	0.00	2.41	0.00	0.00	0.00	0.16	0.00
BR.046	lin-90b047 side b	0.19	17.05	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.14	13.26	9.61	0.00	0.00	9.24	0.00	0.00	5.34	51.95	0.08	0.00	1.99	0.00	0.00	0.00	0.16	0.00
BR.046	average	0.02	0.21	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.22	0.00	0.00	1.93	0.00	0.00	0.65	17.26	0.00	0.33	79.16	0.00	0.00	0.00	0.06	0.00
BR.046	lin-90b047 side a	0.10	7.91	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.05	5.55	4.02	0.00	0.00	2.38	0.00	0.00	3.69	32.67	0.05	0.16	47.05	0.00	0.00	0.00	0.08	0.00
BR.046	lin-90b047 side a	0.00	0.17	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.28	0.00	0.00	0.77	0.00	0.00	0.64	16.61	0.00	0.30	81.01	0.00	0.00	0.00	0.04	0.00
BR.046	lin-90b047 side a	0.04	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	4.03	2.92	0.00	0.00	0.00	0.00	0.00	2.57	30.49	0.00	0.17	58.06	0.00	0.00	0.00	0.08	0.00
BR.046	average	0.24	19.06	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.15	12.21	8.85	0.00	0.00	6.38	0.00	0.18	7.86	50.92	0.13	0.00	2.08	0.00	0.00	0.00	0.12	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.047	SF037.006	0.08	10.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.81	7.11	0.00	0.00	0.00	0.00	0.00	0.69	78.16	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
BR.047	SF037.006	0.08	12.60	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.03	7.96	5.77	0.00	0.00	0.00	0.00	0.00	0.69	76.37	0.00	0.00	1.97	0.06	0.00	0.00	0.00	0.00
BR.047	SF037.006	0.10	13.24	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.00	14.27	10.34	0.00	0.00	0.00	0.04	0.00	0.78	69.95	0.00	0.00	1.32	0.03	0.00	0.00	0.00	0.00
BR.047	average	0.09	12.15	0.00	0.00	0.16	0.00	0.00	0.00	0.01	0.00	10.68	7.74	0.00	0.00	0.00	0.00	0.00	0.72	74.83	0.00	0.00	1.30	0.03	0.00	0.00	0.00	0.00
BR.048	lin-9655a7	0.11	11.54	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	5.13	3.72	0.00	0.00	5.02	0.00	0.00	6.55	67.33	0.05	0.00	3.68	0.00	0.00	0.00	0.19	0.00
BR.048	lin-9655a7	0.12	11.50	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.03	5.05	3.66	0.00	0.00	5.74	0.00	0.00	6.53	66.70	0.05	0.00	3.66	0.00	0.00	0.00	0.25	0.00
BR.048	lin-9655a7	0.12	12.33	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.05	5.47	3.96	0.00	0.00	4.73	0.00	0.00	6.10	66.13	0.04	0.00	4.34	0.00	0.00	0.00	0.31	0.00
BR.048	average	0.11	11.79	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.03	5.22	3.78	0.00	0.00	5.16	0.00	0.00	6.39	66.72	0.04	0.00	3.89	0.00	0.00	0.00	0.25	0.00
BR.049	SF028.009	0.13	10.79	0.00	0.00	0.29	0.00	0.00	0.00	0.01	0.04	8.15	5.90	0.00	0.00	0.00	0.00	0.00	13.22	51.99	0.14	0.00	13.82	0.00	0.00	0.00	0.00	0.00
BR.049	SF028.009	0.13	10.40	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.06	8.06	5.84	0.00	0.00	7.62	0.00	0.00	13.00	42.31	0.19	0.00	17.89	0.00	0.00	0.00	0.00	0.00
BR.049	SF028.009	0.15	12.17	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.06	8.44	6.12	0.00	0.00	4.63	0.00	0.00	5.48	35.50	0.10	0.00	33.16	0.00	0.00	0.00	0.00	0.00
BR.049	average	0.14	11.12	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.06	8.22	5.95	0.00	0.00	4.55	0.00	0.00	10.57	43.27	0.14	0.00	21.63	0.00	0.00	0.00	0.00	0.00
BR.050	lin-eb33a6	0.11	7.71	0.00	0.00	1.67	0.00	0.00	0.00	0.01	0.20	9.13	6.62	0.00	0.23	14.48	19.61	0.00	0.76	32.20	0.00	0.00	3.86	0.05	0.00	0.00	0.22	4.31
BR.050	lin-eb33a6	0.14	17.23	0.00	0.00	2.28	0.00	0.00	0.00	0.01	0.04	12.81	9.28	0.00	0.00	1.54	2.42	0.00	1.19	41.55	0.00	0.00	10.53	0.00	0.00	0.00	0.18	2.33
BR.050	average	0.12	11.04	0.00	0.00	1.95	0.00	0.00	0.00	0.03	0.13	11.94	8.65	0.00	0.14	8.84	9.94	0.00	0.90	35.79	0.00	0.00	6.42	0.04	0.00	0.00	0.22	3.76
BR.050	lin-eb33a6	0.11	8.66	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.00	9.47	6.86	0.00	0.00	0.00	0.00	0.00	0.58	23.07	0.00	0.00	34.41	0.00	0.00	0.00	0.00	5.21
BR.050	lin-eb33a6	0.22	18.60	0.00	0.00	1.01	0.00	0.00	0.00	0.01	0.07	14.03	10.17	0.00	0.00	6.92	0.00	0.00	0.73	33.09	0.00	0.00	6.86	0.00	0.00	0.00	0.00	5.05
BR.050	lin-eb33a6	0.03	3.31	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	4.16	3.01	0.00	0.00	0.00	0.00	0.00	0.24	9.07	0.00	0.10	52.66	0.00	0.00	0.00	0.10	6.81
BR.050	average	0.12	10.19	0.00	0.00	0.49	0.00	0.00	0.00	0.02	0.02	9.22	6.68	0.00	0.00	2.31	0.00	0.00	0.52	21.75	0.00	0.00	31.31	0.00	0.00	0.00	0.00	5.69
BR.050	lin-eb33a6	0.06	5.26	0.00	0.00	1.73	0.00	0.00	0.00	0.03	0.18	11.85	8.58	0.00	0.27	11.63	10.88	0.00	0.72	25.94	0.00	0.00	15.01	0.03	0.00	0.00	0.41	4.67
BR.050	lin-eb33a6	0.08	6.29	0.00	0.00	0.55	0.00	0.00	0.00	0.02	0.10	10.45	7.57	0.00	0.15	7.47	6.86	0.00	0.80	31.12	0.00	0.00	19.07	0.03	0.00	0.00	0.24	5.00
BR.050	lin-eb33a6	0.04	4.43	0.00	0.00	1.58	0.00	0.00	0.00	0.04	0.10	11.96	8.66	0.00	0.36	6.51	0.00	5.34	0.39	28.48	0.00	0.00	23.54	0.03	0.00	0.00	0.19	4.53
BR.050	average	0.06	5.33	0.00	0.00	1.29	0.00	0.00	0.00	0.03	0.13	11.42	8.27	0.00	0.26	8.54	5.91	1.78	0.64	28.51	0.00	0.00	19.21	0.03	0.00	0.00	0.28	4.73
BR.050	lin-eb33a6	0.19	16.11	0.00	0.00	0.87	0.00	0.00	0.00	0.01	0.05	12.52	9.07	0.00	0.00	4.52	0.00	0.00	0.79	31.86	0.04	0.00	13.74	0.00	0.00	0.00	0.26	4.98
BR.050	lin-eb33a6	0.12	10.66	0.00	0.00	0.57	0.00	0.00	0.00	0.01	0.00	8.53	6.18	0.00	0.00	0.00	0.03	0.00	0.66	25.95	0.00	0.00	28.97	0.00	0.00	0.00	0.24	6.17
BR.050	lin-eb33a6	0.00	0.48	0.00	0.00	0.00	0.00	0.01	0.00	0.08	0.00	1.65	1.19	0.00	0.00	0.00	0.00	0.00	0.13	6.35	0.00	0.46	52.60	0.03	0.00	0.00	0.23	6.86

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.050	average	0.11	9.08	0.00	0.00	0.48	0.00	0.00	0.00	0.03	0.00	7.57	5.48	0.00	0.00	1.51	0.01	0.00	0.53	21.38	0.00	0.15	31.77	0.00	0.00	0.00	0.25	6.00
BR.051	SF026.040	0.09	12.75	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.00	24.72	17.91	0.00	0.00	0.00	0.00	0.00	2.42	56.72	0.03	0.00	2.86	0.03	0.00	0.00	0.00	0.00
BR.051	SF026.040	0.04	8.86	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	5.85	4.24	0.00	0.00	0.00	0.00	0.00	1.37	81.63	0.00	0.00	2.20	0.00	0.00	0.00	0.00	0.00
BR.051	SF026.040	0.06	9.58	0.00	0.00	0.19	0.00	0.00	0.00	0.01	0.00	25.84	18.72	0.00	0.00	0.00	0.00	0.00	1.55	60.85	0.00	0.00	1.90	0.00	0.00	0.00	0.00	0.00
BR.051	average	0.06	10.40	0.00	0.00	0.17	0.00	0.00	0.00	0.01	0.00	18.80	13.62	0.00	0.00	0.00	0.00	0.00	1.78	66.40	0.00	0.00	2.32	0.00	0.00	0.00	0.00	0.00
BR.052	SF026.076	0.05	15.31	0.00	0.00	0.30	0.00	0.00	0.00	0.03	0.04	9.17	6.64	0.00	0.00	0.00	0.00	0.00	2.22	61.96	0.00	0.00	10.85	0.07	0.00	0.00	0.00	0.00
BR.052	SF026.076	0.00	5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	2.82	2.04	0.00	0.00	0.00	0.00	0.00	0.42	24.08	0.00	0.24	66.47	0.00	0.00	0.00	0.00	0.00
BR.052	SF026.076	0.02	9.80	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	5.46	3.96	0.00	0.00	0.00	0.00	0.00	1.68	66.39	0.00	0.00	16.56	0.05	0.00	0.00	0.00	0.00
BR.052	average	0.02	10.35	0.00	0.00	0.10	0.00	0.00	0.00	0.02	0.00	5.82	4.22	0.00	0.00	0.00	0.00	0.00	1.44	50.81	0.00	0.08	31.29	0.05	0.00	0.00	0.00	0.00
BR.053	lin-7ac173 bottom sideb	0.16	18.84	0.00	0.00	1.26	0.00	0.00	0.00	0.02	0.10	19.79	14.34	0.00	0.00	0.00	0.06	0.00	1.45	54.62	0.00	0.00	3.57	0.00	0.00	0.00	0.13	0.00
BR.053	lin-7ac173 bottom sideb	0.17	18.83	0.00	0.00	1.26	0.00	0.00	0.00	0.02	0.09	19.82	14.36	0.00	0.00	0.00	0.06	0.00	1.45	54.62	0.00	0.00	3.58	0.00	0.00	0.00	0.00	0.00
BR.053	lin-7ac173 bottom sideb	0.15	18.84	0.00	0.00	1.25	0.00	0.00	0.00	0.02	0.10	19.77	14.32	0.00	0.00	0.00	0.07	0.00	1.44	54.66	0.00	0.00	3.56	0.00	0.00	0.00	0.14	0.00
BR.053	average	0.17	18.86	0.00	0.00	1.26	0.00	0.00	0.00	0.02	0.10	19.80	14.34	0.00	0.00	0.00	0.06	0.00	1.46	54.60	0.00	0.00	3.56	0.00	0.00	0.00	0.13	0.00
BR.053	lin-7ac173 bottom side a	0.08	1.97	0.02	0.00	5.47	0.00	0.00	0.00	0.00	0.09	1.68	1.21	34.48	0.00	4.40	47.45	0.00	0.11	2.72	0.00	0.00	1.18	0.00	0.00	0.08	0.25	0.00
BR.053	lin-7ac173 bottom side a	0.08	1.96	0.02	0.00	5.47	0.00	0.00	0.00	0.00	0.10	1.68	1.22	34.59	0.00	4.44	47.32	0.00	0.11	2.72	0.00	0.00	1.19	0.00	0.00	0.09	0.21	0.00
BR.053	lin-7ac173 bottom side a	0.08	2.01	0.01	0.00	5.47	0.00	0.00	0.00	0.00	0.09	1.68	1.22	34.36	0.00	4.25	47.67	0.00	0.11	2.73	0.00	0.00	1.18	0.00	0.00	0.00	0.27	0.00
BR.053	average	0.08	1.95	0.02	0.00	5.47	0.00	0.00	0.00	0.00	0.08	1.67	1.21	34.48	0.00	4.52	47.36	0.00	0.12	2.72	0.00	0.00	1.19	0.00	0.00	0.00	0.25	0.00
BR.053	lin-7ac173 middle side a	0.14	14.59	0.00	0.00	0.99	0.00	0.00	0.00	0.02	0.04	20.38	14.76	0.00	0.00	0.00	0.04	0.00	2.63	59.72	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00
BR.053	lin-7ac173 middle side a	0.17	17.03	0.00	0.00	1.30	0.00	0.00	0.00	0.01	0.00	18.44	13.36	0.00	0.00	0.00	0.11	0.00	2.88	58.84	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00
BR.053	lin-7ac173 middle side a	0.12	12.84	0.00	0.00	0.93	0.00	0.00	0.00	0.01	0.05	19.47	14.10	0.00	0.00	0.00	0.00	0.00	3.61	61.38	0.00	0.00	1.49	0.00	0.00	0.00	0.00	0.00
BR.053	average	0.12	13.89	0.00	0.00	0.75	0.00	0.00	0.00	0.02	0.05	23.23	16.83	0.00	0.00	0.00	0.00	0.00	1.39	58.94	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00
BR.053	lin-7ac173 middle side a	0.07	1.85	0.02	0.00	5.31	0.00	0.00	0.00	0.00	0.07	1.74	1.26	30.90	0.00	3.87	51.51	0.00	0.12	3.45	0.00	0.00	0.74	0.00	0.00	0.08	0.25	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.053	lin-7ac173 middle side a	0.07	1.91	0.01	0.00	5.11	0.00	0.00	0.00	0.00	0.08	2.68	1.94	31.30	0.00	4.77	50.49	0.00	0.08	2.34	0.00	0.00	0.79	0.00	0.00	0.09	0.26	0.00
BR.053	lin-7ac173 middle side a	0.06	1.42	0.02	0.00	5.56	0.00	0.00	0.00	0.00	0.08	1.08	0.78	29.51	0.00	3.21	53.73	0.00	0.12	4.08	0.00	0.00	0.88	0.00	0.00	0.00	0.21	0.00
BR.053	average	0.08	2.22	0.02	0.00	5.26	0.00	0.00	0.00	0.00	0.06	1.46	1.05	31.89	0.00	3.64	50.31	0.00	0.16	3.94	0.00	0.00	0.56	0.00	0.00	0.11	0.27	0.00
BR.053	lin-7ac173 square head side b	0.07	10.17	0.00	0.00	0.72	0.00	0.00	0.00	0.01	0.05	12.47	9.03	0.00	0.00	2.79	0.02	0.00	2.04	44.48	0.00	0.07	27.01	0.00	0.00	0.00	0.00	0.00
BR.053	lin-7ac173 square head side b	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	2.05	1.48	0.00	0.00	0.00	0.00	0.00	0.72	20.82	0.00	0.21	74.26	0.04	0.00	0.00	0.08	0.00
BR.053	lin-7ac173 square head side b	0.10	15.06	0.00	0.00	1.18	0.00	0.00	0.00	0.01	0.04	11.43	8.28	0.00	0.00	0.00	0.00	0.00	2.94	63.92	0.00	0.00	5.32	0.00	0.00	0.00	0.00	0.00
BR.053	average	0.11	13.66	0.00	0.00	0.99	0.00	0.00	0.00	0.02	0.11	23.93	17.33	0.00	0.00	8.36	0.05	0.00	2.45	48.70	0.00	0.00	1.46	0.00	0.00	0.00	0.18	0.00
BR.053	lin-7ac173 square head side a	0.12	7.41	0.02	0.00	3.87	0.00	0.00	0.00	0.00	0.15	8.80	6.38	22.12	0.00	5.92	36.12	0.00	1.13	12.65	0.00	0.00	1.35	0.00	0.00	0.00	0.25	0.00
BR.053	lin-7ac173 square head side a	0.08	2.09	0.03	0.00	5.34	0.00	0.00	0.00	0.00	0.07	1.26	0.91	28.12	0.00	3.81	52.38	0.00	0.13	5.30	0.00	0.00	1.00	0.00	0.00	0.11	0.27	0.00
BR.053	lin-7ac173 square head side a	0.12	7.59	0.02	0.00	3.31	0.00	0.00	0.00	0.00	0.16	8.23	5.96	20.67	0.00	7.85	31.88	0.00	1.02	18.01	0.00	0.00	0.84	0.00	0.00	0.00	0.25	0.00
BR.053	average	0.15	12.55	0.02	0.00	2.95	0.00	0.00	0.00	0.00	0.23	16.93	12.26	17.58	0.00	6.09	24.09	0.00	2.24	14.63	0.03	0.00	2.23	0.00	0.00	0.00	0.22	0.00
BR.054	lin-9225dbside b	0.10	9.20	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.03	9.36	6.78	0.00	0.00	0.00	0.00	0.00	3.31	52.35	0.00	0.00	25.38	0.00	0.00	0.00	0.00	0.00
BR.054	lin-9225dbside b	0.13	11.30	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.05	14.17	10.26	0.00	0.00	0.00	0.00	0.00	4.90	66.27	0.00	0.00	2.75	0.00	0.00	0.00	0.00	0.00
BR.054	lin-9225dbside b	0.15	13.98	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.03	11.40	8.26	0.00	0.00	0.00	0.00	0.00	3.81	68.13	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00
BR.054	average	0.02	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	1.81	0.00	0.00	0.00	0.00	0.00	1.22	22.65	0.00	0.00	71.30	0.00	0.00	0.00	0.00	0.00
BR.054	lin-9225db	0.10	10.08	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.03	6.91	5.01	0.00	0.00	0.00	0.00	0.00	2.87	64.93	0.00	0.00	14.74	0.00	0.00	0.00	0.00	0.00
BR.054	lin-9225db	0.05	4.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.14	2.28	0.00	0.00	0.00	0.00	0.00	1.08	54.95	0.00	0.00	36.20	0.00	0.00	0.00	0.00	0.00
BR.054	lin-9225db	0.15	15.88	0.00	0.00	0.48	0.00	0.00	0.00	0.01	0.05	8.86	6.42	0.00	0.00	0.00	0.00	0.00	4.47	67.42	0.05	0.00	2.50	0.00	0.00	0.00	0.13	0.00
BR.054	average	0.10	9.81	0.00	0.00	0.30	0.00	0.00	0.00	0.01	0.03	8.73	6.32	0.00	0.00	0.00	0.00	0.00	3.06	72.43	0.00	0.00	5.52	0.00	0.00	0.00	0.00	0.00
BR.055	lin-79d38d bottom side b	0.11	11.73	0.00	0.00	0.20	0.00	0.00	0.00	0.01	0.14	10.91	7.90	0.00	0.00	13.00	0.00	0.00	6.80	55.38	0.25	0.00	1.36	0.00	0.00	0.00	0.10	0.00
BR.055	lin-79d38d bottom side b	0.13	13.23	0.00	0.00	0.31	0.00	0.00	0.00	0.01	0.18	12.78	9.26	0.00	0.00	17.10	0.00	0.00	5.40	48.48	0.19	0.00	2.00	0.00	0.00	0.00	0.19	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.055	lin-79d38d bottom side b	0.11	13.64	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.12	10.40	7.53	0.00	0.00	5.31	0.00	0.00	10.08	58.22	0.46	0.02	1.35	0.00	0.00	0.00	0.00	0.00
BR.055	average	0.10	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	9.54	6.91	0.00	0.00	16.61	0.00	0.00	4.93	59.43	0.11	0.00	0.74	0.00	0.00	0.00	0.11	0.00
BR.055	lin-79d38d bottom side a	0.00	5.24	0.00	0.00	43.27	0.00	0.00	0.00	0.00	0.07	3.53	2.56	3.02	0.00	1.34	4.59	0.00	3.91	33.49	0.08	0.00	1.15	0.00	0.00	0.00	0.00	0.00
BR.055	lin-79d38d bottom side a	0.00	4.40	0.00	0.00	83.76	0.00	0.00	0.00	0.00	0.05	1.34	0.97	0.00	0.00	0.00	0.92	0.00	0.22	8.58	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00
BR.055	lin-79d38d bottom side a	0.00	7.07	0.00	0.00	45.82	0.00	0.00	0.00	0.00	0.09	5.34	3.87	0.60	0.00	3.24	1.18	0.00	3.91	31.04	0.04	0.00	1.10	0.00	0.00	0.20	0.33	0.00
BR.055	average	0.04	4.25	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.08	3.91	2.83	8.40	0.05	0.00	11.69	0.00	7.60	60.86	0.21	0.00	1.83	0.00	0.00	0.00	0.00	0.00
BR.055	lin-79d38d top side b	0.05	8.99	0.00	0.00	0.11	0.00	0.00	0.00	0.01	0.07	6.55	4.74	0.00	0.00	4.92	0.00	0.00	6.75	56.78	0.20	0.08	15.41	0.00	0.00	0.00	0.00	0.00
BR.055	lin-79d38d top side b	0.06	7.64	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	6.26	4.54	0.00	0.00	6.16	0.00	0.00	4.73	67.96	0.11	0.00	6.89	0.00	0.00	0.00	0.10	0.00
BR.055	lin-79d38d top side b	0.09	14.47	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.11	8.38	6.07	0.00	0.00	7.59	0.00	0.00	10.34	57.17	0.30	0.00	1.20	0.00	0.00	0.00	0.00	0.00
BR.055	average	0.00	4.87	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	5.01	3.63	0.00	0.00	0.00	0.00	0.00	5.17	45.21	0.20	0.22	38.13	0.06	0.00	0.00	0.00	0.00
BR.055	lin-79d38dtopsidea	0.10	7.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.17	9.61	6.96	21.00	0.00	9.61	28.85	0.00	3.05	19.48	0.06	0.00	0.73	0.00	0.00	0.00	0.18	0.00
BR.055	lin-79d38dtopsidea	0.14	13.76	0.00	0.02	0.32	0.00	0.01	0.05	0.02	0.12	8.26	5.98	0.00	0.00	6.73	0.00	0.00	7.40	61.88	0.06	0.00	0.95	0.00	0.00	0.00	0.25	0.00
BR.055	average	0.12	9.63	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.16	3.59	2.60	15.81	0.00	5.02	24.43	0.00	3.32	35.98	0.00	0.00	1.36	0.00	0.00	0.00	0.00	0.00
BR.056	lin-18fce2	0.22	6.14	0.00	0.00	17.60	0.00	0.00	0.00	0.02	0.19	16.31	11.82	0.00	0.03	9.00	4.14	0.00	0.25	33.94	0.03	0.00	11.54	0.00	0.00	0.11	0.48	0.00
BR.056	lin-18fce2	0.30	9.36	0.00	0.00	9.74	0.00	0.00	0.00	0.01	0.07	13.20	9.57	0.00	0.03	7.76	0.00	0.08	0.19	47.78	0.00	0.00	10.88	0.08	0.00	0.07	0.46	0.00
BR.056	lin-18fce2	0.28	11.43	0.00	0.00	9.70	0.00	0.00	0.00	0.02	0.00	18.13	13.13	0.00	0.01	0.00	0.00	0.08	0.23	46.99	0.00	0.00	12.50	0.07	0.00	0.00	0.54	0.00
BR.056	average	0.27	8.98	0.00	0.00	12.35	0.00	0.00	0.00	0.02	0.09	15.88	11.51	0.00	0.03	5.58	1.38	0.05	0.22	42.90	0.00	0.00	11.64	0.05	0.00	0.00	0.50	0.00
BR.057	SF028.008	0.07	8.83	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.04	6.68	4.84	0.00	0.00	0.00	0.00	0.00	9.87	70.52	0.15	0.00	3.35	0.00	0.00	0.00	0.00	0.00
BR.057	SF028.008	0.07	7.74	0.00	0.00	0.33	0.00	0.00	0.00	0.02	0.04	8.89	6.44	0.00	0.00	0.00	0.00	0.00	7.08	70.71	0.13	0.00	4.81	0.06	0.00	0.00	0.13	0.00
BR.057	SF028.008	0.07	9.36	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.00	8.32	6.03	0.00	0.00	0.00	0.00	0.00	8.78	55.67	0.18	0.00	17.10	0.00	0.00	0.00	0.00	0.00
BR.057	average	0.07	8.64	0.00	0.00	0.39	0.00	0.00	0.00	0.01	0.03	7.96	5.77	0.00	0.00	0.00	0.00	0.00	8.58	65.63	0.15	0.00	8.42	0.03	0.00	0.00	0.08	0.00
BR.058	lin-71d8c1	0.07	9.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.97	5.05	0.00	0.00	0.00	0.00	0.00	0.85	81.49	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00
BR.058	lin-71d8c1	0.09	12.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.56	6.92	0.00	0.00	0.00	0.00	0.00	0.70	76.47	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.00
BR.058	lin-71d8c1	0.03	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	5.10	3.69	0.00	0.00	0.00	0.00	0.00	0.95	81.74	0.00	0.06	9.62	0.00	0.00	0.00	0.09	0.00

REF NUM	***SAMPLE***	***Sb***	***Sn***	***Cd***	***Pd***	***Ag***	***Ru***	***Mo***	***Nb***	***Zr***	***Bi***	***Pb***	***Pb (scaled down)***	***Hg***	***Se***	***As***	***Au***	***W***	***Zn***	***Cu***	***Ni***	***Co***	***Fe***	***Mn***	***Cr***	***V***	***Ti***	***Al***
BR.058	average	0.06	8.16	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	7.21	5.22	0.00	0.00	0.00	0.00	0.00	0.83	79.90	0.00	0.02	3.79	0.00	0.00	0.00	0.00	0.00
BR.059	lin-925a07 bottom side b	0.07	4.16	0.00	0.00	0.34	0.00	0.00	0.00	0.01	0.00	5.09	3.69	0.00	0.00	0.00	0.00	0.00	8.37	66.85	0.00	0.00	15.01	0.00	0.00	0.00	0.00	0.00
BR.059	lin-925a07 bottom side b	0.09	5.86	0.00	0.00	0.58	0.00	0.00	0.00	0.02	0.00	6.77	4.90	0.00	0.00	0.00	0.00	0.00	9.07	74.54	0.00	0.00	2.97	0.00	0.00	0.00	0.00	0.00
BR.059	lin-925a07 bottom side b	0.04	2.07	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	4.86	3.52	0.00	0.00	0.00	0.00	0.00	5.81	47.35	0.00	0.00	39.76	0.00	0.00	0.00	0.10	0.00
BR.059	average	0.07	4.56	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	3.65	2.64	0.00	0.00	0.00	0.00	0.00	10.22	78.67	0.00	0.00	2.29	0.00	0.00	0.00	0.00	0.00
BR.059	lin-925a07 bottom side a	0.17	8.15	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.04	14.17	10.27	0.00	0.00	0.00	0.00	1.49	14.50	57.85	0.00	0.00	2.85	0.00	0.00	0.00	0.00	0.00
BR.059	lin-925a07 bottom side a	0.15	7.55	0.00	0.00	0.86	0.00	0.00	0.00	0.01	0.03	10.45	7.57	0.00	0.00	0.00	0.00	0.69	12.92	64.05	0.03	0.00	3.14	0.00	0.00	0.00	0.12	0.00
BR.059	lin-925a07 bottom side a	0.16	6.85	0.00	0.00	0.54	0.00	0.00	0.00	0.01	0.00	18.22	13.20	0.00	0.00	0.00	0.00	3.09	19.81	48.96	0.00	0.00	2.34	0.00	0.00	0.00	0.00	0.00
BR.059	average	0.19	10.07	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.07	13.84	10.03	0.00	0.00	0.00	0.00	0.68	10.76	60.54	0.00	0.00	3.06	0.00	0.00	0.00	0.17	0.00
BR.059	lin-925a07 top side b	0.11	4.80	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.00	13.08	9.47	0.00	0.00	0.00	0.00	0.31	9.73	58.08	0.00	0.00	13.33	0.00	0.00	0.00	0.07	0.00
BR.059	lin-925a07 top side b	0.06	2.93	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.02	4.05	2.93	0.00	0.00	0.00	0.00	0.00	6.52	63.52	0.00	0.00	22.55	0.00	0.00	0.00	0.09	0.00
BR.059	lin-925a07 top side b	0.09	4.05	0.00	0.00	0.35	0.00	0.00	0.00	0.01	0.00	14.54	10.54	0.00	0.00	0.00	0.00	0.00	7.13	63.21	0.00	0.00	10.54	0.00	0.00	0.00	0.08	0.00
BR.059	average	0.18	7.41	0.00	0.00	0.76	0.00	0.00	0.00	0.01	0.06	20.63	14.95	0.00	0.00	0.00	0.00	0.93	15.54	47.51	0.00	0.00	6.91	0.00	0.00	0.00	0.00	0.00
BR.059	lin-925a07 top side a	0.16	8.05	0.00	0.00	0.69	0.00	0.00	0.00	0.01	0.05	16.32	11.83	0.00	0.00	0.00	0.00	0.85	10.46	60.79	0.00	0.00	2.52	0.00	0.00	0.00	0.12	0.00
BR.059	lin-925a07 top side a	0.16	8.56	0.00	0.00	0.72	0.00	0.00	0.00	0.01	0.04	14.19	10.28	0.00	0.00	0.00	0.00	1.05	11.99	61.07	0.00	0.00	2.11	0.00	0.00	0.00	0.11	0.00
BR.059	lin-925a07 top side a	0.16	8.03	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.07	16.92	12.26	0.00	0.00	0.00	0.00	1.34	12.10	58.39	0.00	0.00	2.20	0.00	0.00	0.00	0.14	0.00
BR.059	average	0.15	7.57	0.00	0.00	0.70	0.00	0.00	0.00	0.01	0.00	17.85	12.93	0.00	0.00	0.00	0.00	0.15	7.28	62.89	0.00	0.00	3.26	0.00	0.00	0.00	0.11	0.00
BR.060	lin-90cfee side b	0.18	12.62	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.10	6.26	4.54	0.00	0.00	11.24	0.00	0.00	6.49	61.43	0.04	0.00	0.94	0.00	0.00	0.00	0.27	0.00
BR.060	lin-90cfee side b	0.16	9.09	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.13	7.09	5.13	0.00	0.00	16.21	0.00	0.00	5.31	60.43	0.03	0.00	0.98	0.00	0.00	0.00	0.19	0.00
BR.060	lin-90cfee side b	0.21	11.91	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.13	7.37	5.34	0.00	0.00	13.59	0.00	0.00	6.07	58.89	0.04	0.00	1.13	0.00	0.00	0.00	0.13	0.00
BR.060	average	0.15	16.87	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.04	4.34	3.14	0.00	0.00	3.93	0.00	0.00	8.11	64.98	0.05	0.00	0.71	0.00	0.00	0.00	0.50	0.00
BR.060	lin-90cfee side a	0.16	7.88	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.09	6.57	4.76	0.00	0.00	14.43	0.00	0.00	6.47	63.00	0.04	0.00	0.91	0.00	0.00	0.00	0.13	0.00
BR.060	lin-90cfee side a	0.12	6.25	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.05	4.11	2.97	0.00	0.00	7.76	0.00	0.00	7.53	73.15	0.05	0.00	0.67	0.00	0.00	0.00	0.00	0.00
BR.060	lin-90cfee side a	0.16	7.86	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.09	6.55	4.75	0.00	0.00	15.52	0.00	0.00	6.48	61.84	0.04	0.00	0.99	0.00	0.00	0.00	0.15	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.060	average	0.19	9.51	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.14	9.04	6.55	0.00	0.00	20.01	0.00	0.00	5.40	54.02	0.03	0.00	1.06	0.00	0.00	0.00	0.20	0.00
BR.061	kzaa1	0.12	7.96	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.00	36.41	26.38	0.00	0.00	0.00	0.00	0.00	2.25	49.60	0.00	0.00	3.29	0.00	0.00	0.00	0.15	0.00
BR.061	kzaa1	0.09	6.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	26.85	19.45	0.00	0.00	0.00	0.00	0.00	2.86	61.91	0.00	0.00	2.10	0.00	0.00	0.00	0.13	0.00
BR.061	kzaa1	0.10	9.27	0.00	0.00	0.28	0.00	0.00	0.00	0.02	0.06	30.91	22.39	0.00	0.00	0.00	0.00	0.00	2.10	53.00	0.00	0.00	4.05	0.00	0.00	0.00	0.22	0.00
BR.061	average	0.10	7.77	0.00	0.00	0.17	0.00	0.00	0.00	0.01	0.00	31.39	22.74	0.00	0.00	0.00	0.00	0.00	2.40	54.83	0.00	0.00	3.15	0.00	0.00	0.00	0.17	0.00
BR.061	kzaa1	0.12	8.53	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.10	31.91	23.12	0.00	0.00	5.82	0.00	0.00	2.31	48.49	0.00	0.00	2.32	0.00	0.00	0.00	0.13	0.00
BR.061	kzaa1	0.09	7.93	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.00	30.54	22.13	0.00	0.00	0.00	0.00	0.00	2.76	51.22	0.00	0.00	5.58	0.00	0.00	0.00	1.60	0.00
BR.061	kzaa1	0.09	6.82	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.00	27.16	19.68	0.00	0.00	0.00	0.00	0.00	2.69	54.30	0.03	0.00	8.69	0.00	0.00	0.00	0.00	0.00
BR.061	average	0.10	7.76	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.05	29.87	21.64	0.00	0.00	0.00	0.00	0.00	2.59	51.34	0.00	0.00	5.53	0.00	0.00	0.00	0.58	0.00
BR.062	23	0.32	16.53	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	21.53	0.00	0.00	0.00	0.00	0.00	0.19	25.10	0.00	0.00	36.09	0.00	0.00	0.00	0.18	0.00	
BR.062	23	0.36	19.70	0.00	0.00	0.20	0.00	0.00	0.00	0.02	0.05	20.08	0.00	0.00	0.00	0.00	0.00	0.16	18.42	0.00	0.00	40.82	0.00	0.00	0.00	0.20	0.00	
BR.062	23	0.35	18.67	0.00	0.00	0.23	0.00	0.00	0.00	0.02	0.00	25.58	0.00	0.00	0.00	0.00	0.00	0.15	26.86	0.00	0.00	27.97	0.00	0.00	0.00	0.15	0.00	
BR.062	23	0.34	18.30	0.00	0.00	0.14	0.00	0.00	0.00	0.02	0.00	22.40	0.00	0.00	0.00	0.00	0.00	0.17	23.46	0.00	0.00	34.96	0.00	0.00	0.00	0.18	0.00	
BR.063	SF000.008 side b	0.03	0.05	0.02	0.02	0.06	0.01	0.00	0.00	0.00	0.01	0.03	0.02	0.10	0.01	0.89	0.00	0.07	0.04	0.39	0.03	0.03	0.05	0.02	0.04	0.09	0.06	80.00
BR.063	SF000.008 side b	0.04	0.07	0.03	0.02	0.09	0.01	0.00	0.00	0.00	0.01	0.04	0.03	0.12	0.01	1.01	0.00	0.09	0.05	0.39	0.04	0.05	0.08	0.02	0.06	0.09	0.18	80.00
BR.063	SF000.008 side b	0.04	0.04	0.02	0.02	0.06	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.08	0.01	0.81	0.00	0.05	0.03	0.35	0.03	0.03	0.05	0.01	0.03	0.05	0.05	80.00
BR.063	SF000.008 side b	0.03	0.05	0.02	0.02	0.05	0.01	0.01	0.00	0.00	0.02	0.03	0.02	0.12	0.01	0.80	0.00	0.07	0.03	0.37	0.03	0.04	0.06	0.02	0.04	0.06	0.06	80.00
BR.063	average	0.04	0.07	0.02	0.02	0.10	0.01	0.00	0.00	0.00	0.01	0.04	0.03	0.14	0.03	0.86	0.08	0.00	0.05	0.22	0.03	0.05	0.08	0.02	0.05	0.05	0.09	80.00
BR.063	SF000.008 side a	0.04	0.09	0.03	0.02	0.11	0.01	0.00	0.00	0.00	0.01	0.04	0.03	0.17	0.03	0.84	0.10	0.00	0.06	0.14	0.04	0.06	0.12	0.03	0.07	0.11	0.11	80.00
BR.063	SF000.008 side a	0.04	0.07	0.02	0.02	0.10	0.01	0.00	0.00	0.00	0.01	0.04	0.03	0.16	0.03	0.90	0.09	0.00	0.05	0.22	0.03	0.05	0.08	0.02	0.06	0.05	0.09	80.00
BR.063	SF000.008 side a	0.03	0.06	0.02	0.02	0.08	0.01	0.00	0.00	0.00	0.01	0.04	0.03	0.18	0.03	0.79	0.11	0.00	0.04	0.19	0.03	0.04	0.08	0.02	0.05	0.05	0.08	80.00
BR.063	SF000.008 side a	0.04	0.06	0.02	0.02	0.09	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.11	0.01	0.91	0.03	0.00	0.04	0.34	0.03	0.04	0.06	0.04	0.05	0.04	0.07	80.00
BR.063	average	0.02	0.04	0.02	0.01	0.04	0.01	0.00	0.00	0.00	0.01	0.03	0.02	0.08	0.01	0.75	0.00	0.05	0.03	0.34	0.03	0.03	0.04	0.01	0.03	0.04	0.04	80.00
BR.064	SF000.007 side b	0.02	0.03	0.02	0.01	0.03	0.01	0.00	0.00	0.00	0.01	0.02	0.02	0.08	0.01	0.58	0.00	0.04	0.02	0.29	0.02	0.02	0.03	0.01	0.02	0.04	0.04	80.00
BR.064	SF000.007 side b	0.01	0.05	0.02	0.01	0.07	0.00	0.00	0.00	0.00	0.01	0.04	0.03	0.09	0.01	0.99	0.00	0.06	0.03	0.42	0.03	0.03	0.04	0.03	0.03	0.03	0.05	80.00
BR.064	SF000.007 side b	0.03	0.03	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.07	0.01	0.63	0.00	0.04	0.03	0.30	0.02	0.02	0.03	0.01	0.02	0.03	0.04	80.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.064	SF000.007 side b	0.02	0.04	0.02	0.01	0.03	0.01	0.00	0.00	0.00	0.01	0.03	0.02	0.09	0.01	0.78	0.00	0.06	0.03	0.36	0.05	0.07	0.07	0.01	0.03	0.04	0.04	80.00
BR.064	average	0.02	0.03	0.02	0.01	0.04	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.09	0.01	0.69	0.01	0.03	0.03	0.30	0.02	0.03	0.05	0.01	0.03	0.05	0.04	80.00
BR.064	SF000.007 side a	0.01	0.04	0.02	0.02	0.05	0.00	0.00	0.00	0.00	0.01	0.03	0.02	0.07	0.01	0.39	0.03	0.00	0.03	0.29	0.02	0.07	0.09	0.02	0.03	0.03	0.05	80.00
BR.064	SF000.007 side a	0.02	0.03	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.09	0.01	0.54	0.00	0.04	0.02	0.26	0.02	0.02	0.03	0.02	0.02	0.04	0.03	80.00
BR.064	SF000.007 side a	0.02	0.04	0.02	0.01	0.04	0.01	0.00	0.00	0.00	0.01	0.03	0.02	0.10	0.01	0.63	0.00	0.05	0.03	0.28	0.02	0.03	0.04	0.01	0.03	0.05	0.05	80.00
BR.064	SF000.007 side a												0.00															
BR.064	average	0.04	0.01	0.01	0.04	0.00	0.00	0.00	0.00	0.01	0.03	0.10	0.07	0.01	0.80	0.00	0.05	0.02	0.35	0.02	0.02	0.04	0.01	0.03	0.04	0.04	80.00	
BR.065	lin-95aa41	0.00	4.16	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	48.28	34.98	0.00	0.00	0.00	0.00	0.00	0.26	33.42	0.00	0.00	2.88	0.00	0.00	0.00	0.00	0.00
BR.065	lin-95aa41	0.00	2.74	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.00	43.97	31.86	0.00	0.00	0.00	0.00	0.00	0.26	38.13	0.00	0.00	1.64	0.00	0.00	0.00	0.00	0.00
BR.065	lin-95aa41	0.00	4.15	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	31.72	22.98	0.00	0.00	0.00	0.00	0.00	0.26	32.06	0.00	0.00	4.02	0.00	0.00	0.00	0.00	6.86
BR.065	average	0.00	3.68	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	41.32	29.94	0.00	0.00	0.00	0.00	0.00	0.26	34.54	0.00	0.00	2.85	0.00	0.00	0.00	0.00	2.63
BR.066	ayxx6	0.07	0.73	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.04	1.80	1.30	0.63	0.00	13.96	6.04	0.00	7.77	65.86	0.02	0.00	2.72	0.01	0.00	0.00	0.11	0.00
BR.066	ayxx6	0.06	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	2.00	1.45	0.22	0.00	13.43	2.28	0.00	8.40	70.70	0.02	0.00	2.04	0.00	0.00	0.00	0.06	0.00
BR.066	ayxx6	0.06	0.88	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.05	2.19	1.59	0.53	0.00	13.71	5.92	0.00	6.96	65.64	0.00	0.00	3.62	0.00	0.00	0.00	0.16	0.00
BR.066	average	0.06	0.79	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.04	2.00	1.45	0.46	0.00	13.70	4.74	0.00	7.71	67.40	0.00	0.00	2.79	0.00	0.00	0.00	0.11	0.00
BR.066	ayxx6	0.08	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	2.46	1.78	0.00	0.00	18.54	0.00	0.00	6.28	68.54	0.02	0.00	2.77	0.00	0.00	0.00	0.09	0.00
BR.066	ayxx6	0.06	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	2.37	1.72	0.00	0.00	15.04	0.00	0.00	8.29	69.94	0.02	0.00	2.56	0.00	0.00	0.00	0.12	0.00
BR.066	ayxx6	0.05	7.35	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.88	1.36	0.00	0.00	19.48	0.00	0.00	4.09	63.58	0.02	0.00	3.20	0.02	0.00	0.00	0.31	0.00
BR.066	average	0.06	3.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	2.24	1.62	0.00	0.00	17.69	0.00	0.00	6.22	67.35	0.02	0.00	2.84	0.00	0.00	0.00	0.18	0.00
BR.067	ewab 1	0.02	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	33.21	24.06	0.00	0.00	20.74	0.00	0.00	3.38	38.30	0.02	0.00	1.32	0.00	0.00	0.00	0.17	0.00
BR.067	ewab 1	0.02	1.95	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	33.62	24.36	0.00	0.00	19.58	0.00	0.00	3.32	39.17	0.00	0.00	1.93	0.02	0.00	0.00	0.14	0.00
BR.067	ewab 1	0.03	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	38.61	27.97	0.00	0.02	21.15	0.00	0.00	2.52	34.41	0.00	0.00	1.27	0.00	0.00	0.00	0.17	0.00
BR.067	average	0.02	2.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	35.15	25.46	0.00	0.00	20.49	0.00	0.00	3.07	37.29	0.00	0.00	1.51	0.00	0.00	0.00	0.16	0.00
BR.067	ewab 1	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	53.54	38.79	0.00	0.00	0.00	0.00	0.00	1.40	43.32	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00
BR.067	ewab 1	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	51.64	37.41	0.00	0.00	0.00	0.00	0.00	2.19	44.50	0.00	0.00	1.46	0.00	0.00	0.00	0.00	0.00
BR.067	ewab 1	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	48.97	35.48	0.00	0.00	0.00	0.00	0.00	1.92	47.37	0.00	0.00	1.63	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.067	average	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	51.38	37.23	0.00	0.00	0.00	0.00	0.00	1.84	45.06	0.00	0.00	1.49	0.00	0.00	0.00	0.00	0.00
BR.068	1994.082.179	0.00	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	36.92	26.74	0.00	0.00	0.00	0.00	0.00	1.64	57.82	0.00	0.00	1.52	0.00	0.00	0.00	0.19	0.00
BR.068	1994.082.179	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	29.78	21.57	0.00	0.00	0.00	0.00	0.00	2.97	65.57	0.00	0.00	1.40	0.00	0.00	0.00	0.18	0.00
BR.068	1994.082.179	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.14	18.21	0.00	0.00	5.61	0.00	0.00	1.46	66.55	0.00	0.00	0.75	0.00	0.00	0.00	0.13	0.00
BR.068	average	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	30.61	22.18	0.00	0.00	0.00	0.00	0.00	2.02	63.31	0.00	0.00	1.22	0.00	0.00	0.00	0.17	0.00
BR.069	spaa 3	0.00	0.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.57	70.69	0.00	0.00	0.00	0.00	0.00	0.04	0.15	0.00	0.00	1.38	0.00	0.00	0.00	0.00	0.00
BR.069	spaa 3	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.15	71.11	0.00	0.00	0.00	0.00	0.00	0.04	0.13	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00
BR.069	spaa 3	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.74	71.54	0.00	0.00	0.00	0.00	0.00	0.02	0.08	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00
BR.069	average	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.15	71.11	0.00	0.00	0.00	0.00	0.00	0.03	0.12	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00
BR.070	SFXX 210	0.00	0.68	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	33.84	24.51	0.00	0.00	3.08	0.00	0.00	2.19	58.42	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00
BR.071	sfcr 1	0.02	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.33	5.31	0.00	0.00	0.00	0.00	0.00	2.23	89.01	0.00	0.00	0.87	0.00	0.00	0.00	0.11	0.00
BR.071	sfcr 1	0.01	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.41	8.26	0.00	0.00	0.00	0.00	0.00	2.58	82.13	0.00	0.00	3.30	0.02	0.00	0.00	0.15	0.00
BR.071	sfcr 1	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	11.43	8.28	0.00	0.00	0.00	0.00	0.00	2.59	82.10	0.00	0.00	3.30	0.02	0.00	0.00	0.13	0.00
BR.071	average	0.01	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.06	7.28	0.00	0.00	0.00	0.00	0.00	2.47	84.41	0.00	0.00	2.49	0.02	0.00	0.00	0.13	0.00
BR.071	sfcr 1	0.00	0.46	0.00	0.00	0.26	0.00	0.00	0.01	0.18	0.00	34.72	25.16	0.00	0.00	0.00	0.00	0.00	1.49	32.99	0.00	0.00	29.02	0.12	0.00	0.00	0.65	0.00
BR.071	sfcr 1	0.00	0.47	0.00	0.00	0.27	0.00	0.00	0.01	0.18	0.00	34.84	25.24	0.00	0.00	0.00	0.00	0.00	1.52	32.89	0.00	0.00	28.98	0.12	0.00	0.00	0.63	0.00
BR.071	sfcr 1	0.00	0.47	0.00	0.00	0.27	0.00	0.00	0.01	0.18	0.06	34.75	25.18	0.00	0.00	0.00	0.00	0.00	1.51	32.96	0.00	0.00	29.02	0.11	0.00	0.00	0.60	0.00
BR.071	average	0.00	0.46	0.00	0.00	0.27	0.00	0.00	0.01	0.18	0.00	34.77	25.19	0.00	0.00	0.00	0.00	0.00	1.51	32.95	0.00	0.00	29.01	0.12	0.00	0.00	0.63	0.00
BR.072	lin-6bbeb1	0.08	0.42	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.15	34.07	24.68	0.00	0.03	19.97	0.00	0.00	2.02	38.82	0.00	0.00	4.02	0.00	0.00	0.00	0.16	0.00
BR.072	lin-6bbeb1	0.09	0.38	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.15	41.19	29.84	0.00	0.04	17.97	0.00	0.00	1.54	31.34	0.03	0.00	7.02	0.00	0.00	0.00	0.16	0.00
BR.072	lin-6bbeb1	0.02	0.19	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.00	20.44	14.81	0.00	0.00	0.00	0.00	0.00	2.22	42.54	0.00	0.14	33.96	0.10	0.00	0.00	0.27	0.00
BR.072	lin-6bbeb1	0.05	0.33	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	68.24	49.44	0.00	0.00	0.00	0.00	0.00	2.41	15.28	0.00	0.00	13.55	0.00	0.00	0.00	0.00	0.00
BR.072	lin-6bbeb1	0.05	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	36.10	26.16	0.00	0.00	10.51	0.00	0.00	2.31	42.98	0.00	0.00	7.38	0.03	0.00	0.00	0.16	0.00
BR.072	lin-6bbeb1	0.07	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	56.64	41.04	0.00	0.00	0.00	0.00	0.00	2.04	26.60	0.07	0.00	13.64	0.00	0.00	0.00	0.35	0.00
BR.072	average	0.06	0.36	0.00	0.00	0.04	0.00	0.00	0.00	0.02	0.06	42.78	30.99	0.00	0.00	8.07	0.00	0.00	2.09	32.93	0.00	0.00	13.26	0.00	0.00	0.00	0.21	0.00
BR.072	lin-6bbeb1	0.08	0.45	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.10	36.21	26.24	0.00	0.03	16.60	0.00	0.00	2.10	38.81	0.00	0.00	5.20	0.00	0.00	0.00	0.14	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.072	lin-6bbeb1	0.05	0.33	0.00	0.00	0.21	0.00	0.00	0.00	0.02	0.13	30.08	21.80	0.00	0.03	19.10	0.00	0.00	2.19	40.77	0.00	0.00	6.81	0.00	0.00	0.00	0.28	0.00
BR.072	lin-6bbeb1	0.07	0.32	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.16	36.67	26.56	0.00	0.04	22.15	0.00	0.00	1.52	31.90	0.00	0.00	6.84	0.03	0.00	0.04	0.23	0.00
BR.072	lin-6bbeb1	0.08	0.37	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.15	38.70	28.03	0.00	0.04	20.10	0.00	0.00	1.64	34.04	0.06	0.00	4.56	0.00	0.00	0.07	0.18	0.00
BR.072	lin-6bbeb1	0.08	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.20	60.44	43.79	0.00	0.04	15.57	0.00	0.00	1.66	11.83	0.00	0.00	9.59	0.00	0.00	0.00	0.21	0.00
BR.072	lin-6bbeb1	0.07	0.42	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	30.49	22.09	0.00	0.00	12.93	0.00	0.00	2.27	49.71	0.05	0.00	3.59	0.00	0.00	0.00	0.15	0.00
BR.072	average	0.07	0.37	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.13	38.76	28.08	0.00	0.03	17.74	0.00	0.00	1.90	34.51	0.00	0.00	6.10	0.00	0.00	0.00	0.20	0.00
BR.073	spwd 39	0.01	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	19.92	14.43	0.00	0.00	9.31	0.00	0.00	2.46	65.42	0.00	0.00	2.34	0.00	0.00	0.00	0.07	0.00
BR.073	spwd 39	0.01	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	16.46	11.93	0.00	0.00	8.16	0.00	0.00	2.82	70.44	0.00	0.00	1.66	0.00	0.00	0.00	0.00	0.00
BR.073	spwd 39	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	16.58	12.01	0.00	0.00	7.29	0.00	0.00	2.85	71.17	0.00	0.00	1.67	0.00	0.00	0.00	0.00	0.00
BR.073	average	0.01	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	17.65	12.79	0.00	0.00	8.25	0.00	0.00	2.71	69.01	0.00	0.00	1.89	0.00	0.00	0.00	0.00	0.00
BR.074	nlm4223	0.51	0.05	0.00	0.00	1.31	0.00	0.00	0.00	0.01	0.00	3.73	2.70	4.43	0.00	7.20	0.00	0.00	0.28	79.96	0.00	0.00	2.22	0.00	0.00	0.00	0.23	0.00
BR.074	nlm4223	0.53	0.00	0.07	0.04	3.30	0.00	0.00	0.00	0.01	0.00	2.71	1.96	15.03	0.00	5.02	0.00	0.00	0.22	70.68	0.00	0.00	1.81	0.00	0.03	0.10	0.43	0.00
BR.074	nlm4223	0.48	0.85	0.03	0.02	1.94	0.00	0.00	0.00	0.00	0.00	3.35	2.43	7.97	0.00	7.16	0.00	0.00	0.37	76.27	0.00	0.00	1.24	0.00	0.00	0.05	0.21	0.00
BR.074	average	0.51	0.30	0.04	0.02	2.18	0.00	0.00	0.00	0.01	0.00	3.26	2.36	9.14	0.00	6.46	0.00	0.00	0.29	75.64	0.00	0.00	1.76	0.00	0.00	0.06	0.29	0.00
BR.075	nolms.2012.111	0.03	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.56	0.40	0.00	0.02	1.78	0.00	0.00	2.79	87.95	0.00	0.00	0.22	0.00	0.00	0.00	0.06	1.24
BR.075	nolms.2012.111	0.03	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.58	0.42	0.00	0.02	1.58	0.00	0.00	2.81	87.68	0.00	0.00	0.22	0.00	0.00	0.00	0.07	1.55
BR.075	nolms.2012.111	0.03	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.55	0.40	0.00	0.03	1.88	0.00	0.00	2.82	88.10	0.00	0.00	0.22	0.00	0.00	0.00	0.05	0.80
BR.075	average	0.03	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.56	0.41	0.00	0.03	1.75	0.00	0.00	2.81	87.91	0.00	0.00	0.22	0.00	0.00	0.00	0.06	1.20
BR.075	nolms.2012.111	0.03	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.41	1.02	0.00	0.04	5.68	0.00	0.00	3.02	82.87	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00
BR.075	nolms.2012.111	0.03	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.39	1.01	0.00	0.04	5.35	0.00	0.00	3.01	82.52	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00
BR.075	nolms.2012.111	0.03	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1.39	1.01	0.00	0.03	5.77	0.00	0.00	3.01	82.67	0.00	0.00	0.99	0.00	0.00	0.00	0.06	0.00
BR.075	average	0.03	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	1.40	1.01	0.00	0.04	5.60	0.00	0.00	3.01	82.68	0.00	0.00	0.98	0.00	0.00	0.00	0.04	0.00
BR.076	sfxx 29s	0.00	0.19	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	9.62	6.97	0.00	0.00	4.14	0.00	0.00	2.61	82.56	0.00	0.00	0.44	0.00	0.00	0.00	0.05	0.00
BR.076	sfxx 29s	0.00	0.19	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.03	9.99	7.24	0.00	0.00	7.10	0.00	0.00	2.43	79.33	0.00	0.00	0.47	0.00	0.00	0.00	0.05	0.00
BR.076	sfxx 29s	0.00	0.19	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.03	10.05	7.28	0.00	0.00	6.62	0.00	0.00	2.46	79.73	0.00	0.00	0.47	0.00	0.00	0.00	0.06	0.00
BR.076	average	0.00	0.19	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	9.89	7.16	0.00	0.00	5.95	0.00	0.00	2.50	80.54	0.00	0.00	0.46	0.00	0.00	0.00	0.06	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.077	lin-9bb619	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	18.27	13.24	0.00	0.00	9.20	0.00	0.00	5.10	66.20	0.00	0.00	0.99	0.00	0.00	0.00	0.09	0.00
BR.077	lin-9bb619	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	29.68	21.50	0.00	0.02	7.76	0.00	0.00	4.70	54.01	0.00	0.00	3.48	0.00	0.00	0.00	0.18	0.00
BR.077	lin-9bb619	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.40	10.43	0.00	0.00	7.58	0.00	0.00	6.27	71.18	0.00	0.00	0.42	0.00	0.00	0.00	0.07	0.00
BR.077	average	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	20.78	15.06	0.00	0.00	8.18	0.00	0.00	5.36	63.79	0.00	0.00	1.63	0.00	0.00	0.00	0.11	0.00
BR.078	sfwg 2	0.26	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.34	30.15	21.84	0.00	0.00	32.18	0.00	0.00	2.69	33.42	0.02	0.00	0.64	0.00	0.03	0.04	0.16	0.00
BR.078	sfwg 2	0.27	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.38	30.69	22.24	0.00	0.03	32.74	0.00	0.00	2.33	32.76	0.02	0.00	0.53	0.00	0.00	0.03	0.13	0.00
BR.078	sfwg 2	0.27	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.43	31.58	22.88	0.00	0.03	36.11	0.00	0.00	1.97	28.82	0.02	0.00	0.43	0.00	0.04	0.06	0.16	0.00
BR.078	average	0.27	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.39	30.81	22.32	0.00	0.02	33.68	0.00	0.00	2.33	31.66	0.02	0.00	0.53	0.00	0.03	0.05	0.15	0.00
BR.078	sfwg 2	0.22	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	21.15	15.32	0.00	0.00	23.94	0.00	0.00	3.82	50.07	0.00	0.00	0.42	0.00	0.00	0.00	0.07	0.00
BR.078	sfwg 2	0.21	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	24.23	17.55	0.00	0.00	25.19	0.00	0.00	3.75	43.85	0.00	0.00	2.36	0.00	0.00	0.04	0.09	0.00
BR.078	sfwg 2	0.23	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.28	26.05	18.88	0.00	0.02	28.32	0.00	0.00	3.29	40.95	0.00	0.00	0.63	0.00	0.00	0.00	0.11	0.00
BR.078	average	0.22	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	23.81	17.25	0.00	0.00	25.82	0.00	0.00	3.62	44.96	0.00	0.00	1.14	0.00	0.00	0.00	0.09	0.00
BR.079	1998-378-38	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.89	4.99	1.83	0.00	2.45	3.30	0.00	3.02	81.29	0.00	0.00	1.01	0.02	0.00	0.00	0.09	0.00
BR.079	1998-378-38	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.83	4.23	0.93	0.00	3.97	1.68	0.00	3.96	82.99	0.00	0.00	0.50	0.00	0.00	0.00	0.04	0.00
BR.079	1998-378-38	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.47	3.96	0.97	0.00	3.05	1.74	0.00	3.32	84.64	0.00	0.00	0.66	0.02	0.00	0.00	0.05	0.00
BR.079	average	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.07	4.39	1.24	0.00	3.16	2.24	0.00	3.43	82.98	0.00	0.00	0.72	0.02	0.00	0.00	0.06	0.00
BR.079	1998-378-38	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.53	5.45	0.00	0.00	6.21	0.00	0.00	4.29	80.4 0	0.00	0.00	1.39	0.04	0.00	0.00	0.08	0.00
BR.079	1998-378-38	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.93	5.02	0.00	0.02	5.96	0.00	0.00	4.24	81.65	0.00	0.00	1.07	0.03	0.00	0.00	0.00	0.00
BR.079	1998-378-38	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	8.20	5.94	0.00	0.02	2.95	0.00	0.00	3.47	83.62	0.00	0.00	1.51	0.04	0.00	0.00	0.09	0.00
BR.079	average	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.55	5.47	0.00	0.01	5.04	0.00	0.00	4.00	81.89	0.00	0.00	1.32	0.04	0.00	0.00	0.07	0.00
BR.08 0	sfwd 38	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	5.55	4.02	1.18	0.00	3.32	1.99	0.00	3.33	83.78	0.00	0.00	0.68	0.01	0.00	0.00	0.07	0.00
BR.08 0	sfwd 38	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	5.43	3.94	2.18	0.00	2.67	3.75	0.00	3.35	81.16	0.00	0.00	1.17	0.03	0.00	0.00	0.12	0.00
BR.08 0	sfwd 38	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	6.60	4.78	1.12	0.00	4.26	2.11	0.00	3.66	81.17	0.00	0.00	0.90	0.02	0.00	0.00	0.07	0.00
BR.08 0	sfwd 38	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	7.50	5.43	0.00	0.02	5.62	0.00	0.00	4.59	80.75	0.00	0.00	1.37	0.05	0.00	0.00	0.06	0.00
BR.08 0	sfwd 38	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	8.66	6.27	0.00	0.01	5.26	0.00	0.00	4.16	80.18	0.00	0.00	1.49	0.04	0.00	0.00	0.11	0.00
BR.08 0	sfwd 38	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	7.36	5.33	0.00	0.02	5.89	0.00	0.00	4.48	81.07	0.00	0.00	1.04	0.03	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.080	average	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	6.85	4.96	0.75	0.00	4.50	1.31	0.00	3.93	81.35	0.00	0.00	1.11	0.03	0.00	0.00	0.08	0.00
BR.080	sfwd 38	0.00	2.25	0.00	0.00	0.20	0.00	0.00	0.00	0.02	0.00	39.43	28.57	0.00	0.00	0.00	0.00	0.00	2.08	53.86	0.00	0.00	1.96	0.00	0.00	0.00	0.18	0.00
BR.080	sfwd 38	0.00	0.42	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.08	23.48	17.01	0.00	0.01	11.30	0.00	0.00	1.15	62.84	0.00	0.00	0.58	0.00	0.00	0.00	0.10	0.00
BR.080	sfwd 38	0.00	1.18	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	49.38	35.78	0.00	0.00	0.00	0.00	0.00	1.77	45.37	0.00	0.00	1.88	0.00	0.00	0.00	0.23	0.00
BR.080	sfwd 38	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	36.16	26.20	0.00	0.00	0.00	0.00	0.00	3.07	58.34	0.04	0.00	2.03	0.00	0.00	0.00	0.20	0.00
BR.080	sfwd 38	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	32.55	23.58	0.00	0.00	0.00	0.00	0.00	3.00	62.32	0.00	0.00	1.83	0.00	0.00	0.00	0.18	0.00
BR.080	sfwd 38	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	22.02	15.95	0.00	0.02	7.17	0.00	0.00	2.05	67.77	0.00	0.00	0.69	0.00	0.00	0.00	0.14	0.00
BR.080	average	0.00	0.68	0.00	0.00	0.07	0.00	0.00	0.00	0.02	0.00	33.84	24.51	0.00	0.00	3.08	0.00	0.00	2.19	58.42	0.00	0.00	1.50	0.00	0.00	0.00	0.17	0.00
BR.081	ayxx 3	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	12.55	9.09	0.00	0.02	8.87	0.00	0.00	2.12	76.18	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
BR.081	ayxx 3	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	12.61	9.13	0.00	0.00	8.59	0.00	0.00	2.13	76.41	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
BR.081	ayxx 3	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.63	9.15	0.00	0.00	8.24	0.00	0.00	2.12	76.73	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
BR.081	average	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.60	9.13	0.00	0.00	8.56	0.00	0.00	2.13	76.44	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
BR.081	ayxx 3	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	19.48	14.12	0.00	0.00	11.53	0.00	0.00	1.86	66.61	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
BR.081	ayxx 3	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	19.61	14.21	0.00	0.02	11.04	0.00	0.00	1.88	67.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
BR.081	ayxx 3	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	19.45	14.09	0.00	0.00	12.17	0.00	0.00	1.86	65.99	0.00	0.00	0.36	0.00	0.00	0.00	0.06	0.00
BR.081	average	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	19.52	14.14	0.00	0.00	11.58	0.00	0.00	1.87	66.53	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
BR.082	sfn005	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	25.90	18.77	0.00	0.02	16.15	0.00	0.00	2.40	54.22	0.00	0.00	0.97	0.03	0.00	0.00	0.14	0.00
BR.082	sfn005	0.00	0.02	0.00	0.00	0.19	0.00	0.00	0.00	0.04	0.14	38.40	27.82	0.00	0.00	9.52	0.00	0.00	3.06	46.54	0.00	0.00	1.87	0.07	0.00	0.00	0.15	0.00
BR.082	sfn005	0.05	0.04	0.01	0.00	0.21	0.00	0.00	0.00	0.00	0.34	34.73	25.16	0.00	0.04	32.99	0.00	0.00	1.66	28.93	0.00	0.00	0.70	0.00	0.03	0.06	0.20	0.00
BR.082	average	0.02	0.03	0.00	0.00	0.14	0.00	0.00	0.00	0.02	0.19	33.01	23.92	0.00	0.02	19.55	0.00	0.00	2.37	43.23	0.00	0.00	1.18	0.04	0.00	0.00	0.17	0.00
BR.083	lnaa 6	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.32	53.67	38.88	0.00	0.00	16.84	0.00	0.00	2.82	21.42	0.00	0.00	4.66	0.07	0.00	0.00	0.10	0.00
BR.083	lnaa 6	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.36	52.56	38.08	0.00	0.03	20.29	0.00	0.00	2.43	19.44	0.00	0.00	4.53	0.05	0.00	0.06	0.15	0.00
BR.083	lnaa 6	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.37	49.85	36.11	0.00	0.02	21.55	0.00	0.00	2.96	21.00	0.00	0.00	4.03	0.08	0.00	0.00	0.09	0.00
BR.083	average	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.35	52.02	37.69	0.00	0.02	19.56	0.00	0.00	2.74	20.62	0.00	0.00	4.41	0.07	0.00	0.00	0.11	0.00
BR.084	keaa 2	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	22.41	16.24	0.00	0.03	7.57	0.00	0.00	1.19	67.57	0.00	0.00	1.09	0.00	0.00	0.00	0.07	0.00
BR.084	keaa 2	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.15	24.18	17.52	0.00	0.03	19.88	0.00	0.00	1.45	53.12	0.00	0.00	1.02	0.00	0.00	0.00	0.14	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
BR.084	keaa 2	0.00	0.03	0.00	0.00	0.22	0.00	0.00	0.00	0.02	0.00	34.06	24.68	0.00	0.00	0.00	0.00	0.00	2.07	60.57	0.00	0.00	2.73	0.00	0.00	0.00	0.28	0.00
BR.084	average	0.00	0.03	0.00	0.00	0.07	0.00	0.00	0.00	0.01	0.07	26.88	19.48	0.00	0.02	9.15	0.00	0.00	1.57	60.42	0.00	0.00	1.61	0.00	0.00	0.00	0.16	0.00
BR.085	1996.158.4	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	18.00	13.04	0.00	0.00	0.00	0.00	0.00	1.91	78.47	0.00	0.00	1.46	0.00	0.00	0.00	0.13	0.00
BR.085	1996.158.4	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	22.76	16.49	0.00	0.00	0.00	0.00	0.00	2.02	71.08	0.00	0.00	3.84	0.00	0.00	0.00	0.27	0.00
BR.085	1996.158.4	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	18.07	13.09	0.00	0.00	0.00	0.00	0.00	1.92	78.44	0.00	0.00	1.45	0.00	0.00	0.00	0.09	0.00
BR.085	average	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	19.61	14.21	0.00	0.00	0.00	0.00	0.00	1.95	76.00	0.00	0.00	2.25	0.00	0.00	0.00	0.16	0.00
BR.085	1996.158.4	0.00	0.03	0.00	0.00	0.21	0.00	0.00	0.00	0.02	0.00	26.50	19.20	0.00	0.00	0.00	0.00	0.00	1.60	67.05	0.00	0.00	4.34	0.00	0.00	0.00	0.24	0.00
BR.085	1996.158.4	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	22.77	16.49	0.00	0.02	8.30	0.00	0.00	1.42	64.75	0.00	0.00	2.48	0.00	0.00	0.00	0.19	0.00
BR.085	1996.158.4	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	21.36	15.47	0.00	0.03	16.75	0.00	0.00	1.83	58.94	0.00	0.00	0.82	0.00	0.03	0.00	0.11	0.00
BR.085	average	0.00	0.02	0.00	0.00	0.07	0.00	0.00	0.00	0.01	0.05	23.54	17.06	0.00	0.02	8.35	0.00	0.00	1.62	63.58	0.00	0.00	2.55	0.00	0.00	0.00	0.18	0.00
BR.086	lin-df27ac	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.39	8.97	0.00	0.00	2.90	0.00	0.00	5.07	79.46	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00
BR.086	lin-df27ac	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	13.57	9.83	0.00	0.00	0.00	0.00	0.00	5.33	80.51	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00
BR.086	lin-df27ac	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.99	11.59	0.00	0.00	0.00	0.00	0.00	4.42	79.42	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
BR.086	average	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.98	10.13	0.00	0.00	0.00	0.00	0.00	4.94	79.80	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
BR.087	elbw	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	28.45	20.61	0.00	0.02	18.35	0.00	0.00	2.12	49.66	0.00	0.00	1.06	0.00	0.00	0.00	0.09	0.00
BR.087	elbw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	28.09	20.35	0.00	0.02	12.67	0.00	0.00	2.18	53.85	0.00	0.00	3.09	0.00	0.00	0.00	0.00	0.00
BR.087	elbw	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.10	27.32	19.79	0.00	0.00	10.69	0.00	0.00	2.24	52.84	0.00	0.00	6.79	0.00	0.00	0.00	0.00	0.00
BR.087	average	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	27.95	20.25	0.00	0.01	13.90	0.00	0.00	2.18	52.12	0.00	0.00	3.65	0.00	0.00	0.00	0.00	0.00
BR.088	lin-a78b55	0.16	29.75	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	10.36	7.51	0.00	0.00	1.89	0.18	0.00	2.05	47.15	0.08	0.00	2.67	0.00	0.00	0.00	0.35	0.00
BR.088	lin-a78b55	0.14	28.88	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.04	9.26	6.71	0.00	0.00	1.83	0.20	0.00	1.98	45.37	0.08	0.00	4.53	0.00	0.00	0.00	0.41	0.00
BR.088	lin-a78b55	0.13	27.12	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.05	9.00	6.52	0.00	0.00	4.53	0.18	0.00	1.80	46.22	0.05	0.00	3.96	0.00	0.00	0.00	0.42	0.00
BR.088	average	0.14	28.58	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.04	9.54	6.91	0.00	0.00	2.75	0.19	0.00	1.94	46.24	0.07	0.00	3.72	0.00	0.00	0.00	0.39	0.00
BR.088	lin-a78b55	0.12	23.56	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.04	8.06	5.84	0.00	0.00	4.00	0.16	0.00	1.68	51.46	0.03	0.00	2.92	0.00	0.00	0.00	0.35	1.46
BR.088	lin-a78b55	0.13	27.05	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.05	8.44	6.12	0.00	0.00	3.81	0.17	0.00	1.59	42.05	0.05	0.00	3.82	0.00	0.00	0.00	0.42	2.77
BR.088	lin-a78b55	0.11	20.47	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.04	7.21	5.23	0.00	0.00	5.26	0.15	0.00	1.58	52.11	0.04	0.00	2.75	0.00	0.00	0.00	0.29	2.46
BR.088	average	0.12	23.69	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.04	7.91	5.73	0.00	0.00	4.36	0.16	0.00	1.62	48.54	0.04	0.00	3.16	0.00	0.00	0.00	0.35	2.23

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.088	lin-a78b55	0.16	29.75	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	10.36	7.51	0.00	0.00	1.89	0.18	0.00	2.05	47.15	0.08	0.00	2.67	0.00	0.00	0.00	0.35	0.00
BR.088	lin-a78b55	0.14	28.88	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.04	9.26	6.71	0.00	0.00	1.83	0.20	0.00	1.98	45.37	0.08	0.00	4.53	0.00	0.00	0.00	0.41	0.00
BR.088	lin-a78b55	0.13	27.12	0.00	0.00	0.57	0.00	0.00	0.00	0.00	0.05	9.00	6.52	0.00	0.00	4.53	0.18	0.00	1.80	46.22	0.05	0.00	3.96	0.00	0.00	0.00	0.42	0.00
BR.088	average	0.14	28.58	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.04	9.54	6.91	0.00	0.00	2.75	0.19	0.00	1.94	46.24	0.07	0.00	3.72	0.00	0.00	0.00	0.39	0.00
BR.088	lin-a78b55	0.12	23.56	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.04	8.06	5.84	0.00	0.00	4.00	0.16	0.00	1.68	51.46	0.03	0.00	2.92	0.00	0.00	0.00	0.35	1.46
BR.088	lin-a78b55	0.13	27.05	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.05	8.44	6.12	0.00	0.00	3.81	0.17	0.00	1.59	42.05	0.05	0.00	3.82	0.00	0.00	0.00	0.42	2.77
BR.088	lin-a78b55	0.11	20.47	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.04	7.21	5.23	0.00	0.00	5.26	0.15	0.00	1.58	52.11	0.04	0.00	2.75	0.00	0.00	0.00	0.29	2.46
BR.088	average	0.12	23.69	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.04	7.91	5.73	0.00	0.00	4.36	0.16	0.00	1.62	48.54	0.04	0.00	3.16	0.00	0.00	0.00	0.35	2.23
BR.089	lin-6b7bd1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.53	5.46	0.00	0.00	0.00	0.00	0.00	8.85	83.37	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	5.44	0.00	0.00	0.00	0.00	0.00	8.84	83.45	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.54	7.63	0.00	0.00	0.00	0.00	0.00	7.27	80.02	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.52	7.62	0.00	0.00	0.00	0.00	0.00	7.11	82.05	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00
BR.089	average	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.52	6.90	0.00	0.00	0.00	0.00	0.00	7.74	81.84	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2 back	0.08	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.65		0.00		0.00	52.70	1.89	0.00			0.35	0.00	0.96	0.17	0.19	0.29	0.58	0.00
BR.089	lin-6b7bd2 back	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45		0.00		0.10	30.57	0.00	7.15			0.47	0.00	0.99	0.18	0.25	0.31	0.48	0.00
BR.089	lin-6b7bd2 back	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54		0.00		0.00	43.81	2.56	0.00			0.42	0.00	1.40	0.17	0.22	0.32	0.61	0.00
BR.089	average	0.08	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.55		0.00		0.03	42.36	1.49	2.39			0.41	0.00	1.12	0.17	0.22	0.31	0.56	0.00
BR.089	lin-6b7bd2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.53	5.46	0.00	0.00	0.00	0.00	0.00	8.85	83.37	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.50	5.44	0.00	0.00	0.00	0.00	0.00	8.84	83.45	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.54	7.63	0.00	0.00	0.00	0.00	0.00	7.27	80.02	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.52	7.62	0.00	0.00	0.00	0.00	0.00	7.11	82.05	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00
BR.089	average	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.52	6.90	0.00	0.00	0.00	0.00	0.00	7.74	81.84	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
BR.089	lin-6b7bd2 back	0.08	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.65		0.00		0.00	52.70	1.89	0.00			0.35	0.00	0.96	0.17	0.19	0.29	0.58	0.00
BR.089	lin-6b7bd2 back	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45		0.00		0.10	30.57	0.00	7.15			0.47	0.00	0.99	0.18	0.25	0.31	0.48	0.00
BR.089	lin-6b7bd2 back	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54		0.00		0.00	43.81	2.56	0.00			0.42	0.00	1.40	0.17	0.22	0.32	0.61	0.00
BR.089	average	0.08	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.55		0.00		0.03	42.36	1.49	2.39			0.41	0.00	1.12	0.17	0.22	0.31	0.56	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
BR.090	lin-95e801	0.22	14.06	0.00	0.00	1.09	0.00	0.00	0.00	0.02	0.08	11.48	8.32	0.00	0.03	2.99	5.23	0.00	0.31	50.42	0.00	0.00	2.06	0.00	0.00	0.00	0.16	2.62
BR.090	lin-95e801	0.23	14.73	0.00	0.00	1.12	0.00	0.00	0.00	0.03	0.08	11.25	8.15	0.00	0.00	2.03	5.46	0.00	0.31	52.85	0.00	0.00	1.53	0.00	0.00	0.00	0.17	2.62
BR.090	lin-95e801	0.32	18.65	0.00	0.00	1.57	0.00	0.00	0.00	0.00	0.18	11.34	8.22	0.00	0.00	11.80	11.67	0.00	0.35	38.14	0.00	0.00	0.87	0.00	0.00	0.00	0.26	2.29
BR.090	average	0.26	15.81	0.00	0.00	1.26	0.00	0.00	0.00	0.02	0.11	11.36	8.23	0.00	0.00	5.60	7.45	0.00	0.33	47.14	0.00	0.00	1.49	0.00	0.00	0.00	0.20	2.51
BR.090	lin-95e801 back	0.17	13.06	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.03	6.77	4.90	0.00	0.00	0.00	2.02	0.00	0.35	63.03	0.00	0.00	1.54	0.00	0.00	0.00	0.00	2.16
BR.090	lin-95e801 back	0.27	18.06	0.00	0.00	1.23	0.00	0.00	0.00	0.00	0.04	10.08	7.30	0.00	0.00	1.67	1.45	0.00	0.44	55.30	0.00	0.00	1.36	0.00	0.00	0.00	0.00	1.83
BR.090	lin-95e801 back	0.29	19.19	0.00	0.00	1.22	0.00	0.00	0.00	0.01	0.00	15.00	10.86	0.00	0.00	0.00	1.14	0.00	0.37	48.07	0.00	0.00	2.33	0.00	0.00	0.00	0.00	2.69
BR.090	average	0.24	16.77	0.00	0.00	1.16	0.00	0.00	0.00	0.01	0.03	10.61	7.69	0.00	0.00	0.00	1.54	0.00	0.39	55.47	0.00	0.00	1.74	0.00	0.00	0.00	0.00	2.23
BR.090	lin-95e801	0.22	14.06	0.00	0.00	1.09	0.00	0.00	0.00	0.02	0.08	11.48	8.32	0.00	0.03	2.99	5.23	0.00	0.31	50.42	0.00	0.00	2.06	0.00	0.00	0.00	0.16	2.62
BR.090	lin-95e801	0.23	14.73	0.00	0.00	1.12	0.00	0.00	0.00	0.03	0.08	11.25	8.15	0.00	0.00	2.03	5.46	0.00	0.31	52.85	0.00	0.00	1.53	0.00	0.00	0.00	0.17	2.62
BR.090	lin-95e801	0.32	18.65	0.00	0.00	1.57	0.00	0.00	0.00	0.00	0.18	11.34	8.22	0.00	0.00	11.80	11.67	0.00	0.35	38.14	0.00	0.00	0.87	0.00	0.00	0.00	0.26	2.29
BR.090	average	0.26	15.81	0.00	0.00	1.26	0.00	0.00	0.00	0.02	0.11	11.36	8.23	0.00	0.00	5.60	7.45	0.00	0.33	47.14	0.00	0.00	1.49	0.00	0.00	0.00	0.20	2.51
BR.090	lin-95e801 back	0.17	13.06	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.03	6.77	4.90	0.00	0.00	0.00	2.02	0.00	0.35	63.03	0.00	0.00	1.54	0.00	0.00	0.00	0.00	2.16
BR.090	lin-95e801 back	0.27	18.06	0.00	0.00	1.23	0.00	0.00	0.00	0.00	0.04	10.08	7.30	0.00	0.00	1.67	1.45	0.00	0.44	55.30	0.00	0.00	1.36	0.00	0.00	0.00	0.00	1.83
BR.090	lin-95e801 back	0.29	19.19	0.00	0.00	1.22	0.00	0.00	0.00	0.01	0.00	15.00	10.86	0.00	0.00	0.00	1.14	0.00	0.37	48.07	0.00	0.00	2.33	0.00	0.00	0.00	0.00	2.69
BR.090	average	0.24	16.77	0.00	0.00	1.16	0.00	0.00	0.00	0.01	0.03	10.61	7.69	0.00	0.00	0.00	1.54	0.00	0.39	55.47	0.00	0.00	1.74	0.00	0.00	0.00	0.00	2.23
BR.50	lin-eb33a6	0.09	8.17	0.00	0.00	1.90	0.00	0.00	0.00	0.07	0.16	13.86	10.04	0.00	0.17	10.50	7.79	0.00	0.76	33.63	0.00	0.00	4.87	0.05	0.00	0.00	0.27	4.64
CH.001	SF028.021	0.20	36.57	0.00	0.00	1.35	0.00	0.00	0.00	0.04	0.00	16.00	11.59	0.00	0.00	0.00	0.09	0.00	0.37	35.77	0.10	0.00	9.33	0.13	0.00	0.00	0.00	0.00
CH.001	SF028.021	0.15	20.73	0.00	0.00	0.79	0.00	0.00	0.00	0.01	0.00	9.11	6.60	0.00	0.00	0.00	0.00	0.00	0.20	64.67	0.05	0.00	4.20	0.07	0.00	0.00	0.00	0.00
CH.001	SF028.021	0.23	34.25	0.00	0.00	1.44	0.00	0.00	0.00	0.02	0.00	17.96	13.01	0.00	0.00	0.00	0.05	0.00	0.43	37.25	0.20	0.00	7.80	0.00	0.00	0.00	0.00	0.00
CH.001	average	0.19	30.52	0.00	0.00	1.20	0.00	0.00	0.00	0.02	0.00	14.36	10.40	0.00	0.00	0.00	0.05	0.00	0.33	45.90	0.11	0.00	7.11	0.08	0.00	0.00	0.00	0.00
DS.001	lin-1a1f1c	0.76	3.16	0.00	0.00	0.25	0.00	0.01	0.00	0.01	0.09	23.74	17.20	0.00	0.00	0.00	0.00	0.00	2.24	63.18	0.00	0.00	6.39	0.05	0.00	0.00	0.13	0.00
DS.001	lin-1a1f1c	0.66	2.75	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.16	24.66	17.86	0.00	0.00	11.29	0.00	0.00	2.57	53.96	0.03	0.00	3.56	0.00	0.00	0.00	0.10	0.00
DS.001	lin-1a1f1c	0.79	3.06	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.09	24.37	17.65	0.00	0.00	4.91	0.00	0.00	2.59	61.19	0.00	0.00	2.64	0.00	0.00	0.00	0.14	0.00
DS.001	average	0.74	2.99	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.11	24.25	17.57	0.00	0.00	5.40	0.00	0.00	2.47	59.44	0.00	0.00	4.20	0.00	0.00	0.00	0.12	0.00
F.001	SF028.024	0.17	18.93	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	22.11	16.02	0.00	0.00	0.00	0.00	0.00	1.52	41.93	0.04	0.00	15.08	0.04	0.00	0.00	0.13	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
F.001	SF028.024	0.19	21.29	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	21.76	15.77	0.00	0.00	0.00	0.04	0.00	2.00	30.61	0.00	0.00	24.03	0.00	0.00	0.00	0.00	0.00
F.001	SF028.024	0.25	29.26	0.00	0.00	0.22	0.00	0.00	0.00	0.02	0.00	34.93	25.31	0.00	0.00	0.00	0.00	0.00	2.04	30.81	0.00	0.00	2.37	0.00	0.00	0.00	0.00	0.00
F.001	average	0.20	23.16	0.00	0.00	0.07	0.00	0.00	0.00	0.02	0.00	26.27	19.03	0.00	0.00	0.00	0.00	0.00	1.85	34.45	0.00	0.00	13.83	0.00	0.00	0.00	0.00	0.00
GH.00 1	tf 46827 68749	0.20	34.58	0.00	0.00	0.63	0.00	0.00	0.00	0.01	0.08	21.22	15.37	0.00	0.00	4.33	0.00	0.00	0.82	35.75	0.00	0.00	1.96	0.00	0.00	0.00	0.39	0.00
GH.00 1	tf 46827 68749	0.19	32.52	0.00	0.00	0.62	0.00	0.00	0.00	0.01	0.00	26.31	19.06	0.00	0.00	0.00	0.00	0.00	0.71	35.58	0.00	0.00	3.70	0.00	0.00	0.00	0.32	0.00
GH.00 1	tf 46827 68749	0.23	35.99	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.14	23.59	17.09	0.00	0.00	7.37	0.00	0.00	0.76	27.87	0.04	0.00	2.84	0.06	0.00	0.00	0.50	0.00
GH.00 1	average	0.21	34.37	0.00	0.00	0.61	0.00	0.00	0.00	0.01	0.08	23.71	17.18	0.00	0.00	3.90	0.00	0.00	0.76	33.07	0.00	0.00	2.83	0.00	0.00	0.00	0.40	0.00
GH.00 2	lin-a50105	0.26	30.88	0.00	0.00	1.11	0.00	0.00	0.00	0.00	0.00	9.73	7.05	0.00	0.00	0.00	0.18	0.00	1.66	45.27	0.00	0.00	10.71	0.00	0.00	0.00	0.18	0.00
GH.00 2	lin-a50105	0.20	29.45	0.00	0.00	1.14	0.00	0.00	0.00	0.02	0.04	17.50	12.68	0.00	0.00	0.00	0.09	0.00	2.60	29.13	0.00	0.00	19.70	0.00	0.00	0.00	0.00	0.00
GH.00 2	lin-a50105	0.26	29.40	0.00	0.00	1.39	0.00	0.00	0.00	0.01	0.00	9.38	6.79	0.00	0.00	0.00	0.17	0.00	1.39	52.08	0.00	0.00	5.83	0.00	0.00	0.00	0.00	0.00
GH.00 2	average	0.24	29.91	0.00	0.00	1.21	0.00	0.00	0.00	0.01	0.00	12.20	8.84	0.00	0.00	0.00	0.15	0.00	1.88	42.16	0.00	0.00	12.08	0.00	0.00	0.00	0.00	0.00
GH.00 3	lin-941fda side b	0.15	32.49	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.05	6.60	4.78	0.00	0.00	0.00	0.05	0.00	0.63	56.65	0.00	0.00	2.24	0.00	0.00	0.00	0.26	0.00
GH.00 3	lin-941fda side b	0.15	30.96	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.05	5.92	4.29	0.00	0.00	0.00	0.08	0.00	0.62	58.65	0.00	0.00	2.88	0.00	0.00	0.00	0.24	0.00
GH.00 3	lin-941fda side b	0.15	30.18	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.06	7.52	5.45	0.00	0.00	0.00	0.06	0.00	0.75	57.40	0.00	0.00	1.87	0.00	0.00	0.00	0.28	0.00
GH.00 3	average	0.15	36.33	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	6.37	4.62	0.00	0.00	0.00	0.00	0.00	0.51	53.92	0.05	0.00	1.96	0.00	0.00	0.00	0.25	0.00
GH.00 3	lin-941fda side a	0.13	29.03	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.05	6.00	4.35	0.00	0.00	0.00	0.06	0.00	0.58	61.51	0.00	0.00	1.63	0.00	0.00	0.00	0.32	0.00
GH.00 3	lin-941fda side a	0.14	30.60	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.05	6.20	4.49	0.00	0.00	0.00	0.07	0.00	0.57	59.92	0.00	0.00	1.72	0.00	0.00	0.00	0.33	0.00
GH.00 3	lin-941fda side a	0.14	29.65	0.00	0.00	0.39	0.00	0.00	0.00	0.01	0.05	5.92	4.29	0.00	0.00	0.00	0.07	0.00	0.59	61.18	0.00	0.00	1.69	0.00	0.00	0.00	0.33	0.00
GH.00 3	average	0.13	26.85	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.04	5.88	4.26	0.00	0.00	0.00	0.00	0.00	0.57	63.44	0.04	0.00	1.47	0.00	0.00	0.00	0.30	0.00
GH.00 4	lin-a4edf7	0.20	25.43	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.00	20.72	15.01	0.00	0.00	0.00	0.00	0.00	1.27	43.15	0.03	0.00	8.48	0.00	0.00	0.00	0.00	0.00
GH.00 4	lin-a4edf7	0.19	24.30	0.00	0.00	0.43	0.00	0.00	0.00	0.01	0.04	18.16	13.16	0.00	0.00	0.00	0.00	0.00	1.54	44.03	0.00	0.00	11.10	0.05	0.00	0.00	0.00	0.00
GH.00 4	lin-a4edf7	0.19	26.26	0.00	0.00	0.63	0.00	0.00	0.00	0.02	0.00	17.37	12.58	0.00	0.00	0.00	0.00	0.00	1.02	48.20	0.00	0.00	6.08	0.05	0.00	0.00	0.00	0.00
GH.00 4	average	0.19	25.33	0.00	0.00	0.55	0.00	0.00	0.00	0.01	0.00	18.75	13.58	0.00	0.00	0.00	0.00	0.00	1.28	45.13	0.00	0.00	8.55	0.04	0.00	0.00	0.00	0.00
GH.00 5	SF036.092	0.10	15.68	0.00	0.00	0.62	0.00	0.00	0.00	0.02	0.04	5.19	3.76	0.00	0.00	0.00	0.00	0.00	3.00	69.28	0.00	0.00	5.83	0.13	0.00	0.00	0.00	0.00
GH.00 5	SF036.092	0.17	25.77	0.00	0.00	0.85	0.00	0.00	0.00	0.01	0.07	10.67	7.73	0.00	0.00	3.04	0.00	0.12	5.32	49.24	0.06	0.00	4.39	0.00	0.00	0.00	0.26	0.00
GH.00 5	SF036.092	0.11	18.70	0.00	0.00	0.64	0.00	0.00	0.00	0.01	0.03	5.76	4.18	0.00	0.00	0.00	0.00	0.00	1.59	39.90	0.00	0.00	33.26	0.00	0.00	0.00	0.00	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
GH.005	average	0.13	20.05	0.00	0.00	0.70	0.00	0.00	0.00	0.01	0.05	7.21	5.22	0.00	0.00	0.00	0.00	0.00	3.30	52.80	0.00	0.00	14.49	0.05	0.00	0.00	0.12	0.00
GH.006	lin-7b42a2 side b	0.12	15.71	0.00	0.00	1.19	0.00	0.00	0.00	0.01	0.06	5.89	4.27	0.00	0.00	1.27	2.33	0.00	4.78	53.28	0.00	0.00	15.26	0.00	0.00	0.00	0.00	0.00
GH.006	lin-7b42a2 side b	0.08	9.92	0.00	0.00	0.74	0.00	0.00	0.00	0.01	0.03	4.16	3.01	0.00	0.00	0.00	1.05	0.00	3.97	39.42	0.00	0.00	40.62	0.00	0.00	0.00	0.00	0.00
GH.006	lin-7b42a2 side b	0.15	18.63	0.00	0.00	1.42	0.00	0.00	0.00	0.01	0.07	6.78	4.91	0.00	0.00	1.56	2.98	0.00	5.21	60.45	0.00	0.00	2.58	0.00	0.00	0.00	0.18	0.00
GH.006	average	0.14	18.57	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.08	6.73	4.87	0.00	0.00	2.24	2.96	0.00	5.16	59.99	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00
GH.006	lin-7b42a2 side a	0.16	18.02	0.00	0.00	1.27	0.00	0.00	0.00	0.01	0.09	8.63	6.25	0.00	0.00	6.39	2.60	0.00	5.63	53.56	0.00	0.00	3.40	0.00	0.00	0.00	0.23	0.00
GH.006	lin-7b42a2 side a	0.18	22.12	0.00	0.00	1.44	0.00	0.00	0.00	0.01	0.12	9.85	7.13	0.00	0.00	4.58	2.89	0.00	6.09	45.97	0.03	0.00	6.52	0.00	0.00	0.00	0.20	0.00
GH.006	lin-7b42a2 side a	0.18	20.36	0.00	0.00	1.46	0.00	0.00	0.00	0.01	0.09	8.65	6.27	0.00	0.00	6.11	2.92	0.00	6.25	51.64	0.04	0.00	2.01	0.00	0.00	0.00	0.29	0.00
GH.006	average	0.11	11.57	0.00	0.00	0.92	0.00	0.00	0.00	0.00	0.07	7.38	5.35	0.00	0.00	8.48	2.00	0.00	4.56	63.07	0.00	0.00	1.65	0.00	0.00	0.00	0.19	0.00
GH.007	lin-e13628	0.18	18.56	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.08	13.84	10.03	0.00	0.00	16.07	0.00	0.00	2.30	42.68	0.04	0.00	0.56	0.00	0.00	0.00	0.31	0.00
GH.007	lin-e13628	0.16	17.18	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.06	13.89	10.07	0.00	0.00	12.13	0.00	0.00	2.24	45.58	0.04	0.00	0.52	0.00	0.00	0.00	0.26	1.98
GH.007	lin-e13628	0.19	22.08	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.09	15.20	11.01	0.00	0.00	14.21	0.00	0.00	2.32	39.00	0.04	0.00	0.66	0.00	0.00	0.00	0.39	0.00
GH.007	average	0.18	19.28	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.08	14.31	10.37	0.00	0.00	14.14	0.00	0.00	2.29	42.42	0.04	0.00	0.58	0.00	0.00	0.00	0.32	0.00
GH.007	lin-e13628	0.14	15.22	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.04	10.10	7.32	0.00	0.00	11.12	0.00	0.00	2.50	52.97	0.04	0.00	0.46	0.00	0.00	0.00	0.28	0.00
GH.007	lin-e13628	0.17	17.92	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.04	12.30	8.91	0.00	0.00	10.93	0.00	0.00	2.65	48.66	0.06	0.00	0.55	0.00	0.00	0.00	0.32	0.00
GH.007	lin-e13628	0.15	16.08	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.03	10.62	7.69	0.00	0.00	9.43	0.00	0.00	2.58	54.68	0.05	0.00	0.48	0.00	0.00	0.00	0.29	0.00
GH.007	lin-e13628	0.15	15.92	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.04	10.80	7.82	0.00	0.00	10.08	0.00	0.00	2.54	53.73	0.04	0.00	0.50	0.00	0.00	0.00	0.27	0.00
GH.007	average	0.16	16.64	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.04	11.24	8.14	0.00	0.00	10.15	0.00	0.00	2.59	52.36	0.05	0.00	0.51	0.00	0.00	0.00	0.30	0.00
GH.008	lin-a6b892 side b	0.06	22.04	0.00	0.00	0.58	0.00	0.00	0.01	0.02	0.03	7.08	5.13	0.00	0.00	0.00	0.00	0.00	1.45	36.60	0.00	0.11	31.66	0.19	0.00	0.00	0.00	0.00
GH.008	lin-a6b892 side b	0.06	39.71	0.00	0.00	0.81	0.00	0.01	0.01	0.03	0.04	11.79	8.54	0.00	0.00	0.00	0.00	0.00	1.94	42.05	0.00	0.00	3.22	0.34	0.00	0.00	0.00	0.00
GH.008	lin-a6b892 side b	0.12	25.31	0.00	0.00	0.92	0.00	0.01	0.01	0.02	0.05	8.80	6.37	0.00	0.00	0.00	0.00	0.00	2.15	59.14	0.00	0.00	3.33	0.15	0.00	0.00	0.00	0.00
GH.008	average	0.01	1.10	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.65	0.47	0.00	0.00	0.40	0.00	0.00	0.26	8.61	0.00	0.34	88.44	0.07	0.00	0.00	0.10	0.00
GH.008	lin-a6b892 side a	0.09	14.35	0.00	0.00	0.71	0.00	0.00	0.00	0.02	0.03	5.94	4.30	0.00	0.00	0.00	0.00	0.00	1.66	50.95	0.00	0.10	25.77	0.36	0.00	0.00	0.00	0.00
GH.008	lin-a6b892 side a	0.14	19.58	0.00	0.00	1.04	0.00	0.00	0.00	0.02	0.03	9.24	6.70	0.00	0.00	0.00	0.00	0.00	2.48	65.11	0.00	0.00	1.91	0.45	0.00	0.00	0.00	0.00
GH.008	lin-a6b892 side a	0.13	21.52	0.00	0.00	1.08	0.00	0.00	0.00	0.02	0.05	7.68	5.57	0.00	0.00	0.00	0.00	0.00	2.01	64.37	0.00	0.00	2.62	0.51	0.00	0.00	0.00	0.00
GH.008	average	0.00	1.95	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.88	0.64	0.00	0.00	0.00	0.00	0.00	0.48	23.35	0.00	0.31	72.79	0.11	0.00	0.00	0.07	0.00

REF NUM	***SAMPLE***	***Sb***	***Sn***	***Cd***	***Pd***	***Ag***	***Ru***	***Mo***	***Nb***	***Zr***	***Bi***	***Pb***	***Pb (scaled down)***	***Hg***	***Se***	***As***	***Au***	***W***	***Zn***	***Cu***	***Ni***	***Co***	***Fe***	***Mn***	***Cr***	***V***	***Ti***	***Al***
GH.009	lin-a52255	0.09	6.55	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	8.84	6.41	0.00	0.00	6.45	0.00	0.00	2.27	68.43	0.02	0.00	0.81	0.00	0.00	0.00	0.00	0.00
GH.009	lin-a52255	0.09	6.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	10.25	7.42	0.00	0.00	6.95	0.00	0.00	1.84	63.48	0.02	0.00	0.90	0.00	0.00	0.00	0.00	2.18
GH.009	lin-a52255	0.10	6.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.03	6.54	0.00	0.00	8.06	0.00	0.00	1.59	62.70	0.00	0.00	0.89	0.00	0.00	0.00	0.00	2.28
GH.009	average	0.09	6.39	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	9.37	6.79	0.00	0.00	7.16	0.00	0.00	1.90	64.87	0.02	0.00	0.86	0.00	0.00	0.00	0.00	1.95
GH.009	lin-a52255	0.10	6.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.55	7.64	0.00	0.00	8.60	0.00	0.00	1.43	60.41	0.02	0.00	0.92	0.00	0.00	0.00	0.00	1.83
GH.009	lin-a52255	0.09	6.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.77	7.08	0.00	0.00	9.79	0.00	0.00	1.81	58.37	0.02	0.00	1.16	0.00	0.00	0.00	0.06	2.18
GH.009	lin-a52255	0.09	6.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	12.74	9.23	0.00	0.00	12.13	0.00	0.00	1.70	55.40	0.02	0.00	1.05	0.00	0.00	0.00	0.00	0.00
GH.009	average	0.09	6.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.02	7.98	0.00	0.00	10.17	0.00	0.00	1.65	58.06	0.02	0.00	1.04	0.00	0.00	0.00	0.00	1.87
GH.009	lin-a52255	0.08	6.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	7.79	5.64	0.00	0.00	8.88	0.00	0.00	2.42	57.05	0.03	0.00	1.10	0.00	0.00	0.00	0.16	4.63
GH.009	lin-a52255	0.09	6.37	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.04	10.02	7.26	0.00	0.00	11.49	0.00	0.00	1.78	55.60	0.00	0.00	1.04	0.00	0.00	0.00	0.08	3.56
GH.009	lin-a52255	0.09	5.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.02	7.26	0.00	0.00	8.59	0.00	0.00	1.29	56.07	0.02	0.00	1.27	0.00	0.00	0.00	0.00	4.00
GH.009	average	0.09	6.07	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.03	9.27	6.72	0.00	0.00	9.65	0.00	0.00	1.83	56.24	0.02	0.00	1.14	0.00	0.00	0.00	0.10	4.06
HT.001	lin-4a611a side a	0.00	40.47	0.00	0.00	0.61	0.00	0.00	0.00	0.01	0.03	8.41	6.09	0.00	0.00	0.00	0.00	0.00	0.33	43.01	0.07	0.00	6.22	0.17	0.00	0.00	0.67	0.00
HT.001	lin-4a611a side a	0.00	43.98	0.00	0.00	0.71	0.00	0.00	0.00	0.01	0.04	8.73	6.33	0.00	0.00	0.00	0.00	0.00	0.31	38.28	0.05	0.00	6.83	0.18	0.00	0.00	0.84	0.00
HT.001	lin-4a611a side a	0.00	51.73	0.00	0.00	0.75	0.00	0.00	0.00	0.01	0.03	9.46	6.86	0.00	0.00	0.00	0.00	0.00	0.24	31.71	0.05	0.00	5.22	0.18	0.00	0.00	0.60	0.00
HT.001	average	0.00	45.39	0.00	0.00	0.69	0.00	0.00	0.00	0.01	0.03	8.87	6.42	0.00	0.00	0.00	0.00	0.00	0.29	37.66	0.06	0.00	6.09	0.18	0.00	0.00	0.70	0.00
HT.001	lin-4a611a side b	0.00	41.05	0.00	0.00	0.64	0.00	0.00	0.00	0.01	0.03	7.65	5.54	0.00	0.00	0.00	0.00	0.00	0.35	42.65	0.09	0.00	5.74	0.15	0.00	0.00	0.70	0.00
HT.001	lin-4a611a side b	0.00	47.95	0.00	0.00	0.76	0.00	0.00	0.00	0.01	0.00	9.37	6.78	0.00	0.00	0.00	0.00	0.00	0.29	35.23	0.05	0.00	5.40	0.19	0.00	0.00	0.73	0.00
HT.001	lin-4a611a side b	0.00	58.34	0.00	0.00	0.85	0.00	0.00	0.00	0.01	0.00	10.79	7.82	0.00	0.00	0.00	0.00	0.00	0.21	22.53	0.00	0.00	6.63	0.19	0.00	0.00	0.44	0.00
HT.001	average	0.00	49.11	0.00	0.00	0.75	0.00	0.00	0.00	0.01	0.00	9.27	6.71	0.00	0.00	0.00	0.00	0.00	0.28	33.47	0.00	0.00	5.92	0.18	0.00	0.00	0.62	0.00
HT.002	LIN-843884	0.24	37.70	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.01	2.96	2.15	0.00	0.00	1.64	0.07	0.00	0.33	41.67	0.00	0.00	10.08	0.00	0.00	0.00	0.21	0.00
HT.002	LIN-843884	0.24	37.62	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.02	3.10	2.25	0.00	0.00	1.12	0.08	0.00	0.33	41.82	0.00	0.00	8.92	0.00	0.00	0.00	0.18	0.00
HT.002	LIN-843884	0.24	39.83	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	3.14	2.28	0.00	0.00	1.12	0.07	0.00	0.32	40.15	0.00	0.00	9.17	0.00	0.00	0.00	0.23	0.00
HT.002	LIN-843884 AVERAGE	0.24	38.39	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	3.07	2.22	0.00	0.00	1.29	0.07	0.00	0.33	41.21	0.00	0.00	9.39	0.00	0.00	0.00	0.20	0.00
HT.002	LIN-843884	0.09	14.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	1.01	0.00	0.00	0.00	0.00	0.00	0.32	67.80	0.00	0.00	6.44	0.04	0.00	0.00	0.00	2.16
HT.002	LIN-843884	0.21	33.25	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	2.91	2.11	0.00	0.00	0.00	0.04	0.00	0.36	48.63	0.00	0.00	7.81	0.00	0.00	0.00	0.00	1.38

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
HT.002	LIN-843884	0.21	33.44	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	2.90	2.10	0.00	0.00	0.00	0.03	0.00	0.35	48.68	0.00	0.00	7.76	0.00	0.00	0.00	0.00	0.00
HT.002	LIN-843884 AVERAGE	0.17	27.22	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	2.40	1.74	0.00	0.00	0.00	0.02	0.00	0.34	55.04	0.00	0.00	7.34	0.00	0.00	0.00	0.00	1.59
HT.003	lin-6d1a64	0.27	21.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.46	3.23	0.05	0.00	6.00	0.00	0.00	0.38	59.67	0.00	0.00	0.59	0.00	0.00	0.00	0.41	0.00
HT.003	lin-6d1a64	0.27	20.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63	3.35	0.05	0.00	5.03	0.00	0.00	0.38	59.58	0.00	0.00	0.64	0.00	0.00	0.00	0.34	0.00
HT.003	lin-6d1a64	0.30	24.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.94	3.58	0.00	0.00	3.99	0.00	0.00	0.36	54.82	0.00	0.00	0.98	0.00	0.00	0.00	0.35	0.00
HT.003	average	0.28	22.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.67	3.39	0.00	0.00	5.01	0.00	0.00	0.37	58.02	0.00	0.00	0.74	0.00	0.00	0.00	0.37	0.00
HT.003	lin-6d1a64	0.24	19.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.11	2.98	0.07	0.00	5.20	0.00	0.00	0.38	62.81	0.00	0.00	0.63	0.00	0.00	0.00	0.34	0.00
HT.003	lin-6d1a64	0.23	18.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.92	2.84	0.05	0.00	4.98	0.00	0.00	0.37	61.82	0.00	0.00	0.75	0.00	0.00	0.00	0.39	0.00
HT.003	lin-6d1a64	0.23	18.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	3.91	2.83	0.00	0.00	4.35	0.00	0.00	0.36	61.69	0.00	0.00	0.92	0.00	0.00	0.00	0.36	0.00
HT.003	average	0.24	18.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.98	2.88	0.05	0.00	4.84	0.00	0.00	0.37	62.10	0.00	0.00	0.77	0.00	0.00	0.00	0.36	0.00
HT.004	lin-6d31b6	0.29	16.99	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.08	15.82	11.46	0.00	0.01	11.14	0.00	0.00	0.68	44.33	0.08	0.00	1.77	0.00	0.00	0.00	0.33	0.00
HT.004	lin-6d31b6	0.31	17.39	0.00	0.00	0.62	0.00	0.00	0.00	0.01	0.07	15.72	11.39	0.00	0.00	9.29	0.00	0.00	0.68	45.59	0.09	0.00	1.92	0.00	0.00	0.00	0.32	2.41
HT.004	lin-6d31b6	0.30	17.61	0.00	0.00	0.62	0.00	0.00	0.00	0.01	0.06	16.49	11.94	0.00	0.00	7.06	0.00	0.00	0.67	44.22	0.08	0.00	1.92	0.00	0.00	0.00	0.33	3.32
HT.004	average	0.30	17.33	0.00	0.00	0.61	0.00	0.00	0.00	0.01	0.07	16.01	11.60	0.00	0.00	9.16	0.00	0.00	0.67	44.71	0.08	0.00	1.87	0.00	0.00	0.00	0.33	2.41
HT.004	lin-6d31b6	0.28	15.48	0.00	0.00	0.57	0.00	0.00	0.00	0.01	0.08	16.25	11.77	0.00	0.00	10.47	0.00	0.00	0.69	48.16	0.06	0.00	1.34	0.00	0.00	0.00	0.29	0.00
HT.004	lin-6d31b6	0.26	15.07	0.00	0.00	0.56	0.00	0.00	0.00	0.01	0.07	15.71	11.38	0.00	0.00	8.51	0.00	0.00	0.65	46.05	0.06	0.00	1.56	0.00	0.00	0.00	0.30	3.15
HT.004	lin-6d31b6	0.28	16.75	0.00	0.00	0.61	0.00	0.00	0.00	0.01	0.04	16.03	11.61	0.00	0.00	4.30	0.00	0.00	0.65	44.38	0.08	0.00	1.86	0.00	0.00	0.00	0.24	3.77
HT.004	average	0.27	15.77	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.07	16.00	11.59	0.00	0.00	7.76	0.00	0.00	0.66	46.19	0.07	0.00	1.59	0.00	0.00	0.00	0.28	2.89
HT.005	lin 96ae27 side a	0.26	2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	4.67	3.39	0.00	0.00	4.32	0.00	0.00	7.84	79.88	0.00	0.00	0.28	0.00	0.00	0.00	0.08	0.00
HT.005	lin 96ae27 side a	0.27	2.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	5.31	3.85	0.00	0.00	6.39	0.00	0.00	7.84	77.18	0.00	0.00	0.28	0.00	0.00	0.00	0.09	0.00
HT.005	lin 96ae27 side a	0.28	2.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	6.02	4.36	0.00	0.00	7.38	0.00	0.00	6.90	76.35	0.00	0.00	0.28	0.00	0.00	0.00	0.08	0.00
HT.005	average	0.27	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	5.33	3.86	0.00	0.00	6.03	0.00	0.00	7.53	77.80	0.00	0.00	0.28	0.00	0.00	0.00	0.08	0.00
HT.005	lin 96ae27 side b	0.26	2.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	5.60	4.05	0.00	0.00	6.36	0.00	0.00	7.59	76.68	0.00	0.00	0.59	0.00	0.00	0.00	0.09	0.00
HT.005	lin 96ae27 side b	0.55	4.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82		0.00		0.00	5.37	0.00	5.69			0.44	0.00	1.99	0.15	0.20	0.29	0.74	0.00
HT.005	lin 96ae27 side b	0.26	2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	5.41	3.92	0.00	0.00	4.47	0.00	0.00	7.39	79.40	0.00	0.00	0.32	0.00	0.00	0.00	0.09	0.00
HT.005	average	0.36	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	3.67	2.66	0.00	0.00	5.40	0.00	1.90	4.99	52.03	0.15	0.00	0.97	0.05	0.07	0.10	0.31	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
HT.005	lin-96ae27	0.23	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	5.13	3.72	0.00	0.00	6.69	0.00	0.00	6.88	69.53	0.00	0.00	0.50	0.00	0.00	0.00	0.08	1.66
HT.005	lin-96ae27	0.23	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	5.11	3.70	0.00	0.00	6.32	0.00	0.00	6.91	69.67	0.00	0.00	0.50	0.00	0.00	0.00	0.08	2.01
HT.005	lin-96ae27	0.23	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	5.18	3.75	0.00	0.00	5.69	0.00	0.00	6.94	70.36	0.00	0.00	0.50	0.00	0.00	0.00	0.06	1.69
HT.005	average	0.23	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	5.14	3.72	0.00	0.00	6.23	0.00	0.00	6.91	69.85	0.00	0.00	0.50	0.00	0.00	0.00	0.07	1.79
HT.005	lin-96ae27	0.22	2.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	4.09	2.97	0.00	0.00	4.43	0.00	0.00	7.32	73.03	0.02	0.00	0.21	0.00	0.00	0.00	0.07	1.60
HT.005	lin-96ae27	0.21	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	4.09	2.96	0.00	0.00	4.38	0.00	0.00	7.26	72.47	0.00	0.00	0.23	0.00	0.00	0.00	0.08	2.06
HT.005	lin-96ae27	0.22	2.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	4.05	2.93	0.00	0.00	4.74	0.00	0.00	7.22	72.38	0.02	0.00	0.21	0.00	0.00	0.00	0.09	2.13
HT.005	average	0.22	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	4.08	2.95	0.00	0.00	4.52	0.00	0.00	7.26	72.63	0.02	0.00	0.22	0.00	0.00	0.00	0.08	1.93
HT.006	rf13067	0.08	2.04	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.08	16.81	12.18	0.00	0.00	16.83	0.00	0.00	10.73	52.71	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
HT.006	rf13067	0.08	1.97	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.11	18.66	13.52	0.00	0.00	20.19	0.00	0.00	9.85	48.44	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00
HT.006	rf13067	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.07	12.10	8.77	0.00	0.00	18.19	0.00	0.00	11.46	56.84	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00
HT.006	average	0.06	1.66	0.00	0.00	0.19	0.00	0.00	0.01	0.00	0.09	15.86	11.49	0.00	0.00	18.40	0.00	0.00	10.68	52.67	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00
HT.007	lin-9c1045 side a	0.24	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24	3.14	2.27	0.00	0.00	18.58	0.00	0.00	0.00	76.44	0.00	0.00	1.09	0.04	0.00	0.05	0.16	0.00
HT.007	lin-9c1045 side a	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	2.85	2.06	0.00	0.00	17.13	0.00	0.00	0.00	78.63	0.00	0.00	0.72	0.03	0.00	0.03	0.11	0.00
HT.007	lin-9c1045 side a	0.23	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.21	2.65	1.92	0.00	0.00	15.88	0.03	0.00	0.00	80.05	0.00	0.00	0.70	0.03	0.00	0.04	0.15	0.00
HT.007	average	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	2.88	2.09	0.00	0.00	17.20	0.00	0.00	0.00	78.37	0.00	0.00	0.84	0.03	0.00	0.04	0.14	0.00
HT.007	lin-9c1045 side b	0.22	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24	3.24	2.35	0.00	0.00	17.83	0.04	0.00	0.00	77.72	0.00	0.00	0.51	0.02	0.00	0.04	0.12	0.00
HT.007	lin-9c1045 side b	0.24	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	3.19	2.31	0.00	0.00	19.16	0.00	0.00	0.00	76.39	0.00	0.00	0.56	0.02	0.00	0.04	0.10	0.00
HT.007	lin-9c1045 side b	0.24	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	3.61	2.61	0.00	0.00	20.32	0.00	0.00	0.00	74.26	0.00	0.00	0.89	0.03	0.00	0.08	0.18	0.00
HT.007	average	0.24	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	3.34	2.42	0.00	0.00	19.10	0.02	0.00	0.00	76.12	0.00	0.00	0.65	0.02	0.00	0.05	0.13	0.00
HT.008	rf 12752	0.09	8.13	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	4.95	3.59	0.00	0.00	2.41	0.00	0.00	4.41	79.20	0.04	0.00	0.31	0.00	0.00	0.00	0.18	0.00
HT.008	rf 12752	0.11	9.89	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.06	8.09	5.86	0.00	0.00	10.90	0.00	0.00	3.86	65.39	0.05	0.00	1.09	0.00	0.00	0.00	0.20	0.00
HT.008	rf 12752	0.11	9.91	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.05	8.09	5.86	0.00	0.00	10.38	0.00	0.00	3.89	65.85	0.05	0.00	1.10	0.00	0.00	0.00	0.20	0.00
HT.008	average	0.10	9.31	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.04	7.04	5.10	0.00	0.00	7.90	0.00	0.00	4.05	70.14	0.05	0.00	0.83	0.00	0.00	0.00	0.19	0.00
HT.009	rf 10786	0.07	21.21	0.00	0.00	2.68	0.00	0.00	0.00	0.00	0.04	5.36	3.88	0.00	0.00	7.82	0.47	0.00	0.78	59.51	0.11	0.00	1.54	0.00	0.00	0.00	0.34	0.00
HT.009	rf 10786	0.07	24.22	0.00	0.00	3.80	0.00	0.00	0.00	0.00	0.05	6.01	4.35	0.00	0.00	6.22	0.57	0.00	0.91	55.34	0.12	0.00	2.39	0.00	0.00	0.00	0.31	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
HT.009	rf 10786	0.07	23.24	0.00	0.00	2.79	0.00	0.00	0.00	0.00	0.04	5.83	4.22	0.00	0.00	7.50	0.48	0.00	0.80	56.83	0.11	0.00	1.79	0.00	0.00	0.00	0.48	0.00
HT.009	average	0.07	22.89	0.00	0.00	3.09	0.00	0.00	0.00	0.00	0.04	5.73	4.15	0.00	0.00	7.18	0.50	0.00	0.83	57.23	0.11	0.00	1.90	0.00	0.00	0.00	0.38	0.00
I.001	lin-72deba	0.27	27.77	0.00	0.00	1.93	0.00	0.00	0.00	0.02	0.17	26.81	19.42	0.00	0.04	3.48	0.00	0.91	1.19	29.04	0.00	0.00	8.25	0.00	0.00	0.00	0.00	0.00
I.001	lin-72deba	0.27	27.33	0.00	0.00	1.92	0.00	0.00	0.00	0.02	0.20	26.58	19.25	0.00	0.04	5.24	0.00	0.90	1.17	28.07	0.00	0.00	8.03	0.00	0.00	0.00	0.18	0.00
I.001	lin-72deba	0.27	27.75	0.00	0.00	1.91	0.00	0.00	0.00	0.02	0.19	26.79	19.41	0.00	0.04	3.55	0.00	0.91	1.19	28.88	0.00	0.00	8.26	0.00	0.00	0.00	0.20	0.00
I.001	average	0.27	27.61	0.00	0.00	1.92	0.00	0.00	0.00	0.02	0.19	26.72	19.36	0.00	0.04	4.09	0.00	0.91	1.19	28.66	0.00	0.00	8.18	0.00	0.00	0.00	0.00	0.00
M.001	sfn007	0.34	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.11	25.50	18.48	0.00	0.00	0.00	0.00	0.00	7.27	62.83	0.03	0.00	3.11	0.04	0.00	0.00	0.25	0.00
M.001	sfn007	0.34	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	25.47	18.46	0.00	0.00	0.00	0.00	0.00	7.32	62.75	0.03	0.00	3.12	0.03	0.00	0.00	0.31	0.00
M.001	sfn007	0.43	0.71	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.13	32.83	23.79	0.00	0.00	0.00	0.00	0.00	6.03	55.46	0.05	0.00	3.81	0.03	0.00	0.00	0.26	0.00
M.001	average	0.37	0.58	0.00	0.00	0.08	0.00	0.00	0.00	0.02	0.11	27.94	20.24	0.00	0.00	0.00	0.00	0.00	6.87	60.35	0.04	0.00	3.35	0.03	0.00	0.00	0.27	0.00
M.002	lin-d1abcb side b	0.05	27.64	0.00	0.00	0.52	0.00	0.00	0.00	0.02	0.06	7.58	5.49	0.00	0.00	6.82	0.00	0.00	5.35	47.39	0.00	0.00	4.38	0.10	0.00	0.00	0.00	0.00
M.002	lin-d1abcb side b	0.06	23.41	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.06	7.07	5.12	0.00	0.00	8.46	0.00	0.00	5.95	50.73	0.05	0.00	3.49	0.07	0.00	0.00	0.20	0.00
M.002	lin-d1abcb side b	0.00	30.26	0.00	0.00	0.57	0.00	0.00	0.01	0.02	0.08	8.79	6.36	0.00	0.00	8.50	0.00	0.00	5.32	42.64	0.00	0.00	3.73	0.07	0.00	0.00	0.00	0.00
M.002	average	0.07	29.26	0.00	0.00	0.52	0.00	0.00	0.00	0.03	0.05	6.89	4.99	0.00	0.00	3.51	0.00	0.00	4.77	48.80	0.00	0.00	5.91	0.16	0.00	0.00	0.00	0.00
M.002	lin-d1abcb side a	0.04	19.03	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.04	4.91	3.55	0.00	0.00	5.98	0.00	0.00	5.54	62.02	0.06	0.00	1.81	0.00	0.00	0.00	0.18	0.00
M.002	lin-d1abcb side a	0.04	19.78	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.04	5.44	3.94	0.00	0.00	4.63	0.00	0.00	5.91	60.99	0.07	0.00	2.58	0.03	0.00	0.00	0.11	0.00
M.002	lin-d1abcb side a	0.05	17.44	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.04	4.77	3.46	0.00	0.00	8.92	0.00	0.00	4.43	62.68	0.03	0.00	1.08	0.00	0.00	0.00	0.28	0.00
M.002	average	0.04	19.88	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.04	4.50	3.26	0.00	0.00	4.39	0.00	0.00	6.28	62.39	0.08	0.00	1.78	0.00	0.00	0.00	0.16	0.00
M.003	lin-9bcf25 pattern side	0.27	9.68	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	48.97	35.48	0.00	0.00	0.00	0.00	0.00	0.21	17.01	0.00	0.00	23.73	0.00	0.00	0.00	0.00	0.00
M.003	lin-9bcf25 pattern side	0.26	9.68	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.09	48.99	35.49	0.00	0.00	0.00	0.00	0.00	0.18	17.12	0.00	0.00	23.61	0.00	0.00	0.00	0.00	0.00
M.003	lin-9bcf25 pattern side	0.27	9.65	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.08	48.98	35.49	0.00	0.00	0.00	0.00	0.00	0.20	16.97	0.00	0.00	23.77	0.00	0.00	0.00	0.00	0.00
M.003	average	0.27	9.67	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.08	48.98	35.49	0.00	0.00	0.00	0.00	0.00	0.20	17.03	0.00	0.00	23.70	0.00	0.00	0.00	0.00	0.00
M.003	lin-9bcf25 reverse	0.38	12.29	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.21	32.28	23.39	0.00	0.02	9.24	0.00	0.41	0.28	22.38	0.00	0.00	22.28	0.00	0.00	0.00	0.13	0.00
M.003	lin-9bcf25 reverse	0.38	12.43	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.22	32.62	23.63	0.00	0.00	7.51	0.00	0.40	0.29	23.14	0.00	0.00	22.85	0.00	0.00	0.00	0.00	0.00
M.003	lin-9bcf25 reverse	0.38	12.36	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.22	32.45	23.51	0.00	0.02	8.41	0.00	0.40	0.30	22.72	0.00	0.00	22.60	0.00	0.00	0.00	0.00	0.00
M.003	average	0.38	12.36	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.22	32.45	23.51	0.00	0.01	8.39	0.00	0.40	0.29	22.75	0.00	0.00	22.58	0.00	0.00	0.00	0.00	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
M.004	sfxx 230	0.39	3.81	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.28	16.44	11.91	0.00	0.00	0.00	0.00	0.00	5.83	70.74	0.00	0.00	2.36	0.00	0.00	0.00	0.13	0.00
M.004	sfxx 230	0.41	4.09	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.31	16.01	11.60	0.00	0.00	2.37	0.00	0.00	5.58	68.26	0.00	0.00	2.75	0.00	0.00	0.00	0.18	0.00
M.004	sfxx 230	0.46	4.72	0.00	0.00	0.28	0.00	0.00	0.00	0.03	0.33	18.85	13.66	0.00	0.00	0.00	0.00	0.00	5.78	65.72	0.00	0.00	3.64	0.00	0.00	0.00	0.19	0.00
M.004	sfxx 230	0.36	3.42	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.35	16.99	12.31	0.00	0.00	7.94	0.00	0.00	5.78	62.78	0.00	0.00	2.16	0.00	0.00	0.00	0.20	0.00
M.004	sfxx 230	0.39	3.63	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.47	17.85	12.93	0.00	0.00	15.00	0.00	0.00	5.19	55.18	0.00	0.00	2.15	0.00	0.00	0.00	0.14	0.00
M.004	sfxx 230	0.36	3.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	18.33	13.28	0.00	0.00	10.71	0.00	0.00	5.50	59.65	0.00	0.00	1.72	0.00	0.00	0.00	0.14	0.00
M.004	average	0.39	3.82	0.00	0.00	0.05	0.00	0.00	0.00	0.02	0.34	17.41	12.61	0.00	0.00	6.00	0.00	0.00	5.61	63.72	0.00	0.00	2.46	0.00	0.00	0.00	0.16	0.00
M.005	sfxx 165	0.50	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.19	6.30	4.56	0.00	0.00	17.69	0.00	0.00	2.40	69.87	0.00	0.00	1.72	0.03	0.00	0.00	0.34	0.00
M.005	sfxx 165	0.47	0.85	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	5.56	4.03	0.00	0.00	17.82	0.00	0.00	2.04	71.31	0.00	0.00	1.54	0.03	0.00	0.00	0.20	0.00
M.005	sfxx 165	0.44	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	5.44	3.94	0.00	0.00	16.27	0.00	0.00	1.88	73.75	0.00	0.00	1.11	0.02	0.00	0.00	0.17	0.00
M.005	sfxx 165	0.58	1.11	0.00	0.00	0.24	0.00	0.00	0.00	0.10	0.17	10.76	7.80	0.00	0.00	10.64	0.00	0.00	3.43	68.38	0.03	0.00	4.03	0.09	0.00	0.00	0.45	0.00
M.005	sfxx 165	0.46	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	6.28	4.55	0.00	0.00	16.67	0.00	0.00	2.13	72.06	0.00	0.00	1.22	0.03	0.00	0.00	0.18	0.00
M.005	sfxx 165	0.47	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.16	5.40	3.91	0.00	0.00	12.74	0.00	0.00	2.22	75.94	0.00	0.00	1.83	0.05	0.00	0.00	0.28	0.00
M.005	average	0.49	0.89	0.00	0.00	0.04	0.00	0.00	0.00	0.03	0.16	6.62	4.80	0.00	0.00	15.31	0.00	0.00	2.35	71.89	0.00	0.00	1.91	0.04	0.00	0.00	0.27	0.00
M.006	elxx 7	0.33	0.85	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.43	30.8 o	22.31	0.00	0.03	31.67	0.00	0.00	2.30	32.17	0.02	0.00	1.13	0.00	0.00	0.04	0.20	0.00
M.006	elxx 7	0.28	0.69	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.37	27.48	19.91	0.00	0.03	33.30	0.00	0.00	2.56	33.85	0.02	0.00	1.16	0.00	0.00	0.05	0.19	0.00
M.006	elxx 7	0.35	0.93	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.44	32.66	23.66	0.00	0.03	32.06	0.00	0.00	2.16	29.71	0.01	0.00	1.35	0.00	0.00	0.05	0.21	0.00
M.006	average	0.32	0.82	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.41	30.31	21.96	0.00	0.03	32.34	0.00	0.00	2.34	31.91	0.02	0.00	1.21	0.00	0.00	0.05	0.20	0.00
M.006	elxx 7	0.29	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.37	32.19	23.32	0.00	0.02	29.88	0.00	0.00	2.68	31.04	0.02	0.00	2.48	0.02	0.00	0.05	0.24	0.00
M.006	elxx 7	0.30	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.35	31.77	23.02	0.00	0.02	26.31	0.00	0.00	2.90	35.44	0.00	0.00	1.92	0.00	0.00	0.00	0.23	0.00
M.006	elxx 7	0.28	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.30	35.96	26.05	0.00	0.00	19.40	0.00	0.00	3.00	36.96	0.00	0.00	3.05	0.00	0.00	0.07	0.22	0.00
M.006	average	0.29	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.34	33.31	24.13	0.00	0.02	25.20	0.00	0.00	2.86	34.48	0.00	0.00	2.48	0.00	0.00	0.05	0.23	0.00
M.007	akxx1	0.38	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.14	11.13	8.06	0.00	0.00	20.55	0.00	0.00	3.57	63.46	0.02	0.00	0.60	0.00	0.00	0.00	0.07	0.00
M.007	akxx1	0.34	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	12.22	8.85	0.00	0.00	22.53	0.00	0.00	3.89	59.97	0.00	0.00	0.74	0.00	0.00	0.00	0.10	0.00
M.007	akxx1	0.36	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	11.21	8.12	0.00	0.00	21.55	0.00	0.00	3.81	62.15	0.00	0.00	0.62	0.00	0.00	0.00	0.08	0.00
M.007	average	0.36	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	11.52	8.35	0.00	0.00	21.55	0.00	0.00	3.76	61.86	0.00	0.00	0.65	0.00	0.00	0.00	0.08	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
M.007	akxx1	0.31	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	13.07	9.47	0.00	0.00	20.90	0.00	0.00	3.95	59.33	0.00	0.00	1.97	0.02	0.00	0.00	0.25	0.00
M.007	akxx1	0.32	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	13.10	9.49	0.00	0.00	22.98	0.00	0.00	3.87	58.36	0.00	0.00	1.03	0.00	0.00	0.00	0.12	0.00
M.007	akxx1	0.31	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	13.62	9.87	0.00	0.00	20.95	0.00	0.00	3.89	58.70	0.00	0.00	2.06	0.03	0.00	0.00	0.24	0.00
M.007	average	0.31	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.13	13.27	9.61	0.00	0.00	21.61	0.00	0.00	3.90	58.80	0.00	0.00	1.68	0.00	0.00	0.00	0.21	0.00
M.008	1baa 1	0.30	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	12.07	8.75	0.00	0.00	19.23	0.00	0.00	2.40	65.05	0.00	0.00	0.67	0.00	0.00	0.00	0.07	0.00
M.008	1baa 1	0.29	0.02	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.17	10.69	7.74	0.00	0.00	23.10	0.00	0.00	2.56	60.63	0.00	0.00	1.38	0.00	0.00	0.00	0.07	0.00
M.008	1baa 1	0.26	0.00	0.00	0.00	10.25	0.00	0.00	0.00	0.00	0.16	12.61	9.13	0.00	0.00	22.36	0.00	0.00	3.04	48.26	0.00	0.00	2.81	0.02	0.00	0.00	0.19	0.00
M.008	average	0.28	0.02	0.00	0.00	3.78	0.00	0.00	0.00	0.00	0.16	11.79	8.54	0.00	0.00	21.56	0.00	0.00	2.66	57.98	0.00	0.00	1.62	0.00	0.00	0.00	0.11	0.00
M.008	1baa 1	0.30	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.25	20.98	15.20	0.00	0.00	30.47	0.00	0.00	2.20	43.71	0.00	0.00	1.77	0.00	0.00	0.00	0.23	0.00
M.008	1baa 1	0.31	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	16.15	11.70	0.00	0.00	24.82	0.00	0.00	2.56	54.42	0.00	0.00	1.40	0.00	0.00	0.00	0.07	0.00
M.008	1baa 1	0.33	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.16	24.41	17.69	0.00	0.00	14.66	0.00	0.00	3.38	53.27	0.00	0.00	3.59	0.03	0.00	0.00	0.13	0.00
M.008	average	0.31	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	20.51	14.86	0.00	0.00	23.32	0.00	0.00	2.72	50.47	0.00	0.00	2.25	0.02	0.00	0.00	0.14	0.00
M.009	sfwe 77	0.67	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	5.31	3.85	0.00	0.00	6.06	0.00	0.00	3.00	84.26	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00
M.009	sfwe 77	0.68	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	7.35	5.33	0.00	0.00	7.12	0.00	0.00	2.65	81.45	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
M.009	sfwe 77	0.67	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	5.17	3.75	0.00	0.00	6.49	0.00	0.00	3.00	84.03	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00
M.009	sfwe 77	0.67	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.23	5.39	3.90	0.00	0.00	6.45	0.00	0.00	2.96	83.98	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
M.009	sfwe 77	0.69	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	4.88	3.54	0.00	0.00	6.42	0.00	0.00	2.75	84.81	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
M.009	sfwe 77	0.69	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	5.14	3.73	0.00	0.00	4.78	0.00	0.00	3.30	85.58	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
M.009	average	0.68	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	5.54	4.02	0.00	0.00	6.22	0.00	0.00	2.95	84.02	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	3.57	2.58	0.00	0.00	0.00	0.00	0.00	14.63	81.08	0.03	0.00	0.48	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	4.53	3.28	0.00	0.00	0.00	0.00	0.00	14.45	80.50	0.02	0.00	0.28	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	3.22	2.33	0.00	0.00	0.00	0.00	0.00	12.26	84.06	0.02	0.00	0.17	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.12	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	5.99	4.34	0.00	0.00	0.00	0.00	0.00	7.99	85.27	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	2.29	1.66	0.00	0.00	0.00	0.00	0.00	7.76	88.49	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	1.86	1.35	0.00	0.00	0.00	0.00	0.00	7.89	89.79	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
M.010	average	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	3.58	2.59	0.00	0.00	0.00	0.00	0.00	10.83	84.87	0.02	0.00	0.31	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
M.010	lin-a64a26	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	5.10	3.70	0.00	0.00	0.00	0.00	0.00	13.69	80.83	0.03	0.00	0.16	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	6.83	4.95	0.00	0.00	0.00	0.00	0.00	11.92	80.68	0.02	0.00	0.33	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	3.46	2.50	0.00	0.00	0.00	0.00	0.00	11.84	84.28	0.02	0.00	0.15	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	5.38	3.90	0.00	0.00	0.00	0.00	0.00	8.43	85.48	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	4.00	2.90	0.00	0.00	0.00	0.00	0.00	8.62	86.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00
M.010	lin-a64a26	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	1.83	1.33	0.00	0.00	0.00	0.00	0.00	7.94	89.79	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
M.010	average	0.13	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	4.43	3.21	0.00	0.00	0.00	0.00	0.00	10.41	84.51	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00
M.011	LIN-8FCB77	0.00	16.27	0.00	0.00	4.39	0.00	0.00	0.00	0.00	0.00	1.96	1.53	10.64	0.00	1.17	8.93	0.00	0.28	36.91	0.00	0.00	18.28	0.00	0.00	0.00	0.00	0.00
M.011	LIN-8FCB77	0.00	3.85	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.98	0.77	3.49	0.00	0.00	2.88	0.00	0.29	32.17	0.00	0.00	54.70	0.00	0.00	0.00	0.00	0.00
M.011	LIN-8FCB77	0.00	17.19	0.00	0.00	5.22	0.00	0.00	0.00	0.00	0.00	1.99	1.55	11.45	0.00	1.35	10.38	0.00	0.26	33.35	0.00	0.00	17.46	0.00	0.00	0.00	0.00	0.00
M.011	LIN-8FCB77	0.00	12.44	0.00	0.00	3.64	0.00	0.00	0.00	0.00	0.00	1.64	1.19	8.53	0.00	0.84	7.40	0.00	0.28	34.14	0.00	0.00	30.15	0.00	0.00	0.00	0.00	0.00
P.001	wtnaf 14	0.06	13.59	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.04	10.06	7.29	0.00	0.00	0.00	0.00	0.00	1.68	71.45	0.05	0.00	2.63	0.06	0.00	0.00	0.14	0.00
P.001	wtnaf 14	0.05	12.47	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.00	13.06	9.46	0.00	0.00	0.00	0.00	0.00	1.62	69.73	0.04	0.00	2.74	0.04	0.00	0.00	0.00	0.00
P.001	wtnaf 14	0.06	14.09	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.04	11.65	8.44	0.00	0.00	0.00	0.00	0.00	1.56	69.75	0.05	0.00	2.41	0.04	0.00	0.00	0.11	0.00
P.001	average	0.06	13.38	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.03	11.59	8.40	0.00	0.00	0.00	0.00	0.00	1.62	70.31	0.05	0.00	2.59	0.05	0.00	0.00	0.00	0.00
P.001	wtnaf 14	0.05	33.26	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.02	8.33	6.03	0.00	0.00	0.00	0.00	0.00	1.35	38.01	0.04	0.00	17.79	0.00	0.00	0.00	0.59	0.00
P.001	wtnaf 14	0.06	27.46	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.04	7.19	5.21	0.00	0.00	0.00	0.06	0.00	1.46	54.67	0.04	0.00	7.12	0.00	0.00	0.00	0.42	0.00
P.001	wtnaf 14	0.06	27.94	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.05	10.16	7.36	0.00	0.00	0.00	0.04	0.00	1.38	49.88	0.05	0.00	8.41	0.05	0.00	0.00	0.36	0.00
P.001	average	0.05	29.55	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.04	8.56	6.20	0.00	0.00	0.00	0.04	0.00	1.40	47.52	0.04	0.00	11.11	0.00	0.00	0.00	0.46	0.00
PN.001	LIN A0BFCE	0.32	39.78	0.00	0.00	2.86	0.00	0.00	0.00	0.02	0.07	29.34	21.26	0.00	0.00	0.00	0.00	0.00	0.13	17.97	0.06	0.00	9.15	0.00	0.00	0.00	0.28	0.00
PN.001	LIN A0BFCE	0.32	41.47	0.04	0.00	3.03	0.00	0.00	0.00	0.02	0.05	29.58	21.43	0.00	0.00	0.00	0.00	0.00	0.11	15.44	0.18	0.00	9.59	0.00	0.00	0.00	0.00	0.00
PN.001	LIN A0BFCE	0.34	41.84	0.02	0.00	3.10	0.00	0.00	0.00	0.02	0.00	29.33	21.25	0.00	0.00	0.00	0.00	0.00	0.13	15.84	0.10	0.00	9.23	0.00	0.00	0.00	0.00	0.00
PN.001	average	0.33	41.03	0.00	0.00	3.00	0.00	0.00	0.00	0.02	0.06	29.42	21.31	0.00	0.00	0.00	0.00	0.00	0.13	16.42	0.11	0.00	9.33	0.00	0.00	0.00	0.00	0.00
PN.002	lin-72ff8b	0.09	46.33	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	10.13	7.34	0.00	0.00	0.00	0.09	0.00	0.43	39.51	0.00	0.00	3.02	0.00	0.00	0.00	0.00	0.00
PN.002	lin-72ff8b	0.07	41.29	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.94	7.93	0.00	0.00	0.00	0.06	0.00	0.48	43.50	0.00	0.00	2.85	0.00	0.00	0.00	0.58	0.00
PN.002	lin-72ff8b	0.05	33.74	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	9.59	6.95	0.00	0.00	0.00	0.00	0.00	0.54	53.37	0.00	0.00	2.05	0.07	0.00	0.00	0.53	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
PN.002	average	0.07	40.45	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.22	7.41	0.00	0.00	0.00	0.05	0.00	0.48	45.46	0.00	0.00	2.64	0.00	0.00	0.00	0.45	0.00
PN.003	LIN AoE3DF	0.00	39.36	0.03	0.00	1.81	0.00	0.00	0.00	0.00	0.04	13.67	9.90	0.00	0.00	0.00	0.00	0.00	0.16	41.52	0.09	0.00	3.22	0.00	0.00	0.00	0.00	0.00
PN.003	LIN AoE3DF	0.00	35.91	0.00	0.00	1.42	0.00	0.00	0.00	0.00	0.00	9.48	6.87	0.00	0.00	0.00	0.07	0.00	0.10	51.36	0.00	0.00	1.38	0.00	0.00	0.00	0.29	0.00
PN.003	LIN AoE3DF	0.00	38.20	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	10.53	7.63	0.00	0.00	0.00	0.05	0.00	0.10	47.41	0.00	0.00	1.96	0.00	0.00	0.00	0.00	0.00
PN.003	average	0.00	37.82	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	11.22	8.13	0.00	0.00	0.00	0.04	0.00	0.12	46.76	0.00	0.00	2.19	0.00	0.00	0.00	0.00	0.00
PN.00 4	LIN 76A918	0.11	27.76	0.00	0.01	0.36	0.00	0.00	0.00	0.02	0.03	19.10	13.84	0.00	0.00	0.00	0.00	0.00	0.34	16.75	0.00	0.00	34.81	0.06	0.00	0.19	0.45	0.00
PN.00 4	LIN 76A918	0.16	33.94	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	19.47	14.10	0.00	0.00	0.00	0.00	0.47	0.61	33.90	0.00	0.00	10.44	0.00	0.00	0.00	0.54	0.00
PN.00 4	LIN 76A918	0.14	24.88	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.00	15.78	11.43	0.00	0.00	0.00	0.00	0.00	0.58	51.34	0.00	0.00	6.54	0.00	0.00	0.00	0.35	0.00
PN.00 4	average	0.14	28.86	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.00	18.12	13.13	0.00	0.00	0.00	0.00	0.16	0.51	34.00	0.00	0.00	17.26	0.00	0.00	0.00	0.45	0.00
PN.005	lin-968c84	0.24	25.57	0.00	0.00	1.45	0.00	0.00	0.00	0.01	0.00	25.37	18.38	0.00	0.00	0.00	0.00	0.00	0.46	21.80	0.05	0.00	6.01	0.00	0.00	0.00	0.20	4.37
PN.005	lin-968c84	0.24	25.13	0.00	0.00	1.32	0.00	0.00	0.00	0.01	0.00	22.50	16.30	0.00	0.00	0.00	0.00	0.00	0.43	22.23	0.07	0.00	6.36	0.00	0.00	0.00	0.00	4.89
PN.005	lin-968c84	0.25	20.36	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	29.63	21.47	0.00	0.02	9.45	0.00	0.00	0.36	17.59	0.00	0.00	5.27	0.00	0.00	0.00	0.29	3.58
PN.005	average	0.24	23.69	0.00	0.00	0.92	0.00	0.00	0.00	0.01	0.06	25.83	18.72	0.00	0.00	3.15	0.00	0.00	0.42	20.54	0.05	0.00	5.88	0.00	0.00	0.00	0.22	4.28
PN.005	lin-968c84 shaft	0.33	31.82	0.00	0.00	1.82	0.00	0.00	0.00	0.01	0.05	22.30	16.16	0.00	0.00	7.04	0.00	0.00	0.40	20.20	0.00	0.00	4.73	0.00	0.00	0.00	0.42	0.00
PN.005	lin-968c84 shaft	0.33	33.01	0.00	0.00	1.88	0.00	0.00	0.00	0.01	0.00	24.32	17.62	0.00	0.00	6.30	0.00	0.00	0.41	19.95	0.00	0.00	5.25	0.00	0.00	0.00	0.00	0.00
PN.005	lin-968c84 shaft	0.32	33.05	0.00	0.00	1.91	0.00	0.00	0.00	0.01	0.05	23.99	17.38	0.00	0.00	5.25	0.00	0.00	0.48	21.28	0.00	0.00	5.82	0.00	0.00	0.00	0.00	0.00
PN.005	average	0.33	32.62	0.00	0.00	1.87	0.00	0.00	0.00	0.01	0.00	23.54	17.05	0.00	0.00	6.20	0.00	0.00	0.43	20.48	0.00	0.00	5.27	0.00	0.00	0.00	0.00	0.00
PN.005	lin 968c84	0.36	34.32	0.03	0.02	1.82	0.00	0.00	0.00	0.03	0.14	28.30	20.50	0.00	0.00	0.00	0.00	0.00	0.47	26.25	0.16	0.00	7.78	0.00	0.00	0.00	0.30	0.00
PN.005	lin 968c84	0.32	29.51	0.00	0.01	1.64	0.00	0.00	0.00	0.03	0.11	31.60	22.89	0.00	0.00	0.00	0.00	0.00	0.52	28.64	0.10	0.00	7.15	0.00	0.00	0.00	0.35	0.00
PN.005	lin 968c84	0.34	34.85	0.04	0.01	2.03	0.00	0.00	0.00	0.03	0.14	32.29	23.40	0.00	0.00	0.00	0.00	0.00	0.47	21.60	0.16	0.00	7.87	0.00	0.00	0.00	0.00	0.00
PN.005	average	0.34	32.89	0.00	0.01	1.83	0.00	0.00	0.00	0.03	0.13	30.73	22.26	0.00	0.00	0.00	0.00	0.00	0.49	25.50	0.14	0.00	7.60	0.00	0.00	0.00	0.27	0.00
PN.005	lin 968c84	0.34	32.84	0.00	0.00	1.99	0.00	0.00	0.00	0.02	0.21	25.34	18.36	0.00	0.00	12.94	0.15	0.00	0.36	19.59	0.00	0.00	5.76	0.00	0.00	0.00	0.00	0.00
PN.005	lin 968c84	0.35	33.38	0.00	0.00	1.98	0.00	0.00	0.00	0.02	0.16	27.56	19.96	0.00	0.00	10.05	0.11	0.00	0.37	19.61	0.00	0.00	5.91	0.00	0.00	0.00	0.37	0.00
PN.005	lin 968c84	0.30	33.01	0.00	0.00	1.99	0.00	0.00	0.00	0.02	0.13	25.00	18.11	0.00	0.00	5.26	0.14	0.00	0.53	25.91	0.00	0.00	7.27	0.00	0.00	0.00	0.41	0.00
PN.005	average	0.33	33.07	0.00	0.00	1.98	0.00	0.00	0.00	0.02	0.17	25.96	18.81	0.00	0.00	9.42	0.13	0.00	0.42	21.70	0.00	0.00	6.32	0.00	0.00	0.00	0.00	0.00
PN.005	lin-968c84	0.24	25.57	0.00	0.00	1.45	0.00	0.00	0.00	0.01	0.00	25.37	18.38	0.00	0.00	0.00	0.00	0.00	0.46	21.80	0.05	0.00	6.01	0.00	0.00	0.00	0.20	4.37

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
PN.005	lin-968c84	0.24	25.13	0.00	0.00	1.32	0.00	0.00	0.00	0.01	0.00	22.50	16.30	0.00	0.00	0.00	0.00	0.00	0.43	22.23	0.07	0.00	6.36	0.00	0.00	0.00	0.00	4.89
PN.005	lin-968c84	0.25	20.36	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	29.63	21.47	0.00	0.02	9.45	0.00	0.00	0.36	17.59	0.00	0.00	5.27	0.00	0.00	0.00	0.29	3.58
PN.005	average	0.24	23.69	0.00	0.00	0.92	0.00	0.00	0.00	0.01	0.06	25.83	18.72	0.00	0.00	3.15	0.00	0.00	0.42	20.54	0.05	0.00	5.88	0.00	0.00	0.00	0.22	4.28
PN.005	lin-968c84 shaft	0.33	31.82	0.00	0.00	1.82	0.00	0.00	0.00	0.01	0.05	22.30	16.16	0.00	0.00	7.04	0.00	0.00	0.40	20.20	0.00	0.00	4.73	0.00	0.00	0.00	0.42	0.00
PN.005	lin-968c84 shaft	0.33	33.01	0.00	0.00	1.88	0.00	0.00	0.00	0.01	0.00	24.32	17.62	0.00	0.00	6.30	0.00	0.00	0.41	19.95	0.00	0.00	5.25	0.00	0.00	0.00	0.00	0.00
PN.005	lin-968c84 shaft	0.32	33.05	0.00	0.00	1.91	0.00	0.00	0.00	0.01	0.05	23.99	17.38	0.00	0.00	5.25	0.00	0.00	0.48	21.28	0.00	0.00	5.82	0.00	0.00	0.00	0.00	0.00
PN.005	average	0.33	32.62	0.00	0.00	1.87	0.00	0.00	0.00	0.01	0.00	23.54	17.05	0.00	0.00	6.20	0.00	0.00	0.43	20.48	0.00	0.00	5.27	0.00	0.00	0.00	0.00	0.00
PN.006	lin-96f393	0.30	20.65	0.00	0.00	1.71	0.00	0.00	0.00	0.01	0.00	20.24	14.67	0.00	0.00	0.00	0.00	0.00	0.31	21.87	0.00	0.00	6.29	0.00	0.00	0.00	0.23	9.91
PN.006	lin-96f393	0.33	21.91	0.00	0.01	1.82	0.00	0.00	0.00	0.01	0.00	20.37	14.76	0.00	0.00	0.00	0.00	0.00	0.31	21.98	0.00	0.00	6.04	0.00	0.00	0.00	0.28	9.30
PN.006	lin-96f393	0.35	24.76	0.00	0.00	1.99	0.00	0.00	0.00	0.01	0.00	25.87	18.75	0.00	0.00	0.00	0.00	0.00	0.17	17.36	0.00	0.00	7.37	0.00	0.00	0.00	0.00	6.07
PN.006	lin-96f393	0.38	25.04	0.03	0.00	1.99	0.00	0.00	0.00	0.01	0.00	18.56	13.45	0.00	0.00	0.00	0.00	0.00	0.28	19.62	0.15	0.00	5.79	0.00	0.00	0.00	0.00	10.10
PN.006	average	0.34	23.09	0.00	0.00	1.88	0.00	0.00	0.00	0.01	0.00	21.26	15.40	0.00	0.00	0.00	0.00	0.00	0.27	20.21	0.04	0.00	6.37	0.00	0.00	0.00	0.20	8.84
PN.007	lin-fia362	0.26	20.40	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.10	36.12	26.17	0.00	0.00	8.42	0.00	0.00	0.10	11.64	0.13	0.00	5.21	0.00	0.00	0.00	0.00	3.77
PN.007	lin-fia362	0.25	20.03	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.10	27.89	20.21	0.00	0.00	7.72	0.00	0.00	0.10	13.77	0.08	0.00	7.16	0.00	0.00	0.00	0.00	5.59
PN.007	lin-fia362	0.27	22.60	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.07	32.74	23.72	0.00	0.00	5.14	0.00	0.00	0.11	13.18	0.11	0.00	6.22	0.00	0.00	0.00	0.00	4.57
PN.007	average	0.26	21.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.09	32.25	23.36	0.00	0.00	7.09	0.00	0.00	0.10	12.86	0.11	0.00	6.20	0.00	0.00	0.00	0.00	4.64
PN.007	lin-fia362	0.26	20.40	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.10	36.12	26.17	0.00	0.00	8.42	0.00	0.00	0.10	11.64	0.13	0.00	5.21	0.00	0.00	0.00	0.00	3.77
PN.007	lin-fia362	0.25	20.03	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.10	27.89	20.21	0.00	0.00	7.72	0.00	0.00	0.10	13.77	0.08	0.00	7.16	0.00	0.00	0.00	0.00	5.59
PN.007	lin-fia362	0.27	22.60	0.03	0.00	0.00	0.00	0.00	0.00	0.01	0.07	32.74	23.72	0.00	0.00	5.14	0.00	0.00	0.11	13.18	0.11	0.00	6.22	0.00	0.00	0.00	0.00	4.57
PN.007	average	0.26	21.01	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.09	32.25	23.36	0.00	0.00	7.09	0.00	0.00	0.10	12.86	0.11	0.00	6.20	0.00	0.00	0.00	0.00	4.64
PN.008	public-a7a4ea	0.49	17.29	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	3.31	2.39	0.00	0.00	1.02	0.00	0.00	0.21	74.73	0.00	0.00	1.83	0.00	0.00	0.00	0.22	0.00
PN.008	public-a7a4ea	0.49	17.35	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	3.36	2.43	0.00	0.00	0.00	0.00	0.00	0.20	75.66	0.00	0.00	1.85	0.00	0.00	0.00	0.26	0.00
PN.008	public-a7a4ea	0.79	27.17	0.00	0.00	0.96	0.00	0.01	0.01	0.16	0.02	3.34	2.42	0.00	0.00	0.00	0.00	0.00	0.38	55.06	0.00	0.00	11.12	0.08	0.00	0.00	0.91	0.00
PN.008	average	0.59	20.61	0.00	0.00	0.87	0.00	0.00	0.00	0.05	0.00	3.34	2.42	0.00	0.00	0.00	0.00	0.00	0.27	68.48	0.00	0.00	4.93	0.00	0.00	0.00	0.46	0.00
PN.009	lin-f18c0c	0.25	21.51	0.00	0.00	1.51	0.00	0.00	0.00	0.01	0.12	24.61	17.83	0.00	0.02	11.77	0.00	0.00	0.40	24.37	0.00	0.00	3.49	0.00	0.00	0.00	0.34	3.48
PN.009	lin-f18c0c	0.32	20.84	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	28.65	20.76	0.00	0.00	6.51	0.00	0.00	0.43	22.99	0.08	0.00	4.85	0.00	0.00	0.00	0.37	2.80

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
PN.009	lin-f18c0c	0.27	14.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	40.39	29.26	0.00	0.03	13.43	0.00	0.00	0.22	13.19	0.03	0.00	4.18	0.00	0.00	0.00	0.21	2.21
PN.009	average	0.28	18.92	0.00	0.00	0.50	0.00	0.00	0.00	0.01	0.10	31.22	22.62	0.00	0.02	10.57	0.00	0.00	0.35	20.18	0.04	0.00	4.18	0.00	0.00	0.00	0.31	2.83
PN.009	lin-f18c0c	0.25	21.51	0.00	0.00	1.51	0.00	0.00	0.00	0.01	0.12	24.61	17.83	0.00	0.02	11.77	0.00	0.00	0.40	24.37	0.00	0.00	3.49	0.00	0.00	0.00	0.34	3.48
PN.009	lin-f18c0c	0.32	20.84	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	28.65	20.76	0.00	0.00	6.51	0.00	0.00	0.43	22.99	0.08	0.00	4.85	0.00	0.00	0.00	0.37	2.80
PN.009	lin-f18c0c	0.27	14.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	40.39	29.26	0.00	0.03	13.43	0.00	0.00	0.22	13.19	0.03	0.00	4.18	0.00	0.00	0.00	0.21	2.21
PN.009	average	0.28	18.92	0.00	0.00	0.50	0.00	0.00	0.00	0.01	0.10	31.22	22.62	0.00	0.02	10.57	0.00	0.00	0.35	20.18	0.04	0.00	4.18	0.00	0.00	0.00	0.31	2.83
PN.010	SF036.004	0.09	15.58	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.03	14.58	10.56	0.00	0.00	0.00	0.00	0.00	4.86	59.48	0.00	0.00	4.82	0.05	0.00	0.00	0.00	0.00
PN.010	SF036.004	0.15	21.62	0.00	0.00	0.72	0.00	0.00	0.00	0.01	0.13	30.79	22.30	0.00	0.00	6.82	0.00	0.00	4.79	29.40	0.04	0.00	5.39	0.00	0.00	0.00	0.00	0.00
PN.010	SF036.004	0.12	16.36	0.00	0.00	0.51	0.00	0.00	0.00	0.02	0.00	23.94	17.34	0.00	0.00	0.00	0.00	0.00	4.15	48.35	0.00	0.00	6.35	0.09	0.00	0.00	0.00	0.00
PN.010	average	0.12	17.85	0.00	0.00	0.57	0.00	0.00	0.00	0.01	0.05	23.10	16.74	0.00	0.00	2.27	0.00	0.00	4.60	45.74	0.00	0.00	5.52	0.05	0.00	0.00	0.00	0.00
PN.011	lin-72c904 head	0.15	9.92	0.03	0.00	5.98	0.00	0.00	0.00	0.00	0.12	5.39	3.90	8.78	0.00	4.44	32.69	0.00	0.20	29.19	0.09	0.00	2.56	0.07	0.00	0.12	0.28	0.00
PN.011	lin-72c904 head	0.12	7.70	0.02	0.00	4.69	0.00	0.00	0.00	0.00	0.13	7.36	5.33	6.36	0.00	6.80	26.56	0.00	0.22	36.56	0.06	0.00	2.72	0.11	0.00	0.17	0.41	0.00
PN.011	lin-72c904 head	0.12	7.74	0.02	0.00	4.68	0.00	0.00	0.00	0.00	0.14	7.38	5.35	6.54	0.00	6.11	26.65	0.00	0.22	36.80	0.07	0.00	2.77	0.11	0.00	0.18	0.46	0.00
PN.011	average	0.13	8.45	0.02	0.00	5.11	0.00	0.00	0.00	0.00	0.13	6.71	4.86	7.23	0.00	5.78	28.63	0.00	0.21	34.18	0.07	0.00	2.68	0.10	0.00	0.15	0.39	0.00
PN.011	lin-72c904 shaft	0.14	16.15	0.00	0.00	7.07	0.00	0.00	0.00	0.02	0.05	11.23	8.14	0.00	0.02	0.00	0.43	0.00	0.19	60.28	0.00	0.00	3.81	0.07	0.00	0.00	0.38	0.00
PN.011	lin-72c904 shaft	0.15	16.17	0.00	0.00	7.09	0.00	0.00	0.00	0.02	0.05	11.24	8.14	0.00	0.02	0.00	0.44	0.00	0.18	60.31	0.00	0.00	3.84	0.06	0.00	0.10	0.34	0.00
PN.011	lin-72c904 shaft	0.14	16.07	0.00	0.00	7.08	0.00	0.00	0.00	0.02	0.05	11.26	8.15	0.00	0.02	0.00	0.44	0.00	0.19	60.26	0.00	0.00	3.85	0.09	0.00	0.00	0.41	0.00
PN.011	average	0.14	16.13	0.00	0.00	7.08	0.00	0.00	0.00	0.02	0.05	11.24	8.14	0.00	0.02	0.00	0.44	0.00	0.19	60.28	0.00	0.00	3.83	0.07	0.00	0.08	0.38	0.00
PN.012	lin-3022c6	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	9.27	6.71	0.00	0.00	11.09	0.00	0.00	4.35	71.59	0.00	0.00	3.36	0.05	0.00	0.03	0.13	0.00
PN.012	lin-3022c6	0.09	0.07	0.03	0.03	0.32	0.00	0.01	0.00	0.00	0.63		0.00		0.00	10.80	1.35	0.00			0.31	0.00	7.78	0.22	0.14	0.28	0.58	0.00
PN.012	lin-3022c6	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	9.32	6.75	0.00	0.00	10.82	0.00	0.00	4.39	71.82	0.00	0.00	3.36	0.05	0.00	0.00	0.12	0.00
PN.012	average	0.04	0.04	0.01	0.01	0.11	0.00	0.00	0.00	0.00	0.24	6.20	4.49	0.00	0.00	10.90	0.45	0.00	2.91	47.80	0.11	0.00	4.83	0.11	0.05	0.11	0.28	0.00
PN.013	lin-aa4fe3	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.50	0.00	0.00	3.96	0.00	0.00	7.44	81.58	0.00	0.00	0.20	0.00	0.00	0.00	0.00	1.88
PN.013	lin-aa4fe3	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	1.30	0.00	0.00	6.44	0.00	0.00	5.47	73.84	0.01	0.00	0.62	0.00	0.00	0.00	0.00	3.01
PN.013	lin-aa4fe3	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.62	0.00	0.00	4.70	0.00	0.00	7.06	82.53	0.04	0.00	0.23	0.00	0.00	0.00	0.00	1.07
PN.013	average	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.81	0.00	0.00	5.03	0.00	0.00	6.65	79.31	0.02	0.00	0.35	0.00	0.00	0.00	0.00	1.99

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
PN.014	lin-9562f1	0.00	43.43	0.04	0.00	1.04	0.00	0.00	0.00	0.01	0.00	19.82	14.36	0.00	0.00	0.00	0.00	0.00	0.19	24.51	0.13	0.00	10.82	0.00	0.00	0.00	0.00	0.00
PN.014	lin-9562f1	0.00	43.28	0.02	0.00	1.09	0.00	0.00	0.00	0.01	0.00	15.97	11.57	0.00	0.00	0.00	0.00	0.00	0.20	29.27	0.11	0.00	9.80	0.00	0.00	0.00	0.00	0.00
PN.014	lin-9562f1	0.00	39.10	0.00	0.02	1.16	0.00	0.00	0.00	0.02	0.00	15.07	10.91	0.00	0.00	0.00	0.00	0.00	0.23	32.08	0.00	0.00	12.01	0.00	0.00	0.00	0.31	0.00
PN.014	lin-9562f1	0.00	42.21	0.03	0.00	1.06	0.00	0.00	0.00	0.01	0.00	16.54	11.98	0.00	0.00	0.00	0.00	0.00	0.20	27.55	0.08	0.00	12.09	0.00	0.00	0.00	0.00	0.00
PN.014	lin-9562f1	0.00	40.76	0.00	0.00	1.08	0.00	0.00	0.00	0.05	0.00	15.20	11.01	0.00	0.00	0.00	0.00	0.00	0.22	31.85	0.05	0.00	10.50	0.00	0.00	0.00	0.27	0.00
PN.014	lin-9562f1	0.00	40.10	0.00	0.01	0.99	0.00	0.00	0.00	0.01	0.00	21.31	15.44	0.00	0.00	0.00	0.00	0.00	0.22	26.13	0.00	0.00	10.96	0.00	0.00	0.00	0.26	0.00
PN.014	average	0.00	41.48	0.02	0.00	1.07	0.00	0.00	0.00	0.02	0.00	17.32	12.55	0.00	0.00	0.00	0.00	0.00	0.21	28.57	0.06	0.00	11.03	0.00	0.00	0.00	0.00	0.00
PN.015	lin-aa9635	0.06	32.69	0.03	0.01	0.81	0.00	0.00	0.00	0.01	0.00	10.09	7.31	0.00	0.00	0.00	0.00	0.00	5.92	31.89	0.11	0.00	3.58	0.00	0.00	0.00	0.35	3.29
PN.015	lin-aa9635	0.06	34.48	0.03	0.00	0.70	0.00	0.00	0.00	0.01	0.00	12.67	9.18	0.00	0.00	0.00	0.00	0.00	6.44	27.47	0.17	0.00	3.26	0.00	0.00	0.00	0.29	1.92
PN.015	lin-aa9635	0.04	32.95	0.00	0.00	0.68	0.00	0.00	0.00	0.01	0.00	12.03	8.72	0.00	0.00	0.00	0.00	0.00	6.37	30.40	0.09	0.00	3.48	0.00	0.00	0.00	0.31	2.65
PN.015	average	0.05	33.37	0.02	0.00	0.73	0.00	0.00	0.00	0.01	0.00	11.60	8.40	0.00	0.00	0.00	0.00	0.00	6.24	29.92	0.12	0.00	3.44	0.00	0.00	0.00	0.32	2.62
PN.015	lin-aa9635	0.06	32.69	0.03	0.01	0.81	0.00	0.00	0.00	0.01	0.00	10.09	7.31	0.00	0.00	0.00	0.00	0.00	5.92	31.89	0.11	0.00	3.58	0.00	0.00	0.00	0.35	3.29
PN.015	lin-aa9635	0.06	34.48	0.03	0.00	0.70	0.00	0.00	0.00	0.01	0.00	12.67	9.18	0.00	0.00	0.00	0.00	0.00	6.44	27.47	0.17	0.00	3.26	0.00	0.00	0.00	0.29	1.92
PN.015	lin-aa9635	0.04	32.95	0.00	0.00	0.68	0.00	0.00	0.00	0.01	0.00	12.03	8.72	0.00	0.00	0.00	0.00	0.00	6.37	30.40	0.09	0.00	3.48	0.00	0.00	0.00	0.31	2.65
PN.015	average	0.05	33.37	0.02	0.00	0.73	0.00	0.00	0.00	0.01	0.00	11.60	8.40	0.00	0.00	0.00	0.00	0.00	6.24	29.92	0.12	0.00	3.44	0.00	0.00	0.00	0.32	2.62
PN.016	lin-953fd7	0.28	28.45	0.02	0.00	1.58	0.00	0.00	0.00	0.01	0.00	15.31	11.09	0.00	0.00	0.00	0.00	0.00	0.17	27.50	0.11	0.00	26.35	0.00	0.00	0.00	0.20	0.00
PN.016	lin-953fd7	0.23	26.36	0.00	0.00	1.32	0.00	0.00	0.00	0.01	0.03	19.47	14.11	0.00	0.00	0.00	0.00	0.00	0.16	26.13	0.00	0.00	25.95	0.00	0.00	0.00	0.31	0.00
PN.016	lin-953fd7	0.24	27.22	0.00	0.01	1.44	0.00	0.00	0.00	0.01	0.04	17.02	12.33	0.00	0.00	0.00	0.00	0.00	0.17	25.93	0.00	0.00	27.62	0.00	0.00	0.00	0.30	0.00
PN.016	lin-953fd7	0.26	27.23	0.00	0.00	1.35	0.00	0.00	0.00	0.01	0.00	19.40	14.05	0.00	0.00	0.00	0.00	0.00	0.17	25.34	0.00	0.00	25.87	0.00	0.00	0.00	0.34	0.00
PN.016	lin-953fd7	0.24	27.23	0.00	0.00	1.34	0.00	0.00	0.00	0.02	0.00	19.45	14.09	0.00	0.00	0.00	0.00	0.00	0.16	25.44	0.00	0.00	25.81	0.00	0.00	0.00	0.30	0.00
PN.016	lin-953fd7	0.25	27.36	0.00	0.00	1.34	0.00	0.00	0.00	0.01	0.03	19.41	14.06	0.00	0.00	0.00	0.00	0.00	0.16	25.36	0.00	0.00	25.77	0.00	0.00	0.00	0.30	0.00
PN.016	average	0.25	27.31	0.00	0.00	1.39	0.00	0.00	0.00	0.01	0.00	18.34	13.29	0.00	0.00	0.00	0.00	0.00	0.17	25.95	0.00	0.00	26.23	0.00	0.00	0.00	0.29	0.00
PN.017	lin-970f44	0.16	25.55	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.09	7.31	0.00	0.00	0.00	0.00	0.00	0.19	44.02	0.00	0.00	4.08	0.00	0.00	0.00	0.00	4.78
PN.017	lin-970f44	0.19	30.27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	9.71	7.03	0.00	0.00	0.00	0.00	0.00	0.20	38.89	0.06	0.00	3.35	0.00	0.00	0.00	0.16	5.43
PN.017	lin-970f44	0.20	30.35	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	9.82	7.12	0.00	0.00	0.00	0.00	0.00	0.20	39.25	0.05	0.00	3.37	0.00	0.00	0.00	0.00	5.01
PN.017	lin-970f44	0.20	30.34	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.03	9.81	7.11	0.00	0.00	0.00	0.00	0.00	0.20	39.14	0.05	0.00	3.38	0.00	0.00	0.00	0.00	5.14

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
PN.017	lin-970f44	0.14	23.38	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	9.89	7.17	0.00	0.00	0.00	0.00	0.00	0.19	45.72	0.00	0.00	4.42	0.00	0.00	0.00	0.00	4.81
PN.017	lin-970f44	0.18	27.27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	9.05	6.56	0.00	0.00	0.00	0.00	0.00	0.19	41.59	0.00	0.00	4.85	0.00	0.00	0.00	0.00	5.41
PN.017	average	0.17	27.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	9.58	6.94	0.00	0.00	0.00	0.00	0.00	0.19	42.15	0.00	0.00	4.22	0.00	0.00	0.00	0.00	5.12
PN.017	lin-970f44	0.19	30.21	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.28	7.44	0.00	0.00	0.00	0.00	0.00	0.22	39.18	0.05	0.00	4.91	0.00	0.00	0.00	0.00	4.60
PN.017	lin-970f44	0.21	31.55	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.17	7.37	0.00	0.00	0.00	0.00	0.00	0.22	40.8 0	0.04	0.00	3.96	0.00	0.00	0.00	0.17	3.90
PN.017	lin-970f44	0.21	31.59	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	10.82	7.84	0.00	0.00	0.00	0.00	0.00	0.22	38.06	0.00	0.00	4.77	0.00	0.00	0.00	0.00	3.97
PN.017	average	0.20	31.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	10.42	7.55	0.00	0.00	0.00	0.00	0.00	0.22	39.35	0.00	0.00	4.55	0.00	0.00	0.00	0.00	4.15
PN.017	lin-970f44	0.16	25.55	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.09	7.31	0.00	0.00	0.00	0.00	0.00	0.19	44.02	0.00	0.00	4.08	0.00	0.00	0.00	0.00	4.78
PN.017	lin-970f44	0.19	30.27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	9.71	7.03	0.00	0.00	0.00	0.00	0.00	0.20	38.89	0.06	0.00	3.35	0.00	0.00	0.00	0.16	5.43
PN.017	lin-970f44	0.20	30.35	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	9.82	7.12	0.00	0.00	0.00	0.00	0.00	0.20	39.25	0.05	0.00	3.37	0.00	0.00	0.00	0.00	5.01
PN.017	lin-970f44	0.20	30.34	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.03	9.81	7.11	0.00	0.00	0.00	0.00	0.00	0.20	39.14	0.05	0.00	3.38	0.00	0.00	0.00	0.00	5.14
PN.017	lin-970f44	0.14	23.38	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	9.89	7.17	0.00	0.00	0.00	0.00	0.00	0.19	45.72	0.00	0.00	4.42	0.00	0.00	0.00	0.00	4.81
PN.017	lin-970f44	0.18	27.27	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	9.05	6.56	0.00	0.00	0.00	0.00	0.00	0.19	41.59	0.00	0.00	4.85	0.00	0.00	0.00	0.00	5.41
PN.017	average	0.17	27.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	9.58	6.94	0.00	0.00	0.00	0.00	0.00	0.19	42.15	0.00	0.00	4.22	0.00	0.00	0.00	0.00	5.12
PN.017	lin-970f44	0.19	30.21	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.28	7.44	0.00	0.00	0.00	0.00	0.00	0.22	39.18	0.05	0.00	4.91	0.00	0.00	0.00	0.00	4.60
PN.017	lin-970f44	0.21	31.55	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.17	7.37	0.00	0.00	0.00	0.00	0.00	0.22	40.8 0	0.04	0.00	3.96	0.00	0.00	0.00	0.17	3.90
PN.017	lin-970f44	0.21	31.59	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	10.82	7.84	0.00	0.00	0.00	0.00	0.00	0.22	38.06	0.00	0.00	4.77	0.00	0.00	0.00	0.00	3.97
PN.017	average	0.20	31.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	10.42	7.55	0.00	0.00	0.00	0.00	0.00	0.22	39.35	0.00	0.00	4.55	0.00	0.00	0.00	0.00	4.15
PN.018	lin-955304	0.21	24.05	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	34.89	25.28	0.00	0.00	0.00	0.00	0.00	3.74	23.99	0.13	0.00	12.89	0.00	0.00	0.00	0.00	0.00
PN.018	lin-955304	0.22	30.19	0.03	0.00	0.49	0.00	0.00	0.00	0.02	0.00	30.23	21.90	0.00	0.00	0.00	0.00	0.00	3.13	21.25	0.15	0.00	14.26	0.00	0.00	0.00	0.00	0.00
PN.018	lin-955304	0.21	29.74	0.04	0.02	0.47	0.00	0.00	0.00	0.01	0.00	31.17	22.58	0.00	0.00	0.00	0.00	0.00	2.52	22.51	0.15	0.00	13.03	0.00	0.00	0.00	0.00	0.00
PN.018	lin-955304	0.21	23.57	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	35.40	25.64	0.00	0.00	0.00	0.00	0.00	2.88	25.66	0.00	0.00	12.05	0.00	0.00	0.00	0.20	0.00
PN.018	lin-955304	0.20	23.58	0.00	0.02	0.00	0.00	0.00	0.00	0.02	0.00	35.53	25.74	0.00	0.00	0.00	0.00	0.00	2.86	25.64	0.00	0.00	11.98	0.00	0.00	0.00	0.00	0.00
PN.018	lin-955304	0.22	24.21	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	36.80	26.66	0.00	0.00	0.00	0.00	0.00	2.94	24.25	0.00	0.00	11.35	0.00	0.00	0.00	0.00	0.00
PN.018	average	0.21	25.89	0.00	0.01	0.16	0.00	0.00	0.00	0.02	0.00	34.00	24.63	0.00	0.00	0.00	0.00	0.00	3.01	23.88	0.08	0.00	12.59	0.00	0.00	0.00	0.00	0.00
PN.019	lin-9575ca	0.31	19.79	0.00	0.00	1.50	0.00	0.00	0.00	0.01	0.15	24.92	18.06	0.00	0.01	15.12	0.00	0.00	0.43	32.87	0.02	0.00	4.49	0.00	0.00	0.00	0.35	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
PN.019	lin-9575ca	0.26	17.17	0.00	0.00	1.49	0.00	0.00	0.00	0.02	0.13	27.16	19.68	0.00	0.02	12.57	0.00	0.00	0.43	31.90	0.03	0.00	8.42	0.00	0.00	0.00	0.31	0.00
PN.019	lin-9575ca	0.28	17.18	0.00	0.01	1.50	0.00	0.00	0.00	0.02	0.11	27.30	19.78	0.00	0.00	12.02	0.00	0.00	0.43	32.25	0.03	0.00	8.45	0.00	0.00	0.00	0.35	0.00
PN.019	average	0.28	18.04	0.00	0.00	1.50	0.00	0.00	0.00	0.02	0.13	26.46	19.17	0.00	0.00	13.24	0.00	0.00	0.43	32.34	0.03	0.00	7.12	0.00	0.00	0.00	0.34	0.00
PN.020	lin-3060a0	0.39	12.35	0.02	0.01	0.62	0.00	0.00	0.00	0.01	0.32	25.13	18.21	0.00	0.00	35.21	0.00	0.00	1.58	17.09	0.02	0.00	6.78	0.00	0.00	0.09	0.33	0.00
PN.020	lin-3060a0	0.38	12.13	0.02	0.01	0.60	0.00	0.00	0.00	0.01	0.30	25.26	18.30	0.00	0.00	29.73	0.00	0.00	1.69	20.51	0.04	0.00	8.88	0.00	0.00	0.07	0.34	0.00
PN.020	lin-3060a0	0.42	13.40	0.03	0.01	0.68	0.00	0.00	0.00	0.01	0.35	25.48	18.46	0.00	0.00	35.01	0.00	0.00	1.60	16.11	0.06	0.00	6.34	0.00	0.04	0.05	0.39	0.00
PN.020	lin-3060a0	0.42	13.27	0.03	0.02	0.68	0.00	0.00	0.00	0.02	0.26	24.48	17.73	0.00	0.00	26.13	0.00	0.00	1.79	20.66	0.07	0.00	11.71	0.00	0.03	0.05	0.37	0.00
PN.020	lin-3060a0	0.43	13.91	0.02	0.00	0.71	0.00	0.00	0.00	0.01	0.31	24.69	17.89	0.00	0.00	30.97	0.00	0.00	1.60	20.01	0.05	0.00	6.86	0.00	0.00	0.07	0.31	0.00
PN.020	lin-3060a0	0.33	11.21	0.00	0.01	0.53	0.00	0.00	0.00	0.01	0.31	25.01	18.12	0.00	0.00	31.25	0.00	0.00	1.61	21.20	0.00	0.00	8.10	0.00	0.00	0.07	0.29	0.00
PN.020	average	0.40	12.71	0.02	0.01	0.64	0.00	0.00	0.00	0.01	0.31	25.01	18.12	0.00	0.00	31.38	0.00	0.00	1.65	19.26	0.04	0.00	8.11	0.00	0.00	0.07	0.34	0.00
PN.020	lin-3060a0	0.35	11.92	0.02	0.00	0.57	0.00	0.00	0.00	0.01	0.26	25.74	18.65	0.00	0.00	28.62	0.00	0.00	1.81	21.43	0.00	0.00	8.87	0.00	0.00	0.06	0.28	0.00
PN.020	lin-3060a0	0.35	12.08	0.02	0.00	0.59	0.00	0.00	0.00	0.01	0.28	25.93	18.78	0.00	0.00	30.29	0.00	0.00	1.56	20.50	0.00	0.00	8.05	0.00	0.00	0.06	0.25	0.00
PN.020	lin-3060a0	0.38	12.57	0.02	0.00	0.61	0.00	0.00	0.00	0.01	0.25	22.29	16.15	0.00	0.00	37.63	0.00	0.00	1.47	19.92	0.00	0.00	4.54	0.00	0.00	0.07	0.22	0.00
PN.020	lin-3060a0	0.40	13.02	0.02	0.00	0.66	0.00	0.00	0.00	0.01	0.30	25.19	18.25	0.00	0.00	35.10	0.00	0.00	1.59	16.74	0.04	0.00	6.50	0.00	0.03	0.07	0.32	0.00
PN.020	lin-3060a0	0.38	12.15	0.02	0.01	0.61	0.00	0.00	0.00	0.01	0.28	23.56	17.07	0.00	0.00	34.66	0.00	0.00	1.56	19.81	0.02	0.00	6.52	0.00	0.00	0.08	0.30	0.00
PN.020	lin-3060a0	0.38	12.28	0.01	0.01	0.61	0.00	0.00	0.00	0.01	0.27	23.78	17.23	0.00	0.00	33.88	0.00	0.00	1.59	20.15	0.00	0.00	6.58	0.00	0.03	0.06	0.33	0.00
PN.020	average	0.37	12.34	0.02	0.00	0.61	0.00	0.00	0.00	0.01	0.27	24.41	17.69	0.00	0.00	33.36	0.00	0.00	1.59	19.76	0.00	0.00	6.84	0.00	0.00	0.07	0.28	0.00
PN.021	lin-aa7626	0.08	0.74	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.27	30.95	22.42	0.00	0.04	27.19	0.00	0.00	2.13	18.29	0.05	0.00	5.82	0.00	0.03	0.07	0.23	2.99
PN.021	lin-aa7626	0.09	0.75	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.28	30.98	22.45	0.00	0.04	24.64	0.00	0.00	2.00	18.17	0.07	0.00	6.48	0.00	0.00	0.07	0.19	3.60
PN.021	lin-aa7626	0.07	0.69	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.26	29.24	21.18	0.00	0.03	21.35	0.00	0.00	1.63	14.94	0.05	0.00	7.77	0.02	0.00	0.06	0.20	6.41
PN.021	average	0.08	0.72	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.27	30.39	22.02	0.00	0.04	24.39	0.00	0.00	1.92	17.13	0.06	0.00	6.69	0.00	0.02	0.07	0.21	4.33
PN.021	lin-aa7626	0.08	0.74	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.27	30.95	22.42	0.00	0.04	27.19	0.00	0.00	2.13	18.29	0.05	0.00	5.82	0.00	0.03	0.07	0.23	2.99
PN.021	lin-aa7626	0.09	0.75	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.28	30.98	22.45	0.00	0.04	24.64	0.00	0.00	2.00	18.17	0.07	0.00	6.48	0.00	0.00	0.07	0.19	3.60
PN.021	lin-aa7626	0.07	0.69	0.02	0.01	0.00	0.00	0.00	0.00	0.01	0.26	29.24	21.18	0.00	0.03	21.35	0.00	0.00	1.63	14.94	0.05	0.00	7.77	0.02	0.00	0.06	0.20	6.41
PN.021	average	0.08	0.72	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.27	30.39	22.02	0.00	0.04	24.39	0.00	0.00	1.92	17.13	0.06	0.00	6.69	0.00	0.02	0.07	0.21	4.33
PN.022	lin-a76e70	0.02	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.46	0.00	0.00	3.24	0.00	0.00	10.90	73.25	0.09	0.00	0.29	0.00	0.00	0.00	0.05	4.28

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
PN.022	lin-a76e70	0.01	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.61	0.00	0.00	4.22	0.00	0.00	10.01	75.29	0.07	0.00	0.25	0.00	0.00	0.00	0.00	3.60
PN.022	lin-a76e70	0.01	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.43	0.00	0.00	3.12	0.00	0.00	12.13	73.26	0.09	0.00	0.28	0.00	0.00	0.00	0.00	3.93
PN.022	average	0.01	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.50	0.00	0.00	3.53	0.00	0.00	11.01	73.93	0.08	0.00	0.27	0.00	0.00	0.00	0.00	3.94
PN.022	lin-a76e70	0.02	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.46	0.00	0.00	3.24	0.00	0.00	10.90	73.25	0.09	0.00	0.29	0.00	0.00	0.00	0.05	4.28
PN.022	lin-a76e70	0.01	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.61	0.00	0.00	4.22	0.00	0.00	10.01	75.29	0.07	0.00	0.25	0.00	0.00	0.00	0.00	3.60
PN.022	lin-a76e70	0.01	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.43	0.00	0.00	3.12	0.00	0.00	12.13	73.26	0.09	0.00	0.28	0.00	0.00	0.00	0.00	3.93
PN.022	average	0.01	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.50	0.00	0.00	3.53	0.00	0.00	11.01	73.93	0.08	0.00	0.27	0.00	0.00	0.00	0.00	3.94
PN.023	lin-aa6c00	0.03	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	2.20	1.59	0.00	0.00	7.68	0.00	0.00	1.77	51.24	0.03	0.00	1.72	0.04	0.00	0.00	0.19	10.31
PN.023	lin-aa6c00	0.02	0.09	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	1.79	1.29	0.00	0.00	5.41	0.00	0.00	1.81	42.28	0.02	0.00	2.33	0.03	0.00	0.00	0.33	10.54
PN.023	lin-aa6c00	0.03	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.02	2.18	0.00	0.00	9.33	0.00	0.00	2.98	56.17	0.02	0.00	1.13	0.00	0.00	0.00	0.15	7.71
PN.023	average	0.03	0.11	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	2.33	1.69	0.00	0.00	7.47	0.00	0.00	2.19	49.89	0.02	0.00	1.73	0.03	0.00	0.00	0.22	9.52
PN.023	lin-aa6c00	0.03	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	2.20	1.59	0.00	0.00	7.68	0.00	0.00	1.77	51.24	0.03	0.00	1.72	0.04	0.00	0.00	0.19	10.31
PN.023	lin-aa6c00	0.02	0.09	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	1.79	1.29	0.00	0.00	5.41	0.00	0.00	1.81	42.28	0.02	0.00	2.33	0.03	0.00	0.00	0.33	10.54
PN.023	lin-aa6c00	0.03	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.02	2.18	0.00	0.00	9.33	0.00	0.00	2.98	56.17	0.02	0.00	1.13	0.00	0.00	0.00	0.15	7.71
PN.023	average	0.03	0.11	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	2.33	1.69	0.00	0.00	7.47	0.00	0.00	2.19	49.89	0.02	0.00	1.73	0.03	0.00	0.00	0.22	9.52
PN.024	lin-aa6211	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.15	0.00	0.00	4.86	0.00	0.00	9.62	76.40	0.03	0.00	0.22	0.00	0.00	0.00	0.00	3.22
PN.024	lin-aa6211	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.18	0.00	0.00	5.06	0.00	0.00	11.15	76.78	0.02	0.00	0.16	0.00	0.00	0.00	0.00	2.55
PN.024	lin-aa6211	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.18	0.00	0.00	5.05	0.00	0.00	10.43	71.91	0.03	0.00	0.24	0.00	0.00	0.00	0.04	4.19
PN.024	average	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.17	0.00	0.00	4.99	0.00	0.00	10.40	75.03	0.02	0.00	0.21	0.00	0.00	0.00	0.00	3.32
PN.024	lin-aa6211	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.15	0.00	0.00	4.86	0.00	0.00	9.62	76.40	0.03	0.00	0.22	0.00	0.00	0.00	0.00	3.22
PN.024	lin-aa6211	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.18	0.00	0.00	5.06	0.00	0.00	11.15	76.78	0.02	0.00	0.16	0.00	0.00	0.00	0.00	2.55
PN.024	lin-aa6211	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.18	0.00	0.00	5.05	0.00	0.00	10.43	71.91	0.03	0.00	0.24	0.00	0.00	0.00	0.04	4.19
PN.024	average	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.17	0.00	0.00	4.99	0.00	0.00	10.40	75.03	0.02	0.00	0.21	0.00	0.00	0.00	0.00	3.32
R.001	lin-304a15	0.10	28.59	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.03	13.62	9.87	0.00	0.00	0.00	0.00	0.00	5.95	34.69	0.00	0.00	16.12	0.13	0.00	0.00	0.28	0.00
R.001	lin-304a15	0.12	26.99	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.04	12.96	9.39	0.00	0.00	3.21	0.00	0.00	5.91	41.25	0.00	0.00	8.73	0.07	0.00	0.00	0.24	0.00
R.001	lin-304a15	0.13	30.38	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.05	13.68	9.91	0.00	0.00	0.00	0.00	0.00	6.02	37.56	0.00	0.00	11.47	0.07	0.00	0.00	0.19	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
R.001	average	0.12	28.65	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.04	13.42	9.72	0.00	0.00	0.00	0.00	0.00	5.96	37.83	0.00	0.00	12.11	0.09	0.00	0.00	0.24	0.00
SC.001	SF041.055	0.03	34.44	0.00	0.00	0.26	0.00	0.00	0.01	0.01	0.03	4.13	2.99	0.00	0.00	0.00	0.00	0.00	7.23	43.56	0.00	0.00	9.84	0.00	0.00	0.00	0.45	0.00
SC.001	SF041.055	0.03	39.80	0.00	0.00	0.20	0.00	0.00	0.00	0.01	0.04	2.93	2.12	0.00	0.00	0.00	0.00	0.00	5.58	43.12	0.00	0.00	7.77	0.00	0.00	0.00	0.49	0.00
SC.001	SF041.055	0.00	40.28	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.04	5.44	3.94	0.00	0.00	0.00	0.00	0.00	6.39	41.29	0.00	0.00	5.94	0.00	0.00	0.00	0.37	0.00
SC.001	average	0.03	38.17	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.04	4.16	3.02	0.00	0.00	0.00	0.00	0.00	6.40	42.65	0.00	0.00	7.85	0.00	0.00	0.00	0.44	0.00
SC.002	lin-4cacf3	0.12	39.81	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	7.49	5.42	0.00	0.00	0.00	0.03	0.00	0.65	41.90	0.00	0.00	0.79	0.00	0.00	0.00	0.00	2.69
SC.002	lin-4cacf3	0.13	40.27	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	8.61	6.24	0.00	0.00	0.00	0.00	0.00	0.40	42.61	0.00	0.00	0.82	0.00	0.00	0.00	0.00	2.31
SC.002	lin-4cacf3	0.05	49.37	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	11.37	8.24	0.00	0.00	0.00	0.00	0.00	0.64	30.23	0.00	0.00	1.41	0.00	0.00	0.00	0.38	0.00
SC.002	average	0.10	43.15	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	9.16	6.63	0.00	0.00	0.00	0.02	0.00	0.57	38.25	0.00	0.00	1.01	0.00	0.00	0.00	0.23	2.25
SC.002	lin-4cacf3	0.15	39.50	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	9.26	6.71	0.00	0.00	0.00	0.03	0.00	0.45	39.98	0.00	0.00	1.07	0.00	0.00	0.00	0.45	0.00
SC.002	lin-4cacf3	0.13	35.97	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	7.71	5.58	0.00	0.00	0.00	0.03	0.00	0.48	45.97	0.00	0.00	1.00	0.00	0.00	0.00	0.26	0.00
SC.002	lin-4cacf3	0.10	30.88	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	8.44	6.12	0.00	0.00	0.00	0.03	0.00	0.56	45.69	0.00	0.00	1.41	0.00	0.00	0.00	0.30	3.75
SC.002	average	0.13	35.45	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	8.47	6.14	0.00	0.00	0.00	0.03	0.00	0.50	43.88	0.00	0.00	1.16	0.00	0.00	0.00	0.34	2.40
SC.003	SF026.078	0.14	32.40	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.09	24.93	0.00	0.00	5.06	0.00	0.00	1.60	33.63	0.00	0.00	1.77	0.00	0.00	0.00	0.00	0.00	
SC.003	SF026.078	0.10	23.17	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.05	19.53	0.00	0.00	5.48	0.00	0.00	2.63	45.47	0.00	0.00	3.20	0.00	0.00	0.00	0.00	0.00	
SC.003	SF026.078	0.08	34.10	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.05	22.23	0.00	0.00	0.00	0.00	0.00	1.47	37.33	0.00	0.00	4.49	0.00	0.00	0.00	0.00	0.00	
SC.003	SF026.078	0.11	29.89	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.06	22.23	0.00	0.00	3.51	0.00	0.00	1.90	38.81	0.00	0.00	3.15	0.00	0.00	0.00	0.00	0.00	
SC.004	SF026.077	0.12	35.87	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.00	22.19	16.08	0.00	0.00	0.00	0.00	0.00	4.76	31.65	0.00	0.00	4.92	0.00	0.00	0.00	0.00	0.00
SC.004	SF026.077	0.11	29.94	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	27.03	19.58	0.00	0.00	0.00	0.00	0.00	2.10	36.74	0.00	0.00	3.69	0.00	0.00	0.00	0.00	0.00
SC.004	SF026.077	0.14	35.98	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.05	17.43	12.63	0.00	0.00	0.00	0.00	0.00	4.89	36.52	0.00	0.00	4.49	0.00	0.00	0.00	0.00	0.00
SC.004	average	0.12	33.93	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.00	22.22	16.09	0.00	0.00	0.00	0.00	0.00	3.92	34.97	0.00	0.00	4.36	0.00	0.00	0.00	0.00	0.00
SC.004	SF026.077	0.14	32.40	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.09	24.93	18.06	0.00	0.00	5.06	0.00	0.00	1.60	33.63	0.00	0.00	1.77	0.00	0.00	0.00	0.00	0.00
SC.004	SF026.077	0.10	23.17	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.05	19.53	14.15	0.00	0.00	5.48	0.00	0.00	2.63	45.47	0.00	0.00	3.20	0.00	0.00	0.00	0.00	0.00
SC.004	SF026.077	0.08	34.10	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.05	22.23	16.11	0.00	0.00	0.00	0.00	0.00	1.47	37.33	0.00	0.00	4.49	0.00	0.00	0.00	0.00	0.00
SC.004	average	0.11	29.89	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.06	22.23	16.11	0.00	0.00	3.51	0.00	0.00	1.90	38.81	0.00	0.00	3.15	0.00	0.00	0.00	0.00	0.00
SC.005	lin-d07376 side b	0.16	24.06	0.00	0.00	0.53	0.00	0.00	0.00	0.01	0.09	11.97	8.67	0.00	0.00	7.66	0.04	0.00	1.85	51.70	0.03	0.00	1.64	0.00	0.00	0.00	0.26	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SC.005	lin-d07376 side b	0.17	28.20	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.11	13.31	9.64	0.00	0.00	8.44	0.04	0.00	1.79	45.30	0.00	0.00	1.72	0.00	0.00	0.00	0.30	0.00
SC.005	lin-d07376 side b	0.17	24.41	0.00	0.00	0.54	0.00	0.00	0.00	0.01	0.11	11.99	8.69	0.00	0.00	7.20	0.06	0.00	1.74	51.38	0.00	0.00	2.11	0.00	0.00	0.00	0.25	0.00
SC.005	average	0.15	19.57	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.05	10.61	7.69	0.00	0.00	7.35	0.00	0.00	2.02	58.41	0.04	0.00	1.08	0.00	0.00	0.00	0.23	0.00
SC.005	lin-d07376 side a	0.18	25.18	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.07	11.34	8.22	0.00	0.00	2.36	0.03	0.00	1.49	57.51	0.00	0.00	1.15	0.00	0.00	0.00	0.19	0.00
SC.005	lin-d07376 side a	0.17	23.77	0.00	0.00	0.41	0.00	0.00	0.00	0.01	0.06	10.54	7.63	0.00	0.00	0.00	0.05	0.00	1.08	62.93	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
SC.005	lin-d07376 side a	0.21	29.76	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.09	15.35	11.12	0.00	0.00	2.25	0.04	0.00	1.59	48.62	0.00	0.00	1.36	0.00	0.00	0.00	0.20	0.00
SC.005	average	0.16	22.00	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.05	8.14	5.90	0.00	0.00	4.84	0.00	0.00	1.80	60.99	0.06	0.00	1.11	0.00	0.00	0.00	0.39	0.00
SC.006	SF000.5002	0.13	27.70	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	7.91	5.73	0.00	0.00	0.00	0.00	0.00	3.64	57.03	0.00	0.00	3.26	0.04	0.00	0.00	0.00	0.00
SC.006	SF000.5002	0.10	27.93	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.02	5.95	4.31	0.00	0.00	0.00	0.00	0.00	2.83	58.65	0.00	0.00	4.21	0.07	0.00	0.00	0.00	0.00
SC.006	SF000.5002	0.13	19.37	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.00	5.05	3.66	0.00	0.00	0.00	0.00	0.00	3.87	68.18	0.00	0.00	3.09	0.03	0.00	0.00	0.00	0.00
SC.006	average	0.12	25.00	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.00	6.30	4.57	0.00	0.00	0.00	0.00	0.00	3.45	61.29	0.00	0.00	3.52	0.05	0.00	0.00	0.00	0.00
SC.007	SF000.5001	0.23	18.81	0.00	0.00	0.79	0.00	0.00	0.00	0.01	0.03	4.88	3.54	0.00	0.00	2.50	0.00	0.00	2.23	68.11	0.05	0.00	2.07	0.03	0.00	0.00	0.26	0.00
SC.007	SF000.5001	0.25	20.44	0.00	0.00	0.78	0.00	0.00	0.00	0.01	0.04	5.38	3.90	0.00	0.00	2.52	0.00	0.00	1.94	66.02	0.04	0.00	2.27	0.03	0.00	0.00	0.27	0.00
SC.007	SF000.5001	0.23	19.21	0.00	0.00	0.74	0.00	0.00	0.00	0.01	0.04	5.71	4.13	0.00	0.00	2.56	0.00	0.00	2.10	66.49	0.03	0.00	2.58	0.04	0.00	0.00	0.25	0.00
SC.007	average	0.24	19.49	0.00	0.00	0.77	0.00	0.00	0.00	0.01	0.04	5.32	3.86	0.00	0.00	2.52	0.00	0.00	2.09	66.88	0.04	0.00	2.31	0.03	0.00	0.00	0.26	0.00
SC.008	lin-d1172c side b	0.11	19.07	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.09	11.35	8.22	0.00	0.00	4.31	0.00	0.00	5.02	56.66	0.00	0.00	2.60	0.00	0.00	0.00	0.27	0.00
SC.008	lin-d1172c side b	0.12	19.41	0.00	0.00	0.53	0.00	0.00	0.00	0.01	0.09	11.56	8.38	0.00	0.00	4.52	0.00	0.00	6.11	54.50	0.00	0.00	2.86	0.00	0.00	0.00	0.29	0.00
SC.008	lin-d1172c side b	0.11	18.96	0.00	0.00	0.50	0.00	0.00	0.00	0.01	0.08	10.99	7.96	0.00	0.00	3.37	0.00	0.00	4.52	58.33	0.00	0.00	2.87	0.00	0.00	0.00	0.28	0.00
SC.008	average	0.11	18.83	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.09	11.50	8.33	0.00	0.00	5.05	0.00	0.00	4.45	57.15	0.00	0.00	2.06	0.00	0.00	0.00	0.24	0.00
SC.008	lin-d1172c sidea	0.10	25.53	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.06	11.61	8.41	0.00	0.00	3.62	0.00	0.00	5.12	51.47	0.00	0.00	1.46	0.00	0.00	0.00	0.60	0.00
SC.008	lin-d1172c sidea	0.11	22.52	0.00	0.00	0.43	0.00	0.00	0.00	0.01	0.07	11.75	8.51	0.00	0.00	4.64	0.00	0.00	4.81	53.14	0.00	0.00	2.04	0.00	0.00	0.00	0.48	0.00
SC.008	lin-d1172c sidea	0.10	31.12	0.00	0.00	0.38	0.00	0.00	0.00	0.01	0.05	12.02	8.71	0.00	0.00	0.00	0.00	0.00	5.00	48.36	0.00	0.00	1.29	0.00	0.00	0.00	0.69	0.00
SC.009	lin-9633e6	0.11	18.72	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.05	8.44	6.12	0.00	0.00	7.62	0.00	0.00	0.84	51.09	0.03	0.00	2.57	0.00	0.00	0.00	0.36	2.27
SC.009	lin-9633e6	0.10	15.42	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.04	6.86	4.97	0.00	0.00	6.65	0.00	0.00	0.86	58.27	0.03	0.00	1.89	0.00	0.00	0.00	0.32	2.42
SC.009	lin-9633e6	0.12	19.88	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.07	9.36	6.78	0.00	0.00	8.02	0.00	0.00	0.83	49.35	0.03	0.00	1.44	0.00	0.00	0.00	0.37	2.46
SC.009	average	0.11	18.01	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.05	8.22	5.96	0.00	0.00	7.43	0.00	0.00	0.84	52.90	0.03	0.00	1.97	0.00	0.00	0.00	0.35	2.38

REF NUM	***SAMPLE***	***Sb***	***Sn***	***Cd***	***Pd***	***Ag***	***Ru***	***Mo***	***Nb***	***Zr***	***Bi***	***Pb***	***Pb (scaled down)***	***Hg***	***Se***	***As***	***Au***	***W***	***Zn***	***Cu***	***Ni***	***Co***	***Fe***	***Mn***	***Cr***	***V***	***Ti***	***Al***
SC.009	lin-9633e6 back	0.10	15.38	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.05	7.16	5.19	0.00	0.00	8.40	0.00	0.00	0.85	54.94	0.02	0.00	1.15	0.00	0.00	0.00	0.33	2.19
SC.009	lin-9633e6 back	0.11	18.38	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.04	7.84	5.68	0.00	0.00	6.40	0.00	0.00	0.81	51.03	0.04	0.00	1.10	0.00	0.00	0.00	0.38	3.49
SC.009	lin-9633e6 back	0.10	16.55	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.05	7.65	5.54	0.00	0.00	7.90	0.00	0.00	0.80	49.62	0.00	0.00	1.02	0.00	0.00	0.00	0.37	4.15
SC.009	average	0.11	16.77	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.05	7.55	5.47	0.00	0.00	7.57	0.00	0.00	0.82	51.86	0.02	0.00	1.09	0.00	0.00	0.00	0.36	3.28
SC.009	lin-9633e6	0.11	18.72	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.05	8.44	6.12	0.00	0.00	7.62	0.00	0.00	0.84	51.09	0.03	0.00	2.57	0.00	0.00	0.00	0.36	2.27
SC.009	lin-9633e6	0.10	15.42	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.04	6.86	4.97	0.00	0.00	6.65	0.00	0.00	0.86	58.27	0.03	0.00	1.89	0.00	0.00	0.00	0.32	2.42
SC.009	lin-9633e6	0.12	19.88	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.07	9.36	6.78	0.00	0.00	8.02	0.00	0.00	0.83	49.35	0.03	0.00	1.44	0.00	0.00	0.00	0.37	2.46
SC.009	average	0.11	18.01	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.05	8.22	5.96	0.00	0.00	7.43	0.00	0.00	0.84	52.90	0.03	0.00	1.97	0.00	0.00	0.00	0.35	2.38
SC.009	lin-9633e6 back	0.10	15.38	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.05	7.16	5.19	0.00	0.00	8.40	0.00	0.00	0.85	54.94	0.02	0.00	1.15	0.00	0.00	0.00	0.33	2.19
SC.009	lin-9633e6 back	0.11	18.38	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.04	7.84	5.68	0.00	0.00	6.40	0.00	0.00	0.81	51.03	0.04	0.00	1.10	0.00	0.00	0.00	0.38	3.49
SC.009	lin-9633e6 back	0.10	16.55	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.05	7.65	5.54	0.00	0.00	7.90	0.00	0.00	0.80	49.62	0.00	0.00	1.02	0.00	0.00	0.00	0.37	4.15
SC.009	average	0.11	16.77	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.05	7.55	5.47	0.00	0.00	7.57	0.00	0.00	0.82	51.86	0.02	0.00	1.09	0.00	0.00	0.00	0.36	3.28
SC.010	SF037.004b	0.09	22.15	0.00	0.00	0.74	0.00	0.01	0.01	0.05	0.04	9.16	6.64	0.00	0.00	0.00	0.00	0.00	9.09	49.27	0.00	0.00	8.90	0.34	0.00	0.00	0.00	0.00
SC.010	SF037.004b	0.08	19.07	0.00	0.00	0.43	0.00	0.00	0.00	0.02	0.03	10.97	7.94	0.00	0.00	0.00	0.00	0.00	10.29	52.10	0.03	0.00	6.45	0.18	0.00	0.00	0.35	0.00
SC.010	SF037.004b	0.10	11.10	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.03	11.89	8.62	0.00	0.00	4.78	0.00	0.00	9.88	58.31	0.03	0.00	3.14	0.08	0.00	0.00	0.22	0.00
SC.010	average	0.09	17.44	0.00	0.00	0.53	0.00	0.00	0.01	0.03	0.04	10.67	7.73	0.00	0.00	0.00	0.00	0.00	9.75	53.23	0.00	0.00	6.16	0.20	0.00	0.00	0.24	0.00
SC.011	SF036.044	0.27	19.95	0.00	0.00	0.81	0.00	0.00	0.00	0.01	0.09	10.04	7.27	0.00	0.00	3.77	0.00	0.79	15.54	45.92	0.03	0.00	2.78	0.00	0.00	0.00	0.00	0.00
SC.011	SF036.044	0.18	12.16	0.00	0.00	0.61	0.00	0.00	0.00	0.02	0.08	9.29	6.73	0.00	0.00	4.19	0.00	0.63	20.70	48.45	0.04	0.00	3.57	0.08	0.00	0.00	0.00	0.00
SC.011	SF036.044	0.18	14.09	0.00	0.00	0.66	0.00	0.00	0.00	0.03	0.08	10.72	7.77	0.00	0.00	0.00	0.00	0.36	18.71	49.42	0.00	0.00	5.56	0.15	0.00	0.00	0.00	0.00
SC.011	average	0.21	15.40	0.00	0.00	0.69	0.00	0.00	0.00	0.02	0.08	10.02	7.26	0.00	0.00	2.65	0.00	0.60	18.32	47.93	0.03	0.00	3.97	0.08	0.00	0.00	0.00	0.00
SC.012	lin-d0ae9e side b	0.08	14.59	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.02	2.69	1.95	0.00	0.00	0.00	0.00	0.00	7.55	71.60	0.00	0.00	2.14	0.00	0.00	0.00	0.12	0.00
SC.012	lin-d0ae9e side b	0.08	14.69	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.02	2.46	1.78	0.00	0.00	0.00	0.00	0.00	7.80	71.60	0.00	0.00	2.02	0.04	0.00	0.00	0.11	0.00
SC.012	lin-d0ae9e side b	0.07	14.26	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	2.33	1.69	0.00	0.00	0.00	0.00	0.00	7.32	72.58	0.00	0.00	2.67	0.00	0.00	0.00	0.11	0.00
SC.012	average	0.08	14.82	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.03	3.28	2.38	0.00	0.00	1.11	0.00	0.00	7.52	70.62	0.00	0.00	1.75	0.00	0.00	0.00	0.16	0.00
SC.012	lin-d0ae9e side a	0.08	13.53	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.03	3.06	2.22	0.00	0.00	1.73	0.00	0.00	6.91	73.02	0.00	0.00	0.91	0.00	0.00	0.00	0.21	0.00
SC.012	lin-d0ae9e side a	0.07	12.06	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.02	2.50	1.81	0.00	0.00	1.52	0.00	0.00	7.20	75.32	0.00	0.00	0.66	0.00	0.00	0.00	0.20	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
SC.012	lin-doae9e side a	0.07	12.46	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.02	2.67	1.94	0.00	0.00	1.07	0.00	0.00	7.06	75.27	0.00	0.00	0.74	0.00	0.00	0.00	0.16	0.00
SC.012	average	0.09	16.06	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.04	4.00	2.90	0.00	0.00	2.59	0.00	0.00	6.46	68.48	0.00	0.00	1.35	0.00	0.00	0.00	0.27	0.00
SC.013	SF036.005	0.18	13.17	0.00	0.00	0.57	0.00	0.00	0.00	0.01	0.10	11.44	8.29	0.00	0.00	10.69	0.00	0.00	7.06	54.46	0.00	0.00	2.26	0.05	0.00	0.00	0.00	0.00
SC.013	SF036.005	0.16	12.20	0.00	0.00	0.49	0.00	0.00	0.00	0.01	0.07	16.92	12.26	0.00	0.00	7.03	0.00	0.00	8.12	52.38	0.00	0.00	2.57	0.05	0.00	0.00	0.00	0.00
SC.013	SF036.005	0.14	9.85	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.09	11.87	8.60	0.00	0.00	14.73	0.00	0.00	7.00	53.81	0.00	0.00	2.07	0.03	0.00	0.00	0.00	0.00
SC.013	average	0.16	11.74	0.00	0.00	0.49	0.00	0.00	0.00	0.01	0.09	13.41	9.72	0.00	0.00	10.82	0.00	0.00	7.39	53.55	0.00	0.00	2.30	0.04	0.00	0.00	0.00	0.00
SC.014	SF041.001	0.11	11.85	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.03	7.97	5.77	0.00	0.00	0.00	0.00	0.00	5.04	70.28	0.00	0.00	4.08	0.02	0.00	0.00	0.17	0.00
SC.014	SF041.001	0.08	12.83	0.00	0.00	0.44	0.00	0.00	0.00	0.02	0.04	6.97	5.05	0.00	0.00	0.00	0.00	0.00	4.82	69.49	0.00	0.00	5.17	0.00	0.00	0.00	0.13	0.00
SC.014	SF041.001	0.06	8.61	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.00	2.86	2.07	0.00	0.00	0.00	0.00	0.00	3.31	80.23	0.00	0.00	4.60	0.00	0.00	0.00	0.00	0.00
SC.014	average	0.08	11.09	0.00	0.00	0.38	0.00	0.00	0.00	0.01	0.00	5.93	4.30	0.00	0.00	0.00	0.00	0.00	4.39	73.34	0.00	0.00	4.61	0.00	0.00	0.00	0.12	0.00
SC.015	SF037.004a	0.11	9.76	0.00	0.00	0.36	0.00	0.00	0.00	0.02	0.06	16.28	11.79	2.12	0.22	0.00	0.00	2.47	0.46	65.21	0.00	0.00	2.78	0.07	0.00	0.00	0.00	0.00
SC.015	SF037.004a	0.12	9.44	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.04	11.87	8.60	2.71	0.00	0.00	2.86	0.00	1.18	69.24	0.00	0.00	2.03	0.05	0.00	0.00	0.00	0.00
SC.015	SF037.004a	0.12	13.08	0.00	0.00	0.77	0.00	0.00	0.00	0.01	0.05	25.09	18.18	1.46	0.15	0.00	0.00	1.90	0.76	55.01	0.00	0.00	1.50	0.03	0.00	0.00	0.00	0.00
SC.015	average	0.12	10.76	0.00	0.00	0.50	0.00	0.00	0.00	0.01	0.05	17.75	12.86	2.10	0.12	0.00	0.95	1.46	0.80	63.15	0.00	0.00	2.10	0.05	0.00	0.00	0.00	0.00
SC.016	SF036.046	0.18	13.09	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.09	10.37	7.51	0.00	0.00	4.64	0.00	0.00	9.22	58.83	0.00	0.00	3.02	0.05	0.00	0.00	0.00	0.00
SC.016	SF036.046	0.15	9.33	0.00	0.00	0.40	0.00	0.00	0.00	0.01	0.06	8.81	6.38	0.00	0.00	5.17	0.00	0.00	14.26	59.36	0.03	0.00	2.40	0.03	0.00	0.00	0.00	0.00
SC.016	SF036.046	0.16	9.59	0.00	0.00	0.42	0.00	0.00	0.00	0.01	0.14	20.79	15.06	0.00	0.00	19.11	0.00	0.00	5.71	41.55	0.00	0.00	2.44	0.04	0.00	0.00	0.00	0.00
SC.016	average	0.16	10.67	0.00	0.00	0.45	0.00	0.00	0.00	0.01	0.09	13.32	9.65	0.00	0.00	9.64	0.00	0.00	9.73	53.25	0.00	0.00	2.62	0.04	0.00	0.00	0.00	0.00
SC.017	SF037.003a	0.06	9.90	0.00	0.00	0.30	0.00	0.00	0.00	0.01	0.00	4.70	3.40	0.00	0.00	0.00	0.00	0.00	1.89	81.09	0.02	0.00	1.93	0.05	0.00	0.00	0.00	0.00
SC.017	SF037.003a	0.08	9.29	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.00	5.84	4.23	0.00	0.00	0.00	0.00	0.00	1.19	81.97	0.00	0.00	1.28	0.04	0.00	0.00	0.00	0.00
SC.017	SF037.003a	0.05	8.12	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.00	13.64	9.88	0.00	0.00	0.00	0.00	0.00	1.29	75.32	0.00	0.00	1.29	0.04	0.00	0.00	0.00	0.00
SC.017	average	0.06	9.10	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.00	8.06	5.84	0.00	0.00	0.00	0.00	0.00	1.46	79.46	0.00	0.00	1.50	0.05	0.00	0.00	0.00	0.00
SC.018	SF037.003b	0.07	8.94	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.00	15.28	11.07	0.00	0.00	0.00	0.00	0.00	1.23	71.80	0.00	0.00	2.25	0.08	0.00	0.00	0.00	0.00
SC.018	SF037.003b	0.04	7.47	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.00	3.90	2.83	0.00	0.00	0.00	0.00	0.00	1.60	85.10	0.03	0.00	1.58	0.07	0.00	0.00	0.00	0.00
SC.018	SF037.003b	0.09	10.62	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.00	9.41	6.81	0.00	0.00	0.00	0.00	0.00	1.88	75.19	0.00	0.00	2.34	0.09	0.00	0.00	0.00	0.00
SC.018	average	0.07	9.01	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.00	9.53	6.90	0.00	0.00	0.00	0.00	0.00	1.57	77.37	0.00	0.00	2.06	0.08	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SD.001	tf 46898 68619	0.02	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.86	2.80	0.00	0.00	6.92	0.00	0.00	8.80	79.83	0.05	0.00	0.33	0.00	0.00	0.00	0.00	0.00
SD.001	tf 46898 68619	0.02	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	2.89	0.00	0.00	9.26	0.00	0.00	8.49	77.57	0.05	0.00	0.42	0.00	0.00	0.00	0.00	0.00
SD.001	tf 46898 68619	0.02	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	2.50	0.00	0.00	6.53	0.00	0.00	9.69	79.78	0.05	0.00	0.28	0.00	0.00	0.00	0.00	0.00
SD.001	average	0.02	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.77	2.73	0.00	0.00	7.57	0.00	0.00	9.00	79.06	0.05	0.00	0.34	0.00	0.00	0.00	0.00	0.00
SE.001	sfn010	0.12	24.42	0.00	0.00	0.92	0.00	0.00	0.01	0.15	0.10	19.57	14.18	0.00	0.00	0.00	0.06	0.00	1.92	39.65	0.00	0.00	12.11	0.21	0.00	0.00	0.78	0.00
SE.001	sfn010	0.18	24.03	0.00	0.00	0.97	0.00	0.00	0.00	0.02	0.08	24.62	17.84	0.00	0.00	0.00	0.20	0.00	2.00	39.92	0.00	0.00	7.54	0.00	0.00	0.00	0.44	0.00
SE.001	sfn010	0.18	22.94	0.00	0.00	0.92	0.00	0.00	0.00	0.02	0.08	25.52	18.49	0.00	0.00	0.00	0.17	0.00	1.71	40.88	0.00	0.00	7.23	0.00	0.00	0.00	0.36	0.00
SE.001	average	0.16	23.80	0.00	0.00	0.94	0.00	0.00	0.00	0.06	0.09	23.24	16.84	0.00	0.00	0.00	0.14	0.00	1.88	40.15	0.00	0.00	8.96	0.07	0.00	0.00	0.53	0.00
SE.002	PUBLIC-2e95bd side a	0.23	10.43	0.00	0.00	1.11	0.00	0.00	0.00	0.02	0.05	7.71	5.58	0.00	0.00	0.00	0.70	0.00	2.05	31.70	0.00	0.00	45.57	0.29	0.00	0.00	0.14	0.00
SE.002	PUBLIC-2e95bd side a	0.43	18.62	0.00	0.00	1.95	0.00	0.00	0.00	0.01	0.09	11.73	8.50	0.00	0.00	0.00	1.61	0.00	3.08	45.93	0.00	0.00	16.33	0.05	0.00	0.00	0.15	0.00
SE.002	PUBLIC-2e95bd side a	0.43	20.27	0.00	0.00	2.02	0.00	0.00	0.00	0.05	0.12	14.60	10.57	0.00	0.00	0.00	1.73	0.00	4.10	46.06	0.00	0.00	10.16	0.12	0.00	0.00	0.29	0.00
SE.002	average	0.36	16.44	0.00	0.00	1.69	0.00	0.00	0.00	0.03	0.09	11.35	8.22	0.00	0.00	0.00	1.35	0.00	3.08	41.23	0.00	0.00	24.02	0.15	0.00	0.00	0.19	0.00
SE.002	PUBLIC-2e95bd side b	0.35	16.41	0.00	0.00	1.57	0.00	0.00	0.00	0.02	0.11	15.07	10.92	0.00	0.00	0.00	1.43	0.00	2.42	39.74	0.00	0.00	22.50	0.15	0.00	0.00	0.23	0.00
SE.002	PUBLIC-2e95bd side b	0.48	25.77	0.00	0.00	2.15	0.00	0.00	0.00	0.07	0.14	18.78	13.61	0.00	0.00	0.00	1.74	0.00	2.46	45.17	0.00	0.00	2.89	0.08	0.00	0.00	0.25	0.00
SE.002	PUBLIC-2e95bd side b	0.47	25.19	0.00	0.00	2.09	0.00	0.00	0.00	0.06	0.15	17.20	12.46	0.00	0.00	0.00	1.72	0.00	2.50	47.77	0.00	0.00	2.50	0.08	0.00	0.00	0.28	0.00
SE.002	average	0.44	22.46	0.00	0.00	1.94	0.00	0.00	0.00	0.05	0.13	17.02	12.33	0.00	0.00	0.00	1.63	0.00	2.46	44.23	0.00	0.00	9.30	0.10	0.00	0.00	0.25	0.00
SE.003	public-2e7e44 side a	1.69	18.96	0.00	0.00	2.23	0.00	0.00	0.00	0.02	0.23	29.79	21.58	0.00	0.00	5.13	0.00	0.00	6.23	30.79	0.00	0.00	4.58	0.06	0.00	0.00	0.29	0.00
SE.003	public-2e7e44 side a	1.73	19.17	0.00	0.00	2.27	0.00	0.00	0.00	0.02	0.22	30.18	21.86	0.00	0.00	3.07	0.00	0.00	6.44	31.79	0.00	0.00	4.74	0.05	0.00	0.00	0.31	0.00
SE.003	public-2e7e44 side a	1.69	18.75	0.00	0.00	2.21	0.00	0.00	0.00	0.02	0.24	29.70	21.52	0.00	0.00	6.13	0.00	0.00	6.15	30.23	0.00	0.00	4.54	0.06	0.00	0.00	0.28	0.00
SE.003	average	1.70	18.96	0.00	0.00	2.24	0.00	0.00	0.00	0.02	0.23	29.89	21.65	0.00	0.00	4.78	0.00	0.00	6.28	30.94	0.00	0.00	4.62	0.06	0.00	0.00	0.30	0.00
SE.003	public-2e7e44 side a	1.65	18.06	0.00	0.00	5.55	0.00	0.00	0.00	0.03	0.18	28.70	20.79	0.00	0.00	0.00	0.00	0.00	6.51	35.52	0.00	0.00	3.42	0.00	0.00	0.00	0.31	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SE.003	public-2e7e44 side a	1.58	18.06	0.00	0.00	2.22	0.00	0.00	0.00	0.03	0.21	28.89	20.93	0.00	0.00	0.00	0.00	0.14	7.00	37.84	0.00	0.00	3.64	0.04	0.00	0.00	0.35	0.00
SE.003	public-2e7e44 side a	1.57	17.99	0.00	0.00	2.22	0.00	0.00	0.00	0.02	0.20	28.93	20.96	0.00	0.00	0.00	0.00	0.13	6.98	37.94	0.00	0.00	3.67	0.05	0.00	0.00	0.29	0.00
SE.003	average	1.60	18.04	0.00	0.00	3.33	0.00	0.00	0.00	0.03	0.20	28.84	20.90	0.00	0.00	0.00	0.00	0.00	6.83	37.10	0.00	0.00	3.58	0.04	0.00	0.00	0.32	0.00
SE.003	public-2e7e44 side a	1.41	16.44	0.00	0.00	1.90	0.00	0.00	0.00	0.02	0.29	27.27	19.75	0.00	0.00	9.62	0.00	0.00	5.31	34.90	0.00	0.00	2.66	0.00	0.00	0.00	0.18	0.00
SE.003	public-2e7e44 side a	1.63	18.74	0.00	0.00	2.14	0.00	0.00	0.00	0.02	0.23	26.74	19.38	0.00	0.00	3.02	0.00	0.11	7.25	36.74	0.00	0.00	3.22	0.00	0.00	0.00	0.17	0.00
SE.003	public-2e7e44 side a	1.67	18.52	0.00	0.00	2.15	0.00	0.00	0.00	0.02	0.20	33.68	24.40	0.00	0.00	0.00	0.00	0.00	6.19	33.05	0.00	0.00	4.29	0.00	0.00	0.00	0.19	0.00
SE.003	average	1.57	17.90	0.00	0.00	2.06	0.00	0.00	0.00	0.02	0.24	29.23	21.18	0.00	0.00	4.21	0.00	0.00	6.25	34.90	0.00	0.00	3.39	0.00	0.00	0.00	0.18	0.00
SE.004	lin-4a9154 side a	0.09	11.79	0.00	0.00	1.97	0.00	0.00	0.00	0.01	0.16	9.65	6.99	0.56	0.00	9.90	20.92	0.00	0.30	41.96	0.03	0.00	2.19	0.08	0.00	0.09	0.30	0.00
SE.004	lin-4a9154 side a	0.09	11.79	0.00	0.00	1.97	0.00	0.00	0.00	0.01	0.17	9.61	6.96	0.59	0.00	9.97	20.97	0.00	0.30	41.83	0.04	0.00	2.19	0.09	0.00	0.07	0.31	0.00
SE.004	lin-4a9154 side a	0.09	11.82	0.00	0.00	1.99	0.00	0.00	0.00	0.01	0.17	9.67	7.00	0.63	0.00	9.34	21.13	0.00	0.29	42.21	0.04	0.00	2.19	0.10	0.00	0.00	0.27	0.00
SE.004	average	0.09	11.80	0.00	0.00	1.98	0.00	0.00	0.00	0.01	0.16	9.64	6.98	0.59	0.00	9.74	21.01	0.00	0.30	42.00	0.04	0.00	2.19	0.09	0.00	0.07	0.29	0.00
SE.004	lin-4a9154 side a	0.09	11.82	0.00	0.00	1.95	0.00	0.00	0.00	0.01	0.16	9.61	6.96	0.60	0.00	9.88	20.96	0.00	0.30	41.92	0.03	0.00	2.19	0.10	0.00	0.00	0.31	0.00
SE.004	lin-4a9154 side a	0.09	11.81	0.00	0.00	1.98	0.00	0.00	0.00	0.01	0.15	9.65	6.99	0.81	0.00	9.37	21.03	0.00	0.30	42.10	0.03	0.00	2.20	0.11	0.00	0.06	0.29	0.00
SE.004	lin-4a9154 side a	0.08	11.83	0.00	0.00	1.97	0.00	0.00	0.00	0.01	0.16	9.64	6.98	0.55	0.00	9.75	21.04	0.00	0.29	42.00	0.03	0.00	2.21	0.10	0.00	0.00	0.29	0.00
SE.004	average	0.09	11.82	0.00	0.00	1.97	0.00	0.00	0.00	0.01	0.16	9.63	6.98	0.65	0.00	9.67	21.01	0.00	0.30	42.01	0.03	0.00	2.20	0.10	0.00	0.00	0.30	0.00
SE.004	lin-4a9154 side b	0.11	16.50	0.00	0.00	1.33	0.00	0.00	0.00	0.01	0.09	12.84	9.30	0.00	0.00	10.53	0.00	0.00	0.24	56.45	0.00	0.00	1.63	0.05	0.00	0.00	0.17	0.00
SE.004	lin-4a9154 side b	0.12	16.49	0.00	0.00	1.34	0.00	0.00	0.00	0.01	0.08	12.87	9.33	0.00	0.00	10.12	0.00	0.00	0.24	56.81	0.00	0.00	1.64	0.04	0.00	0.00	0.21	0.00
SE.004	lin-4a9154 side b	0.12	16.53	0.00	0.00	1.33	0.00	0.00	0.00	0.01	0.09	12.92	9.36	0.00	0.00	10.11	0.00	0.00	0.25	56.80	0.00	0.00	1.60	0.05	0.00	0.00	0.16	0.00
SE.004	average	0.12	16.51	0.00	0.00	1.33	0.00	0.00	0.00	0.01	0.08	12.88	9.33	0.00	0.00	10.25	0.00	0.00	0.24	56.69	0.00	0.00	1.62	0.05	0.00	0.00	0.18	0.00
SE.005	lin-6db27	0.15	14.39	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.06	5.41	3.92	0.00	0.00	30.82	0.00	0.00	3.89	41.06	0.00	0.00	3.81	0.00	0.00	0.00	0.21	0.00
SE.005	lin-6db27	0.14	13.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	5.30	3.84	0.00	0.00	30.29	0.00	0.00	3.97	42.51	0.00	0.00	4.05	0.00	0.00	0.00	0.29	0.00
SE.005	lin-6db27	0.17	15.66	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.06	6.03	4.37	0.00	0.00	31.67	0.00	0.00	3.19	38.27	0.00	0.00	4.49	0.00	0.00	0.00	0.23	0.00
SE.005	average	0.15	14.48	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.06	5.58	4.04	0.00	0.00	30.93	0.00	0.00	3.68	40.61	0.00	0.00	4.12	0.00	0.00	0.00	0.24	0.00
SE.006	rf1618	0.00	13.36	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	19.37	14.03	0.00	0.00	0.00	0.00	0.00	0.64	65.47	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SE.006	rf1618	0.00	13.26	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	29.78	21.57	0.00	0.00	0.00	0.00	0.00	0.65	55.14	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00
SE.006	rf1618	0.00	13.11	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	32.99	23.90	0.00	0.00	0.00	0.00	0.00	0.63	52.01	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.00
SE.006	average	0.00	13.24	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	27.38	19.84	0.00	0.00	0.00	0.00	0.00	0.64	57.54	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00
SE.007	lin-96dfc4	1.06	2.92	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.13	15.64	11.33	0.00	0.00	24.13	0.00	0.00	3.93	34.70	0.06	0.00	4.75	0.00	0.00	0.00	0.14	0.00
SE.007	lin-96dfc4	0.31	16.82	0.00	0.00	0.74	0.00	0.00	0.00	0.02	0.07	12.31	8.92	0.50	0.00	8.26	0.81	0.00	2.09	25.46	0.00	0.00	10.62	0.04	0.00	0.00	0.21	6.36
SE.007	lin-96dfc4	0.20	22.97	0.00	0.00	0.87	0.00	0.00	0.00	0.01	0.03	14.00	10.15	0.43	0.00	0.00	1.03	0.00	2.06	28.98	0.00	0.00	11.85	0.00	0.00	0.00	0.29	5.41
SE.007	average	0.52	14.24	0.00	0.00	0.60	0.00	0.00	0.00	0.01	0.08	13.98	10.13	0.31	0.00	10.80	0.61	0.00	2.69	29.71	0.03	0.00	9.07	0.00	0.00	0.00	0.21	4.48
SE.007	lin-96dfc4	0.88	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.09	13.43	9.73	0.00	0.00	18.93	0.00	0.00	4.71	38.14	0.08	0.00	3.10	0.00	0.00	0.00	0.16	4.26
SE.007	lin-96dfc4	0.17	15.12	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.02	10.64	7.71	0.00	0.00	1.92	0.00	0.00	1.78	29.35	0.00	0.00	14.86	0.04	0.00	0.00	0.13	7.68
SE.007	lin-96dfc4	0.17	21.99	0.00	0.00	0.71	0.00	0.00	0.00	0.01	0.04	10.77	7.80	0.00	0.00	0.00	0.00	0.00	2.02	36.12	0.00	0.00	10.14	0.00	0.00	0.00	0.26	4.05
SE.007	average	0.40	13.17	0.00	0.00	0.43	0.00	0.00	0.00	0.01	0.05	11.61	8.41	0.00	0.00	7.39	0.00	0.00	2.84	34.54	0.04	0.00	9.37	0.00	0.00	0.00	0.19	5.33
SE.008	rf10785	0.00	10.56	0.00	0.00	2.15	0.00	0.03	0.02	0.00	0.00	2.51	0.00	0.00	7.93	0.00	0.00	2.85	73.70	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	
SE.008	rf10785	0.04	10.87	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	2.24	0.00	0.00	6.93	0.00	0.00	2.85	75.78	0.07	0.00	0.34	0.00	0.00	0.00	0.17	0.00	
SE.008	rf10785	0.03	11.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	2.29	0.00	0.00	6.90	0.00	0.00	2.86	75.74	0.07	0.00	0.38	0.00	0.00	0.00	0.11	0.00	
SE.008	rf10785	0.00	10.81	0.00	0.00	1.15	0.00	0.01	0.01	0.00	0.00	2.35	0.00	0.00	7.26	0.00	0.00	2.85	75.08	0.05	0.00	0.32	0.00	0.00	0.00	0.00	0.00	
SE.009	avac 1	0.07	7.40	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.08	15.32	11.10	0.00	0.00	9.78	0.00	0.00	2.80	56.87	0.00	0.00	6.34	0.05	0.00	0.00	0.26	0.00
SE.009	avac 1	0.06	6.16	0.00	0.00	0.82	0.00	0.00	0.00	0.01	0.07	15.47	11.21	0.00	0.00	9.27	0.00	0.00	2.47	60.82	0.00	0.00	4.61	0.05	0.00	0.00	0.19	0.00
SE.009	avac 1	0.06	6.53	0.00	0.00	0.82	0.00	0.00	0.00	0.01	0.10	19.99	14.48	0.00	0.00	12.59	0.00	0.00	2.46	47.77	0.00	0.00	9.40	0.09	0.00	0.00	0.16	0.00
SE.009	average	0.06	6.70	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.09	16.93	12.26	0.00	0.00	10.55	0.00	0.00	2.58	55.15	0.00	0.00	6.78	0.06	0.00	0.00	0.20	0.00
SE.009	avac 1	0.09	9.03	0.00	0.00	1.12	0.00	0.00	0.00	0.01	0.12	21.46	15.55	0.00	0.00	14.24	0.00	0.00	2.57	49.09	0.00	0.00	2.04	0.03	0.00	0.00	0.22	0.00
SE.009	avac 1	0.07	7.11	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.10	16.77	12.15	0.00	0.00	14.22	0.00	0.00	2.24	57.25	0.00	0.00	1.00	0.00	0.00	0.00	0.27	0.00
SE.009	avac 1	0.08	9.79	0.00	0.00	1.28	0.00	0.00	0.00	0.01	0.06	23.91	17.33	0.00	0.00	4.67	0.00	0.00	2.28	54.76	0.00	0.00	2.88	0.04	0.00	0.00	0.23	0.00
SE.009	average	0.08	8.65	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.09	20.71	15.01	0.00	0.00	11.04	0.00	0.00	2.36	53.70	0.00	0.00	1.97	0.03	0.00	0.00	0.24	0.00
SE.010	rf100	0.00	6.98	0.00	0.00	0.51	0.00	0.01	0.02	0.00	0.06	24.08	17.45	0.00	0.00	8.95	0.41	0.00	1.22	57.56	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
SE.010	rf100	0.00	7.38	0.00	0.00	0.96	0.00	0.00	0.01	0.00	0.06	18.90	13.69	0.00	0.00	8.94	0.48	0.00	1.27	61.75	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00
SE.010	rf100	0.00	8.38	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.04	9.26	6.71	0.00	0.00	5.62	0.70	0.00	1.47	73.41	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
SE.010	average	0.00	7.58	0.00	0.00	0.76	0.00	0.00	0.01	0.00	0.05	17.41	12.62	0.00	0.00	7.84	0.53	0.00	1.32	64.24	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
SE.011	kyxx 450	0.12	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	35.81	25.95	0.00	0.00	5.17	0.00	0.00	3.82	42.02	0.00	0.00	5.75	0.00	0.00	0.00	0.24	0.00
SE.011	kyxx 450	0.11	6.63	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.15	34.94	25.31	0.00	0.00	9.19	0.00	0.00	3.72	40.39	0.00	0.00	4.64	0.00	0.00	0.00	0.23	0.00
SE.011	kyxx 450	0.11	6.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	35.07	25.41	0.00	0.00	12.58	0.00	0.00	3.56	37.84	0.00	0.00	4.26	0.00	0.00	0.00	0.19	0.00
SE.011	average	0.11	6.61	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.11	35.28	25.56	0.00	0.00	8.98	0.00	0.00	3.70	40.08	0.00	0.00	4.88	0.00	0.00	0.00	0.22	0.00
SE.011	kyxx 450	0.12	4.88	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.22	46.94	34.01	0.00	0.00	12.27	0.00	0.00	2.36	27.45	0.00	0.00	5.36	0.00	0.00	0.00	0.34	0.00
SE.011	kyxx 450	0.10	7.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	34.97	25.34	0.00	0.00	0.00	0.00	0.00	4.09	44.43	0.00	0.00	9.00	0.00	0.00	0.00	0.36	0.00
SE.011	kyxx 450	0.13	7.50	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	38.44	27.85	0.00	0.00	8.03	0.00	0.00	3.52	37.12	0.00	0.00	4.92	0.00	0.00	0.00	0.21	0.00
SE.011	average	0.12	6.47	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	40.12	29.06	0.00	0.00	6.77	0.00	0.00	3.32	36.33	0.00	0.00	6.43	0.00	0.00	0.00	0.31	0.00
SE.012	rf554	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.30	0.18	0.00	11.86	8.59	0.00	0.00	21.94	0.00	0.00	4.57	60.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE.012	rf554	0.00	5.06	0.00	0.00	0.00	0.00	0.02	0.03	0.01	0.05	7.18	5.20	0.00	0.00	17.68	0.00	0.00	4.77	64.44	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00
SE.012	rf554	0.11	5.86	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.07	7.18	5.20	0.00	0.03	18.39	0.00	0.00	5.14	61.77	0.00	0.00	0.62	0.00	0.00	0.00	0.14	0.00
SE.012	average	0.00	3.64	0.00	0.00	0.23	0.00	0.13	0.11	0.06	0.00	8.74	6.33	0.00	0.00	19.34	0.00	0.00	4.83	62.33	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00
SE.013	rf1193	0.00	2.46	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	4.92	3.57	0.00	0.00	6.71	0.00	0.00	11.66	73.17	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00
SE.013	rf1193	0.07	3.58	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00	5.01	3.63	0.00	0.00	5.05	0.00	0.00	11.83	73.08	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00
SE.013	rf1193	0.00	3.73	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.03	5.42	3.93	0.00	0.00	5.77	0.00	0.00	11.74	72.08	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
SE.013	average	0.00	3.26	0.00	0.00	0.19	0.00	0.00	0.01	0.00	0.00	5.12	3.71	0.00	0.00	5.84	0.00	0.00	11.74	72.77	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00
SE.014	lin-7228a7 side a	0.19	2.99	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.10	4.66	3.38	0.00	0.00	62.24	0.00	0.00	0.51	27.10	0.01	0.00	1.72	0.07	0.02	0.06	0.30	0.00
SE.014	lin-7228a7 side a	0.13	1.76	0.01	0.00	6.34	0.00	0.00	0.00	0.01	0.09	4.53	3.28	0.00	0.00	46.53	0.02	0.00	1.06	36.76	0.00	0.00	2.33	0.07	0.00	0.06	0.29	0.00
SE.014	lin-7228a7 side a	0.12	1.56	0.00	0.00	10.79	0.00	0.00	0.00	0.01	0.09	4.48	3.25	0.00	0.00	44.27	0.07	0.00	1.10	34.25	0.00	0.00	2.78	0.09	0.00	0.07	0.29	0.00
SE.014	average	0.15	2.10	0.01	0.00	5.71	0.00	0.00	0.00	0.01	0.09	4.56	3.30	0.00	0.00	51.01	0.03	0.00	0.89	32.70	0.00	0.00	2.27	0.08	0.00	0.06	0.30	0.00
SE.014	lin-7228a7 side b	0.28	4.04	0.03	0.00	0.23	0.00	0.01	0.00	0.00	0.26		0.00		0.00	43.40	1.10	0.00			0.24	0.00	3.06	0.24	0.13	0.26	0.81	0.00
SE.014	lin-7228a7 side b	0.14	2.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.07	4.10	2.97	0.00	0.00	46.18	0.00	0.00	1.30	43.72	0.00	0.00	1.97	0.08	0.00	0.04	0.20	0.00
SE.014	lin-7228a7 side b	0.14	2.20	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	4.05	2.94	0.00	0.00	47.13	0.00	0.00	1.33	42.75	0.00	0.00	1.99	0.10	0.00	0.03	0.21	0.00
SE.014	average	0.18	2.81	0.02	0.00	0.08	0.00	0.01	0.00	0.00	0.13	2.72	1.97	0.00	0.00	45.57	0.37	0.00	0.88	28.82	0.08	0.00	2.34	0.14	0.04	0.11	0.41	0.00
SE.015	tf 0653 4982 (1)	0.07	2.58	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.00	27.87	20.19	0.00	0.00	0.00	0.00	0.00	3.86	64.01	0.00	0.00	1.24	0.00	0.00	0.00	0.10	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
SE.015	tf 0653 4982 (1)	0.08	2.07	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	22.78	16.50	0.00	0.00	0.00	0.00	0.00	4.21	68.11	0.00	0.00	0.75	0.00	0.00	0.00	0.08	0.00
SE.015	tf 0653 4982 (1)	0.08	2.04	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.04	24.91	18.05	0.00	0.00	9.34	0.00	0.00	3.45	59.09	0.00	0.00	0.70	0.00	0.00	0.00	0.12	0.00
SE.015	average	0.08	2.23	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.00	25.18	18.25	0.00	0.00	3.68	0.00	0.00	3.84	63.74	0.00	0.00	0.90	0.00	0.00	0.00	0.10	0.00
SE.015	tf 0653 4982 (2)	0.14	0.50	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.05	5.51	3.99	0.00	0.00	30.82	0.00	0.00	7.94	51.30	0.02	0.00	3.13	0.00	0.02	0.03	0.16	0.00
SE.015	tf 0653 4982 (2)	0.15	0.61	0.00	0.00	1.54	0.00	0.00	0.00	0.01	0.07	6.70	4.85	0.00	0.00	34.24	0.00	0.00	5.17	45.20	0.00	0.00	5.95	0.02	0.02	0.05	0.27	0.00
SE.015	tf 0653 4982 (2)	0.12	0.41	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.04	4.59	3.33	0.00	0.00	28.46	0.00	0.00	8.58	55.58	0.02	0.00	1.90	0.00	0.00	0.00	0.08	0.00
SE.015	average	0.14	0.51	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.05	5.60	4.06	0.00	0.00	31.17	0.00	0.00	7.23	50.69	0.02	0.00	3.66	0.00	0.00	0.00	0.17	0.00
SE.016	slad 2	0.04	2.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	38.63	27.99	0.00	0.03	21.47	0.00	0.00	1.46	34.76	0.00	0.00	0.92	0.00	0.00	0.00	0.12	0.00
SE.016	slad 2	0.07	1.79	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.43	40.59	29.41	0.00	0.05	30.86	0.00	0.00	1.04	24.30	0.03	0.00	0.57	0.00	0.03	0.04	0.19	0.00
SE.016	slad 2	0.05	2.31	0.01	0.00	0.25	0.00	0.00	0.00	0.00	0.35	36.08	26.14	0.00	0.03	26.77	0.00	0.00	1.27	31.97	0.00	0.00	0.71	0.00	0.00	0.00	0.15	0.00
SE.016	average	0.05	2.13	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.36	38.44	27.85	0.00	0.04	26.37	0.00	0.00	1.26	30.35	0.00	0.00	0.73	0.00	0.00	0.00	0.15	0.00
SE.016	slad 2	0.05	2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.34	37.43	27.12	0.00	0.04	25.18	0.00	0.00	1.09	32.66	0.02	0.00	0.77	0.00	0.00	0.00	0.14	0.00
SE.016	slad 2	0.04	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	39.63	28.71	0.00	0.04	24.27	0.00	0.00	1.13	31.06	0.02	0.00	0.86	0.00	0.00	0.00	0.80	0.00
SE.016	slad 2	0.05	1.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	37.57	27.22	0.00	0.04	26.56	0.00	0.00	1.07	30.45	0.00	0.00	0.86	0.00	0.00	0.00	1.10	0.00
SE.016	average	0.05	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	38.21	27.69	0.00	0.04	25.34	0.00	0.00	1.10	31.39	0.02	0.00	0.83	0.00	0.00	0.00	0.68	0.00
SE.017	lin-2c7956	0.05	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	14.87	10.78	0.00	0.00	16.18	0.00	0.00	6.91	58.99	0.00	0.00	1.35	0.00	0.00	0.00	0.07	0.00
SE.017	lin-2c7956	0.05	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.21	5.23	0.00	0.00	16.99	0.00	0.00	8.25	65.10	0.02	0.00	0.82	0.00	0.00	0.00	0.05	0.00
SE.017	lin-2c7956	0.06	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.32	3.13	0.00	0.00	13.13	0.00	0.00	9.60	71.06	0.00	0.00	0.35	0.00	0.00	0.00	0.05	0.00
SE.017	lin-2c7956	0.08	2.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	5.64	4.08	0.00	0.00	29.30	0.00	0.00	5.05	56.27	0.00	0.00	1.17	0.00	0.00	0.00	0.13	0.00
SE.017	lin-2c7956	0.07	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	4.91	3.56	0.00	0.00	24.40	0.00	0.00	6.04	61.42	0.00	0.00	1.21	0.00	0.00	0.00	0.07	0.00
SE.017	lin-2c7956	0.07	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	5.21	3.77	0.00	0.00	25.69	0.00	0.00	5.46	60.12	0.00	0.00	1.26	0.00	0.00	0.00	0.08	0.00
SE.017	average	0.06	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	7.03	5.09	0.00	0.00	20.95	0.00	0.00	6.88	62.16	0.00	0.00	1.03	0.00	0.00	0.00	0.08	0.00
SE.017	lin-2c7956	0.04	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.92	10.81	0.00	0.00	15.48	0.00	0.00	7.08	59.40	0.00	0.00	1.45	0.00	0.00	0.00	0.07	0.00
SE.017	lin-2c7956	0.05	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.15	5.18	0.00	0.00	15.48	0.00	0.00	8.80	66.28	0.02	0.00	0.73	0.00	0.00	0.00	0.05	0.00
SE.017	lin-2c7956	0.05	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.29	3.11	0.00	0.00	13.72	0.00	0.00	9.21	70.91	0.00	0.00	0.35	0.00	0.00	0.00	0.05	0.00
SE.017	lin-2c7956	0.07	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	4.99	3.62	0.00	0.00	26.73	0.00	0.00	5.34	59.76	0.00	0.00	0.96	0.00	0.00	0.00	0.09	0.00

REF NUM	***SAMPLE***	***Sb***	***Sn***	***Cd***	***Pd***	***Ag***	***Ru***	***Mo***	***Nb***	***Zr***	***Bi***	***Pb***	***Pb (scaled down)***	***Hg***	***Se***	***As***	***Au***	***W***	***Zn***	***Cu***	***Ni***	***Co***	***Fe***	***Mn***	***Cr***	***V***	***Ti***	***Al***
SE.017	lin-2c7956	0.06	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	4.76	3.45	0.00	0.00	23.56	0.00	0.00	6.27	62.35	0.00	0.00	1.10	0.00	0.00	0.00	0.06	0.00
SE.017	lin-2c7956	0.07	2.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	5.18	3.75	0.00	0.00	23.68	0.00	0.00	5.45	62.47	0.00	0.00	0.99	0.00	0.00	0.00	0.08	0.00
SE.017	average	0.06	1.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	6.88	4.99	0.00	0.00	19.78	0.00	0.00	7.03	63.53	0.00	0.00	0.93	0.00	0.00	0.00	0.07	0.00
SE.018	RAAM 63	0.02	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.36	37.73	27.33	0.00	0.04	27.90	0.00	0.00	0.88	31.20	0.00	0.00	1.38	0.00	0.00	0.00	0.34	0.00
SE.018	RAAM 63	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.26	35.05	25.40	0.00	0.03	23.48	0.00	0.00	1.25	38.09	0.00	0.00	1.23	0.00	0.00	0.00	0.22	0.00
SE.018	RAAM 63	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.24	36.83	26.68	0.00	0.02	19.04	0.00	0.00	1.54	38.59	0.00	0.00	2.85	0.00	0.00	0.00	0.23	0.00
SE.018	average	0.02	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.29	36.54	26.47	0.00	0.03	23.47	0.00	0.00	1.23	35.96	0.00	0.00	1.82	0.00	0.00	0.00	0.27	0.00
SE.018	RAAM 63	0.03	4.05	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.30	34.20	24.78	0.00	0.03	25.59	0.00	0.00	2.12	30.86	0.00	0.00	2.37	0.00	0.00	0.00	0.38	0.00
SE.018	RAAM 63	0.03	0.48	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.33	32.59	23.61	0.00	0.04	31.66	0.00	0.00	1.67	32.02	0.00	0.00	0.55	0.00	0.00	0.00	0.55	0.00
SE.018	RAAM 63	0.03	0.28	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.30	29.74	21.55	0.00	0.03	32.35	0.00	0.00	2.25	33.92	0.02	0.00	0.67	0.00	0.00	0.04	0.34	0.00
SE.018	average	0.03	1.60	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.31	32.18	23.31	0.00	0.03	29.87	0.00	0.00	2.02	32.27	0.00	0.00	1.19	0.00	0.00	0.00	0.43	0.00
SE.019	sfn012	0.10	1.28	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.03	2.45	1.77	0.00	0.03	16.37	0.00	0.00	5.07	73.53	0.00	0.00	0.76	0.00	0.00	0.00	0.11	0.00
SE.019	sfn012	0.13	1.57	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.04	3.30	2.39	0.00	0.04	20.71	0.00	0.00	4.87	68.12	0.00	0.00	0.75	0.00	0.00	0.00	0.14	0.00
SE.019	sfn012	0.12	1.47	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.04	3.48	2.52	0.00	0.04	23.03	0.00	0.00	5.66	65.04	0.00	0.00	0.71	0.00	0.00	0.00	0.12	0.00
SE.019	average	0.12	1.44	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.04	3.08	2.23	0.00	0.04	20.04	0.00	0.00	5.20	68.89	0.00	0.00	0.74	0.00	0.00	0.00	0.12	0.00
SE.020	sfn011	0.05	1.03	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.07	9.83	7.12	0.00	0.00	21.84	0.00	0.00	7.00	58.96	0.00	0.00	0.89	0.00	0.00	0.00	0.10	0.00
SE.020	sfn011	0.05	0.94	0.00	0.00	7.05	0.00	0.00	0.00	0.00	0.12	10.90	7.89	0.00	0.00	27.10	0.00	0.00	4.96	48.11	0.00	0.00	0.60	0.00	0.00	0.00	0.16	0.00
SE.020	sfn011	0.04	1.06	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.07	8.78	6.36	0.00	0.00	24.30	0.00	0.00	5.83	59.18	0.00	0.00	0.45	0.00	0.00	0.00	0.07	0.00
SE.020	average	0.05	1.01	0.00	0.00	2.49	0.00	0.00	0.00	0.00	0.08	9.83	7.12	0.00	0.00	24.41	0.00	0.00	5.93	55.42	0.00	0.00	0.65	0.00	0.00	0.00	0.11	0.00
SE.021	sfn009	0.02	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.48	5.14	3.72	0.00	0.00	3.08	0.00	0.00	15.94	71.36	0.06	0.00	2.73	0.03	0.00	0.00	0.07	0.00
SE.021	sfn009	0.03	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	3.09	2.24	0.00	0.00	6.81	0.00	1.79	18.68	67.02	0.05	0.00	1.22	0.02	0.00	0.06	0.00	0.00
SE.021	sfn009	0.03	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	3.11	2.25	0.00	0.00	2.04	0.00	0.62	20.59	59.97	0.05	0.00	12.43	0.03	0.00	0.06	0.00	0.00
SE.021	average	0.03	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.34	3.78	2.74	0.00	0.00	3.98	0.00	0.80	18.40	66.12	0.05	0.00	5.46	0.03	0.00	0.05	0.00	0.00
SE.022	lin-71ba17	0.07	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66	2.65	0.00	0.00	8.57	0.00	0.00	9.68	75.61	0.02	0.00	1.62	0.00	0.00	0.00	0.00	0.00
SE.022	lin-71ba17	0.06	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.32	1.68	0.00	0.00	3.93	0.00	0.00	14.44	78.33	0.03	0.00	0.31	0.00	0.00	0.00	0.00	0.00
SE.022	lin-71ba17	0.07	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.79	2.02	0.00	0.00	5.39	0.00	0.00	11.39	78.16	0.02	0.00	1.53	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SE.022	average	0.07	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.92	2.12	0.00	0.00	5.96	0.00	0.00	11.83	77.37	0.02	0.00	1.16	0.00	0.00	0.00	0.00	0.00
SE.023	tf 0653 4982 (1)	0.07	2.58	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.00	27.87	0.00	0.00	0.00	0.00	0.00	3.86	64.01	0.00	0.00	1.24	0.00	0.00	0.00	0.10	0.00	
SE.023	tf 0653 4982 (1)	0.08	2.07	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	22.78	0.00	0.00	0.00	0.00	0.00	4.21	68.11	0.00	0.00	0.75	0.00	0.00	0.00	0.08	0.00	
SE.023	tf 0653 4982 (1)	0.08	2.04	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.04	24.91	0.00	0.00	9.34	0.00	0.00	3.45	59.09	0.00	0.00	0.70	0.00	0.00	0.00	0.12	0.00	
SE.023	tf 0653 4982 (1)	0.08	2.23	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.00	25.18	0.00	0.00	3.68	0.00	0.00	3.84	63.74	0.00	0.00	0.90	0.00	0.00	0.00	0.10	0.00	
SE.023	tf 0653 4982 (2)	0.14	0.50	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.05	5.51	0.00	0.00	30.82	0.00	0.00	7.94	51.30	0.02	0.00	3.13	0.00	0.02	0.03	0.16	0.00	
SE.023	tf 0653 4982 (2)	0.15	0.61	0.00	0.00	1.54	0.00	0.00	0.00	0.01	0.07	6.70	0.00	0.00	34.24	0.00	0.00	5.17	45.20	0.00	0.00	5.95	0.02	0.02	0.05	0.27	0.00	
SE.023	tf 0653 4982 (2)	0.12	0.41	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.04	4.59	0.00	0.00	28.46	0.00	0.00	8.58	55.58	0.02	0.00	1.90	0.00	0.00	0.00	0.08	0.00	
SE.023	tf 0653 4982 (2)	0.14	0.51	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.05	5.60	0.00	0.00	31.17	0.00	0.00	7.23	50.69	0.02	0.00	3.66	0.00	0.00	0.00	0.17	0.00	
SE.024	lin-a57432	0.03	0.31	0.00	0.00	0.68	0.00	0.00	0.00	0.01	0.00	0.49	0.35	0.00	0.00	5.14	0.00	0.00	5.86	86.77	0.00	0.00	0.60	0.02	0.00	0.00	0.07	0.00
SE.024	lin-a57432	0.04	0.45	0.00	0.00	1.18	0.00	0.00	0.00	0.01	0.01	1.08	0.78	0.00	0.00	8.77	0.00	0.00	4.72	82.61	0.00	0.00	0.99	0.04	0.00	0.00	0.11	0.00
SE.024	lin-a57432	0.02	0.26	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.39	0.29	0.00	0.00	4.62	0.00	0.00	5.50	88.39	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
SE.024	average	0.03	0.34	0.00	0.00	0.80	0.00	0.00	0.00	0.01	0.00	0.65	0.47	0.00	0.00	6.18	0.00	0.00	5.36	85.92	0.00	0.00	0.61	0.02	0.00	0.00	0.06	0.00
SE.025	2002.033.696	0.49	0.14	0.02	0.00	4.43	0.00	0.00	0.00	0.00	0.75		0.00		0.00	45.43	0.83	0.00			0.19	0.00	4.36	0.37	0.20	2.37	5.51	0.00
SE.025	2002.033.696	0.28	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	8.98	6.50	0.00	0.00	11.42	0.00	0.00	2.44	57.57	0.00	0.00	2.32	0.04	0.00	0.28	0.80	4.60
SE.025	2002.033.696	0.49	0.25	0.00	0.00	4.75	0.00	0.00	0.00	0.00	0.81		0.00		0.00	49.13	0.83	0.00			0.22	0.00	4.86	0.29	0.17	1.74	3.95	0.00
SE.025	average	0.42	0.17	0.00	0.00	3.06	0.00	0.00	0.00	0.00	0.58		0.00		0.00	35.32	0.55	0.00			0.14	0.00	3.85	0.23	0.13	1.46	3.42	2.20
SE.025	2002.033.696	0.25	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	5.13	3.72	0.00	0.00	3.93	0.00	0.00	2.42	67.40	0.00	0.00	1.74	0.13	0.00	1.09	2.58	5.39
SE.025	2002.033.696	0.28	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17	9.02	6.53	0.00	0.00	9.37	0.00	0.00	2.39	58.42	0.00	0.00	2.15	0.08	0.00	0.64	1.61	4.92
SE.025	2002.033.696	0.75	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70		0.00		0.08	26.44	0.00	8.79			0.47	0.00	5.61	0.51	0.30	2.20	5.46	0.00
SE.025	average	0.42	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34		0.00		0.03	13.25	0.00	2.93			0.16	0.00	3.17	0.24	0.10	1.31	3.22	3.44
SE.026	1986-12-6	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.27	13.24	0.00	0.00	2.83	0.00	0.00	5.67	71.44	0.00	0.00	1.62	0.00	0.00	0.00	0.00	0.00
SE.026	1986-12-6	0.01	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.92	5.01	0.00	0.00	6.09	0.00	0.00	6.93	79.67	0.02	0.00	0.29	0.00	0.00	0.00	0.00	0.00
SE.026	1986-12-6	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.37	5.34	0.00	0.00	8.90	0.00	0.00	6.47	76.88	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00
SE.026	average	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.85	7.86	0.00	0.00	5.94	0.00	0.00	6.36	75.99	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00
SE.026	1986-12-6	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	23.36	16.93	0.00	0.00	0.00	0.00	0.00	4.37	68.03	0.04	0.00	3.85	0.00	0.00	0.00	0.19	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SE.026	1986-12-6	0.02	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.12	18.92	0.00	0.00	0.00	0.00	0.00	3.98	66.27	0.00	0.00	3.42	0.00	0.00	0.00	0.07	0.00
SE.026	1986-12-6	0.03	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.11	21.09	0.00	0.00	0.00	0.00	0.00	3.90	63.84	0.00	0.00	2.95	0.00	0.00	0.00	0.07	0.00
SE.026	average	0.02	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	26.19	18.98	0.00	0.00	0.00	0.00	0.00	4.08	66.05	0.00	0.00	3.41	0.00	0.00	0.00	0.11	0.00
SE.027	tf 46899 68617	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.21	1.60	0.00	0.00	5.40	0.00	0.00	7.77	84.37	0.04	0.00	0.14	0.00	0.00	0.00	0.00	0.00
SE.027	tf 46899 68617	0.03	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.63	2.63	0.00	0.00	6.13	0.00	0.00	7.49	82.18	0.04	0.00	0.40	0.00	0.00	0.00	0.00	0.00
SE.027	tf 46899 68617	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.11	1.53	0.00	0.00	4.15	0.00	0.00	8.75	84.78	0.05	0.00	0.11	0.00	0.00	0.00	0.00	0.00
SE.027	average	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.65	1.92	0.00	0.00	5.23	0.00	0.00	8.00	83.78	0.05	0.00	0.22	0.00	0.00	0.00	0.00	0.00
SE.028	kmax s	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.18	22.74	16.48	0.00	0.03	25.83	0.00	0.00	2.47	48.18	0.00	0.00	0.38	0.00	0.00	0.00	0.09	0.00
SE.028	kmax s	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	21.34	15.46	0.00	0.03	26.42	0.00	0.00	2.45	49.05	0.00	0.00	0.37	0.00	0.00	0.00	0.07	0.00
SE.028	kmax s	0.04	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.19	21.10	15.29	0.00	0.03	27.04	0.00	0.00	2.44	48.54	0.00	0.00	0.44	0.00	0.00	0.00	0.12	0.00
SE.028	average	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.18	21.73	15.74	0.00	0.03	26.43	0.00	0.00	2.46	48.59	0.00	0.00	0.40	0.00	0.00	0.00	0.10	0.00
SE.028	kmax s	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	24.52	17.76	0.00	0.04	27.68	0.00	0.00	1.98	44.55	0.00	0.00	0.47	0.00	0.00	0.00	0.49	0.00
SE.028	kmax s	0.05	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.24	26.15	18.95	0.00	0.04	31.97	0.00	0.00	1.99	38.89	0.00	0.00	0.36	0.00	0.00	0.03	0.20	0.00
SE.028	kmax s	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.21	23.43	16.98	0.00	0.04	28.62	0.00	0.00	1.94	45.16	0.00	0.00	0.35	0.00	0.00	0.00	0.13	0.00
SE.028	average	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.22	24.70	17.90	0.00	0.04	29.42	0.00	0.00	1.97	42.87	0.00	0.00	0.39	0.00	0.00	0.00	0.27	0.00
SE.029	sfn008	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.31	41.71	30.22	0.00	0.03	23.31	0.00	0.00	1.45	29.66	0.03	0.00	2.80	0.04	0.00	0.00	0.48	0.00
SE.029	sfn008	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.19	40.75	29.52	0.00	0.02	15.28	0.00	0.00	1.61	38.74	0.00	0.00	2.83	0.06	0.00	0.00	0.44	0.00
SE.029	sfn008	0.05	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.19	29.42	21.31	0.00	0.02	19.53	0.00	0.00	2.14	46.31	0.00	0.00	1.97	0.03	0.00	0.00	0.27	0.00
SE.029	average	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.23	37.29	27.02	0.00	0.02	19.37	0.00	0.00	1.73	38.24	0.00	0.00	2.53	0.04	0.00	0.00	0.40	0.00
SE.030	sfxx 164	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.01	0.04	0.08	48.00	34.77	0.00	0.00	0.00	0.00	0.00	1.79	43.79	0.00	0.00	5.50	0.11	0.00	0.00	0.44	0.00
SE.030	sfxx 164	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.01	0.06	0.00	42.08	30.49	0.00	0.00	0.00	0.00	0.00	1.85	50.01	0.00	0.00	5.14	0.08	0.00	0.00	0.47	0.00
SE.030	sfxx 164	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.01	0.03	0.08	34.56	25.04	0.00	0.00	6.40	0.00	0.00	1.79	52.66	0.00	0.00	3.80	0.04	0.00	0.00	0.41	0.00
SE.030	average	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.01	0.04	0.07	41.55	30.10	0.00	0.00	0.00	0.00	0.00	1.81	48.82	0.00	0.00	4.81	0.08	0.00	0.00	0.44	0.00
SE.030	sfxx 164	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.10	24.58	17.81	0.00	0.02	13.62	0.00	0.00	1.48	59.32	0.00	0.00	0.72	0.00	0.00	0.00	0.11	0.00
SE.030	sfxx 164	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	27.94	20.24	0.00	0.00	6.46	0.00	0.00	1.45	62.67	0.00	0.00	1.22	0.02	0.00	0.00	0.13	0.00
SE.030	sfxx 164	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	24.25	17.57	0.00	0.02	12.79	0.00	0.00	1.54	60.45	0.00	0.00	0.72	0.00	0.00	0.00	0.08	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SE.030	average	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.09	25.59	18.54	0.00	0.02	10.96	0.00	0.00	1.49	60.81	0.00	0.00	0.89	0.00	0.00	0.00	0.10	0.00
SE.031	lin-5020b3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.39	7.53	0.00	0.00	0.00	0.00	0.00	7.17	80.97	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.77
SE.031	lin-5020b3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.04	8.72	0.00	0.00	0.00	0.00	0.00	5.37	79.26	0.00	0.00	0.19	0.00	0.00	0.00	0.00	1.33
SE.031	lin-5020b3	0.13	0.04	0.04	0.00	0.32	0.00	0.00	0.00	0.00	1.00		0.00		0.00	64.42	1.14	0.00			0.28	0.00	0.38	0.14	0.22	0.30	0.64	0.00
SE.031	average	0.05	0.02	0.01	0.00	0.11	0.00	0.00	0.00	0.00	0.33		0.00		0.00	21.47	0.38	0.00			0.09	0.00	0.22	0.05	0.07	0.10	0.21	0.00
SE.031	lin-5020b3 back	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.79	12.16	0.00	0.00	0.00	0.00	0.00	2.89	77.97	0.00	0.00	0.23	0.00	0.00	0.00	0.00	1.57
SE.031	lin-5020b3 back	0.11	0.04	0.03	0.00	0.31	0.00	0.00	0.00	0.00	0.92		0.00		0.04	62.75	0.00	1.83			0.25	0.00	1.34	0.11	0.19	0.26	0.53	0.00
SE.031	lin-5020b3 back	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.01	10.15	0.00	0.00	0.00	0.00	0.00	3.66	79.40	0.00	0.00	0.57	0.00	0.00	0.00	0.00	1.25
SE.031	average	0.04	0.02	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.31	10.27	7.44	0.00	0.01	20.92	0.00	0.61	2.18	52.46	0.08	0.00	0.71	0.04	0.06	0.09	0.18	0.94
SE.032	lin-5020b3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.39	7.53	0.00	0.00	0.00	0.00	0.00	7.17	80.97	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.77
SE.032	lin-5020b3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.04	8.72	0.00	0.00	0.00	0.00	0.00	5.37	79.26	0.00	0.00	0.19	0.00	0.00	0.00	0.00	1.33
SE.032	lin-5020b3	0.13	0.04	0.04	0.00	0.32	0.00	0.00	0.00	0.00	1.00		0.00		0.00	64.42	1.14	0.00			0.28	0.00	0.38	0.14	0.22	0.30	0.64	0.00
SE.032	average	0.05	0.02	0.01	0.00	0.11	0.00	0.00	0.00	0.00	0.33		0.00		0.00	21.47	0.38	0.00			0.09	0.00	0.22	0.05	0.07	0.10	0.21	0.00
SE.032	lin-5020b3 back	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.79	12.16	0.00	0.00	0.00	0.00	0.00	2.89	77.97	0.00	0.00	0.23	0.00	0.00	0.00	0.00	1.57
SE.032	lin-5020b3 back	0.11	0.04	0.03	0.00	0.31	0.00	0.00	0.00	0.00	0.92		0.00		0.04	62.75	0.00	1.83			0.25	0.00	1.34	0.11	0.19	0.26	0.53	0.00
SE.032	lin-5020b3 back	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.01	10.15	0.00	0.00	0.00	0.00	0.00	3.66	79.40	0.00	0.00	0.57	0.00	0.00	0.00	0.00	1.25
SE.032	average	0.04	0.02	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.31	10.27	7.44	0.00	0.01	20.92	0.00	0.61	2.18	52.46	0.08	0.00	0.71	0.04	0.06	0.09	0.18	0.94
SE.032	lin-6d3ab7	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.40	0.00	0.00	9.47	0.00	0.00	13.79	76.09	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
SE.032	lin-6d3ab7	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.34	0.00	0.00	8.71	0.00	0.00	13.33	77.38	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00
SE.032	lin-6d3ab7	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.43	0.00	0.00	6.12	0.00	0.00	8.11	85.05	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
SE.032	average	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.39	0.00	0.00	8.10	0.00	0.00	11.74	79.51	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
SP.001	lin-863764	0.13	37.93	0.00	0.00	0.35	0.00	0.00	0.00	0.01	0.03	9.09	6.59	0.00	0.00	0.00	0.00	0.00	0.50	20.62	0.00	0.00	11.37	0.00	0.00	0.00	0.43	5.45
SP.001	lin-863764	0.13	39.42	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.03	9.46	6.86	0.00	0.00	0.00	0.00	0.00	0.56	23.04	0.00	0.00	10.51	0.00	0.00	0.00	0.45	4.43
SP.001	lin-863764	0.12	36.69	0.00	0.00	0.35	0.00	0.00	0.00	0.01	0.03	8.53	6.18	0.00	0.00	0.00	0.00	0.00	0.57	24.03	0.00	0.00	8.97	0.00	0.00	0.00	0.39	5.23
SP.001	average	0.13	38.01	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.03	9.03	6.54	0.00	0.00	0.00	0.00	0.00	0.54	22.57	0.00	0.00	10.28	0.00	0.00	0.00	0.42	5.04
SP.001	lin-863764	0.14	39.33	0.00	0.00	0.38	0.00	0.00	0.00	0.01	0.03	9.61	6.96	0.00	0.00	0.00	0.00	0.00	0.63	26.23	0.00	0.00	10.58	0.00	0.00	0.00	0.52	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SP.001	lin-863764	0.14	38.42	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.03	9.42	6.82	0.00	0.00	0.00	0.00	0.00	0.64	26.14	0.00	0.00	10.85	0.00	0.00	0.00	0.48	3.09
SP.001	lin-863764	0.13	38.14	0.00	0.00	0.33	0.00	0.00	0.00	0.01	0.04	9.52	6.90	0.00	0.00	0.00	0.00	0.00	0.54	19.96	0.00	0.00	14.00	0.00	0.00	0.00	0.45	4.77
SP.001	average	0.14	38.63	0.00	0.00	0.35	0.00	0.00	0.00	0.01	0.03	9.52	6.90	0.00	0.00	0.00	0.00	0.00	0.60	24.11	0.00	0.00	11.81	0.00	0.00	0.00	0.48	3.39
SP.002	lin-a71381sideb	0.11	15.97	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.04	5.25	3.80	0.00	0.00	5.71	0.02	0.00	1.12	70.39	0.02	0.00	0.84	0.00	0.00	0.00	0.28	0.00
SP.002	lin-a71381sideb	0.11	15.35	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.04	5.87	4.25	0.00	0.00	6.52	0.04	0.00	1.11	69.58	0.03	0.00	0.85	0.00	0.00	0.00	0.27	0.00
SP.002	lin-a71381sideb	0.10	16.31	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.04	4.99	3.61	0.00	0.00	5.60	0.03	0.00	1.00	70.76	0.00	0.00	0.62	0.00	0.00	0.00	0.27	0.00
SP.002	average	0.11	16.25	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.05	4.88	3.53	0.00	0.02	4.99	0.00	0.00	1.24	70.82	0.02	0.00	1.05	0.00	0.00	0.00	0.29	0.00
SP.002	lin-a71381side a	0.08	12.04	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.03	3.92	2.84	0.00	0.00	3.53	0.00	0.00	1.28	78.07	0.03	0.00	0.70	0.00	0.00	0.00	0.24	0.00
SP.002	lin-a71381side a	0.08	10.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.19	2.31	0.00	0.02	2.36	0.00	0.00	1.02	81.93	0.03	0.00	0.49	0.00	0.00	0.00	0.19	0.00
SP.002	lin-a71381side a	0.07	11.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.55	2.57	0.00	0.00	3.45	0.00	0.00	1.02	79.46	0.03	0.00	0.42	0.00	0.00	0.00	0.25	0.00
SP.002	average	0.10	13.69	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.06	5.03	3.64	0.00	0.00	4.79	0.00	0.00	1.80	72.81	0.03	0.00	1.19	0.00	0.00	0.00	0.27	0.00
SU.001	lin-4b503c	0.12	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	1.14	0.83	0.00	0.00	2.78	0.00	0.00	7.60	87.82	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00
SU.001	lin-4b503c	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	1.09	0.79	0.00	0.00	3.09	0.00	0.00	6.38	88.78	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00
SU.001	lin-4b503c	0.11	10.92	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	9.75	7.07	0.00	0.00	4.98	0.00	0.00	4.31	68.46	0.04	0.00	1.25	0.00	0.00	0.00	0.13	0.00
SU.001	average	0.12	3.66	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	3.99	2.89	0.00	0.00	3.62	0.00	0.00	6.10	81.69	0.02	0.00	0.70	0.00	0.00	0.00	0.06	0.00
SU.002	lin-e9d910	10.58	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.47	34.16	24.75	0.00	0.03	26.77	0.00	0.00	0.04	17.37	0.26	0.00	9.08	0.00	0.00	0.00	0.22	0.00
SU.002	lin-e9d910	10.35	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.39	32.82	23.78	0.00	0.02	25.29	0.00	0.00	0.09	15.80	0.13	0.00	14.00	0.00	0.00	0.00	0.20	0.00
SU.002	lin-e9d910	10.53	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.48	33.35	24.16	0.00	0.03	31.82	0.00	0.00	0.04	14.09	0.29	0.00	7.87	0.00	0.00	0.07	0.17	0.00
SU.002	average	10.49	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.45	33.44	24.23	0.00	0.03	27.96	0.00	0.00	0.06	15.75	0.22	0.00	10.32	0.00	0.00	0.00	0.20	0.00
SU.003	1989-366-1	0.33	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	9.89	7.16	0.00	0.00	14.83	0.00	0.00	2.17	71.36	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00
SU.003	1989-366-1	0.31	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	8.93	6.47	0.00	0.00	12.04	0.00	0.00	2.54	74.88	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00
SU.003	1989-366-1	0.34	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	10.60	7.68	0.00	0.00	13.17	0.00	0.00	1.73	72.67	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00
SU.003	average	0.33	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	9.81	7.10	0.00	0.00	13.35	0.00	0.00	2.15	72.97	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00
SU.003	1989-366-1	0.33	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	13.00	9.42	0.00	0.00	17.10	0.00	0.00	2.02	66.18	0.00	0.00	0.54	0.00	0.00	0.00	0.05	0.00
SU.003	1989-366-1	0.31	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	11.89	8.61	0.00	0.00	14.62	0.00	0.00	2.48	69.52	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00
SU.003	1989-366-1	0.34	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	11.84	8.58	0.00	0.00	12.19	0.00	0.00	2.41	72.02	0.00	0.00	0.43	0.00	0.00	0.00	0.06	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SU.003	average	0.33	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	12.24	8.87	0.00	0.00	14.64	0.00	0.00	2.30	69.24	0.00	0.00	0.46	0.00	0.00	0.00	0.05	0.00
SU.004	lin-599a34	0.15	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	4.13	2.99	0.00	0.00	0.00	0.00	0.00	7.02	87.83	0.02	0.00	0.31	0.00	0.00	0.00	0.00	0.00
SU.004	lin-599a34	0.15	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	3.17	2.30	0.00	0.00	0.00	0.00	0.00	7.22	88.55	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00
SU.004	lin-599a34	0.16	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	5.13	3.72	0.00	0.00	0.00	0.00	0.00	7.14	86.43	0.03	0.00	0.46	0.00	0.00	0.00	0.00	0.00
SU.004	average	0.15	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	4.14	3.00	0.00	0.00	0.00	0.00	0.00	7.13	87.61	0.02	0.00	0.37	0.00	0.00	0.00	0.00	0.00
SU.005	lin-3af7d7	0.34	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.28	32.58	23.60	0.00	0.00	27.78	0.00	0.00	2.80	27.61	0.02	0.00	8.15	0.04	0.00	0.00	0.23	0.00
SU.005	lin-3af7d7	0.27	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.35	35.11	25.44	0.00	0.04	36.22	0.00	0.00	1.76	21.30	0.02	0.00	4.45	0.02	0.02	0.06	0.23	0.00
SU.005	lin-3af7d7	0.24	0.08	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.16	22.86	16.56	0.00	0.00	26.15	0.00	0.00	1.69	47.20	0.00	0.00	1.45	0.00	0.00	0.03	0.11	0.00
SU.005	lin-3af7d7	0.37	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.18	35.74	25.90	0.00	0.00	16.41	0.00	0.00	2.74	30.06	0.00	0.00	14.07	0.05	0.00	0.00	0.24	0.00
SU.005	lin-3af7d7	0.29	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24	27.00	19.56	0.00	0.00	29.72	0.00	0.00	2.76	33.61	0.00	0.00	6.05	0.03	0.00	0.04	0.15	0.00
SU.005	lin-3af7d7	0.25	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	22.36	16.20	0.00	0.00	25.88	0.00	0.00	2.10	45.54	0.00	0.00	3.49	0.00	0.00	0.00	0.12	0.00
SU.005	average	0.29	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.22	29.27	21.21	0.00	0.00	27.03	0.00	0.00	2.31	34.22	0.00	0.00	6.28	0.03	0.00	0.04	0.18	0.00
SU.005	lin-3af7d7	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.57	22.87	0.00	0.00	35.77	0.00	0.00	2.16	24.18	0.00	0.00	5.56	0.00	0.00	0.00	0.00	0.00
SU.005	lin-3af7d7	0.32	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.31	32.47	23.52	0.00	0.01	33.03	0.00	0.00	2.32	25.44	0.02	0.00	5.68	0.03	0.00	0.07	0.18	0.00
SU.005	lin-3af7d7	0.25	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.26	29.34	21.26	0.00	0.03	31.97	0.00	0.00	1.86	31.44	0.02	0.00	4.47	0.02	0.02	0.05	0.16	0.00
SU.005	lin-3af7d7	0.24	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	20.56	14.89	0.00	0.00	26.12	0.00	0.00	1.53	49.34	0.00	0.00	1.88	0.00	0.00	0.00	0.10	0.00
SU.005	lin-3af7d7	0.26	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.22	23.45	16.99	0.00	0.03	33.03	0.00	0.00	1.84	37.04	0.00	0.00	3.81	0.00	0.00	0.00	0.18	0.00
SU.005	lin-3af7d7	0.32	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.24	29.02	21.02	0.00	0.00	27.96	0.00	0.00	3.12	31.91	0.00	0.00	7.06	0.03	0.00	0.04	0.17	0.00
SU.005	lin-3af7d7	0.29	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.22	26.41	19.14	0.00	0.00	30.65	0.00	0.00	2.67	33.80	0.00	0.00	5.63	0.02	0.00	0.03	0.16	0.00
SU.005	average	0.28	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.23	26.88	19.47	0.00	0.01	30.46	0.00	0.00	2.22	34.83	0.00	0.00	4.76	0.02	0.00	0.04	0.16	0.00
SU.006	sfaa 4	0.18	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	11.49	8.32	0.00	0.00	12.23	0.00	0.00	6.01	69.60	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.00
SU.006	sfaa 4	0.18	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	8.50	6.16	0.00	0.00	7.76	0.00	0.00	6.89	76.14	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00
SU.006	sfaa 4	0.18	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.18	22.57	16.35	0.00	0.00	20.01	0.00	0.00	4.49	51.90	0.00	0.00	0.52	0.00	0.00	0.00	0.08	0.00
SU.006	average	0.18	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	14.19	10.28	0.00	0.00	13.33	0.00	0.00	5.79	65.88	0.00	0.00	0.41	0.00	0.00	0.00	0.05	0.00
SU.007	tf 126046032	0.27	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	2.24	1.62	0.00	0.00	6.36	0.00	0.00	4.92	84.90	0.00	0.00	1.06	0.01	0.00	0.00	0.13	0.00
SU.007	tf 126046032	0.27	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	3.02	2.18	0.00	0.00	7.69	0.00	0.00	4.81	82.72	0.00	0.00	1.25	0.00	0.00	0.00	0.09	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
SU.007	tf 126046032	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	1.82	1.32	0.00	0.00	4.93	0.00	0.00	4.76	87.42	0.00	0.00	0.64	0.00	0.00	0.00	0.06	0.00
SU.007	average	0.27	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	2.36	1.71	0.00	0.00	6.33	0.00	0.00	4.83	85.01	0.00	0.00	0.98	0.00	0.00	0.00	0.09	0.00
SU.008	lin-a683e5	0.83	1.60	0.00	0.00	0.34	0.00	0.01	0.00	0.01	0.10	36.68	26.58	0.00	0.00	0.00	0.00	0.00	3.36	49.73	0.00	0.00	7.25	0.00	0.00	0.00	0.00	0.00
SU.008	lin-a683e5	0.65	1.00	0.00	0.00	0.23	0.00	0.00	0.00	0.02	0.00	33.27	24.10	0.00	0.00	0.00	0.00	0.00	3.55	53.12	0.00	0.00	7.98	0.00	0.00	0.00	0.12	0.00
SU.008	lin-a683e5	0.74	1.41	0.00	0.00	0.29	0.00	0.00	0.00	0.01	0.11	34.51	25.00	0.00	0.00	0.00	0.00	0.00	3.23	50.87	0.00	0.00	8.66	0.00	0.00	0.00	0.16	0.00
SU.008	average	0.74	1.34	0.00	0.00	0.29	0.00	0.00	0.00	0.01	0.08	34.82	25.23	0.00	0.00	0.00	0.00	0.00	3.38	51.24	0.00	0.00	7.96	0.00	0.00	0.00	0.12	0.00
SU.009	tf 46868 68464	0.32	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	8.40	6.08	0.00	0.00	2.56	0.00	0.00	1.79	85.81	0.00	0.00	0.53	0.00	0.00	0.00	0.09	0.00
SU.009	tf 46868 68464	0.25	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.12	5.17	3.74	0.00	0.00	0.00	0.00	0.00	4.19	88.25	0.00	0.00	1.48	0.00	0.00	0.00	0.11	0.00
SU.009	tf 46868 68464	0.28	0.48	0.00	0.00	0.21	0.00	0.00	0.00	0.04	0.14	11.99	8.69	0.00	0.00	0.00	0.00	0.00	4.17	80.68	0.00	0.00	1.81	0.00	0.00	0.00	0.19	0.00
SU.009	average	0.28	0.43	0.00	0.00	0.07	0.00	0.00	0.00	0.03	0.11	8.52	6.17	0.00	0.00	0.00	0.00	0.00	3.38	84.91	0.00	0.00	1.27	0.00	0.00	0.00	0.13	0.00
SU.010	tf 46727 68520	0.30	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	17.90	12.97	0.00	0.00	9.87	0.00	0.00	4.91	58.65	0.00	0.00	7.53	0.10	0.00	0.05	0.21	0.00
SU.010	tf 46727 68520	0.31	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.18	18.04	13.07	0.00	0.00	15.68	0.00	0.00	3.93	57.70	0.00	0.00	3.56	0.08	0.00	0.04	0.14	0.00
SU.010	tf 46727 68520	0.31	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	21.28	15.42	0.00	0.00	25.86	0.00	0.00	3.77	41.79	0.00	0.00	6.00	0.11	0.00	0.05	0.21	0.00
SU.010	average	0.31	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	19.07	13.82	0.00	0.00	17.14	0.00	0.00	4.20	52.71	0.00	0.00	5.69	0.10	0.00	0.05	0.19	0.00
SW.001	toxx 24	0.16	10.02	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.06	3.97	2.87	0.00	0.00	19.04	0.00	0.00	4.17	58.61	0.00	0.00	3.23	0.00	0.00	0.00	0.25	0.00
SW.001	toxx 24	0.29	5.02	0.10	0.07	0.74	0.00	0.00	0.00	0.01	0.06	2.67	1.93	14.59	0.00	9.90	20.84	0.00	2.07	38.74	0.03	0.00	3.57	0.09	0.09	0.21	0.91	0.00
SW.001	toxx 24	0.28	7.17	0.08	0.05	0.84	0.00	0.00	0.00	0.04	0.11	4.64	3.36	12.00	0.00	13.58	17.63	0.00	1.66	35.46	0.00	0.00	5.06	0.12	0.07	0.20	0.99	0.00
SW.001	average	0.24	7.40	0.06	0.04	0.69	0.00	0.00	0.00	0.02	0.08	3.76	2.72	8.86	0.00	14.17	12.82	0.00	2.63	44.27	0.00	0.00	3.96	0.07	0.05	0.14	0.72	0.00
SW.002	toxx25	0.24	0.36	0.00	0.01	0.26	0.00	0.00	0.00	0.00	0.00	11.20	8.11	0.00	0.00	0.00	1.28	0.00	4.43	80.28	0.05	0.00	1.58	0.05	0.00	0.00	0.22	0.00
SW.002	toxx25	0.29	0.33	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.07	9.62	6.97	0.00	0.00	9.98	0.00	0.00	3.72	73.89	0.02	0.00	1.54	0.11	0.00	0.00	0.13	0.00
SW.002	toxx25	0.25	0.37	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.04	11.48	8.32	0.00	0.00	0.00	0.73	0.00	4.79	80.17	0.00	0.00	1.63	0.03	0.00	0.00	0.19	0.00
SW.002	average	0.26	0.35	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.05	10.77	7.80	0.00	0.00	3.33	0.67	0.00	4.31	78.11	0.03	0.00	1.58	0.06	0.00	0.00	0.18	0.00
SY.001	stylus	0.23	47.27	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.10	8.59	6.22	0.00	0.00	0.00	0.00	0.00	0.23	18.07	0.00	0.00	24.92	0.00	0.00	0.00	0.00	0.00
SY.001	stylus	0.08	34.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	5.27	3.82	0.00	0.00	0.00	0.03	0.00	0.29	36.93	0.00	0.00	21.37	0.00	0.00	0.00	0.34	0.00
SY.001	stylus	0.08	35.13	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	5.74	4.16	0.00	0.00	2.38	0.05	0.00	0.25	32.77	0.00	0.00	22.92	0.00	0.00	0.00	0.60	0.00
SY.001	average	0.13	38.96	0.00	0.00	0.13	0.00	0.00	0.00	0.01	0.07	6.53	4.73	0.00	0.00	0.00	0.03	0.00	0.26	29.26	0.00	0.00	23.07	0.00	0.00	0.00	0.38	0.00

REF NUM	***SAMPLE***	***Sb***	***Sn***	***Cd***	***Pd***	***Ag***	***Ru***	***Mo***	***Nb***	***Zr***	***Bi***	***Pb***	***Pb (scaled down)***	***Hg***	***Se***	***As***	***Au***	***W***	***Zn***	***Cu***	***Ni***	***Co***	***Fe***	***Mn***	***Cr***	***V***	***Ti***	***Al***
TW.001	lin-735f56 side a	0.25	30.38	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.11	11.97	8.67	0.00	0.00	5.60	0.00	0.00	0.58	46.95	0.00	0.00	3.50	0.00	0.00	0.00	0.33	0.00
TW.001	lin-735f56 side a	0.23	27.67	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.10	10.90	7.89	0.00	0.00	6.19	0.00	0.00	0.60	50.60	0.00	0.00	3.03	0.00	0.00	0.00	0.38	0.00
TW.001	lin-735f56 side a	0.23	28.11	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.09	10.29	7.45	0.00	0.00	5.75	0.00	0.00	0.61	50.84	0.00	0.00	3.34	0.00	0.00	0.00	0.45	0.00
TW.001	average	0.24	28.72	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.10	11.05	8.01	0.00	0.00	5.84	0.00	0.00	0.60	49.46	0.00	0.00	3.29	0.00	0.00	0.00	0.38	0.00
TW.001	lin-735f56 side b	0.23	27.25	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.09	9.95	7.21	0.00	0.00	7.14	0.00	0.00	0.65	51.20	0.00	0.00	2.80	0.00	0.00	0.00	0.39	0.00
TW.001	lin-735f56 side b	0.21	25.85	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.09	9.72	7.05	0.00	0.00	7.15	0.00	0.00	0.64	52.93	0.00	0.00	2.77	0.00	0.00	0.00	0.34	0.00
TW.001	lin-735f56 side b	0.20	24.48	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.08	9.42	6.82	0.00	0.00	5.93	0.00	0.00	0.66	55.87	0.00	0.00	2.71	0.00	0.00	0.00	0.38	0.00
TW.001	average	0.21	25.86	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.09	9.70	7.03	0.00	0.00	6.74	0.00	0.00	0.65	53.34	0.00	0.00	2.76	0.00	0.00	0.00	0.37	0.00
TW.002	lin-73be4e side a	0.48	15.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	4.49	3.25	0.00	0.00	5.39	0.00	0.00	2.64	66.00	0.02	0.00	4.94	0.34	0.00	0.00	0.43	0.00
TW.002	lin-73be4e side a	0.71	21.57	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.33		0.00		0.00	5.10	0.00	4.20			0.26	0.00	10.87	0.85	0.11	0.20	1.16	0.00
TW.002	lin-73be4e side a	0.49	15.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	4.54	3.29	0.00	0.00	4.86	0.00	0.00	2.64	66.45	0.00	0.00	4.93	0.36	0.00	0.00	0.44	0.00
TW.002	average	0.56	17.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	3.01	2.18	0.00	0.00	5.12	0.00	1.40	1.76	44.15	0.10	0.00	6.91	0.52	0.04	0.09	0.67	0.00
TW.002	lin-73be4e side b	0.58	17.81	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.06	5.98	4.33	0.00	0.00	6.25	0.00	0.00	2.98	59.18	0.00	0.00	6.25	0.28	0.00	0.00	0.41	0.00
TW.002	lin-73be4e side b	0.56	16.93	0.00	0.00	0.20	0.00	0.00	0.00	0.01	0.06	6.07	4.40	0.00	0.00	6.90	0.00	0.00	3.51	59.56	0.00	0.00	5.54	0.30	0.00	0.00	0.36	0.00
TW.002	lin-73be4e side b	0.56	16.99	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.06	6.06	4.39	0.00	0.00	6.72	0.00	0.00	3.53	59.61	0.00	0.00	5.53	0.30	0.00	0.00	0.43	0.00
TW.002	average	0.57	17.24	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.06	6.04	4.37	0.00	0.00	6.63	0.00	0.00	3.34	59.45	0.00	0.00	5.77	0.29	0.00	0.00	0.40	0.00
TW.003	LIN A4AE2C	0.12	11.35	0.00	0.00	0.47	0.00	0.00	0.00	0.01	0.04	17.13	12.41	0.00	0.00	0.00	0.00	0.00	3.51	44.42	0.00	0.00	22.74	0.00	0.00	0.00	0.15	0.00
TW.003	LIN A4AE2C	0.11	10.16	0.00	0.00	0.38	0.00	0.00	0.00	0.01	0.00	14.82	10.73	0.00	0.00	0.00	0.00	0.00	3.90	44.81	0.00	0.00	25.52	0.03	0.00	0.00	0.19	0.00
TW.003	LIN A4AE2C	0.08	5.66	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.03	7.95	5.76	0.00	0.00	2.81	0.00	0.00	7.08	61.86	0.03	0.00	14.03	0.00	0.00	0.04	0.18	0.00
TW.003	average	0.10	9.06	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.03	13.30	9.64	0.00	0.00	0.00	0.00	0.00	4.83	50.36	0.00	0.00	20.76	0.00	0.00	0.00	0.17	0.00
UK.001	lin-39f3e4 side b	0.36	13.72	0.00	0.01	0.39	0.00	0.00	0.00	0.01	0.12	17.45	12.64	0.00	0.00	6.02	0.00	0.00	0.26	60.41	0.00	0.00	0.96	0.00	0.00	0.00	0.26	0.00
UK.001	lin-39f3e4 side b	0.36	13.69	0.00	0.01	0.39	0.00	0.00	0.00	0.01	0.12	17.48	12.67	0.00	0.00	6.09	0.00	0.00	0.24	60.33	0.02	0.00	0.96	0.00	0.00	0.00	0.27	0.00
UK.001	lin-39f3e4 side b	0.37	13.79	0.00	0.01	0.39	0.00	0.00	0.00	0.01	0.12	17.51	12.68	0.00	0.00	5.49	0.00	0.00	0.27	60.83	0.00	0.00	0.96	0.00	0.00	0.00	0.24	0.00
UK.001	average	0.35	13.70	0.00	0.01	0.40	0.00	0.00	0.00	0.01	0.12	17.36	12.58	0.00	0.00	6.48	0.00	0.00	0.26	60.07	0.00	0.00	0.95	0.00	0.00	0.00	0.25	0.00
UK.001	lin-39f3e4 side a	0.37	13.70	0.00	0.02	0.38	0.00	0.00	0.00	0.01	0.10	15.68	11.36	0.00	0.00	5.81	0.00	0.00	0.25	62.44	0.02	0.00	0.95	0.00	0.00	0.00	0.26	0.00
UK.001	lin-39f3e4 side a	0.37	13.65	0.00	0.01	0.37	0.00	0.00	0.00	0.01	0.11	15.57	11.28	0.00	0.00	6.75	0.00	0.00	0.25	61.72	0.03	0.00	0.93	0.00	0.00	0.00	0.22	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.001	lin-39f3e4 side a	0.37	13.70	0.00	0.02	0.37	0.00	0.00	0.00	0.01	0.10	15.69	11.37	0.00	0.00	5.74	0.00	0.00	0.24	62.49	0.00	0.00	0.96	0.00	0.00	0.00	0.28	0.00
UK.001	average	0.37	13.76	0.00	0.02	0.38	0.00	0.00	0.00	0.01	0.09	15.79	11.44	0.00	0.00	4.94	0.00	0.00	0.26	63.11	0.03	0.00	0.97	0.00	0.00	0.00	0.27	0.00
UK.002	429	0.22	38.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.39	0.28	0.00	0.00	2.69	0.00	0.00	0.31	30.11	0.00	0.00	26.55	0.00	0.00	0.00	0.70	0.00
UK.002	429	0.24	39.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.41	0.29	0.00	0.00	2.51	0.00	0.00	0.30	30.11	0.00	0.00	26.56	0.00	0.00	0.00	0.78	0.00
UK.002	429	0.22	39.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.40	0.29	0.00	0.00	2.60	0.00	0.00	0.30	30.09	0.00	0.00	26.65	0.00	0.00	0.00	0.69	0.00
UK.002	average	0.23	39.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.40	0.29	0.00	0.00	2.60	0.00	0.00	0.30	30.10	0.00	0.00	26.59	0.00	0.00	0.00	0.72	0.00
UK.003	195	0.15	36.67	0.00	0.00	1.31	0.00	0.00	0.00	0.01	0.11	10.82	7.84	0.00	0.00	0.00	0.07	0.00	1.93	34.43	0.00	0.00	14.05	0.00	0.00	0.00	0.44	0.00
UK.003	195	0.12	21.83	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.10	10.45	7.57	0.00	0.00	6.58	0.00	0.00	2.83	54.27	0.00	0.00	2.64	0.00	0.00	0.00	0.42	0.00
UK.003	195	0.18	36.89	0.00	0.00	1.41	0.00	0.00	0.00	0.02	0.09	8.59	6.23	0.00	0.00	0.00	0.07	0.00	1.76	15.78	0.00	0.00	34.90	0.00	0.00	0.00	0.24	0.00
UK.003	average	0.15	31.80	0.00	0.00	1.16	0.00	0.00	0.00	0.01	0.10	9.95	7.21	0.00	0.00	2.19	0.05	0.00	2.17	34.83	0.00	0.00	17.20	0.00	0.00	0.00	0.37	0.00
UK.004	458	0.12	42.90	0.00	0.00	2.99	0.00	0.00	0.00	0.01	0.07	9.81	7.11	0.00	0.00	0.00	0.00	0.00	0.11	14.09	0.00	0.00	29.28	0.00	0.00	0.00	0.51	0.00
UK.004	458	0.03	23.48	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.00	6.69	4.84	0.00	0.00	0.00	0.13	0.00	0.09	16.19	0.00	0.00	52.63	0.00	0.00	0.00	0.20	0.00
UK.004	458	0.05	28.98	0.00	0.00	0.37	0.00	0.00	0.00	0.01	0.03	6.85	4.96	0.00	0.00	0.00	0.07	0.00	0.09	10.87	0.00	0.00	52.46	0.00	0.00	0.00	0.17	0.00
UK.004	average	0.06	31.79	0.00	0.00	1.24	0.00	0.00	0.00	0.01	0.04	7.78	5.64	0.00	0.00	0.00	0.07	0.00	0.10	13.72	0.00	0.00	44.79	0.00	0.00	0.00	0.29	0.00
UK.005	010 b	0.26	26.97	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.22		0.00		0.00	0.00	0.20	0.00			0.07	0.00	1.07	0.00	0.00	0.00	0.24	0.00
UK.005	010 b	0.37	34.05	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.58		0.00		0.00	0.00	0.58	0.00			0.16	0.00	1.26	0.05	0.11	0.15	0.62	0.00
UK.005	010 b	0.12	15.21	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.03	4.06	2.94	0.00	0.00	0.00	0.00	0.00	1.78	77.97	0.05	0.00	0.49	0.00	0.00	0.00	0.00	0.00
UK.005	average	0.29	31.66	0.00	0.00	0.50	0.00	0.00	0.00	0.01	0.06	11.01	7.97	0.00	0.00	0.00	0.00	0.00	1.29	53.60	0.00	0.00	1.46	0.00	0.00	0.00	0.00	0.00
UK.005	010 a	0.30	31.27	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.23	5.81	4.21	0.00	0.00	4.19	0.04	0.54	1.06	35.16	0.05	0.00	1.55	0.00	0.00	0.00	0.48	0.00
UK.005	010 a	0.28	29.51	0.00	0.00	0.57	0.00	0.00	0.00	0.01	0.07	9.41	6.81	0.00	0.00	4.92	0.05	0.00	1.66	52.04	0.00	0.00	1.15	0.00	0.00	0.00	0.34	0.00
UK.005	010 a	0.34	32.62	0.02	0.00	0.69	0.00	0.01	0.00	0.00	0.53		0.00		0.00	5.60	0.00	1.61			0.15	0.00	1.42	0.06	0.12	0.15	0.86	0.00
UK.005	average	0.27	31.69	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.08	8.01	5.81	0.00	0.00	2.06	0.06	0.00	1.50	53.43	0.00	0.00	2.08	0.00	0.00	0.00	0.24	0.00
UK.006	013 b	0.21	28.50	0.00	0.00	0.56	0.00	0.00	0.00	0.01	0.08	10.55	7.65	0.00	0.00	5.00	0.00	0.00	2.52	50.95	0.00	0.00	1.13	0.00	0.00	0.00	0.46	0.00
UK.006	013 b	0.21	27.46	0.00	0.00	0.52	0.00	0.00	0.00	0.01	0.07	9.83	7.12	0.00	0.00	5.48	0.00	0.00	2.65	51.96	0.00	0.00	1.29	0.00	0.00	0.00	0.51	0.00
UK.006	013 b	0.20	29.26	0.00	0.00	0.56	0.00	0.00	0.00	0.01	0.08	10.15	7.35	0.00	0.00	4.47	0.00	0.00	2.33	51.29	0.00	0.00	1.15	0.00	0.00	0.00	0.47	0.00
UK.006	average	0.22	28.79	0.00	0.00	0.59	0.00	0.00	0.00	0.01	0.09	11.68	8.47	0.00	0.00	5.06	0.00	0.00	2.57	49.61	0.00	0.00	0.95	0.00	0.00	0.00	0.39	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.006	013 a	0.19	25.06	0.00	0.00	0.49	0.00	0.00	0.00	0.01	0.09	9.74	7.06	0.00	0.00	6.80	0.02	0.00	2.00	53.92	0.00	0.00	1.25	0.00	0.00	0.00	0.42	0.00
UK.006	013 a	0.17	22.41	0.00	0.00	0.46	0.00	0.00	0.00	0.01	0.08	8.94	6.48	0.00	0.00	6.01	0.00	0.00	2.02	58.63	0.00	0.00	0.92	0.00	0.00	0.00	0.35	0.00
UK.006	013 a	0.21	26.62	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.11	10.80	7.82	0.00	0.00	7.40	0.06	0.00	1.96	50.82	0.00	0.00	1.09	0.00	0.00	0.00	0.41	0.00
UK.006	average	0.20	26.15	0.00	0.00	0.50	0.00	0.00	0.00	0.01	0.09	9.48	6.87	0.00	0.00	6.99	0.00	0.00	2.02	52.32	0.00	0.00	1.73	0.00	0.00	0.00	0.49	0.00
UK.007	580	0.30	38.36	0.05	0.00	0.42	0.00	0.00	0.00	0.01	0.04	9.06	6.56	0.00	0.00	0.00	0.00	0.00	0.24	16.87	0.14	0.00	34.08	0.11	0.00	0.00	0.00	0.00
UK.007	580	0.17	29.37	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.04	9.95	7.21	0.00	0.00	0.00	0.00	0.00	0.31	25.83	0.00	0.00	33.51	0.06	0.00	0.10	0.37	0.00
UK.007	580	0.18	30.56	0.00	0.01	0.32	0.00	0.00	0.00	0.01	0.04	10.96	7.94	0.00	0.00	0.00	0.00	0.00	0.24	19.11	0.00	0.00	38.00	0.11	0.00	0.10	0.35	0.00
UK.007	average	0.21	32.76	0.00	0.00	0.34	0.00	0.00	0.00	0.01	0.04	9.99	7.24	0.00	0.00	0.00	0.00	0.00	0.26	20.60	0.00	0.00	35.20	0.09	0.00	0.10	0.30	0.00
UK.007	580	0.13	30.10	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.00	10.98	7.95	0.00	0.00	0.00	0.04	0.00	0.26	18.68	0.00	0.00	39.15	0.00	0.00	0.00	0.24	0.00
UK.007	580	0.06	20.47	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	8.15	5.90	0.00	0.00	0.00	0.00	0.33	0.11	15.29	0.00	0.00	54.79	0.09	0.00	0.19	0.52	0.00
UK.007	580	0.05	18.11	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	7.23	5.24	0.00	0.00	0.00	0.00	0.00	0.22	12.72	0.00	0.00	60.53	0.12	0.00	0.36	0.61	0.00
UK.007	average	0.08	22.89	0.00	0.00	0.09	0.00	0.00	0.00	0.02	0.00	8.78	6.36	0.00	0.00	0.00	0.00	0.11	0.19	15.56	0.00	0.00	51.49	0.09	0.00	0.21	0.46	0.00
UK.009	526	0.16	21.68	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	7.38	5.35	0.00	0.00	0.00	0.00	0.00	0.43	41.90	0.00	0.00	27.14	0.04	0.00	0.12	0.43	0.00
UK.009	526	0.15	21.96	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	6.75	4.89	0.00	0.00	1.28	0.00	0.00	0.47	42.68	0.00	0.00	26.11	0.04	0.00	0.12	0.42	0.00
UK.009	526	0.16	24.17	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	7.81	5.66	0.00	0.00	0.00	0.00	0.00	0.36	33.38	0.00	0.00	33.58	0.00	0.00	0.14	0.33	0.00
UK.009	average	0.16	22.60	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	7.31	5.30	0.00	0.00	0.00	0.00	0.00	0.42	39.32	0.00	0.00	28.94	0.04	0.00	0.12	0.39	0.00
UK.010	333	0.00	8.87	0.00	0.03	0.00	0.00	0.00	0.00	0.06	0.00	2.88	0.00	0.00	0.00	0.00	0.00	0.10	4.13	0.00	0.20	82.73	0.36	0.00	0.22	0.38	0.00	
UK.010	333	0.00	13.03	0.00	0.03	0.26	0.00	0.00	0.00	0.05	0.00	5.67	0.00	0.00	0.00	0.00	0.00	0.13	8.40	0.00	0.00	71.66	0.44	0.00	0.10	0.22	0.00	
UK.010	333	0.00	12.23	0.00	0.03	0.24	0.00	0.00	0.00	0.08	0.00	4.74	0.00	0.00	0.00	0.00	0.00	0.13	6.86	0.00	0.13	74.62	0.31	0.00	0.16	0.46	0.00	
UK.010	333	0.00	11.38	0.00	0.03	0.17	0.00	0.00	0.00	0.07	0.00	4.43	0.00	0.00	0.00	0.00	0.00	0.12	6.46	0.00	0.11	76.34	0.37	0.00	0.16	0.36	0.00	
UK.010	333	0.00	23.67	0.00	0.00	0.36	0.00	0.00	0.00	0.02	0.00	9.93	0.00	0.00	0.00	0.00	0.00	0.18	19.19	0.00	0.00	46.25	0.16	0.00	0.12	0.00	0.00	
UK.010	333	0.00	16.74	0.00	0.00	0.29	0.00	0.00	0.00	0.02	0.00	4.82	0.00	0.00	0.00	0.00	0.00	0.10	6.75	0.00	0.00	70.68	0.20	0.00	0.19	0.20	0.00	
UK.010	333	0.00	26.91	0.00	0.00	0.42	0.00	0.00	0.00	0.03	0.00	9.75	0.00	0.00	0.00	0.04	0.00	0.16	12.89	0.00	0.00	49.34	0.00	0.00	0.14	0.30	0.00	
UK.010	333	0.00	22.44	0.00	0.00	0.36	0.00	0.00	0.00	0.02	0.00	8.17	0.00	0.00	0.00	0.00	0.00	0.14	12.94	0.00	0.00	55.42	0.14	0.00	0.15	0.21	0.00	
UK.011	379	0.10	22.78	0.00	0.00	0.60	0.00	0.00	0.00	0.01	0.05	5.47	3.96	0.00	0.00	0.00	0.10	0.00	0.10	11.44	0.00	0.00	59.35	0.00	0.00	0.00	0.00	0.00
UK.011	379	0.10	23.70	0.00	0.00	0.62	0.00	0.00	0.00	0.01	0.03	5.40	3.91	0.00	0.00	0.00	0.09	0.00	0.11	11.14	0.00	0.00	58.66	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
UK.011	379	0.08	23.96	0.00	0.00	0.77	0.00	0.00	0.00	0.01	0.03	6.45	4.67	0.00	0.00	0.00	0.09	0.00	0.13	10.57	0.00	0.00	57.61	0.00	0.00	0.00	0.22	0.00
UK.011	379	0.09	23.15	0.00	0.00	0.71	0.00	0.00	0.00	0.01	0.00	6.26	4.53	0.00	0.00	0.00	0.08	0.00	0.13	11.34	0.00	0.00	57.98	0.00	0.00	0.00	0.20	0.00
UK.011	average	0.09	23.61	0.00	0.00	0.70	0.00	0.00	0.00	0.01	0.02	6.03	4.37	0.00	0.00	0.00	0.09	0.00	0.12	11.02	0.00	0.00	58.08	0.00	0.00	0.00	0.18	0.00
UK.011	379	0.07	21.63	0.00	0.00	0.72	0.00	0.00	0.00	0.01	0.00	5.72	4.14	0.00	0.00	0.00	0.00	0.21	0.18	15.92	0.00	0.00	55.34	0.00	0.00	0.00	0.00	0.00
UK.011	379	0.08	18.94	0.00	0.00	0.70	0.00	0.00	0.00	0.01	0.00	5.77	4.18	0.00	0.00	0.00	0.00	0.00	0.27	23.16	0.00	0.00	50.74	0.00	0.00	0.00	0.17	0.00
UK.011	379	0.08	20.15	0.00	0.00	0.58	0.00	0.00	0.00	0.01	0.03	5.28	3.83	0.00	0.00	0.00	0.08	0.00	0.09	11.45	0.00	0.00	62.17	0.00	0.00	0.09	0.00	0.00
UK.011	average	0.07	20.24	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.03	5.59	4.05	0.00	0.00	0.00	0.03	0.09	0.18	16.84	0.00	0.00	56.08	0.00	0.00	0.00	0.00	0.00
UK.012	014 b	0.32	19.46	0.00	0.00	0.14	0.00	0.00	0.00	0.01	0.18	3.13	2.27	0.00	0.00	13.53	0.00	0.00	3.95	51.11	0.00	0.00	7.77	0.09	0.00	0.00	0.29	0.00
UK.012	014 b	0.34	20.79	0.00	0.00	0.21	0.00	0.00	0.00	0.01	0.17	3.55	2.57	0.00	0.00	10.48	0.00	0.00	4.57	47.79	0.00	0.00	11.63	0.14	0.00	0.00	0.26	0.00
UK.012	014 b	0.34	20.96	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.20	3.41	2.47	0.00	0.00	14.46	0.00	0.00	3.87	47.66	0.00	0.00	8.50	0.10	0.00	0.00	0.28	0.00
UK.012	average	0.29	16.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	2.43	1.76	0.00	0.00	15.66	0.00	0.00	3.40	57.87	0.00	0.00	3.19	0.02	0.00	0.00	0.34	0.00
UK.012	014 a	0.36	19.89	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.20	3.56	2.58	0.00	0.00	15.40	0.00	0.00	3.50	48.66	0.00	0.00	7.89	0.10	0.00	0.00	0.30	0.00
UK.012	014 a	0.36	20.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	3.26	2.36	0.00	0.00	15.72	0.00	0.00	3.11	48.58	0.00	0.00	8.01	0.10	0.00	0.00	0.30	0.00
UK.012	014 a	0.36	19.56	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.20	3.56	2.58	0.00	0.00	16.72	0.00	0.00	3.43	50.26	0.00	0.00	5.29	0.08	0.00	0.00	0.31	0.00
UK.012	average	0.35	19.77	0.00	0.00	0.20	0.00	0.00	0.00	0.01	0.20	3.87	2.80	0.00	0.00	13.75	0.00	0.00	3.96	47.13	0.00	0.00	10.36	0.12	0.00	0.00	0.28	0.00
UK.014	rf 12750	0.21	13.38	0.00	0.00	0.58	0.00	0.00	0.00	0.00	0.10	12.41	8.99	0.00	0.00	14.50	0.00	0.00	1.50	55.95	0.03	0.00	1.02	0.00	0.00	0.00	0.27	0.00
UK.014	rf 12750	0.30	20.04	0.00	0.00	0.82	0.00	0.00	0.00	0.00	0.13	19.59	14.19	0.00	0.00	12.99	0.15	0.00	1.43	42.38	0.00	0.00	1.74	0.00	0.00	0.00	0.29	0.00
UK.014	rf 12750	0.33	22.77	0.00	0.00	0.93	0.00	0.00	0.00	0.01	0.14	19.10	13.84	0.00	0.00	10.51	0.00	0.00	1.54	42.44	0.00	0.00	1.87	0.00	0.00	0.00	0.36	0.00
UK.014	average	0.28	18.73	0.00	0.00	0.78	0.00	0.00	0.00	0.00	0.12	17.03	12.34	0.00	0.00	12.67	0.06	0.00	1.49	46.92	0.03	0.00	1.54	0.00	0.00	0.00	0.31	0.00
UK.015	025 b	0.20	18.19	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.07	6.88	4.98	0.00	0.00	7.94	0.00	0.00	3.14	61.16	0.00	0.00	1.83	0.00	0.00	0.00	0.38	0.00
UK.015	025 b	0.20	18.18	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.06	6.86	4.97	0.00	0.00	7.95	0.00	0.00	3.14	61.17	0.00	0.00	1.82	0.00	0.00	0.00	0.38	0.00
UK.015	025 b	0.20	18.20	0.00	0.00	0.20	0.00	0.00	0.00	0.01	0.08	6.89	4.99	0.00	0.00	7.88	0.00	0.00	3.14	61.18	0.00	0.00	1.82	0.00	0.00	0.00	0.38	0.00
UK.015	average	0.20	18.17	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.06	6.88	4.99	0.00	0.00	7.99	0.00	0.00	3.14	61.13	0.00	0.00	1.83	0.00	0.00	0.00	0.37	0.00
UK.015	025 a	0.18	19.32	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	7.07	5.12	0.00	0.00	5.61	0.00	0.00	2.89	63.38	0.00	0.00	1.14	0.00	0.00	0.00	0.30	0.00
UK.015	025 a	0.18	19.32	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	7.07	5.12	0.00	0.00	5.49	0.00	0.00	2.90	63.47	0.02	0.00	1.15	0.00	0.00	0.00	0.30	0.00
UK.015	025 a	0.18	19.30	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	7.07	5.12	0.00	0.00	5.67	0.00	0.00	2.89	63.35	0.02	0.00	1.13	0.00	0.00	0.00	0.30	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.015	average	0.18	19.33	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.06	7.06	5.12	0.00	0.00	5.68	0.00	0.00	2.89	63.31	0.00	0.00	1.14	0.00	0.00	0.00	0.30	0.00
UK.016	007 b	0.19	21.05	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.20	4.83	3.50	0.00	0.00	2.84	0.00	0.73	1.29	45.62	0.09	0.00	2.45	0.00	0.05	0.00	0.34	0.00
UK.016	007 b	0.16	19.48	0.00	0.00	0.50	0.00	0.00	0.00	0.01	0.05	7.84	5.68	0.00	0.00	1.52	0.00	0.00	1.66	66.01	0.03	0.00	2.56	0.00	0.00	0.00	0.17	0.00
UK.016	007 b	0.12	15.04	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.06	6.66	4.82	0.00	0.00	3.04	0.00	0.00	2.21	70.85	0.00	0.00	1.40	0.00	0.00	0.00	0.14	0.00
UK.016	average	0.29	28.64	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.50		0.00		0.00	3.96	0.00	2.18			0.21	0.00	3.39	0.07	0.14	0.14	0.70	0.00
UK.016	007 a	0.10	17.62	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.04	7.48	5.42	0.00	0.00	2.45	0.03	0.00	2.23	68.16	0.00	0.00	0.71	0.00	0.00	0.00	0.34	0.00
UK.016	007 a	0.11	20.75	0.00	0.00	1.28	0.00	0.00	0.00	0.01	0.05	9.67	7.00	0.00	0.00	1.67	0.09	0.00	2.44	62.46	0.00	0.00	0.95	0.00	0.00	0.00	0.50	0.00
UK.016	007 a	0.10	14.84	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.03	5.70	4.13	0.00	0.00	4.69	0.00	0.00	1.95	71.23	0.00	0.00	0.47	0.00	0.00	0.00	0.31	0.00
UK.016	average	0.08	17.27	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.03	7.07	5.12	0.00	0.00	0.00	0.00	0.00	2.28	70.79	0.03	0.00	0.70	0.00	0.00	0.00	0.21	0.00
UK.017	005 b	0.72	16.54	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.11	6.86	4.97	0.00	0.00	13.80	0.00	0.00	3.85	54.79	0.03	0.00	2.59	0.00	0.00	0.00	0.32	0.00
UK.017	005 b	0.69	15.20	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.12	7.22	5.23	0.00	0.00	13.64	0.00	0.00	3.85	56.17	0.04	0.00	2.42	0.00	0.00	0.00	0.29	0.00
UK.017	005 b	0.70	16.44	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.09	7.09	5.14	0.00	0.00	13.98	0.00	0.00	3.72	54.59	0.03	0.00	2.53	0.00	0.00	0.00	0.39	0.00
UK.017	average	0.77	17.96	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.12	6.26	4.54	0.00	0.00	13.78	0.00	0.00	3.96	53.60	0.00	0.00	2.81	0.00	0.00	0.00	0.27	0.00
UK.017	005 a	0.78	17.12	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.19	3.84	2.78	0.00	0.00	11.20	0.00	1.28	2.51	39.49	0.12	0.00	3.99	0.00	0.00	0.00	0.48	0.00
UK.017	005 a	0.75	16.88	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.06	5.95	4.31	0.00	0.00	11.36	0.00	0.00	3.47	56.64	0.06	0.00	4.07	0.00	0.00	0.00	0.34	0.00
UK.017	005 a	1.02	21.38	0.00	0.00	0.54	0.00	0.01	0.00	0.00	0.42		0.00		0.00	10.44	0.00	3.85			0.31	0.00	5.44	0.10	0.12	0.20	0.85	0.00
UK.017	average	0.58	13.10	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.08	5.58	4.04	0.00	0.00	11.80	0.00	0.00	4.05	61.82	0.00	0.00	2.46	0.00	0.00	0.00	0.23	0.00
UK.018	523	0.04	17.53	0.00	0.00	8.60	0.00	0.00	0.00	0.02	0.03	6.76	4.90	0.00	0.00	0.00	0.14	0.00	0.25	16.17	0.00	0.00	49.24	0.05	0.00	0.37	0.80	0.00
UK.018	523	0.00	15.16	0.00	0.00	8.06	0.00	0.00	0.00	0.02	0.00	6.32	4.58	0.00	0.00	0.00	0.16	0.00	0.22	14.91	0.00	0.00	53.78	0.00	0.00	0.46	0.81	0.00
UK.018	523	0.00	17.04	0.00	0.01	9.09	0.00	0.00	0.00	0.03	0.03	5.93	4.29	0.00	0.00	0.00	0.07	0.00	0.17	14.38	0.00	0.00	52.06	0.00	0.00	0.32	0.85	0.00
UK.018	average	0.00	16.57	0.00	0.00	8.58	0.00	0.00	0.00	0.02	0.03	6.33	4.59	0.00	0.00	0.00	0.12	0.00	0.21	15.16	0.00	0.00	51.69	0.00	0.00	0.39	0.82	0.00
UK.018	523	0.00	15.70	0.00	0.00	8.47	0.00	0.00	0.00	0.03	0.00	6.30	4.56	0.00	0.00	0.00	0.11	0.00	0.21	14.66	0.00	0.00	53.23	0.00	0.00	0.42	0.80	0.00
UK.018	523	0.00	14.81	0.00	0.00	7.89	0.00	0.00	0.00	0.03	0.00	5.64	4.08	0.00	0.00	0.00	0.07	0.00	0.16	14.15	0.00	0.00	56.05	0.00	0.00	0.42	0.72	0.00
UK.018	523	0.00	14.37	0.00	0.00	7.49	0.00	0.00	0.00	0.05	0.00	4.96	3.60	0.00	0.00	0.00	0.00	0.17	0.20	21.11	0.00	0.00	50.45	0.00	0.00	0.42	0.71	0.00
UK.018	average	0.00	14.96	0.00	0.00	7.95	0.00	0.00	0.00	0.04	0.00	5.63	4.08	0.00	0.00	0.00	0.06	0.06	0.19	16.64	0.00	0.00	53.24	0.00	0.00	0.42	0.75	0.00
UK.019	21	0.00	0.74	0.00	0.00	89.24	0.00	0.00	0.00	0.00	0.19	1.12	0.81	0.00	0.00	0.00	0.52	0.00	0.39	2.44	0.00	0.00	4.83	0.00	0.00	0.00	0.44	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.019	21	0.00	0.73	0.00	0.00	89.38	0.00	0.00	0.00	0.00	0.18	1.14	0.82	0.00	0.00	0.00	0.52	0.00	0.40	2.46	0.00	0.00	4.76	0.00	0.00	0.00	0.00	0.00
UK.019	21	0.00	0.60	0.00	0.03	87.08	0.00	0.00	0.00	0.00	0.19	1.11	0.81	0.00	0.00	0.00	0.52	0.00	0.38	2.30	0.00	0.00	7.33	0.00	0.00	0.00	0.37	0.00
UK.019	average	0.00	0.69	0.00	0.00	88.57	0.00	0.00	0.00	0.00	0.18	1.12	0.81	0.00	0.00	0.00	0.52	0.00	0.39	2.40	0.00	0.00	5.64	0.00	0.00	0.00	0.39	0.00
UK.019	21	0.28	35.52	0.00	0.00	0.73	0.00	0.00	0.00	0.01	0.07	17.22	12.48	0.00	0.00	0.00	0.00	0.00	1.49	34.86	0.00	0.00	9.60	0.00	0.00	0.00	0.00	0.00
UK.019	21	0.42	45.45	0.00	0.00	1.12	0.00	0.00	0.00	0.01	0.09	11.48	8.32	0.00	0.00	0.00	0.04	0.00	1.09	32.43	0.04	0.00	7.68	0.00	0.00	0.00	0.00	0.00
UK.019	21	0.29	35.71	0.00	0.00	0.79	0.00	0.00	0.00	0.01	0.09	15.98	11.58	0.00	0.00	2.75	0.00	0.00	1.35	33.28	0.00	0.00	9.55	0.00	0.00	0.00	0.00	0.00
UK.019	average	0.33	38.89	0.00	0.00	0.88	0.00	0.00	0.00	0.01	0.09	14.89	10.79	0.00	0.00	0.00	0.00	0.00	1.31	33.52	0.00	0.00	8.95	0.00	0.00	0.00	0.00	0.00
UK.020	018 b	0.57	12.37	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.44	6.78	4.91	0.00	0.00	14.84	0.00	0.00	1.26	59.74	0.05	0.00	3.42	0.00	0.00	0.00	0.25	0.00
UK.020	018 b	0.58	12.75	0.00	0.00	0.28	0.00	0.00	0.00	0.01	0.47	6.70	4.85	0.00	0.00	17.97	0.00	0.00	1.31	54.76	0.05	0.00	4.69	0.03	0.00	0.00	0.39	0.00
UK.020	018 b	0.59	12.56	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.47	7.17	5.20	0.00	0.00	15.63	0.00	0.00	1.27	58.95	0.04	0.00	2.86	0.00	0.00	0.00	0.21	0.00
UK.020	average	0.56	11.80	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.38	6.46	4.68	0.00	0.00	10.92	0.00	0.00	1.20	65.50	0.05	0.00	2.72	0.00	0.00	0.00	0.16	0.00
UK.020	018 a	0.51	12.20	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.52	5.67	4.11	0.00	0.00	20.32	0.00	0.00	1.41	58.01	0.04	0.00	0.85	0.00	0.00	0.00	0.28	0.00
UK.020	018 a	0.60	14.96	0.00	0.00	0.32	0.00	0.00	0.00	0.01	0.66	7.00	5.07	0.00	0.01	23.21	0.00	0.00	1.53	50.28	0.04	0.00	1.06	0.00	0.00	0.00	0.33	0.00
UK.020	018 a	0.51	12.43	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.53	5.82	4.22	0.00	0.00	21.08	0.00	0.00	1.45	56.78	0.04	0.00	0.79	0.00	0.00	0.00	0.30	0.00
UK.020	average	0.40	9.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	4.18	3.02	0.00	0.00	16.67	0.00	0.00	1.25	66.97	0.03	0.00	0.71	0.00	0.00	0.00	0.21	0.00
UK.021	009 smaller frag b	0.17	12.24	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.05	7.17	5.19	0.00	0.00	5.44	0.00	0.00	1.56	72.27	0.00	0.00	0.48	0.00	0.00	0.00	0.19	0.00
UK.021	009 smaller frag b	0.17	12.26	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.04	6.81	4.93	0.00	0.00	4.40	0.00	0.00	1.60	73.67	0.00	0.00	0.46	0.00	0.00	0.00	0.17	0.00
UK.021	009 smaller frag b	0.17	12.14	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.05	6.77	4.90	0.00	0.00	5.05	0.00	0.00	1.53	73.19	0.00	0.00	0.48	0.00	0.00	0.00	0.18	0.00
UK.021	average	0.17	12.33	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.05	7.93	5.74	0.00	0.00	6.86	0.00	0.00	1.55	69.96	0.00	0.00	0.50	0.00	0.00	0.00	0.21	0.00
UK.021	009 smaller frag a	0.26	17.50	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.26	7.55	5.47	0.00	0.00	6.83	0.33	0.00	1.43	38.99	0.07	0.00	3.31	0.00	0.04	0.00	0.38	0.00
UK.021	009 smaller frag a	0.23	19.29	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.10	13.54	9.81	0.00	0.00	6.49	0.00	0.00	2.46	55.76	0.00	0.00	1.28	0.00	0.00	0.00	0.21	0.00
UK.021	009 smaller frag a	0.34	19.65	0.03	0.00	0.72	0.00	0.01	0.00	0.00	0.61		0.00		0.00	7.83	1.00	0.00			0.21	0.00	1.46	0.07	0.13	0.15	0.73	0.00
UK.021	average	0.20	13.57	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.07	9.10	6.59	0.00	0.00	6.17	0.00	0.00	1.82	61.20	0.00	0.00	7.19	0.00	0.00	0.00	0.20	0.00
UK.021	009 larger frag b	0.20	15.10	0.00	0.00	0.35	0.00	0.00	0.00	0.01	0.16	23.83	17.26	0.00	0.00	9.14	0.00	0.00	4.84	44.81	0.03	0.00	1.38	0.00	0.00	0.00	0.15	0.00
UK.021	009 larger frag b	0.24	20.68	0.00	0.00	0.48	0.00	0.00	0.00	0.01	0.15	19.68	14.26	0.00	0.00	7.71	0.00	0.00	5.63	43.66	0.05	0.00	1.43	0.00	0.00	0.00	0.26	0.00
UK.021	009 larger frag b	0.15	12.04	0.00	0.00	0.27	0.00	0.00	0.00	0.01	0.06	23.23	16.83	0.00	0.00	0.00	0.00	0.00	5.16	57.72	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.021	average	0.20	12.57	0.00	0.00	0.31	0.00	0.00	0.00	0.01	0.27	28.58	20.70	0.00	0.00	19.72	0.00	0.00	3.73	33.04	0.00	0.00	1.37	0.00	0.00	0.00	0.20	0.00
UK.021	009 larger frag a	0.24	19.22	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.14	18.63	13.49	0.00	0.00	6.72	0.00	0.00	5.89	46.84	0.04	0.00	1.67	0.00	0.00	0.00	0.17	0.00
UK.021	009 larger frag a	0.28	21.96	0.00	0.00	0.51	0.00	0.00	0.00	0.01	0.14	17.51	12.69	0.00	0.00	7.79	0.00	0.00	5.09	44.83	0.04	0.00	1.65	0.00	0.00	0.00	0.19	0.00
UK.021	009 larger frag a	0.16	16.01	0.00	0.00	0.39	0.00	0.00	0.00	0.01	0.06	10.82	7.84	0.00	0.00	0.00	0.00	0.00	7.43	62.97	0.07	0.00	2.01	0.00	0.00	0.00	0.00	0.00
UK.021	average	0.27	19.69	0.00	0.00	0.44	0.00	0.00	0.00	0.02	0.22	27.55	19.96	0.00	0.00	12.36	0.00	0.00	5.14	32.72	0.03	0.00	1.35	0.00	0.00	0.00	0.23	0.00
UK.022	016 b	0.60	11.21	0.00	0.00	0.37	0.00	0.01	0.00	0.00	0.74		0.00		0.00	19.96	0.00	1.81			0.15	0.00	7.12	0.12	0.08	0.14	0.70	0.00
UK.022	016 b	0.68	11.61	0.00	0.00	0.39	0.00	0.01	0.00	0.00	0.80		0.00		0.00	16.76	0.00	3.16			0.26	0.00	10.15	0.18	0.12	0.24	0.95	0.00
UK.022	016 b	0.41	8.24	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.42	6.21	4.50	0.00	0.00	20.62	0.00	0.00	3.78	55.58	0.00	0.00	4.10	0.04	0.00	0.00	0.34	0.00
UK.022	average	0.71	13.78	0.00	0.00	0.45	0.00	0.01	0.00	0.00	1.01		0.00		0.00	22.50	0.00	2.25			0.19	0.00	7.11	0.12	0.13	0.19	0.82	0.00
UK.022	016 a	0.58	11.94	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.64	7.97	5.77	0.00	0.00	26.23	0.00	0.00	3.07	45.82	0.00	0.00	3.05	0.02	0.00	0.00	0.29	0.00
UK.022	016 a	0.60	12.15	0.00	0.00	0.38	0.00	0.00	0.00	0.01	0.63	8.08	5.86	0.00	0.00	25.51	0.00	0.00	2.95	45.65	0.00	0.00	3.67	0.03	0.00	0.00	0.30	0.00
UK.022	016 a	0.56	11.53	0.00	0.00	0.35	0.00	0.00	0.00	0.01	0.65	7.80	5.65	0.00	0.00	27.09	0.00	0.00	3.15	46.46	0.00	0.00	2.14	0.00	0.00	0.00	0.26	0.00
UK.022	average	0.58	12.15	0.00	0.00	0.36	0.00	0.00	0.00	0.01	0.63	8.02	5.81	0.00	0.00	26.08	0.00	0.00	3.12	45.37	0.00	0.00	3.34	0.02	0.00	0.00	0.32	0.00
UK.023	001 b	0.07	9.05	0.00	0.00	0.44	0.00	0.00	0.00	0.01	0.04	5.79	4.20	0.00	0.00	2.62	0.00	0.41	11.70	42.49	0.00	0.06	27.24	0.00	0.00	0.00	0.00	0.00
UK.023	001 b	0.11	15.69	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.07	8.81	6.38	0.00	0.00	3.81	0.00	0.44	18.32	47.40	0.00	0.00	4.62	0.00	0.00	0.00	0.00	0.00
UK.023	001 b	0.10	10.63	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.05	7.05	5.11	0.00	0.00	0.00	0.00	0.78	11.87	60.77	0.00	0.00	5.88	0.00	0.00	0.00	0.00	0.00
UK.023	average	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	1.51	1.09	0.00	0.00	1.83	0.00	0.00	4.92	19.30	0.00	0.19	71.21	0.03	0.00	0.00	0.13	0.00
UK.023	001 a	0.10	11.20	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.06	8.39	6.08	0.00	0.00	6.79	0.00	0.84	13.08	54.00	0.00	0.00	4.79	0.00	0.00	0.00	0.18	0.00
UK.023	001 a	0.12	16.47	0.00	0.00	0.65	0.00	0.00	0.00	0.01	0.07	8.59	6.22	0.00	0.00	4.41	0.00	0.50	15.05	48.58	0.00	0.00	5.34	0.00	0.00	0.00	0.22	0.00
UK.023	001 a	0.09	8.63	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.05	7.32	5.30	0.00	0.00	6.82	0.00	1.38	12.86	59.90	0.00	0.00	2.26	0.00	0.00	0.00	0.16	0.00
UK.023	average	0.11	8.50	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.07	9.27	6.72	0.00	0.00	9.13	0.00	0.65	11.33	53.52	0.00	0.00	6.78	0.00	0.00	0.00	0.16	0.00
UK.024	s_21	0.19	12.77	0.00	0.00	0.26	0.00	0.01	0.00	0.00	0.83		0.00		0.00	0.00	0.00	1.27			0.14	0.00	4.40	0.17	0.12	0.17	0.62	0.00
UK.024	s_21	0.06	10.97	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	19.81	14.36	0.00	0.00	0.00	0.06	0.00	2.04	59.99	0.00	0.00	6.65	0.17	0.00	0.00	0.22	0.00
UK.024	s_21	0.13	8.65	0.00	0.00	0.25	0.00	0.01	0.00	0.00	0.84		0.00		0.00	0.00	0.00	1.43			0.18	0.00	9.94	0.24	0.11	0.18	0.65	0.00
UK.024	average	0.13	10.80	0.00	0.00	0.17	0.00	0.01	0.00	0.01	0.56		0.00		0.00	0.00	0.02	0.90			0.11	0.00	7.00	0.19	0.08	0.12	0.50	0.00
UK.025	019 b	0.51	10.64	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.10	2.86	2.07	0.00	0.00	8.81	0.00	0.00	5.24	66.29	0.00	0.00	4.71	0.17	0.00	0.00	0.25	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
UK.025	019 b	0.52	10.87	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.10	2.93	2.12	0.00	0.00	8.28	0.00	0.00	5.24	66.21	0.00	0.00	4.98	0.15	0.00	0.00	0.29	0.00
UK.025	019 b	0.48	10.06	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.09	2.79	2.02	0.00	0.00	8.91	0.00	0.00	5.52	67.31	0.00	0.00	4.06	0.19	0.00	0.00	0.20	0.00
UK.025	average	0.53	10.98	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.10	2.88	2.08	0.00	0.00	9.24	0.00	0.00	4.96	65.33	0.00	0.00	5.10	0.18	0.00	0.00	0.26	0.00
UK.025	019 a	0.48	10.31	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.09	2.73	1.98	0.00	0.00	8.16	0.00	0.00	4.99	67.90	0.00	0.00	4.56	0.17	0.00	0.00	0.20	0.00
UK.025	019 a	0.46	9.91	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.09	2.76	2.00	0.00	0.00	7.71	0.00	0.00	5.28	68.69	0.00	0.00	4.32	0.18	0.00	0.00	0.20	0.00
UK.025	019 a	0.46	9.91	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.08	2.70	1.95	0.00	0.00	7.86	0.00	0.00	5.17	69.20	0.00	0.00	3.85	0.18	0.00	0.00	0.22	0.00
UK.025	average	0.52	11.12	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.10	2.73	1.98	0.00	0.00	8.92	0.00	0.00	4.53	65.81	0.00	0.00	5.52	0.16	0.00	0.00	0.18	0.00
UK.026	rf 12752	0.09	8.13	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	4.95	0.00	0.00	2.41	0.00	0.00	4.41	79.20	0.04	0.00	0.31	0.00	0.00	0.00	0.18	0.00	
UK.026	rf 12752	0.11	9.89	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.06	8.09	0.00	0.00	10.90	0.00	0.00	3.86	65.39	0.05	0.00	1.09	0.00	0.00	0.00	0.20	0.00	
UK.026	rf 12752	0.11	9.91	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.05	8.09	0.00	0.00	10.38	0.00	0.00	3.89	65.85	0.05	0.00	1.10	0.00	0.00	0.00	0.20	0.00	
UK.026	rf 12752	0.10	9.31	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.04	7.04	0.00	0.00	7.90	0.00	0.00	4.05	70.14	0.05	0.00	0.83	0.00	0.00	0.00	0.19	0.00	
UK.027	022 a	0.05	9.15	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.20	7.71	5.59	0.00	0.00	10.76	0.00	0.00	8.98	60.62	0.14	0.00	1.96	0.00	0.00	0.00	0.19	0.00
UK.027	022 a	0.05	8.84	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.19	7.62	5.52	0.00	0.00	11.55	0.00	0.00	9.00	59.87	0.16	0.00	2.32	0.00	0.00	0.00	0.18	0.00
UK.027	022 a	0.05	9.05	0.00	0.00	0.23	0.00	0.00	0.00	0.01	0.18	7.39	5.36	0.00	0.00	10.10	0.00	0.00	9.43	61.03	0.15	0.00	2.16	0.00	0.00	0.00	0.22	0.00
UK.027	022 a	0.04	9.55	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.23	8.12	5.88	0.00	0.00	10.63	0.00	0.00	8.51	60.97	0.12	0.00	1.40	0.00	0.00	0.00	0.17	0.00
UK.028	011 b	0.14	8.09	0.00	0.00	2.56	0.00	0.00	0.00	0.01	0.03	6.31	4.57	0.00	0.00	0.00	0.03	0.00	0.57	71.52	0.00	0.00	10.70	0.04	0.00	0.00	0.00	0.00
UK.028	011 b	0.14	8.10	0.00	0.00	2.57	0.00	0.00	0.00	0.01	0.00	6.30	4.57	0.00	0.00	0.00	0.00	0.00	0.56	71.57	0.00	0.00	10.67	0.04	0.00	0.00	0.00	0.00
UK.028	011 b	0.13	8.10	0.00	0.00	2.56	0.00	0.00	0.00	0.01	0.03	6.33	4.58	0.00	0.00	0.00	0.00	0.00	0.57	71.52	0.00	0.00	10.71	0.03	0.00	0.00	0.00	0.00
UK.028	average	0.14	8.06	0.00	0.00	2.56	0.00	0.00	0.00	0.01	0.04	6.31	4.57	0.00	0.00	0.00	0.04	0.00	0.57	71.47	0.00	0.00	10.73	0.03	0.00	0.00	0.00	0.00
UK.028	011 a	0.16	9.13	0.00	0.00	3.88	0.00	0.00	0.00	0.01	0.04	10.12	7.33	0.00	0.00	0.00	0.16	0.00	1.29	71.17	0.00	0.00	3.86	0.05	0.00	0.00	0.14	0.00
UK.028	011 a	0.16	9.13	0.00	0.00	3.87	0.00	0.00	0.00	0.01	0.03	10.14	7.35	0.00	0.00	0.00	0.16	0.00	1.29	71.16	0.00	0.00	3.88	0.04	0.00	0.00	0.14	0.00
UK.028	011 a	0.16	9.13	0.00	0.00	3.87	0.00	0.00	0.00	0.01	0.06	10.08	7.30	0.00	0.00	0.00	0.17	0.00	1.29	71.18	0.00	0.00	3.85	0.06	0.00	0.00	0.15	0.00
UK.028	average	0.16	9.12	0.00	0.00	3.89	0.00	0.00	0.00	0.01	0.04	10.14	7.35	0.00	0.00	0.00	0.15	0.00	1.27	71.17	0.00	0.00	3.87	0.05	0.00	0.00	0.13	0.00
UK.029	218	0.19	8.85	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.07	38.70	28.04	0.00	0.00	0.00	0.00	0.00	0.43	23.59	0.00	0.00	28.09	0.05	0.00	0.00	0.00	0.00
UK.029	218	0.16	8.84	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	39.00	28.25	0.00	0.00	0.00	0.00	0.00	0.29	19.06	0.00	0.00	32.51	0.00	0.00	0.00	0.00	0.00
UK.029	218	0.13	7.44	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	37.44	27.13	0.00	0.00	0.00	0.00	0.00	0.28	18.71	0.00	0.00	35.80	0.00	0.00	0.00	0.00	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.029	218	0.13	7.55	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.05	30.75	22.28	0.00	0.00	0.00	0.00	0.00	0.22	23.84	0.00	0.00	37.37	0.07	0.00	0.00	0.00	0.00
UK.029	average	0.14	7.94	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06	35.73	25.89	0.00	0.00	0.00	0.00	0.00	0.26	20.54	0.00	0.00	35.23	0.05	0.00	0.00	0.00	0.00
UK.030	rf 13198	0.16	7.99	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.05	13.29	9.63	0.00	0.00	7.63	0.00	0.00	3.32	66.55	0.04	0.00	0.61	0.00	0.00	0.00	0.12	0.00
UK.030	rf 13198	0.16	7.99	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.04	13.28	9.62	0.00	0.00	7.68	0.00	0.00	3.32	66.56	0.02	0.00	0.60	0.00	0.00	0.00	0.08	0.00
UK.030	rf 13198	0.15	7.63	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.00	8.37	6.07	0.00	0.00	0.00	0.00	0.00	2.49	80.02	0.00	0.00	0.96	0.02	0.00	0.00	0.07	0.00
UK.030	average	0.16	7.87	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.04	11.65	8.44	0.00	0.00	5.10	0.00	0.00	3.04	71.04	0.03	0.00	0.72	0.00	0.00	0.00	0.09	0.00
UK.031	017 b	0.36	5.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	5.07	3.67	0.00	0.00	21.47	0.00	0.00	4.65	56.86	0.00	0.00	5.05	0.07	0.00	0.00	0.20	0.00
UK.031	017 b	0.37	5.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	5.05	3.66	0.00	0.00	21.49	0.00	0.00	4.65	56.83	0.00	0.00	5.07	0.07	0.00	0.00	0.22	0.00
UK.031	017 b	0.36	5.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	5.10	3.70	0.00	0.00	21.46	0.00	0.00	4.65	56.90	0.02	0.00	5.03	0.07	0.00	0.00	0.18	0.00
UK.031	average	0.37	5.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	5.05	3.66	0.00	0.00	21.48	0.00	0.00	4.64	56.84	0.02	0.00	5.06	0.07	0.00	0.00	0.19	0.00
UK.031	017 a	0.39	6.59	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	7.35	5.32	0.00	0.00	18.85	0.00	0.00	4.35	56.62	0.00	0.00	5.26	0.06	0.00	0.00	0.25	0.00
UK.031	017 a	0.39	6.55	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.27	7.33	5.31	0.00	0.00	18.98	0.00	0.00	4.35	56.49	0.00	0.00	5.27	0.07	0.00	0.00	0.28	0.00
UK.031	017 a	0.39	6.61	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	7.35	5.33	0.00	0.00	18.73	0.00	0.00	4.36	56.75	0.00	0.00	5.25	0.06	0.00	0.00	0.22	0.00
UK.031	average	0.39	6.59	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	7.36	5.34	0.00	0.00	18.83	0.00	0.00	4.36	56.62	0.00	0.00	5.24	0.06	0.00	0.00	0.25	0.00
UK.032	s_17	0.23	6.35	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	8.47	6.14	0.00	0.00	4.24	0.00	0.00	2.69	70.55	0.00	0.00	7.09	0.11	0.00	0.00	0.20	0.00
UK.032	s_17	0.38	13.74	0.00	0.00	0.24	0.00	0.00	0.00	0.03	0.06	4.94	3.58	0.00	0.00	0.00	0.00	0.00	1.78	68.09	0.06	0.00	10.20	0.23	0.00	0.00	0.23	0.00
UK.032	s_17	0.51	18.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36		0.00		0.00	0.00	0.00	3.59			0.29	0.00	20.07	0.50	0.00	0.21	0.76	0.00
UK.032	average	0.37	12.74	0.00	0.00	0.08	0.00	0.00	0.00	0.02	0.16		0.00		0.00	0.00	0.00	1.20			0.12	0.00	12.46	0.28	0.00	0.00	0.39	0.00
UK.033	333	0.00	8.87	0.00	0.03	0.00	0.00	0.00	0.00	0.06	0.00	2.88	2.09	0.00	0.00	0.00	0.00	0.00	0.10	4.13	0.00	0.20	82.73	0.36	0.00	0.22	0.38	0.00
UK.033	333	0.00	13.03	0.00	0.03	0.26	0.00	0.00	0.00	0.05	0.00	5.67	4.11	0.00	0.00	0.00	0.00	0.00	0.13	8.40	0.00	0.00	71.66	0.44	0.00	0.10	0.22	0.00
UK.033	333	0.00	12.23	0.00	0.03	0.24	0.00	0.00	0.00	0.08	0.00	4.74	3.43	0.00	0.00	0.00	0.00	0.00	0.13	6.86	0.00	0.13	74.62	0.31	0.00	0.16	0.46	0.00
UK.033	average	0.00	11.38	0.00	0.03	0.17	0.00	0.00	0.00	0.07	0.00	4.43	3.21	0.00	0.00	0.00	0.00	0.00	0.12	6.46	0.00	0.11	76.34	0.37	0.00	0.16	0.36	0.00
UK.033	333	0.00	23.67	0.00	0.00	0.36	0.00	0.00	0.00	0.02	0.00	9.93	7.19	0.00	0.00	0.00	0.00	0.00	0.18	19.19	0.00	0.00	46.25	0.16	0.00	0.12	0.00	0.00
UK.033	333	0.00	16.74	0.00	0.00	0.29	0.00	0.00	0.00	0.02	0.00	4.82	3.49	0.00	0.00	0.00	0.00	0.00	0.10	6.75	0.00	0.00	70.68	0.20	0.00	0.19	0.20	0.00
UK.033	333	0.00	26.91	0.00	0.00	0.42	0.00	0.00	0.00	0.03	0.00	9.75	7.06	0.00	0.00	0.00	0.04	0.00	0.16	12.89	0.00	0.00	49.34	0.00	0.00	0.14	0.30	0.00
UK.033	average	0.00	22.44	0.00	0.00	0.36	0.00	0.00	0.00	0.02	0.00	8.17	5.92	0.00	0.00	0.00	0.00	0.00	0.14	12.94	0.00	0.00	55.42	0.14	0.00	0.15	0.21	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.033	rf 10660	0.00	5.43	0.00	0.00	0.00	0.00	0.01	0.00	0.05	0.09	59.61	43.19	0.00	0.00	0.00	0.00	0.00	0.17	31.80	0.00	0.00	2.79	0.00	0.00	0.00	0.00	0.00
UK.033	rf 10660	0.00	4.59	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	61.49	44.55	0.00	0.00	0.00	0.00	0.00	0.15	30.95	0.12	0.00	2.59	0.08	0.00	0.00	0.00	0.00
UK.033	rf 10660	0.07	8.22	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.12	59.68	43.24	0.00	0.00	0.00	0.00	0.00	0.19	29.54	0.00	0.00	2.01	0.00	0.00	0.00	0.00	0.00
UK.033	average	0.00	6.08	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	60.26	43.66	0.00	0.00	0.00	0.00	0.00	0.17	30.76	0.00	0.00	2.46	0.00	0.00	0.00	0.00	0.00
UK.034	rf 7326	0.20	2.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	42.63	30.88	0.00	0.04	34.08	0.00	0.00	1.44	17.88	0.03	0.00	0.66	0.00	0.03	0.07	0.25	0.00
UK.034	rf 7326	0.28	4.39	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.05	13.02	9.43	0.00	0.00	11.14	0.00	0.00	5.35	63.34	0.00	0.00	1.66	0.00	0.00	0.00	0.13	0.00
UK.034	rf 7326	0.29	4.31	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.12	13.51	9.79	0.00	0.00	19.66	0.00	0.00	5.23	54.41	0.03	0.00	1.59	0.00	0.00	0.00	0.11	0.00
UK.034	average	0.26	3.62	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.22	23.05	16.70	0.00	0.01	21.63	0.00	0.00	4.00	45.21	0.03	0.00	1.30	0.00	0.00	0.00	0.16	0.00
UK.035	rf 14022	0.13	3.11	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.03	7.04	5.10	0.00	0.00	5.15	0.00	0.00	12.93	67.58	0.00	0.00	1.15	0.00	0.00	0.00	0.09	0.00
UK.035	rf 14022	0.13	3.35	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	7.25	5.25	0.00	0.00	4.40	0.00	0.00	13.38	69.67	0.00	0.00	1.15	0.00	0.00	0.00	0.11	0.00
UK.035	rf 14022	0.13	3.27	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.03	7.05	5.11	0.00	0.00	5.94	0.00	0.00	13.05	68.97	0.00	0.00	1.09	0.00	0.00	0.00	0.11	0.00
UK.035	average	0.13	3.24	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.03	7.11	5.15	0.00	0.00	5.16	0.00	0.00	13.12	68.74	0.00	0.00	1.13	0.00	0.00	0.00	0.10	0.00
UK.035	rf 14022	0.13	3.11	0.00	0.00	2.78	0.00	0.00	0.00	0.00	0.03	7.04	0.00	0.00	5.15	0.00	0.00	12.93	67.58	0.00	0.00	1.15	0.00	0.00	0.00	0.09	0.00	
UK.035	rf 14022	0.13	3.35	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	7.25	0.00	0.00	4.40	0.00	0.00	13.38	69.67	0.00	0.00	1.15	0.00	0.00	0.00	0.11	0.00	
UK.035	rf 14022	0.13	3.27	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.03	7.05	0.00	0.00	5.94	0.00	0.00	13.05	68.97	0.00	0.00	1.09	0.00	0.00	0.00	0.11	0.00	
UK.035	rf 14022	0.13	3.24	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.03	7.11	0.00	0.00	5.16	0.00	0.00	13.12	68.74	0.00	0.00	1.13	0.00	0.00	0.00	0.10	0.00	
UK.036	608	0.05	6.42	0.00	0.00	36.90	0.00	0.00	0.00	0.00	0.05	1.81	1.31	22.00	0.00	0.00	19.30	0.00	0.20	6.91	0.00	0.00	5.77	0.00	0.00	0.26	0.31	0.00
UK.036	608	0.00	4.28	0.00	0.00	24.38	0.00	0.00	0.00	0.01	0.00	1.82	1.31	0.00	0.00	0.00	0.50	0.00	0.33	19.42	0.00	0.00	48.44	0.20	0.00	0.23	0.39	0.00
UK.036	608	0.00	6.41	0.00	0.00	45.31	0.00	0.00	0.00	0.00	0.04	3.31	2.40	0.00	0.00	0.00	1.12	0.00	0.45	15.91	0.00	0.00	26.66	0.11	0.00	0.25	0.35	0.00
UK.036	average	0.00	5.70	0.00	0.00	35.53	0.00	0.00	0.00	0.00	0.03	2.31	1.67	7.36	0.00	0.00	6.97	0.00	0.32	14.08	0.00	0.00	26.96	0.10	0.00	0.25	0.35	0.00
UK.036	608	0.00	2.40	0.00	0.02	9.29	0.00	0.00	0.00	0.02	0.00	0.66	0.48	0.56	0.00	1.15	0.46	0.00	0.20	11.61	0.00	0.11	72.69	0.08	0.16	0.19	0.41	0.00
UK.036	608	0.00	2.41	0.00	0.02	9.28	0.00	0.00	0.00	0.02	0.00	0.69	0.50	0.62	0.00	0.93	0.46	0.00	0.19	11.74	0.00	0.14	72.69	0.09	0.15	0.21	0.39	0.00
UK.036	608	0.00	2.39	0.00	0.02	9.31	0.00	0.00	0.00	0.02	0.00	0.69	0.50	0.55	0.00	0.89	0.46	0.00	0.19	11.74	0.00	0.10	72.82	0.09	0.17	0.18	0.40	0.00
UK.036	average	0.00	2.40	0.00	0.02	9.29	0.00	0.00	0.00	0.02	0.00	0.68	0.49	0.58	0.00	0.99	0.46	0.00	0.20	11.70	0.00	0.11	72.73	0.09	0.16	0.19	0.40	0.00
UK.037	004 b	0.20	2.36	0.02	0.00	0.17	0.00	0.00	0.00	0.01	0.63	21.68	15.71	0.00	0.00	18.37	0.08	0.00	2.76	21.93	0.03	0.00	9.93	0.00	0.00	0.08	0.23	0.00
UK.037	004 b	0.15	2.65	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.34	30.15	21.84	0.00	0.00	15.07	0.00	0.00	3.89	35.79	0.00	0.00	11.51	0.00	0.00	0.00	0.14	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.037	004 b	0.20	2.29	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.34	34.89	25.28	0.00	0.00	15.73	0.00	0.00	4.40	29.99	0.00	0.00	11.89	0.00	0.00	0.00	0.18	0.00
UK.037	average	0.25	2.14	0.05	0.02	0.28	0.00	0.00	0.00	0.00	1.21		0.00		0.00	24.31	0.25	0.00			0.06	0.00	6.38	0.04	0.08	0.16	0.37	0.00
UK.037	004 a	0.22	2.27	0.04	0.02	0.28	0.00	0.00	0.00	0.00	0.96		0.00		0.00	20.81	0.15	0.00			0.06	0.00	7.32	0.03	0.06	0.13	0.32	0.00
UK.037	004 a	0.24	1.98	0.06	0.02	0.30	0.00	0.01	0.00	0.00	1.25		0.00		0.00	23.04	0.23	0.00			0.08	0.00	4.81	0.04	0.09	0.14	0.39	0.00
UK.037	004 a	0.24	2.01	0.05	0.02	0.29	0.00	0.00	0.00	0.00	1.26		0.00		0.00	19.55	0.21	0.00			0.07	0.00	4.73	0.04	0.09	0.16	0.40	0.00
UK.037	average	0.18	2.81	0.01	0.00	0.25	0.00	0.00	0.00	0.01	0.38	31.21	22.61	0.00	0.00	19.85	0.00	0.00	3.73	28.86	0.04	0.00	12.41	0.00	0.00	0.09	0.17	0.00
UK.038	015 b	0.02	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.48	0.34	0.00	0.02	12.09	0.00	0.00	0.12	82.29	0.00	0.00	3.95	0.04	0.00	0.00	0.18	0.00
UK.038	015 b	0.03	0.86	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.53	0.38	0.00	0.02	12.15	0.00	0.00	0.12	82.13	0.00	0.00	3.91	0.04	0.00	0.00	0.17	0.00
UK.038	015 b	0.03	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.53	0.38	0.00	0.02	12.29	0.00	0.00	0.12	81.96	0.00	0.00	3.91	0.04	0.00	0.00	0.18	0.00
UK.038	average	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.37	0.27	0.00	0.02	11.82	0.00	0.00	0.13	82.80	0.00	0.00	4.04	0.05	0.00	0.00	0.18	0.00
UK.038	015 a	0.04	2.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.18	0.13	0.00	0.00	10.46	0.00	0.00	0.10	85.49	0.02	0.00	1.25	0.02	0.00	0.00	0.10	0.00
UK.038	015 a	0.04	2.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	0.10	0.00	0.00	9.49	0.00	0.00	0.13	86.01	0.03	0.00	1.37	0.01	0.00	0.00	0.11	0.00
UK.038	015 a	0.04	2.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	0.10	0.00	0.00	9.81	0.00	0.00	0.13	85.69	0.03	0.00	1.35	0.02	0.00	0.00	0.11	0.00
UK.038	average	0.05	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.26	0.19	0.00	0.00	12.08	0.00	0.00	0.04	84.78	0.00	0.00	1.02	0.02	0.00	0.00	0.09	0.00
UK.039	003 b	0.06	0.85	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.76	13.57	9.83	0.00	0.00	23.43	0.00	0.81	20.63	36.73	0.00	0.00	2.86	0.00	0.00	0.00	0.00	0.00
UK.039	003 b	0.07	0.88	0.02	0.00	0.25	0.00	0.00	0.00	0.01	0.85	17.60	12.75	0.00	0.00	31.59	0.00	0.12	14.80	30.56	0.00	0.00	3.19	0.00	0.00	0.00	0.00	0.00
UK.039	003 b	0.05	0.86	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.69	10.72	7.76	0.00	0.00	15.17	0.00	1.65	26.61	41.37	0.00	0.00	2.64	0.00	0.00	0.00	0.00	0.00
UK.039	average	0.07	0.82	0.01	0.00	0.22	0.00	0.00	0.00	0.01	0.73	12.40	8.98	0.00	0.00	23.52	0.00	0.68	20.48	38.28	0.00	0.00	2.75	0.00	0.00	0.00	0.00	0.00
UK.039	003 a	0.06	0.80	0.00	0.00	0.15	0.00	0.00	0.00	0.01	0.83	9.43	6.83	0.00	0.00	22.60	0.00	0.46	14.15	48.30	0.00	0.00	3.15	0.00	0.00	0.00	0.00	0.00
UK.039	003 a	0.07	0.75	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.74	11.11	8.05	0.00	0.00	28.83	0.00	0.51	10.36	44.15	0.00	0.00	3.40	0.00	0.00	0.00	0.05	0.00
UK.039	003 a	0.06	0.81	0.01	0.00	0.20	0.00	0.00	0.00	0.01	1.02	5.26	3.81	0.00	0.00	17.63	0.00	0.00	8.35	63.66	0.00	0.00	2.91	0.00	0.00	0.00	0.08	0.00
UK.039	average	0.07	0.85	0.00	0.00	0.24	0.00	0.00	0.00	0.01	0.74	11.91	8.63	0.00	0.00	21.34	0.00	0.86	23.74	37.08	0.03	0.00	3.13	0.00	0.00	0.00	0.00	0.00
UK.040	477	0.08	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.24	0.00	0.00	0.00	0.00	0.00	0.00	87.14	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00
UK.040	477	0.08	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.24	0.00	0.00	0.00	0.00	0.00	0.00	87.11	0.00	0.00	2.65	0.00	0.00	0.00	0.00	0.00
UK.040	477	0.07	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.25	0.00	0.00	0.00	0.00	0.00	0.00	87.39	0.00	0.00	2.63	0.00	0.00	0.00	0.00	0.00
UK.040	average	0.08	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.25	0.00	0.00	0.00	0.00	0.00	0.00	87.21	0.00	0.00	2.64	0.00	0.00	0.00	0.00	0.00

REF NUM	*SAMPLE*	*Sb*	*Sn*	*Cd*	*Pd*	*Ag*	*Ru*	*Mo*	*Nb*	*Zr*	*Bi*	*Pb*	*Pb (scaled down)*	*Hg*	*Se*	*As*	*Au*	*W*	*Zn*	*Cu*	*Ni*	*Co*	*Fe*	*Mn*	*Cr*	*V*	*Ti*	*Al*
UK.041	s_20	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56	1.13	0.00	0.00	0.00	0.00	0.00	15.33	78.67	0.00	0.00	2.43	0.00	0.00	0.00	0.00	0.00
UK.041	s_20	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	2.06	1.49	0.00	0.00	2.23	0.00	0.00	12.71	77.48	0.00	0.00	4.97	0.12	0.00	0.00	0.18	0.00
UK.041	s_20	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83	1.33	0.00	0.00	2.66	0.00	0.00	15.16	77.57	0.00	0.00	2.39	0.03	0.00	0.00	0.10	0.00
UK.041	s_20	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	1.20	0.00	0.00	3.12	0.00	0.00	12.98	80.0 9	0.00	0.00	1.80	0.00	0.00	0.00	0.06	0.00
UK.041	average	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	1.85	1.34	0.00	0.00	2.67	0.00	0.00	13.62	78.38	0.00	0.00	3.05	0.05	0.00	0.00	0.12	0.00
UK.04 2	024 S B	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.26	0.19	0.00	0.00	0.43	0.00	0.00	12.85	85.66	0.09	0.00	0.61	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 S B	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.26	0.19	0.00	0.00	0.36	0.00	0.00	12.90	85.69	0.09	0.00	0.61	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 S B	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.25	0.18	0.00	0.00	0.54	0.00	0.00	12.83	85.58	0.09	0.00	0.61	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 S B	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.26	0.19	0.00	0.00	0.38	0.00	0.00	12.83	85.71	0.09	0.00	0.62	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 S A	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.33	0.24	0.00	0.00	0.37	0.00	0.00	14.19	84.07	0.10	0.00	0.84	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 S A	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.33	0.24	0.00	0.00	0.00	0.00	0.00	14.17	84.12	0.10	0.00	0.84	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 S A	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.33	0.24	0.00	0.00	0.00	0.00	0.00	14.22	84.12	0.10	0.00	0.84	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 S A	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.32	0.23	0.00	0.00	0.50	0.00	0.00	14.18	83.95	0.09	0.00	0.83	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 M B	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.20	0.00	0.00	1.16	0.00	0.00	11.22	86.53	0.00	0.00	0.66	0.00	0.00	0.00	0.04	0.00
UK.04 2	024 M B	0.00	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.19	0.00	0.00	1.17	0.00	0.00	11.16	86.58	0.00	0.00	0.69	0.00	0.00	0.00	0.04	0.00
UK.04 2	024 M B	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.20	0.00	0.00	1.12	0.00	0.00	11.17	86.57	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 M B	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.20	0.00	0.00	1.18	0.00	0.00	11.34	86.45	0.02	0.00	0.60	0.00	0.00	0.00	0.04	0.00
UK.04 2	024 M A	0.09	2.15	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.04	6.38	4.62	0.00	0.00	6.88	0.00	0.00	10.65	72.70	0.00	0.00	1.01	0.00	0.00	0.00	0.07	0.00
UK.04 2	024 M A	0.00	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.29	0.00	0.00	1.66	0.00	0.00	11.28	86.10	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00
UK.04 2	024 M A	0.15	3.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.05	9.15	6.63	0.00	0.00	6.12	0.00	0.00	10.68	69.38	0.00	0.00	1.29	0.00	0.00	0.00	0.08	0.00
UK.04 2	024 M A	0.12	3.30	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06	9.59	6.95	0.00	0.00	12.87	0.00	0.00	9.99	62.62	0.00	0.00	1.29	0.00	0.00	0.00	0.13	0.00
UK.04 2	024 L B	10.19	75.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.44	0.32	0.00	0.00	1.01	0.00	0.00	0.05	0.46	0.00	0.00	12.25	0.13	0.00	0.00	0.00	0.00
UK.04 2	024 L B	8.08	62.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.36	0.26	0.00	0.00	0.89	0.00	0.00	0.04	0.42	0.00	0.00	27.68	0.13	0.00	0.00	0.00	0.00
UK.04 2	024 L B	11.30	81.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.49	0.35	0.00	0.00	1.08	0.00	0.00	0.05	0.47	0.00	0.00	4.50	0.10	0.00	0.00	0.00	0.00
UK.04 2	024 L B	11.20	81.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.46	0.33	0.00	0.00	1.06	0.00	0.00	0.05	0.49	0.00	0.00	4.57	0.17	0.00	0.00	0.00	0.00
UK.04 2	024 L A	6.77	52.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.32	0.23	0.00	0.00	0.49	0.00	0.00	0.00	0.47	0.00	0.00	39.72	0.00	0.00	0.00	0.00	0.00

REF NUM	SAMPLE	Sb	Sn	Cd	Pd	Ag	Ru	Mo	Nb	Zr	Bi	Pb	Pb (scaled down)	Hg	Se	As	Au	W	Zn	Cu	Ni	Co	Fe	Mn	Cr	V	Ti	Al
UK.042	024 L A	4.24	33.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.18	0.00	0.00	0.00	0.00	0.00	0.02	0.38	0.00	0.00	61.33	0.08	0.00	0.00	0.00	0.00
UK.042	024 L A	8.33	64.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.34	0.25	0.00	0.00	0.68	0.00	0.00	0.00	0.52	0.00	0.00	25.53	0.00	0.00	0.00	0.00	0.00
UK.042	024 L A	7.75	58.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.36	0.26	0.00	0.00	0.64	0.00	0.00	0.00	0.50	0.00	0.00	32.31	0.00	0.00	0.00	0.00	0.00
UK.043	rf 7896	0.07	0.04	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.01	0.67	0.49	0.00	0.00	1.83	0.00	0.00	0.04	96.80	0.03	0.00	0.20	0.02	0.00	0.00	0.00	0.00
UK.043	rf 7896	0.07	0.04	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.03	0.48	0.35	0.00	0.00	1.43	0.00	0.00	0.00	97.54	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
UK.043	rf 7896	0.08	0.04	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.03	0.49	0.35	0.00	0.00	1.51	0.00	0.00	0.00	97.46	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00
UK.043	average	0.07	0.04	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.02	0.55	0.40	0.00	0.00	1.59	0.00	0.00	0.00	97.27	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
UK.044	006 b	0.38	0.03	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.49	1.23	0.89	0.00	0.00	9.91	0.00	0.00	0.00	83.54	0.06	0.00	3.94	0.02	0.00	0.00	0.13	0.00
UK.044	006 b	0.37	0.02	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.46	1.03	0.74	0.00	0.00	9.92	0.00	0.00	0.00	84.40	0.05	0.00	3.37	0.02	0.00	0.00	0.12	0.00
UK.044	006 b	0.40	0.05	0.00	0.00	0.25	0.00	0.00	0.00	0.01	0.50	1.34	0.97	0.00	0.02	9.02	0.00	0.00	0.00	85.02	0.06	0.00	3.24	0.02	0.00	0.00	0.10	0.00
UK.044	average	0.38	0.02	0.00	0.00	0.26	0.00	0.00	0.00	0.01	0.53	1.33	0.96	0.00	0.00	10.81	0.00	0.00	0.00	81.18	0.06	0.00	5.21	0.03	0.00	0.00	0.18	0.00
UK.044	006 a	0.38	0.03	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.48	1.32	0.95	0.22	0.00	10.57	0.58	0.00	0.00	82.57	0.05	0.00	3.49	0.02	0.00	0.00	0.09	0.00
UK.044	006 a	0.38	0.03	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.45	1.30	0.94	0.17	0.00	10.44	0.52	0.00	0.00	83.16	0.05	0.00	3.21	0.00	0.00	0.00	0.07	0.00
UK.044	006 a	0.40	0.02	0.00	0.00	0.22	0.00	0.00	0.00	0.01	0.52	1.42	1.03	0.32	0.00	10.96	0.75	0.00	0.00	81.91	0.06	0.00	3.28	0.02	0.00	0.00	0.13	0.00
UK.044	average	0.37	0.03	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.46	1.24	0.90	0.17	0.00	10.31	0.47	0.00	0.00	82.63	0.05	0.00	3.96	0.02	0.00	0.00	0.06	0.00
V.001	lin-d1bd32 side b	0.10	22.94	0.00	0.00	0.39	0.00	0.00	0.00	0.01	0.06	11.04	8.00	0.00	0.00	5.26	0.00	0.00	5.55	52.92	0.00	0.00	1.06	0.00	0.00	0.00	0.63	0.00
V.001	lin-d1bd32 side b	0.13	12.40	0.00	0.00	0.38	0.00	0.00	0.00	0.01	0.22	36.99	26.80	0.00	0.00	11.91	0.00	0.00	0.22	37.27	0.00	0.00	0.27	0.00	0.00	0.00	0.20	0.00
V.001	lin-d1bd32 side b	0.14	9.39	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.47	48.69	35.27	0.00	0.03	22.45	0.00	0.00	0.19	18.11	0.00	0.00	0.35	0.00	0.00	0.00	0.18	0.00
V.001	average	0.10	10.91	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.13	78.51	56.88	0.00	0.00	0.00	0.00	0.00	0.34	9.15	0.12	0.00	0.67	0.00	0.00	0.00	0.00	0.00
V.001	lin-d1bd32 side a	0.14	13.85	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	60.55	43.87	0.00	0.00	0.00	0.00	0.00	0.21	24.73	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
V.001	lin-d1bd32 side a	0.00	4.62	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.34	48.06	0.00	0.00	0.00	0.00	0.00	0.00	28.42	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00
V.001	average	0.09	10.34	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.11	80.81	58.55	0.00	0.00	0.00	0.00	0.00	0.21	8.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00
W.001	toxx 21	0.53	1.62	0.02	0.02	0.26	0.00	0.00	0.00	0.01	0.00	24.91	18.05	0.00	0.00	4.16	0.00	0.00	6.91	57.88	0.07	0.00	3.20	0.05	0.00	0.00	0.29	0.00
W.001	toxx 21	0.51	1.81	0.02	0.02	0.31	0.00	0.00	0.00	0.05	0.13	23.60	17.10	0.00	0.00	11.35	0.00	0.00	6.48	51.18	0.08	0.00	4.02	0.05	0.00	0.00	0.36	0.00
W.001	toxx 21	0.44	1.53	0.00	0.02	0.27	0.00	0.00	0.00	0.01	0.13	20.93	15.16	0.00	0.00	13.40	0.00	0.00	5.41	54.00	0.02	0.00	3.36	0.04	0.00	0.05	0.39	0.00
W.001	average	0.49	1.65	0.01	0.02	0.28	0.00	0.00	0.00	0.03	0.10	23.15	16.77	0.00	0.00	9.64	0.00	0.00	6.27	54.35	0.06	0.00	3.53	0.05	0.00	0.00	0.35	0.00

Appendix Two

Appendix Two shows the relevant alloy value of tin, lead, and zinc as well as their scaled values used to create relative comparisons with the ternary diagrams. In addition, Appendix Two shows the relevant information about the object such as type, date range, style, and collection point.

Table 5 Tin, Lead, and Zinc pXRF Data with Object Information

Reference Number	***Sn***	***Pb, Scaled Down***	***Zn***	***Sum***	***Scale Factor***	***Scaled Sn***	***Scaled Pb***	***Scaled Zn***	***New Sum***	***Ascribed Culture***	***Object Type***	***Date Range***	***Style***	***Type***	***Finds Spot/Collection Point***
BC.001	35.88	10.84	2.88	49.59	2.02	72.35	21.85	5.80	100.00	Anglo-Saxon	Buckle	E. Saxon	Kentish		Scremby
BC.002	18.14	5.46	5.36	28.96	3.45	62.65	18.85	18.50	100.00	Anglo-Scandinavian	Buckle	Second VA	Borre	D-Shaped,	North Lincs
BC.003	10.69	4.44	1.89	17.02	5.88	62.80	26.11	11.09	100.00	Anglo-Saxon	Buckle	E. Saxon		D-Shaped	Scremby
BC.004	10.27	12.57	5.11	27.94	3.58	36.75	44.97	18.28	100.00	Scandinavian	Buckle	Second VA	Borre	D-Shaped	Peter Jarnell
BC.005	2.93	26.00	2.04	30.97	3.23	9.45	83.95	6.60	100.00	Scandinavian	Buckle	LS/1 VA	Borre		North Lincs
BC.006	2.47	12.54	3.34	18.35	5.45	13.43	68.35	18.21	100.00	Scandinavian	Buckle	Second VA		D-Shaped	North Lincs
BC.007	0.80	2.78	5.91	9.49	10.54	8.47	29.28	62.25	100.00	Anglo-Scandinavian	Buckle	Second VA	Ringerike	D-Shaped	Osbournby
BC.008	0.26	8.33	5.30	13.89	7.20	1.84	59.97	38.19	100.00	Scandinavian	Buckle	Second VA	Ringerike	D-Shaped	North Lincs
BC.009	0.12	2.98	8.69	11.79	8.48	1.00	25.26	73.74	100.00	Anglo-Saxon	Buckle	E. Saxon		Tongue	Osbournby
BC.010	0.06	11.02	4.89	15.97	6.26	0.35	69.02	30.63	100.00	Anglo-Scandinavian	Buckle	Second VA	Zoomorphic	D-Shaped	North Lincs
BC.011	0.04	5.11	1.98	7.13	14.03	0.52	71.76	27.72	100.00	Scandinavian	Buckle	Second VA	Urnes	D-Shaped	North Lincs
BC.012	0.03	3.05	6.52	9.60	10.41	0.35	31.76	67.88	100.00	Scandinavian	Buckle	Second VA		D-Shaped	North Lincs
BE.001	12.25	27.65	0.77	40.67	2.46	30.12	67.99	1.90	100.00	Scandinavian	Bell	Second VA		Meol type	North Lincs
BE.002	5.74	22.30	2.79	30.83	3.24	18.62	72.33	9.06	100.00	Scandinavian	Bell	Second VA	Meol type		North Lincs
BE.003	2.49	24.11	1.31	27.91	3.58	8.92	86.39	4.70	100.00	Scandinavian	Bell	Second VA	Meol type		North Lincs

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
BE.004	1.15	12.76	1.08	15.00	6.67	7.67	85.11	7.22	100.00	Scandinavian	Bell	Second VA	Meol type		North Lincs
BE.005	1.12	34.98	0.35	36.45	2.74	3.08	95.97	0.95	100.00	Scandinavian	Bell	Second VA	Norse bell		Osbournby
BF.001	18.30	16.23	0.17	34.70	2.88	52.75	46.77	0.48	100.00	Anglo-Scandinavian	Bridle Fitting	Second VA			Osbournby
BF.002	17.81	16.00	0.21	34.03	2.94	52.35	47.03	0.61	100.00	Anglo-Scandinavian	Bridle Fitting	Second VA			Osbournby
BF.003	16.69	3.08	0.10	19.87	5.03	83.99	15.51	0.50	100.00	Anglo-Saxon	Bridle fitting	E. Saxon	Style I		Osbournby
BF.004	0.15	4.47	9.67	14.29	7.00	1.06	31.30	67.64	100.00	Scandinavian	Bridle Fitting	Second VA			North Lincs
BF.005	0.15	1.76	3.88	5.78	17.29	2.52	30.43	67.05	100.00	Anglo-Scandinavian	Bridle Fitting	Second VA	Lozenge	Williams Type 2	Osbournby
BF.006	0.11	13.27	9.06	22.44	4.46	0.48	59.13	40.39	100.00	Scandinavian	Bridle Fitting	Second VA			North Lincs
BF.007	0.09	22.27	11.56	33.93	2.95	0.27	65.65	34.08	100.00	Scandinavian	Bridle Fitting	Second VA	Ringerike		North Lincs
BF.008	0.08	10.89	2.77	13.74	7.28	0.55	79.28	20.17	100.00	Anglo-Scandinavian	Bridle fitting	Second VA		Plano-Convex	Osbournby
BF.009	0.07	6.86	9.08	16.01	6.25	0.41	42.87	56.72	100.00	Anglo-Scandinavian	Bridle fitting	Second VA		D-Shaped	Osbournby
BF.010	0.05	28.39	5.13	33.56	2.98	0.15	84.58	15.27	100.00	Scandinavian	Bridle Fitting	Second VA			North Lincs
BF.011	0.04	3.64	3.14	6.82	14.66	0.54	53.42	46.03	100.00	Scandinavian	Bridle Fitting	Second VA	Urnes		North Lincs
BF.012	9.44	29.34	5.35	44.13	2.27	21.40	66.47	12.13	100.00	Scandinavian	Bridle Fitting	Second VA			North Lincs
BR.001	3.65	2.20	5.87	11.71	8.54	31.13	18.78	50.08	100.00	Anglo-Scandinavian	Brooch	Second VA	Equal Arm	Equal Arm	North Lincs
BR.002	47.38	7.32	0.21	54.90	1.82	86.29	13.33	0.38	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Osbournby
BR.003	42.61	8.56	1.79	52.96	1.89	80.46	16.17	3.37	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.004	41.11	7.16	0.77	49.05	2.04	83.82	14.60	1.57	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.005	37.19	10.91	1.61	49.72	2.01	74.81	21.94	3.25	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.006	36.78	7.02	0.62	44.42	2.25	82.80	15.80	1.40	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Osbournby
BR.007	35.71	8.84	0.30	44.85	2.23	79.63	19.70	0.67	100.00	Anglo-Saxon	Brooch	E. Saxon		Saucer	Scremby
BR.008	35.59	8.32	0.38	44.29	2.26	80.36	18.78	0.86	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.009	34.12	3.56	0.24	37.92	2.64	89.97	9.40	0.63	100.00	Anglo-Saxon	Brooch	E. Saxon	Style I	Square Head (small)	Osbournby
BR.010	33.43	6.10	0.79	40.33	2.48	82.91	15.13	1.96	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Osbournby

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
BR.011	32.88	8.22	2.41	43.51	2.30	75.57	18.90	5.53	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.012	32.71	16.45	2.29	51.45	1.94	63.57	31.97	4.46	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Osbournby
BR.013	32.58	10.98	0.55	44.11	2.27	73.86	24.88	1.26	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.014	31.84	2.53	0.32	34.69	2.88	91.79	7.29	0.93	100.00	Anglo-Saxon	Brooch	M. Saxon		Annular	Little Carlton
BR.015	31.58	7.14	0.94	39.66	2.52	79.63	18.01	2.36	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Osbournby
BR.016	30.39	7.79	0.94	39.13	2.56	77.68	19.91	2.41	100.00	Anglo-Saxon	Brooch	E. Saxon	Martin Group 2	Cruciform	Scremby
BR.017	30.08	7.56	2.23	39.87	2.51	75.45	18.97	5.58	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.018	28.36	9.68	1.41	39.44	2.54	71.91	24.53	3.56	100.00	Anglo-Saxon	Brooch	E. Saxon	Concentric circles	Annular	Scremby
BR.019	28.20	6.86	1.44	36.50	2.74	77.25	18.80	3.95	100.00	Anglo-Saxon	Brooch	E. Saxon	Incised lines	Annular	Scremby
BR.020	27.22	15.38	1.29	43.88	2.28	62.02	35.05	2.93	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.021	26.87	9.62	1.64	38.12	2.62	70.48	25.22	4.30	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.022	26.70	2.29	0.17	29.16	3.43	91.56	7.85	0.58	100.00	Anglo-Saxon	Brooch	M. Saxon		Annular	Little Carlton
BR.023	25.12	12.37	1.00	38.49	2.60	65.26	32.15	2.60	100.00	Anglo-Saxon	Brooch	E. Saxon		Annular	Scremby
BR.024	24.19	13.46	0.76	38.42	2.60	62.97	35.04	1.99	100.00	Anglo-Saxon	Brooch	E. Saxon	Punched Crescents	Small Long	Osbournby
BR.025	23.97	18.02	3.25	45.23	2.21	52.99	39.83	7.17	100.00	Anglo-Saxon	Brooch	E. Saxon	2 spots of 3 transverse lines	Annular	Scremby
BR.026	23.36	4.79	1.29	29.43	3.40	79.36	16.26	4.38	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Scremby
BR.027	21.83	11.79	1.52	35.14	2.85	62.12	33.57	4.32	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Osbournby
BR.028	21.67	7.21	11.14	40.01	2.50	54.15	18.01	27.84	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.029	21.07	4.76	2.46	28.30	3.53	74.47	16.82	8.70	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Scremby
BR.030	20.78	13.67	0.63	35.09	2.85	59.23	38.97	1.80	100.00	Anglo-Saxon	Brooch	LS/1 VA	Weetch type XI	Ansante	Osbournby
BR.031	20.65	14.92	1.93	37.50	2.67	55.07	39.78	5.14	100.00	Anglo-Saxon	Brooch	E. Saxon	Zoomorphic	Cruciform	Osbournby
BR.032	19.99	10.52	1.70	32.20	3.11	62.07	32.66	5.27	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.033	18.77	8.46	1.53	28.77	3.48	65.25	29.43	5.32	100.00	Anglo-Saxon	Brooch	E. Saxon	Martin 3.2.1	Cruciform	Scremby

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
BR.034	18.77	8.96	3.09	30.82	3.24	60.89	29.08	10.02	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.035	18.28	10.24	1.09	29.60	3.38	61.75	34.58	3.67	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.036	18.15	3.79	1.75	23.69	4.22	76.61	15.99	7.40	100.00	Anglo-Saxon	Brooch	E. Saxon	Matrin 4.4.1	Cruciform	Scremby
BR.037	17.46	12.63	1.94	32.03	3.12	54.52	39.42	6.06	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Osbournby
BR.038	17.03	34.97	1.35	53.35	1.87	31.93	65.54	2.53	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.039	16.92	9.53	4.85	31.30	3.20	54.05	30.46	15.49	100.00	Anglo-Saxon	Brooch	E. Saxon		Annular brooch	Osbournby
BR.040	15.86	18.33	1.35	35.54	2.81	44.63	51.58	3.79	100.00	Anglo-Saxon	Brooch	E. Saxon	Undecorated	Square Head	Osbournby
BR.041	15.42	7.94	0.28	23.64	4.23	65.22	33.58	1.20	100.00	Anglo-Saxon	Brooch	E. Saxon	Zoomorphic	Cruciform	Osbournby
BR.042	14.86	3.03	1.18	19.07	5.25	77.92	15.90	6.18	100.00	Anglo-Saxon	Brooch	E. Saxon	Incised lines	Annular	Scremby
BR.043	14.12	11.38	0.78	26.28	3.81	53.72	43.32	2.96	100.00	Anglo-Saxon	Brooch	E. Saxon	Florid	Cruciform	Osbournby
BR.044	14.10	10.35	1.07	25.52	3.92	55.26	40.57	4.17	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Scremby
BR.045	12.79	4.85	10.07	27.71	3.61	46.14	17.51	36.35	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.046	12.20	6.63	3.82	22.65	4.41	53.85	29.29	16.86	100.00	Anglo-Saxon	Brooch	E. Saxon	Punched Dot	Annular	Scremby
BR.047	12.15	7.74	0.72	20.61	4.85	58.97	37.55	3.48	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.048	11.79	3.78	6.39	21.96	4.55	53.68	17.21	29.11	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.049	11.12	5.95	10.57	27.64	3.62	40.23	21.54	38.23	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby
BR.050	11.04	8.65	0.90	20.58	4.86	53.61	42.01	4.38	100.00	Anglo-Saxon	Brooch	E. Saxon	Late Florid	Cruciform	Osbournby
BR.051	10.40	13.62	1.78	25.80	3.88	40.30	52.80	6.90	100.00	Anglo-Saxon	Brooch	E. Saxon	Martin 3.2.1	Cruciform	Scremby
BR.052	10.35	4.22	1.44	16.00	6.25	64.65	26.34	9.01	100.00	Anglo-Saxon	Brooch	E. Saxon		Small Long	Scremby
BR.053	10.17	9.03	2.04	21.24	4.71	47.89	42.53	9.59	100.00	Anglo-Saxon	Brooch	E. Saxon	Style I	Square Headed	Scremby
BR.054	10.08	5.01	2.87	17.96	5.57	56.14	27.88	15.98	100.00	Anglo-Saxon	Brooch	E. Saxon	Punched Triangles	Annular	Scremby
BR.055	8.99	4.74	6.75	20.48	4.88	43.90	23.16	32.94	100.00	Anglo-Saxon	Brooch	E. Saxon	Hines subgroup IV	Square Headed	Scremby
BR.056	8.98	11.51	0.22	20.70	4.83	43.36	55.58	1.07	100.00	Anglo-Saxon	Brooch	E. Saxon	Zoomorphic	Cruciform	Osbournby
BR.057	8.64	5.77	8.58	22.99	4.35	37.60	25.10	37.31	100.00	Anglo-Saxon	Brooch	E. Saxon	Leeds Type G	Annular	Scremby

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
BR.058	8.16	5.22	0.83	14.21	7.04	57.41	36.75	5.84	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.059	8.15	10.27	14.50	32.91	3.04	24.77	31.19	44.04	100.00	Anglo-Saxon	Brooch	E. Saxon	Martin Group 2	Cruciform	Scremby
BR.060	7.88	4.76	6.47	19.10	5.24	41.24	24.90	33.86	100.00	Anglo-Saxon	Brooch	E. Saxon		Annular	Scremby
BR.061	7.76	21.64	2.59	31.98	3.13	24.25	67.66	8.09	100.00	Scandinavian	Brooch	Second VA	Plant Ornament	Trefoil	North Lincs
BR.062	6.36	0.78	3.61	10.74	9.31	59.18	7.25	33.57	100.00	Anglo-Saxon	Brooch	E. Saxon			Scremby
BR.063	6.14	1.23	1.82	9.19	10.88	66.79	13.40	19.81	100.00	Anglo-Saxon	Brooch	E. Saxon			Scremby
BR.064	5.60	1.93	1.45	8.98	11.14	62.33	21.54	16.13	100.00	Anglo-Saxon	Brooch	E. Saxon			Scremby
BR.065	3.68	29.94	0.26	33.88	2.95	10.87	88.37	0.76	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform brooch	Osbournby
BR.066	3.37	1.62	6.22	11.21	8.92	30.08	14.45	55.48	100.00	Scandinavian	Brooch	Second VA	Plant Ornament	Trefoil	North Lincs
BR.067	2.02	25.46	3.07	30.56	3.27	6.61	83.34	10.05	100.00	Scandinavian	Brooch	Second VA	Jellinge	Trefoil	North Lincs
BR.068	0.75	22.18	2.02	24.95	4.01	3.00	88.89	8.11	100.00	Scandinavian	Brooch	Second VA			North Lincs
BR.069	0.69	71.11	0.03	71.83	1.39	0.96	99.00	0.05	100.00	Anglo-Scandinavian	Brooch	Second VA	Borre	Disc	North Lincs
BR.070	0.68	24.51	2.19	27.38	3.65	2.47	89.55	7.99	100.00	Scandinavian	Brooch	Second VA			North Lincs
BR.071	0.41	7.28	2.47	10.16	9.85	4.00	71.72	24.28	100.00	Scandinavian	Brooch	LS/1 VA	Zoomorphic	Domed	North Lincs
BR.072	0.37	28.08	1.90	30.35	3.30	1.20	92.54	6.25	100.00	Anglo-Saxon	Brooch	Ls/1 VA		Ansante Weetch Type II.A	Osbournby
BR.073	0.36	12.79	2.71	15.86	6.31	2.28	80.64	17.07	100.00	Scandinavian	Brooch	Second VA	Borre	Domed	North Lincs
BR.074	0.30	2.36	0.29	2.95	33.89	10.17	80.11	9.73	100.00	Anglo-Saxon	Brooch	E. Saxon		Cruciform	Osbournby
BR.075	0.22	1.01	3.01	4.25	23.54	5.27	23.86	70.87	100.00	Scandinavian	Brooch	Second VA	Borre	Domed	North Lincs
BR.076	0.19	7.16	2.50	9.85	10.15	1.91	72.73	25.36	100.00	Scandinavian	Brooch	Second VA	Borre	Domed	North Lincs
BR.077	0.10	15.06	5.36	20.51	4.87	0.48	73.40	26.11	100.00	Anglo-Scandinavian	Brooch	Second VA	Borre	Disc	Osbournby
BR.078	0.05	17.25	3.62	20.92	4.78	0.25	82.44	17.30	100.00	Anglo-scandinavian	Brooch	LS/1 VA	Weetch Type 30.C	Bird	North Lincs
BR.079	0.05	5.47	3.10	8.62	11.60	0.59	63.46	35.95	100.00	Scandinavian	Brooch	Second VA	Ringerike	Domed	North Lincs
BR.080	0.05	4.96	3.93	8.94	11.19	0.53	55.53	43.95	100.00	Scandinavian	Brooch	Second VA	Ringerike	Domed	North Lincs
BR.081	0.03	9.13	2.13	11.28	8.86	0.27	80.89	18.84	100.00	Scandinavian	Brooch	Second VA	Borre	Domed	North Lincs

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
BR.082	0.03	23.92	2.37	26.32	3.80	0.11	90.87	9.02	100.00	Scandinavian	Brooch	Second VA	Borre	Disc	North Lincs
BR.083	0.03	37.69	2.74	40.45	2.47	0.06	93.17	6.76	100.00	Scandinavian	Brooch	Second VA	Borre	Lozenge	North Lincs
BR.084	0.03	19.48	1.57	21.07	4.75	0.12	92.43	7.44	100.00	Scandinavian	Brooch	LS/1 VA	Equal Armed	Equal Armed	North Lincs
BR.085	0.02	17.06	1.62	18.69	5.35	0.11	91.24	8.66	100.00	Scandinavian	Brooch	Second VA	Jellinge	Trefoil	North Lincs
BR.086	0.02	10.13	4.94	15.09	6.63	0.13	67.13	32.74	100.00	Anglo-Scandinavian	Brooch	Second VA	Borre	Disc	Osbournby
BR.087	0.00	20.25	2.18	22.43	4.46	0.00	90.27	9.73	100.00	Scandinavian	Brooch	Second VA	Borre	Lozenge	North Lincs
BR.088	28.58	6.91	1.94	37.43	2.67	76.35	18.46	5.19	100.00	Anglo-Saxon	Brooch	E. Saxon	Incised Lines	Annular	Osbournby
BR.089	0.00	6.90	7.74	14.64	6.83	0.00	47.12	52.88	100.00	Anglo-Scandinavian	Brooch	Second VA	Borre	Disc	Osbournby
BR.090	16.77	7.69	0.39	24.85	4.02	67.50	30.95	1.55	100.00	Anglo-Saxon	Brooch frag	E. Saxon	Style I	Square Head	Osbournby
CH.001	30.52	10.40	0.33	41.25	2.42	73.98	25.21	0.81	100.00	Anglo-Saxon	Chatelaine	E. Saxon			Scremby
DS.001	2.99	17.57	2.47	23.02	4.34	12.98	76.32	10.71	100.00	Scandinavian	Die Stamp	LS/1 VA	Thors Hammer?		Osbournby
F.001	23.16	19.03	1.85	44.04	2.27	52.58	43.21	4.21	100.00	Anglo-Saxon	Flyer	E. Saxon	Zoomorphic		Scremby
GH.001	34.37	17.18	0.76	52.30	1.91	65.71	32.84	1.45	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon			Undiscolsed- South Lindsey
GH.002	29.91	8.84	1.88	40.63	2.46	73.61	21.76	4.63	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon			Osbournby
GH.003	29.03	4.35	0.58	33.96	2.94	85.49	12.80	1.71	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon	Zoomorphic		Scremby
GH.004	25.33	13.58	1.28	40.19	2.49	63.03	33.80	3.18	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon			Osbournby
GH.005	20.05	5.22	3.30	28.58	3.50	70.16	18.28	11.56	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon			Scremby
GH.006	18.02	6.25	5.63	29.90	3.34	60.26	20.90	18.84	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon		Felder's Group B2c	Scremby
GH.007	16.64	8.14	2.59	27.37	3.65	60.79	29.75	9.47	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon	Crescents		Osbournby
GH.008	14.35	4.30	1.66	20.31	4.92	70.67	21.18	8.16	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon			Scremby
GH.009	6.39	6.79	1.90	15.08	6.63	42.37	45.03	12.60	100.00	Anglo-Saxon	Girdle Hanger	E. Saxon	Crescents		Osbournby
HT.001	49.11	6.71	0.28	56.11	1.78	87.53	11.97	0.50	100.00	Anglo-Saxon	Hooked Tag	LS/1 VA	Ring and Dot	B1	Torksey
HT.002	38.39	2.22	0.33	40.94	2.44	93.77	5.43	0.80	100.00	Anglo-Saxon	Hooked Tag	E. Saxon	Style II	D.2	Osbournby
HT.003	18.49	2.88	0.37	21.74	4.60	85.06	13.26	1.68	100.00	Anglo-Saxon	Hooked Tag	M. Saxon	Undecorated	B.1	Osbournby

Reference Number	***Sn***	***Pb, Scaled Down***	***Zn***	***Sum***	***Scale Factor***	***Scaled Sn***	***Scaled Pb***	***Scaled Zn***	***New Sum***	***Ascribed Culture***	***Object Type***	***Date Range***	***Style***	***Type***	***Finds Spot/Collection Point***
HT.004	15.77	11.59	0.66	28.02	3.57	56.27	41.36	2.37	100.00	Anglo-Saxon	Hooked Tag	M. Saxon	Ring and Dot	B.1	Osbournby
HT.005	2.05	2.95	7.26	12.27	8.15	16.71	24.08	59.21	100.00	Anglo-Saxon	Hooked Tag	LS/1 VA	Undecorated	C.2	Osbournby
HT.006	1.66	11.49	10.68	23.82	4.20	6.96	48.22	44.82	100.00	Anglo-Saxon	Hooked Tag	E. Saxon		UK	North Lincs
HT.007	0.02	2.09	0.00	2.10	47.58	0.71	99.29	0.00	100.00	Anglo-Saxon	Hooked Tag	M. Saxon	Ring and Dot	B1	Torksey
HT.008	9.31	5.10	4.05	18.46	5.42	50.42	27.63	21.95	100.00	Anglo-Saxon	Hooked Tag	Early Saxon		B2	North Lincs
HT.009	22.89	4.15	0.83	27.87	3.59	82.12	14.90	2.98	100.00	Anglo-Saxon	Hooked Tag	Early Saxon		UK	North Lincs
I.001	27.61	19.36	1.19	48.16	2.08	57.34	40.20	2.46	100.00	Anglo-Scandinavian	Ingot	LS/1 VA			Torksey
M.001	0.58	20.24	6.87	27.69	3.61	2.10	73.08	24.82	100.00	Anglo-Scandinavian	Mount	Second VA	Terminal		North Lincs
M.002	19.03	3.55	5.54	28.13	3.56	67.67	12.64	19.70	100.00	Anglo-Saxon	Mount	E. Saxon	Punched Dot	Crecentric	Scremby
M.003	12.36	23.51	0.29	36.16	2.77	34.18	65.01	0.81	100.00	Irish	Mount	LS/1 VA			Torksey
M.004	3.82	12.61	5.61	22.05	4.54	17.34	57.22	25.44	100.00	Scandinavian	Mount	Second VA	Jellinge		North Lincs
M.005	0.89	4.80	2.35	8.04	12.45	11.04	59.73	29.23	100.00	Scandinavian	Mount	Second VA	Urnes		North Lincs
M.006	0.69	24.13	2.86	27.68	3.61	2.48	87.19	10.34	100.00	Scandinavian	Mount	Second VA	Ringerike		North Lincs
M.007	0.05	9.61	3.90	13.57	7.37	0.38	70.84	28.78	100.00	Scandinavian	Mount	Second VA	Urnes		North Lincs
M.008	0.04	14.86	2.72	17.62	5.68	0.25	84.34	15.41	100.00	Anglo-Scandinavian	Mount	Second VA	Ringerike		North Lincs
M.009	0.04	4.02	2.95	7.00	14.29	0.57	57.36	42.07	100.00	Scandinavian	Mount	Second VA	Urnes		North Lincs
M.010	0.04	3.21	10.41	13.65	7.32	0.26	23.53	76.22	100.00	Anglo-Scandinavian	Mount	Second VA	Mammen	Williams Class A Type 1	Osbournby
M.011	12.44	1.19	0.28	13.90	7.19	89.44	8.56	2.00	100.00	Anglo-Saxon	Mount	Ls/1 VA	Interlace	Lozenge	Osbournby
P.001	29.55	6.20	1.40	37.15	2.69	79.55	16.69	3.76	100.00	Scandinavian	Pendant	E. Saxon			North Lincs
PN.001	41.03	21.31	0.13	62.47	1.60	65.68	34.12	0.20	100.00	Anglo-Saxon	Pin	M. Saxon	Ring and Dot	Irregular Globular	Little Carlton
PN.002	40.45	7.41	0.48	48.34	2.07	83.68	15.32	1.00	100.00	Anglo-Saxon	Pin	M. Saxon	Middle Saxon		Torksey
PN.003	37.82	8.13	0.12	46.07	2.17	82.09	17.65	0.26	100.00	Anglo-Saxon	Pin	M. Saxon	Collared	Globular, Flat top	Little Carlton
PN.004	28.86	13.13	0.51	42.50	2.35	67.91	30.88	1.21	100.00	Anglo-Saxon	Pin	M. Saxon	Ring and Dot	Polyheadral	Little Carlton
PN.005	23.69	18.72	0.42	42.82	2.34	55.32	43.71	0.97	100.00	Anglo-Saxon	Pin	M. Saxon	Curved Ribs	Globular Head, Collared	Osbournby

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
PN.006	23.09	15.40	0.27	38.76	2.58	59.57	39.74	0.69	100.00	Anglo-Saxon	Pin	M. Saxon	Mid Saxon	Globular Head, Collared	Osbournby
PN.007	21.01	23.36	0.10	44.48	2.25	47.24	52.53	0.23	100.00	Anglo-Saxon	Pin	M. Saxon	Ring and Dot	Collared	Osbournby
PN.008	20.61	2.42	0.27	23.29	4.29	88.49	10.38	1.14	100.00	Anglo-Saxon	Pin	LS/1 VA		Linked Pin	Undiscolsed- South Lindsey
PN.009	18.92	22.62	0.35	41.89	2.39	45.17	53.99	0.84	100.00	Anglo-Saxon?	Pin	M. Saxon	Ring and Dot	Polyheadral, Collared	Osbournby
PN.010	17.85	16.74	4.60	39.19	2.55	45.55	42.71	11.74	100.00	Anglo-Saxon	Pin	E. Saxon	Flat head	Cloak Pin	Scremby
PN.011	16.13	8.14	0.19	24.46	4.09	65.94	33.29	0.76	100.00	Anglo-Saxon	Pin	M. Saxon	Middle Saxon	Biconical Head	Torksey
PN.012	0.04	4.49	2.91	7.44	13.43	0.59	60.30	39.11	100.00	Anglo-Saxon	Pin	M. Saxon	Middle Saxon	Faceted cuboid	Torksey
PN.013	0.02	0.81	6.65	7.48	13.36	0.31	10.79	88.91	100.00	Anglo-Saxon?	Pin	M. Saxon		Biconical Head, Narrow Collar	Osbournby
PN.014	41.48	12.55	0.21	54.23	1.84	76.48	23.13	0.39	100.00	Anglo-Saxon	Pin Head	M. Saxon	Ring and Dot	Globular head	Osbournby
PN.015	33.37	8.40	6.24	48.02	2.08	69.50	17.50	13.00	100.00	Anglo-Saxon	Pin Head	M. Saxon		Globular head	Osbournby
PN.016	27.31	13.29	0.17	40.76	2.45	66.99	32.60	0.41	100.00	Anglo-Saxon	Pin Head	M. Saxon	Ring and Dot	Globular head	Osbournby
PN.017	27.00	6.94	0.19	34.13	2.93	79.09	20.34	0.57	100.00	Anglo-Saxon?	Pin Head	M. Saxon	Ring and Dot	Polyheadral	Osbournby
PN.018	25.89	24.63	3.01	53.54	1.87	48.36	46.02	5.62	100.00	Anglo-Saxon	Pin Head	M. Saxon	Ring and Dot	Facet Cube	Osbournby
PN.019	18.04	19.17	0.43	37.65	2.66	47.93	50.92	1.15	100.00	Anglo-Saxon	Pin Head	M. Saxon	Ring and Dot	Facet Cube	Osbournby
PN.020	12.34	17.69	1.59	31.62	3.16	39.01	55.94	5.04	100.00	Anglo-Saxon	Pin Head	M. Saxon	Ring and Dot	Facet Cube	Osbournby
PN.021	0.72	22.02	1.92	24.66	4.05	2.94	89.27	7.79	100.00	Anglo-Saxon	Pin Head	M. Saxon		Biconical head	Osbournby
PN.022	0.36	0.50	11.01	11.87	8.42	3.04	4.20	92.76	100.00	Anglo-Saxon	Pin Head	M. Saxon		Biconical head	Osbournby
PN.023	0.11	1.69	2.19	3.98	25.11	2.66	42.47	54.87	100.00	Anglo-Saxon	Pin Head	M. Saxon		Biconical head	Osbournby
PN.024	0.04	0.17	10.40	10.61	9.43	0.38	1.61	98.02	100.00	Anglo-Saxon	Pin Head	M. Saxon		Biconical head	Osbournby
R.001	28.65	9.72	5.96	44.34	2.26	64.62	21.93	13.44	100.00	Anglo-Saxon	Ring	E. Saxon	Lines decorating front		Osbournby
SC.001	38.17	3.02	6.40	47.59	2.10	80.21	6.34	13.45	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B7	Scremby
SC.002	35.45	6.14	0.50	42.08	2.38	84.24	14.58	1.18	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines form b12	Osbournby
SC.003	33.93	16.09	3.92	53.94	1.85	62.90	29.84	7.26	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon	Style I	Hines B7	Scremby

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
SC.004	29.89	16.11	1.90	47.89	2.09	62.41	33.63	3.96	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon	Style I	Hines B7	Scremby
SC.005	25.18	8.22	1.49	34.88	2.87	72.18	23.55	4.27	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon	Repousse	Hines Form B7	Scremby
SC.006	25.00	4.57	3.45	33.01	3.03	75.73	13.83	10.44	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B	Scremby
SC.007	19.49	3.86	2.09	25.43	3.93	76.62	15.16	8.21	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B	Scremby
SC.008	19.07	8.22	5.02	32.31	3.09	59.00	25.45	15.55	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hine's B13c	Scremby
SC.009	18.01	5.96	0.84	24.80	4.03	72.59	24.02	3.39	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon	Punch Dot	Hines form B7	Osbournby
SC.010	17.44	7.73	9.75	34.92	2.86	49.93	22.14	27.92	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B13	Scremby
SC.011	15.40	7.26	18.32	40.98	2.44	37.59	17.71	44.70	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B12	Scremby
SC.012	13.53	2.22	6.91	22.65	4.42	59.72	9.79	30.50	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon	Repousse	Hines Form B7	Scremby
SC.013	11.74	9.72	7.39	28.85	3.47	40.69	33.68	25.63	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B	Scremby
SC.014	11.09	4.30	4.39	19.78	5.06	56.09	21.73	22.18	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B7	Scremby
SC.015	10.76	12.86	0.80	24.42	4.10	44.06	52.66	3.28	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B18	Scremby
SC.016	10.67	9.65	9.73	30.05	3.33	35.50	32.12	32.38	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B12	Scremby
SC.017	9.10	5.84	1.46	16.40	6.10	55.52	35.60	8.88	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B20	Scremby
SC.018	9.01	6.90	1.57	17.48	5.72	51.54	39.49	8.97	100.00	Anglo-Saxon	Sleeve Clasp	E. Saxon		Hines B20	Scremby
SD.001	0.16	2.73	9.00	11.89	8.41	1.36	22.98	75.66	100.00	Scandinavian	Strap Distributor	Second VA	Borre		Undiscolsed- South Lindsey
SE.001	23.80	16.84	1.88	42.51	2.35	55.98	39.61	4.42	100.00	Anglo-Saxon	Strap End	M. Saxon	Trewhiddle	Type A1a	North Lincs
SE.002	22.46	12.33	2.46	37.24	2.69	60.30	33.10	6.60	100.00	Anglo-Saxon	Strap End	LS/1 VA		UK	Torksey
SE.003	18.04	20.90	6.83	45.76	2.19	39.41	45.66	14.93	100.00	Anglo-Saxon	Strap End	LS/1 VA	Trewhiddle	Thomas Type A	Torksey
SE.004	16.51	9.33	0.24	26.08	3.83	63.29	35.78	0.93	100.00	Anglo-Scandinavian	Strap End	LS/1 VA		UK	Torksey
SE.005	14.48	4.04	3.68	22.20	4.50	65.21	18.21	16.58	100.00	Anglo-Saxon	Strap End	LS/1 VA		Thomas Type B	Osbournby
SE.006	13.24	19.84	0.64	33.72	2.97	39.27	58.83	1.90	100.00	Anglo-Saxon	Strap End	M. Saxon			North Lincs
SE.007	13.17	8.41	2.84	24.41	4.10	53.94	34.45	11.61	100.00	Anglo-Saxon	Strap End	LS/1 VA	Trewhiddle	Thomas Type A	Osbournby
SE.008	10.81	1.70	2.85	15.36	6.51	70.36	11.06	18.58	100.00	Anglo-Saxon	Strap End	M. Saxon			North Lincs

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
SE.009	8.65	15.01	2.36	26.02	3.84	33.24	57.68	9.08	100.00	Scandinavian	Strap End	Second VA		Type F1	North Lincs
SE.010	7.58	12.62	1.32	21.51	4.65	35.23	58.64	6.14	100.00	Anglo-Saxon	Strap End	M. Saxon			North Lincs
SE.011	6.47	29.06	3.32	38.85	2.57	16.64	74.81	8.55	100.00	Scandinavian	Strap End	Second VA		Type E3	North Lincs
SE.012	3.64	6.33	4.83	14.80	6.76	24.59	42.78	32.63	100.00	Anglo-Saxon	Strap End	M. Saxon			North Lincs
SE.013	3.26	3.71	11.74	18.71	5.35	17.42	19.82	62.76	100.00	Anglo-Saxon	Strap End	M. Saxon			North Lincs
SE.014	2.81	1.97	0.88	5.65	17.69	49.64	34.84	15.52	100.00	Anglo-Saxon	Strap End	LS/1 VA	Trewhiddle	Thomas Type A	Torksey
SE.015	2.23	18.25	3.84	24.31	4.11	9.16	75.04	15.80	100.00	Anglo-Scandinavian	Strap End	LS/1 VA		Thomas Class A.5	Undiscolsed- South Lindsey
SE.016	2.13	27.85	1.26	31.23	3.20	6.81	89.17	4.02	100.00	Scandinavian	Strap End	Second VA	Ring-and-dot	Type E3	North Lincs
SE.017	1.70	4.99	7.03	13.71	7.29	12.40	36.36	51.24	100.00	Anglo-Saxon	Strap End	Second VA		Thomas Type A	Osbournby
SE.018	1.60	23.31	2.02	26.93	3.71	5.95	86.57	7.48	100.00	Scandinavian	Strap End	Second VA		Type E4c	North Lincs
SE.019	1.44	2.23	5.20	8.87	11.28	16.24	25.14	58.62	100.00	Anglo-Saxon	Strap End	M. Saxon	Trewhiddle	A1a	North Lincs
SE.020	1.01	7.12	5.93	14.06	7.11	7.17	50.66	42.17	100.00	Anglo-Saxon	Strap End	LS/1 VA	Trewhiddle	Type A2	North Lincs
SE.021	0.91	2.74	18.40	22.05	4.54	4.12	12.42	83.46	100.00	Anglo-Scandinavian	Strap End	Second VA		Type E1 or E3	North Lincs
SE.022	0.64	2.12	11.83	14.59	6.85	4.38	14.51	81.11	100.00	Anglo-Scandinavian	Strap End	LS/1 VA	Interlace	Thomas Type B	Osbournby
SE.023	0.51	4.06	7.23	11.79	8.48	4.28	34.41	61.31	100.00	Anglo-Scandinavian	Strap End	Second VA		Thomas Type G	Undiscolsed- South Lindsey
SE.024	0.34	0.47	5.36	6.17	16.20	5.49	7.68	86.83	100.00	Anglo-Saxon	Strap End	LS/1 VA		Thomas Typle A.2	Undiscolsed- South Lindsey
SE.025	0.12	6.53	2.39	9.04	11.06	1.33	72.25	26.42	100.00	Scandinavian	Strap End	Second VA	Urnes	Type A	North Lincs
SE.026	0.09	7.86	6.36	14.31	6.99	0.66	54.93	44.42	100.00	Anglo-scandinavian	Strap End	Second VA		Type B4	North Lincs
SE.027	0.05	1.92	8.00	9.97	10.03	0.51	19.26	80.23	100.00	Anglo-Scandinavian	Strap End	Second VA	Borre	Thomas Type B.4b	Undiscolsed- South Lindsey
SE.028	0.03	15.74	2.46	18.23	5.49	0.19	86.35	13.47	100.00	Scandinavian	Strap End	Second VA		Type E5	North Lincs
SE.029	0.03	27.02	1.73	28.79	3.47	0.12	93.86	6.02	100.00	Anglo-Scandinavian	Strap End	Second VA		Type E4	North Lincs
SE.030	0.02	18.54	1.49	20.05	4.99	0.10	92.46	7.44	100.00	Scandinavian	Strap End	Second VA	Borre	Type E3	North Lincs
SE.031	0.02	7.44	2.18	9.64	10.38	0.19	77.16	22.65	100.00	Anglo-Saxon	Strap End	Second VA	Winchester	Thomas Type E.1	Osbournby
SE.032	0.01	0.39	11.74	12.14	8.24	0.08	3.20	96.72	100.00	Anglo-Saxon	Strap End	LS/1 VA	Trewhiddle	Thomas A2 (poss)	Osbournby

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
SF.001	0.02	21.32	6.57	27.91	3.58	0.07	76.38	23.55	100.00	Anglo-Scandinavian	Strap Fitting	Second VA	Ringerike		Osbournby
SP.001	38.63	6.90	0.60	46.13	2.17	83.75	14.95	1.31	100.00	Anglo-Saxon	Spangle	E. Saxon	Linear along sides		Osbournby
SP.002	12.04	2.84	1.28	16.16	6.19	74.51	17.59	7.90	100.00	Anglo-Saxon	Spangle	E. Saxon			Scremby
SU.001	3.66	2.89	6.10	12.64	7.91	28.91	22.89	48.21	100.00	Anglo-Scandinavian	Stirrup	Second VA	Zoomorphic	Terminal	Osbournby
SU.002	1.01	24.23	0.06	25.30	3.95	4.01	95.77	0.22	100.00	Anglo-Scandinavian	Stirrup	Second VA		Terminal	Osbournby
SU.003	0.64	8.87	2.30	11.81	8.47	5.39	75.11	19.49	100.00	Scandinavian	Stirrup	Second VA		Class A	North Lincs
SU.004	0.49	3.00	7.13	10.62	9.42	4.64	28.27	67.09	100.00	Anglo-Scandinavian	Stirrup	Second VA	Zoomorphic		Osbournby
SU.005	0.09	19.47	2.22	21.78	4.59	0.42	89.38	10.20	100.00	Anglo-Scandinavian	Stirrup	Second VA		Williams Class A	Osbournby
SU.006	0.05	10.28	5.79	16.12	6.20	0.30	63.75	35.94	100.00	Scandinavian	Stirrup	Second VA	Ringerike		North Lincs
SU.007	0.04	1.71	4.83	6.58	15.20	0.65	25.97	73.38	100.00	Anglo-Scandinavian	Stirrup	Second VA	Zoomorphic	Terminal	Undiscolsed- South Lindsey
SU.008	1.34	25.23	3.38	29.94	3.34	4.48	84.25	11.28	100.00	Anglo-Scandinavian	Stirrup mount	Second VA		Williams' Class B, Type 2, Group 2	Osbournby
SU.009	0.43	6.17	3.38	9.98	10.02	4.33	61.82	33.86	100.00	Anglo-Scandinavian	Stirrup Mount	Second VA	Urnes	Williams Class B.3 Group 1	Undiscolsed- South Lindsey
SU.010	0.34	13.82	4.20	18.36	5.45	1.86	75.26	22.89	100.00	Anglo-Scandinavian	Stirrup Mount	Second VA	Ringerike	Williams Class A.7	Undiscolsed- South Lindsey
SW.001	7.40	2.72	2.63	12.76	7.84	58.02	21.34	20.64	100.00	Scandinavian	Sword Fitting	LS/1 VA		Crown shaped	North Lincs
SW.002	0.35	7.80	4.31	12.46	8.02	2.81	62.59	34.60	100.00	Scandinavian	Sword Fitting	LS/1 VA			North Lincs
SY.001	38.96	4.73	0.26	43.95	2.28	88.64	10.77	0.59	100.00	Anglo-Saxon	Stylus	M. Saxon			Little Carlton
TW.001	25.86	7.03	0.65	33.53	2.98	77.12	20.95	1.93	100.00	Anglo-Saxon	Tweezers	E. Saxon			Torksey
TW.002	17.24	4.37	3.34	24.96	4.01	69.09	17.53	13.38	100.00	Anglo-Saxon	Tweezers	E. Saxon			Torksey
TW.003	9.06	9.64	4.83	23.52	4.25	38.49	40.96	20.55	100.00	Anglo-Saxon	Tweezers	M. Saxon	Ring and Dot		Little Carlton
UK.001	13.70	11.36	0.25	25.31	3.95	54.13	44.88	0.98	100.00	Anglo-Saxon	Unknown	E. Saxon			Scremby
UK.002	39.01	0.29	0.30	39.60	2.53	98.50	0.73	0.77	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.003	31.80	7.21	2.17	41.18	2.43	77.21	17.51	5.28	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.004	31.79	5.64	0.10	37.52	2.66	84.71	15.03	0.26	100.00	Anglo-Saxon		M. Saxon			Little Carlton

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
UK.005	31.27	4.21	1.06	36.53	2.74	85.60	11.51	2.89	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.006	25.06	7.06	2.00	34.11	2.93	73.46	20.69	5.85	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.007	22.89	6.36	0.19	29.45	3.40	77.73	21.61	0.66	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.009	22.60	5.30	0.42	28.32	3.53	79.81	18.71	1.48	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.010	22.44	5.92	0.14	28.50	3.51	78.74	20.76	0.51	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.011	20.24	4.05	0.18	24.47	4.09	82.71	16.55	0.74	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.012	19.46	2.27	3.95	25.67	3.90	75.80	8.83	15.37	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.013	19.07	4.32	1.38	24.77	4.04	76.98	17.44	5.58	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.014	18.73	12.34	1.49	32.56	3.07	57.53	37.90	4.58	100.00	Anglo-Saxon		M.Saxon			North Lincs
UK.015	18.19	4.98	3.14	26.31	3.80	69.13	18.94	11.94	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.016	17.62	5.42	2.23	25.26	3.96	69.74	21.45	8.81	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.017	16.54	4.97	3.85	25.35	3.94	65.23	19.60	15.18	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.018	14.96	4.08	0.19	19.22	5.20	77.79	21.22	0.98	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.019	12.69	2.30	4.12	19.11	5.23	66.42	12.05	21.54	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.020	12.37	4.91	1.26	18.54	5.39	66.72	26.48	6.80	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.021	12.24	5.19	1.56	19.00	5.26	64.45	27.33	8.22	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.022	11.94	5.77	3.07	20.79	4.81	57.45	27.77	14.78	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.023	11.20	6.08	13.08	30.36	3.29	36.88	20.03	43.09	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.024	10.97	14.36	2.04	27.36	3.66	40.09	52.47	7.44	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.025	10.64	2.07	5.24	17.95	5.57	59.25	11.56	29.19	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.026	9.31	5.10	4.05	18.46	5.42	50.42	27.63	21.95	100.00	Anglo-Saxon		M.Saxon			North Lincs
UK.027	9.15	5.59	8.98	23.71	4.22	38.57	23.56	37.88	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.028	9.13	7.33	1.29	17.74	5.64	51.43	41.32	7.25	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.029	7.94	25.89	0.26	34.09	2.93	23.30	75.94	0.76	100.00	Anglo-Saxon		M. Saxon			Little Carlton

Reference Number	Sn	Pb, Scaled Down	Zn	Sum	Scale Factor	Scaled Sn	Scaled Pb	Scaled Zn	New Sum	Ascribed Culture	Object Type	Date Range	Style	Type	Finds Spot/Collection Point
UK.030	7.87	8.44	3.04	19.35	5.17	40.66	43.62	15.72	100.00	Anglo-Saxon		M.Saxon			North Lincs
UK.031	6.59	5.32	4.35	16.26	6.15	40.50	32.74	26.76	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.032	6.35	6.14	2.69	15.18	6.59	41.82	40.44	17.74	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.033	6.08	43.66	0.17	49.91	2.00	12.18	87.48	0.34	100.00	Anglo-Saxon		M.Saxon			North Lincs
UK.034	3.62	16.70	4.00	24.33	4.11	14.89	68.66	16.46	100.00	Anglo-Saxon		M.Saxon			North Lincs
UK.035	3.24	5.15	13.12	21.51	4.65	15.07	23.96	60.97	100.00	Anglo-Saxon		M.Saxon			North Lincs
UK.036	2.40	0.49	0.20	3.09	32.39	77.73	15.96	6.32	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.037	2.36	15.71	2.76	20.83	4.80	11.32	75.42	13.26	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.038	2.32	0.13	0.10	2.55	39.22	91.06	5.06	3.88	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.039	0.80	6.83	14.15	21.78	4.59	3.67	31.36	64.97	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.040	0.50	0.25	0.00	0.75	133.63	67.08	32.92	0.00	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.041	0.22	1.34	13.62	15.18	6.59	1.44	8.84	89.73	100.00	Anglo-Saxon		M. Saxon			Little Carlton
UK.042	0.08	0.20	11.22	11.50	8.70	0.66	1.72	97.62	100.00	Anglo-Saxon		E. Saxon			Scremby
UK.043	0.04	0.40	0.00	0.43	231.32	8.33	91.67	0.00	100.00	Anglo-Saxon		M.Saxon			North Lincs
UK.044	0.03	0.89	0.00	0.92	108.65	3.26	96.74	0.00	100.00	Anglo-Saxon		E. Saxon			Scremby
V.001	10.90	39.65	0.25	50.80	1.97	21.46	78.06	0.49	100.00	Anglo-Saxon	Vessel	E. Saxon		Suspension Loop	Scremby
W.001	1.65	16.77	6.27	24.69	4.05	6.69	67.93	25.38	100.00	Scandinavian	Weight	LS/1 VA		Bullion	North Lincs

Appendix Three

Appendix Three shows the standard data used throughout the thesis. The first table shows the known values of the standards used and the second table show the readings taken during analysis.

Table 6 Known Standard Values

Standards Used		**Sn**	**Ag**	**Pb**	**As**	**Au**	**Zn**	**Cu**	**Fe**
364		9.35	0.00	9.25	0.07	0.00	0.13	80.60	0.01
344		0	0.00	0.00	0.00	0.00	30.98	68.98	0.00
207/2		9.74	0.00	0.70	0.07	0.00	1.60	87.35	0.03
183/4		7.27	0.00	3.15	0.13	0.00	3.47	84.08	0.06

Table 7 Standard Results

SAMPLE	**AVERAGE**	**Sn**	**Ag**	**Pb**	**As**	**Au**	**Zn**	**Cu**	**Fe**
207-2		10.58	0.00	0.89	0.00	0.00	1.73	85.87	0.03
207-2		10.59	0.00	0.87	0.68	0.00	1.71	85.58	0.03
207-2		10.54	0.00	0.88	0.00	0.00	1.70	85.77	0.02
	Avg of 374-376	10.57	0.00	0.88	0.00	0.00	1.71	85.74	0.03
	Standard Deviation	0.02	0.00	0.01	0.39	0.00	0.02	0.15	0.00
	Precision	0.23		1.25			1.14	0.17	14.02
	Accuracy	7.85		20.45			6.54	-1.88	-7.41
344		0.00	0.00	0.00	0.00	0.00	30.42	69.04	0.00
344		0.00	0.00	0.00	0.00	0.00	30.41	68.86	0.01
344		0.00	0.00	0.00	0.00	0.00	30.48	68.97	0.01
	Avg of 378-380	0.00	0.00	0.00	0.00	0.00	30.44	68.96	0.01
	Standard Deviation						0.04	0.09	0.01
	Precision						0.13	0.13	66.58

SAMPLE	AVERAGE	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
	Accuracy						-1.79	-0.03	100.00
364		10.00	0.00	12.48	0.00	0.00	0.00	76.83	0.00
364		9.59	0.00	11.97	4.86	0.00	0.21	71.96	0.00
364		9.53	0.00	11.84	6.02	0.00	0.22	70.95	0.00
	Avg of 382-384	9.70	0.00	12.09	3.63	0.00	0.21	73.25	0.00
	Standard Deviation	0.25	0.00	0.34	3.19	0.00	0.12	3.15	0.00
	Precision	2.61		2.80	88.08		60.02	4.30	
	Accuracy	3.65		23.52	98.07		36.59	-10.04	
183-4		7.70	0.00	4.89	5.48	0.00	3.24	77.04	0.04
183-4		7.69	0.00	4.89	5.54	0.00	3.25	76.99	0.05
183-4		7.72	0.00	4.96	4.98	0.00	3.28	77.40	0.05
	Avg of 386-388	7.70	0.00	4.91	5.33	0.00	3.25	77.14	0.05
	Standard Deviation	0.02	0.00	0.04	0.31	0.00	0.02	0.22	0.01
	Precision	0.23		0.90	5.77		0.66	0.29	13.29
	Accuracy	5.63		35.88	97.56		-6.64	-8.99	-19.15
183-4		7.74	0.00	4.87	4.45	0.00	3.20	78.07	0.06
183-4		7.77	0.00	4.82	4.87	0.00	3.21	77.59	0.05
183-4		7.79	0.00	4.83	4.78	0.00	3.19	77.70	0.05
183-4	Avg of 466-468	7.77	0.00	4.84	4.70	0.00	3.20	77.79	0.05
	Standard Deviation	0.02	0.00	0.02	0.22	0.00	0.01	0.25	0.00
	Precision	0.29		0.50	4.75		0.28	0.32	4.66
	Accuracy	6.39		34.94	97.23		-8.51	-8.09	-3.70
183-4		7.68	0.00	4.74	4.58	0.00	3.19	78.09	0.06
183-4		7.63	0.00	4.71	4.80	0.00	3.22	77.89	0.05
183-4		7.66	0.00	4.78	4.51	0.00	3.19	78.15	0.05

SAMPLE	AVERAGE	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
183-4	Avg of 682-684	7.66	0.00	4.74	4.63	0.00	3.20	78.05	0.05
	Standard Deviation	0.02	0.00	0.04	0.15	0.00	0.02	0.13	0.00
	Precision	0.30		0.77	3.25		0.54	0.17	4.75
	Accuracy	5.04		33.57	97.19		-8.37	-7.73	-5.66
364		9.69	0.00	12.11	5.46	0.00	0.11	72.03	0.00
364		9.69	0.00	12.22	4.84	0.00	0.12	72.47	0.00
364		9.67	0.00	12.03	6.22	0.00	0.10	71.37	0.00
364	Avg of 686-688	9.68	0.00	12.12	5.51	0.00	0.11	71.96	0.00
	Standard Deviation	0.01	0.00	0.09	0.69	0.00	0.01	0.56	0.00
	Precision	0.12		0.78	12.54		9.30	0.77	
	Accuracy	3.42		23.69	98.73		-15.04	-12.01	
344		0.00	0.00	0.00	0.00	0.00	30.51	68.99	0.01
344		0.00	0.00	0.00	0.00	0.00	30.45	69.01	0.01
344		0.00	0.00	0.00	0.00	0.00	30.45	69.06	0.01
344	Avg of 690-692	0.00	0.00	0.00	0.00	0.00	30.47	69.02	0.01
	Standard Deviation						0.03	0.04	0.00
	Precision						0.10	0.05	9.62
	Accuracy						-1.67	0.06	100.00
207-2		10.28	0.00	1.03	1.13	0.00	1.57	85.43	0.03
207-2		10.26	0.00	1.04	0.86	0.00	1.56	85.67	0.03
207-2		10.28	0.00	1.04	1.08	0.00	1.57	85.45	0.04

SAMPLE	AVERAGE	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
207-2	Avg of 694-696	10.27	0.00	1.04	1.02	0.00	1.57	85.52	0.03
	Standard Deviation	0.01	0.00	0.01	0.14	0.00	0.01	0.13	0.01
	Precision	0.09		0.77	13.67		0.40	0.15	15.73
	Accuracy	5.18		32.37	93.55		-2.11	-2.15	9.38
364		9.76	0.00	12.10	5.49	0.00	0.23	71.79	0.00
364		9.83	0.00	12.09	4.74	0.00	0.22	72.56	0.00
364		9.84	0.00	12.09	4.17	0.00	0.21	73.12	0.00
	Avg of 1317-1319	9.81	0.00	12.09	4.80	0.00	0.22	72.49	0.00
	Standard Deviation	0.04	0.00	0.00	0.66	0.00	0.01	0.67	0.00
	Precision	0.44		0.03	13.85		3.64	0.92	
	Accuracy	4.67		23.51	98.54		41.44	-11.19	
344		0.00	0.00	0.00	0.00	0.00	30.62	69.33	0.01
344		0.00	0.00	0.00	0.00	0.00	30.68	69.24	0.02
344		0.00	0.00	0.00	0.00	0.00	30.72	69.23	0.01
	Avg of 1321-1323	0.00	0.00	0.00	0.00	0.00	30.67	69.27	0.02
	Standard Deviation	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.00
	Precision						0.16	0.08	20.09
	Accuracy						-1.00	0.41	100.00
207-2		10.47	0.00	0.87	0.91	0.00	1.68	85.47	0.05
207-2		10.48	0.00	0.88	0.79	0.00	1.63	85.62	0.03
207-2		10.49	0.00	0.87	0.76	0.00	1.67	85.60	0.04
	Avg of 1325-1327	10.48	0.00	0.87	0.82	0.00	1.66	85.56	0.04
	Standard Deviation	0.01	0.00	0.00	0.08	0.00	0.03	0.08	0.01
	Precision	0.11		0.41	9.56		1.69	0.10	18.90
	Accuracy	7.07		19.72	91.92		3.38	-2.09	25.64

SAMPLE	AVERAGE	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
183-4		7.76	0.00	4.76	4.48	0.00	3.29	78.01	0.05
183-4		7.75	0.00	4.73	4.78	0.00	3.24	77.77	0.06
183-4		7.76	0.00	4.78	4.29	0.00	3.29	78.11	0.06
	Avg of 1329-1331	7.76	0.00	4.76	4.52	0.00	3.27	77.96	0.06
	Standard Deviation	0.01	0.00	0.03	0.25	0.00	0.03	0.18	0.01
	Precision	0.09		0.61	5.46		0.85	0.23	11.48
	Accuracy	6.27		33.75	97.12		-6.02	-7.85	3.45
364		9.52	0.00	12.10	5.68	0.00	0.09	72.05	0.00
364		9.56	0.00	12.14	5.25	0.00	0.09	72.33	0.00
364		9.49	0.00	12.12	5.87	0.00	0.10	71.77	0.00
	Avg of 1419-1421	9.52	0.00	12.12	5.60	0.00	0.10	72.05	0.00
	Standard Deviation	0.03	0.00	0.02	0.32	0.00	0.01	0.28	0.00
	Precision	0.33		0.17	5.71		7.54	0.39	
	Accuracy	1.81		23.69	98.75		-35.42	-11.87	
344		0.00	0.00	0.00	0.00	0.00	30.61	69.21	0.02
344		0.00	0.00	0.00	0.00	0.00	30.60	69.26	0.02
344		0.00	0.00	0.00	0.00	0.00	30.59	69.26	0.01
	Avg of 1423-1425	0.00	0.00	0.00	0.00	0.00	30.60	69.25	0.02
	Standard Deviation						0.01	0.03	0.00
	Precision						0.04	0.04	17.97
	Accuracy						-1.24	0.38	100.00
207-2		10.34	0.00	0.94	0.81	0.00	1.55	85.75	0.04
207-2		10.40	0.00	0.94	0.00	0.00	1.54	85.98	0.03
207-2		10.37	0.00	0.95	0.89	0.00	1.54	85.66	0.04

SAMPLE	AVERAGE	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
	Avg of 1427-1429	10.37	0.00	0.94	0.76	0.00	1.54	85.80	0.04
	Standard Deviation	0.03	0.00	0.00	0.49	0.00	0.01	0.17	0.01
	Precision	0.30		0.34	64.95		0.39	0.19	17.38
	Accuracy	6.08		25.77	91.27		-3.69	-1.81	17.14
183-4		7.74	0.00	4.75	3.73	0.00	3.19	78.80	0.07
183-4		7.71	0.00	4.69	4.47	0.00	3.18	78.18	0.05
183-4		7.74	0.00	4.74	4.17	0.00	3.19	78.40	0.06
	Avg of 1431-1433	7.73	0.00	4.73	4.13	0.00	3.19	78.46	0.06
	Standard Deviation	0.02	0.00	0.03	0.37	0.00	0.00	0.31	0.01
	Precision	0.22		0.72	9.01		0.13	0.40	12.71
	Accuracy	5.94		33.39	96.85		-8.88	-7.17	3.45
364		9.76	0.00	12.02	4.91	0.00	0.17	72.48	0.00
364		9.74	0.00	12.06	5.02	0.00	0.17	72.39	0.00
364		9.73	0.00	11.99	5.29	0.00	0.17	72.20	0.00
	Avg of 1459-1461	9.75	0.00	12.03	5.07	0.00	0.17	72.35	0.00
	Standard Deviation	0.02	0.00	0.04	0.20	0.00	0.00	0.14	
	Precision	0.15		0.30	3.86		1.89	0.20	
	Accuracy	4.05		23.08	98.62		23.53	-11.40	
344		0.00	0.00	0.00	0.00	0.00	30.70	69.21	0.01
344		0.00	0.00	0.00	0.00	0.00	30.64	69.30	0.01
344		0.00	0.00	0.00	0.00	0.00	30.60	69.30	0.02
	Avg of 1463-1465	0.00	0.00	0.00	0.00	0.00	30.65	69.27	0.01
	Standard Deviation						0.05	0.05	0.00
	Precision						0.16	0.07	14.87
	Accuracy						-1.09	0.42	100.00

SAMPLE	AVERAGE	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
207-2		10.25	0.00	0.90	0.00	0.00	1.62	86.25	0.04
207-2		10.28	0.00	0.87	0.99	0.00	1.58	85.70	0.03
207-2		10.25	0.00	0.88	0.00	0.00	1.62	86.27	0.04
	Avg of 1467-1469	10.26	0.00	0.88	0.00	0.00	1.60	86.07	0.04
	Standard Deviation	0.01	0.00	0.02	0.57	0.00	0.02	0.32	0.00
	Precision	0.14		1.70			1.33	0.37	12.98
	Accuracy	5.06		20.72			0.25	-1.48	23.68
183-4		7.72	0.00	4.92	5.62	0.00	3.19	76.85	0.06
183-4		7.65	0.00	4.90	5.83	0.00	3.20	76.67	0.06
183-4		7.69	0.00	4.88	5.37	0.00	3.21	77.12	0.06
	Avg of 1471-1473	7.69	0.00	4.90	5.61	0.00	3.20	76.88	0.06
	Standard Deviation	0.03	0.00	0.02	0.23	0.00	0.01	0.23	0.00
	Precision	0.43		0.42	4.06		0.33	0.29	4.19
	Accuracy	5.41		35.73	97.68		-8.44	-9.37	6.67
364		9.64	0.00	11.96	5.00	0.00	0.09	72.68	0.00
364		9.62	0.00	12.03	4.58	0.00	0.10	73.03	0.00
364		9.61	0.00	11.97	4.87	0.00	0.10	72.78	0.00
	Avg of 1583-1585	9.62	0.00	11.99	4.82	0.00	0.10	72.83	0.00
	Standard Deviation	0.02	0.00	0.04	0.22	0.00	0.01	0.18	0.00
	Precision	0.20		0.31	4.49		8.95	0.25	
	Accuracy	2.82		22.83	98.55		-36.84	-10.67	
344		0.00	0.00	0.00	0.00	0.00	30.49	69.20	0.03
344		0.00	0.00	0.00	0.00	0.00	30.50	69.22	0.02
344		0.00	0.00	0.00	0.00	0.00	30.61	69.26	0.02
	Avg of 1587-1589	0.00	0.00	0.00	0.00	0.00	30.54	69.23	0.02

SAMPLE	AVERAGE	Sn	Ag	Pb	As	Au	Zn	Cu	Fe
	Standard Deviation						0.06	0.03	0.00
	Precision						0.21	0.05	16.84
	Accuracy						-1.46	0.36	100.00
207-2		10.32	0.00	0.93	0.71	0.00	1.56	85.85	0.05
207-2		10.35	0.00	0.93	0.00	0.00	1.52	86.05	0.03
207-2		10.32	0.00	0.92	0.00	0.00	1.54	86.09	0.05
	Avg of 1591-1593	10.33	0.00	0.93	0.00	0.00	1.54	86.00	0.04
	Standard Deviation	0.02	0.00	0.00	0.41	0.00	0.02	0.13	0.01
	Precision	0.18		0.43			1.34	0.15	22.18
	Accuracy	5.70		24.41			-4.17	-1.57	32.56
183-4		7.64	0.00	4.67	4.14	0.00	3.23	78.58	0.06
183-4		7.62	0.00	4.60	4.74	0.00	3.19	78.05	0.07
183-4		7.65	0.00	4.71	4.24	0.00	3.18	78.52	0.06
	Avg of 1595-1597	7.64	0.00	4.66	4.37	0.00	3.20	78.38	0.07
	Standard Deviation	0.01	0.00	0.05	0.32	0.00	0.02	0.29	0.00
	Precision	0.20		1.16	7.25		0.72	0.37	4.70
	Accuracy	4.81		32.43	97.03		-8.44	-7.27	13.85