Metallurgy in the Merovingian settlement of Oegstgeest

An inventarisation of the evidence for early medieval ferrous and non-ferrous metallurgy

Marianne Dieuwertje Talma

Image on cover: crucible fragment with scrap metal attached. Trench 86, V00588MSL.
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Author: M.D.Talma
Studentnumber: s0942960
Course: Bachelor Thesis
Course code: 1043BASCRY
Supervisor: Drs. E. Bult
Specialisation: Archaeology of Northwestern Europe
University Leiden, Faculty of Archaeology
Steenbergen (NB), April 2012

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Foreword & Acknowledgements

While it is not customary to thank an extensive list of people in a Bachelor thesis, I would like to acknowledge the valuable contributions made by the people who helped me in the course of this BA- research.

Firstly, I would like to thank my thesis supervisor Drs. Epko Bult, for his helpful suggestions troughout the process. The same goes for Dr. Alexander Verpoorte from the thesis class. I want to thank Drs. Jasper de Bruin (current excavation leader) for giving me the opportunity to research this material for my bachelorthesis.

I want to thank all employees of Archol B.V, especially Marleen van Zon and Svenja Hagendoorn for their help in localizing and managing material from Oegstgeest.

I wish to express warm thanks to Janneke Nienhuis (TU DELFT, Phd) for introducing me to XRF analysis, performing the XRF analysis (in two sessions!) and interpreting the results in a detailed report. Via Janneke Nienhuis I also came into contact with Dr. Ineke Joosten (RCE), one of the foremost slag specialists in the Netherlands. She was so kind to identify some slag fragments from Oegstgeest and provided me with literature that was hard to come by. Thank you!

I want to thank Arent Pol (numismatic expert) who identified some coins found at Oegstgeest. I am grateful to Frans Theuws for his advise and for providing me with yet unpublished manuscripts that help to put the evidence of Oegstgeest into a theorethical framework.

I would like to thank André Cardol from ArcheoPLAN (in Delft) for showing me the material from Oegstgeest in their care and explaining the process of conservation of metallic objects.

I am grateful to Annemarieke Willemsen (National Museum of Antiquities, Leiden) and Ernst Taayke (Noordelijke Archeologisch Depot, Nuis) for their time and effort spent in gathering relevant crucibles from their institutions' collections so I could compare them to those found in Oegstgeest.

I want to thank Milco Wansleeben and Eric Dullaart for helping me with the analysis in Mapinfo and even teaching me something about it, remarkable given the fact that computers usually are confused by the commands I give them.

Lastly I am grateful to Stefanie Hoss and Marijn Stolk for their literature suggestions and Anders Söderberg for his helpful comments on the analysis of the crucibles.

1 Introduction

1.1 Introduction

The village Oegstgeest is situated in the western parts of the Netherlands and to the north of the city Leiden. Its name is derived from the *geests* found in the area (a coastal barrier with sand dune formation).

The North Sea is less than 10 kms away and the Old Rhine flanks Oegstgeest on the southern side. In the area near the A44 highway (near the museum Corpus) a number of infrastructural works are planned in the district Rijnfront, such as an urban living area in the northern part, as well as a Bioscience park for the University of Leiden.

In line with the treaty of Malta[1], legislation demands archaeological investigations prior to construction. A couple of IVO's (Inventarisend Veld Onderzoek, or Inventorizing Field Research) were carried out, as well as some smallscale excavations to enhance the understanding of some house features identified during the IVO. During the investigations between 1998-2005 a number of findspots were identified, one of which concerned early medieval (Merovingian) material dating between 500-775 AD (Dijkstra 2008, 48). From this period the historical sources are scarce and archaeology can provide a vital contribution to the knowledge of this time.

Due to its excellent preservation, the Merovingian settlement of Oegstgeest plays a keyrole in complementing the picture of Early Medieval rural settlements in the coastal area of the Low Countries. There is evidence for largescale infrastructural works, as well as evidence for crafts and trade, that would have been facilitated and stimulated by the strategic location near important waterways. This will be discussed in more detail in Chapter 2.

[1] This Treaty was signed in Valetta, Malta in 1992 by various European countries, and aims to protect archaeological heritage that may be threatened by ground disturbance related to construction activities.

Fig. 1.1: Location of Oegstgeest and direction of North (arrow).

Slightly altered, source: http://www.jufjo.nl/kaartNL2_1600.gif

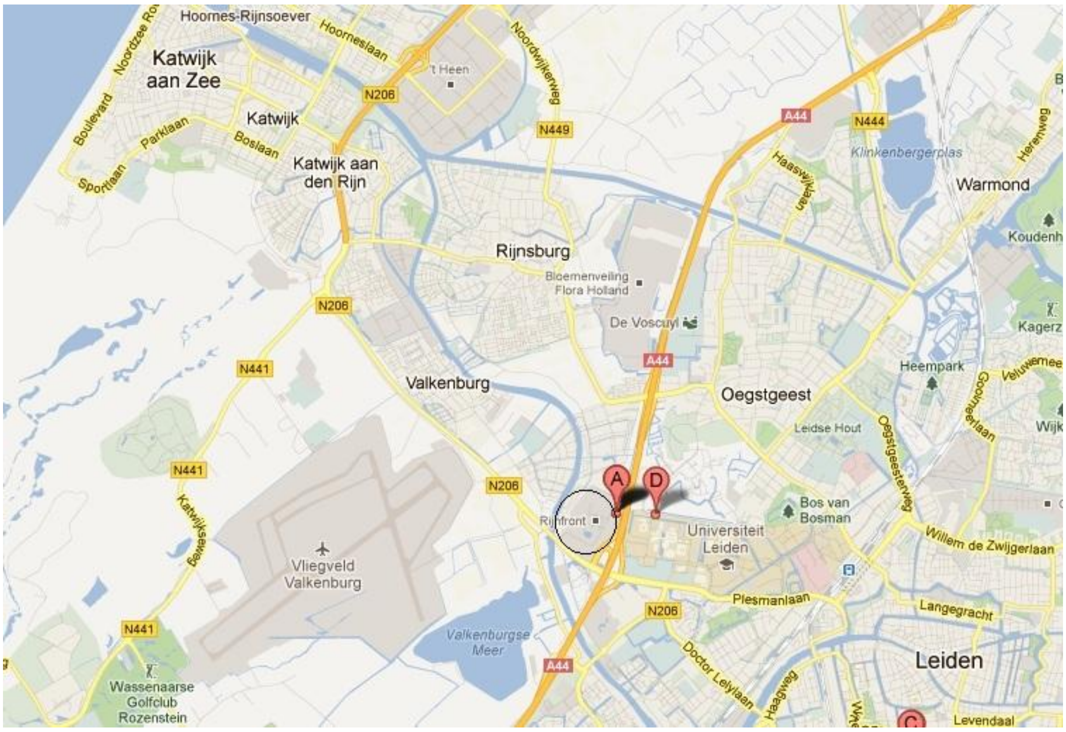

Fig. 1.2: Location of planning area and archaeological investigation(s) within the circle.

Map slightly altered after Google Maps (24-3-2012)

1.2 Previous research & importance of the study

One of the pioneering studies in the field of archaeometallurgy is *Metallurgy in Archaeology* (Tylecote 1962), which discusses the technical aspects of metallurgy from prehistory untill the Middle Ages.

Archaeometallurgy is a sub-discipline within Archaeometry which is the study of artefacts by use of analythical methods borrowed from the fields of physics, chemistry, biology, geology and botany (sometimes supplemented with practical knowledge of relevant crafts). Archaeometallurgy focusses specifically on the metallic (and metallurgy related) artefacts. In the past few decades, archaeometallurgy has gained in importance as a discipline, especially in countries and regions rich in ore such as the United Kingdom, Sweden and Germany.

In the Netherlands, there are studies that discuss the symbolic and political implications of metallic artefacts, but very few that discuss the technical aspects of metallurgy. This in spite of the early publications by J.D. Moerman (from the late 20's untill the late 50's) who was convinced about Early Medieval iron production in the Veluwe, a region in the province of Gelderland. He surveyed the area, identified slagheaps and even engaged in practical experiments to prove his theory. Unfortunately, his work was not recognised prior to his passing but it inspired a doctoral thesis on settlements and central places on the Veluwe in the Early Middle Ages (Heidinga 1984).

In recent years a few important studies on the technology of Early Medieval ferrous metallurgy in Northwestern Europe and the Netherlands have been published. These are 'Technology of Early Historical Iron production in the Netherlands' (Joosten 2004) and 'De Scoriis: Eisenverhütting und Eisenverarbeitung im Nordwestlichen Elbe-Weser Raum'(de Rijk 2003).

The study of non-ferrous metallurgy appears to be still underrepresented within the Netherlands, despite a great number of crucibles stocked in depots and museum collections. Apparantly this is also the case in Germany (pers.comm.Prof. Dr. W. Ebel-Zepezauer, 2-4-2012).[2]

More research in non-ferrous metallurgy has been done in the United Kingdom (for instance the publications of the Historical Metallurgy Society, S.Youngs 1989 (ed.), Coatsworth and Pinder (2002) and by individual authors (such as B. Armbrüster, N. Adams and others).

[2] Prof. Dr.W. Ebel-Zepezauer teaches 'Ur-und Frühgeschichte' on the 'Fakultät Archäologische Wissenschaften' of the Ruhr University in Bochum, Germany.

A detailed overview of crafts in the Early Middle Ages (including metallurgy) is *Kunst und Handwerk im frühen Mittelalter* (H. Roth 1986).

In recent years, within the Netherlands more attention is paid to slag material in terms of economy and iniatives such as the CAAS project (discussed briefly in Chapter 7) underline an increasing interest in archaeometry and archaeometallurgy.

In my opinion, in some publications the emphasis is put on exceptional objects (jewellery) at the expense of objects deemed of less importance (such as crucibles lacking noble metal residue).

Investigating material like crucibles and slag can be a key part in solving the puzzle each excavation trows at us, and can be instrumental in our interpretation of the people in their time. Hopefully this thesis will contribute to the interpretation of the Merovingian settlement in Oegsgeest.

1.3 Research objectives

The focus of this thesis is to investigate the available evidence for (ferrous and non-ferrous) metallurgy in the Merovingian settlement Oegstgeest. First the finds from previous campaigns will be examined to see which finds may be attributed to (the result of) metallurgical practice.

The slag material found in this site, will not be subjected to chemical analysis as this is costly, specialistic work and currently beyond the capacities of the author.

The slag material will be analyzed by its morphological characteristics, and a sample will be presented to a specialist (Dr. I. Joosten) for identification. Furthermore, an attempt will be made to plot the finds of slag and slagfragments in Mapinfo to see how the finds are distributed and if possible to identify concentrations.

This thesis hopes to offer an interpretation of the metallurgy related finds found so far, and to offer ideas on how to recognise and collect evidence of metallurgical activities for the upcoming excavation campaigns.

The main research question can thus be formulated as:

“What kind of artisinal activities related to metallurgy can be identified in the Merovingian settlement of Oegstgeest?”

1.4 Related research questions

1. Is it possible to identify locations where these activities are concentrated? If so, what kind of features and other finds are related to these activities?
2. What processes influence the conservation of metallic objects?
3. What parameters are indicative of metallurgical practices and can be used to recognise them in the field?

2 The Merovingian settlement Oegstgeest

2.1 Research history

After some Early Medieval finds were reported in 1987 and 1991 a small testexcavation followed during which a refuse pit was discovered that also contained 10 pieces of iron slag (Hessing 1992, 106). As the University of Leiden plans to enlarge their Bioscience park in Oegstgeest, Vastgoed BV Universiteit Leiden commissioned ADC Archeoprojecten to excavate the building plot ‘Nieuw-Rhijngeest Zuid’ where in the area previous investigations by Archol BV identified the well preserved remains of an Early Medieval settlement.

Under the direction of the company Archeologic, ADC Archeoprojecten excavated the plot between the 19th of January - 13th of March 2009 (Jezeer 2011, 9). Since the summer of 2009 the excavations of the Merovingian settlement of Oegsgeest are carried out by the Faculty of Archeology from the University of Leiden, who uses the site as a fieldschool for its firstyears archaeology students.

Three summercampaigns have been carried out so far, each on different building plots which is why each campaign bares a different name. The excavation from 2009 is called ‘Oegstgeest Nieuw Rhijngeest Zuid’ (ONRZ09), the excavation of 2010 ‘Oegstgeest Nieuw-Rhijngeest Zuid’ (ONRZ10) and ‘Oegstgeest SL Plaza’(OSLP10).

Since the summer of 2011 untill circa 2014(the estimated end date) the project will be called ‘Oegstgeest Bioscience Park’(OBSP11 and further, see fig. 2.1).

Archol BV is linked to the University of Leiden, and they are regularly asked for particular services concerning the project. Amongst other things they manage the database and give all the finds an electronic findnumber (Fig. 2.5).

2.2 Geography and Landscape

The site is situated in close proximity to the river the Old Rhine, that flanks Oegstgeest on the Southern side and comes out into the Northsea about 10 kms to the west. The Old Rhine is a meandering river, which means that (unless managed by dykes) it changes its position gradually due to erosion of the river banks caused by the different speeds the water runs in the inner-and outer bends of the river (Brijker 2011, 17).

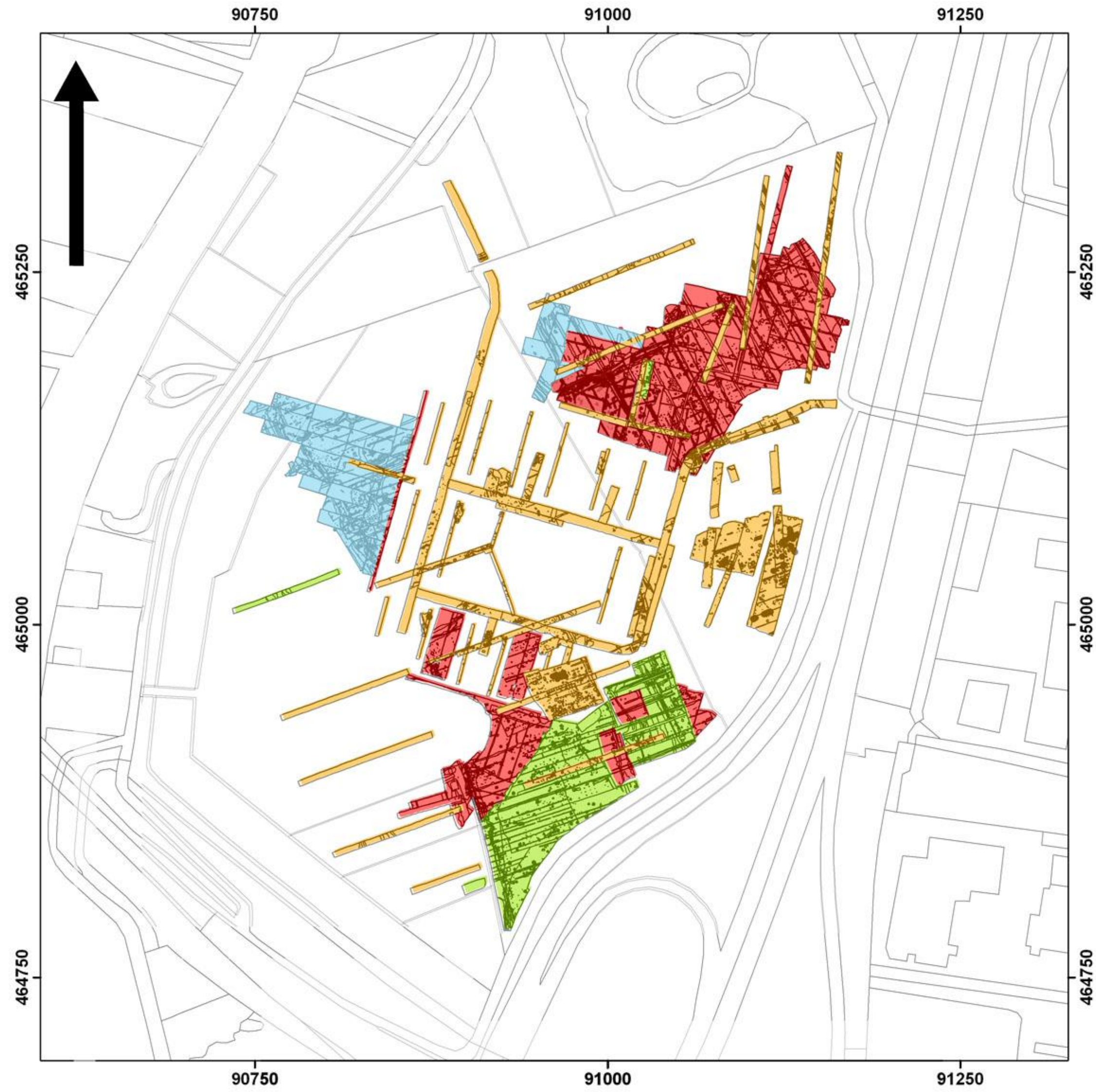

Fig. 2.1: The excavation so far. ***Orange:*** **Archol 2004-2005,** ***green*****: ADC 2009,** ***red*****: Faculty of Archeology 2009-2011(image courtesy of Faculty of Archaeology, Leiden University).**

The water runs slower along the inner bend of the river so that sediment can be deposited, whereas in the outer bend it streams faster and erodes the river bank on that side. Interestingly, there are indications of attempts at land reclamation by the inhabitants of the Merovingian settlement Oegstgeest (pers.comm. Jasper de Bruin 12-4-2012).
When the river experiences more debit it can overflow and deposit fine sediment in the depositional zone. In Merovingian times, this happened regularly (Brijker 2011, 17).
Because the settlement was located in a perimarine area, the influence of the sea was considerable and we should imagine a wet delta-like landscape with dry elevated areas as islands inbetween (free after Brijker 2011, 17-18).
The find of horseburials indicate that some travelling was probably also done over land.

Fig. 2.2 An example of perimarine influence (an estuary), with more inland a similar situation as imagined for the Merovingian settlement Oegstgeest.

Source: www.bonalva.com/momos/blog/wp-content/uploads/2009/05/estuarium.jpg

2.3 Features

Historical sources tell us that from the early 16th century many tile-and brickwork factories were active in the region, which in combination with ploughing activities have caused disturbances in some findlayers, but this damage appears to have been restricted (Hemminga and Hamburg 2006, 20). There are also recent disturbances of drainage pipes and ditches (recognizable by their very regular layout of parallel lines).
Previous investigations identified at least 4 farmhouses with a (west)southwest-(east)northeast orientation (Hemminga and Hamburg 2006, 24; Jezeer 2011, 27). These houses have a rectangular groundform with outlying posts parallel to the wall posts (Hemminga and Hamburg 2006, 24). The dimensions of the houses are estimated to have been between 15-20 m long x 5,45-6,15 wide (Hemminga and Hamburg 2006, 22-24). These houses were previously interpreted as belonging to housetypes Odoorn B and C (Hemminga and Hamburg 2006, 24; Jezeer 2011, 27) but have recently been classified in a local typology as Katwijk B and an outbuilding as type Rijnsburg (Fig. 2.3) (Dijkstra 2011a, 197). What sets them apart from type Odoorn B or C is the location of the entrances, the length of the buildings and the different development of the outer walls (Dijkstra 2011a, 194). Type Katwijk B has one entrance located in the front, and three entrances on the sides, two of them opposite eachother and only the stable has a tripartite floorplan (Dijkstra 2011a, 196).
For some houses only the surrounding ditches are preserved, as well as the rows of narrow stakes at the boundaries of each plot (pers.comm. Jasper de Bruin, 12-4-2012). A number of outbuildings were identified, as well as four- and six poled stock sheds (Jezeer 2011, 30). These would have been used for the storage of grain or other goods. Some outbuildings may have been used for artisinal activities.
Another Katwijk B houseplan was found recently, and the previously discovered isolated 10th century house has received company of other contemporary houseplan in vicinity during the current summercampaign of 2012.

Some of the wells found in Oegstgeest were constructed from wine barrels originating from Southern Germany (pers.comm. Jasper de Bruin, 19-04-2012).
The wells were categorized by Archol into 3 types: type 1 were square wells lined with wood, type 2 were wells made from barrels and type 3 were the wells whose lining was

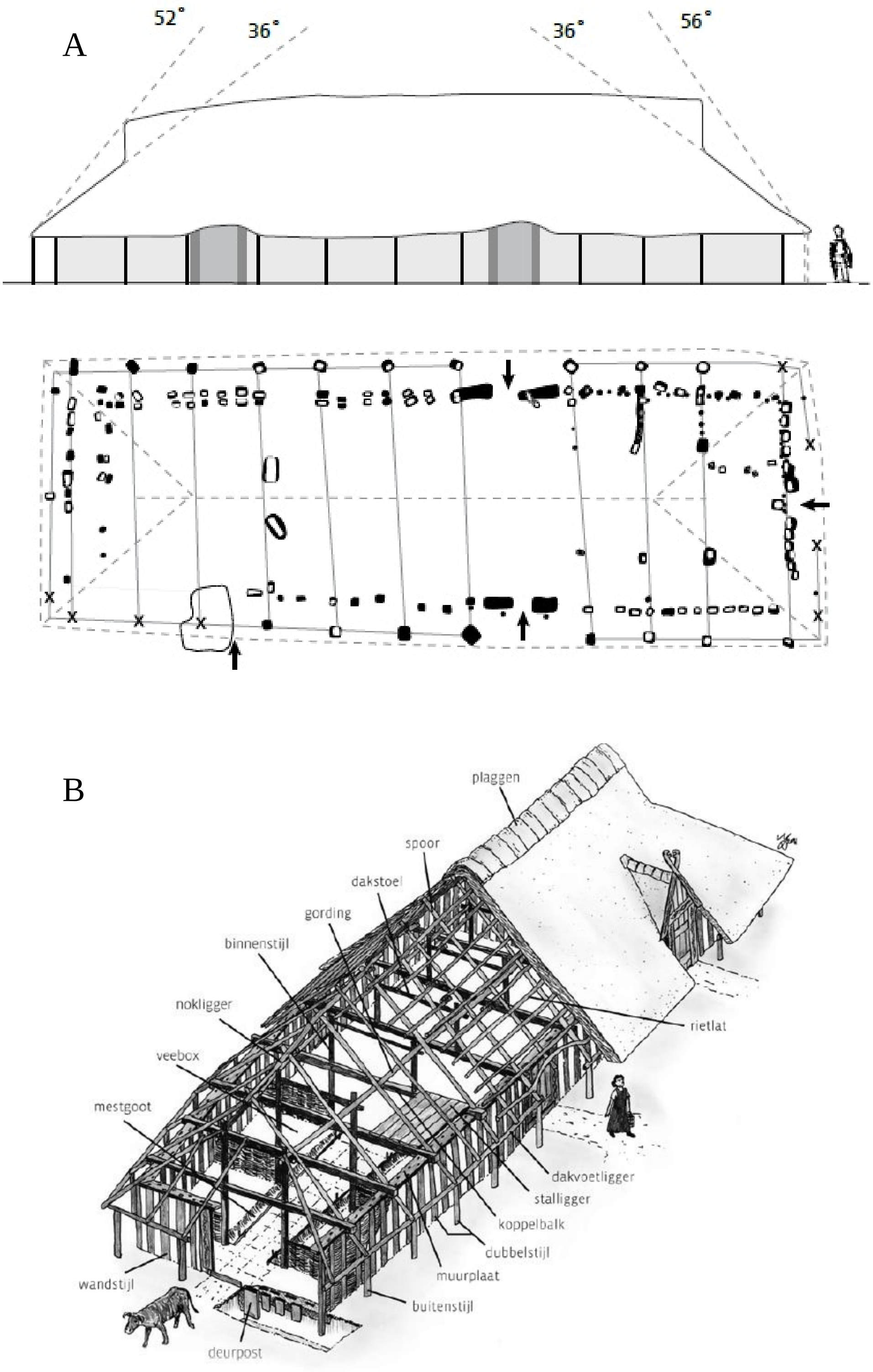

Fig. 2.3 Housetype Katwijk B.

A: projected from a houseplan found in Oegstgeest; B: a reconstruction.

Source: Dijkstra 2011a, 195-196.

badly or not preserved and from which a square or round form couldn't be discerned (Hamburg and Hemminga 2006, 36).
Some of the wells from type 1 were constructed with mortise and tenon joints while others were made from pointed logs lined up next to eachother (Jezeer 2011, 34-36).
Besides wells there are also features designated as refuse pits, hearth pits or possible water pits (Jezeer 2011, 38-41). The refuse pits have a charcoal rich filling and contained mainly animal bones and pottery fragments (Hemminga and Hamburg 2006, 25).
A number of gullies have been found in the settlement, with a northwest/southeast orientation. Some were connected to other gullies who in turn were connected to natural watersources. Their primary function was dewatering (Hemminga and Hamburg 2006, 32). In the western part of the settlement a ±78 m long wooden revetment was discovered on the banks of a gully (Jezeer 2011, 41).

2.4 Finds

Amongst the finds are indications for the working of amber (beads), fragments of glass, bone combs (Fig. 2.6) , spindle whorls, shoe lasts, pieces of leather, pottery, milling and hammer stones, animal bones and metallic finds such as fibulae and other things (Fig. 2.5) (Hemminga *et al.* 2008, 97-104; Knippenberg 2008, 69-77; Jezeer 2011, 90). An example of a find from last year is a spindle whorl or netsinker made of lead (Fig. 2.4).

Fig. 2.4 A spindle whorl or netsinker made of lead.

Found in trench 83, V00423MPB, ⌀ 34 mm x 6,8 mm thick.

Fig. 2.5 Findlabels and the remains of (a decoration on) horsegear.

They were found close to a horseburial. The smaller piece may have been part of a decoration or attachment of the plate to the bridle.

Fig. 2.6 A bone comb in the process of being restored by Archeoplan, Delft.

Findnumber 405, trench 82.

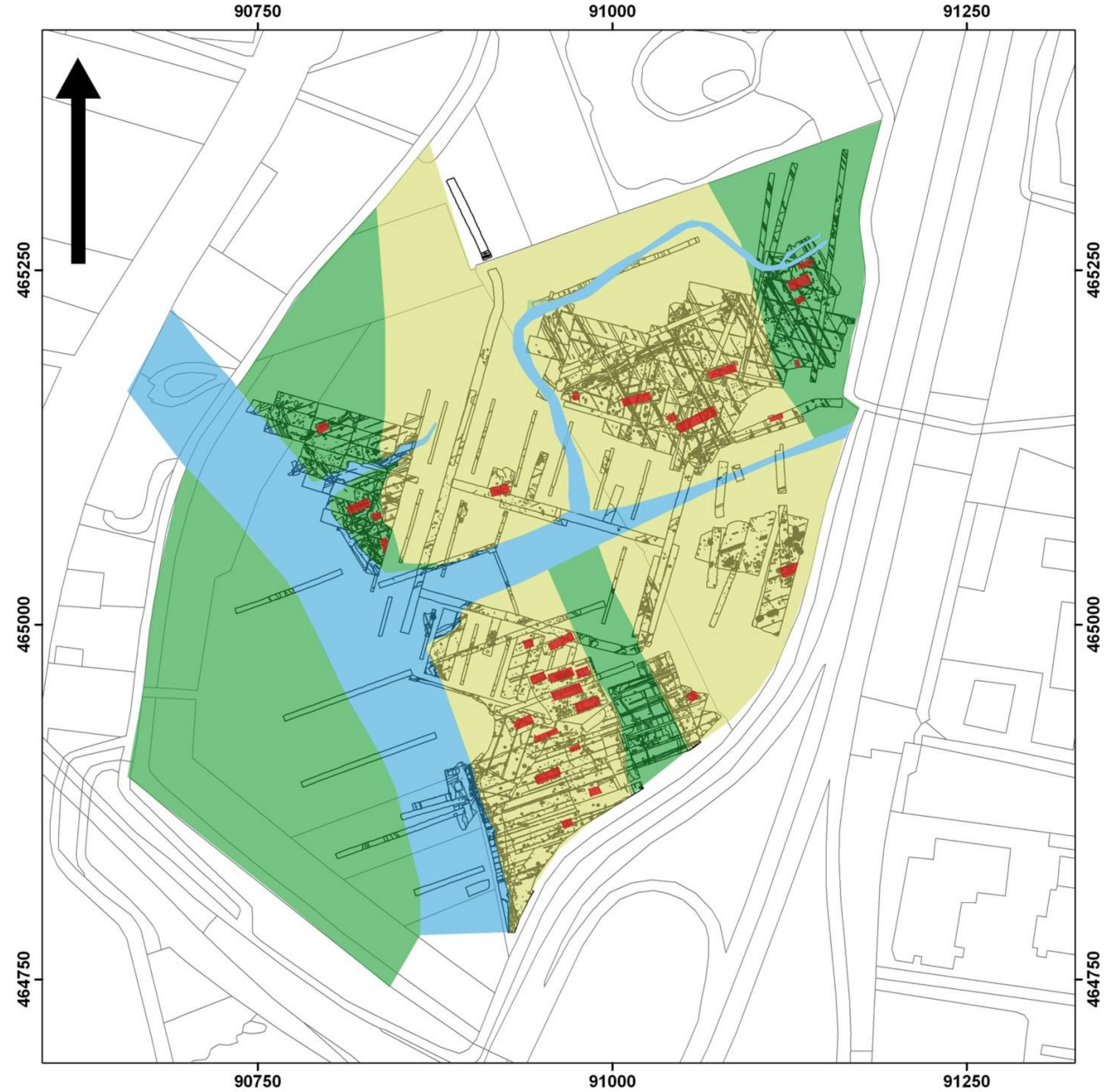

Fig. 2.7 A preliminary interpretation of the layout of the settlement, that may be subject to change. *Arrow*: direction of North, *blue*: water, *dark green*: lower lying areas, *light olive*: higher areas, *red*: location of houses (image courtesy of Faculty of Archaeology, Leiden University).

2.5 Dating

The phasing of the settlement is uncompleted as the excavation is still ongoing, however the evidence suggests a dating of the settlement from the 6th to the 7th century (Jezeer 2011, 115). Some coins found in the settements date to 620-650 AD (Arent Pol, pers.comm. 19-1-2012). The wood used in the wells gave datings ranging from 593 to ca. 672 AD (Jezeer 2011, 37). The datings of the pottery ranges from 550 to 675/700 AD (Dijkstra 2011b, 56). One interpretation is that the Early Medieval settlement was abandoned around 700 AD when the Old Rhine decreased its direct influence in the area followed by a new habitation phase in the 10th/11th century (Dijkstra 2011a, 135-136). There are barely any potteryfragments from the Carolingian period, but 10th century ceramics are well-represented. This also speaks against the idea of continual habitation, but it is possible that the settlement was moved to a nearby yet undiscovered location (pers.comm. Drs. E. Bult 24-5-2012).

2.6 Metallurgy related finds

For this thesis the complete contents of box 63, 65 and 27 have been examined in detail (N= 268 individuals) while box 36, 37, 39, 49 and 64 has been browsed through for any striking finds pointing to metallurgy. The term *individuals* refers to the (fragmented) individual objects that can be identified. The unrecognisable pieces of metals still encased in sediment or corrosion have been counted as 1 individual, though this could be more. The number of browsed individuals is ± 721 totalling the investigated material to ± 989.

In the appendix are excel-sheets from the material investigated in box 63, 65 and 27 and tables describing briefly the content of the browsed boxes per pit and any outliers observed, with a brief conclusion and recommendations.

2.6.1 Iron Slag

The slag found in Oegstgeest seems to be primarily smithing slag, with a few ambiguous pieces that may also have come from the production of iron. A sample was examined by Dr. I. Joosten (per findnumber) in the facilities of the RCE in Amsterdam (05-04-2012). The list of this examined material is available in the appendix (page 100). This sample also gave little indication for the production of iron.

Other fragments have been carefully studied and determined by the author, by which a margin for error should still be taken into account that can be attributed to lack of experience. A recently discovered box (Box 49)contained a piece of slag that may very well be production slag, but for a positive identification a second opinion is needed from a specialist (V01000MSL, feature 29). It seems to have flowing structures and had a markedly different make up than most of the material that was investigated in this thesis.

2.6.2 Crucibles

During the last campaigns a number of ceramic crucibles and crucible fragments were discovered. The crucibles with residues were subjected to XRF analysis for identification (see Chapter 7). After this analysis more material was discovered totalling the number of individual crucibles to ± 8 individuals, for which of 6 it is (almost) certain that they were used for metallurgy. Eventhough the other two fragments (V00065MXX, V00738MSL see Fig. 2.14, Fig. 2.15) do have typical greenish discolouration they should be analyzed with XRF to confirm that they have not derived from other activities such as glassproduction.

From the campaign of 2009 two fairly complete crucibles and two fragments were recovered. These were found in trench 25 (findnumber V01066BIJZK, Fig. 2.10) and trench 21(findnumber V0986BIJZK, Fig. 2.11) in the Northern part of the excavation area, close to the settlement boundaries (Fig. 6.1, Fig. 6.2, Fig. 6.3).

From trench 23 comes a small fragment from a crucible or a mould (findnumber V01025BIJZK, Fig. 2.16).

The crucibles are handformed from clay with a short handle and show vitrification on the bottom and sides. They are fairly small, approximately 50 mm long x 40 mm wide x 40 mm high. Their shape is oval at the bottom and slightly triangular at the top. It seems like something may have been broken off the top, so it is possible that they were lidded.

The handle is short and slightly off-center, whether this is purposefully done or accidental is unclear. The handle is too short to be held by itself, and perhaps its function was to stabilize thongs under it (which I think together with the portruding spout would provide a secure grip).

No residues have been identified on the handles indicating that something else was attached to it, but this is possible. By holding the crucibles with thongs, it seems easier to control moving it sideways.

A few fragments from a larger crucible found in 2011 was discovered after the detailed XRF analysis was performed on the smaller crucibles. Attached to this fragment is a cut-off piece of a (probably) bronze object, demonstrating the recycling of metallic objects in Oegstgeest (Fig. 2.12).

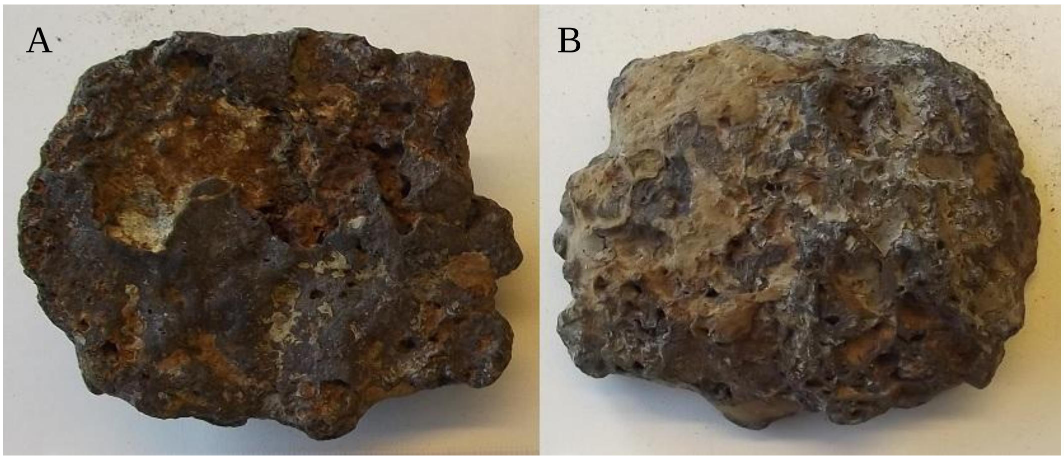

Fig. 2.8 An example of smithing slag showing the shape and size of the smithing hearth

A: top view, B : bottom view (findnumber V00662, trench 8, feature 1, size 86x67x33mm)

Fig. 2.9 A piece of iron stuck in smithing slag (arrow).

Findnumber V00196MXX, trench 8, feature 1 (size ± 63x43x22 mm).

The fragments were briefly analyzed with XRF by Dr. I. Joosten (05-04-2012), but not in great detail (for preliminary results see Chapter 7).
The browsing of box 39 and 49 uncovered two more fragments that have not been analyzed with XRF yet . They are a bottom fragment (V00065MXX, trench 32, box 39) and a wallfragment (V00738MSL, trench 47, box 49) and both show signs of vitrification indicating they have been exposed to intense heat.

2.6.3 Mouldfragment

Findnumber V01069 (trench 25) may represent a clay mouldfragment or a crucible fragment, however this piece is too small for a clear identification (33x 26 x 21 mm). Based on the steep angle of the bottom and a portruding piece on the inside (possibly for a circular form) it does not seem a logical shape for a crucible (see Fig. 2.16 and chapter 7). A one-piece clay mould can only be used once and is broken open after the casted metal has cooled-down. It is likely that the model in the mould would have been constructed of wax (the lost-wax technique).This is a fairly easy and quick way to cast an object for which the production of a stone mould is too industrious or the shape impossible to carve out.

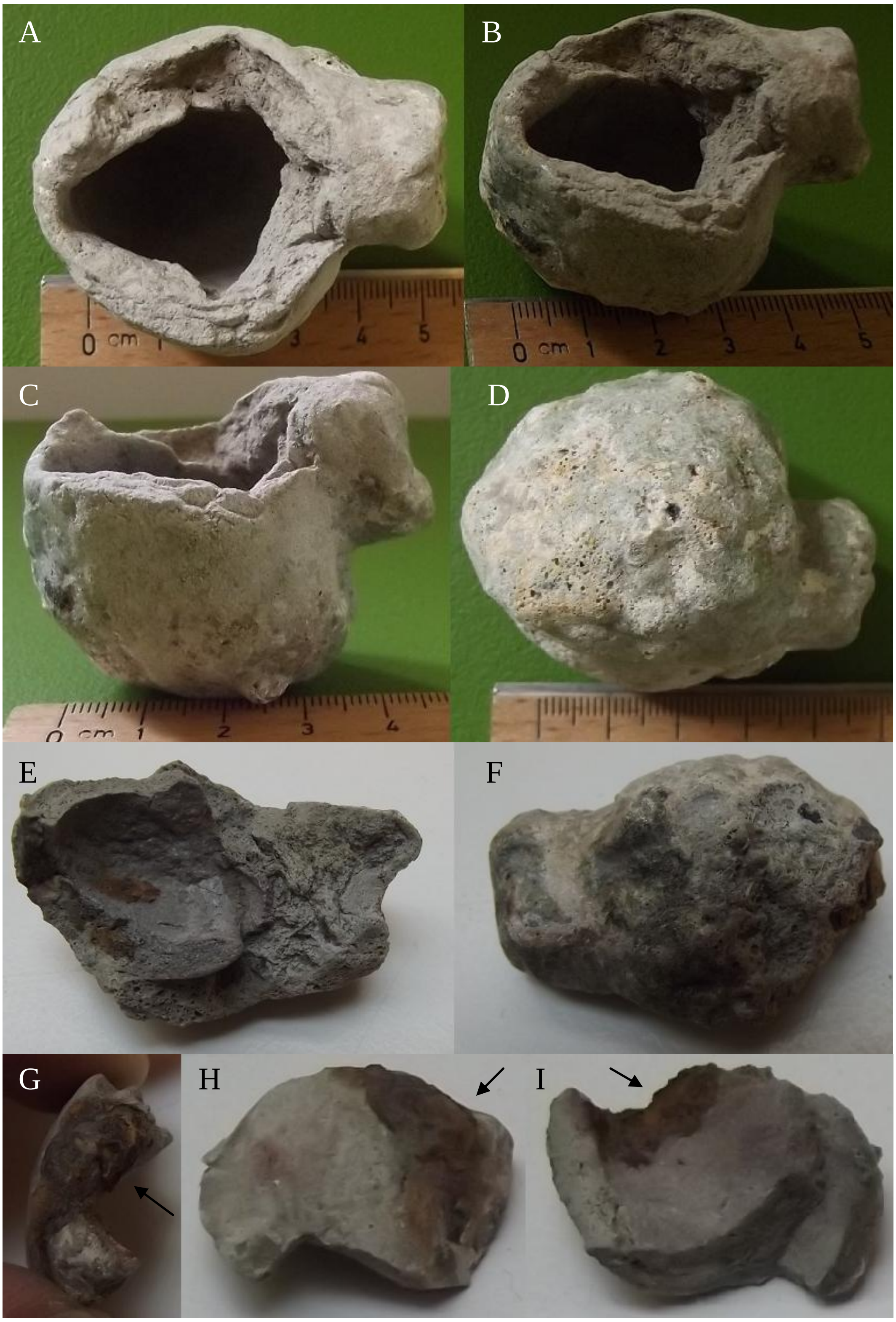

Fig. 2.10 Crucible (fragments) from trench 25, findnumber V001066MXX.

A-D: complete crucible. E-F: bottomfragment of a crucible. G-I: spoutfragment from a crucible with iron residue (black arrows pointing to residue).

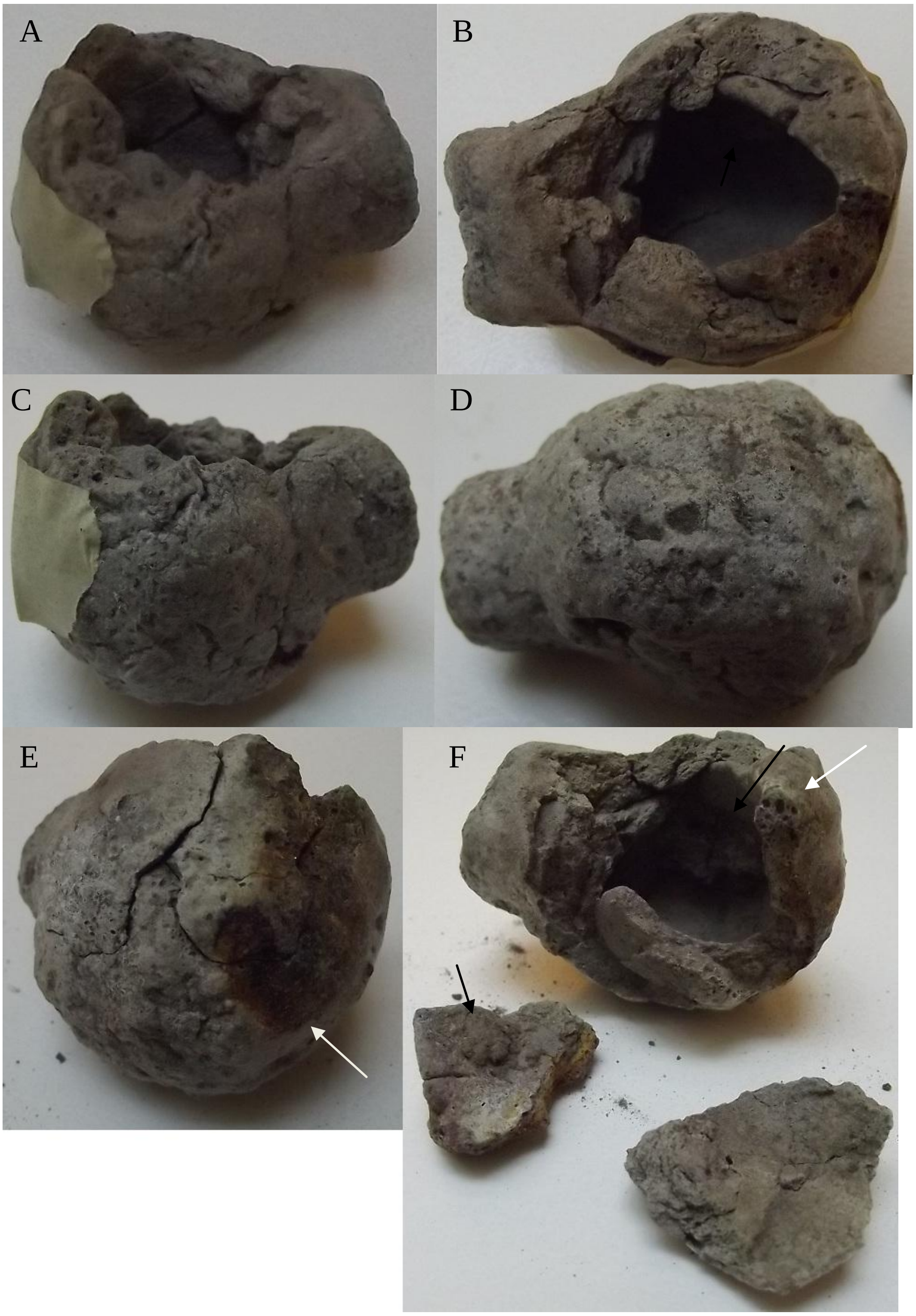

Fig. 2.11 Crucible from Trench 21, findnumber V00986MXX.

A-D the crucible with fragments taped together. E: detail of the fragment pieced together, showing a mark where the fire has been. F:the crucible with lose fragments and metallic residues (black arrows). White arrows pointing to intensely heated spots and vitrification.

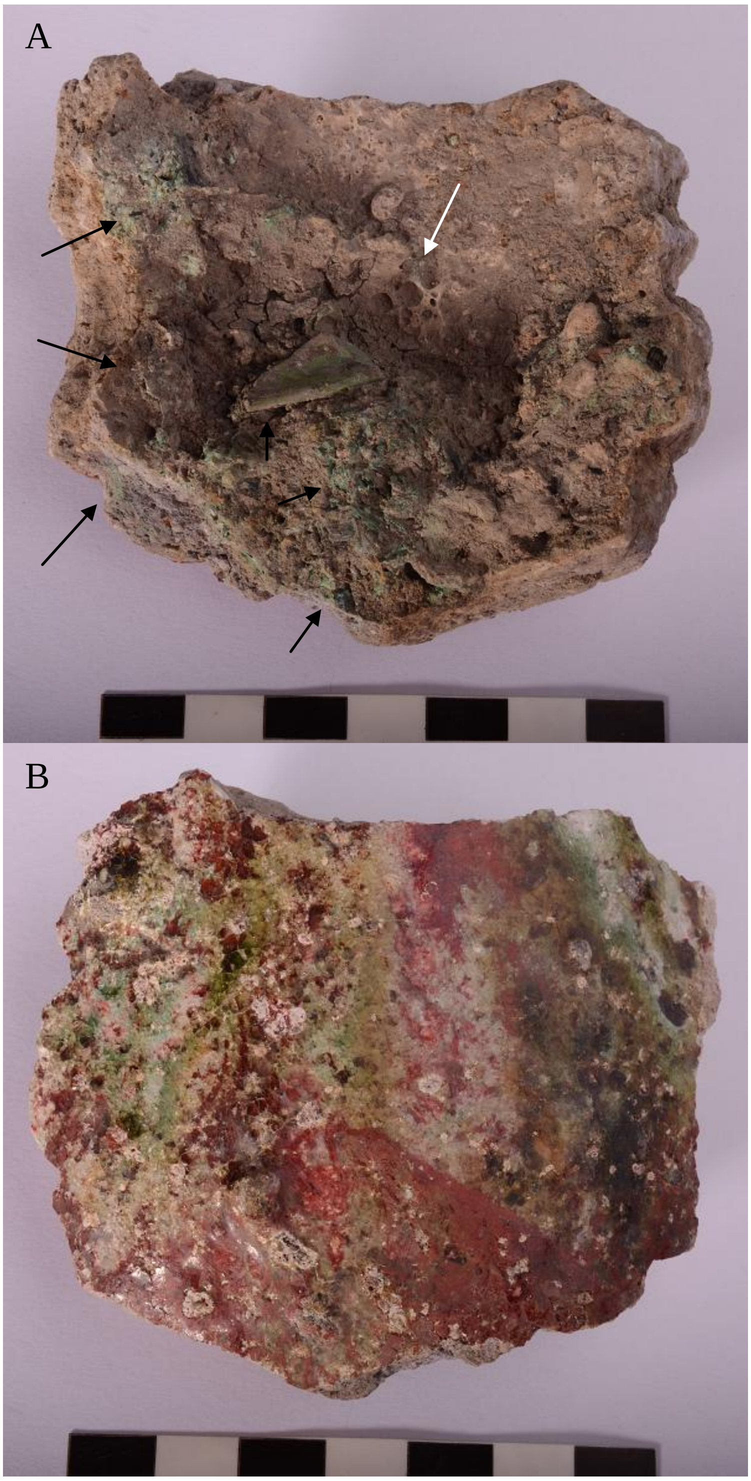

Fig. 2.12 Crucible fragment from with a piece of scrap metal and copper residue present (trench 83, findnumber V00588MSL).

A: black arrows pointing to copper (alloy) residu and scrapmetal, white arrow to vitrification.

B: typical vitrification and red and green discolouration due to intense heat.

Source: © Joella Donkersgoed 2012.

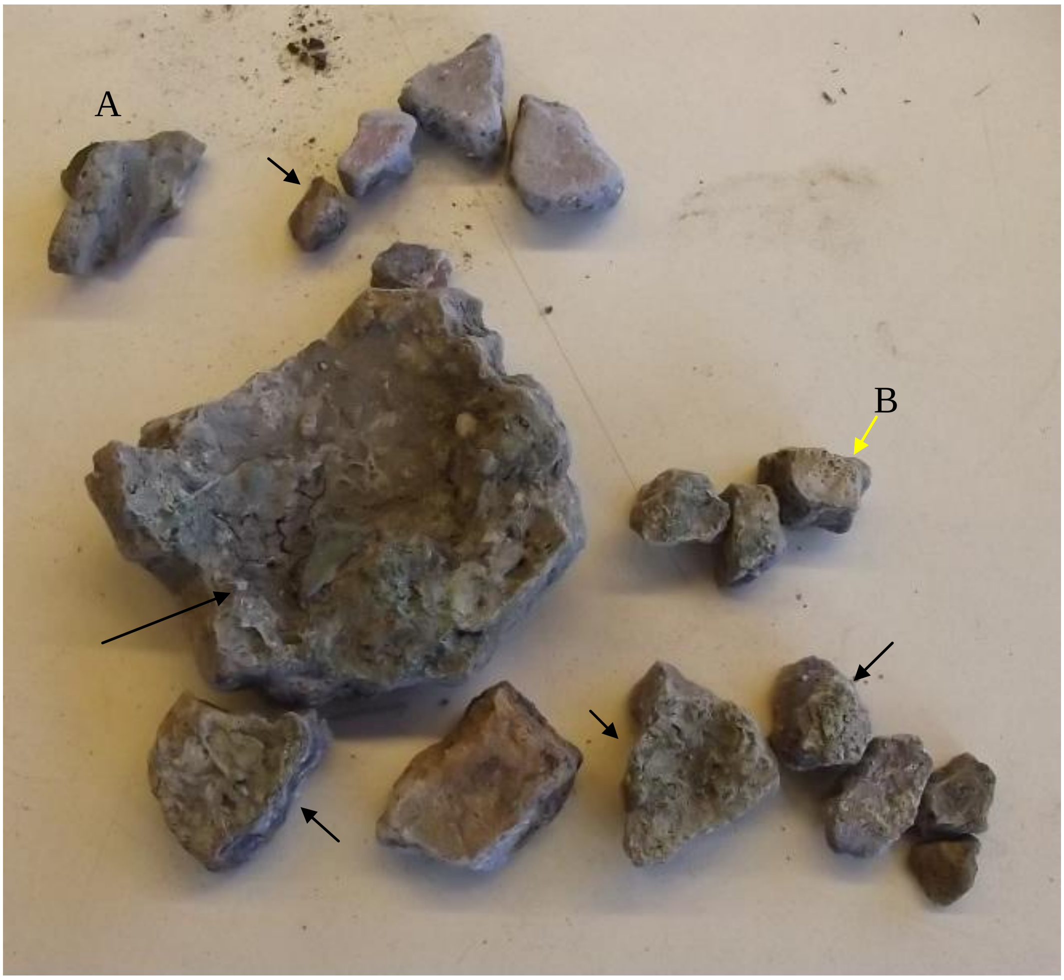

Fig. 2.13 All crucible fragments from findnumber V00588MSL, Trench 83.

A= fragment of a lid, B= this yellowish piece gave a high signal for zinc during the brief XRF analysis, amongst other elements. Black arrows: metallic residue.

Fig. 2.14 Bottom fragment of a crucible with findnumber V00340MXX, Trench 36.

White arrows: vitrification, black arrow: metallic residue. Dimensions ± 34x26x11 mm.

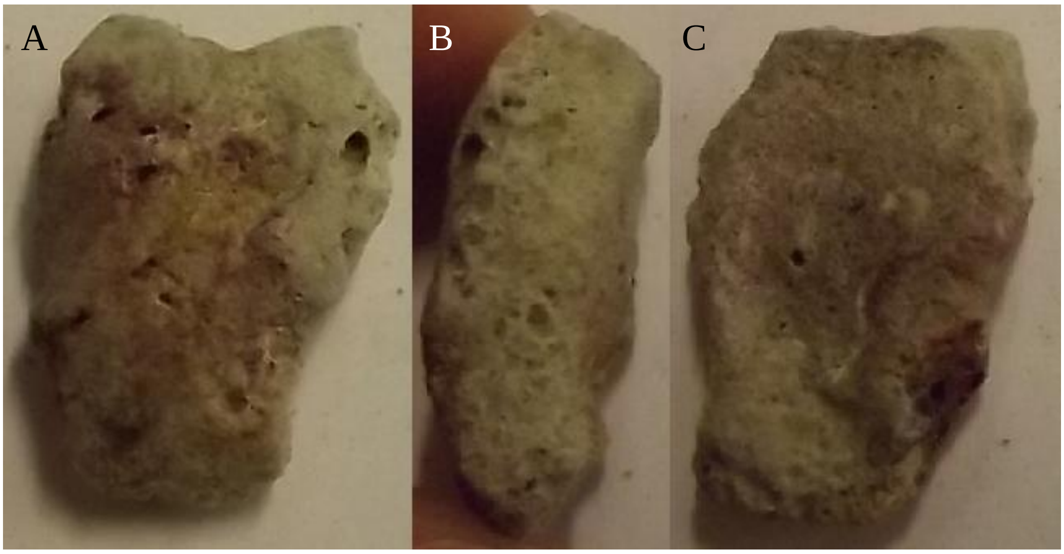

Fig. 2.15 A crucible fragment from trench 47, feature 45, V00738MSL.

A: outer surface; B: section / side; C: inner surface. Dimensions 22 x 15 x 7,5 mm.

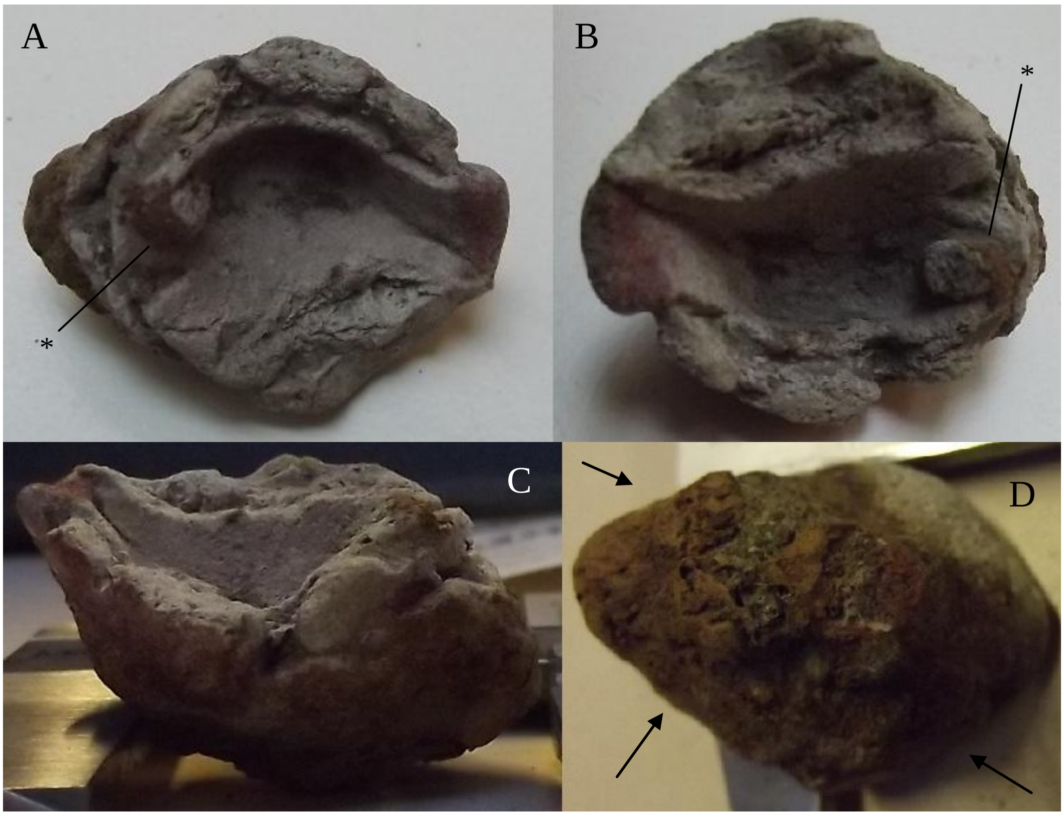

Fig. 2.16 Possible mouldfragment from trench 25, findnumber V001069MXX.

A: view from one side; B: view from top; C: View from side; D: View from bottom with black arrows pointing to iron residue. * = base of portruding piece. Dimensions:33x26x21mm.

Fig. 2.17 The (possible) scrapmaterial from copper-alloys.

A: a small piece of brass (findnumber V00097MAU, trench 34); B: front and back of a piece of bronze or brass (findnumber V00311MBR, trench 40) ; C&D: bottom, side and top of a piece of bronze or brass (findnumber V002006MBR, trench 42); E: a possible piece of scrap from a copper alloy (brass or bronze (findnumber V00353MXX, trench 10).

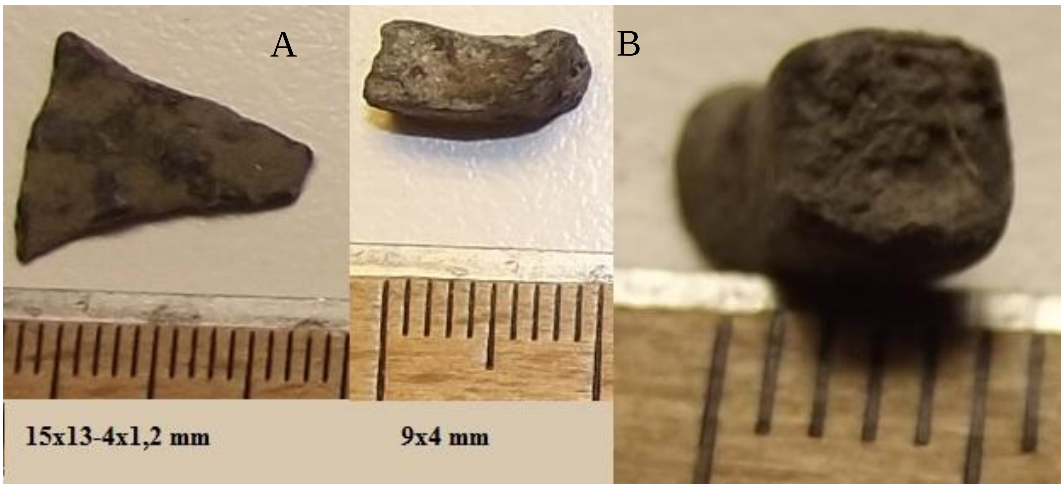

Fig. 2.18 Two fragments from unknown metal(s) interpreted as scrap.

A: V00340MXX, trench 36, feature 30; B: V00101MXX, trench 34, feature 1.

Fig. 2.19 The (possible) lead scrap material.

A:V00145MXX, trench 33; B: V00312MPB, trench 40; C: V00232MPB, trench 36; D:V00193MXX, trench 8; E:V00703MPB, trench 82; F: V00214MPB, trench 77; G: V00468MPB, trench 46.

2.6.4 Scrap and ingots: copper-based alloys

Some of the metallic finds seem to represent scrap metal or ingots. They show signs of being molten, casted or cut and have probably derived from metallurgical activities (Fig. 2.17). From trench 34 emerged a small piece of copper-alloy that was identified as brass by XRF analysis (V00097MAU, see chapter 7).
The browsing of box 39 and 49 produced two more small pieces of copper alloy, V002006MBR (trench 42, ± 21x10x9 mm) and V00311MBR (trench 40, 15x12x5,6 mm). A possible piece of scrap from a copper alloy is V00352MXX (trench 10, size 68x 8-2 (point) x3 mm). It has rough edges on the sides and one straight edge in the front (sawn?) and some smithing marks on the edges.
Maybe it was in the process of being made into something but the smith was dissatisfied with the result and it was discarded(?).

2.6.5 Scrap and ingots: lead

Some of the (supposed) lead scrap pieces have clearly been casted (findnumber V00312MPB trench 40, V00193MXX trench 8, V00145MXX trench 33) while others are hammered (V00468MPB trench 46, V00232MPB trench 36 and) and some may simply be remains of objects (V00703MPB trench 82).
They all have been interpreted as scrap. Unfortunately from two finds there is no picture: V00322MXX(trench 9) and V005045MXX (trench 11). V00322MXX is a small bar-shaped (ingot?) piece of lead, flat on one side and rounded on the other. Its dimensions are 23,55 x 8,8 x5,6 mm.V005045 (trench 11) is an oval flat shaped piece of lead.
It is a surface find and measures 23 x 15 x 6 mm. They are all fairly small.

2.6.6 Scrap and ingots: unknown

From trench 36 (feature 30) comes a triangular-shaped piece of dark metal (V00340MXX) that looks like it was hammered flat (but it could also have been flattened by processes in the soil). It could have come from a ring or a bracelet. The metal is unknown, but based on the dark colour it might be silver (with an oxidation layer). From trench 34 (feature 1) comes a small, square piece that is slightly bend (V00101MXX). The U-shaped end (‘sharp edge’) on one side is interesting, it indicates that the metal was deformed into that direction. It is likely that it was hammered in that direction, though it is also possible that it was formed in a draw iron. Another possibility is that is has come from an existing object, perhaps a piece of jewellery like a ring or a bracelet. The break could have originated from a flaw in the metal. This piece might be silver, but since archaeological silver can look markedly different from 'fresh' silver, I am unsure. I tend to lean more to this last piece looking like silver than the former. Perhaps an XRF analysis would provide a definitive answer.

2.6.7 Burnt clay

Burnt clay is often associated with hearth lining and in the case of Oegstgeest most pieces seem to have come from smithing hearths. Some fragments have pieces of slag attached (and vice versa). Lining a hearth with clay improves its thermal properties. It is unknown whether the hearth was build on the ground or on an elevation. There is one one piece of smithing slag that has a portrusion pointing upward and was probably formed near the nozzle. The angle suggests that a pit was dug into the ground, but it may also very well have been an elevated smithing hearth with a deep pit (V00225MXX, trench 4). According to Heidinga and Offenberg there was a difference in practice in 'the north' where a hearth was dug into the ground and in 'the south' where they made use of an elevated hearth (Heidinga and Offenberg 1992, 113).

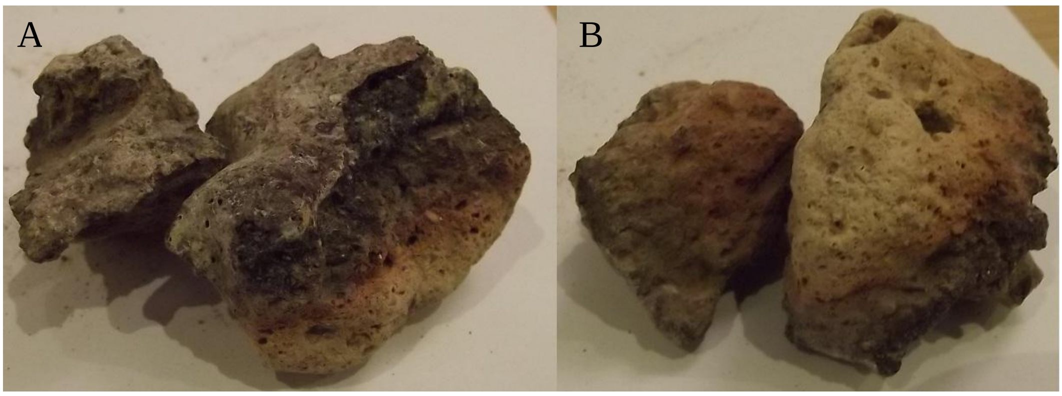

Fig. 2.20 Slag and clay findnumber V00424MSL, trench 83.

A: top with dark grey slag; B:bottom with burned clay

3 Conservation and degradation of metals

The metals found in Oegstgeest show a varying degree of preservation. Especially iron and bronze seem to have been vulnerable to processes in the ground, while most lead objects (apart from having white patina) survived relatively unscatched. Not only corrosion or weathering rendered some objects unrecognisable, some damage could have been avoided if particular items (especially those of bronze) were packaged more carefully. The following will give a brief summary of the factors that influence the conservation and degradation of certain metals prior, during and after excavation, and offer advise on how to store items so to better preserve them for future research. The following information has been narrowed down to the situation (that may be) applicable to Oegstgeest. A handy fanning publication for any vulnerable type of archaeological material encountered in the field is 'Eerste hulp bij kwetsbaar vondstmateriaal'(Huisman 2010).

3.1 In situ

The term '*in situ'* literally means '*in position'* which in archaeology relates to the objects being in their original place of deposition, their 'primary position'. Some objects in Oegstgeest (such as some metallurgy related finds near the former banks of a gully in the western research area) are in so-called 'secondary position' due to water overflowing the banks in times that the river had an increase in debit. It is thought that these particular objects haven't been displaced far from their original source (pers.comm. J. de Bruin, 12-4-2012). Any object displaced from its original location however is usually '*ex-situ'*, the same goes for excavated objects.

This paragraph will detail the processes influencing conservation '*in situ'* while the next paragraph will do the same for objects during and after excavation.

3.1.1 Iron

Iron objects usually contain some carbon (C), iron with a low carbon content is soft and mallable, while carbon-rich iron is hard and brittle. It can contain inclusions of slag, oven wall or flux (used to lower the temperature during the production of iron) (Huisman 2009, 91). Iron is only pliable when heated to about 900 °C.

In its metallic form it oxidises when coming into contact with oxygen, sulphate, water or acid (Huisman 2009, 92). On an elemental level, iron (Fe^0, from latin *Ferrum*) is oxidised to Fe^2 and later into Fe^3 (where it dissolves and is transported out of the object) (Huisman 2009, 98). These are oxidation processes: the iron atom loses electrons (Huisman 2009, 92).

Each reducing reaction creates a different form of corrosion layer, and a different type and degree of degradation. The type of soil will determine which reaction takes place.

In oxygen-rich soils, oxygen is able to penetrate the soil at least part of the year.

This includes ploughsoils, all well-drained soil layers and soils that are infiltrated by oxygen-rich water (Huisman 2009, 93). In these soils, a 'dense product layer' is formed around the metal, which consists mostly of goethite and some other minerals.The oxidation of iron occurs at the boundary of the metal and this 'dense product layer', depositing rust in the soil surrounding the object. This crust can be firm, but also soft or crumbly (Huisman 2009, 96). Sometimes a thin crust of lime is observed around the concretion, or if magnetite is deposited in parallel cracks it can have a marbled appearance (Huisman 2009, 96, Fig. 3.1). Sometimes hollow blisters of magnetite are formed on the outer surface: this was also observed in several iron objects found in Oegstgeest.The oxidation of iron produces cavities inside it and eventually all metallic iron will dissapear, leaving only a thin wall of magnetite(Fig. 3.1). Inclusions of slag and carbon are unaffected (Huisman 2009, 97). If the supply of oxygen is slow, oxidation will also occur more slowly. Theoretically, the oxidation of iron is slower in soils with low permeability (i.e. clay) as opposed to porous soils (i.e. sandy soils)(Huisman 2009, 98). Furthermore, an acidic environment can speed up the corrosion process, whereas in an alkaline (i.e. calcareous) environment it proceeds more slowly. Salinity of the soilwater makes it more conductive, so that the transportation of electrons in the iron (and therefore the iron elements) is accelerated (Huisman 2009, 98). Anoxic, sulphur-rich soils are permanently water saturated but contain no dissolved oxygen in their pore water.This is common in marine environments, and in areas where saline groundwater wells up (Huisman 2009, 93). In this environment iron (Fe^0) inside the object is transformed into Fe^2, but not into Fe^3. Sulphite (HS^-)will appear on the outer surface as a counter-reaction (Huisman 2009, 98). In this process iron monosulphides are formed. If Fe^3 is present in the surrounding soil, it reacts with the iron monosulphide and creates a concretion on the iron object that contains soil material. It will usually appear grey-black to black in colour, but it can also contain gold-coloured pieces(Huisman 2009, 98).

3.1.2 Copper and copper alloys

Copper ($Cu^{0)}$ is a soft, mallable metal that by itself is unsuitable for casting. Its chemical element is Cu, based on its latin term *Cuprum*. Copper can be cold-hammered into a desired shape. Combined with other metals that lower its melting point (i.e. tin or zink) it can be casted. Addition of tin (or arsenic) will make bronze, while adding zink to copper will make brass. An addition of 10-20% zink will give a colour similar to gold (Huisman and Joosten 2009, 111).

The copper ions can have a univalent (Cu^1) or bivalent form (Cu^2), and during weathering will react to form 2Cu+. (Huisman and Joosten 2009, 114). These are oxidation processes: the copper atom loses electrons (Huisman and Joosten 2009, 115). Patina is a common surface layer on copper and copper-based artefacts, which can form naturally or by artificial means (Huisman and Joosten 2009, 111). Although different terms for the same weathering proces, patina is a smooth, continuous (protective) layer while mineral deposits that form an irregular (destructive) layer is called corrosion (Huisman and Joosten 2009, 112). Natural patina is formed over the course of years, and its specific layered structures can confirm its authenticity. Artificial patina's are created by using chemicals (Huisman and Joosten 2009, 112).

Copper (based alloys) react to oxygen, sulphate, water and acid (Huisman and Joosten 2009, 115).

In an oxygen rich soil or environment, the oxygen is reduced and the copper oxidises. It dissolves to form a compact layer of red cuprite on the metallic surface (Huisman and Joosten 2009, 116).

Progressive corrosion by interaction of the copper and chemical elements in the environment will form other minerals (alkaline copper carbonates) such as green malachite in wet conditions and sometimes blue azurite in dry conditions (Huisman and Joosten 2009, 116).

In a saline oxic environment chlorides (besides oxides and carbonates) can form, that have a detrimental effect on the copper object. The chlorides can migrate through the protective oxide film and form a white waxy layer of copper chloride (nantokite) on the metallic surface (Huisman and Joosten 2009, 117). Chlorides can speed up the corrosion process in such a way that a porous crust is formed, which gives access to water and oxygen that react with the nantokite to form powdery green paratacimate. Crystals (from green paratacamite and atacamite) can also form, whose large crystal destablize the

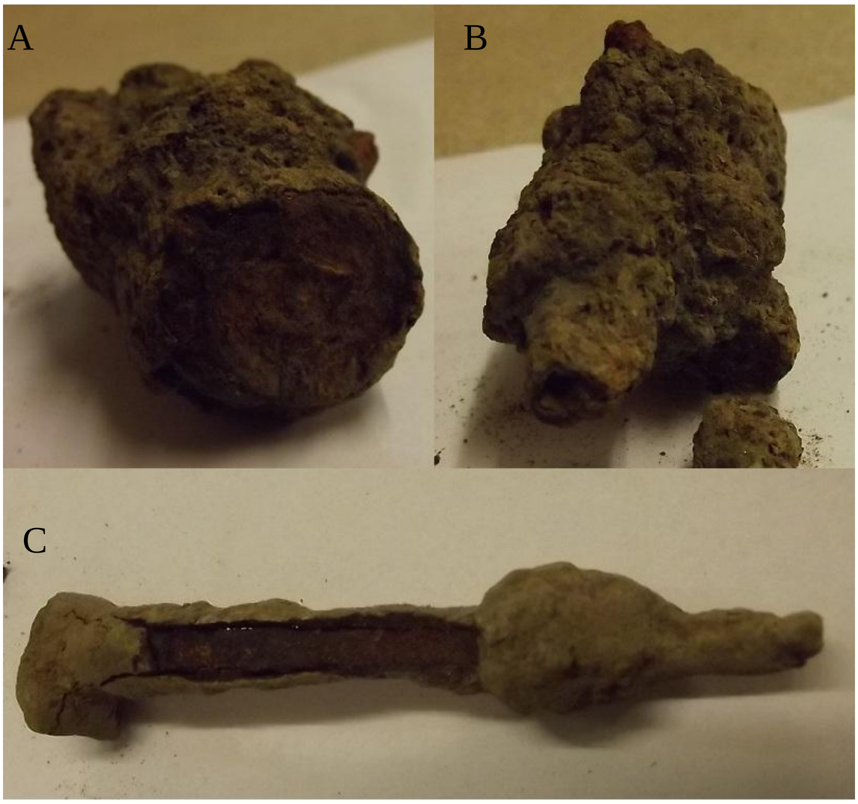

Fig. 3.1 Iron nails in corrosion

A: front, B: back (V00380MXX, trench 10); C: iron nail in corrosion (V00593MXX, trench 12).

Fig. 3.2 Badly degraded copper-alloy from trench 21,V00900MBR.

corrosion crust, causing it to crumble (Huisman and Joosten 2009, 117, Fig. 3.2). It is also possible that alloyed components erode out of the object, such as dezincification. This may give the object a pink colour (Huisman and Joosten 2009, 117).

The pH level of a soil is one aspect that determines which copper compounds are formed. A pH level of >5 will facilitate the formation of a cuprite layer around the object while in a more acidic environment (pH < 5) the copper salt dissolves preventing the formation of a protective patina (Huisman and Joosten 2009, 118). Sometimes all that remains is a green patch in the soil (Huisman and Joosten 2009, 118). Carbonate-rich soils generally have good preservation qualities for copper (-based) objects (Huisman and Joosten 2009, 118).

In a sulphate rich environment, sulphide will facilitate the oxidation of copper. In this process usually hydrogen sulphide(HS^-) is formed (Huisman and Joosten 2009, 119). Corroding copper reacts with hydrogen sulphide to form copper sulphides such as the black copper (I) sulphide chalcosite or the blue-black copper (II) sulphide coveline. As a result corrosion pits can form in the process (Huisman and Joosten 2009, 119). The copper sulphide can form a protective layer or an uneven crust on the metallic surface, and sometimes lime or sediment adhering to the lime accumulates on the outside of this sulphide layer. In these conditions copper objects may survive relatively well, apart from the corrosion pits (Huisman and Joosten 2009, 119). In sulphate poor environments (such as bogs) a copper object can survive relatively well, though in the process a gold-coloured layer of chalcopyrite can form on the object, sometimes referred to as bog-patina (Huisman and Joosten 2009, 120).

NOTE: As copper is toxic to living organisms, organic material that would otherwise biodegrade is often well preserved if found in proximity to corroding copper objects in the soil. The organic material (wood, textile or leather) will often be impregnated with copper (Huisman and Joosten 2009, 120).

3.1.3 Lead

Lead (Pb, from latin *Plumbum*) is a soft, pliable and tough metal that is bluish white-grey in colour. It is a poor conductor and fairly resistant to corrosion, although it discolours rapidly when exposed to air (van Os, Huisman and Meijers 2009, 125). It can absorb minor movements, which may contribute to its preservation (van Os, Huisman and

Meijers 2009, 125). Lead and lead-tin alloys are usually stable in burial conditions, even in saline environments, due to the formation of a lead oxide/carbonate layer (van Os, Huisman and Meijers 2009, 132). If the water is very soft (such as in peat bogs) the formation of protective salt layers is difficult, and lead and lead-tin alloys may dissolve under the influence of organic acids (van Os, Huisman and Meijers 2009, 132). Rainwater can also dissolve lead objects in sandy soils (van Os, Huisman and Meijers 2009, 132). Although toxic, lead has no preservative effect on organic remains, since it is (like tin) less soluble deeper in the soil (van Os, Huisman and Meijers 2009, 132).

3.1.4 Tin

Tin (Sn, from latin *Stannum*) is a silver-grey metal that is fairly pliable, tough and has a well-ordered crystal structure (van Os, Huisman and Meijers 2009, 125). The element occurs in two forms (allotropes). When cooled down to below 13,2° C it converts from its normal form (β-tin) to α-tin that is dull grey in appearance and has a different density. This process is what causes tin-pest (van Os, Huisman and Meijers 2009, 125). Extended exposure to temperatures below 13°C causes a change in volume, which in turn pulverizes the tin (van Os, Huisman and Meijers 2009, 130). Tin is used in alloys (bronze and pewter). Addition of lead, bismuth, antimony or arsenic can prevent tin-pest (van Os, Huisman and Meijers 2009, 130). Tin is resistant to distilled water, seawater and soft tap water, but vulnerable to strong acids, alkalis and acid salts. Dissolved oxygen accelerates the degradation of tin (van Os, Huisman and Meijers 2009, 125). Tin reacts (like lead) with oxygen to form tin (di)oxide, and dissolves in contact with salt (Cl^-). If in an alloy with lead it is protected from further degradation by lead oxides and carbonates that form a protective layer (van Os, Huisman and Meijers 2009, 130). While it is not very soluble when deeper in the soil, under anaerobic conditions it can form a layer of tin sulphide, which has a preserving effect on organic remains (van Os, Huisman and Meijers 2009, 133).

3.1.5 Silver

Because silver is a precious metal, it is resistant to oxidation and not subject to galvanic corrosion. It is slightly harder than gold and easy to work. It has the highest electical and thermal conductivity of all metals (van Os, Huisman and Meijers 2009, 126). However, it is made up of individual grains that can lose their cohesion over a period of time (van Os,

Huisman and Meijers 2009, 129). Alloys with silver and copper can turn black as they react with hydrogen sulphide anion (HS^-)(van Os, Huisman and Meijers 2009, 130).
Upon oxidation silver becomes univalent (Ag^+). It can turn many hues during oxidation and will only turn black if the damage exceeds 100 nm (0.1 µm) (van Os, Huisman and Meijers 2009, 130).
Silver dissolves in nitrous acid, though not in aqua regia (see gold)(van Os, Huisman and Meijers 2009, 130). Alloys of silver and copper are susceptible to degradation, and can become brittle. When the silver grains lose their cohesion the cracks that appear are further corroded by the copper content, which will desintegrate the object (van Os, Huisman and Meijers 2009, 131). Physical erosion by the scouring effect of sand can cause distortion or loss of fine details, due to the softness of the metal (van Os, Huisman and Meijers 2009, 130). In the soil, silver can corrode in moist conditions when dissolved salts (like chloride) are present. This forms silver chloride. Although less common, a reaction with bromide is possible, and silver bromide is much less soluble (van Os, Huisman and Meijers 2009, 132 after Hedges 1976. Silver deters microbes and curbs the effect of biodegration of textiles, wood and leather (van Os, Huisman and Meijers 2009, 132). In sandy (or other well aerated) soils a thick layer of silver chloride will form, which will discolour from white to purple under the influence of light (van Os, Huisman and Meijers 2009, 132). The silver can deteriate faster than copper alloys in those soils, which makes restauration in most cases impossible (van Os, Huisman and Meijers 2009, 132). In anaerobic conditions a black silver sulphide can form a concretion on the original surface, sometimes with soil elements. The original surface is often still preserved under these concretions, sometimes with a sulphide patina. Restored, the object can look either black or silver in appearance (van Os, Huisman and Meijers 2009, 132).

3.1.6 Gold

Gold is a precious metal and therefore resistant to oxidation, corrosion and discolouration. However, it is made up of individual grains that can lose their cohesion over a period of time (van Os, Huisman and Meijers 2009, 129). Concerning gold alloys, the lower the content of gold the more susceptible it is to discolouration and corrosion. Gold can only dissolve under the influence of extreme substances such as aqua regia (a highly corrosive mix of acids), in which case it produces a gold ion (Au^{3+}). Gold is also solluble in mercury (amalgamation), lead, tin and their alloys (van Os, Huisman and

Meijers 2009, 130). Alloys of gold with copper are susceptible to corrosion and can become brittle. When the gold grains lose their cohesion the cracks that appear are further corroded by the copper content, which will desintegrate the object (van Os, Huisman and Meijers 2009, 131). Physical erosion by the scouring effect of sand can cause distortion or loss of fine details, due to the softness of the metal (van Os, Huisman and Meijers 2009, 130).

3.2 Ex situ

3.2.1 Iron

Excavated iron objects need to be sent to a professional conservator as soon as possible, as delay can cause severe damage to the object. Repeatedly drying and wetting of the object can have a detrimental effect. For instance, specific minerals (such as akaginite) can form that damage the object and are hard to remove (Huisman 2009, 107). It is best to keep the objects in a bag with the sediment it was found in(Huisman 2009, 107). The object needs to be protected from sunlight to prevent rapid drying (Huisman 2009, 108). Cleaning in the field can be detrimental to the object and is best avoided. The rusty outer layer provides the object with initial protection from drying, accelerated corrosion, and scratches (Huisman 2009, 108). When lifting an iron object, proceed with caution as it may be brittle. Long objects (i.e. swords) are best lifted by sliding a plate underneath them (Huisman 2009, 109).

NOTE: Iron objects corroded to shapeless clumbs cán still contain interesting artefacts. It is recommended to subject unrecognisable artefacts to an X-ray analysis (Huisman 2009, 108).

3.2.2 Copper and copper alloys

Excavated objects made from copper or copper-alloy need to be sent to a professional conservator as soon as possible, as delay can cause severe damage to the object. Cleaning in the field is prohibited, as it can damage the object (Huisman and Joosten 2009, 122-123).

Repeated wetting and drying is detrimental to the copper object and should be avoided. If object from a wet soil dry out rapidly, they can develop bronze disease (this has been observed for some objects from Oegstgeest). This is a very agressive form of corrosion which can occur within a few hours of excavation and is facilitated by nantokite (a copper chloride) that reacts with water to form paratacamite (Huisman and Joosten 2009, 122). This corrosive process does not begin unless the protective patina is disturbed. It is best to keep the objects as close as possible to the (moist) conditions in which they were found, by temporarily storing them in plastic with surrounding soil (Huisman and Joosten 2009, 122). They must be kept out of the sun, to prevent rapid drying. Alternatively, dry metal should not be made wet: the damage will already have been done and making it wet only makes it worse (Huisman and Joosten 2009, 120 after Cronyn 1990, Scott 2002 and Selwyn 2004).

3.2.3 Gold, silver, lead and tin

In most cases gold, silver, lead and lead-tin alloys are well preserved. There are exceptions, such as when underlying composite objects with gold and silver desintegrate or in saline soil conditions, and a layer of chlorargyrite can form on the silver object (van Os, Huisman and Meijers 2009, 133). The oxidation layer on lead, tin and lead-tin alloys can obscure details on the original surface (van Os, Huisman and Meijers 2009, 133). Although usually well preserved, lead is so soft that the original surface may have been distorted and lead-tin, thin silver or gold objects can become brittle (van Os, Huisman and Meijers 2009, 133). Saltwater seepage (such as in deep polders along the coast) can have a detrimental effect on lead, tin or silver objects. They are often found composite with other vulnerable materials such as iron, bone or wood that will require extra care if one wishes to lift and conserve the whole object (van Os, Huisman and Meijers 2009, 135-136). Gold, silver, lead, tin and lead-tin alloys are barely affected by drying out, but this is not the case for iron, copper or bronze (van Os, Huisman and Meijers 2009, 135). It is best to keep composite objects close to the condition in where they were found (package them with surrounding soil in plastic as a moisture buffer). They need to be protected from sunlight to prevent rapid drying which can result in cracks. Cleaning in the field is not recommended(van Os, Huisman and Meijers 2009, 135).

3.3 Storage

Temperature and the relative humidity (RH) are factors that can negatively influence the conservation of metallic artefacts. Also the fluctuation of the two can have detrimental effects: one should keep the (ideal) temperature and RH constant (Ankersmit 2009, 10). The Canadian Conservation Institute (CCI) offers 'Environmental Guidelines for Museums' for (amongst other things) the safe storage of metallic artefacts.[3] The Instituut Collectie Nederland (ICN) also has recommendations, but their information seems less updated than that of the CCI. A recent publication by Bart Ankersmit in co-operation with the ICN (2009) only mentions metals in passing. My recommendations are based on these three sources. It is important to determine which objects are already corroding and what is causing the corrosion (see this chapter). If the object is found in moist conditions, it would be best to keep it in this milieu as long as possible untill a specialist can determine the cause of action.

For further reading the guidelines (CCI note 9/1 and 9/2 and ICNs *conservatiestandaard*) are enclosed in the appendix (page 132).

The CCI notes contain important advice on suitable storage supplies and furniture (for example wooden or wood-pulp based cabinets are not recommended due to the release of organic acid vapors and sulphur compounds (Logan 2009, 2). Air circulation is also important to prevent built-up of corrosive gasses (Logan 2009, 4).

In mixed collections (i.e.with other materials) stable metals (those that do not show signs of corrosion) can be stored an RH between 35-55% (Logan 2007, 1). The ICN recommends a temperature between 2-25°C (for tin not lower than 14°C to prevent tin-pest) and a humidity of less then 45%. Gold has no specific requirements. For unstable (corroding metals) the CCI recommends to store the items in a separate area with a RH of less than 35%. The drier the conditions the better (Ankersloot 2009, 41; Logan 2009, 1). Store the items with silica dehumidifiers (Logan 2009, 1). This may slow further corrosion but not stop it, for this the object requires the attention of a conservation specialist (Logan 2009, 1). Ankersloot adds that concerning iron the influence of corrosion is also dependant on the presence of active ions in the corrosion layers. If these aren't removed iron objects can corrode completely in a couple decennia no matter how dry the conditions are (Ankersloot 2009, 41). Based on this information I recommend that

[3] http://www.cci-icc.gc.ca/caringfor-prendresoindes/articles/enviro/index-eng.aspx (9-5-2012)

metal objects are stored in a seperate, well-ventilated room with a constant temperature of 18°C with a humidity of 35% (see also recommendations by the CCI in the appendix on storage materials). This should minimize the risk for objects containing tin, yet also provide a longer shelf-life of other metallic objects.

4 Metallurgy in the early Middle Ages

The finds from the past century or so, show a range from common household items to high quality jewellery with a level of craftmanship that amazes modern day artisans. The Frankish swords were reknowned for their quality and splendour, and even found their way into Viking territory (by illegal or legal means). Just as in preceding times, (precious) metals were often recycled. In Oegstgeest we have evidence of this in form of a cut, unmolten piece of bronze attached to a crucible fragment (Fig. 2.12).

4.1 Ferrous metallurgy

The latin word for Iron is *ferrum* and its chemical element Fe. Iron was an important resource in the Early Middle Ages, and one of the main export products from the Veluwe in this period.

The Veluwe, The 'Utrechtse Heuvelrug' and Montferland are characterized by the presence of preglacial ice-pushed moraines where limonite nodules in the form of rattlestones are abundant(Heidinga 1984, 223).

The minimal output of iron from this area is estimated to have been close to 55,000 tons in total, the largest known from Early Medieval Western Europe. The slagheaps and rows of open cast mining pits extend over a length of 82 km (Joosten 2004, 71).

Historical records indicate that slag heaps were exploited for hardening roads and for ore in 19th century blast furnaces, so the original amount of slag would have been far greater (Joosten 2004, after Van Nie 1997). Despite the great demand for charcoal (estimated at 105,000 metric tons) pollen diagrams show that deforestation of the Veluwe area only began áfter the Early Medieval iron industry had ceased (Joosten 2004, 71).

The morphology of the slag points to the use of slag-tapping furnaces for the production of iron (Joosten 2004, 71; also see § 4.1.3 and Fig. 4.2).

Some of the slag found here have a chemical association with the rattlestones found in the area, while the finds at the 7th century site of Braamberg indicate that the blooms smithed there had a different origin (Joosten 2004, 71). It is possible that bog ore was exploited at this site before the use of rattlestones and that Braamberg had no connection to the large scale iron production in the area (Joosten 2004, 71).

4.1.1 Raw Materials

Iron ore

Iron ore comes in a variety of forms: it can be extracted from certain minerals (i.e. hematite, limonite, goethite and others), from bog iron ore and rattlestones. Meteoric iron can be considered its native form, but it is quite rare (Tylecote 1962, 1).

Iron ore is usually made up of two components: an iron component and a non-iron component known as gangue (de Rijk 2003, 11). This gangue is usually comprised of silicates, calcium, manganese and phosphorous compounds (Joosten 2004, 7).

The suitability of the ore is determined by the following factors: the ore grade, the chemical composition of the gangue and the reductibility of the ore (Joosten 2004, 10). The slag material from early iron production can sometimes contain up to 40-50% of iron, a considerable loss which means that the ore grade had to be high enough to produce a workable piece of iron. Handpicking the ore, washing and roasting it improves the ore grade (Joosten 2004, 10). To roast the ores they were heated up to temperatures from 500-800°C which expelled water, organic material and sulphur from the ore (Joosten 2004, 10). Roasting the ore will thus also increase its porosity (Joosten 2004, 11 after Jakobsen 1983). The reductibility of the ore is determined by its porosity and the reaction surface of the ore grains that the reducing agent (i.e.carbon monoxide gas) has access to (Joosten 2004, 11). The reaction surface is determined by the density of the ore, its grain size and crystal structure (Joosten 2004, 11).

Some of the main early iron sources were the gossan deposits in the Holy Cross mountains in Central Poland (Joosten 2004, 11). A gossan is a deposit rich in iron (hydr)oxides, which form by oxidation of iron sulphides (Joosten 2004, after Bielenin 1996).). A common source of ore in (Atlantic) Europe and Scandinavia is bog iron (Joosten 2004, 11. Bog iron ore has good reductibility, and roasting it will improve the grade and porosity of the ore (Joosten 2004, 11).

Bog iron ore

Bog iron ore is formed by the upwelling of ferrous rich water where ferri(hydr)oxides like limonite and goethite precipitate (Joosten 2004, 11). Bog iron ore was sometimes used in small scale iron production, for example in Uden, Swalmen, Barvoorde or Haag Sittard (Joosten 2004, 32).

Fig. 4.1 A pit clamp, in principle similar to a *meiler* albeit on a much smaller scale. It was used to fire ceramic crucibles and a mould with as byproduct charcoal that was used in the ensuing casting experiment. The main woodsource was pine (internship in Norway, May 2011). A: in a round hole of ¾ of a meter deep, upon a layer of smoldering embers, a plateau of green brush is built upon which the ceramic items to be fired are placed, covered with more brush. B: logs are stacked on top of it. C: this is first loosely covered with sods and earth, and closed properly when blue smoke appears. D: for the remaining 2-3 days the pit clamp will exhale white smoke untill the fire has died out. E+F: the kiln is opened up and the charcoal laid out in sand for further cooling.

Rattlestones

Rattlestones are naturally occurring limonite concentrations that contains the iron mineral goethite mixed with fine sediment (for instance those produced by glaciers).
When the clay has dried out it leaves a cavity in the stone, that with some lose material on the inside cause the rattling sound that give it its name. They are usually not magnetic, unless they're heated and maghemite is formed (pers.comm. I. Joosten 30-03-2012). Rattlestones were probably used in the largescale iron production on the Veluwe (Joosten 2004, 72).

Charcoal

Charcoal is a fuel with a high caloric value (355 kJ/g) that has a high affinity to reduce under the influence of oxygen. It contains hardly any for iron detrimental elements such as phosphor (P) or sulphur (S) (Joosten 2004, 11). It is produced by exposing wood to slow partial combustion under a limited airsupply. One way to do this is by using a *Grubenmeiler* (a large pit) or by covering freestanding stacks with sods and earth (known as a *meiler,* in principle not unlike a *pit clamp* used for baking pottery, see Fig. 4.1 (Joosten 2004, 12).

4.1.2 Reduction process

Bloom

To extract a bloom from an iron ore the ore has to undergo various processes. Most iron ores contain iron (hydr)oxides, and this oxide needs to be reduced first (the oxygen removed from the ore). The oxide reacts to the carbon monoxide (CO) that is released by burning carbon-based fuel (i.e. charcoal) (Joosten 2004, 7).
The iron oxides will reduce to lower oxides untill finally metallic iron is left. The oxygen/ iron ratios reduce from 3/2, via 4/3 to 1 (Joosten 2004, 8). Chemically this translates as Fe_2O_3 (iron oxide) reducing to Fe_3O_4 (magnetite) and from Fe_3O_4 to FeO (wüstite) from which it finally reduces to metallic iron (Joosten 2004, 8). These last two reactions occur at temperatures above 720°C and a maximal CO/CO_2 pressure of 1 bar (Joosten 2004, 9). Via interaction with CO_2 the CO leaves the furnace through the chimney (Joosten 2004, 9).

The metallic iron particles form fairly high in the furnace and are coated in slag, that offers protection against carbon diffusing into the metal and against re-oxidation in the tuyère (air-inlet) zone (Joosten 2004, 9). The metallic iron is separated from the gangue in the furnace at temperatures above 1176°C where the wüstite reacts with silica in the gangue and forms an iron olivine (fayalite, $2FeO.SiO_2$) (Joosten 2004, 9).
The metal particles clump together into an iron mass (the bloom) in the hottest part of the furnace (near the air-inlet), but slaginclusions will still be present (Joosten 2004, 9). Besides slag it can also contain charcoal and has a spongy appearance (Moerman 1962,3; Joosten 2004, 15). To remove the inclusions and voids in the bloom it is forged at around 1200°C degrees, but some slag still remains which melts off during the entire smithing process (Joosten 2004, 15).

Slag

Slag is a byproduct that forms during the production of iron but also during the (re)-working of iron. It is highly resistant to weathering.
Its chemical composition and morphology varies based on its main source material(ore), contamination during forming (i.e. charcoal, flux), the furnace and by the processes where it was formed (Joosten 2004, 16).
Slag formed during the production of iron can be categorized into four groups: furnace bottom slag, slag block, tap slag and cinder (Joosten 2004, 16 after McDonnell 1983). Furnace bottom slag forms under the bloom in the furnace and usually has some metal left on the surface. They tend to be plano-convex in shape, and their appearances varies from an agglomerated to a smoother surface, indicating it melted further during the process (Joosten 2004, 16). It may contain inclusions of furnace lining, partly reduced ore or charcoal and is in section grey/black in appearance. The bottom is vesicular while the centre is uniformly fine grained (Joosten 2004, 16). A slag block solidifies in a slag pit under the furnace and its surface usually has vertical flowing structures and sometimes imprints of organic material (Joosten 2004, 16). Inclusions of charcoal, partly reduced ore or fragments of furnace lining can also be present (Joosten 2004, 17). In section it can display a heteregenous structure indicative of a discontinious smelting process (Joosten 2004, 17). Tap slag is formed when escaping the furnace through a taphole and can be V-shaped or round in appearance. It has a smooth appearance with shrinkage ripples and looks like lava flow (Joosten 2004, 17). Cinder is formed during an incomplete reaction between an ore and charcoal fused together by slag (Joosten 2004, 17). They are brittle,

have a low density and a random shape (Joosten 2004, 17). Smithing slag is formed by iron oxides that flake of or melt off during the working of the iron (smithing and welding). This can be hammerscale, small solidified drops or an agglomeration of these materials that solidified in the smithing hearth (Joosten 2004, 18). To work the metal it needs to be heated to working temperature (circa 900°C), but there is also a risk of heating it up too much which results in a piece melting off in the smithing hearth. Findnumber V00196MXX from trench 8 is a classic example of this (Fig. 2.9).

How to tell smithing slag from production slag

There are mineralogical criteria by which it is possible to recognise the process in which the slag was formed. Smelting slags are usually homogenous in structure and made up of fayalite, wüstite and glass; in tap-slag the fayalite is elongated or acicular, formed in other furnaces it can be elongated or equidimensional. The wüstite crystals are rounded and in dentritic form (Joosten 2004, 17). Reheating slag (to remove slag from the bloom) has en uneven distribution of wüstite, whose crystals drop-like or dentritic in appearance. Here the fayalite is elongated or equidimensional and sometimes also magnetite is present. Smithing slag usually consist of magnetite, unmolten quartz grains and sometimes pyroxenes(Joosten 2004, 18).

4.1.3 Type of furnaces

In the Early Middle ages for our part of Europe basicly two type of furnaces were in use: the slag pit furnace and the slag-tapping furnace (Joosten 2004, 27). The slag pit furnace was used from the Middle Iron Age to the Early Middle Ages throughout Europe outside the Roman empire untill it largely fell in obsolescence during the 6th century (Joosten 2004, 13 and 27). The slag-tapping furnace was used untill the Late Middle Ages (Joosten 2004, 27). The slag pit furnace has a tapering shape and a pit underneath the shaft where slag was deposited (Fig. 4.2). The pit was filled with organic material that was subsequently burned away by the hot slag (yet seperating the bloom from the slag) (Joosten 2004, 13). The slag tapping furnace had a flat or slightly concave hearth with a slag outlet from which the slag could be removed (Fig. 4.2).

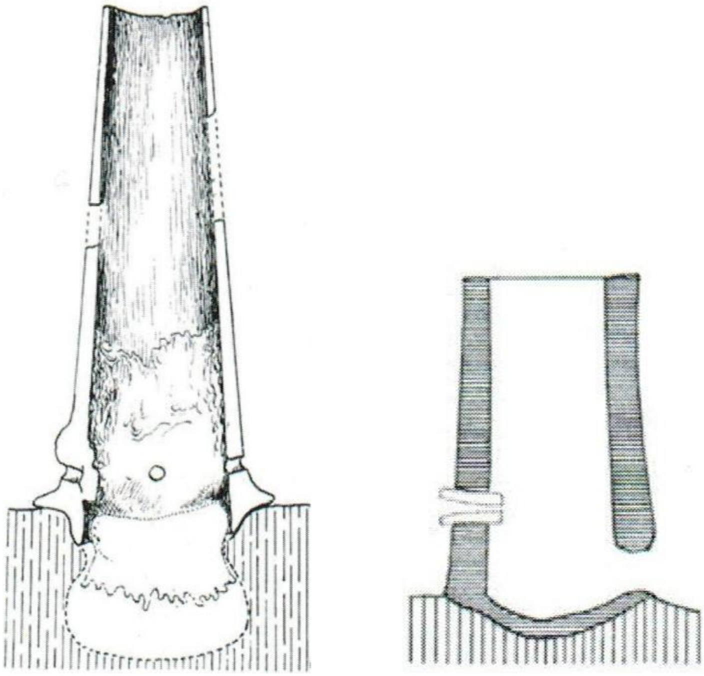

Fig. 4.2 A slag pit furnace (left) and a slag-tapping furnace (right)

(Joosten 2004, 14 after Wegewitz 1957 and Pleiner 1965).

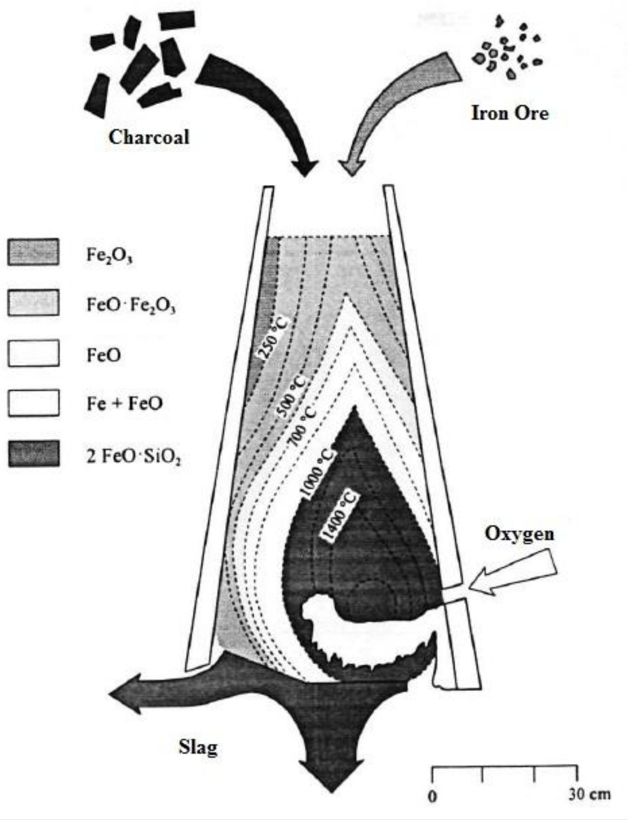

Fig. 4.3 Temperature distribution and process during iron production

(Slightly altered after de Rijk 2003, 17)\

The furnaces were constructed of local clay, coarsely tempered with sand, stones or organic material to withstand mechanical and thermal stress (Joosten 2004, 15). This is also why often only the furnace bottoms are well preserved: they usually have a layer of slag that protects them (pers.comm. Dr. I.Joosten 05-04-2012).

4.2 Non-ferrous metallurgy

4.2.1 Raw Materials

Raw sources

While some some metals can be found in native form or in mineral compounds (especially with carbonate minerals), the majority of 'raw' material in this period came from existing objects) or were obtained as ingots (Heidinga and Offenberg 1992, 113). One of the most important 'raw' sources in this period were coins, like the golden Solidi (Roth1986, 65). On the Swedish islands of Gotland and Öland more than 800 of these coins dating from the late 5th to the first half of the 6th century were found. They are thought to have originated from the wages of Germanic soldiers in the service of the Roman empire (Roth 1986, 65).Contact with the Arabic world is evidenced by the find of 75000 Dirhams (silver coins) in Gotland that date to the late 8th century(Roth 1986, 111). Most of the metals described below would have been recycled, but as some objects ended up als gravegoods there would have been need to extract the metal from natural sources (Heidinga and Offenberg 1992, 116).

Gold

Gold is a precious metal that occurs naturally in pure form, often with a certain silver content (usually between 5-10%). If it contains more than 25% silver the alloy is known as electrum (van Os, Huisman and Meijers 2009, 127).
Gold is soft but tough, and easy to work. This property makes it possible to produce fine thread and gold leaf (van Os, Huisman and Meijers 2009, 126-127). Gold has a high density (20 kg / dm^2), which is twice as much as lead. Measuring the metals' density can determine its purity(van Os, Huisman and Meijers 2009, 127). Sometimes a touchstone is used which is compared for its colour or resistance to acid. Touchstones were usually made from lydite, a silicous metal (van Os, Huisman and Meijers 2009, 127). It is possible to extract gold in small amounts by panning in rivers. Since it is chemically inert

and has a high density it is often found in heavy mineral deposits in sediments (van Os, Huisman and Meijers 2009, 127).

There were several techniques for gilding objects, for example by applying goldleaf to the object, possibly using some sort of glue (van Os, Huisman and Meijers 2009, 127). Another method was fire gilding which involves dissolving the gold in mercury and pressing it through a chamois leather cloth. The gold remaining had the consistency of butter and was smeared on a prepared surface. When the object was heated the mercury dissapeared, leaving the layer of gold behind (van Os, Huisman and Meijers 2009, 127).

Silver

Silver is a precious metal, and can be found in natural pure form (native silver) or in lead ores that contain large concentrations of silver. The silver most commonly used was not found in pure form but was a byproduct from lead production (van Os, Huisman and Meijers 2009, 126).

Copper

Copper can be found as a native metal and in minerals such as malachite or chalcopyrite. Brass (an alloy of mostly copper and zink) was introduced by the Romans (Huisman and Joosten 2009, 113 after Scott 2002).

Lead

The main lead ore is gallena (lead sulphide). Lead ore is fairly common (van Os, Huisman and Meijers 2009, 125). Lead was used for making models (to be pressed in casting moulds) and for objects such as loomweights or netsinkers (Roth 1986, 48-49; Tylecote 1962, 94).

Tin

Casserite ($Sn0_2$) is the main mineral source for tin. It is an opaque mineral that is resistant to weathering and therefore often found in alluvial deposits (van Os, Huisman and Meijers 2009, 125). In antiquity, the main source for tin was in Cornwall, where it was subject of extensive trade between the Mediterranean region and England (van Os, Huisman and Meijers 2009, 126).

Fig. 4.4. A golden eagle brooch with inlays of almandine and decorated backing foil (second half 5th century).

Source: Adams 2006, 16 after Krüger 1983.

Fig. 4.5. Golden brooch from the Hiddensee hoard (Germany) with granulation and filligree work(9th century).

Source: Armbruster 2006, 28.

Fig. 4.6: A 6th to 7th century shoulder clasp in gold, garnet and glass. It consists of two matching curved halves, hinged upon a removable chained pin. The clasp is decorated with a chequered pattern of millefiori glass and Germanic Style II ribbon animals. Discovered in 1938/1939 in Sutton Hoo.

(source:http://www.forumbiodiversity.com/showthread.php?t=30559)

Gems and glass

Many objects from this time were embellished with non-metallic additions such as gems and glass. A very popular gem in the Merovingian period were red garnets, that came in several types. The most popular one was almandine (Fig. 4.4) (Coatsworth and Pinder 2002, 132). Chemical analysis on some garnets indicated that they (could have) originated from Bohemia, Central Europe, Scandinavia and India/Sri Lanka (Coatsworth and Pinder 2002, 132). Coloured pieces of glass were also used in jewellery, such as millefiori (Fig. 4.6). This was made by fusing rods of coloured glass together, and then stretching them out, making the pattern smaller (Coatsworth and Pinder 2002, 151) . Amber (fossilized resin) was used for the production of beads and other objects.

In Oegstgeest 18 pieces of raw amber were found, some with working traces. No finished objects have been found, it is however possible that some working of amber was done (Knippenberg 2006, 91). In several Early Medieval settlements (Oegstgeest included) raw amber was used for the production of beads. An abundant source of amber can be found in the area near or around the Baltic Sea (Knippenberg 2006, 91).

4.2.2 Crucibles and moulds

Crucibles came in a multitude of forms in the early Middle Ages, and most of them were inspired after Roman examples (Craddock 1989, 171). The majority were made from clay, although there also are examples of (sand)stone crucibles (Craddock 1989, 171). The cillindrical and triangular shapes of the Iron Age continued alongside new forms such as broad and lidded crucibles (Craddock 1989, 171). This might be attributed to the a greater range of metals and alloys in use, some of which required specific measures (apparently the zinc in molten brass has the tendency to evaporate, which could be countered by using a lidded crucible) (Craddock 1989, 171). Alternatively, a lidded crucible would also prevent contamination by pieces of charcoal. It is likely that a goldsmith had a number of different kind of crucibles that he worked with (Roth 1977, 86). Some crucibles may not have been used for casting, but for other applications such as preparing niëllo or parting silver from lead (Roth 1977, 89).

The consensus about casting in this period is that there did not exist just one method, but that several methods were in use such as the lost-wax method (using waxmodels encased in clay) and the ‘direct matrix method’ in which an existing object or model was pressed in clay (Söderberg 2001, 15-24; Roth 1986, 48). For the lost-wax method beeswax was

cut to a desired shape and encased in clay (one-piece mould). After drying, the mould was fired and the wax removed, leaving a cavity that could later be filled with cast metal. The mould had to be destroyed to take the casted form out.
In the ‘direct matrix method’ an existing object or shape was pressed in two pieces of clay that was flat on one side (two piece mould). This shape appears to be more prevalent the Early Middle Ages and appears to be a Roman influence (Craddock 1989, 170).
Moulds from stone are also known (for example those with inventory numbers GE 1312 and WD 27 in the National Museum of Antiquities, Leiden).
The problem with lost-wax casing is also archaeological visibility as wax models and one-piece moulds are usually not preserved (the wax melts away and the mould is fragmented) (Söderberg 2001, 15).

Recognizing a crucible can be difficult especially if they were not (visibly) used and vitrified (glazed) by fire. Context is important (found with slag or tools?). There are still many ‘possible’ crucibles in museum and depot collections that may be positively identified if XRF analysis was performed on them, provided they have any residues.

4.2.3 Decoration techniques

Gems and stones were often set in cloisoinné-technique where the stones were cut to shape and set in thinwalled settings (Fig. 4.4) (Coatsworth& Pinder 2002, 132).
Sometimes objects were also decorated with niëllo, a black mixture of copper, silver and lead sulphide (Craddock 1989, 173).
Other fine decoration was made with filligree (narrow thread) and granulation technique (small spheres) (Fig. 4.5). The thread was made by twisting a thin square rod or for beaded-thread it was hammered into a beading die or a special file was used (Craddock 1989, 173; Armbruster and Eilbracht 2006, 33).
Sometimes decoration was also combined with function as with the pattern welded swords and knives. Here iron and steel (iron with $\leq$ 2% carbon content) is combined and smithed in patterns to have both the hardness of steel and the flexibility of iron . The former keeps the blade sharp for a longer time while the other absorbs blows and minimize the risk of fragmentation. Fig. 4.7 shows the variety in patterns and how they were constructed. Sometimes swords and knives were also laid in with silver thread (the damascening technique).

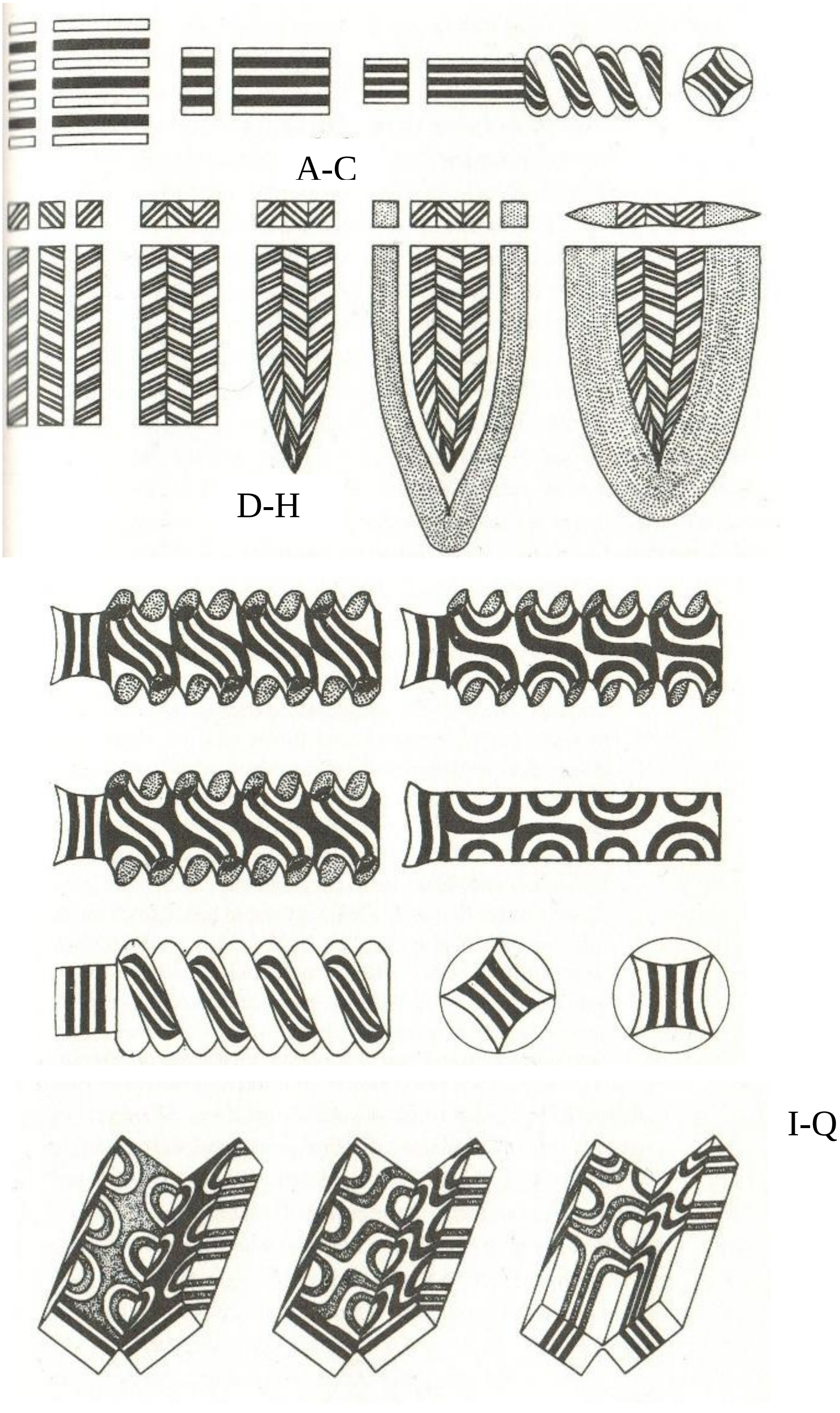

Fig. 4.7:Pattern welding techniques, A-C: 4 plates of iron are welded together with 3 plates of steel and twisted; D-H after folding and smithing it, the piece of damast is welded to the swords' scabbard; I-Q: patterns that are made by carving and folding the metal.

Source: Slightly altered after Roth 1986, 119.

5 The importance of metals and metallurgy in the Merovingian period

5.1 The Dark ages: a brief characterisation

The time period spanning the first 5 centuries after the demise of the West-Roman empire in 476 AD is better known as the Dark Ages, as the written sources are scarce. The majority of our information on this period comes from interdisciplinary investigations involving archaeologists, historians, geographers, numismatic specialists, botanists and more. An important contemporary document is the *Historiae* by hand of the 6th century bishop Gregory of Tours. It provides information about the dynasties in this period and the titles with whom Germanic kings were adressed by Romans and other contemporaries. For example, the Frankish warlords were adressed with '*duces*' or armyleader, and the mightiest warlords were adressed with '*rex*' or kingly leader (van der Tuuk 2008, 21).

5.2 Identity

The Roman empire covered an immeasurable territory and was therefore a multi-ethnic society. Its strengths were an impressive infrastructure, a solid economic and political organization and a well-developed jurisdictional system (Blockmans and Hoppenbrouwers 2007, 10). To protect its massive territory from 'barbarian attacks' a line of fortifications (the *Limes)* was built between the Northsea, along the Rhine untill the Danube (and Hadrians'wall in England) (Blockmans and Hoppenbrouwers 2007, 10). In return for land and priviliges, certain Germanic peoples loyal to Rome settled in the borderlands, and in doing so created a bufferzone against intruders (van der Tuuk 2009, 19-21). A combination of factors led eventually to the downfall of the Western Roman Empire in 476 (weak leadership, increased barbarian attacks and autonomy of the Germanic settlers (van der Tuuk 2009, 19-20; Blockmans and Hoppenbrouwers 2007, 11; 31).

What followed was the so-called migration period (between 400-600 AD), where people moved into abandoned, new or previously uninhabited areas of the former empire. This represented several groups of people: settlers who came from far away but also locals (Blockmans and Hoppenbrouwers 2007, 22-31). Some 'warrior aristocrats' took control over (small) territories they could manage with the help of a group of retainers (a so-called *Gefolgschaft*) who were rewarded in booty or agricultural surplus (Blockmans and Hoppenbrouwers 2007, 29).

It is very difficult to identify these people, as the Roman empire itself was already culturally diverse. Many local or Germanic tribes adopted Roman customs or building styles (so called Gallo-Romans). The distinction between Gallo-Roman or Frankish artefacts are hard to make (James 1988, 8-9). Also in the subsequent Merovingian period (500-700 AD) it is difficult to trace the origins of people, and this includes the dwellers in Oegstgeest.

5.3 Theorethical framework: peasant agency and the position of the (black)smith in the Early middle ages

The rural population

One important question when investigating past societies is the distribution of power. Since the fall of the Western Roman Empire, there was no centralized power and most of its former territory was divided into many small ‘kingdoms’ ruled by magnates or local ‘warlords’ (i.e. the ‘aristocracy’). For the western part of the Netherlands, this aristocracy remains archaeologically invisable in the Merovingian period (Theuws pers.comm. 13-6-2012) .

According to Theuws, the development of some early centres and emporia may have been based primarily on long-distance trade with regional trade as a secundary priority. The decline of many of these centers in the 8th century may be due to lack of being embedded in political, religious structures or regional economies (Theuws *in press*.B, 39). Ofcourse there would have been interaction with the hinterland, but the primary factor that made these ribbon-settlements thrive was long-distance trade.

The settlement of Oegstgeest was strategically located near important traderoutes (Fig. 5.1) in the periphery of two considerable powers in the time: the Frisian kingdom in the North and the Frankish kingdom in the South East(their borders fluctuated over time). This not only provided access to (exotic) trade goods but also gave economic advantages. The evidence indicates that Oegstgeest was a self-sufficient settlement. It is unknown whether it stood under the patronage of a local elite, but if so it appears that they experienced a fair amount of freedom for economic development.

According to Theuws ‘buying power’ of the peasanty was unrelated to the presence of elites (Theuws *in press*.B, 30). The finds from rural settlements indicate that there was considerable demand by the peasantry to acquire fine objects such as cowry shells, amethist beads, glasswork and finely decorated belts. It exemplifies that the peasantry were also important players in large scale networks of exchange and trade (Theuws *in press.*B, 34-35).

The indications for ritual behaviour, in the form of horseburials, a dog burial and the burial of a small (non-local) child, suggests that Christianity was not yet firmly rooted in this settlement. Much is still unknown about their cosmology.

By the time that Oegstgeest is abandoned in the early 8th century, a large trading settlement emerges near contemperary Wijk bij Duurstede: Dorestat. The success of Carolingian emporia like Dorestat may have been due to their initial ideologically neutral position which changed in the late 8th century and may have contributed to its decline (pers.comm. Theuws 19-4-2012).

The paucity of weaponry in the dataset, need not mean that these people were living in idyllic circumstances since slighly later documents such as the late 8th century lawbook *Lex Frisionum* mention specific penalties for very explicit injuries (Post 2000, 46). The fact that there is barely evidence for weaponry in the settlement, may also be attributed to a continuation of the prehistoric practice of ritual deposition in wet places (see Fontijn 2008). This theory has previously been suggested by Theuws who is not convinced that the swords found in the bedding of the tributary river of the Early Medieval emporia[4] Dorestat were a result of lost cargo (pers.comm. Theuws 19-04-2012). The inhabitants of Oegstgeest will probably have carried weapons, or implements that could serve as both cutlery and weapons. Perhaps they were handed down over generations and taken when the inhabitants left the settlement in the early 8th century. Perhaps they simply have not survived the ravages of time.

Hopefully the upcoming excavation campaigns will shed more light on this.

Trade and exchange

Fine objects (such as gold jewellery) are commonly associated with elite members of Early Medieval society however similar objects have also been found in rural contexts for instance in Dommelen and Geldrop (Theuws *in prep*. A, 5-6) and in Leidsche Rijn (Kerkhoven 2009, 218). Sometimes they offer indications for exogamous marital practices, for example the brooch found in a female grave in Oßmannsted (Germany)

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[4] Emporia is a term used to describe trade centers from antiquity untill the Middle Ages.

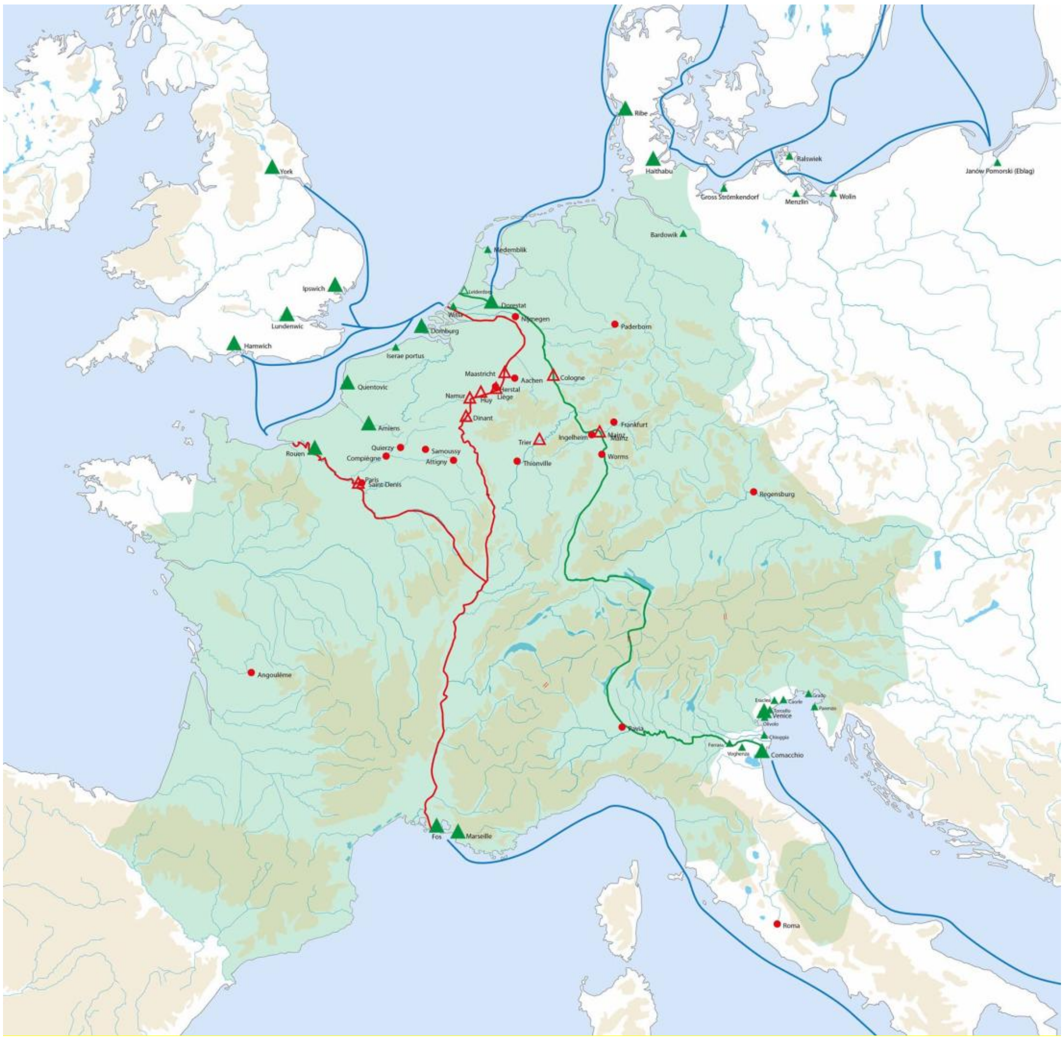

Fig. 5.1 Known and proposed traderoutes connecting Early Medieval Europe to the Middle East and Asia.

Source: courtesy of Prof. F. Theuws

(Fig. 4.4) indicated that the woman may have come from Sarmatia[5] or Eastern Germany (Adams 2006, 12).

While our picture of Oegstgeest is still incomplete, the evidence suggest that the dwellers of Oegstgeest had access to prized goods such as objects made from glass (Dijkstra 2006, 109; Hemminga and Hamburg 2006, 109). Metals were in great demand, as evidenced by the massive iron production on the Veluwe (see chapter 4).

[5] Sarmatia was situated in the western part of Scythia, covering the Balkans, Ukraine and Southern Russia.

As mentioned in paragraph 4.2 (gems and glass) garnets had widespread origins, some even came from India. It is possible that some traderoutes went over the Alps (pers.comm. Prof.F.Theuws 19-4-2012). I do not know if there is a connection but I must say I find the distribution of the smiths'graves from Hennings' article (Fig. 5.2) interesting in comparison with this map (Fig. 5.1).

The (black)smith

As can be imagined, a (black)smith would have been an important craftsperson within a settlement, not only for producing tools and utensils (nails, cooking ware etcetera) but also weaponry, armour and items related to horsemanship. Maybe this person was even engaged in the production of jewellery. With the slightly later (10th century) find of the Mastermyr toolchest in Gotland (Sweden), we know that that some pragmatic individuals turned their hands to anything (as he was not only a blacksmith but also a carpenter).[6]
It is likely that goldsmiths had some proficiency with blacksmithing to create (some of) their own tools, as some modern goldsmiths still do out of economic reasons or personal requirements.
Some tools have also been preserved from Merovingian smith's graves (Fig. 5.2): some appear to have been influenced by Roman metallurgy in the production of their tools (for example the grave in Herouvillette (France) contained a Roman-style metalcutting shear and an iron nail (Henning 1991, 74-75). What is striking that 77% of the Merovingian smiths' graves with good contexts also contained weaponry (Henning 1991, 76).
This ranged from longswords, shields and lances (Henning 1991, 76).
Unfortunately he fails to specify how many of the 28 graves mentioned had uncertain contexts. Henning supposes that this shatters previous ideas of servants working as smiths for their masters without notable possessions of their own (Henning 1991, 76).
He critizises the notion that smithing activities were primarily performed by unfree (*servi*) under the direction of elites. He thinks that many of these smiths may have had a free status, and some may even have been retainers in the service of a local warlord (Henning 1991, 65; 76).
Some smiths may have had a fairly independant status, and the mobility of the smith may have depended on practical circumstances: whether there was demand for his services and whether he owned a farm and had to work the land (Henning 1991, 76).

[6] I have visited this find in the Historiska Museet in Stockholm in the Spring of 2011.

Unfortunately smiths are rarely mentioned in textual sources of this time, all but a few and ónly because they belonged to the clergy and came from prominent families (Roth 1986, 41). One such individual was the monk *Tuotilo* (±850-±913) who was a musician, an ivory carver and a goldsmith. In the mid 6th century a goldsmith and a woodcarver by the name of *Leo* would later succeed Gregory of Tours as bishop (Roth 1986, 41).

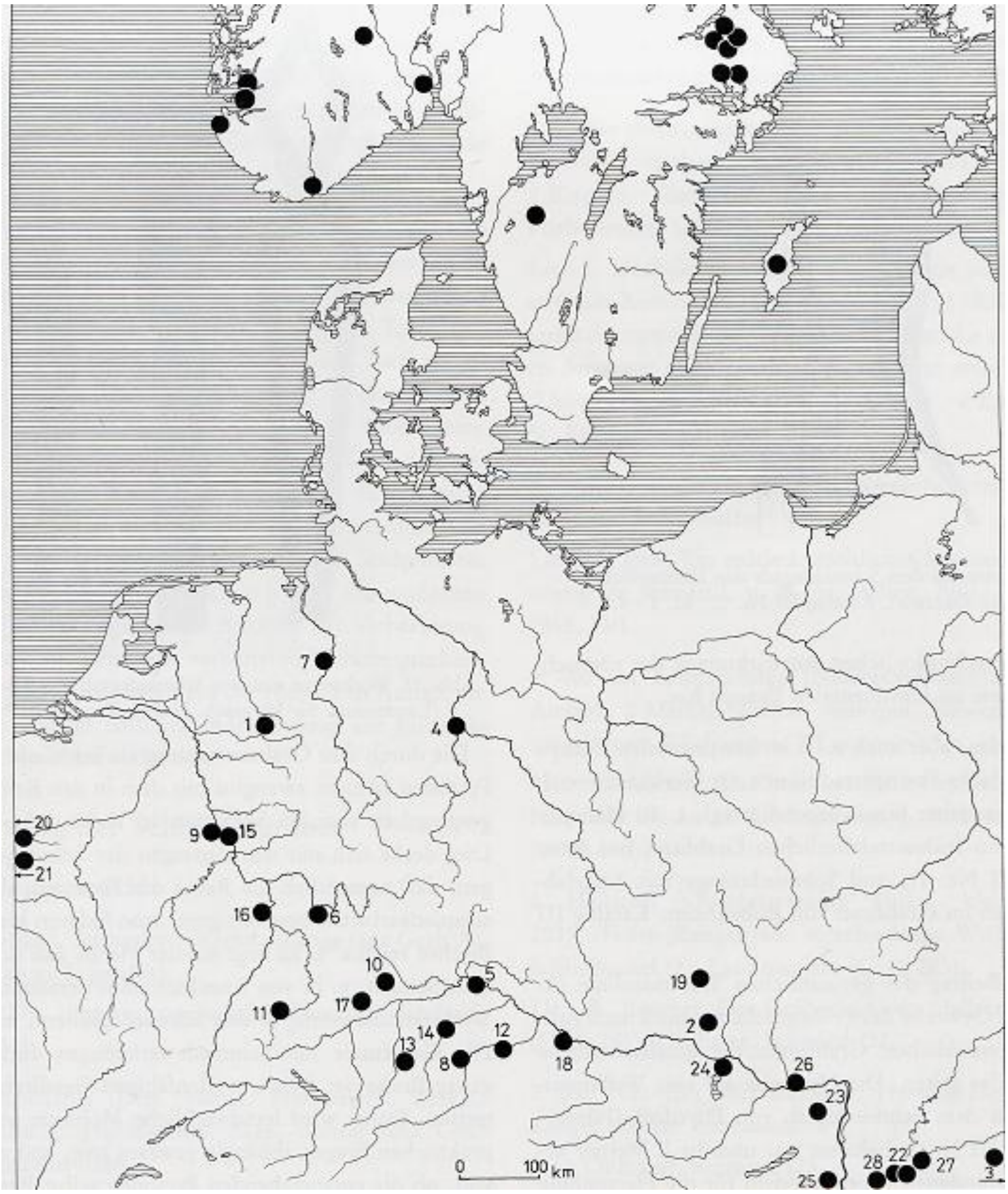

Fig. 5.2 The distribution of smiths' graves in the Migration and Merovingian period.

Source: Henning 1991, 75.

There is only one reference to a goldsmith's position in a section of the lawbook *Lex Frisionum (Lex Thuringorum):*

Lex Thuringorum[7]
Section 23: *Qui harpatorem, qui cum circulo harpare potest, in manum percusserit, componat illud quarta parte maiore compositione, quam alteri eiusdem conditionis homini.* ***Aurifici similiter*** (Post 2000, 101).

Translation: (Those) who hit the hand of a harpplayer (with a weapon), who can play with a circle (possibly: in a circle of people), has to pay one fourth more of the fine, than to a man of the same stature. **Similar (with a) goldsmith** (Post 2000, 66).

In other words: if someone would debilitate the ability of an artisan who needs their hands for their breadwinning, the penalty is greater than that of someone else with the same status. I am inclined to believe that this was merely due to the fact that it would limit this person's ability to perform his (fine) work rather than his social standing, seeing as the text refers to an increased penalty to *someone of the same standing*. Probably (gold)smiths came from all levels of society.

It has been said that smiths were a travelling craftspeople, selling their trait temporarily in the places they visited (Nokkert, Aarts and Wynia 2009, 364). Some villages may not have had a resident smith, but in the case of Oegstgeest it appears that at least one (or more over the course of time) lived and worked there. He may have been skilled in other aspects of metallurgy or other crafts as well. Maybe there were visiting smiths that could offer services beyond the capabilities of the local smith (or perhaps the local smith learned more skills by the visits of collagues?) If anything, most bellows would require an extra hand to operate them (perhaps another smith or apprentice?).

[7] The exact dating of this document is unclear (and controversial), but is generally believed to be of Carolingian origin (von Schwerin 1918, 5-17)

While perhaps not every smith may want to share his knowledge ('the smith's secret' still being a common expression), it is conceivable that not only goods but also knowledge would have been exchanged in places like Oegstgeest. Similarly the affinity of Irish smiths with the majority of the techniques used throughout Europe and the Near East mauy have resulted from missionary and trade contacts (Craddock 1989, 174).

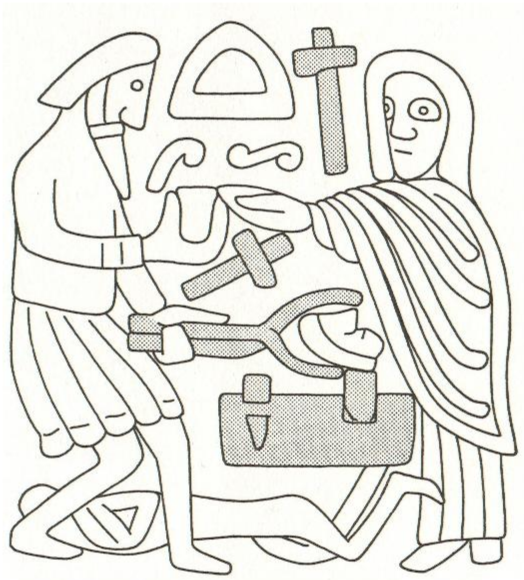

Fig. 5.3 Smithing scene from the Wieland Saga depicted on the wooden chest of Auzon (around 700 AD).

Source: Roth 1986, 64 (after M. Müller-Wille).

6 How to recognise traces of metallurgy in the archaeological record

This chapter will briefly outline the type of findcategories that are indicative of metallurgical practice as well as mention a few strategies on how to recognise metallurgical traces in the archaeological record. Conservation is also a factor in recognition and is treated in more detail in chapter 3. In §3.2 is also a guideline on how to treat each individual metallic object during and after excavation. Raw materials and the configuration of contemporary (production) furnaces is discussed in chapter 4.

6.1 Find categories

There are many different types of material can be associated with metallurgy.
It can range from a ceramic crucible stand to the wooden parts of a bellow.
Table 6.1 summarizes the type of remains expected from various production stages and processes. Without direct association with artefacts that can be distinguished as being attributed to metallurgy (i.e. slag), some remains are not recognised as having resulted from metallurgy. For example, sometimes stones may have been part of an oven or had some other use as a wetstone or a touchstone (Feuerbach and Merkel 1995, 208 after Rothenberg 1983 and Bayley 1992).

6.2 Non-destructive method: geophysical survey

The use of geophysical prospection methods to identify archaeological features are common place in most (preliminary) archaeological investigations. One such geophysical prospection method is measuring the differences in the earths' magnetic field with the help of a magnetometer. This method is especially effective in identifying fired clay structures, pits, ditches and iron objects (Renfrew and Bahn 2008, 101; Kattenberg 2008, 95-104). Recently, in the south of the Netherlands this method was successfully tested to locate possible metalworking places prior to excavation (Kattenberg 2007, 57). The visibility can be determined by geological and antropogenic factors, but usually the signal is so strong that iron smelting ovens are almost always detectable (Kattenberg 2007, 63 and pers.comm. Kattenberg 20-4-2012).

6.3 Destructive method:during excavation

Finds and features that might be related to metallurgy are burned clay, crucibles, slag and smithing debris. Another interesting possibility are tiny remains of hammerscale. One option to collect this material is using a strong magnet. Another option is to use systematic sampling which can tell a great deal about the layout of the smithy, sometimes even give an indication where the anvil of the smith was and where the smith was standing (Jouttijärvi 2009, 975-980).

Table 6.1 (after Chart 1 in Feuerbach and Merkel 1995, 212).

Processes and remains associated with metallurgy

Stage	Type of processes	Types of remains
Mining Ore benifaction Smelting	- firesetting - foasting - crushing - grinding - sorting - washing, panning	Ores, gangues, fluxes, fuel, slag, hearts, furnaces, tools, picks, hammers, buckets, grinding tools, crucibles, tuyères, bellows, vitrified ceramics, washing and sluicing tablets (for panning gold).
Refining Casting Working Decoration Objects	- cupellation - alloying - parting - casting : sand, lost-wax - hammering, smithing - annealing - incising, endgraving, punching - gilding - niello, enamelling, inlaying	Refining slag, tuyères, litharge, crucibles, bone ash, scrap metal, moulds, wax, salt, mercury, metal working tools, ingots, hammer scale, smithing hearth bottoms, bellows, vitrified ceramics, objects in various states of completion, substances used for decoration, completed objects
Deposition	-burial -deterioration -corrosion -decomposition	All of the above with varying degrees of deterioration
Excavation and Post-Excavation		All of the above with varying degrees of deterioration

6.3.1 Significant features

See §2.6, §4.1.3 and §3.2.1 and Table 6.1.

6.4 Distribution of metallurgical finds in Oegstgeest

The distribution of all metallic and metallurgy related finds can be seen in Fig. 6.2, Fig. 6.3, Fig. 6.4, Fig. 6.5. These maps were generated in Mapinfo Professional 10.5 based on the digitized information provided by Archol B.V and the material investigated for this thesis.

Please note that complete features are coloured to indicate in which features particular findscategories were found, but that this does not mean that a whole feature was filled with a particular findcategory (they can represent one find, or the choice to colour for one particular findcategory when more was impossible). It does give a rough overview of the distribution, and what is striking is that the finds seem to concentrate around the edges of the settlement and near watersources, such as gullies or wells.

Fig. 6.1 Total overview of excavated area. *Green:* metal finds, *purple:* slag, *dark yellow*: small crucibles, *brown*: larger crucible fragment, *red*: unsure context, *grey*: recent disturbance.

Fig. 6.2 Northern excavation area: overview of features with metallic and metallurgy related finds (tilted leftward). ***Blue:*** **slag,** ***dark green*****: metal finds,** ***dark yellow*****: crucibles,** ***red*****: unsure context,** ***grey:*** **recent disturbance.**

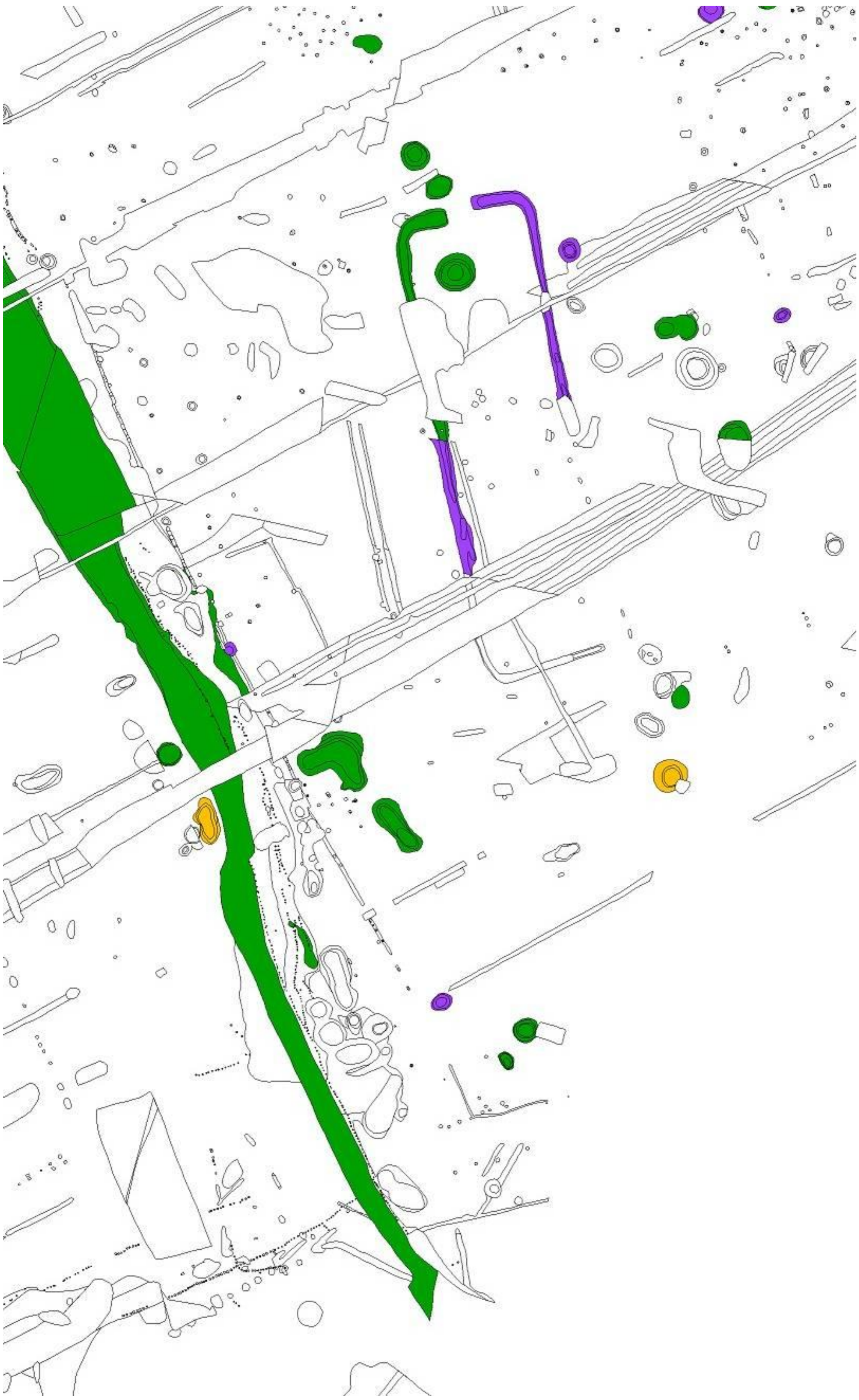

Fig. 6.3 Northern excavation area: detail of features (tilted leftward) *Blue:* slag, *dark green*: metal finds, *dark yellow*: crucibles

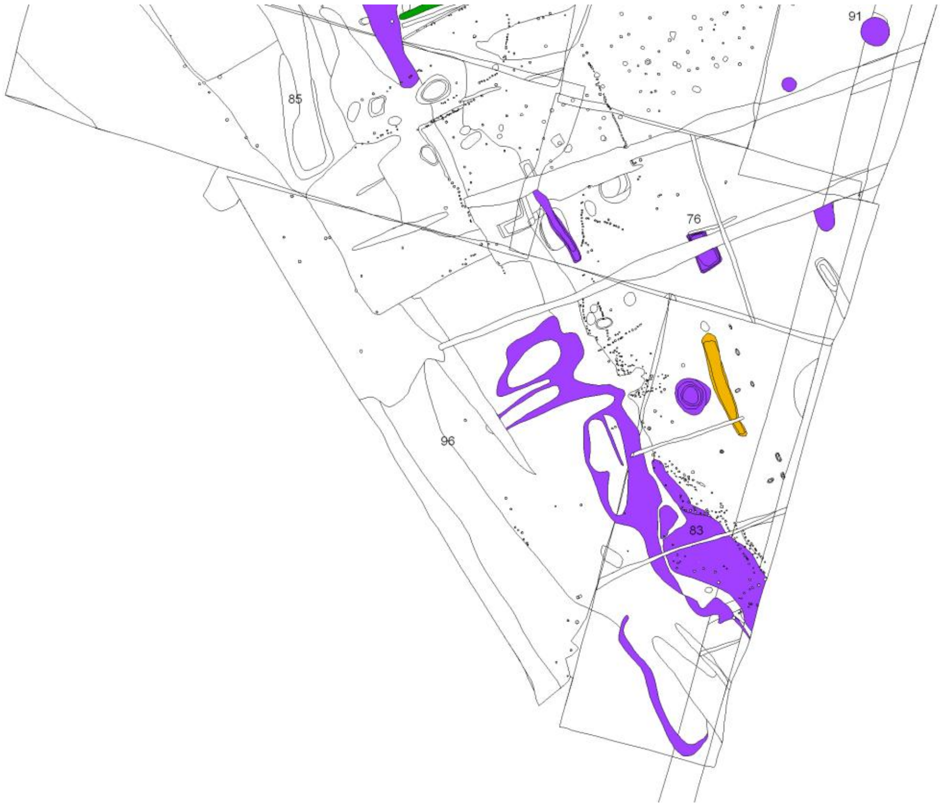

Fig. 6.4 Western excavation area. ***Purple*****: slag,** ***green*****: metallic finds,** ***dark yellow:*** **larger crucible fragment**

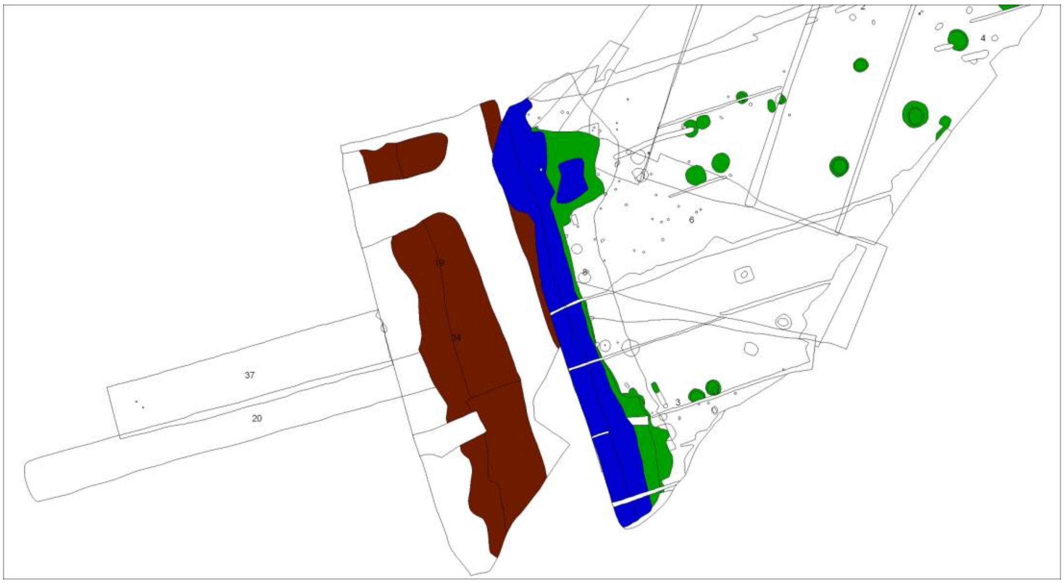

Fig. 6.5 Southern excavation area : ***brown:*** **brass scrapmetal,** ***blue:*** **slag,** ***g*****reen: metal finds**

7 XRF analysis of metallurgy related finds from Oegstgeest

7.1 Research objective : identification

In the dataset of artefacts that could (possibly) be attributed to metallurgy were a couple of nearly complete crucibles, some fragments of crucibles, a fragment of a possible mould and some pieces of metal that could be scrap metal or ingots. These appeared to contain a residue, assumed to be metallic yet sometimes ceramic in appearrance. Identification of these residues could answer the question wheter these objects were used for metallurgy. For this goal I approached Dr. Joris Dik of the department of Maritime and Mechanical Engineering (3ME) from the Technical University of Delft. He is part of a collaborative project that involves researchers from the university of Delft and the university of Leiden (the CAAS project). CAAS stands for Centre of Arts and Archaeological Sciences, and aims to an integrated study of old objects in their art historical and archaeological context while developing and applying scientific techniques to study them.[8] Dr. Joris Dik introduced me to Janneke Nienhuis, a PHD student from TU Delft who currently investigates the influence of conservation treatment on the material properties of archaeological bronze.

She agreed to help me with an XRF analysis of the crucibles and other relevant material. The analyses were done with a portable XRF-instrument (Bruker Tracer III-S, beam width 3x4 mm², RH-tube) within the facilities of the Cultural Heritage Agency of the Netherlands (Rijkdienst Cultureel Erfgoed) in Amsterdam (Fig. 7.2, Fig. 7.3).

The aim of the XRF analysis was to roughly determine the composition of the residues in these crucibles, as well as those of the supposed scrap metal and ingots. It was not necessary to have an exact quantification of the elements present, the main goal was to identify whether it was metal, and if so whether this was a noble metal, a base metal or an alloy.

Besides this material I also wanted to know the composition of a rectangular fragment of an object (V00714, trench 87) possibly the fragment of a(n ornamentation on a) bridle or other horsegear as it was found in close proximity to a horse burial. A small fragment that was previously suspected to be scrap metal (V00441, trench 87) may actually have been part of the attachments from this plate to the bridle as they both originate from the same feature (Fig. 2.5).

[8] www.caasonline.nl (visited 7-4-2012)

7.2 What is XRF analysis?

X-ray Fluorescence (XRF) spectometry is a (usually) non-destructive surface technique that can identify the composition of materials (Henderson 2000, 14-15).
The device fires primary X-rays at a sample, and this interaction produces (amongst others) secondary X-rays whose signature is unique to each of the elements present in the sample (Henderson 2000, 15). The secondary X-rays hit a detector and go through an analogue-to-digital converter were they are processed as electrical pulses with different energies (determined by the atomic weight of the element concerned). The electron pulses are fed into a multi-channel analyser that displays the maxima of the spectrum as an series of peaks with a Gaussian shape. The peaks are formed by a process of counting probability where the maximum number of events that fall in the center of the peak determine its height (Henderson 2000, 15). For a diagram of the principle of XRF analysis, see Fig. 7.1.
The depth to which the primary X-rays can penetrate the sample is determined by the composition of the sample, as well as the energy and the angle of the primary X-rays that are fired at the sample (Henderson 2000, 16). Usually this depth is at about 100 μ m (0,1 mm) under the surface (Nienhuis 2012, 2). The application of this technique to archaeological material has the disadvantage that the results are not completely quantifiable because of the weathered surfaces or patina present (Henderson 2000, 16 ; Nienhuis 2012, 2). It is possible however to get a rough idea of their composition.

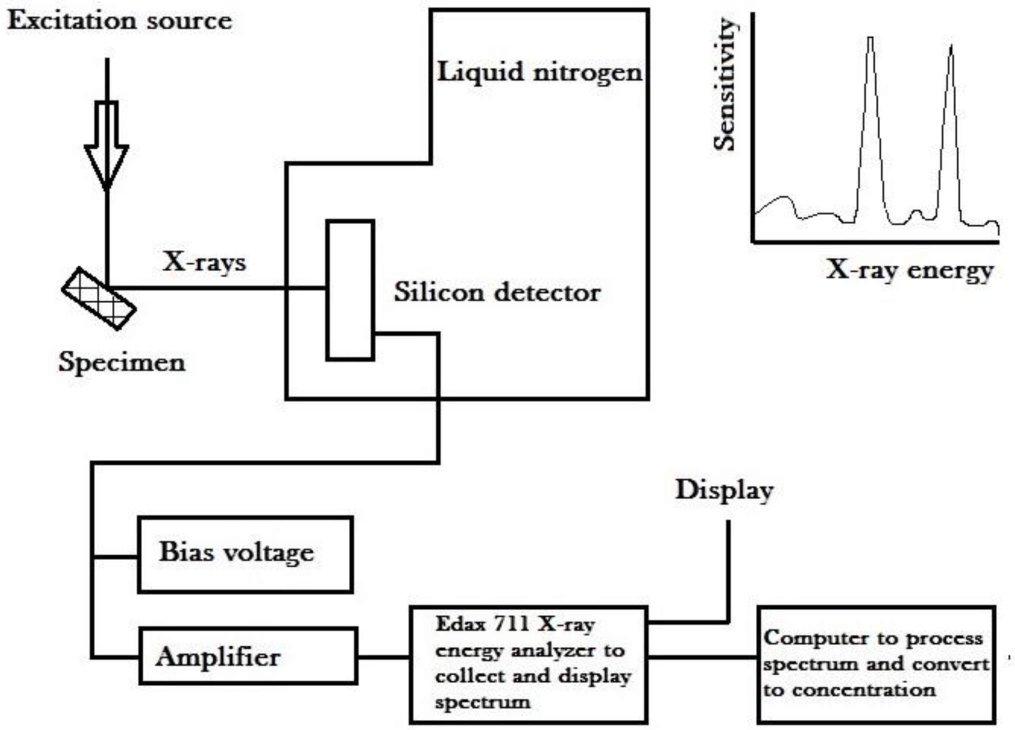

Fig. 7.1: Diagram explaining the XRF- principle (after Henderson 2000, 15).

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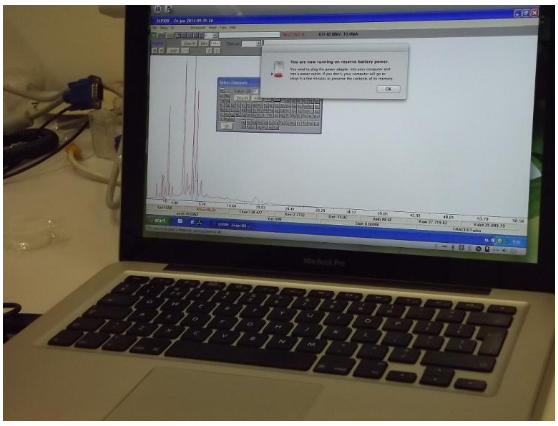

Fig. 7.2: The XRF analysis of the crucibles (24-1-2012).

Fig. 7.3: The Bruker Tracer III-S, linked to a MAC laptop. The black cap is placed over the object before the X-rays are fired. Attached to the front of the device is a portable XRF-instrument.

7.3 The crucibles and possible mould fragment: results

The crucibles (V00986 trench 21, V01066 trench 25) and possible mouldfragment (V01069, trench 25) were measured on the 24th of January 2012 by Janneke Nienhuis with the author present(Fig. 7.2, Fig. 7.3). A second session was held on the 23rd of February 2012.

Several positions were measured to get an idea of the heterogenity or homogenity of the content as well as that of striking features on the outer surface.

Crucial sections of Janneke's report will be translated to English in this thesis.

In the report she notes that the crucibles show counts of the same type of elements, and that the origin of the majority of these elements are clear, but for some more research is required (Nienhuis 2012, 2).

The following is paraphrased to English from the report by Janneke Nienhuis (page 2 and 3, 3.1 Smeltkroezen).

" In general, Aluminium (Al), Silicon (Si), Potassium (K), Calcium (Ca), Titanium (Ti), Manganese(Mn), Strontium (Sr) and Zirconium(Zr) are common elements found in soils. Often bonded with oxigen, hydrogen and carbon they form bonds that have been precipitated on or diffused with the surface layer of the archaeological artefact, that has spent several years in the ground. In this case, the count percentage of these elements are no exception. However, the fairly high count of calcium is striking, so the assumption is that part of the material from the crucible contains calcium. Nickel (Ni), Copper (Cu), Zinc (Zn)and Lead (Pb) are elements common in metals. In this case, these elements are present in all the measured parts of the crucibles. The amount of nickel and lead are stable in these measurements, while the amount of copper and zinc fluctuate the most.The outer surface contains the least quantity(measurement 986_07, 1066_01), the redder areas in the crucibles appear to be richer in zinc (measurement 986_05, 1066_02).

What can be postulated with certainty, is that on the inner surface of the crucibles there are more metallic elements than on the outer surface. It appears that copper, nickel and zinc (and possibly lead) were used in fluid state in the crucibles for casting objects.

Iron is a common element in soils, however the indicated presence of the element was so high that is it likely that iron as a metal has been in the vicinity of the crucible. Also, there tends to be more iron on the outer surface than on the inner surface. From the separate pieces it is more difficult to determine the context of the presence of iron, however the suspicion is that it hasn't been in metallic form inside the crucibles, but that it finds its origin in the surroundings of the crucibles."(Nienhuis 2012, 2-3).

In this light it is interesting to note that the base of the possible mouldfragment (V01069) is magnetic due to the iron residu attached to it (Fig. 2.16). In her report, Janneke Nienhuis finds it probable that the fragment may in fact have been part of a crucible: (Paraphrased from section 3.2 Vorm, page 3):
" The form appears to be part of a mould, because of the pronounced bend edge. The colour, morphology and composition are also quite similar to that of the above mentioned crucibles. The same elements are present, albeit in different ratio's. The amount of aluminium, silicon, potassium, calcium, titanium, manganese, iron, nickel, strontium and zirkonium are similar. The form shows higher peaks for copper and lead, while the amount of zink is less pronounced. In the browner part of the form (measurement Vorm_02) also tin(Sn) was measured. The redder part (measurement Vorm_03) is almost identical in composition to the grey part measured (Vorm_01), although it has a lower lead signal.
The measured grey area from measurement Vorm_01 is quite similar in composition to the grey area of crucible 986; the form contains only a little more zinc, the rest is almost the same. This raises the suspicion that the form has been part of a crucible. It is difficult to say if this is from one of the measured crucibles, because in the different measurements of just one crucible there is already much variation in composition (specifically in the zinc- and coppercontent) ." (Nienhuis 2012, 3).
The fragment is too small to make a definitive identification, but I tend to lean more towards it being the base of a mould, on the following grounds:
The pronounced angle of the shape does not suggest it to be part of a crucible nor from a lid of some kind. The innerside is smooth and flattened but also has a distinct portrusion that may have been intended to form an eye (a ring of sorts). The position of the iron content suggest that it was placed with the base in or near the smithing hearth. The mould would be preheated prior to casting, as it being closer to the temperature of the metal casted would increase the casting succes (as too cold a temperature may cool and slow down the poured metal before it has completely filled the form).
The fact that it has a similar composition and colour can also mean that both the crucible and the (possible) mouldfragment were made from the same claysource or that a similar metallic content was poured into the mould. It is known that from prehistory (bronze age)

untill the viking age horsedung was added to the claymixture of a mould for porosity, firmness and better heat properties. After a mould is fired, the organic material is burned away and leaves pores that help to fill the form with the vacuum-principle (the metal is sucked into the form, as hot gasses escape trough the pores). I do not know wheter the use of horsedung is detectable in a XRF measurement, but I would expect the composition to be slightly different than that of normal clay. So, eventhough I tend to believe it to be a fragment of a clay mould, it is possible that it comes from a crucible.

What is certain is that a non-ferrous metal is present in the object, with iron visibly attached to the outer surface.

Based on this, it is possible that the forge of an iron smithy was also used for casting objects and that iron remains in the forge became attached to the crucibles and possible mould fragment.

The casting of iron in Europe wasn’t practiced untill the invention of the blast furnace in the 12th century, which underlines the assumption that iron hasn’t been used inside the crucibles (Joosten 2004, 27).

Note:

During my visit to Dr. I. Joosten in the RCE in Amsterdam (5-4-2012) for the identification of some slagmaterial from Oegstgeest, findnumber 588 contained besides slag also a fragment of a fairly large crucible with a couple of smaller fragments from crucibles (some likely to have come from the same crucible based on colour and composition, Fig. 2.12, Fig. 2.13). Some smaller fragments were briefly analyzed with XRF, and its composition seemed quite similar to that of the other crucibles analyzed by Janneke Nienhuis. As her report was already finished (it was discovered after her analysis) and my visit to Dr. I. Joosten had a different purpose, due to time contraints it was decided not to export the measured data from the XRF instrument. However it is interesting to mention that the smaller fragments contained copper, some tin, cobalt, nickel, iron and some fragments also contained a high count of zinc (which could be an indication of brass). In one fragment iron was also visible at the rim.

Eventhough these results cannot be quantified without being analyzed with XRF again (perhaps at a later date), at least copper or copper-based alloys can already be distinguished with the naked eye. Some of the fragments have a residu with a green patina and the larger crucible fragment also has an unmelted piece of brownish metal with green patina attached to the inner surface that suggests copper or a copper-alloy (probably bronze). This piece couldn’t be measured with XRF due to its position, although the fact that it was unmelted may mean that the cast was unsuccesful, as unmolten pieces of metal would cause irregulaties in the casted endproduct. The outer surface of these fragments are discoloured and show signs of being heated to high temperatures (with typical red and green discolouration and vitrification).

7.4 Scrap and ingots: results

7.4.1 Copper-based alloys

In the dataset was a small piece of scrap (or ingot) material present(V00097), that was originally labeled as ‘Gold’ (Fig. 2.17). This assumption seemed suspect, as it looked like brass, which was later confirmed by XRF analysis.
The object had a high count of copper (Cu) and zinc(Zn) elements, as well as some counts of iron (Fe), nickel (Ni), lead (Pb) and tin (Sn), see page 6, ‘tabel 2’ of the XRF rapport in the appendix).
It is possible that the brass was intended to appear as gold, but it could also be that it was intended for its material properties, as brass is harder than gold. The piece of brass was found in the southwestern part of the settlement while most of the crucibles were found in the northern part (Fig. 6.2, Fig. 6.3). Eventhough we cannot link this piece of brass directly with any of the crucibles (or possible mouldfragment) it is supporting evidence that brass was casted in the settlement.

7.5 Other

Some other objects were also examined with XRF such as a plate with three holes (V00714, trench 87) that was thought to be connected to a small metallic knob(V00441, trench 87). The plate may have been part of a bridle as it was found with a horse burial, the small knob comes from the same feature (feature 1 in pit 87) and may have been attached to the plate as decoration and/or the attachments of the plate to the bridle. The plate was identified as iron but also contained traces of copper (alloy) in and around the holes (measurement 741_01, 741_02). The small knob (V00441_02, V00441_03) contained primarily copper, lead, zinc and tin, as well as some iron and nickel (Nienhuis 2012, 3). This means that something made from copper (alloy) was probably attached to these holes (Nienhuis 2012, 4).

Measurement 441_04 is a measurement of sediment found with the objects and contains iron, silicon, potassium, titanium, manganese, strontium and zirkonium. There are also peaks of copper, zink, lead and tin that may be small remains (of weathering) from objects, mixed with the sediment (Nienhuis 2012, 3).
In the material investigated is also an object (V00385) that seemed like some kind of (belt)fitting made of brass. It was analyzed and contained copper, zinc and lead with nearly no elements that are expected in soils (Nienhuis 2012, 4).

7.6 Conclusion

The crucibles, crucible fragments and the possible mould fragment appear to have been used for the casting of copper alloys (brass and bronze) and confirm that also non-ferrous metallurgy was practiced at the Merovingian settlement Oegstgeest. The piece of brass (V00097, probably scrap or ingot) also points to the practice of casting brass objects.
It is possible that brass was used to cast an object that appeared to be made from gold, or that it was used for its material properties (brass being harder than gold). The size of crucibles V00986 and V01066 indicates that they were used for the casting of relatively small objects, probably not much larger than 40x 40 x 3 mm (or any size amounting to a volume of about 3 cm^3- 5 cm^3). Traces of lead in the crucibles as well as the presence of lead scrap material/ingots (V00322MXX, trench 9) suggest that either lead was casted or used in alloys.
The crucible fragment V00588MSL, trench 83 that was discovered later, is from a larger crucible with an original diameter of about 12 cm (the ‘rim’ being ca. 15-20 mm thick). The height of the crucible is unknown.
An unmelted piece of a copper alloy (probably bronze) is attached to the inner surface of this fragment. They indicated the use of brass as well as bronze. The use of a copper-alloy is also visible due to the green patina present.
The size is suited for casting larger objects, or a series of smaller objects in one casting session. It’s possible that this crucible was used more than once considering the level of vitrification and the different elements present (but for this last statement to be proven, a more thorough investigation is needed).
The unmelted piece of copper-alloy (bronze?) indicates the recycling of metallic objects, but also that the session where it was used may have been a miscast, as unmelted pieces of metal would cause irregularities in the casted object.

The presence of iron on the crucible and the possible mouldfragment suggest that they were used in an iron rich environment, possibly the iron smithy. The use of iron in the crucible intended for casting is improbable, as the casting of iron in Europe was not practiced untill the invention of the blast furnace in the high middle ages (Joosten 2004, 27). It is possible that a piece of iron found its way inside the crucible. In the material investigated there were no indications for the production of objects made from noble metals.

8 Discussion

The following discussion will be divided into two themes, that although related take slighly different trajectories in terms of the interpretation of the evidence.
Firstly, the metallurgical evidence of the Merovingian settlement of Oegstgeest will be compared to other rural settlements in the region and in other parts of the Netherlands. This evidence will also be discussed in terms of the degree of autonomy of the settlements located along the (Old) Rhine in this time period.
The second part will discuss the crucibles, as well as the search for an analogy. What can their shape tell us about how they were used? And does their shape give any clues for a specific regional influence?

8.1 The metallurgical evidence in comparison to other rural settlements in the region and the rest of the Netherlands

In order to find out how extraordinary the evidence of Oegstgeest is, we need to compare the finds to those found in other river-based Early Medieval rural settlements, preferably on those located near (side-branches of) the Old Rhine. Near Oegstgeest are the Early Medieval settlements of Rijnsburg-Abdij, Katwijk Zanderij-Westerbaan and Koudekerk aan den Rijn.
The Merovingian settlement of Rijnsburg was located on the southern bank of a former tidal channel in an estuary of the Old Rhine. The slow streaming gully that connected the settlement to the Old Rhine is the Vliet (Dijkstra 2011a, 116). The area was previously used for agriculture in Roman times (ca. 250 BC-300 AD) and was first settled in the Merovingian period around 600 AD (Dijkstra 2011a, 117-119). From phase 1a (600-610 AD) there is evidence for ferrous and non-ferrous metallurgy on the fenced compound belonging to House 1 on the eastern bank of the gully (Dijkstra 2011a, 119-121). To the north of this house the remains of an oven and a wooden windscreen were found along with several smithing or reheating hearths and slagmaterial that may indicate the production of iron (Dijkstra 2011a, 121). The distance to the waterline was about 15 meters (based on Fig. 4.5 in Dijkstra 2011a, 120).
Some bronze fragments and two crucibles were found in an oven pit. Together with the sintered clayfragment with an aircanal that was interpreted as a possible mouldfragment, it appears that objects of copper-alloys were casted in the settlement (Dijkstra 2011a, 121).

In phase 1b (ca. 610-640) a house was build over the location of the oven, along with an additional fence, but it is likely that ferrous-metallurgy continued in the settlement. Other craft activities were the brief production of glass beads evidenced by the find of a glass oven and a few production debris in the north of the settlement. This may have been the work of a traveling craftsman possibly dating to phase 1c (ca. 640-680) (Dijkstra 2011a, 121). Since phase 1 the Vliet gradually changed it position northward, diminishing the importance of its side-gully(Dijkstra 2011a, 123). In phase 1d (ca. 680-720) the craft activities seem to decrease in the central area of the settlement but the find of an oven in the southern edge of the planning area may indicate a re-location of these activities (Dijkstra 2011a, 123).

Almost a stonethrow away is the Merovingian settlement of Katwijk Zanderij-Westerbaan, where finds have been reported since the mid 19th century (Dijkstra 2011a, 144). A striking find was a trial-minting of a pseudo- Madelinus on a square piece of bronze, suggesting that local minting was carried out here (Pol & van der Veen 2008, 318-319). In Den Haag-Frankenslag, another nearby settlement, slag remains were found that gave indications for the production of iron (Magendans and Waasdorp 1989, 36).

In Koudekerk aan den Rijn the remains of an Early Medieval graveyard was discovered in 1940, and a nearby settlement in 1979 (Dijkstra 2011a, 254).

A large part of the graveyard hasn't been excavated yet so it is unclear how long it was used. The discovered ceramic urns date from ca. 530-650 AD. The nearby settlement dates between the 5th to the 9th century (Dijkstra 2011a, 256). The indications for craft activities in this settlement are limited to the spinning of wool and the smithing of iron (Dijkstra 2011a, 159).

Located more inland is the Early Medieval rural settlements of Leidsche Rijn (near Utrecht) . The settlement in Leidsche Rijn (excavated in 2005 and 2006) was occupied between the last quarter of the 6th untill the middle of the 8h century (Nokkert, Aarts and Wynia 2009, 16 and 359). A myriad of craft activities took place in this settlement ranging from the working of glas, amber and antler, woodcarving and metallurgy (Nokkert, Aarts and Wynia 2009, 366).

Based on the technical characteristics of the discovered slag material there is evidence for the working ánd the production of iron (Kerkhoven 2009, 241). It appears that imported iron ore was used, although the use of bog iron is also a possibility (Kerkhoven 2009, 242). Similar to Oegstgeest, burned and sintered clayfragments are associated with slag

and some clayfragments also have slagremains adhesed to their surface (Nokkert, Aarts and Wynia 2009, 43).
A piece of ovenwall with airinlet (tuyère) supports the idea of iron production (Nokkert, Aarts and Wynia 2009, 207). An interesting find are 8 fragments of coal (Dutch: 'steenkool') that may have been imported from Belgium, Germany or England (Kerkhoven 2009, 243). Several coal fragments have also been found in Oegstgeest, who may have had similar origins.
The find of 4 small drop-shaped pieces of bronze and 5 fragments of copper-based slag indicates that also non-ferrous metallurgy was practiced (Kerkhoven 2009, 243). There are no crucibles mentioned in the publication. The craft activities are concentrated in compound 3 and 4, central-east in the settlement based on fig. 5.3 in the appendix (Nokkert, Aarts and Wynia 2009, 449).
If we look at evidence from the heartland of the Frisian and Frankish empire, such as Wijnaldum and Gennep respectively, it comes to no surprise that metallurgy was practiced here as well. Both in Gennep and Wijnaldum are indications of recycling metals (from coins) (Dijkstra 2011a, 245 after Van der Vin 1999). In Wijnaldum also a die for making a waffled pattern in goldfoil was found (Schoneveld and Zijlstra 1999,195). Concerning Wijnaldum, it is a pity that so much attention is paid to one exceptional fibula found here, and less than one sentence is spent on mentioning some 'melting pots' (crucibles) (Schoneveld and Zijlstra 1999, 200). Having viewed some material from Wijnaldum, there were objects previously listed as 'slag' who were in fact crucible fragments (the database is now updated). Some of these fragments contain copper-residues (F2010-VI-8256a) and it would certainly be interesting to have these fragments analyzed with XRF. It may very well be that they reflect demands of the rural population, not (just) from the supposed elites.

In conclusion it appears that the evidence of Oegstgeest corresponds to the evidence from other rural settlements in its direct vicinity, but also shows similarities to contemporary settlements elsewhere.

8.2 The crucibles: the search for an analogy

During this BA-research I also looked into finding an analogy for the crucibles with findnumber 986 (trench 21) and 1066 (trench 25). Based on information I received that an analogy of the crucibles might be present in the Saalburg museum (Germany) I browsed through all the Saalburg yearbooks between 1967 (volume 24) and 2005 (number 55) yet came up empty. There was no time to investigate the matter in person.

Browsing through the collection of the Museum of National Antiquities in Leiden and in the northern archaeological depot in Nuis there were two crucibles that were slightly similar to those found in Oegstgeest (but they had no handles and different top edges)

In the collection of the National Museum of Antiquities the crucible with inventory number WD 101 (dimensions 35x 33x38 mm and wall thickness 4,5 mm) has some resemblance to the ones in Oegstgeest but is no direct match. It was found in the excavations of Dorestat. To prevent copyright infringement the picture of this crucible will not be published here, but it can be accessed online via de museums'website.[9]

In the archaeological depot of Nuis the crucible with inventory number 50/31 (46x44x36,5 mm and wallthickness of 10,5 mm) seems to share a gene pool with the Oegstgeest example but its context is uncertain as it came from the leveling of a raised mound ('terp', Halsem-2) in 1925. However this mound yielded Roman material as well as early medieval material so it is possible that it was contemporary to the ones used in Oegstgeest (pers.comm. E.Taayke 9-3-2012).

It could be its distanced cousin. I find the similarities too subtle to say the maker of the crucibles was influenced either by the central river-area (Dorestat, which is not contemporary with Oegstgeest) or had a northern origin (Halsum-2).

Even if an exact analogy was found, we need to bear in mind that they could have been made by a visiting craftperson and not by the resident smith himself. Also this smith may have made these crucibles based on personal preference, not traditions.

The shape of the crucible and fragments from trench 21 (V00986BIJZK and trench 25 (V01066BIJZK) do appear to have been made by the same person, as they have the same design.

In my opinion the function of the short portrusion (the handle) was to provide a stable grip for thongs under it, as crucibles of this nature tend to topple over. What I find striking are the minor signs for vitrification near the bottom. Theoretically speaking if we would have an alloy of 20% zink and 80% copper ('goldish zink') the melt temperature would have been ± 950 ° C and I would have expected more severe deformation.[10]

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[9] www.rmo.nl

[10] During the XRF analysis it was impossible to analyze how much of a material was present, just that it was in there. The temperature of a similar alloy however would not deviate to far from this melttemperature.

It is also possible that a melt was quickly achieved and the crucibles spent a relatively short time in the hearth. Maybe the crucibles were originally lidded, as some pieces have broken of from the top, but it is also possible that the edges were never finished during production.

Both traces of lead, copper and zinc have been detected in the crucibles. In modern day brass, a minor amount of lead is added to improve its machinibility (Dutch: ‘verspaning’). It means that it is easier to manipulate with a saw or a vile. Maybe early medieval craftspeople were aware of this, but it is also possible that the metals were used seperately in the crucible.

9 Conclusion

In the Merovingian settlement of Oegstgeest both ferrous and non – ferrous metallurgy was practised. The slag evidence suggests that iron was smithed in the settlement, but offers no (clear) indications for the production of iron. There are a some pieces that shed some doubt on this assessment (notably V01000MSL from trench 39). Debris from ovens such as baked clay with slag attached may have come from either process, but most are associated with smithing slag and therefore interpreted as fragments from a smithing hearth. It may be fruitful in the upcoming campaigns to survey the area with a magnetometer before opening a trench to identify where the anomalies are. I would expect smithing activities near the settlements boundaries and close to watersources.
In the findmaterial are ± 8 (fragmented) crucibles, some with residues. A possible mouldfragment also contained brass residue. Together with scrapmetal of brass, bronze and lead it strongly points to unnoble metals being casted in the settlement.
The choice of brass may have been motivated by its golden colour, or by its material characteristics.
Iron residu on the outer surface of some crucibles and the possible mouldfragment suggest that an iron smithing hearth was used during the casting. These activities probably reflect several phases of the settlement (however this information is not available yet). Based on the distribution of the find material, it appears that metallurgy related finds are concentrated on or near the boundaries of the settlement and near watersources such as wells and streams.
The evidence found in Oegstgeest has strong similarities to (relatively) nearby rural settlements such as Koudekerk aan den Rijn, Leidsche Rijn and Katwijk-Zanderij Westerbaan where metallurgy was also practiced.
It appears that there was great demand for metallurgy in this period.

Recommendations

The following is not intended to point fingers, but merely an observation.
During my investigation I encountered several fragile items (of bronze and iron) ‘improperly’ packaged with heavy items and overfilled bags. I do not know in what condition they were stored away, but this certainly has not done them any favours.
Sometimes all that was left from a bronze object was green powder.

I recommend the purchase of simple plastic boxes and proper packaging material (see CCI notes 9/2) to store fragile items in, together with silicate dehumidifiers.
I recommend that the the Faculty of Archaeology makes a longterm investment to improve the storage conditions of metallic (and other fragile) artefacts. Ideally a separate well ventilated room with a controlled temperature (20°C with an RH of $\leq$ 35%) , furnished with metallic, powder-coated storage racks (see also CCI note 9/2).

I recommend that two fragments of a single-edged knife or sword (V00087) from trench 1(box 36 ONRZ10) and object V00881MXX from trench 15 are sent to a specialist for stabilization and conservation as soon as possible.
I recommend a brief XRF analysis for the crucibles that were not analyzed, as well as the two 'scrapmetal' of unknown composition (possibly silver).

I recommend to get a specialists opinion on the slagmaterial in box 49 as there are some ambigiuous pieces there, notably V01000MSL from trench 39 and feature 29.

Dutch Summary

Een aantal jaren geleden is nabij de oever van de Oude Rijn een goed bewaarde vroeg middeleeuwse (Merovingische) nederzetting ontdekt, die een belangrijke bijdrage kan leveren over de bewoningsgeschiedenis van de kuststreken in deze periode. Wegens bouwplannen worden deze resten bedreigd, waardoor nu grootschalig onderzoek plaatsvind die nog tot circa 2014 zal voortduren. De centrale vraag in deze BA-thesis luidt óf er metaalbewerking in deze nederzetting plaatsvond en zo ja, welke metalen er werden bewerkt. Hiervoor is een groot deel van de metalen en aan metaalbewerking gerelateerde vondsten bekeken. Behalve (ijzer) slakmateriaal zijn ook smeltkroezen en fragmenten hiervan aangetroffen, die wijzen op het gieten met legeringen van onedele metalen. Hiervoor werden vaak materiaal van bestaande objecten hergebruikt.De motivatie voor het gebruik van messing kan door diens goudkleur bepaald zijn. Betreffende het slakmateriaal zijn er meer aanwijzingen voor ijzerbewerking dan ijzerproductie.

English Summary

A few years ago a well-preserved Early Medieval (Merovingian) settlement was discovered near the banks of the river the Old Rhine that will play a vital part in the understanding of the habitational history in the coastal area in this period. These remains are threathened by development plans, which is why a large-scale excavation is taking place and will continue untill circa 2014. The central question in this thesis is wheter metallurgy was practiced in this settlement and if so, which metals were used. A majority of the metallic and metallurgy related finds have been examined. Besides (iron)slagmaterial a couple of crucibles and fragments thereof have been found, that point to the casting of unnoble metals. For this end they recycled material from existing objects. The motivation for the use of brass could be its gold colour. Concerning the slagmaterial the evidence seems to point more at the smithing of iron than iron production.

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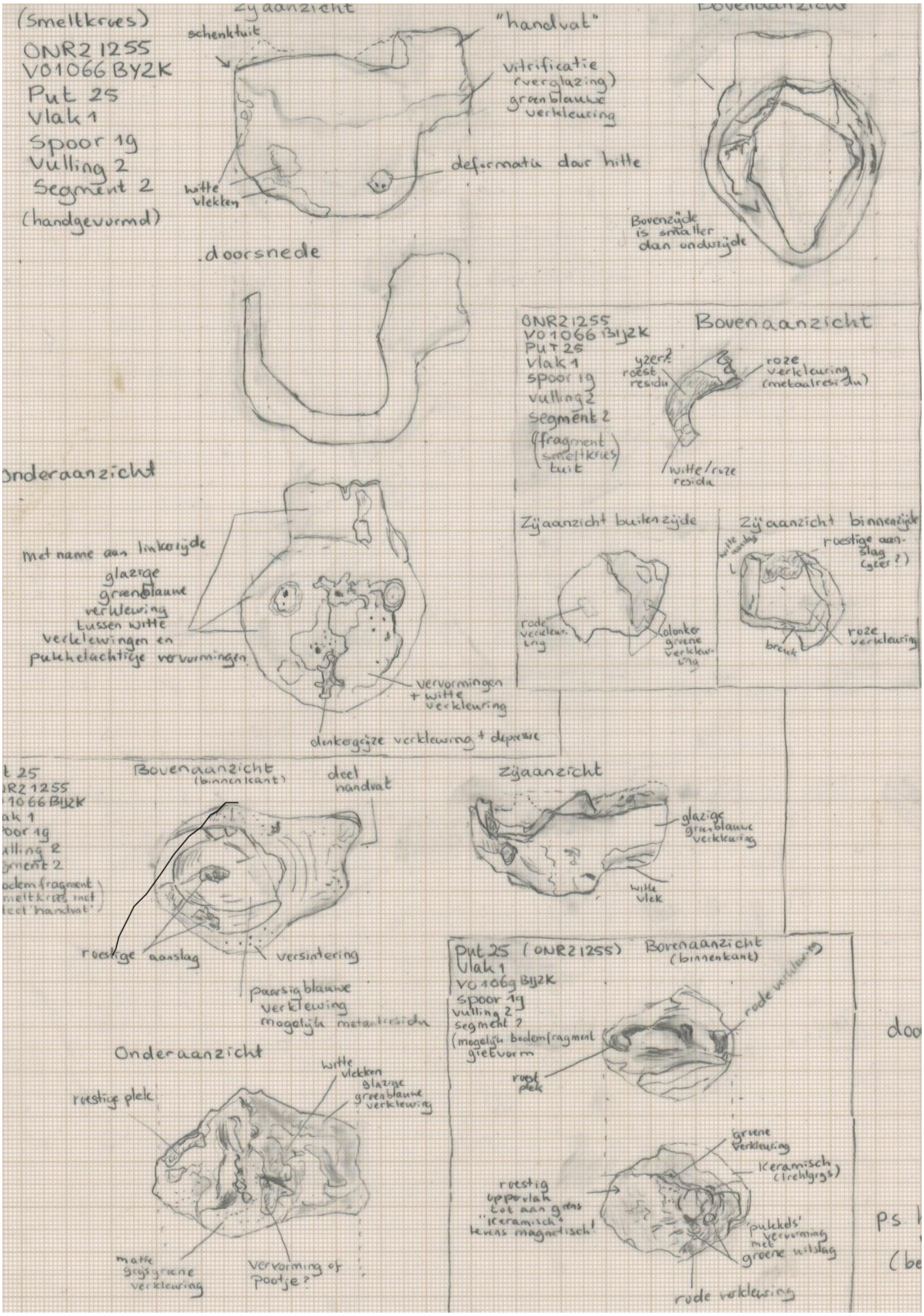
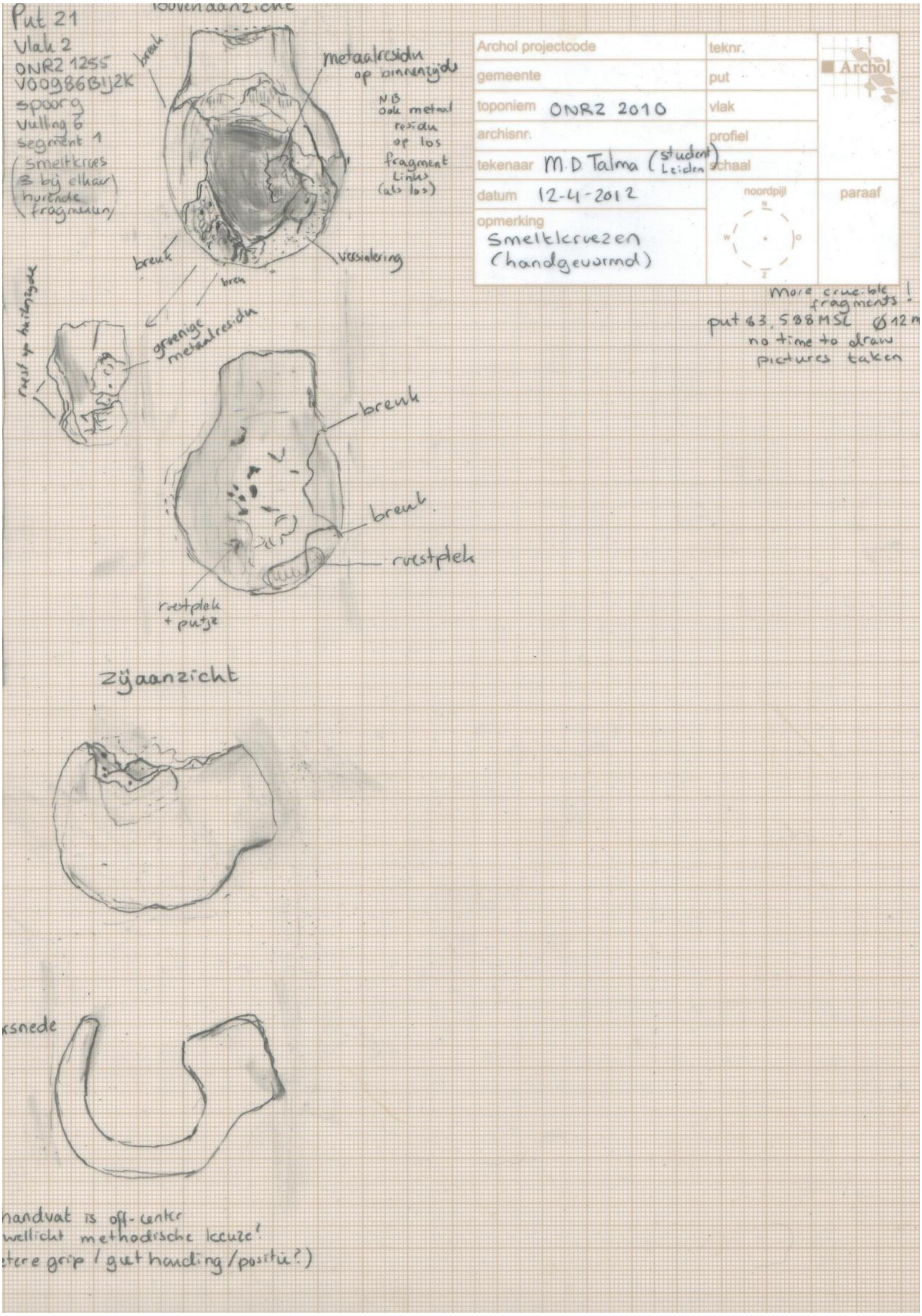
Appendix

Drawing of crucibles and mouldfragment




Put 21
Vlak 2
ONRZ 1255
V00986BIJ2K
spoor 9
vulling 6
segment 1
(smeltkroes
3 bij elkaar
horende
fragmenten)
bovenaanzicht
breuk
metaalresidu
op binnenzijde
NB
ook metaal
residu
op los
fragment
Links
(als los)
versiering
groenige
metaalresidu
breuk
breuk
roestplek
roestplek
+ putje
Zijaanzicht
snede
handvat is off-center
wellicht methodische keuze?
betere grip / gut handling / positie?)
Archol projectcode
teknr.
gemeente
put
toponiem ONRZ 2010
vlak
archisnr.
profiel
tekenaar M.D Talma (student Leiden)
schaal
datum 12-4-2012
noordpijl
paraaf
opmerking
Smeltkroezen
(handgevormd)
Archol
More crucible fragments!
put 63, 588 MSL Ø 12 m
no time to draw
pictures taken

List of examined slag samples

The following list is the sample of slag material (and other material) that was examined by Dr. I. Joosten (slagspecialist) in the facilities of the RCE (Cultural Heritage Agency of the Netherlands) in Amsterdam on the 5th of april 2012. The list is in chronological order of trench number. More slagmaterial has been examined by the author (M.D. Talma), where no production slag was identified but mostly smithing slag. However, a margin for error (due to inexperience) should be taken into account.

Trench 8, V00662MXX, level 2, feature 1, filling -, segment - .
Remarks: Smithing slag, high iron content. Uneconomical use of iron (considerable loss of material). The shape follows that of the smithing hearth.

Trench 9, V00366MXX, level 1, feature 22, filling 4, segment 2.
Remarks: corroded object.

Trench 11, V00431MXX, level 1, feature 30, filling 1, segment 2 .
Remarks: Probably smithing slag. Could also be from a production oven (borderline case). Based on the other material, smithing slag seems more likely.

Trench 14, V00603MXX, level 1, feature 4, filling 1, segment 2.
Remarks: smithing slag (slag cake), nice example showing the form of the smithing hearth.

Trench 18, V00974MXX, level 1, feature 70, filling 1, segment -.
Remarks: corroded object.

Trench 27, V02011MXX, level 1, feature 10, filling 1.
Remarks: smithing slag with a flat side where the mouth of the ‘tuyere’ would have been.

Trench 27, V02017MSL, level 1, feature 4, filling 1, segment 1.
Remarks: vitrified stone (Dutch: ‘verslakt steentje’)

Trench 76, V00193MSL, level 1, feature 3, filling 4, segment 3.
Remark: could be production slag (it is very tough) or smithing slag smithed on coal (Dutch: ‘steenkool’). (Coal burns with higher energy)

Trench 76, V00196MXX, level 1, feature 2, filling 1, segment 2
Remarks: iron object (corroded)

Trench 76,V00228MXX, level 1, feature 2, filling 1, segment 3
Remarks: iron object in rust (corrosion)

Trench 76, V00236MSL, level 1, feature 3, filling 4, segment 3
Remarks: smithing slag and vitrified ovenwall/hearthwall.

Trench 76, V00240MSL, level 1, feature 3, filling 4, segment 3
Remarks: small piece of smithing slag; also sintered ash, associated with iron.

Trench 77, V00278MSL, level 3, feature 1, -
Remarks: Probably smithing slag

Trench 76, V00342MSL, level 1, feature 6, filling 3, segment 2
Remarks: iridescent piece of sintered cinder, could be from any metal but since in association with iron, probably iron. Also: a piece of corrosion husk.

Trench 83, V00374MSL, level 1, feature 56, filling 5, segment 1
Remarks: tough slag with burned clay residu, could have been attached later. Possibly smithing slag.

Trench 83, V00419MXX, level 1 , feature 6, filling 5, segment.
Remarks: smithing slag

Trench 83, V00420, level 1, feature 6, filling 1, segment 4
Remarks: found close to crucible with findnumber 588MSL.

Trench 83, V00424MXX, level 1 , feature 6, filling 1, segment 6

Remarks: smithing slag, glazed ash, ovenwall/hearthwall (could be from smithing hearth).

Trench 83, V00425MSL, level, feature 6, filling 1, segment 6

Remarks: Brick and slag. Possibly shape of tuyère, not very clear (wishful thinking?). The brick may have been used in the oven. Does look more like production slag than smithing slag, but not very conclusive; some pieces of slag are borderline cases. What is clear is that intense heat has been applied to this material; pieces of clay are completely vitrified.

Trench 83, V00430MXX, level 1, feature 9, filling 1, segment 2

Remarks: vitrified cinder, two corrosion husks (Dutch: 'corrosie huidjes') .

Trench 83, V00463MXX, level 1, feature 9, filling 2, segment 3

Remarks: iron object in rust (corrosion)

Trench 83, V00588MSL, level 1, feature 6, filling 1, segment 4

Remarks: iron slag (2x), fragment of large crucible with residu from copper (alloy), more fragments from crucibles, some apparantly from this larger crucible. Shortly analyzed with XRF (smaller fragments and larger fragment): counts for copper, zink, cobalt, nickel, tin and iron.

Pers.comm. Dr. I. Joosten: the working of copper in iron smithing hearths is common, as the hearth was often already there (convenient).

Trench 86, V00437, level 1, feature 1, filling 1, segment 1

Remarks: corroded object.

Trench 86, V00531MSL, level 1, feature 1, filling 1, segment 2

Remarks: Smithing slag, iridescent, vitrified. Here also indication for the use of coal (Dutch:' steenkool')

Trench 86, V00542, level 2, feature 1, filling 1, segment 6

Remarks: vitrified cokes, strange material. Could be contemporary for the time (but check context!)

Trench 86, V00538MSL, level 2, feature 1, filling 1, segment 8

Remarks: Strange, seems to be vitrified cokes, not Roman-period coal, also quite heavy. Recommend to check context, this might be younger (later) material!

Trench 86, V00541MSL, level 2, feature 1, filling 1

Remarks: strange piece of slag with coal attached at the bottom . (Dutch: 'steenkool'). Coal has been found in smithing hearths of Roman times, unsuitable during production due to emittance of sulphur.

Trench 86, V00553MSL, level 2, feature 1, filling 1, segment 14

Remarks: sintered ovenwall/hearth wall. Red colour (clay+ slag) has been close to tuyêre/ air inlet, extensively vitrified.

Trench 86, V00727MSL, level 2, feature 8, filling 1

Remarks: big piece of slag with traces of charcoal and coal (Dutch: steenkool). Typical morphology of slag worked with coal, possibly also some slate. Recommendation to check context (it has been found in Roman times, but this may be modern!).

Tables of browsed boxes

Box 36 (ONRZ09)	Category	Feature	Material	Outliers
Trench 1	Mostly smithing slag, some objects (fragment single edged knife/ sword)	2, 5,6,18	Fe	V00087: 2x fragments of sword/knife
Trench 2	Smithing slag, slag, objects	17, 18, 19	Fe	
Trench 3	Smithing slag, slag, objects, hearth	1, 2, 6, 18	Fe, Clay	V00015: no feature, smithing slag, vitrified burned clay (hearth)
Trench 3	Fragment of objects with square/ rhombus-shaped holes (could be corroded nail)	1	Fe	V00109:3 x fragments of objects with hole, 1x smithing slag
Trench 5	Mostly smithing slag, objects	14, 15, 18, 20, 21, 24, 27, 29	Fe, Clay	V00333: smithing slag with burned clay
Trench 6	Smithing slag, slag	1, 37	Fe	
Tranch 8	Mostly smithing slag, also lead pieces; V00196 also contains a piece of smithing slag with inbedded piece of iron (and possible organic (?), could also be iron, need to id chemically	1	Fe Pb	V00193: small plate, likely lead V00194: lead (curse?)plate V00195: lead plate
Trench 8	Smithing slag w/clay		Fe, Clay	V00521:smithing slag with burned clay
Trench 13	Mostly objects, variably preserved	19, 23,32	Fe	V00519: 1 x slag
Trench 16	1 x slag, light grey, sintered	2	Fe	

Conclusion:

Box 36 has finds from trench 1,2,3,5, 8, 13 and 16 and seems to contain mostly smithing slag. It has a couple of nice examples with a plano-convex shape i.e. flat at the top and rounded at the bottom, giving an indication of the shape of the smithing hearth (trench 8,V00533). Two fairly well preserved fragments from a iron/steel one-sided sword or knife were also present (V00087, trench 3) and is recommended for conservation.

BOX 37 (ONRZ09)	Category	Features	Material	Outliers
Trench 4	Mostly corroded objects, some smithing slag and burned clay	3, 14, 17, 22, 25, 33, 36, 37	Fe, ORG	V00220MXX (feature 25): square flat piece of bone/antler looks abrased (as if used as a tool)(26x26x13 mm)
Trench 7	Strange square piece of iron or slag (as if smithed)	1		V00175, 52x50x38.
Trench 10	Mostly corroded objects 1x scrap of copper-alloy	11,13, 29	Fe, Cu+Zn/Sn	V00380MXX (feature 13). Long, pointy piece of copper alloy (looks like zink or bronze) with ragged edge
Trench 12	Mostly corroded objects some greenish yellow slag	24, 75, 90, 95	Fe	
Trench 14	1 x bronze object (has been at Restaura)	1	Cu+Sn	V00541MXX
Trench 15	Mostly objects (corroding),1x burned clay with slag	20, 25, 40, 53	Fe, Fe+clay	V00881MXX (feature 20) Square iron pin, beltgear or ornamentation of horsegear, corroding but heavy & well recognisable; perhaps salvageable.
Trench 17	Corroded object	10	Fe	
Trench 21	Corroded objects (3 iron nails + bronze object)	9,48, 58	Fe, Cu+Sn	1x crumbled bronze object☹ V00900MBR (feature 48)

Trench 26	Corroded objects + 2x vitrified, burned clay	4,5,17,32	Fe Clay	

Conclusion: for box 37 the conservation of V00881MXX (feature 20) is highly recommended, as it seems to be an interesting piece in salvageable condition.
Also: better packaging required for items of bronze!

Box 39 (OSLP10)	Category	Features	Material	Outliers
Trench 31	Mostly slag, some burned clay	1, 2, 4, 5	Fe Fe, Clay	Piece of smithing slag with possible airinlet V00039MXX
Trench 32	Mostly slag, some corroded objects, some vitr. clay	20, 21, 50, 58, 60	Fe	Crucible bottom fragment V0065MXX (feature 21)
Trench 33	Mostly slag, some corroded objects. Piece of lead (scrap?)	6, 7,16, 29, 30,51,57	Fe	Piece of crucible (V00127MXX), white clay?: 13x12x13mm (feature 6) Piece of lead (scrap?): v00145MXX (feature 16) Piece of vitr. clay with green+red discolouration (V00095) feature 6.
Trench 34	Mostly slag, some corroded objects	1	Fe	Ambiguous pieces of slag (production?): V00102MXX, V00113MXX Fragment of silver(?) which may have been used a drawing die (‘trekijzer’) or broken due to tension (U-shaped edge) (V00101MXX)
Trench 36	Mostly slag, some corroded objects, possible fragments	5, 16, 30	Fe	4x small fragments of vitr.clay or fragm. (V00254MXX) 2x cox like material (V00337,

	of crucible.			feature 30, level 2).
Trench 39	Slag and objects	9,11,29, 38,39,43, 44,45,60, 63,66,67, 68,77,80,	Fe, Pb?	Crucible/mouldfragment! V00065MXX 2 fragments of lead pipe(?) (V00366MXX)
Trench 40	Only objects	7	Fe, Pb	2x slag w.vitr.clay(V00353MXX, feature 7) 1x oval piece of lead (V00312MPB)
Trench 42	Mostly objects	45	Fe	10+ fragments of iron object, possibly fitting (V00436MXX)
Trench 43	Mostly corroded objects	-	Fe	
Trench 46	Slag and objects	2, 68, 71, 87	Fe,	4 fragments of iron oject in corrossion(knife?):v00498MXX, in bad condition.
Trench 47	Slag and (corroded)objects	4	Cu+Sn, Fe	Small bronze fragment of fibula (?)(V00755MBR)
Trench 50	Corroded object		Fe	V00521MXX (flat object in corrosion)
Trench 51	Corroded bronze objects	35	Cu+Sn	In bad condition:5x fragments of bronze corroded object(V00555MXX)
Trench 55	Object	9	Fe	Fragment of lightly bend needle or pin (V00707MFE); magnetic.

Conclusion:A mixed content of objects and slag. Yielded some more (previously unknown) crucible fragments. Recommend closer inspection to those items mentioned as outliers, particulary the possible silver piece (trench 34, V00101MXX). Could indicate metallurgical practice of noble metals, or may have come from a bracelot or used as payment (rough silver?).

BOX 49	Category	Features	Material	Outliers
Trench 32	Only slag	21	Fe	
Trench 34	Few corroded objects , mostly (smithing)slag	XX	Fe	
Trench 36	Vitrified clay, slag	30	Fe, Clay	
Trench 39	Vitrified clay w/ slag *possibly prod slag!*	29, 45	Fe, Clay Fe	! this may be productionslag; V01000MSL (feature 29) Size 65x51x35mm. 1x burned clay with possible airinlet (V02010MSL, feature 45)
Trench 43	1xSmithing slag		Fe	
Trench 44	1x corroded object, mostly smithing slag	12	Fe	Check context of V00450MSL and V00452MSL, might be modern
Trench 46	1x object in corrosion	87	Fe	
Trench 47	Object in corrosion, burned clay w/ slag (magnetic)	9, 42, 45		!Crucible/mouldfragment (V00738MSL, feature 45) 22x 15x7,5 mm
Trench 50	(smithing)slag	1, 25, 29	Fe	
Trench 54	Unrecognisable corroded object	28	Fe	V00690MSL
Trench 55	(smithing)slag with burned clay	9, 33	Fe Fe, Clay	
Trench 56	Smithing slag	8, 25	Fe	Big piece smithing slag V00749MSL,feature 25.
Trench 62	One piece of slag	4	Fe	

Conclusion: the content of box 49 may shed a new light on the question wheter iron was produced in Oegstgeest! And it yielded another crucible fragment.

BOX 64 (ONRZ 09/10 MSL)	Category	Features	Material	Outliers
1	Slag (yellowwhite)	5	Fe	V00051MSL, feature 5, locally magnetic
9	Mostly slag	19,22,28	Fe	
10	1x smithing slag	29	Fe	V00417MSL (feature 29) 30x24x19
11	Smithing slag, 1x with burned clay	8, 24	Fe Fe, Clay	V05048MSL, feature 24 (slag with clay) 90x71x36 mm
13	1x slag d.grey	18	Fe	
14	Smithing slag	19	Fe	
17	Vitrified clay, red discolouration	10	Clay	V0797MSL, feature 10
18	Only objects in corrosion	69	Fe	
21	Only corroded objects	37	Fe	
24	Corroded objects	30	Fe	

DATABASE sheets from box 27, 63 and 65 (next pages).

Id	putnr	vlaknr	vondstnr	spoornr	vul	segm	aantal	MAI	Jaar vondst	CAT	SUBCAT	MATERIAAL	Lengte (mm)	Breedte (mm)	Dikte (mm)	Buitendiameter	Binnendiameter (mm)	Compleetheid (%)	Oppervlak	Bewerking	Magnetisch?	publicatiecode
20621	10	1	5038	0	0	0	2	2	2010	MXX	BIJZM	CU, ZN			1,2	11,3 - 21		100%	patina	geslagen	nee	stortvondst
20622	11	1	5045	0	0	0	1	1	2010	MXX	BIJZM	CU, ZN			1,2	ca. 21		100%	patina	geslagen	nee	stortvondst
20623	12	1	5039	0	0	0	1	1	2010	MXX	BIJZM	CU, ZN			1,1	ca. 20		100%	patina	geslagen	nee	stortvondst
20624	1	1	55	2	1	2	1	1	2010	MXX	MFE	FE	>77	< 31	< 9			30% ?	corrosie	gesmeed	ja	spoor 2
20625	1	1	51	5	2	2	1	1	2010	MXX	MFE	FE	>37	<42 mm	<26			?	corrosie	?	ja	spoor 5
20626	24	1	1026	35	1	1	1	1	2010	MXX	MFE	FE	>59,5	>33	ca.18,5	ca.11		80%?	corrosie	gesmeed	ja	spoor 35
20627	24	1	1027	35	2	2	1	1	2010	MXX	MXX	FE	>37,8	> of = 10	2,35			75%	corrosie	gesmeed	ja	spoor 35
20628	24	1	1012	36	2	2	1	1	2010	MXX	MFE	FE	>27	>36	ca. 8			10?	corrosie	gesmeed	ja	spoor 36
20629	8	2	662	1	0	1	1	1	2010	MXX	MSL	FE	ca.86	ca. 67	ca. 32,9			100%	enige roest, aanslag	gesmolten	ja	spoor 1
20630	9	1	337	22	1	1	1	1	2010	MXX	MSL?	FE	ca. 41	ca. 27	ca. 12			?	enige roest, aanslag	?	ja	spoor 1
20631	9	1	322	22	3	2	1	1	2010	MXX	MPB	PB	>23,55	ca. 8,8	ca. 5,6			100%	patina	gegoten	nee	spoor 22
20632	9	1	364	22	2	2	9	9	2010	MXX	MSL	FE	20 - 60	13 - 41	11-19			100%	patina	gesmolten	ja	spoor 22
20633	9	1	320	27	3	2	1	1	2010	MXX	MSL?	FE	ca.54	ca.44	ca.34,4			100%	enige roest, patina	gesmolten?	ja	spoor 27
20634	9	1	349	28	3	2	1	1	2010	MXX	MFE	FE	ca.14,2	ca.21	ca.9			?	enige roest	gesmeed	ja	spoor 28
20635	9	1	317	27	1	1	1	1	2010	MXX	MSL	FE	ca. 70	ca.56	ca. 21			100%	patina	gesmolten	ja	spoor 27
20636	9	1	366	22	4	2	1	1	2010	MXX	MFE	FE	>37	ca.32	<18,3	>5,7		50%	eniroest, corrosie	gesmeed	ja	spoor 22
20637	9	1	326	28	1	2	5	5	2010	MXX	MSL	FE	12,3 - 32,4	9 - 22,2	9,2- 18,4			?	enige roest, patina	gesmolten	ja	spoor 28
20638	9	1	276	28	1	2	1	1	2010	MXX	MSL?	?	22	20	ca.11,5			10%?	patina	?	nee	spoor 28
20639	9	1	327	19	1	1	2	1	2010	MXX	MSL	FE	68,3	52,6	30,4			?	patina	gesmolten	ja	spoor 19
20640	9	1	328	19	2	1	3	3	2010	MXX	MSL?	FE	12,4-33,1	7,2-26,4	5-16			?	patina	gesmolten	ja	spoor 19
20641	9	1	336	19	2	2	13	12	2010	MXX	MSL	FE en MXX?	16-58	12,8-29,6	4-27,6			?	patina	gesmolten	ja	spoor 19
20642	9	1	324	22	2	2	1	1	2010	MXX	MSL	FE	26,7	21,6	19			100%	enige roest	gesmolten	ja	spoor 22
20643	9	1	351	22	2	2	5	3	2010	MXX	MSL	FE	14,3-76	15-38	11-39			?	patina	gesmolten?	ja	spoor 22
20644	9	1	323	22	3	2	4	3	2010	MXX	MSL	FE	8-34,3	10-25	11-18,6			100%	patina	gesmolten	ja	spoor 22
20645	25	1	1082	7	2	2	1	1	2010	MXX	MSL	FE	51,6	41	20			100%	patina	gesmolten	ja	spoor 22
20646	25	1	1069	1	2	2	1	1	2010	MXX	KER	KER	klein					?	?	gebakken	nee	spoor 7
20647	25	1	1062	1	1	1	1	1	2010	MXX	MFE	FE	76	n.v.t	<12,4			5%	corrosie	gesmeed	ja	spoor 1
20648	28	1	2029	4	1	1	1	1	2010	MXX	MSL	FE	ca. 52	ca. 45, 4	ca. 35			100%	patina	gesmolten	ja	spoor 4
20649	23	1	1025	3	2	2	1	1	2010	MXX	KER	KER	klein	-	-				-	gebakken	nee	spoor 3
20650	23	1	993	3	2	2	5	1	2010	MXX	MFE	FE	> 47	<-6,5-<20				?	corrosie	gesmeed	ja	spoor 3
20651	23	1	1024	3	1	2	1	1	2010	MXX	MFE	FE	>41	<11	ca.8			60%?	corrosie	gesmeed	ja	spoor 3
20652	23	1	998	4	3	2	3	1	2010	MXX	MBR	CU, SN	klein					?	patina	gegoten	nee	spoor 4
20653	23	1	990	4	2	2	1	1	2010	MXX	MFE	FE	>22,5	<5,4	3,7-8			70%?	corrosie/sediment	gesmeed	ja	spoor 4
20654	29	1	5034	1	1	2	1	1	2010	MXX	MFE	FE	<27	<22,5	<20			?	corrosie	gesmeed		spoor 1
20655	29	1	2064	2	1	2	2	2	2010	MXX	MSL	FE	21-27,5	16-19,5	11-20			100%	-	gesmolten	ja	spoor 2
20656	18	1	919	73	3	2	1	1	2010	MXX	MSL?	?	53	42,8	31			100%	patina	gesmolten	nee	spoor 73
20657	18	1	974	70	1	0	1	1	2010	MXX	MSL	FE	60	43	26			100%	enige roest, corrosie	gesmeed?	ja	spoor 70
20658	27	1	2017	4	1	1	1	1	2010	MXX	MSL	FE	20	19	18			100%	enige roest	gesmolten	ja	spoor 4
20659	27	1	2011	10	1	0	2	2	2010	MXX	MSL?	FE	51-73	33-63	19-23			100%?	enige roest, patina	gesmolten	ja	spoor 10
20660	11	1	431	30	1	2	1	1	2010	MXX	MSL	FE	77	63	34			60%?	enige roest	gesmolten	ja	spoor 30
20661	11	1	398	8	3	2	2	1	2010	MXX	MXX	?	35	20	<4			33%	corrosie	?	nee	spoor 8
20662	11	1	5045	0	0	0	1	1	2010	MXX	MPB	PB	23	15	6			?	patina	gegoten, gesmeed	nee	stortvondst
20663	11	1	405	8	3	2	9	3	2010	MXX	MFE	FE	14->55	4-ca.19	4			20-70%	corrosie, roest	gesmeed	ja	spoor 8
20664	11	1	399	24	1	1	2	1	2010	MXX	MFE	FE	<27	<26	<13			90%	corrosie	gesmeed	ja	spoor 24
20665	11	1	406	8	5	2	2	1	2010	MXX	MFE	FE	<85	<10-<36	<12-<26	ca.4,8		99%?	corrosie	?	ja	spoor 8

Id	putnr	vlaknr	vondstnr	spoornr	vul	segm	aantal	MAI	Jaar vondst	CAT	SUBCAT	MATERIAAL	Lengte (mm)	Breedte (mm)	Dikte (mm)	Buitendiameter	Binnendiameter (mm)	Compleetheid (%)	Oppervlak	Bewerking	Magnetisch?	publicatiecode
20666	11	1	5046	0	0	0	1	1	2010	MXX	MBR?	Cu, Sn	ca.7,5	ca. 7	ca.2,7			?	patina	gegoten, gevijld/gezaagd	nee	stortvondst
20667	11	1	428	24	2	2	1	1	2010	MXX	MFE	FE	>57	<17	3-13			?	corrosie	gesmeed	ja	spoor 24
20668	11	1	5035	24	1	1	1	1	2010	MXX	MSL?	?	32	22	11			100%	aanslag	gesmolten	nee	spoor 24
20669	11	1	404	8	5	2	3	3	2010	MXX	MSL?	?	26-51	19-49	10,5-34			95%	patina	gesmolten	nee	spoor 8
20670	34	2	97	1	0	0	1	1	2010	MXX	Cu, Zn	Cu, Zn				ca.15		100%	patina	gegoten	nee	spoor 1
20671	14	1	483	10	1	1	2	1	2010	MXX	MFE	FE	<52,7	<31	<27,7			?	?	?	ja	spoor 10
20672	14	1	503	20	1	1	1	1	2010	MXX	MXX	FE	30	27	17			100%	roest	gesmolten?	ja	spoor 20
20673	14	1	536	24	2	2	3	1	2010	MXX	MFE	FE	28	17	<12	16,4	<11,7	90%	corrosie	gesmeed	ja	spoor 24
20674	14	1	537	24	6	2	5	1	2010	MXX	MFE	FE	30	23,5	20			80%?	enige roest, patina	gesmeed	ja	spoor 24
20675	14	1	538	24	6	2	1	1	2010	MXX	MFE	FE	>33	>32	ca.20			?	roest	?	ja	spoor 24
20676	14	1	492	13	1	1	13	0	2010	MXX	KER	KER	8-30	5-27				?	-	handgevormd	nee	spoor 13
20677	14	1	573	13	1	2	4	1	2010	MXX	MFE	FE	ca.27	ca.5,7	ca.4,5			70%?	corosie, roest	gesmeed	-	spoor 13
20678	14	2	577	1	7	2	3	1	2010	MXX	MFE	FE	>78	<7	<7	<7		75%?	corrosie, roest	gesmeed	?	spoor 1
20679	14	1	583	10	4	2	2	2	2010	MXX	MFE?	FE?	32	22,4-31,5	<24-30			?	roest, sediment	?	nee	spoor 10
20680	14	1	586	10	1	1	3	1	2010	MXX	MFE	FE	31	21	<5			?	roest, aanslag	gesmeed?	ja	spoor 10
20681	14	1	603	4	1	2	1	1	2010	MXX	MFE	FE	118,2	95	59			15%	roest, aanslag	gesmolten	ja	spoor 4
20682	14	1	646	20	2	1	1	1	2010	MXX	MFE	FE	>23	12	5			80%?	corrosie	gesmeed	-	spoor 20
20683	14	1	692	19	1	8	1	1	2010	MXX	MFE?	FE?	24.6	21,2	12,5			?	roest	?	ja	spoor 19
20684	14	2	771	17	8	2	1	1	2010	MXX	MFE	FE	23	20	12,5			?	corrosie	gesmeed?	ja	spoor 17
20685	14	1	759	17	4	2	1	0	2010	MXX	MFE	FE	45	38	29			?	enige roest, patina	?	ja	spoor 17
20686	12	1	5039	0	0	0	1	1	2010	MXX	MXX	Cu, Zn?	24	17,5	2			100%	patina	gegoten	nee	stortvondst
20687	12	1	5039	0	0	0	1	1	2010	MXX	TIN?	SN?	21,3	13	3,5			15%	patina?	gesmeed?	nee	stortvondst
20688	24	1	1026	35	1	1	1	0	2010	MXX	MFE	FE	ca.62	<51	<25,5			?	corrosie	gesmeed?	Ja	spoor 35
20689	9	1	366	22	4	2	1	1	2010	MXX	MSL	FE	ca.49	ca.36	ca.37			100%	corrosie,roest	gesmolten	Ja	spoor 22
20690	9	1	351	22	2	2	1	1	2010	MXX	MFE	FE	ca. 50	ca.40	30			?	corrosie	?	Ja	spoor 22
20691	9	1	351	22	2	2	1	1	2010	MXX	MFE	FE	< 45 (?)	< 27	<19			?	corrosie	?	ja	spoor 22
20692	25	1	1062	1	1	1	1	1	2010	MXX	MFE	FE	65	39,4	32			?	corrosie, enige roest	gesmeed?	ja	spoor 1
20693	25	1	1062	1	1	1	1	1	2010	MXX	MFE	FE	83	40	30			99%	patina	gesmolten	ja	spoor 1
20694	11	1	404	8	5	2	1	1	2010	MXX	MFE	FE	<42	28	30			95%?	enige roest, patina	gesmolten	ja	spoor 8
20695	11	1	398	8	3	2	1	1	2010	MXX	MFE	FE	<42	<30- <20	19			?	corrosie	?	ja	spoor 8
20696	11	1	398	8	3	2	1	1	2010	MXX	MFE	FE	44	58	28			100%	patina?	gesmolten?	ja	spoor 8
20697	14	2	771	17	8	2	1	1	2010	BOT	BOT	ORG	24	15	7			?	onverbrand	n.v.t.	nee	spoor 17
20698	14	2	771	17	8	2	1	1	2010	ORG	ORG?	ORG	22	20	10			?	?	?	nee	spoor 17
20699	10	1	5038	0	0	0	1	1	2010	MXX	BIJZM	CU, ZN	19,3	18,7	0,7	ca.19		99%	patina	geslagen	nee	stortvondst
20700	12	1	5039	0	0	0	0	0	2010	MXX	BIJZM	CU, ZN	20	18,7	0,65	ca.20		99%	patina	geslagen	nee	stortvondst
20811	23	1	993	3	2	2	1	1	2010	MXX	MFE	FE	<28	<25	<21			?	corrosie	gesmeed	nee	spoor 3
20812	23	1	1024	3	1	2	1	0	2010	MXX	MFE	FE	69	37	<32			?	corrosie	gesmeed?	ja	spoor 3
20813	23	1	1025	3	2	2	1	1	2010	MXX	MFE	FE	30	<14- < 7,5	<6,5	<7,5	< 14	50%	corrosie	gesmeed	ja	spoor 3
20814	23	1	1025	3	2	2	1	1	2010	MXX	MSL	FE	46	38	19			100%	enige roest	gesmolten	ja	spoor 3
20815	29	1	2	2	1	2	2	2	2010	MXX	KER? MXX?	?	ca.25-27	ca.14-7,5	ca.8			?	patina	?	nee	spoor 2

ID	Voorwerp	Functie	Groep	Decoratie	literatuur	teknr	foto	Determinatie	Datering	doosnr	omschrijving	extra opmerking
20621	munt	betaalmiddel	geld	tekening, tekst	Purmer& Wiel (2007)	0		A. Pol	1823 en 175(4)	63	2 munten groen uitgeslagen.A. Pol: 1x 1/2 cent Nederland Willem I 1823, 1x Holland Duit 175(4) (Purmer& Wiel 2007).	De kleinste maat betreft de 1/2 cent Willem I Nederland
20622	munt	betaalmiddel?	geld	tekening(?)		0		A. Pol	18e eeuw	63	1 munt, slecht leesbaar. Groen uitgeslagen, koperlegering? Gedetermineerd door Dhr. A. Pol d.d. 19-01-2012	A. Pol: Duits? 18e eeuws (mogelijk Keuls of Kleefs)
20623	munt	betaalmiddel	geld	tekening en tekst	Purmer & Wiel (1010)	0		A. Pol	1619	63	1x Gelderland Duit 1691 (Purmer & Wiel 1010), gedetermineerd door Dhr. A.Pol dd. 19-1-2012	Koperlegering? Tekening toont wapenschild op één kant en aan de andere kant tekst GELRE **91 (via literatuur datering vastgesteld)
20624	mes/zwaard?	wapen?	?	Nee		0		M.D. Talma	merovingisch	63	Fragment van een mes, zwaard of speer? Roestig met concretie/corrosielagen, blazen. Lijkt versterkt met staal, opbouw in 3 lagen.	Opbouw in 3 lagen, versterkt met staal in het midden?
20625	?	?	?	?	n.v.t.	0		M.D. Talma	merovingisch?	63	Onherkenbaar ovaal object in corrosielaag/blazen. Aan één zijde vierkant gat zichtbaar.Iets buidelvormigs? Röntgen?.	NB. Ws uitgecorrodeerde spijker
20626	bout?	gereedschap?	nijverheid?	Nee	n.v.t.	0		M.D. Talma	merovingisch	63	Een fragment van een voorwerp met afgeronde steel, mogelijk een flinke spijker/bout, of wellicht een deel van een lepel. Corrosielagen en blazen.	
20627	deel schede?	opbergen	militaria?	Nee	n.v.t.	0		M.D. Talma	merovingisch	63	Fragment van een ovaal, mogelijk stripvormig/hol object, aan een zijde bladerdeegachtig oppervlak, moeilijk te zeggen hoever doorloopt.Ook corrosieblazen.Mogelijk van een schede voor mes of zwaard?breedte binnenk:12,7 mm	
20628	mes/zwaard?	mes?	militaria?	?	n.v.t.	0		M.D. Talma	merovingisch	63	Mogelijk deel van mes of zwaard (of plaatvormig object), vrij plat in corrosielaag met blazen, enige roest en grijsblauwe aanslag. Glimmende doorsnede, donkergrijsblauw aan randen, roodbruine kern. RÖNTGEN?	
20629	smeedslak	ijzerbewerking	nijverheid	n.v.t.	evt. Tylecote?	0		M.D. Talma	merovingisch	63	Groot,ovaal massief blok ijzer,sterk magnetisch, grotendeels grijsblauw, met enig witgroene aanslag en roestige aanslag, op enkele plekken turquoise en witte aanslag.Onregelmatig oppervlak, uit haard(ijzerwinning)?een kant plat	smeedslak laat vorm en grootte haard zien
20630	slak?	ijzerbewerking?	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Slak of vrij plat voorwerp, donkerblauwgrijs met roestige vlekken, oogt sterk gedegradeerd, broos.	
20631	baartje	metaalbewerking	nijverheid	n.v.t		0		M.D. Talma	merovingisch	63	Langwerpig voorwerp van lood, plat aan één kant, bol aan de andere kant (determinatie metaal d.m.v. XRF d.d. 24-01-2012)	
20632	slak	ijzerbewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Slakmateriaal van ijzer. Oppervlak glimt plaatselijk. Donkerblauwgrijs van kleur, soms aan andere zijde lichtgrijs uitgeslagen. Sommige stukken zijn paars-rood uitgeslagen, hier lijkt ook meer metaal in te zitten.	7 van de 9 stukken reageren magnetisch; overige 2 stukken lijken ook ijzerslak, maar weinig metaalgehalte.
20633	slak?	ijzerbewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Waarschijnlijk slakmateriaal. Donkergrijsblauw oppervlak, met lichtgrijze uitslag en roestplekken(?).	
20634	?	?	?	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Vrij klein plat object, zeer broos.Deel van oppervlak afgebroken en in zak aanwezig.Oppervlak is	Niet zeker of sprake van plaatopbouw of door slechte

ID	Voorwerp	Functie	Groep	Decoratie	literatuur	teknr	foto	Determinatie	Datering	doosnr	omschrijving	extra opmerking
											donkergrijsblauw, binnenkant roestig.Niet opgemeten vanwege broosheid. Mogelijk deel van een mesje o.i.d Plaatopbouw: wellicht met staal versterkt?	conservering uit elkaar gevallen? Mogelijk deel mesje?
20635	slak	ijzerproductie/bewerking	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Slak? Niet heel glimmend, overwegend lichtgrijs. Aan een zijde ronde vorm, voor de rest hoekig.	
20636	spijker?	gereedschap	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Waarschijnlijk een spijker (opgemeten), een deel afgebroken. Donkergrijsblauw, enige roest.	
20637	slak	ijzerproductie/bewerking	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	5 fragmenten slak. Donkergrijs met lichtgrijze aanslag en roestplekjes. Reageren allen magnetisch, sommige sterker dan anderen.	
20638	?	?	?	nee	n.v.t.	0		M.D. Talma	merovingisch	63	Massief buisvormig fragment, glimmend, blauwmiddengrijs oppervlak- misschien toch slak? Geen idee. Heft ook iets weg van bot.	
20639	slak	ijzerproductie?	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Waarschijnlijk slak, bolle zijde aan één kant Misschien van bodem haard.Onderzijde oogt keramischer en afgeplat, reageert magnetisch.	De twee fragmenten horen bij elkaar.
20640	slak	ijzerproductie/bewerking	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Mogelijk slak of verkitte as, vrij licht. Middengrijsblauw, met lichtere plekken en enkele paarsrode vlekken.	Alle stukken reageren magnetisch, twee van de 3 stukken lichtjes anderen sterker.
20641	slak	ijzerproductie/bewerking	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Stukjes slak, kleur varierend van lichtgrijs, middengrijs naar donkergrijs. De donkergrijze stukken zijn zwaarder, waarschijnlijk rijker in metaal. Tevens paarsrode verkleuring. Hier en daar glimmend oppervlak. Blast furnace slak?	3 van de 12 stukken reageren sterk magnetisch, 5 van de 12 stukken licht magnetisch en 4 van de 12 stukken reageren niet magnetisch.
20642	slak	ijzerbewerking	nijverheid	n.v.t	n.v.t.	0		M.D. Talma/ I.Joosten	merovingisch	63	Verslakte as (I. Joosten d.d. 19-1-2012), Vrij zwaar, donkerblauwgrijs. Reageert magnetisch.	
20643	slak	ijzerproductie/bewerking	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	5 stuks slak , reageren allen magnetisch.	
20644	slak	ijzerproductie/bewerking	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Slak. Paarsrood oppervlak, met witgrijze aanslag. Enigszins glimmend oppervlak. Ook twee bij elkaar horende fragmenten van een wittig stukje slak (verkitte as?). Laatste reageert niet magnetisch.	
20645	slak	ijzerproductie	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Dit ziet eruit als haardslak, kaarsvetachtige vorm met indrukken waar mogelijk organisch materiaal heeft gezeten, oogt heel metalisch en reageert magnetisch.	
20646	gietvorm?	metaalbewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Dit ziet eruit als keramiek, wellicht bodem van gietvorm (het is vrij spits)? Enig residu zichtbaar, aan buitenkant groen en paarsrood uitgeslagen. XRF analyse op uitvoeren.	eerste resultaat XRF: messing gebruikt (koper en zink); moet nog exact worden opgemeten, nu in andere doos geplaatst!
20647	ketel	voedselbereiding	huishouden	nee		0		M.D. Talma	merovingisch	63	Vrij groot fragment, licht gebogen waarschijnlijk rand van een ketel.	RÖNTGEN!
20648	smeedhaardslak	ijzerbewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Vrij massief stuk slak, vrij hoekig en regelmatig, wellicht haardslak (bodem), aan één vlakke zijde redelijk magnetisch	
20649	smeltkroes/gietvorm	metaalbewerking	nijverheid	nee		0		M.D. Talma	merovingisch	63	Een stukje KER van smeltkroes/gietvorm (d.d.8-3-2012, niet in vondstzakje MXX, nu bij KER?)	opmeten nu niet mogelijk omdat stukje hergeplaatst is elders (waarschijnlijk KER).
20650	?	?	?	?		0		M.D. Talma	merovingisch	63	1 buisvormig fragment(1,5 cm lang, magnetisch hoort bij ovaalvormig object (3 cm) waarin buis nog te zien is.Veel corrosie omheen.	

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20651	haak	opbergen	huishouden?	?		0		M.D. Talma	merovingisch	63	haakvormig fragment in corrosie (hierdoor slecht zichtbaar)echter denk ook aan een haakje, het uiteinde komt uit in een punt. Geen flinke haak voor scheepstouwen o.i.d., vermoed eerder huishoudelijke functie.	
20652	fibula?	sluiting	versiering	?		0		M.D. Talma	merovingisch	63	3 fragmenten van cilindrisch object (koperlegering, groen uitgeslagen). Zeer fragiel, gedegradeerd, fragmenten passen bij elkaar (Fibula?),Geen versiering zichtbaar.In plastic doos in doos 63.	te fragiel om op te meten
20653	spijker?	gereedschap	nijverheid			0		M.D. Talma	merovingisch	63	Cillindrisch, conisch object in corrosie/sediment, wellicht een spijker.Sterk magnetisch.	
20654	?	?	?			0		M.D. Talma	merovingisch	63	brokje waar een buisvormig stuk ijzer in lijkt te zitten,dit reageert magnetisch. Heeft dit verband met vondstnummer 933?	
20655	slak	ijzerproductieg/bewerking	nijverheid			0		M.D. Talma	merovingisch	63	2 brokjes slak, het grotere fragment grillig en magnetisch, het kleinere afgerond, schuimig, reageert niet magnetisch.	
20656	slak	ijzerproductie/bewerking?	nijverheid	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	Vrij groot brok slakmateriaal (?), ziet er vooral zandig/keramisch uit, lijkt ook wat metaal in te zitten maar reageert niet magnetisch,	
20657	object in corrosie	?	?	n.v.t.	n.v.t.	0		M.D. Talma	merovingisch	63	1 relatief groot object in corrosie, vrij zwaar, metaal zichtbaar, sterk magnetisch (vooral onderkant). Vrij platte onderkant.	
20658	verslakt steentje	ijzerbewerking	nijverheid			0		M.D. Talma	merovingisch	63	1 brokje slak, driehoekig van vorm, donkergrijsblauwpaarsig van kleur. Sterk magnetisch.	
20659	smeedslak	ijzerbewerking	nijverheid?			0		M.D. Talma	merovingisch	63	2 stukken slak(?), met concave en convexe vorm, sterk magnetisch. Paarsig blauw met witte uitslag en roestvlekken.	met uitstulping waar tuyere heeft gezeten!
20660	smeed/productieslak	ijzerproductie/bewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Vrij groot stuk slak, sterk magnetisch, op één kant (de onderkant) niet. Grijsblauwig van kleur met roestplekken.	Ambigue stuk, kan zowel productie als smeedslak zijn. Op basis van andere slakvondsten waarschijnlijk smeedslak.
20661	lepelbak	eetgerei	huishouden	?		0		M.D. Talma	merovingisch?	63	2 fragmenten van onbekend metaalsoort die bij elkaar horen (wellicht lepelbak).Niet magnetisch.	
20662	?	?	?	nee		0		M.D. Talma	?	63	1 ovaal plat stukje lood met uitstulping, plat aan de onderkant (alsof op een plaat of de grond gegoten), randje ziet gesmeed uit. Wit uitgeslagen.	
20663	spijker	gereedschap	nijverheid	Nee		0		M.D. Talma	merovingisch	63	Een aantal spijkers en fragmenten van spijkers.1 lijkt vrij compleet (45 mm lang, 3,5 mm breed). Ik zie fragmenten van 4 spijkers. Objecten zijn vrij fragiel en deels gehuld in corrosielaag.	
20664	beslag?	versiering?	versiering?	?		0		M.D. Talma	merovingisch	63	1 vierkant, plat/kussenvormig object met uitstulping. Magnetisch, gehuld in corrossielaag met barsten (lichtgroengrijs). Het andere fragment hoort erbij, bij blootgestelde laag ijzer zichtbaar.	mogelijk piramide beslag?
20665	?	?	?	?		0		M.D. Talma	merovingisch	63	1 langwerpig cillindrisch object met bol uiteinde (twee fragmenten horen bij elkaar). Gehuld in corrosielaag.	Aanbeveling Röntgen!
20666	fibula?	sluiting?	versiering?	mogelijk		0		M.D. Talma	?	63	1 klein plat fragment van een object van koperlegering, duidelijk bewerkt (met groeven en platgevijlde stukjes), wellicht een deel van een fibula? (om angel aan achterkant op te laten rusten?)	.

ID	Voorwerp	Functie	Groep	Decoratie	literatuur	teknr	foto	Determinatie	Datering	doosnr	omschrijving	extra opmerking
20667	?	?	?			0		M.D. Talma	merovingisch	63	Lang, dun cillindrisch object, lijkt vrij lang voor een spijker maar het zou kunnen. De kop is niet duidelijk zichtbaar.	
20668	slak	ijzerproductie/bewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Schuimig, slakachtig materiaal. Niet-magnetisch.Enig houtskool zichtbaar. Lichtgrijsblauwpaarsig van kleur, met enige roestige vlekken.	
20669	slak	ijzerbewerking?	nijverheid	nee		0		M.D. Talma	merovingisch	63	Schuimig slakachtig materiaal met gelig uiterlijk.	
20670	baartje	metaalbewerking	nijverheid			0		M.D. Talma	merovingisch	39	(OSLP10), Omschreven als goud, twijfel hier over.XRF analyse d.d.23-2-2012 wijst ook op messing.	Houdt mogelijk verband met de smeltkroesjes waarin ook messing aangetroffen is, vondstnummers
20671	?	?	?	?		0		M.D. Talma	merovingisch	63	Een langwerpig stukje metaal dat ingebed zit in sediment/ corrosielaag. In het midden is de buitenste laag van het metaal weggecorrodeerd. Het reageert licht magnetisch. Verder een klompje sediment (ca 17 mm) waar misschien iets in zit, niet magnetisch.	
20672	slak?	ijzerbewerking?	nijverheid?	n.v.t.		0		M.D. Talma	merovingisch	63	Een plat afgerond object met lichtgrijsgroene aanslag, vorm onherkenbaar.Het voelt vrij zwaar, er zou wel een object in kunnen zitten. Het reageert magnetisch.	
20673	spijker	gereedschap	nijverheid			0		M.D. Talma	merovingisch	63	Het betreft een bout of spijker die grotendeels in concretie zit.Van de kop is een stuk afgebroken (waarschijnlijk om te zien wat erin zit), Het oogt roestig.	buitendiameter is kop van de spijker, binnendiameter is de 'naald'.
20674	spijker?	gereedschap?	nijverheid?	?		0		M.D. Talma	merovingisch	63	5 fragmenten van een voorwerp (spijker?) die bij elkaar horen. 3 fragmenten reageren magnetisch, de rest niet. Vorm: deel van spijker met deel van bovenkant (kop)	
20675	?	?	?	?		0		M.D. Talma	merovingisch	63	Fragment van een object van ijzer, lijkt of dubbelgeklapt of dubbelwandig te zijn, buitenkant heeft een groen/grijze aanslag maar reageert wel licht magnetisch.	
20676	gietmal?	metaalbewerking	nijverheid	functioneel:indrukken.		0		M.D. Talma	merovingisch	63	13 fragmenten van onbekend materiaal, vermoedelijk keramisch. Er zijn indrukken zichtbaar, vermoedelijk zijn dit fragmenten van een gietmal, maar vooralsnog slecht in elkaar te puzzelen.Vrij kleine fractie, met grillig oppervlak,ook gaatjes te .	mogelijk fragmenten van een gietmal XRF sessie 3?
20677	spijker?	gereedschap?	nijverheid?			0		M.D. Talma	merovingisch	63	Het betreft een vrij klein, smal langwerpig fragment van ijzer dat zeer broos is. Misschien restant spijker of angel (van sluiting)?	
20678	spijker?	gereedschap?	nijverheid?			0		M.D. Talma	merovingisch	63	Langwerpig stuk ijzer in corrosielaag, waarschijnlijk een flinke spijker.	
20679	?	?	?	?		0		M.D. Talma	merovingisch	63	Twee brokken sediment waar metaal in zit (lijkt ijzer, reageert niet magnetisch). Een van de stukken heeft een soort gleuf dat taps toe loopt.	weet niet hoe goed röntgen hier mogelijk is i.v.m. dichtheid omliggende sediment.
20680	mes?	?	?	?		0		M.D. Talma	merovingisch	63	Enigszins driehoekig, plaatvormig fragment. Lijkt op uiteinde van een mes, kan ook iets anders zijn want is over de breedte licht verbogen.	
20681	smeedslak	ijzerbewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Groot blok ijzerslak met corrosie of sediment eraan vast. Gezien enige hoekige vorm zou het gevormd kunnen zijn op de bodem van een haard. De buitenkant heeft lichtgrijsgroene aanslag + roest.	Slag cake, laat vorm smeedhaard zien.
20682	angel?	sluiting	kleding			0		M.D. Talma	merovingisch	63	Klein conisch fragment, mogelijk van een angel (van gesp o.i.d.) of deel van een spijker(het is wel vrij plat). Er	

ID	Voorwerp	Functie	Groep	Decoratie	literatuur	teknr	foto	Determinatie	Datering	doosnr	omschrijving	extra opmerking
											zit een corrosielaag omheen en het oogt broos.	
20683	?	?	?	?		0		M.D. Talma	merovingisch	63	klein onherkenbaar fragment van een voorwerp,heeft oranje/roestige kleur en reageert magnetisch.	
20684	?	?	?	nee		0		M.D. Talma	merovingisch	63	Een kussenvormig, halfrond stukje ijzer, sterk verweerd en slecht herkenbaar.	
20685	?	?	?	?		0		M.D. Talma	merovingisch	63	Een stuk ijzer, aan de buitenkant grijsgroen uitgeslagen, verweerd. Kern oogt roestig en reageert magnetisch. Onderkant enigszins regelmatige hoek, misschien gevormd op bodem van smeltoven/kuil of zodanig gesmeed?	
20686	gesp	kleding, schoen	sluiting	nee		0		M.D. Talma	18e eeuw?	63	Kleine gesp, beetje een 8-vorm, inclusief angel. Oogt ca. 18e eeuw, mogelijk van een schoen.	
20687	lepelbak	eetgerei	eetgerei	nee		0		M.D. Talma	?	63	Fragment van een lepelbak (klein deel van steel en bak), Wellicht tin.	
20688	?	?	?	?	n.v.t.	0		M.D. Talma	merovingisch	63	Onherkenbaar object in corrosielaag, klein deel steekt uit (plat, langwerpig?) dit reageert magnetisch.	
20689	object in corrosie	ijzerbewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	object in corrosie, enigszins conisch, donkerblauwgrijs en lichtgrijs met roestplekken, onderkant reageert magnetisch.	
20690	?	?	?	?	n.v.t.	0		M.D. Talma	merovingisch	63	Onherkenbaar plat voorwerp in corrosielagen. Vermoedt niet dat röntgen iets oplevert i.v.m. massiefheid corrosie.	
20691	sleutel?	afsluiten	huishouden		n.v.t.	0		M.D. Talma	merovingisch	63	langwerpig object in vrij dikke corrosielaag, Deel ontbloot. De vorm doet een beetje aan een sleutel denken maar ben niet geheel overtuigd. Lastig te zien, uiteinde (in corrosielaag) zal vermoedelijk rond zijn geweest, uitstekend deel is langwerpig.	
20692	?	?	?	?		0		M.D. Talma	merovingisch	63	langwerpig halfrond (of ingeklapt) object in corrosielaag, onherbaar.	
20693	smeedslak	ijzerbewerking	nijverheid	n.v.t.		0		M.D. Talma	merovingisch	63	Een stuk slak met veel ijzer erin, waarschijnlijk smeedslak.	
20694	?	?	?	n.v.t.		0		M.D. Talma	merovingisch	63	Enigszins vierkant object in corrosielaag met puntig uitsteeksel, onherkenbaar.	
20695	spijker/ bout	gereedschap?	nijverheid	?		0		M.D. Talma	merovingisch	63	Cillindrisch object met grotere kop (wellicht bout in corrosie)	
20696	?	?	?	?		0		M.D. Talma	merovingisch	63	afgeplat halfrond schuimachtig stukje slak, met uitstekend stukje ijzer. Dit reageert magnetisch.	
20697	bot	?	bot	n.v.t.		0		M.D. Talma	merovingisch	63	stukje bot (puntig, afgebroken), slecht te zien of het evt een werktuig is geweest, vermoedelijk niet. Per abuis bij metaal terecht gekomen.	
20698	?	?	?	nee		0		M.D. Talma	merovingisch	63	Dit oogt organisch, maar ik zou ernaast kunnen zitten. Het is een dubbelwandig fragment dat in een punt toeloopt en waarvan een deel afgebroken is. Geen idee wat het is.	
20699	speelpenning	amusement	amusement	tekening en tekst		0		A. Pol	18e eeuw	63	Speelpenning 18e eeuws Neurenberg (determinatie A.Pol 19-01-2012), van een koperlegering.Decoratie: plantmotief aan een zijde, en "koningsportret" aan andere zijde, en streepjes haaks op de rand.	
20700	speelpenning	amusement	amusement	tekening en tekst		0		A. Pol	1711-1725	63	1 x speelpenning Jakob Johann Dietzel 1711-1725 Neurenberg (determinatie A. Pol 19-01-2012)	
20811	buisje?	?	?			0		M.D. Talma	merovingisch	63	grillig rechthoekig fragment met roestige kleur waarin mogelijk een klein buisje in zit, mogelijk hoort dit bij de	

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											andere fragmenten van dit vondstnummer, maar past er niet direct aan.	
20812	?	?	?			0		M.D. Talma	merovingisch	63	groter fragment van voorwerp, licht gebogen en in dikke corrosielaag. Slecht herkenbaar. Wel magnetisch.	
20813	spijker	gereedschap	nijverheid			0		M.D. Talma	merovingisch	63	waarschijnlijk fragment van een spijker in corrosielaag	
20814	slak	ijzerproductie/bewerking	nijverheid			0		M.D. Talma	merovingisch	63	relatief plat fragment, enigszins 5 hoekige vorm, ik vermoed toch slakmateriaal.Reageert heel licht magnetisch.	
20815	?	?	?			0		M.D. Talma	merovingisch	63	twee cillindrische fragmenten (één met dubbele cillinder) die afgebroken lijken te zijn. Op de breuk zijn gaatjes zichtbaar.Ze lijken qua kleur en vorm bij elkaar te horen maar passen niet op elkaar.Niet magnetisch, oogt meer keramisch dan metalisch	

Id	putnr	vlaknr	vondstnummer	spoornr	vul	segm	aantal	MAI	CAT	SUBCAT	Lengte (mm)	Breedte (mm)	Dikte	Buitendiameter (mm)	Binnendiameter (mm)	decoratie	periode	dat begin	dat eind	literatuur	teknr	foto	doosnr
20621	83	1	423	56	3	0	1	1	MXX	MPB			6,8	34	9,4	geen	merovingisch				1		27
20622	87	1	435	0	0	0	1	1	MXX	MFE	>58		<15		0	n.v.t.	?				0		27
20623	87	1	435	0	0	0	1	1	MXX	MFE	>39		<10,7		0	n.v.t.	?				0		27
20624	82	1	703	8	1	2	1	1	MXX	MPB?	22,4	7,4	3,5		0	geen	merovingisch				0		27
20625	87	1	445	1	1	1	3	0	MXX	MCU? MAG?MFE?					0						0		27
20626	77	1	214	15	1	0	1	1	MXX	MPB	31,6	23	ca.7,4		0	mogelijk	merovingisch				0		27
20627	87	1	440	1	1	1	1	1	MXX?	MXX?	35	33,5	20		0	n.v.t.					0		27
20628	83	1	418	56	8	1	1	1	BIJZM	MAU	12-13				0	Ja	merovingisch	630	650		0		
20629	87	1	446	1	1	1	1	1	MXX	MXX	48,7	31			0	n.v.t.	merovingisch?				0		27
20630	77	2	227	0	0	0	1	1	MXX	MPB	7	5	2,5		0	n.v.t.	?				0		27
20631	87	1	712	1	1	2	3	1	MXX	MBR					0		merovingisch				0		27
20632	87	1	441	1	1	1	2	2	MXX	MXX, MCU?				3	0		merovingisch				0		27
20633	96	1	567	0	0	0	0	1	BIJZM	MAU	7					Ja	merovingisch	600	650		0		
20634	87	1	445	1	1	1	6	0	MXX	MFE en MBR of MAG					0		merovingisch				0		27
20635	87	1	434	0	0	0	3	1	MXX	MFE, STN?	< 74	< 36,4	<23		0	mogelijk	?				0		27
20636	87	1	436	2	1	0	0	0	MXX	MFE					0		merovingisch				0		67
20637	96	1	579	5020	1	0	1	1	MXX	MPB	ca. 27	ca. 25	12	27	8						2		27
20638	76	1	193	3	1	1	1	1	MXX	MSL, MFE	ca. 34	ca.16	ca. 15		0		merovingisch				0		27

Id	putnr	vlaknr	vondstnummer	spoornr	vul	segm	aantal	MAI	CAT	SUBCAT	Lengte (mm)	Breedte (mm)	Dikte	Buitendiameter (mm)	Binnendiameter (mm)	decoratie	periode	dat begin	dat eind	literatuur	teknr	foto	doosnr
20639	65	1	15	5	1	1	1	1	MXX	MFE?	< 48,7	< 20,9			0						0		27
20640	83	1	450	56	1	0	1	1	MXX	MSL	ca.25	ca.22	ca.9		0		merovingisch				0		27
20641	77	3	368	1	13	1	1	1	MXX	MFE	> 25	ca. 32	ca. 10								0		27
20642	74	1	146	4	1	1	1	1	MXX	MXX, MFE?	ca. 42, 7	ca. 17,7			0						0		27
20643	66	1	36	11	1	3	1	1	MXX	MFE?					0						0		27
20644	84	1	602	7	1	1	1	1	MXX	MSL					0						0		27
20645	83	1	466	9	3	4	1	1	MXX	MSL	17	11	11		0		merovingisch				0		27
20646	77	3	256	1	3	0	1	1	MXX	MXX, BOT?, MFE?	20	13	12		0	mogelijk	merovingisch				0		27
20647	87	1	433	1	1	1	1	1	MXX	MFE	17	16	11,5		0		merovingisch				0		27
20648	83	1	430	9	1	2	1	1	MXX	FE	ca. 8	ca. 6	ca. 2,9		0	nee	merovingisch				0		27
20649	87	1	714	1	1	2	2	1	MXX	MXX	>28,4	>19,4	ca. 8,3		0		merovingisch				3		27
20650	66	1	129	22	1	2	3	1	MXX	MXX, MFE					0						0		27
20651	66	1	65	17	1	2	1	1	MXX	MSL?					0						0		27
20652	83	1	389	56	6	1	1	1	MXX	MFE	ca.31	ca.29	ca.12,4		0	?	merovingisch				0		27
20653	64	1	3	1	1	3	1	1	MXX	MFE	ca. 33,2	ca. 20, 7	ca. 7		0		merovingisch				0	ja	27
20654	74	1	144	5	1	1	2	1	MXX	MXX	32	9	6		0		merovingisch				0		27
20655	72	1	97	12	1	0	1	1	MXX	MFE	ca.58,4	ca.37	ca.23,4		0	?	merovingisch				0		27
20656	72	1	97	12	1	0	1	1	MXX	MFE	>32	ca.19	ca.11		5,5	?	merovingisch				0		27
20657	65	1	112	18	1	1	1	1	MXX	MFE	>32	<26	<18		0	?	merovingisch				0		27

Id	putnr	vlaknr	vondstnummer	spoornr	vul	segm	aantal	MAI	CAT	SUBCAT	Lengte (mm)	Breedte (mm)	Dikte	Buitendiameter (mm)	Binnendiameter (mm)	decoratie	periode	dat begin	dat eind	literatuur	teknr	foto	doosnr
20658	65	1	30	20	0	0	1	1	MXX	MXX	13	9,8	7,8		0		merovingisch				0		27
20659	65	1	17	5	1	2	2	1	MXX	MFE	40	31	23		0		merovingisch				0		27
20660	87	1	721	1	1	2	1	1	MXX	MFE	27,9	22	7		0		Merovingisch				0		27
20661	87	1	441	1	1	0	1	1	MXX	MFE?	2	1	0,06		0		merovingisch				0		27
20662	77	3	377	1	13	1	1	1	MXX	MSL	34	30	24		0		merovingisch				0		27
20663	77	3	278	1	0	0	1	1	MXX	MSL	53,5	42,5	20		0		merovingisch				0		27
20664	76	1	228	2	1	3	3	1	MXX	MFE	<74	<37	ca.23		0		merovingisch				0		27
20665	83	1	463	9	2	3	6	1	MXX	MSL	85	48	41		0		merovingisch				0		27
20666	83	1	463	9	2	3	1	1	MXX	MSL	13	12	13		0		merovingisch				0		27
20667	83	1	588	6	1	1	7	1	MXX	KER	17-87	12-63	15-16,5		0		merovingisch				0		27
20668	83	1	588	6	1	1	2	2	MXX	KER	97	70-85	40-48		0		merovingisch				0		27
20669	83	1	430	9	1	2	1	1	MXX	MSL	30	28,5	19		0		merovingisch				0		27
20670	83	1	430	9	1	2	2	2	MXX	MSL?	33-51	9-25	13-19		0		merovingisch				0		27
20671	83	1	431	9	1	1	1	1	MXX	MSL	30	19	11,4		0		merovingisch				0		27
20672	83	1	472	9	1	3	2	1	MXX	MXX?	<54	ca.24	ca.20		0		merovingisch				0		27
20673	76	1	228	2	1	3	1	1	MXX	MFE	>59	40	32		0		merovingisch				0		27
20674	83	1	464	9	1	4	1	1	MXX	MSL	47	44	26		0		merovingisch				0		27
20675	83	1	588	6	1	1	7	7	MXX?	KER	14-38	12-25	8,5-15,2		0		merovingisch?				0		27
20676	83	1	588	6	1	1	2	1	MXX?	KER	>30	>23	14		0	Mogelijk	merovingisch?				0		27

Id	putnr	vlaknr	vondstnummer	spoornr	vul	segm	aantal	MAI	CAT	SUBCAT	Lengte (mm)	Breedte (mm)	Dikte	Buitendiameter (mm)	Binnendiameter (mm)	decoratie	periode	dat begin	dat eind	literatuur	teknr	foto	doosnr
20677	83	1	588	6	1	1	1	1	MXX?	KER	>37,3	>23,4	6-15		0	ja	?				0		27
20678	83	1	588	6	1	1	1	1	MXX?	KER	>25	>13	9		0	ja	?				0		27
20679	83	1	588	6	1	1	1	1	MXX	MSL	41	20	21		0	n.v.t.	context nakijken mpi				0		27
20680	83	1	588	6	1	1	1	1	MXX	MSL	45	33	21,5		0	n.v.t.	context nakijken mpi				0		27
20681	83	1	428	56	6	1	1	1	MXX	MSL	14	8	9		0	n.v.t.	context nakijken mpi				0		27
20682	76	1	196	2	1	2	5	4	MXX	MSL	21,5-49	15-35	7-21		0	n.v.t.	context nakijken mpi				0		27
20683	76	1	342	6	3	2	3	1	MXX	MSL	14-37	8-29	6-25		0	n.v.t.	context nakijken mpi				0		27
20684	76	1	342	6	3	2	1	1	MXX	MSL	34	20	>14		0	n.v.t.	context nakijken mpi				0		27
20685	76	1	240	3	4	3	1	1	MXX	MSL	25	19	13		0	n.v.t.	context nakijken mpi				0		27
20686	83	1	424	6	1	6	1	1	MXX	MSL	58	38	18-36		0	n.v.t.	context nakijken mpi				0		27
20687	83	1	424	6	1	6	3	3	MXX	MSL, KER	33-44	24-33	23-35		0	n.v.t.	context nakijken mpi				0		27
20688	83	1	424	6	1	6	1	1	MXX	MSL	48	>45	32		0	n.v.t.	-				0		27
20689	83	1	424	6	1	6	3	3	MXX	MSL	21	16	26		0	n.v.t.	-				0		27
20690	83	1	424	6	1	6	2	1	MXX	MSL	65	40	14		0	n.v.t.	-				0		27
20691	83	1	424	6	1	6	2	2	MXX?	KER?	28-32	20-24	11-19		0	n.v.t.	-				0		27
20692	83	1	424	6	1	6	2	2	MXX	MSL	45-47	38-43	20-33		0	n.v.t	-				0		27
20693	83	1	419	6	1	7	1	1	MXX	MSL	49	36	45		0	n.v.t.	-				0		27
20694	83	1	374	56	5	1	2	2	MXX	MSL	15-42	13-40	12-24		0	n.v.t.	-				0		27
20695	76	1	195	2	1	1	2	1	MXX	MXX	83	28-48	21-31		0						0		27

Id	putnr	vlaknr	vondstnummer	spoornr	vul	segm	aantal	MAI	CAT	SUBCAT	Lengte (mm)	Breedte (mm)	Dikte	Buitendiameter (mm)	Binnendiameter (mm)	decoratie	periode	dat begin	dat eind	literatuur	teknr	foto	doosnr
20696	76	1	195	2	1	1	1	1	MXX	MXX	73	73	58		0						0		27
20697	76	1	236	3	4	3	2	1	MXX	MSL	45	29	18,5		0						0		27
20698	76	1	334	6	1	3	1	1	MXX	MSL	38	24	8-24		0						0		27
20699	83	1	420	6	1	4	1	1	MXX	MSL	32	12	12		0						0		27
20700	83	1	420	6	1	4	1	1	MXX	MSL	26	23,5	15		0						0		27
20701	83	1	425	6	1	5	1	1	MXX	KER	82	55	34		0						0		27
20702	83	1	425	6	1	5	1	1	MXX	KER	39	30	25,5		0	?					0		27
20703	83	1	425	6	1	5	1	1	MXX	KER	54	38	13		0						0		27
20704	83	1	425	6	1	5	1	1	MXX	MSL	85	64	41		0						0		27
20705	83	1	425	6	1	5	1	1	MXX	MSL	28,5	31	13		0						0		27
20706	83	1	425	6	1	5	3	3	MXX	MSL	32-49	23-40	9-22		0		merovingisch				0		27
20707	83	1	425	6	1	5	1	1	MXX	MSL	34	29	23,5		0		merovingisch				0		27
20708	83	1	425	6	1	5	1	1	MXX	MSL	28	24	23		0		merovingisch				0		27
20709	83	1	425	6	1	5	1	1	MXX	MSL	51	34	21		0		merovingisch				0		27
20710	86	2	727	8	1	0	2	1	MXX	MSL	110	96	67		0		merovingisch				0		27
20711	86	2	553	1	1	14	1	1	MXX	MSL	84	57	33		0		merovingisch				0		27
20712	86	2	553	1	1	14	1	1	MXX	MSL?	27	14	15		0		merovingisch				0		27
20713	86	1	531	1	1	2	1	1	MXX	MSL	53	54	28,5		0		merovingisch				0		27
20714	86	2	542	1	1	6	1	1	MXX	MSL	65	37	32		0		merovingisch				0		27

Id	putnr	vlaknr	vondstnummer	spoornr	vul	segm	aantal	MAI	CAT	SUBCAT	Lengte (mm)	Breedte (mm)	Dikte	Buitendiameter (mm)	Binnendiameter (mm)	decoratie	periode	dat begin	dat eind	literatuur	teknr	foto	doosnr
20715	86	2	557	1	1	21	1	1	MXX	MSL	47	28	14		0		merovingisch				0		27
20716	86	2	541	1	1	3	1	1	MXX	MSL	43	35	27		0		merovingisch?				0		27
20717	86	1	437	1	1	1	6	6	MXX	MSL	13-42	10-26	5-26		0		merovingisch				0		27
20718	86	2	540	1	1	6	1	1	MXX	MSL	80	59	41		0		merovingisch				0		27
20719	86	2	538	1	1	8	2	2	MXX	MSL	43-52	27-42,5	21-41		0		merovingisch				0		27
20720	86	2	530	1	1	9	2	1	MXX	MSL	46	41	17		0		merovingisch				0		27
20721	86	1	438	3	1	1	1	1	MXX	MSL?	20	15	7,5		0		merovingisch				0		27
20722	86	1	539	8	7	0	3	3	MXX	MSL	33-60	18-53	13-26		0		merovingisch				0		27
20723	86	1	459	1	1	2	2	1	MXX	MSL	33,5	44	22,5		0		merovingisch				0		27
20724	86	2	529	1	1	5	11	1	MXX	MSL	44	32	21		0		merovingisch				0		27

Id	Omschrijving	opmerking	Compleetheid (%)	oppervlak	Functie	bewerking	jaar vondst	magnetisch	groep	determinatie	voorwerp
20621	Vrij dik, plat rond voorwerp met centrale doorboring en afgeronde rand, mogelijk een spinklosje of vislood.		100%	patina	vislood/spinklosje	gegoten	2011	nee	nijverheid	M.D.Talma	vislood/spinklos
20622	Waarschijnlijk fragment van een spijker of bout (langwerpig, cillindrisch) omhuld in corrosielaag en roest. Broos, gedegradeerd.	stortvondst of vlakvondst	50%	corrosie, roest	gereedschap	gesmeed	2011	ja	nijverheid	M.D.Talma	spijker
20623	Fragment van een spijker (oogt redelijk fijn, dunner dan de andere uit hetzelfde spoor), omhuld in corrosielaag en roest. Broos, gedegradeerd.	stortvondst of vlakvondst	60%	corrosie, roest	gereedschap	gesmeed	2011	ja	nijverheid	M.D.Talma	spijker
20624	vrij dikke strip metaal (lood?)(langwerpig). Vorm is ideaal als basisvorm voor een ring, kan het ook een ander metaal zijn?(XRF). In het juiste strijklicht lijkt het alsof er heel fijne letters op staan BOD…?	Mogelijk inscriptie? (bijna niet zichtbaar, in strijklicht wel). Letters: BOD..?	?	patina	?	gesmeed	2011	nee	nijverheid	M.D.Talma	halffabrikaat?
20625	3 kluiten sediment waar metaal in zit.Groenige verkleuring zichtbaar en roest, voorwerpen niet te zien. RÖNTGEN!		?	patina, roest	?		2011	nee	-	M.D.Talma	-
20626	Een stuk lood (halfrond/maanvormig, deel afgebroken), met platte en bolle zijde. Wit uitgeslagen, aan bolle zijde ook een rode verkleuring zichtbaar. Mogelijk ook een radvormig patroon vanuit het midden.		?	patina	?	gegoten, gesmeed?	2011	nee	nijverheid	M.D.Talma	?
20627	Dit lijkt meer op samengeklont sediment? Er zijn wel roestplekken zichtbaar, maar het reageert niet magnetisch.		?	roest	?	?	2011	nee	?	M.D.Talma	?
20628	Gouden munt, tremissies, Fries of Frankisch (pers.comm. Specialist A. Pol d.d. 19 jan 2012 gewicht: 1,056 gram	muntslagplaats onbekend	97%	-	betaalmiddel	geslagen	2011	nee	handel	M.D.Talma	geld
20629	Een langwerpig enigsins ovaal object dat doet denken aan een lepelbak maar moeilijk te zeggen. Er zit veel sediment aan vastgekoekt, er steekt ook wat metaal uit dat ruitvormig is. Het reageert niet magnetisch.		?	?	eetgerei?	?	2011	nee	huisraad	M.D. Talma	lepelbak?
20630	Ovaal stukje metaal, waarschijnlijk lood. Wit uitgeslagen.	stortvondst of vlakvondst	100%	patina	baartje	gegoten	2011	nee	nijverheid	M.D.Talma	baartje
20631	3 fragmenten van 1 object, zeer teer en broos. Samengesteld lijkt het op een klein kussentje, wellicht piramidevormig maar is lastig te zien. Misschien een riembeslag? De kleur is groenig, wekt wel de indruk van brons te zijn.	te broos om op te meten	75%	patina	versiering?	gegoten	2011	nee	versiering?	M.D.Talma	piramidebeslag?
20632	Korreltje metaal, halfrond (alsof doormidden gebroken, kern zichtbaar). Mintgroene buitenkant met roodpaarse kern. XRF! Tevens in sediment metaalsnipper gevonden(onder microscoop bevestigd), wordt ook nog op XRF getest.	hoort dit bij mogelijk paardentuig vndstnr 714 (zelfde spoor) mogelijk op een van de gaten rechthoekig fragment	80%	patina	versiering	gesmeed	2011	nee	versiering	M.D.Talma	beslag
20633	Gouden munt, tremissies van niettap-type (pers.comm. Specialist A. Pol. D.d. 19 jan 2012, gewicht: 1,339 gram	muntslagplaats onbekend	100%	-	betaalmiddel	geslagen	2011	nee	handel	M.D.Talma	geld
20634	6 brokken sediment waarvan bij 3 in elk geval metaal in zit. RÖNTGEN Bij grootste brok ook groene verkleuring zichtbaar, ook een klein groen plekje op het langwerpige stukje dat erbij zit.		?	patina, roest	?	?	2011	?	?	M.D.Talma	?
20635	1 vrij groot object van ijzer, enigszins gebogen en deels in sediment (RÖNTGEN, interessant), de andere twee fragmenten lijken meer op steen of sediment, misschien zo	stortvondst of vlakvondst	?	roest	?	gesmeed	2011	ja	?	M.D.Talma	?

Id	Omschrijving	opmerking	Compleetheid (%)	oppervlak	Functie	bewerking	jaar vondst	magnetisch	groep	determinatie	voorwerp
	ingepakt.										
20636	RÖNTGEN maken! Grote kluit sediment waar metaal (ijzer) in zit.		?	roest	?	?	2011	?	?	M.D.Talma	?
20637	Lood,rond met centrale doorboring (sediment nog niet geheel verwijderd, erg aangekoekt.) Ik ga er wel van uit dat volledig doorboord is).. Plat aan één kant, aan de andere kant halfrond. Mogelijk spinklosje of vislood.		100%	patina	vislood/spinklos	gegoten, doorboord	2011	nee	nijverheid	M.D.Talma	Vislood/Spinklos
20638	Slak, grillige vorm (bijna als gietkanalen). Vrij metalig, waarschijnlijk smeedslak (gesmeed op steenkool) maar zou ook productieslak kunnen zijn!(pers.comm. I.Joosten). Magnetisch.		100%	patina	ijzerbewerking?	gesmolten	2011	ja	nijverheid	M.D.Talma	Smeedslak?
20639	Licht gebogen langwerpig voorwerp in concretie met roestplekken. RÖNTGEN		?	corrosie, roest	?	?	2011	ja	?	M.D. Talma	?
20640	Druppelvormig stuk slak, donkergrijs met bruinrood, vrij licht (schuimig), niet magnetisch. Het heeft een lichte glans. Misschien verkitte as?		98%	patina	ijzerbewerking	gesmolten	2011	nee	nijverheid	M.D.Talma	slak
20641	Fragment van een grote ijzeren spijker of bout. De kop is redelijk compleet, op ca 8 mm van onderkant kop is steel afgebroken.		40%	enige corrosie	gereedschap	gesmeed	2011	ja	nijverheid	M.D.Talma	Spijker
20642	Langwerpig licht gebogen voorwerp in concretie (?) met geelgroene aanslag. Interessant is bovenkant die deels afgebroken is. De kern laat en grijze rand aan de buitenrand zien, met een cillindrische kern.		?	roest, corrosie	?	gesmeed	2011	ja	?	M.D.Talma	?
20643	slakachtig fragment, waarschijnlijk smeedlak. Opvallend is de scherpe enigszins driehoekige impressie/gat op de platte kant.										
20644	Relatief klein stukje slak, donkerpaarsgrijs van kleur, reageert niet magnetisch.										
20645	relatief klein, vrij licht slakachtig fragment. Reageert niet magnetisch. Doet qua kleur denken aan ijzer (donkergrijs met paarsige vlekken.		100%?	patina	ijzerbewerking?	gesmolten	2011	nee	nijverheid	M.D.Talma	slak
20646	Vreemd fragment, ziet eruit als uiteinde van een botje of wellicht hoofd van een ram. Denk toch eerder aan botje, het is echter redelijk magnetisch! Kleur; donkergrijs met roestplekken		?	enige roest	?	?	2011	ja	?	M.D.Talma	?
20647	Klompje dat eruit ziet als sediment/ verbrande klei (bijna hazelnootvormig), reageert echter magnetisch. Komt een beetje broos over, met barsten in oppervlak.		?	enige roest	?	?	2011	ja	?	M.D. Talma	?
20648	verslakte sintel, gedegradeerd oppervlak en corrosie huidjes.		?	corrosie	?	?	2011	nee	?	M.D.Talma	?
20649	Langwerpig stukje metaal met 3 gaatjes. Over oppervlak roestige verkleuring, bij 'gaten' wit met groen. Niet magnetisch. Mogelijk van paardentuig. Tweede fragment vrij klein, roestige verkleuring hoort er mogelijk bij maar past er niet direct aan.	gevonden bij 2 paarden		patina, roest	paardentuig?	gesmeed	2011	nee	paardentuig?	M.D.Talma	paardentuig?

Id	Omschrijving	opmerking	Compleetheid (%)	oppervlak	Functie	bewerking	jaar vondst	magnetisch	groep	determinatie	voorwerp
20650	3 relatief kleine fragmenten slak, 1 magnetisch, de andere niet. De kleur van twee fragmenten is donkergrijs (waaronder de magnetische) de laatste is een stuk lichter met ook roodpaarse verkleuring. XRF op laatste binnenkort.										
20651	Heel licht fragment, bijna keramisch/ lava achtig. Lichtgrijs met gelig verkleuring.										
20652	enigszins 6 hoekig, vrij plat fragment, mogelijk de kop van een flinke spijker of bout, aan de onderkant nog resten van een uitstulping.		20	corrosie, roest	gereedschap	gesmeed	2011	ja	Nijverheid	M.D.Talma	
20653	Langwerpig plat fragment van ijzer, magnetisch. Op een kant bij de rand (breuk) een ovaalachtige indruk waar mogelijk iets anders aan was verbonden.	vermoedelijk heeft er nog iets haaks aan vastgezeten (vanwege indruk)	?	beetje roest	?	gesmeed	2011	ja	?	M.D.Talma	?
20654	Langwerpig enigszins cillindrisch voorwerp ziet er een beetje uit als een gietkanaal, vrij licht, waarschijnlijk horen de twee fragmenten bij elkaar.Niet magnetisch.		?	patina?	?	?	2011	nee	?	M.D.Talma	?
20655	Langwerpig, afgeplat conisch voorwerp van ijzer in corrosielaag, licht gebogen. Gok: zou de helft van een paardenbit kunnen zijn, de vorm komt enigszins in de buurt maar kan ook iets anders zijn (slecht zichtbaar_)		40%?	roest, corrosie	paardentuig?	gesmeed	2011	ja	paardentuig?	M.D.Talma	paardenbit? (fragment)
20656	Langwerpig, rechthoekig fragment, hol van binnen met vierkant gat, functie onbekend. Oppervlak gecorrodeerd en roestig.		?	roest, corrosie	?	gesmeed	2011	ja	?	M.D.Talma	?
20657	Langwerpig, sterk gegradeerd object van ijzer, waarvan aan één zijde roest zichtbaar (rechthoekige plek).onduidelijk of dit het object is of restant origineel.		?	roest, corrosie	?	gesmeed	2011	ja	?	M.D.Talma	?
20658	enigszins driehoekig plat fragment van onbekend voorwerp, waarschijnlijk koperlegering (groen uitgeslagen).		?	patina	?	?	2011	nee	?	M.D.Talma	?
20659	Twee grillige fragmenten van onbekend voorwerp in corrosielaag, zeer broos en gedegradeerd, roest zichtbaar.Reageert zwak magnetisch		?	roest, corrrosie	?	gesmeed?	2011	ja	?	M.D. Talma	?
20660	langwerpig, over de lengte licht gebogen fragment van een ijzeren(?) voorwerp, lijkt steen maar heeft roestplekken die magnetisch reageren.		?	roest	?	?	2011	ja	?	M.D.Talma	?
20661	klein snipper metaal in sediment gevonden, mogelijk hamerslag. Met XRF gemeten, gegevens worden verwacht.		100%	?	?	gesmeed	2011	nee	?	M.D.Talma	?
20662	stuk slak (ijzer) met afgeronde hoeken, blauwige aanslag, plaatselijk glanzend, met insluitsels van houtskool.		100%	patina	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D. Talma	Slak
20663	langwerpig, vrij plat stuk smeedslak. Licht gebogen, aan ene zijde veel putjes aan de andere zijde gladder, plaatselijk glanzend, tevens 2 stukjes ijzer ingebed. Kleur middengrijs tot lichtgrijs.		100%	patina, roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	smeedslak
20664	3 fragmenten van een zwaar gedegradeerd object, mogelijk een spijker.Op beide fragmenten resten van soort buis/cillindrische vorm zichtbaar. De fragmenten horen bij elkaar. Reageer magnetisch.		100%	roest	gereedschap	gesmeed	2011	ja	nijverheid	M.D.Talma	spijker?
20665	object in corrosie, grillig met roestplekken, brokkelig. Magnetisch.Fragmenten horen erbij. Enigszins gelige aanslag.		100%	patina, roest.	?	?	2011	ja	?	M.D.Talma	object in corrosie

Id	Omschrijving	opmerking	Compleetheid (%)	oppervlak	Functie	bewerking	jaar vondst	magnetisch	groep	determinatie	voorwerp
20666	klein stukje slak met zachtglanzend metalisch uiterlijk (blauwpaars). Vrij licht in gewicht. Reageert zwak magnetisch.		100%	patina	ijzerbewerking?/productie?	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20667	Groot fragment van tuyêre/ grote smeltkroes met bijbehorende kleinere fragmenten. Aan binnenkant groen uitgeslagen metaal zichtbaar, o.a. plaatvormige stukjes metaal (niet gesmolten). Bruine ondertoon, lijkt koper. Gesinterd, buitenkant glazuur door hitte	grofgemagerd, metaalresidu aanwezig. Onzeker tûyere omdat onversmolten schroot eraan vast, kroes dus? Metalen stukjes niet magnetisch, keramische delen wel.	20%	patina	metaalbewerking	gesmolten, gesinterd	2011	ja	nijverheid	M.D.Talma	kroes/tuyere
20668	Een fragment van een oven(met mogelijk vingerindrukken) en een waarschijnlijk fragment van dezelfde oven, beiden met metaalresidu(ijzer, magnetisch).		?	patina, roest	ijzerwinning/bewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	ovenwand
20669	een stuk slak, licht glanzend, met paarsrode kleur. Voor massa vrij licht (gewicht), reageert licht magnetisch.		100%?	patina	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20670	Twee corrosiehuidjes, vrij broos, plaatvormig en roestig. Grotere stuk licht magnetisch, kleinere stuk sterk magnetisch.		?	roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak?
20671	Stukje slak (nog vrij vuil, slecht zichtbaar). Enige roestplekjes, reageert magnetisch.		?	roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20672	twee stukken slak of fragment van voorwerp, horen bij elkaar. Op breuk vierkante holle vorm zichtbaar, lijkt aan buitenkant door te lopen, op die plekken magnetisch.		?	roest, corrosie	?	?	2011	ja	?	M.D.Talma	?
20673	Fragment van zwaar gedegradeerd voorwerp, hoort mogelijk bij andere fragmenten in de zak, maar past er niet aan. Roestig, aan één kant steekt een soort buis uit. Zwak magnetisch		?	roest, corrosie	?	gesmeed?	2011	ja	?	M.D.Talma	?
20674	Een rechthoekig stuk slakachtig materiaal, lastig te duiden. Weinig sintering, plaatachtige opbouw, roestig uiterlijk maar nog redelijk metalisch(niet teer). Magnetisch.		?	roest	?	?	2011	ja	?	M.D.Talma	?
20675	7 fragmenten van keramiek, mogelijk één pot.Enkele stukken vertonen sporen van ijzer (roest) en wellicht koper(groen). Baksel oogt lila, relatief grof gemagerd.1 fragment van de rand, van binnen en van buiten spits toelopend, rood aan buitenzijde.		?	roest?	?	handgevormd?	2011	nee	?	M.D.Talma	?
20676	Twee fragmenten van keramiek, zeer versinterd aan een kant(bijna als slak), aan de buitenzijde roodgebakken (mat), aan de binnenkant wit. Zou deel van gietmal of smeltkroes kunnen zijn, maar is te klein om te bepalen.		?	versinterd	?	?	2011	nee	?	M.D.Talma	?
20677	Een stuk keramiek met mogelijk metaalresidu aan binnenkant (donkerblauwgrijs residu, niet magnetisch).Buitenzijde groen glazuur met rode versiering (soort rondjes).	haaks fragment aan de binnenkant hiertegenaan mogelijk metaalresidu	?	-	?	geglazuurd	2011	nee	?	M.D.Talma	?
20678	Een klein fragment van keramiek met roodgeglazuurde binnenkant, geen versintering zichtbaar. Buitenkant rood gebakken		?	?	?	geglazuurd	2011	nee	?	M.D.Talma	?
20679	Een langwerpig stuk slak, plaatselijk glimmend, versinterd. Een kant metalischer en zwaarder (tevens magnetisch)		60%	versinterd	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20680	Slakachtig/steenachtig fragment- lastig te duiden. Mogelijk deel van smeltoven(?). Plaatselijk roestsporen, maar ook sediment (+kiezeltje).Reageert plaatselijk magnetisch		80%?	roest	ijzerwinning/bewerking?	gesinterd	2011	ja	nijverheid	M.D. Talma	slak/deel oven

Id	Omschrijving	opmerking	Compleetheid (%)	oppervlak	Functie	bewerking	jaar vondst	magnetisch	groep	determinatie	voorwerp
20681	klein fragment slak, paarsigblauwgrijs, vrij licht in gewicht. Reageert niet magnetisch.		100%?	patina	ijzerwinning/bewerking?	gesmolten	2011	nee	nijverheid	M.D. Talma	slak
20682	5 fragmenten van gecorrodeerd object, aan een zijde enigszins versintering zichtbaar; geheel doet heel bros aan,plaatselijk roestig oppervlak, 2 fragmenten horen bij elkaar. Reageert plaatselijk magnetisch.		100?	roest	?	gesinterd	2011	ja	nijverheid	M:D.Talma	object in corrosie
20683	3 fragmenten slak//sintels, horen op basis van kleur+uiterlijk bij elkaar. Ze hebben een wittig oppervlak met parelmoerglans, lichtgewicht, enigszins brokkelig. Deze zijn niet magnetisch.	pers.comm. I.Joosten: sintels die in elk metaalbew.proces kunnen zijn gevormd, maar ijzerbew. Ws.	?	patina	ijzerbewerking?	gesmolten	2011	nee	nijverheid	M.D.Talma	slak
20684	1 corrosiehuidje, roestig oppervlak, lijkt doormidden gebroken. Reageert magnetisch		50%	roest	?	?	2011	ja	nijverheid	M.D.Talma	corrosiehuidje
20685	1 stukje slak, vrij licht in gewicht, zijdeglans en gesinterd.paarsigblauwgrijs qua kleur. Reageert niet magnetisch.		100%	patina	ijzerbewerking	gesmolten	2011	nee	nijverheid	M.D.Talma	Slak
20686	Een stuk slak, hoekig (als gevormd in haard), op onderzijde ook enig leem zichtbaar en houtskool. Concavo-convex qua vorm.Oppervlak glimt glazig, kleur grijzig. Plaatselijk magnetisch (m.n. hogere zijkant)	slak met deel ovenwand (smeedslak)	?	patina?	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D. Talma	slak
20687	Drie resten van ovenwand en slak (eraan vast), op onderzijde duidelijk gebakken leem zichtbaar, aan bovenzijde gesmolten slak. De stukken passen niet op elkaar, maar lijken qua kleur veel op elkaar, waarschijnlijk van dezelfde oven.	ovenwandfragmenten (ijzerbewerking is waarschijnlijker!)	?	patina?	ijzerwinning/bewerking	gebakken, gesmolten	2011	nee	nijverheid	M.D.Talma	slak/deel oven
20688	Stuk slak met grillige vorm, bijna steenachtig qua uiterlijk (lichtgrijs en donkergrijs), plaatselijk glimmend/glazig, plaatselijk magnetisch	slag block	60%?	patina?	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20689	Een stukje slak, zeer compact en glasachtig, donkergrijs op breuk, aan bovenzijde lichtgrijs en rode kleur. Niet magnetisch.	smeedslak	?	patina	ijzerbewerking	gesmolten	2011	nee	nijverheid	M.D.Talma	slak
20690	Twee fragmenten van een plak stuk slak met heteregene kleurschakering op breuk:paarsig op onderkant, blauwgrijs aan bovenkant. Gevormd in oven op op bodem smeedplaats. Aan bovenzijde magnetisch.	smeedslak	20%?	patina?	ijzerbewerking	gesmolten	2011	ja	njverheid	M.D. Tlma	slak
20691	Twee stukjes 'keramisch' materiaal, lichtgrijs/lichtlila op breuk, gesinterd, aan bovenzijde wit en rood, plaatselijk glimmend. Mogelijk een restproduct.	restproduct?	?	patina?	ijzerbewerking	gesinterd	2011	nee	nijverheid	M.D.Talma	restproduct/slak?
20692	Twee stuks slak met roestig uiterlijk en relatief veel ijzer. Grillig uiterlijk, rechte bodem. Mogelijk gevormd in smeedplaats. Aan beide zijden magnetisch.	gevormd in smeedhaard	?	roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D. Talma	smeedslak
20693	Een stuk slak met roestig uiterlijk en veel ijzer.Kleur roestig en donkergrijs, magnetisch.		?	roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D. Talma	smeedslak
20694	Twee stuks slak, waarvan het grotere stuk een aankoeksel van leem heeft. Beiden donkergrijspaarsig van kleur met roestplekken. Veel ijzer, aan beide zijden magnetisch. Grotere stuk een hoekige vorm, gevormd in haard/oven.	mogelijk smeedslak met leemaankoeksel.	95%	roest, patina	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20695	Twee stukken sediment waar ijzer in zit, vorm cillindrisch/buisachtig(steekt uit aan één kant bij een breuk; deze fragmenten passen op elkaar. Reageert licht magnetisch, verder slecht herkenbaar.		?	enige roest, patina	?	gesmeed?	2011	ja	?	M.D.Talma	?

Id	Omschrijving	opmerking	Compleetheid (%)	oppervlak	Functie	bewerking	jaar vondst	magnetisch	groep	determinatie	voorwerp
20696	Een groot stuk sediment waar ijzer in zit (goed kijken!), vorm niet herkenbaar, reageert licht magnetisch.		?	enige roest, patina	?	?	2011	ja	?	M.D.Talma	?
20697	Twee fragmenten van slakachtig materiaal, passen niet direct op elkaar maar komen qua kleur en vorm zo overeen dat ze van dezelfde herkomst moeten zijn. Het heeft een hoekige vorm, en is magnetisch aan de bovenzijde. Kleur middengrijs.	met deel ovenwand	?	patina	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	smeedslak
20698	Slakachtig materiaal, roestig oppervlak met sintering, ook aan twee zijde uitsteeksels van (mog) plaatvormig voorwerp (?) Lastig te duiden. Reageert licht magnetisch, ook licht in gewicht. Mat, kleur donkergrijs met roest.		?	roest, patina	ijzerbewerking?	gesinterd	2011	ja	nijverheid	M.D.Talma	slak?
20699	Klein langwerpig fragment met rood zwarte verkleuring en glimmend oppervlak, op breuk versintering zichtbaar. Lijkt ook een beetje op slak, expert opinion?	dichtbij smeltkroes 588 gevonden!	?	-	metaalbewerking	gesinterd	2011	nee	nijverheid	M.D.Talma	?
20700	Stukje slakachtig materiaal, lijkt in eerste instantie op steen, maar er is ook sintering zichtbaar, en aan een zijde een glimmende donkergrijze plek.Lastig te duiden. Reageert niet magnetisch.	dichtbij smeltkroes 588 gevonden!	?	-	?	gesinterd	2011	nee	nijverheid?	M.D.Talma	?
20701	Een stuk baksteen met slak eraanvast(of versmolten met de baksteen). Slak donkergrijs met rode verkleuring en glans en baksteen rood.Licht magnetisch op korte kant baksteen bij het slak.	Is het baksteen een reden om aan de context te twijfelen?kan in oven gebruikt zijn.	?	-	ijzerwinning/bewerking	gesinterd?	2011	ja	nijverheid?	M.D.Talma	?
20702	Fragment van een onregelmatig voorwerp, lijkt op aardewerk met slak eraan, buitenzijde d.groen glazuur met rood, kan ook verkleuring door hitte zijn. Reageer magnetisch op breuk bij lu-vormige uitstulpsel(links)		?	gesinterd	ijzerwinning?bewerking?	gesinterd, glazuur(?)	2011	ja	nijverheid?	M.D.Talma	?
20703	Een plat stuk keramisch materiaal met versintering, aan één kant glimmend en grijs, aan andere zijde roodgebakken. Reageert niet magnetisch.		?	gesinterd	metaalbewerking?	verhit	2011	nee	nijverheid	M.D.Talma	deel oven?
20704	Een groot blok slak met veel ijzer erin, kleur donkergrijs met plaatselijk roestplekken. Vorm opvallend: platte onderkant en afgebogen zijkkanten (alsof gevormd in kuil). Vooral aan zijkanten en onderzijde magnetisch.	haardslak	50%?	enige roest	ijzerbewerking	gesinterd, gesmolten	2011	ja	nijverheid	M.D.Talma	smeedhaardslak
20705	Een plat stuk slak (lijkt gevormd op een platte ondergrond), vrij licht en glasachtig. Kleur donkergrijs met rode/paarse verkleuring op oppervlakken. Magnetisch.	op platte ondergrond gevormd (niet zeker of het haardslak is)	?	patina?	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20706	3 stuks slak, passen niet op elkaar maar lijken qua kleur en morfologie van dezelfde context; kleur lichtgrijs, middengrijs, geen roest. De stukken hebben een platte onderkant en zijn vooral aan de onderkant magnetisch.		?	-	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20707	Opvallend slakfragment(?), er is groene metaalresidu met rode verkleuring en parelmoerglans zichtbaar. De kleur is lichtgrijs.Doet ook enigszins keramisch aan, maar is dan vervormd. Vrij licht in gewicht, niet magnetisch.	opvallend fragment!	95%	iridiserend	metaalbewerking?	gesmolten	2011	nee	nijverheid	M.D.Talma	slak?
20708	Donkergekleurd stuk slak met roestplek op één kant, reageert magnetisch.		98%	enige roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20709	Langwerpig plat stuk slakachtig materiaal, her en der stukjes houtskool. Reageert niet magnetisch, lijkt toch op slak van ijzerbewerking.		98%	enige roest	ijzerbewerking	gesmolten	2011	nee	nijverheid	M.D.Talma	slak

Id	Omschrijving	opmerking	Compleetheid (%)	oppervlak	Functie	bewerking	jaar vondst	magnetisch	groep	determinatie	voorwerp
20710	Twee bij elkaar behorende fragmenten van een groot stuk slak met stukjs houtskool erin en plaatselijk roest. Reageert magnetisch.	gesmeed met steenkool! Check context, kan jonger zijn!	100%	enige roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	smeedslak
20711	stuk verslakte ovenwand, licht gebogen over de lengte, vrij rechte onderkant (lijkt in kuil gevormd). Kleur: aan de bovenzijde middengrijs tot lichtgrijs en roestplekken, aan de onderzijde idem maar dan met roodpaarse verkleuring.	heeft dichtbij tuyere gezeten!	60%?	enige roest, patina	ijzerwinning/bewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	ovenwand
20712	langwerpig afgerond fragment, mogelijk van een object, zou ook slak kunnen zijn maar lijkt er niet meteen op. Er zitten barsten in. De kleur is donkergrijs, het reageert magnetisch.		?	enige roest	ijzerbewerking?	gesmeed?	2011	ja	nijverheid	M.D.Talma	voorwerp of slak?
20713	vrij plat stuk slak, aan een zijde glasachtig glimmend en enige roestplekken, aan de andere zijde mat met roestplekken, kleur vooral donkergrijs, maar ook lichtgrijs.Plaatselijk magnetisch.	hier ook indicatie voor gebruik steenkool (pers.comm. I.Joosten 5-4-2012).	90%	enige roest, patina	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	smeedslak
20714	donkergrijs stuk slak, lijkt bijna steenachtig. Hier en daar kleine roestplekjes, aan alle zijden magnetisch. NB met steenkool! Pers.comm.I.Joosten.	met steenkool, check context, zou contemporain kunnen zijn.	99%	enige roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20715	plat stukje slak wordt naar het midden toe breder. Bovenkant is ruw en lichtgrijs (een glimmend plekje) onderkant is glad, donkergrijs en blauwe plekken en roest. Voelt steenachtig aan, wel sintering zichtbaar. Niet magnetisch.		?	enige roest	ijzerbewerking?	gesmolten	2011	nee	nijverheid?	M.D. Talma	slak?
20716	Opvallend stuk slak met houtskool eraan (lijkt bijna steenkool achtig). De bovenkant is lichtgrijs met sintering, de onderkant is zwart met rode verkleuring (en geeft zwart af).	met steenkool, zou contemporain kunnen zijn, maar check context!	?	-	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D. Talma	slak
20717	Broze fragmenten van object in corrosie. De stukken zijn donkergrijs van kleur en vertonen allemaal roestplekjes. Ze reageren magnetisch.		?	enige roest	?	gesmeed?	2011	ja	?	M.D.Talma	object in corrosie
20718	Vrij groot stuk slak, lichtgrijs met grillig uiterlijk. Voelt steenachtig aan en vertoont versintering. Ook aparte plaatvormige structuur en aan de onderkant plaatselijk glimmend. Niet-magnetisch.		?	versintering	ijzerbewerking?	gesmolten	2011	nee	nijverheid	M.D.Talma	slak
20719	Twee stuks verslakte steenkool, donkergrijs, geven af (houtskool?). Passen niet op elkaar, maar lijken veel op elkaar. Ook roestplekjes. Sterk magnetisch!Vorm lijkt in een kuil gemaakt te zijn.	Sterk magnetisch! Hoog ijzergehalte, apart: geeft af!	?	enige roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	steenkool
20720	Twee bij elkaar horende fragmenten slak. Bovenzijde groentgrijs, onderkant donkergrijs met enige roest. Licht in gewicht. Aan onderzijde magnetisch.		60%?	enige roest, patina	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D. Talma	slak
20721	Een piepklein fragmentje slak. Kleur lichtgrijs met roestplekjes, aan onderzijde licht magnetisch.		?	enige roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D. Talma	slak
20722	3 fragmenten van lichtgrijs slak, lichtgewicht. Plaatselijk rode verkleuring. Passen niet op elkaar, lijken wel op elkaar. Reageren magnetisch.		?	enige roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20723	2 bij elkaar horende fragmenten slak. Kleur donkergrijs met plaatselijk roestplekjes. Redelijk gewicht, reageert magnetisch.		?	enige roest	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak
20724	Vrij plat stukje slak met hoekige vorm (in kuil gevormd?), aan bovenzijde grillig met stukjes houtskool ingebed. Verder nog 10 heel kleine fragmenten die er qua kleur op lijken, niet apart beschreven.		98%	-	ijzerbewerking	gesmolten	2011	ja	nijverheid	M.D.Talma	slak

Id	putnr	vlaknr	vondstnummer	spoornr	vul	segm	aantal	MAI	CAT	SUBCAT	Lengte	Breedte	Hoogte	Dikte	decoratie	periode	dat begin	dat eind	literatuur	teknr	foto	doosnr	omschrijving	opmerking	extra	jaar
20621	21	2	986	9	6	1	3	1	BIJZK	MXX	52	40	39	7-8 mm	nee	merovingisch			naar parallel in literatuur wordt nog gezocht	0	ja	65	Smeltkroes met residu. Losse fragmenten samen compleet object.XRF analyse d.d.19-01-2012, eerste indicatie: gieten van messing	Tevens hoog ijzersignaal, gebruikt in nabijheid ijzer.	tekening volgt	2009
20622	25	1	1066	19	2	2	2	1	BIJZK	MXX	53	39	43	2-10	nee	merovingisch			naar parallel in literatuur wordt nog gezocht	0	ja	65	1 vrij complete smeltkroes (oogt schoon),op onderzijde vitrificatie, lichte vervorming.Verkleuring: blauwgroen met witte vlekken. Deze is bij XRF analyse heel gelaten. Fragmenten met hetzelfde vondstnummer hadden residu, deze is gemeten (o.a messing).	Tevens hoog ijzersignaal, gebruikt in nabijheid ijzer.	tekening volgt	2009
20623	25	1	1069	1	2	2	1	1	BIJZK	MXX	33	26	21	9-11	nee	merovingisch				0	?		Een bodemfragment van (mogelijk) een gietvorm, of van een smeltkroes. Vermoeden gietvorm: het is spitser en de holte is smal, gladde binnenkant, geprolongeerd uitsteeksel.Onderzijde buitenkant: aanslag roest, magnetisch.Ook rode verkleuring+versintering,			
20624	23	1	1025	3	2	2	4	3	BIJZK	MFE, KER, MSL	13-20	12		6-8						0		65	Een stukje KER van smeltkroes/gietvorm, (1 spijker in corrosielaag, punt sterk magnetisch kop niet, 1 mogelijk stuk slak, heel licht / schuimig, niet magnetisch) 1 brokje keramisch materiaal, grijs/oranje			
20630	25	1	1066	19	2	2	1	1	BIJZK	MXX	47	32	27	17	nee	merovingisch				0		65	Bodemfragment van smeltkroes met deel van 'handvat' (waarschijnlijk bedoelt om tang eronder tegen te houden) en residu.Residu geanalyseerd met XRF (19-01-2012), eerste indicatie gieten van messing.Zie XRF rapport.			2009
20631	25	1	1066	19	2	2	1	1	BIJZK	MXX	24	21		9	nee	merovingisch			naar parallel in literatuur wordt nog gezocht	0		65	Een fragment van een smeltkroes met residu, lijkt op deel van schenktuit en bovenvoorkant smeltkroesje. Bij schenktuit roestplek, zowel op binnen als buitenkant. Tevens groene en rode verkleuring en vitrificatie. Keramisch ogend metaalresidu(roze	Met XRF geanalyseerd, voornamelijk messing gegoten.		2009

Notes on storage and conservation

Canadian Conservation Institute | Institut canadien de conservation

CCI Notes 9/1

Recognizing Active Corrosion

Introduction

Metal corrosion can be active or inactive. Some objects may be corroded but stable, and therefore inactive; others may be actively corroding. An important part of preventive maintenance of metals is to recognize the early stages of destructive, active corrosion. Very few shiny metal artifacts will remain in that condition. Only metals such as gold and platinum will retain a fully metallic or polished surface for a long time.

Inactive corrosion occurs as a stable oxide layer — a tarnish or colour change that slowly forms on metal artifacts and protects the underlying surface. The oxide layer is often considered to be a desirable patina, particularly if it has a pleasing appearance. Artificial patinas are often applied to the surface of a metal object to protect it and change its appearance. Artificially patinated surfaces on artifacts are found mostly on sculptures, medals, weapons, and tools.

By contrast, *active corrosion* causes a continuing loss of material from the object. Action must be taken to slow down or prevent further deterioration.

Examining a collection to identify corroding metal artifacts can reveal problems with environmental conditions. High relative humidity (RH) or pollutants can initiate many of the corrosion reactions.

Environmental factors that could contribute to active corrosion are discussed under each metal.

Only the metals most commonly found in museum collections are considered in this Note: iron, copper, copper alloys (such as brass and bronze), lead, silver, pewter, and plated metals.

Identification

Active corrosion can be identified by a rapid expansion in volume as the metal alters to form a corrosion product. Flaking or powdering of the surface may occur. **Any metal artifact surrounded by flakes or by loose powder can be considered actively corroding** (see Figure 1). Common signs of active corrosion in specific metals are noted below.

Iron

Stable surfaces on iron are compact, adherent, and vary in colour between blue-black and red-brown.

One form of *active corrosion* is commonly found between the metal core of the artifact and its outer corrosion layer. Clear indications of active iron corrosion include fragments surrounding an object, depressions on the metal surface, and orange spots in the centres of these depressions (see Figure 2).

Another form of particularly active corrosion of iron is recognized by "sweating" or "weeping" — yellow, brown, or orange droplets on the metal surface (see Figure 3). Sweating or weeping occurs where the RH of the environment in which the iron is housed is high (i.e. 55% and above). At lower levels, around 50% RH, the weeping areas will desiccate to produce orange or brown blisters (see Figure 4). (For more information on the care and storage

Figure 1. The lead tokens covered with white corrosion and surrounded by white particles are suffering from active corrosion; the other tokens are not.

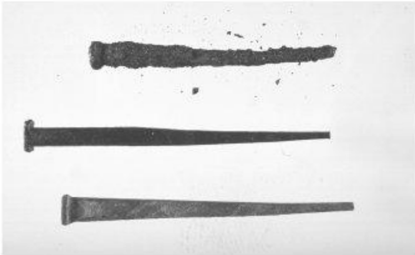

Figure 2. The corrosion products surrounding the top nail provide evidence that this nail is unstable and is suffering from active corrosion. The two lower nails are stable.

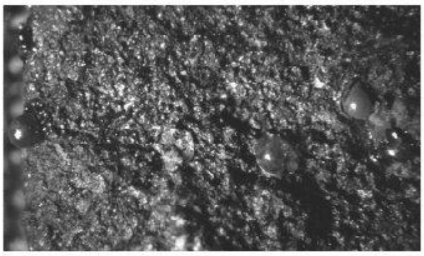

Figure 3. Spherical drops of liquid on the surface of archaeological iron are characteristic of weeping iron and active corrosion caused by chloride ion contamination. Magnification approximately ×6.

of iron, and on composite objects with iron parts, see CCI Notes 9/6 *Care and Cleaning of Iron*. For more information on active iron corrosion, see Turgoose 1982.)

Copper and Copper Alloys: Brass and Bronze

Stable surfaces on copper and copper alloy artifacts are characterized by a wide variety of natural and artificial patinas. Stable patinas on these metals are generally coherent, adherent, and smooth. Stable patinas vary in colour from red, brown, black, and blue to shades of green. Stable corrosion layers, which develop on archaeological copper artifacts, may appear rough and uneven.

Active corrosion of copper and copper alloys is characterized by the rapid development of a light green powder erupting in spots over the surface. This powder may surround an undisturbed object. This type of corrosion is most common on archaeological copper alloys and is known as "bronze disease." As with sweating and weeping, bronze disease occurs where the RH is high (i.e. 55% and above). The corrosion reaction is progressive and may rapidly cause extensive damage. (For more information on bronze disease, see Scott 1990.)

Active corrosion on copper and copper alloys may also appear as a loosely adherent, powdery layer over the surface, rather than as spots. These corrosion layers may be induced by atmospheric pollutants, most commonly airborne chloride particles (particularly in coastal areas) and acetic acid. Both pollutants produce a green surface layer. Ammonia, as a gaseous pollutant often found in window cleaning compounds, produces a bluer corrosion layer.

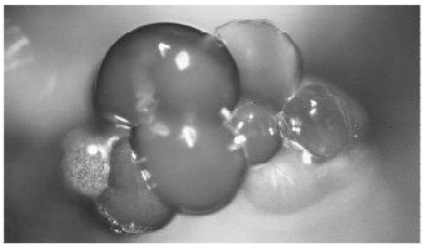

Figure 4. Detail of hollow shells characteristic of weeping iron on archaeological iron. Magnification about ×25.

Lead and Pewter

Stable patina on lead is a darker grey than the stable patina of pewter. The colour may vary depending on the composition of the alloy, the object's past history, and its present storage conditions.

Active corrosion on lead and pewter is characterized by the formation of loosely adherent white powder. The powder may form evenly over the surface, but is often concentrated in pinpoint spots. Powder surrounding an undisturbed object is a clear indication of active corrosion. This white powder is basic lead carbonate (better known as lead white), and is most commonly induced by the vapours of weak organic acids. The most common sources of these acid vapours are wooden storage or display units (especially those made of oak), deteriorated cardboard and poor quality paper, and acetic acid from vinegar used in cleaning.

Silver

Silver in museum collections is generally expected to have a white metallic appearance. The black surface tarnish characteristic of silver corrosion is not usually considered to be a patina.

Tarnish forms as a dense, compact, and adherent layer when silver reacts with sulphide gases. These atmospheric pollutants are found in industrial areas, particularly those close to pulp mills, and are easily detected by their characteristic "rotten egg" smell. The corrosion reaction requires both sulphide gases and atmospheric humidity to begin. Most damage to silver from tarnishing is the result of the abrasion and polishing required to remove tarnish and repolish the silver.

Frequent polishing of plated objects can rapidly remove the silver plating (see CCI Notes 9/7 *Silver — Care and Tarnish Removal*).

Plated Metals

Common combinations of plated metals are:

- copper and silver
- copper and gold
- copper and nickel
- copper and tin
- iron and tin
- iron and zinc ("galvanized" iron)
- iron and chromium (usually with copper and/or nickel in between)
- iron and nickel (usually with a copper "flash" in between, hence the green corrosion in the pit
- cupronickel and silver

Metal platings present special problems and are particularly prone to corrosion. Two dissimilar metals in contact require only an electrolyte (i.e. a salt and atmospheric moisture) to start a corrosive reaction. When examining plated metal objects, it is often difficult to identify either the metal plating or the underlying metal.

Stable surfaces, particularly gold, silver, nickel, and chromium, often retain their original bright metallic appearance when kept under appropriate environmental conditions, although the shine may be obscured by dust or dirt (see CCI Notes 9/3 *The Cleaning, Polishing, and Protective Waxing of Brass and Copper*).

Active corrosion on plated metals manifests itself in various ways. It is most often found in areas where the object has been damaged or has defective plating. The plating usually lifts as the corrosion products of the underlying metal expand. This lifting can be seen, for instance, on the blistered chrome parts of automobiles. Corrosion products from the underlying metal may also occur on top of the plating — often in the form of a compact corrosion layer.

Pitting also occurs on plated objects when the plating is perforated and corrosion products grow in the underlying metal.

All active corrosion on plated metals is accompanied by an expansion in volume, which leads to loose powder around the object, or to blisters of more coherent corrosion products on the surface.

Routine Inspection

Regularly inspecting objects is a vital part of their care. Because many corrosion reactions occur quickly, metal artifacts should be inspected monthly. Deterioration can then be noted at an early stage and preventive measures taken before damage becomes severe.

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CCI Notes 9/2

Storage of Metals

Introduction

Most metals corrode: iron rusts, copper turns green, silver turns black, and lead disintegrates into a white powder. Stored improperly, most of the metals in a museum collection will slowly transform into oxides, sulphides, carbonates, or other compounds. The corrosion processes are faster on metal surfaces contaminated by salts, volatile organic acids (such as those from wooden storage cabinets), ammonia from cleaning fluids, or dust. The rate of corrosion can also be increased through galvanic corrosion, a process that occurs when objects made of different metals are in contact with each other in high relative humidity (RH) conditions. (For more detailed information, see Selwyn 2004.)

For best protection of metal artifacts, museum storage areas must be clean and well-organized, have controlled RH, and have as clean air as possible.

This Note describes general guidelines for the proper storage of metals. It explains the role of RH, recommends general storage conditions and handling procedures, and discusses a few specific metals: aluminum, copper, iron, lead, plated objects, and silver. (For more detailed information, see Drayman-Weisser 1992.)

Relative Humidity

Relative humidity is a key factor in metal corrosion because most metals corrode more quickly in moist conditions. (For more information on RH, see Thomson 1994 and Tétreault 2003.) For ideal storage of metals, the RH should be as low as possible. However, this is rarely practical, especially for mixed collections.

It is reasonable to store stable metal artifacts — that is, metals that do not exhibit signs of active corrosion — with the rest of the collection in controlled storage conditions. The RH should be between 35% and 55%, the range generally recommended for storing and displaying mixed collections. If the RH exceeds 55%, consideration should be given to moving metal artifacts to proper humidity-controlled storage facilities.

Storage of Actively Corroding (Unstable) Metal

When examining a collection, look for metals that exhibit signs of active corrosion (see CCI Notes 9/1 *Recognizing Active Corrosion*). Because actively corroding pieces create dust, chloride, or staining problems by scattering corrosion products, they should be removed from the main collection and stored in a separate area with an RH below 35%. The drier conditions will reduce the corrosion rate, but the source of the corrosion will still need to be addressed. Seek advice from a qualified conservator on the care and treatment of such objects.

Small, important pieces can be stored in desiccators containing silica gel that has been dried completely or conditioned to a low RH. (For more information on how to use silica gel, see Lafontaine 1984 and Tétreault 2003.)

Large numbers of unstable metal objects can be stored together in a small room or in a cabinet where RH can be kept low with a dehumidifier. Small silica gel dehumidifiers are suitable for this purpose. Domestic dehumidifiers are not as effective as silica gel dehumidifiers because they cannot reduce the RH below 40%, but they are better than no dehumidifier at all. Lithium chloride dehumidifiers are not recommended because of the risk of contaminating artifacts with lithium chloride, which could make the corrosion worse. (For information on a low-cost unit for controlling RH, see Michalski 1982.)

Humidity control systems require regular maintenance. Empty the water pans of dehumidifers often, and check and recondition silica gel regularly.

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Organizing Storage

Although not necessary, it can be useful to store artifacts composed of similar metals together. This makes examination and retrieval easy and systematic. If objects such as silver trophies, medals, coins, tools, etc. are stored in groups, shelving systems and storage containers can be standardized to some extent. However, the final decision on organizing storage depends on the collection and should be made by curatorial staff.

Whether storing metal artifacts in a separate room or with the main collection, select an area situated away from windows, doors, vents, and heating units. If windows cannot be avoided, ensure that they are tightly sealed to prevent leaks and condensation.

The storage area should have sufficient air circulation to maintain an even temperature and humidity and to prevent build-up of corrosive gases, such as volatile acidic or alkaline vapours. It is almost impossible to eliminate volatile substances from a museum collection. However, local high concentrations that will damage metal can be prevented if the room is adequately ventilated. Fans in the storage area will help to maintain airflow.

Storage of Stable Metals

Dust that settles on metal retains moisture. In urban areas, dust may contain pollutants, such as sulphur compounds, that tarnish silver. Any chlorides absorbed in the dust on metal objects will accelerate the corrosion of the metal. Storage areas should, therefore, be kept clean and dust-free. Seal concrete walls and floors to reduce dust levels.

Using chemically stable materials (e.g. shelving, cupboards, padding, wrapping) in storage areas will help to prevent problems because these materials last longer than unstable materials and will not damage the collection. Although expensive, metal storage cabinets and shelves with powder coatings are ideal. Other safe materials include polyethylene or clear food-grade polystyrene boxes, and acid-free unbuffered papers. Avoid wood and wood-pulp products because they release sulphur compounds and organic acid vapours (acetic and formic acid). Also avoid oil-based and alkyd paints because they release volatile materials for long periods. Rooms that have been freshly painted with oil or alkyd paints should be aired for at least four months before metals are stored in them. (For more information on coatings and on storage and display materials, see Miles 1986; Padfield 1982; Tétreault 1994, 1999.) If there is doubt regarding the suitability of a material, contact Client Services at CCI for advice.

Ideally, metal objects should be stored in closed systems, such as cabinets with well-sealed doors or drawers. Closed systems will protect metals from dust, pollutants, and, to a degree, changes in RH. Dry silica gel can be placed in the drawers to maintain a low RH; the silica gel should be checked and reconditioned regularly. One hazard associated with closed storage is the tendency for volatile materials to build up slowly over time. To prevent this problem, choose storage systems made of inert materials, such as metal.

If open shelving is to be used for storing metals, the objects must be protected from dust and pollutants. Wrap artifacts in acid-free unbuffered paper or place them in acid-free boxes or in polyethylene bags. (For more information on constructing boxes, see CCI Notes 11/1 *Protective Enclosures for Books and Paper Artifacts*.) As a further precaution, polyethylene or washed cotton dust covers can be draped over shelving units.

Never place metal objects directly on a storage shelf or drawer. Line shelves and drawers with closed-cell polyethylene foam such as Ethafoam, PolyPlank, Volara, Plastazote, or Nalgene. The foam lining also helps to protect the objects from shock or abrasion. Avoid urethane foams because they degrade easily.

Arrange each metal artifact on a shelf or in a drawer so that its weight is evenly supported and so that it can be retrieved without damaging neighbouring artifacts. For metals housed in drawers, place wads of acid-free unbuffered paper or strips of polyethylene foam between the individual objects to keep artifacts from moving when drawers are opened or closed. Alternatively, individual supports for metal artifacts can be carved from thick polyethylene foam (see CCI Schlichting 1994). Metal objects can also be stored in clear plastic food-grade polystyrene boxes, polyolefin freezer containers (e.g. Tupperware), or polyethylene bags. Boxes and bags may need to be perforated to prevent the build-up of condensation on the inside in the event that the storage area is not well controlled for fluctuations in RH. Polyethylene bags can be punctured several times with a small sharp awl or punch although this will leave rough plastic projections on the inside of the bag that could catch on the artifact. Alternatively, the bag can be slit along the side with very small diagonal cuts. All holes must be small enough to prevent the artifact from falling out of the bag. Soft polyolefin boxes can be drilled through the sides (beneath the handles). Avoid Saran Wrap because it contains poly(vinylidene chloride). This slowly degrades to form hydrogen chloride (HCl) gas, which can damage metals. (For an excellent source of ideas and practical solutions to storage problems, see Rose and de Torres 1992.)

Handling

When removing metals from storage, ensure that they are supported well. Transport fragile pieces in padded trays, boxes, or the artifact's own storage support.

Wear well-fitting plastic or clean cotton gloves when handling metals. (Cotton gloves absorb sweat and accumulate salts during use, so be sure to clean them regularly.) Highly polished metals, such as silver and copper, are particularly sensitive to the oils and salts in skin. Avoid handling silver with latex rubber gloves because the sulphur compounds from the rubber may tarnish the silver over the long term. Also, many pure metals and some alloys are soft and are therefore easily scratched or dented.

Storage and Care of Specific Metals

Aluminum

Aluminum resists corrosion because of the protective oxide layer that forms rapidly when aluminum is exposed to air. Normally, if the oxide layer is damaged by an abrasive action like scratching, it re-forms rapidly. Chloride ions prevent the oxide from re-forming and so cause pitting of the aluminum surface. Following the guidelines in this Note will help to prevent the accumulation of surface contaminants that lead to this problem.

Copper

Copper alloys are susceptible to corrosion by ammonia, acids, strong alkalis, chlorides, and sulphide gases. It is best to store small copper artifacts in clear plastic boxes padded with acid-free unbuffered paper, or in boxes made from acid-free or neutral board. Larger artifacts can be wrapped in acid-free unbuffered paper, stored in carved Ethafoam supports, or placed on foam shelf-liners. (More information on brass and copper can be found in CCI Notes 9/3 *The Cleaning, Polishing, and Protective Waxing of Brass and Copper* and 9/4 *Basic Care of Coins and Medals*.)

Bronze disease is a form of active corrosion that affects archaeological copper alloys. It is characterized by the eruption of a light-green powder in spots over the surface. Objects displaying bronze disease should be stored separately to keep the corrosion products away from other artifacts. The RH of the storage environment for these objects should be below 35%.

Iron

All iron rusts when the RH is over about 65%. Uncontaminated iron is stable at 50% RH, but iron contaminated with salts continues to corrode. Actively corroding iron should be separated from the rest of the collection, and stored in conditions where the RH is below 35%. (For more information on caring for iron objects, see CCI Notes 9/6 *Care and Cleaning of Iron*.)

Many of the general storage methods discussed here are not practical for large iron artifacts. Their storage is often dictated more by the availability of space than by environmental considerations. However, maintaining a clean storage environment and providing adequate storage supports for these artifacts contribute to their long-term preservation. (Details on the storage of large iron artifacts are given in CCI Notes 15/2 *Care of Machinery Artifacts Displayed or Stored Outside*.)

Lead

Stable lead surfaces are generally dark grey, while actively corroding lead is usually covered with a loosely adherent white powder. Lead is particularly difficult to store safely because it is easily corroded by very small amounts of volatile organic acids, such as acetic or formic acid. These acids can act rapidly, destroying surface detail and weakening the object. Formaldehyde, a source of formic acid, is released from the adhesives used in certain plywoods and particle boards. (For more information, see Tétreault 2003.)

Inspect lead objects regularly for active corrosion because lead is particularly susceptible to damage in poorly ventilated areas. If an object is actively corroding, isolate it and store it at a low RH. At the same time, identify and, if possible, remove the corrosion source (often wood, paint, or adhesives) or provide better storage conditions.

To protect lead artifacts from harmful acids, wrap the objects with neutral and acid-free materials and store them in suitable containers. Envelopes made for the archival storage of coins are suitable for small lead objects or fragments. Polyethylene and food-grade polystyrene boxes are also safe for lead.

Plated objects

Collections often contain numerous plated objects such as steel cans plated with tin, copper-based objects plated with silver, chrome-plated automobile parts, or iron buckets galvanized with zinc.

These objects may be prone to galvanic corrosion because the two metals are in contact with each other. Such corrosion can be stimulated if there are salts, foods, or other organic residues in the cans or buckets, or if there is polish residue on a silver-plated object. If there is a concern about the stability of plated objects, keep them in as low RH as possible.

Silver
Tarnishing of silver is caused by sulphur-containing gases, such as hydrogen sulphide. In museums, these tarnishing gases may come from air pollutants, certain foods, sulphur-contaminated water, or materials commonly found in storage areas such as natural or synthetic rubber (in stoppers, O-rings, and latex gloves), certain paints, and some textiles (e.g. wool or felt). Because the source of tarnishing may be difficult to isolate or control, the use of closed and, if possible, sealed storage containers is recommended. (For more information on the storage of silver, see CCI Notes 9/7 *Silver — Care and Tarnish Removal*.)

Conclusion

Proper storage conditions and good housekeeping are essential for the long-term preservation of metal artifacts. Environmental controls are important. No corrosion should occur on most stable metal objects in a mixed collection if the RH is maintained at or below 55% (although certain pollutants in the air will still cause silver to tarnish or lead to corrode). Serious damage can be minimized by inspecting the collection regularly and by removing any objects suspected of actively corroding. Isolate these objects and keep them at an RH below 35% until a conservator can be consulted.

Because many natural and synthetic products emit gases that can cause metal to corrode, use safe storage materials and proper air ventilation to minimize the build-up of these corrosive gases. Many metal objects are constructed of soft metals that are easily scratched or of brittle ones that are easily broken. Careful handling of and proper support for metals objects will also ensure their protection.

Suppliers

Note: The following information is provided only to assist the reader. Inclusion of a company in this list does not in any way imply endorsement by the Canadian Conservation Institute.

Cotton gloves:
conservation suppliers

Metal shelves and cabinets with powder coatings:
shelving suppliers such as:

Montel
225 4th Avenue, P.O. Box 130
Montmagny QC G5V 3S5
Canada
tel.: 877-935-0236
www.montel.com

or

Delta Designs Ltd.
P.O. Box 1733
Topeka KS 66601
USA
tel.: 785-234-2244 or 1-800-656-7426
www.deltadesignsltd.com

Neutral, acid-free paper products (non-buffered or unbuffered):
conservation suppliers such as:

Carr McLean
461 Horner Avenue
Toronto ON M8W 4X2
Canada
tel.: 416-252-3371 or 1-800-268-2123
www.carrmclean.ca

or

Conservation Resources International Inc.
8000-H Forbes Place
Springfield VA 22151
USA
tel.: 703-321-7730 or 1-800-634-6932
www.conservationsources.com

Plastic boxes (food-grade polystyrene):
distributors of plastic supplies

Polyethylene bags:
grocery stores, chemical suppliers

Polyethylene foam (closed-cell) such as Ethafoam, PolyPlank, Volara, Plastazote, or Nalgene:
suppliers of packing materials

Polyethylene sheeting:
hardware stores, building suppliers

Silica gel:
laboratory equipment and chemical suppliers

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by Judy Logan
revised by Lyndsie Selwyn

Originally published 1988
Revised 1994, 1995, 2007

Copies are also available in French.
Texte également publié en version française.

Cat. No. NM95-57/9-2-2007E
ISSN 0714-6221

Printed in Canada

Instituut Collectie Nederland

Conserveringsstandaard

Bij de beoordeling van bewaaromstandigheden gaat de Inspectie uit van de waarden aanbevolen door het Instituut Collectie Nederland. De gehanteerde onderstaande tabel is gebaseerd op de tabel en de toelichting gepubliceerd in *Een kleurrijk verleden. Kleur; versieringen en materiaal-imitaties in historische binnenruimtes* (Informatie en Themadagreeks), Centraal Laboratorium voor Onderzoek van Voorwerpen van Kunst en Wetenschap, 1997. Bij de bovenste twee categorieën bedragen fluctuaties in temperatuur en RV niet meer dan 2ºC resp. 2% RV per uur en 3ºC resp. 3% RV per etmaal. De Inspectie houdt bij eigen puntsmetingen rekening met de volgende nauwkeurigheidsmarges: handmeter Environmental Elsec 764: voor T +/- 0,5ºC, voor RV +/- 2,5% in het bereik van 0-90% en +/- 5% in het bereik van 90-100%, voor UV +/- 5% en voor lux +/- 5%; datalogger Hanwell Humbug MkII: voor T +/- 0,2ºC in het bereik van -5ºC tot +50ºC en voor RV +/- 2% in het bereik van 0-100%.

Materiaal	**Temperatuur**		**Relatieve lucht-vochtigheid**	**Verlichtings-sterkte**	**UV-gehalte** *microwatt*
	max.ºC	*min.ºC*	*%*	*Lux*	*per lumen*
Werken op papier, textiel, kostuums, tapijten, behang, veren, was, ivoor, geschilderd leer, perkament, herbaria, droge zoölogische collecties	25	2	48-55	max. 50	max. 75
Ongeverfd leer, hout, schilderijen op doek, paneelschilderingen, gepolychromeerd hout, Aziatisch lakwerk, been, hoorn, parelmoer, beschilderd blik, rubber, fossielen, skeletten, kalkmateriaal, gips	25	2	48-55	max. 150	max. 75
Metaal (ijzer, koper, lood, zink, zilver)	25	2	minder dan 45	geen eis	geen eis
Edele metalen (goud en platina)	geen eis	geen eis	geen eis	geen eis	geen eis
Tin	25	14	minder dan 45	geen eis	geen eis
Stenen beelden	25	2	geen eis	geen eis	geen eis
(Geglazuurd) keramiek, aardewerk, tegels, email, glas	25	2	zo constant mogelijk	max. 300	max. 75
Mineralen/stenen	22	16	30-50	max. 50 of 150	max. 75
Vloeistofpreparaten	18	2	35-50	max. 50	max. 75