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THE POTENTIAL OF METAL DEBRIS: A LATE IRON AGE IRONWORKING SITE AT OSS-SCHALKSKAMP (PROV. NOORD-BRABANT / NL)

The study of iron production during the Iron Age in Northwestern Europe has not had a lack of practitioners in archaeology, attracting a great deal of research in Germany, Great Britain, and Scandinavia (e. g. Tylecote 1987; Jöns 1997; Lyngstrøm 2008). This is not in the last place due to the many remarkable artefacts found, disclosing the occurrence of iron production in these regions. Most research in the Low Countries, however, focusses on Roman and medieval iron production. In the Netherlands, Iron Age production sites are virtually unknown, despite many iron objects having been found. Only a few studies discuss the process of ironworking in the prehistoric Netherlands (Joosten 2001a; 2001b; de Rijk in prep.) and in most archaeological investigations the find category »slags« receives little attention. International research has, however, shown that archaeologists can glean much information from these artefacts. It was with this in mind that we decided to have a close look at an assemblage of nearly 200 iron slags discovered at the excavation of Oss-Schalkskamp (prov. Noord-Brabant/NL) over 20 years ago. The slags were found distributed throughout two Iron Age features, a long ditch and a large, ovular feature, suggesting a possible context for iron production.
This article aims to determine the nature of the slags and deduce the purpose of the two features. We thereby endeavour to gain insight into ironworking in the Late Iron Age south of the river Meuse. Through a detailed macroscopic examination of the iron slags, a selective X-ray fluorescence (XRF) analysis, and an exploration of the site context, this article intends to answer the following questions: Is there evidence for an iron activity area in Schalkskamp? If so, what type of iron production was carried out? How does this fit into the context of the micro-region Oss and into the context of iron production in the Netherlands during the Iron Age?

OSS-SCHALKSKAMP

The site Oss-Schalkskamp lies in the northwest of Oss, a city located just south of the river Meuse in the province of North Brabant (**fig. 1**). Excavations were carried out during the summers of 1990, 1991, and 1992 as a field school project of Universiteit Leiden. The site is situated just north of the Ussen estate, which has been extensively published (Wesselingh 2000; Schinkel 1998). The Roman period settlement at Schalkskamp was published by D. Wesselingh (2000), but the Iron Age and older features will be published as part of the Oss-North project (Fokkens/van As/Jansen in prep). Occupation of the Schalkskamp area most likely began at the end of the Early Bronze Age (c. 1850 cal BC), which is attested by a number of pits and well-dated plank-lined wells. Habitation in this period is episodic, however, with few features datable to the Middle and Late Bronze Age (1500-800 cal BC) or the Early Iron Age (800-500 cal BC). Features from the Middle Iron Age (500-250 cal BC) are completely absent. After 250 BC, the area becomes occupied again, leading to a period of intense habitation in the second half of the Late Iron Age. This is evidenced by the presence of hundreds of artefacts, house plans, pits, wells, and a ditch system surrounding or demarcating

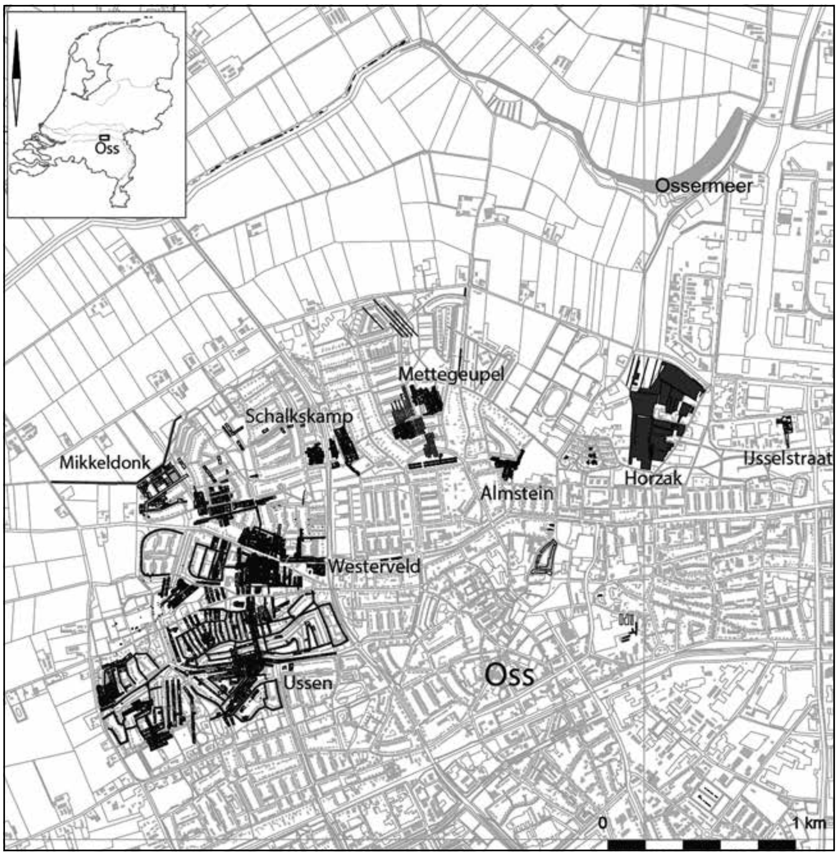

Fig. 1 Overview of excavated sites in the Oss region (prov. Noord-Brabant/NL). Schalkskamp is situated in the northwest. – (Map after Jansen/van As 2012, 96 fig. 1; illustration S. van As).

the settled area (**fig. 2**). Habitation continues in the Roman period, but ends abruptly after the 1st century AD, when Schalkskamp is abandoned until the Late Middle Ages (14th century).

Find context

One of the interesting features of the Late Iron Age settlement at Oss-Schalkskamp is a ditch system that surrounds the settled area. This is a curious phenomenon as it represents a new type of feature in the Iron Age, especially in the region south of the river Meuse, but also in Belgium and northern France. In this area, after 250 cal BC, settlements are frequently demarcated by ditch systems. This is in contrast to preceding periods when these features are completely lacking. Additionally, houses are more frequently rebuilt on (almost) the same location in the Late Iron Age. This development seems to indicate a more permanent organisation of the landscape (cf. Gerritsen 2001, 200; Wesselingh 2000, 213) and a greater awareness of ownership of or belonging to a certain area.

The Schalkskamp Late Iron Age ditch system consists of a 2 m wide ditch with an entrance in the northwest, configured as two parallel ditches (**fig. 2**). It encloses the contemporary houses, granaries, pits, and wells, indicating that it probably functioned as a settlement boundary system. The ditch system was excavated completed during the field campaign and yielded many artefacts. Especially the eastern ditch (feature 1006.23) revealed a striking abundance of finds. Here we discovered a great number of artefacts distributed through the northern most 90 m of the feature. The largest concentration of finds was centred around a feature approximately halfway along the ditch. This ovular feature (1006.34) (**fig. 3**), was positioned on a

Fig. 2 The excavation plan of Oss-Schalkskamp (prov. Noord-Brabant/NL). The Iron Age features are marked in black. Only relevant features are labelled. – (Map S. van As).

naturally filled up layer, indicating that it was constructed in a dry ditch. We initially thought it might have been a pottery oven or kiln since it revealed large amounts of pottery, burnt and not burnt, and a thick layer of charcoal. However, during further excavation we discovered scores of metal slags as well as other artefacts. This gave us reason to suspect that the feature may have had one or more other purposes. Sometime after it had been abandoned, the ditch was entirely filled up and almost erased from the landscape. This occurred before the next phase of the settlement, during the Early Roman period (1st century cal AD).

Dating

The dating of the features is based on a ^{14}C dating and typological analysis of the pottery shards. Like the iron slags, the pottery shards were found distributed throughout the ditch, amounting to over 2800 fragments. The pottery typology is based on the method devised by P. van den Broeke (2012). This system has

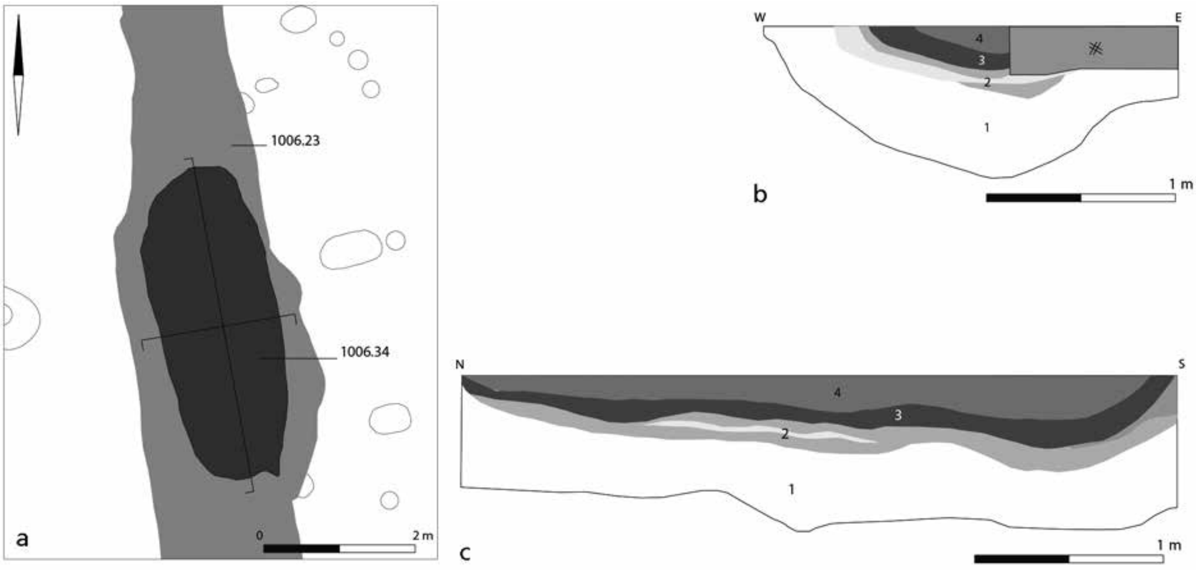

Fig. 3 Oss-Schalkskamp (prov. Noord-Brabant/NL): **a** excavation plan of features 1006.23 and 1006.34. – **b** W-E cross-section. – **c** N-S section. – **1** ditch 1006.23 with its fill; **2** hearth 1006.34; **3** charcoal layer in hearth 1006.34. – (Illustration S. van As).

over the years proven its validity as a dating method for much of the southern Netherlands. It is an important addition to ^{14}C dating, especially because the many wiggle plateaus make the interpretation of ^{14}C dates difficult for the Iron Age. P. van den Broeke's method is based on the seriation of different characteristics of the pottery (decoration, form, etc.). Co-variation of these characteristics is specific for certain periods. In this manner, P. van den Broeke has divided the Iron Age in typo-chronological periods of about 50-75 years, phases A-N, dating from the Early Iron Age (800 BC) to the Late Roman period (AD 270) (van den Broeke 2012).

Using this method, it was evident that the pottery shards date to the Late Iron Age, more specifically to the end of phase J and the beginning of phase K. This places the features 1006.23 and 1006.34 in the 2nd century BC (confirmed by P. van den Broeke, pers. comm. 2013).

A sample from the charcoal layer of feature 1006.34 was ^{14}C dated. This sample gave a ^{14}C date of 2140 ± 30 BP (GRN 21506), which calibrates to 212-88 cal BC (2σ). This corresponds with the beginning of phase J to the beginning of phase K, which is 200-100 cal BC. The ^{14}C analysis thus supports the date derived from the pottery typo-chronology.

THE IRON PRODUCTION PROCESS

The nature of the above-described features and the discovery of metal slags gave us reason to believe that Schalkskamp had been the site of an iron production workplace. However, the presence of such large amounts of pottery and other interesting artefacts suggested an ambiguity that had not yet been resolved in the field. Furthermore, we did not know the nature of the workplace or which steps of the iron production process had taken place at Schalkskamp. Our research therefore focussed on the understanding of which archaeologically visible remains were the result of the different stages in the production process.

The process by which iron was produced remained virtually unchanged from the Iron Age until the introduction of cast iron in the Late Middle Ages (Tylecote 1987; Pleiner 2000; 2006). This type of iron production is

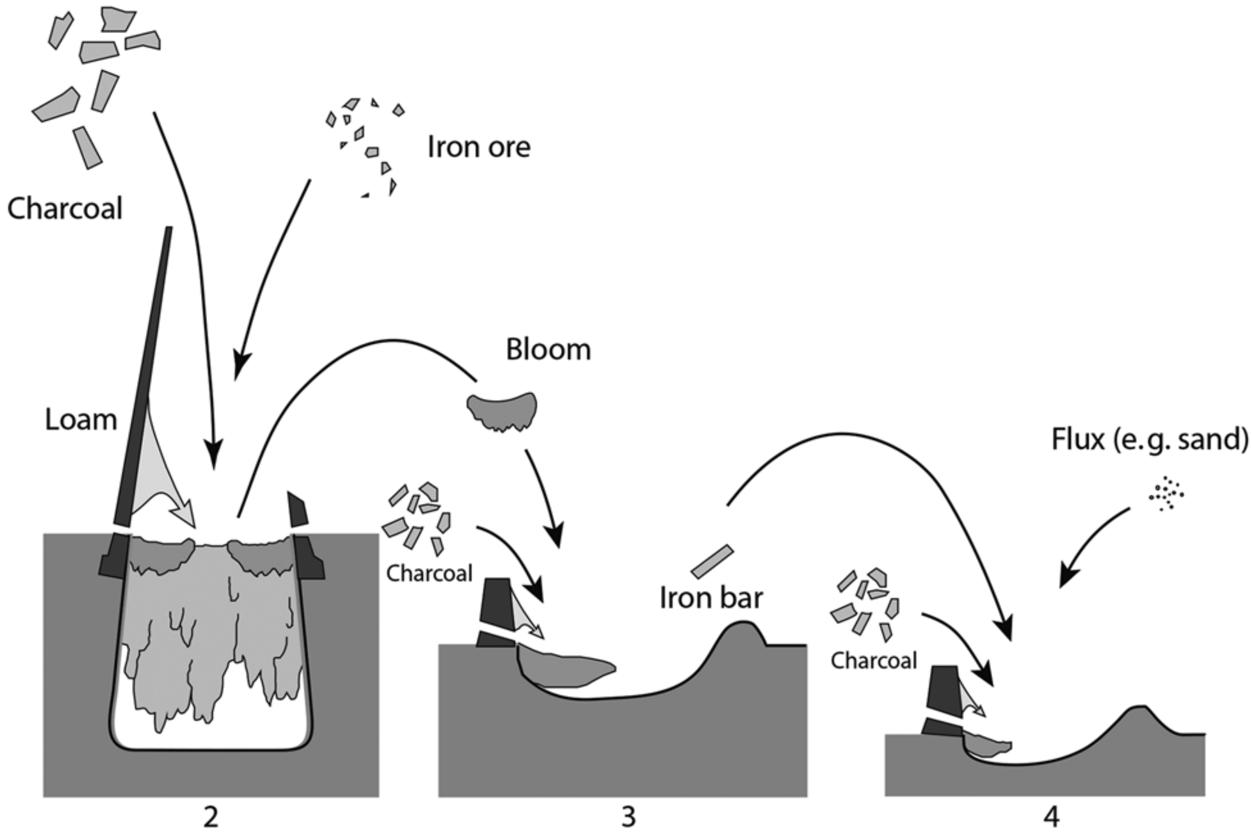

Fig. 4 Schematic drawing of steps 2 (smelting), 3 (primary smithing), and 4 (secondary smithing) of the iron production process. – (After de Rijk 2007, 32 fig. 9).

	step 1 extraction	step 2 smelting	step 3 primary smithing	step 4 secondary smithing
setting	iron ore source	furnace	direct from the furnace or hearth	smithing hearth
raw materials	–	iron ore charcoal	bloom charcoal	iron bar charcoal flux (sand)
product	iron ore	bloom	iron bar/billet	iron product
possible archaeological debris	–	smelting slags charcoal furnace lining (e.g. clay) tuyere (bellows)	primary smithing slags charcoal hearth lining (e.g. clay or loam) tuyere (bellows)	secondary smithing slags charcoal hearth lining (e.g. clay or loam) tuyere (bellows) hearth stone anvil

Tab. 1 The four steps of the bloomery process and their characteristics. The bellows are included in parentheses as they are rarely found archaeologically due to their organic composition.

known as the bloomery or direct process. Four steps can be distinguished in this process: extraction, smelting, reheating (primary smithing), and forging (secondary smithing) (**fig. 4**). In the following description we focus on the debris that each step creates (**tab. 1**) because, in principle, this enables us to deduce which part of the production process took place at a particular site.

After the extraction of the iron ore from the source, smelting takes place in a furnace where the iron oxide in the ore is reduced to metallic iron. The metallic iron coalesces with inclusions of slag and charcoal to form solid iron (the bloom). The slag left over from the smelting process varies in form and composition according to the raw materials and type of furnace used (Blakelock et al. 2009). The bloom still contains a large amount of slag and charcoal, so it subsequently needs to be reheated and hammered to expel these particles. This step, the primary smithing, generally creates very large slags with varying shapes (de Rijk 2007). The product of primary smithing is a bar or billet, which is forged into an iron object by the smith. This last step, the secondary smithing, is carried out by repeatedly heating the bar in a hearth and hammering on it on an anvil. Secondary smithing creates two types of debris: smithing slags and hammerscale. Smithing slags form in the hearth, where fuel, flux, furnace lining, iron, and other particles present in the hearth, conglomerate (de Rijk 2007). The slags formed in the hottest part of the hearth, under the tuyere, have a plano-convex shape in cross-section. Those formed in the charcoal bed have an irregular and heterogeneous shape (Joosten 2001a). Hammerscale are small, magnetic flakes that are expelled when the smith hammers on the iron on the anvil.

The basic form of the smithing hearth is a hollow or lined hollow in which the fuel is burnt and the iron bar is heated (de Rijk 2007, 158). Loam, stones, or even slags could be used as lining (de Rijk 2007, 158). Oxygen is supplied through the tuyere using the bellows. Tuyeres are often found in archaeological contexts as they were made of ceramics, loam, or stone (Joosten 2001a; de Rijk 2007; Young 2012). Various shapes are known, such as cubical, discoid, or conical; these are not specific to iron forging and can be used for the making of, for example, bronze and glass (de Rijk 2007, 160). Bellows are poorly known from archaeological contexts because they were probably made from organic material such as wood and leather (Joosten 2001a; de Rijk 2007; Young 2012). They were therefore also flammable and needed to be protected from the heat. This was often done using a wall made of loam or stone, known as the »hearth stone« or »bellow protectors« (Crew 1996; Joosten 2001a; de Rijk 2007). Anvils are known in a variety of shapes and could be made from stone or iron (Young 2012).

The position and type of smithing hearth needs to be reconstructed from the above-mentioned features, as the hearth structure itself is generally poorly visible archaeologically. The recognition of »heat-affected surfaces« can aid herein, because the continuous exposure to heat and activity sometimes create a worn hollow (Young 2012, 2). A smithing hearth can be a basic structure, with for example only a clay wall needed to separate the fuel and bellows (Crew 1996). A purpose-built structure is thus not necessary and a domestic hearth can suffice (McDonnell 1995). The smithing hearth is found in divergent shapes and dimensions. Rectangular, round, and ovular hearths are known, varying in diameter from 20 to 200 cm and from 15 to over 60 cm deep (de Rijk 2007, 159). For general purposes, however, a hearth does not need to be bigger than 30 cm × 20 cm × 15 cm (de Rijk 2007, 159). As a general rule one can say that the larger the hearth, the more heat it emits, the more oxygen it requires from its surroundings, and the more effort it is to clear after every use. This makes a large hearth impractical (de Rijk 2007, 159).

MATERIALS AND METHOD

In total 203 slag fragments were found distributed throughout the ditch 1006.23 and feature 1006.34. All exemplars larger than 3 cm in diameter (187 in all) were examined macroscopically. This selection was made because it is difficult to identify slags smaller than 3 cm to a specific production step. We based our study on the work of P. T. A. de Rijk (2007) with respect to which characteristics to examine. P. T. A. de Rijk has described how specific characteristics of the slags relate to specific steps in the production process. This enables us to determine whether the Schalkskamp slag debris belongs to the iron smelting, primary smithing, or secondary smithing process (de Rijk 2007, 113). Slags from each process can vary in appearance and therefore a study of only a few exemplars is not beneficial (de Rijk 2007, 113). For this type of investigation the relatively large dataset of 187 slags is therefore considered ideal.

slag category	number	weight (g)	weight (% of the total)
plano-convex	59	9893	64
cinder	106	4283	27.7
charcoal conglomerate	16	620	4
compact	6	566	3.7
hammerscale	–	85	0.6
total	187	15447	100

Tab. 2 The five categories of slag debris.

The macroscopic examination entailed an identification of colour, morphology, the presence of inclusions such as charcoal and quartz, and the presence and colour of glazing. Furthermore, the weight, density, size, and magnetism of each slag were measured. The density was calculated using the weight and volume. The volume was measured by immersing the slags in water in a measuring cup with a 20 ml specification. It was therefore not possible to calculate the density of slags with a volume less than 10 ml. The degree of magnetism was measured using a small, hand-held magnet.
Six slags were selected for an XRF analysis. This sample was small because the purpose of this analysis was solely to evaluate the supplementary value of an XRF analysis. Two typical plano-convex slags (nos 4. 90), the heaviest plano-convex slag (no. 123), one large, irregular shaped slag (no. 19), and two compact slags that had a much higher density than the rest (nos 43. 121) were selected. At the Rijksdienst voor het Culturell Erfgoed in Amersfoort, the six exemplars were cross-sectioned using a diamond saw and subsequently analysed using a Niton XL3 hand-held XRF with a large surface silicon drift detector. Hans Huisman carried out the XRF analysis and the results were calibrated by Bertil van Os.

RESULTS

Macroscopic examination

Based on morphology and composition we were able to divide the 187 slags into five categories (**tab. 2**).
The first group consists of 59 exemplars with a plano-convex shape (**figs 5a; 6**). The shape is typical of slags formed during the primary and secondary smithing processes (de Rijk 2007, 115). These are often referred to as plano-convex (hearth) bottom or PCB slags (McDonnell 1995; Crew 1996; Serneels/Perret 2003). They are formed in the hottest part of the hearth, under the tuyere (Crew 1996; Joosten 2001a). The PCB slags found at Schalkskamp vary in morphology from oblong and round to irregular. Some show a strong plano-convex shape while others only a slight convexity or are almost flat. Such variations are common within this category of slag, their morphology depending on where in the hearth the slag forms, the working conditions, and the raw materials (Serneels/Perret 2003). This is reflected in the heterogeneous structure of the slags, with inclusions of, among others, charcoal, quartz, and clay. In cross-section this structure is visible (**fig. 6**).
The composition of most of the PCB slags is fairly similar. The majority (80%) are magnetic, indicating the presence of metallic iron or iron oxide magnetite (de Rijk 2007, 119). Additionally, 81% have visible charcoal inclusions and just over half have visible quartz inclusions. The presence of quartz has often been connected to the smithing process although the reason for these inclusions has not yet been established (de Rijk 2007, 118). Approximately a third (35.6%) of the slags has a glassy surface. These form when silicate-rich melts cool down quickly after the exposure to a high temperature, conditions which are often present in smithing

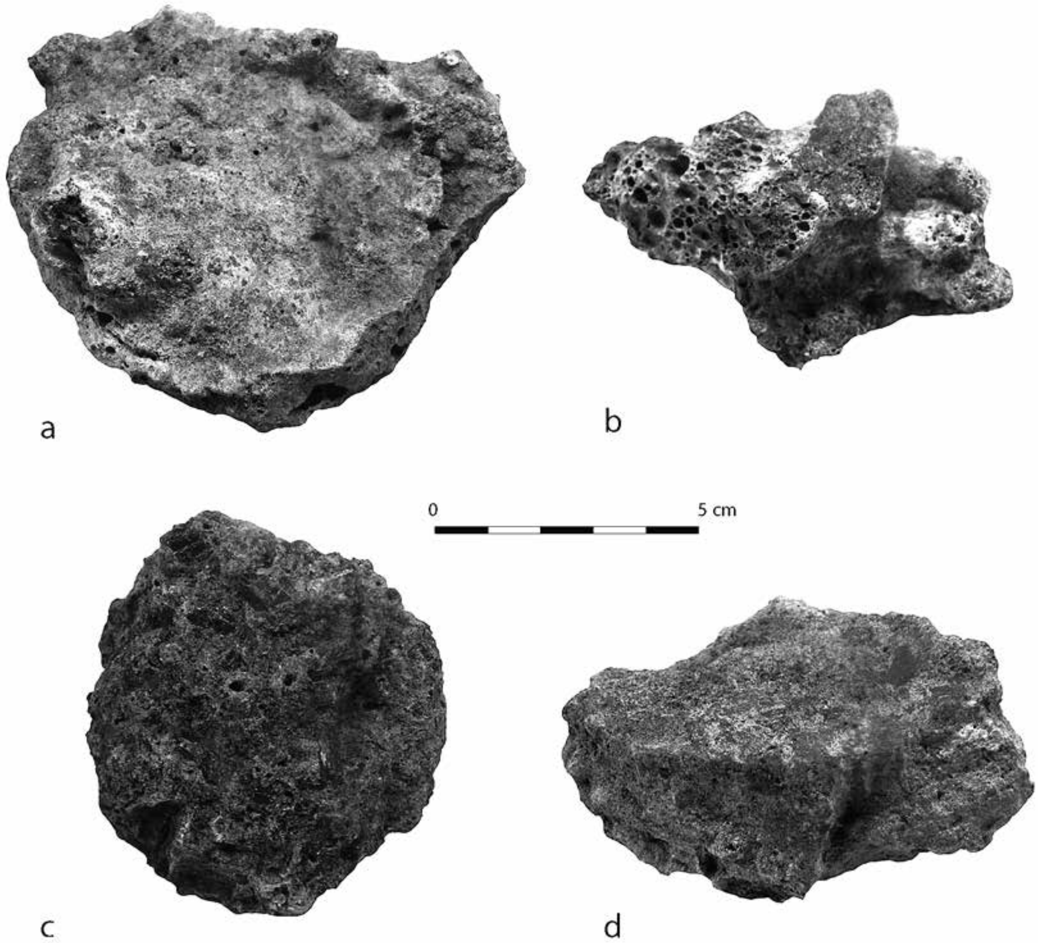

Fig. 5 Oss-Schalkskamp (prov. Noord-Brabant/NL). Four examples of the different slag types: **a** plano-convex slag. – **b** irregular slag. – **c** conglomerate slag. – **d** compact slag. – (Photos N. Ø. Brusgaard).

	diameter (cm)	density (g/cm^3)	weight (g)
mean	8	2.65	167.7
maximum	12.5	4.9	552.9
minimum	3.4	1.09	10.9

Tab. 3 Measurements of the plano-convex slags.

hearths where the air is blown into the hearth (de Rijk 2007, 119). The comparable compositions of the plano-convex slags indicate that, despite possible varying conditions, the slags were formed under influence of the same raw materials and in the same context.

The size, density, and weight of the plano-convex slags point to an origin in the secondary smithing process (**tab. 3**). This step in the iron production sequence generally produces slags measuring less than 15 cm in diameter (de Rijk 2007, 114 f.). The distribution of size ranges of the Schalkskamp exemplars (**fig. 7**) is comparable to assemblages of secondary smithing slags known from other sites in the Netherlands (Joosten 2001a; 2001b; de Rijk in prep.). In general, iron slags have a density between 3.0 and 5.0 g/cm^3, with smelting slags showing the highest densities (de Rijk 2007, 119 f.). The average density of the Schalkskamp plano-convex exemplars is thus comparatively low, indicating that they originate from a smithing process whereby many inclusions and air cavities were contained within the slags. The exemplar with the largest density, 4.9 g/cm^3, has a typical plano-convex shape so therefore appears to be an exception or a methodological error. The average weight of the slags is low and there are only a few outliers weighing more than 300 g (**fig. 8**). This is comparable to known forging slags, especially those known from Iron Age

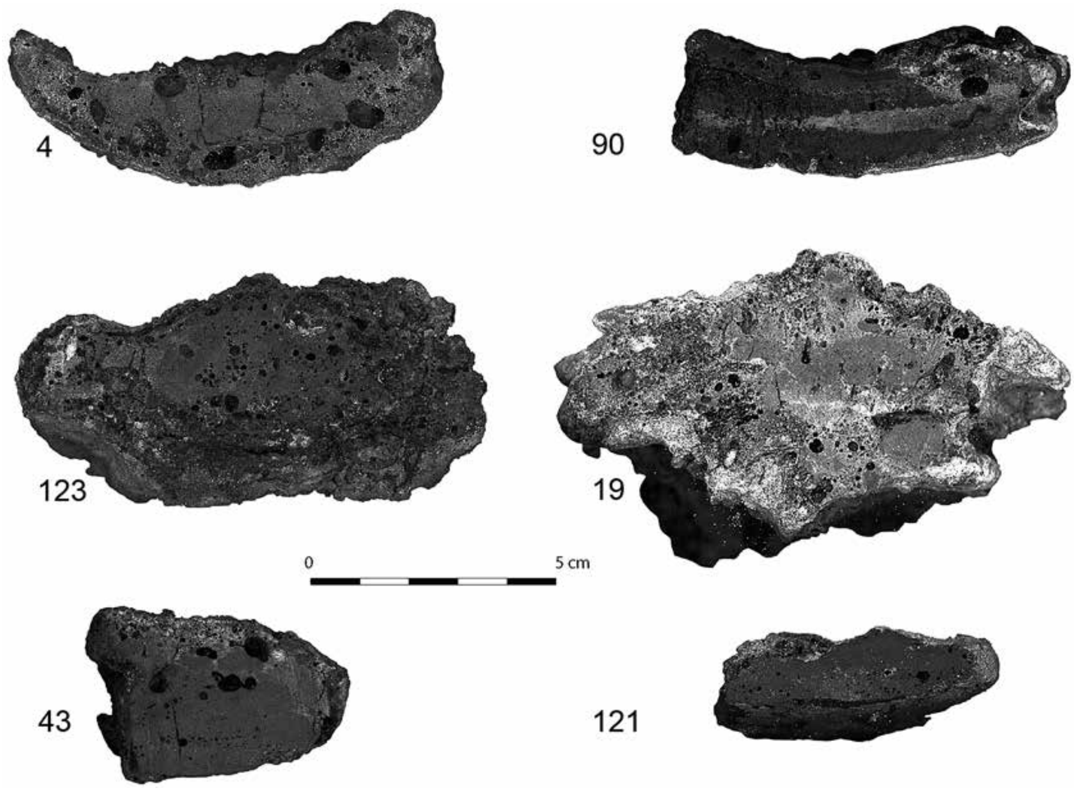

Fig. 6 Oss-Schalkskamp (prov. Noord-Brabant/NL). The cross-section of six slags: nos 4 and 90 are plano-convex slags; no. 123 is the heaviest slag; no. 19 is a large, irregular shaped slag; nos 43 and 121 are compact, highly magnetic slags. – (Photos N. Ø. Brusgaard).

contexts. Secondary smithing exemplars from Dutch Roman period and medieval iron production generally have a much higher average weight (Joosten 2001a; 2001b; 2001c; de Rijk in prep).

The second group consists of 106 slags with an irregular shape and heterogeneous structure, the cinders (**fig. 5b**). Many of these slags contain sintered ash and have a glassy surface. Their structure is otherwise comparable to the plano-convex exemplars. More than half are magnetic, 55% have visible charcoal inclusions and 56% visible quartz inclusions. They have much a lower average diameter (6 cm), density (1.7 g/cm^3), and weight (40.4 g) than the plano-convex slags. These characteristics indicate that these irregular exemplars were formed elsewhere in the hearth than the plano-convex slags, possibly in the fuel bed (Joosten 2001a, 312). Those with sintered ash were most likely formed in the fuel bed whereas those with glassy surfaces were probably formed closer to the air inlet. However, they were under influence of the same raw materials as the plano-convex slags, such as the charcoal and quartz, and are identifiable to the secondary smithing process.

The slags that make up the third group are conglomerations of charcoal, rust, and sand (**fig. 5c**). They are small, light, and have a low average density (1.64 g/cm^3). These slags are non-magnetic and thus contain no metallic iron. This type of slag is probably formed in the fuel bed where fuel and flux conglomerates under the influence of the heat of the hearth.

The fourth, small group consists of six slags. These exemplars are rectangular, compact, smooth, and highly magnetic (**figs 5d; 6**). Three of them have small quartz and charcoal inclusions, but no inclusions of clay or loam and none have a glassy surface. They have a high average density of 3.84 g/cm^3 compared to the other slags. The cross-sections of two of these slags reveal that, compared to the other exemplars, they have a compact, solid structure with few air pockets. However, the XRF results indicate that they have the same mineral composition as the other slags (see **appendix 1**). Based on this, it appears that these slags were also

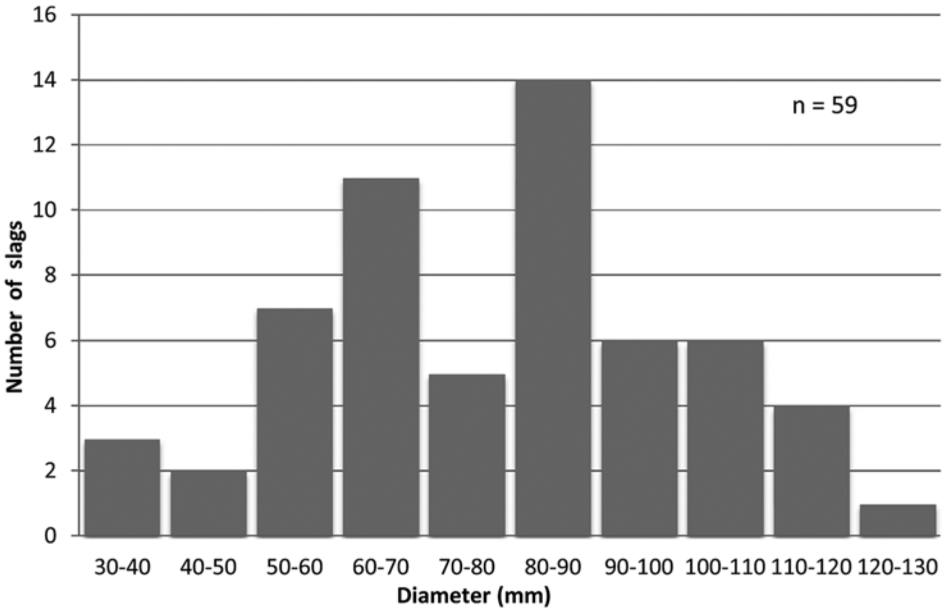

Fig. 7 Oss-Schalkskamp (prov. Noord-Brabant/NL). The diameter sizes of the plano-convex slags. – (Illustration N. Ø. Brusgaard).

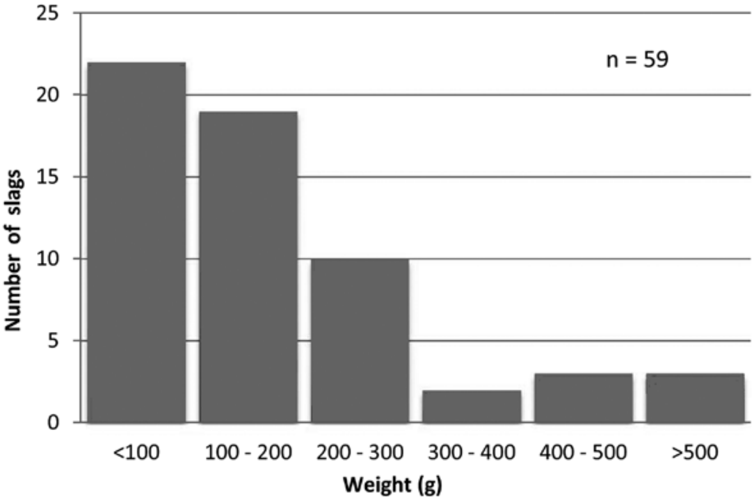

Fig. 8 Oss-Schalkskamp (prov. Noord-Brabant/NL). The weight distribution of the plano-convex slags. – (Illustration N. Ø. Brusgaard).

formed in the smithing hearth, but more rapidly and under little influence of the materials present in the hearth. They thereby acquired few inclusions and a compact structure, leading to a higher density.

The final group of slag is the hammerscale. A total of 85.3 g of hammerscale was discovered at Schalkskamp, all of which were small, magnetic flakes.

Of the total 203 slags, the largest concentrations were found in feature 1006.34 and in the adjacent segments of the ditch (**fig. 9**). In the segments farthest away from the pit, few to none were discovered. The hammerscale was concentrated in the charcoal layer of the pit. This may be a sampling bias or caused by the clearing of the debris around the anvil and depositing it there. The distribution of the slags confers to what one would expect of an abandoned smithing hearth.

XRF analysis

We discuss here the main findings of the XRF analysis. The results are presented in **appendix 1**. Overall, the chemical values of the six slags are similar in their composition, but the concentrations of major elements do vary. The six exemplars are predominantly composed of iron oxide (Fe_2O_3) and silicon oxide (SiO_2), which

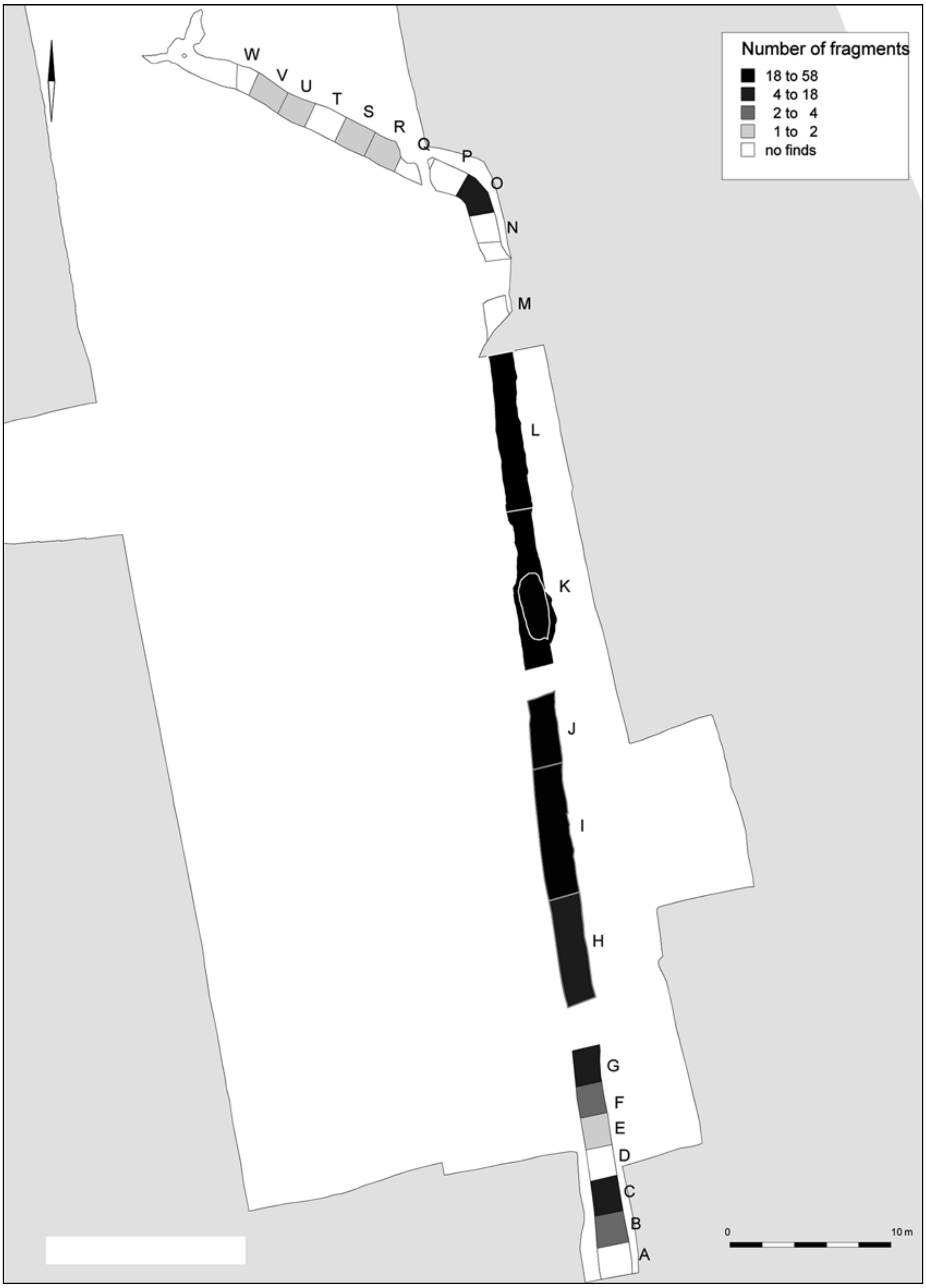

Fig. 9 Oss-Schalkskamp (prov. Noord-Brabant/NL). Distribution of slags found in each excavated segment of ditch 1006.23 and hearth 1006.34. – (Illustration N. Ø. Brusgaard).

is consistent with the composition of smithing slags (Tylecote 1987; Selskiene 2007). The material is relatively rich in iron oxide and thereby poor in silica (Serneels/Perret 2003). Only one measurement, M4143 on the yellow layer in slag no. 90 (visible in **fig. 6**), shows high SiO_2 contents, reaching levels comparable to the iron contents.

	number	total weight (g)
slag (examined)	187	15447
slag (not examined)	25	–
pottery	2803	54529
sintered ceramic	168	2769
crucible	1	11
loom weight	183	14867
spindle whorl	6	162
sling bullet	229	5190
glass La Tène bracelet	9	–
iron	13	613
bronze	2	62
tephrite	31	1534
loam	22	1538
unmodified stone	104	4252
total	3783	100974

Tab. 4 Various artefacts found in the ditch and hearth.

The iron contents in slags nos 19, 90, 121, and 123 are so high that metallic iron or magnetite (Fe_3O_4) must be present in the samples. This was confirmed by the examination with the hand-held magnet. This examination also showed a degree of magnetism in slags nos 4 and 43 that could not be ascertained by the XRF analysis due to lower contents of Fe_3O_4.
The high variability in concentrations of Fe and Si is typical of smithing slags as they are heterogeneous in nature (Blakelock et al. 2009). Silica originates from various sources during the forging process, such as the hearth lining, ashes, or flux (Serneels/Perret 2003). The high silica content in the yellow layer of slag no. 90 when compared to the other measurement on the same exemplar (M4142) was probably due to the formation of this layer under greater influence of the flux or silica-rich contents of the hearth.
The XRF measurements of the two compact, dense slags nos 43 and 121 indicate that they resemble the other smithing slags in composition. Despite their high density and compactness, they can thus be categorised as smithing exemplars.
The small sample of six slags is not enough to draw any conclusions about the conditions in the smithing hearth. However, it does provide insights into the differences in the layers of a slag and solve questions about anomalous slags such as the dense, compact ones.

The features

Feature 1006.34 is an ovular, layered »structure« of 50 cm deep, 380 cm long and 160 cm wide. Its structure and the artefacts found in and near it strongly indicate that it is a hearth. It consists of a red, sandy layer covered by a thick layer of charcoal (**fig. 3**). The sandy layer may have acquired its red colour due to the heat effects of the (forging) activities (Young 2012). The charcoal layer appears to be the remains of the fuel bed of the smithing hearth. The red sandy layer is not »just« burnt substrate, but differs from the surrounding matrix. Therefore, we think it was laid out underneath the charcoal bed and hence we consider it part of the hearth structure. The position of the hearth in the ditch indicates that the constructors made use of a natural hollow in the dry ditch to position their hearth, rather than digging a pit. With a length of 380 cm and a width of 160 cm, the dimensions are large for a smithing hearth. The large size may indicate that large objects were forged or that it was used for other activities than only smithing (de Rijk 2007, 159). Some time after use, the ditch in which the hearth was located was filled in. The location of the slag and associated artefacts relatively close to the hearth suggests that the ditch filled up fast with few disturbances.

Other artefacts

A large amount of other artefacts was found in the hearth and ditch (**tab. 4**). A number of these may relate directly to the smithing process. Three loam blocks were recovered from the hearth that have a similar tri-

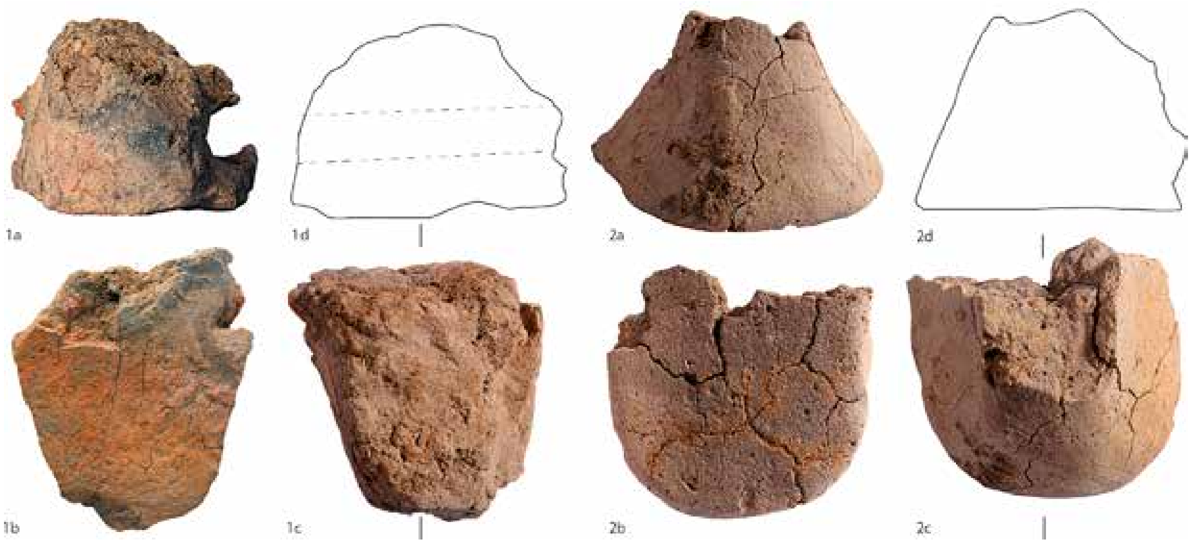

Fig. 10 Oss-Schalkskamp (prov. Noord-Brabant/NL). Possible tuyeres, one with the remains of a blowing hole to one side (**1a-d**) and one of the other two possible tuyeres seen from different angles (**2a-d**). – (Photos J. Donkersgoed / S. van As). – Scale 1:4.

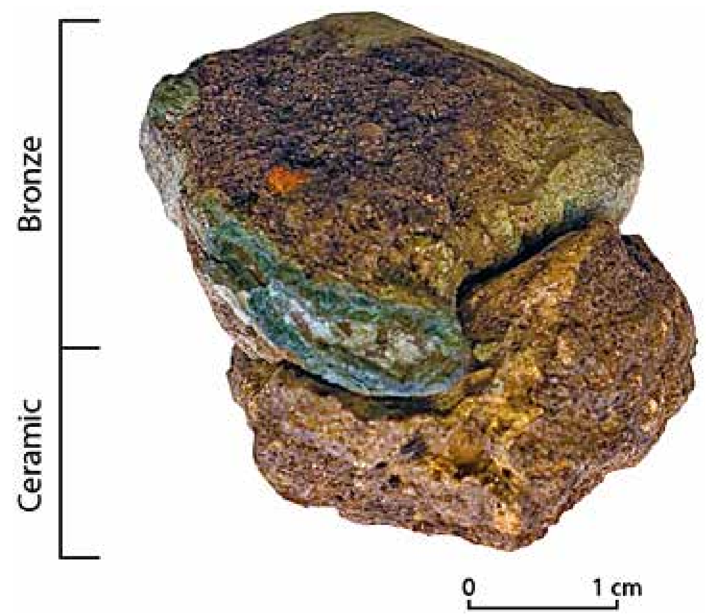

Fig. 11 Oss-Schalkskamp (prov. Noord-Brabant/NL). Fragment of a crucible with a bronze remains attached to it. – (Photo S. van As).

angular shape and have been burnt (**fig. 10**). One of these has a hole to one side, suggesting that it is a tuyere. The other two were possibly used as a tuyere as well, but broken off at the air inlet. We also found 13 iron artefacts, products, and half-products from the forging process, distributed throughout the hearth and ditch. There are eight nails, one (razor) blade, and four unidentifiable objects. Several loam, stone, and tephrite fragments were also found in the hearth, but there is nothing to suggest that they might have been used as hearth lining. It is possible that (some of) the pottery shards were used as hearth lining. Of the 2803 fragments that were found, a significant number were burnt, almost 3 kg was more or less completely sintered, and several were glazed. Alternatively, this may indicate that at some stage the hearth was used for

firing pottery as well. An interesting artefact found in the hearth in layer 3 (**fig. 3**) supports that the hearth was used for multiple purposes. A fragment of a crucible was discovered together with a piece of bronze in the charcoal layer of the hearth. The two fragments were originally stuck together (**fig. 11**). This indicates that bronze casting or working also took place in the hearth. A fragment of a fibula that could not typologically be placed could be a product of casting in this hearth, but it may also have been debris from a later period that ended up in the derelict ditch as waste.
The other finds are not associated with the function of the hearth, but two categories do stand out: the loom weights and sling bullets. A mass of 196 sling bullets was discovered in the corner segment of the ditch. Similarly, 63 of the loom weights were found in one 2-m segment (segment M) of the ditch. These two concentrations of artefacts indicate that the objects may have been purposely deposited in the ditch rather than simply thrown away. As suggested by the dating of the pottery, the artefact assemblage as a whole is a consistent complex, rather than a mix of material collected over ages. The fragments below, on top, and around the hearth are identical in age, so the cycle of digging, use, secondary use, abandonment, and filling-up was relatively short, probably less than a century. It all probably happened in phase J of the Late Iron Age (van den Broeke 2012), in other words in the 2nd century BC.

Associated features

There are several features around the hearth that date to approximately the same period (**fig. 2**), but it is hard to establish a clear relationship. The ditch itself appears to be part of a rectangular ditch system surrounding the Late Iron Age settlement area. An entrance system was found in the north-west and there was at least one house plan and a number of granaries that date to the same period. However, other than their contemporaneity, there is no indication that these features are directly linked to the hearth, for example, as the residence of the smith. Moreover, there is no reason to suggest that in the Iron Age smithing was a full-time specialised profession. So one might expect the smith's house was not much different from a normal farmstead.

DISCUSSION

From the evidence, it is clear that the Oss-Schalkskamp complex of finds and features are the remnants of a smithing hearth and the activities carried out there. It is one of the few from this period in the Netherlands. Based on the Schalkskamp evidence, we can now start to picture, very cautiously, Late Iron Age domestic iron production. At Schalkskamp, the domestic features are contained within an enclosed area and paint the picture of a small Late Iron Age settlement. Set within one of the boundary ditches was a smithing hearth that was in use for approximately a century, where after it was abandoned and filled up. This process resulted in the distribution of debris in and around the workplace. Although we found no evidence for the smith's tools, an anvil, a heat shield, or bellows, we are able to reconstruct the activity area based on the forging debris and features. The smithing hearth was a large, probably unlined hollow positioned on a naturally filled up layer of the ditch. The presence of hammerscale in the hearth suggests that hammering took place alongside it or that the hammerscale was discarded here after the clearing out of the forging area. Interestingly, the hearth was most likely multi-purpose. The inhabitants of Schalkskamp probably used it for all of their craft needs including bronze working (albeit on a smaller scale).

The setting thus looks quite domestic, pointing to a self-sufficient settlement. It is difficult to assess the amount of iron produced in the hearth, but it was probably not much more than would cater to a small settlement and not more than could be produced by one non full-time smith. It is, however, possible that more was produced than what the small one or two family settlement Schalkskamp needed. There is also no indication that the smith was a full-time specialised craftsperson in the Iron Age. A multi-functional hearth in a small settlement fits this picture. This is not to say, however, that no skill was involved. Iron forging is a high-risk activity with highly variable outcomes (Giles 2007, 398). Therefore, the smith would have required specialised knowledge and skilled improvisation (Giles 2007, 398). Furthermore, this person could not have worked in isolation. If surplus iron was produced, it would have been brought elsewhere. Additionally, there is no evidence for iron smelting at the Schalkskamp settlement, so the iron bars would have needed to be brought in from elsewhere.

This begs the question, where did the iron go to and where did the iron come from? The first question is difficult to answer. Although iron artefacts have been found at the other Late Iron Age settlements in Oss North, there is no evidence to suggest that Schalkskamp catered to their iron needs. Furthermore, even though Oss-Schalkskamp has yielded the first clear hearth, remains of iron forging have been discovered in other settlement contexts in Oss (Schinkel 1998; Fokkens/van As/Jansen in prep.). In the Oss-Ussen settlements alone, covering about 33 ha of excavated area, we have ample evidence (Schinkel 1998). K. Schinkel lists slag remains and iron objects from six Early Iron Age pits (Schinkel 1998, 55 f.) and from 18 Middle Iron Age pits (Schinkel 1998, 91-93). Interestingly one pit contained 4 kg of slag and the remains of what is thought to be an oven (Schinkel 1998, 93). Additionally, three crucibles for bronze working and possible fragments of tuyeres were found (without being recognised as such, e. g. Schinkel 1998, fig. 126). Slags from the Late Iron Age were discovered in 25 features, several of which were located in the north of Ussen, a few hundred metres south of Schalkskamp (Schinkel 1998, 132-139). It is thus apparent that in Oss, local iron forging was well-established and probably largely domestic, being carried out for a settlement's own needs.

The second question concerning the origin of the iron affords two possibilities. Either the iron was imported or it was smelted locally. Due to the lack of iron production sites, it is generally theorised that in the Iron Age, iron was imported to the Netherlands and that it was not smelted here until the Roman period (Joosten 2004, 30; van den Broeke 2005, 688). The iron may have been acquired, in the form of iron bars, from across the modern border from Germany, where many Iron Age iron smelting sites are known (Jöns 1997; de Rijk 2007; Jöns 2010), or from Belgium where a few are known (Dijkman 1989). However, there is as of yet no evidence for this and it will probably not be provided in the near future as the method of provenancing iron is still in its infancy (cf. Blakelock et al. 2009).

Given the regional availability of bog iron, it is also possible that smelting could have taken place regionally. Indeed, there is earlier evidence to suggest this at the Middle Iron Age site of Maastricht-Randwijck (prov. Limburg), the southernmost province of the Netherlands (Dijkman 1989). Here W. Dijkman (1989, 38) identified a horse shoe-shaped feature as a smelting furnace and the iron slags found in the feature as smelting slags. The interpretation has since not been reviewed, but if correct, it implies that iron smelting did, at least sporadically, take place in the Iron Age in the Netherlands. Other smelting locations are not known, but the absence of evidence is in this case not evidence for absence. Research on British prehistoric smelting sites indicates that this process was often conducted outside of the settlement, probably due to the risks to houses and structures (Giles 2007, 399). In Middle and Late Iron Age Britain, iron smelting and ironworking were frequently geographically distinct activities (Giles 2007, 398). The same conclusion can be drawn from research on German sites, where H. Jöns (1999; 2010) has demonstrated that ironworking was carried out in the settlement and iron smelting outside. A different picture, however, emerges from Danish sites. There

the two processes appear to go hand in hand, smelting and smithing being carried out at the same workplace (Lyngstrøm 2008; Jöns 2010).
This raises the question of how the situation may have been in the Netherlands, whether it mirrored the British and German, or the Danish processes. At Maastricht-Randwijck no traces of settlement structures were found (Dijkman 1989). Additionally, at the Roman period site of Heeten (prov. Overijssel/NL), where remains of large-scale iron production were discovered, all of the furnaces were located outside the settlement enclosure (Groenewoudt/van Nie 1995). It is possible that if iron smelting was carried out in the prehistoric Netherlands, it took place outside the settled area. The lack of prehistoric iron production sites in the Netherlands may therefore be the result of a research bias towards excavating settlements. Smelting sites are absent, but off-site excavation is also infrequent. This contrasts with wide-scale settlement excavation and the relative abundant occurrence of the debris of secondary iron production. Furthermore, the earliest known undeniable iron smelting sites in the Netherlands, dating to the Roman period, are all situated outside of the Roman Empire (Joosten 2004, 51). This points to the existence of the technology among the indigenous inhabitants rather than it being an import by the imperial power. When we consider that all of the Netherlands' neighbouring countries had production sites in the Iron Age, it is dubious that the knowledge of iron smelting was completely non-existent in the Netherlands until the Roman period. However, having now doubted the traditional picture, it is our task in the future to find data and ideas to form a new picture.

CONCLUSION

This in-depth study of a complex of iron slags and their associated features has proven to us the worth of careful examination of this type of evidence. The presence of a multi-functional smithing hearth gives us new insight into the Schalkskamp settlement and domestic iron production in the Iron Age in Oss and in the Netherlands in general. However, slags and other ironworking debris are still an insufficiently appreciated material category in Dutch archaeology. A short survey of known sites demonstrates that there is more evidence of prehistoric forging than is often accredited in the Netherlands. Equally, material analyses of slags and other forging debris (e.g. Hessing et al. 1997; Joosten 2001a; de Rijk in prep.) illustrate the wealth of information that can be gleaned about a site from this category. The features associated with such debris are of equal importance. Even in Oss, where over 60 ha have been excavated over the past 40 years, we have now only one actual smithing hearth. They appear to be hard to locate because they occur in places where we do not expect them. We look for special structures, but instead we find them in the form of seemingly ordinary hearths and in secondary use situations. Proper recognition of iron production activity must thus begin with a different perception in the field. Additionally, it is apparent that a focus on the peripheral zones of settlements and off-site excavation could help to solve the dilemma of whether iron was smelted in the prehistoric Netherlands. To gain such new insights we need to widen our focus during excavations and afford metal debris as much attention as metal itself.

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APPENDIX 1

XRF measurements of forging slags

	measurement ID	4142	4143	4144	4145	4146	4147	4148	4149
	slag ID	90	90	43	121	4	123	123	19
SiO_2	%	27	46.8	16.3	18.0	10.8	23.1	11.6	28.3
CaO	%	0.550	0.78	1.76	2.69	1.91	3.35	0.718	1.03
P_2O_5	%	0.509	0.48	0.43	1.04	0.60	1.13	2.2	0.35
K_2O	%	0.256	1.10	0.84	0.92	0.79	1.19	0.22	0.95
Al_2O_3	%	1.02	1.47	1.49	1.77	1.91	0.941	1.05	2.16
TiO_2	%	0.021	0.05	0.0	0.0	0.11	0.04	0.01	0.03
Fe_2O_3	%	76	49.2	67.0	80.9	52.4	72.8	54.5	73.8
MnO	%	0.027	0.03	0.11	0.07	0.10	0.10	0.14	0.06
Bal	%	–5.659	0.1	12.1	–5.5	31.3	–2.7	29.5	–6.6
S	mg/kg	651	1124	1094	1437	1596	3865	1346	2370
Cl	mg/kg	629	448	740	793	607	702	341	682
Cr	mg/kg	509	408	583	676	473	465	306	597
Zr	mg/kg	99	157	63	53	131	79	63	77
Sr	mg/kg	22	42	87	85	79	90	36	49
Rb	mg/kg	0	31	36	35	66	56	35	41
Ba	mg/kg	264	435	623	528	586	381	464	407
V	mg/kg	154	94	134	177	156	159	92	185

Zusammenfassung / Summary / Résumé

Die Aussagekraft von Metallresten: eine späteisenzeitliche Fundstelle mit Eisenverarbeitung von Oss-Schalkskamp (prov. Noord-Brabant/NL)

Untersuchungen zur Eisenherstellung während der Eisenzeit in Nordwesteuropa haben eine große Aufmerksamkeit erfahren, besonders in Deutschland, Großbritannien und Skandinavien. Immer noch ist aber wenig über die eisenzeitliche Eisenproduktion in den Niederlanden bekannt. Der Artikel versucht hier Abhilfe zu schaffen, indem er eine umfangreiche Studie über ein Ensemble von fast 200 Eisenschlacken aus einer späteisenzeitlichen Siedlung bei Oss-Schalkskamp, nur wenig südlich der Maas gelegen, vorstellt. Hierbei wird der Versuch unternommen, den Charakter der auf das Eisen bezogenen Aktivitäten an diesem Fundplatz näher zu bestimmen und die Ergebnisse in einen klein- und großräumigen Zusammenhang einzuordnen. Die Untersuchung des Fundkontextes zeigt, dass die Schlacken in und um eine Feuerstelle entdeckt worden waren, die zum Schmieden des Eisens diente. Die Ergebnisse an diesem Fundplatz und von benachbarten Siedlungen dokumentieren die Existenz kleinräumiger Hausproduktion an Orten, die schwer zu identifizieren sind und vermutlich im Randbereich von Siedlungen lagen.

The Potential of Metal Debris: a Late Iron Age Ironworking Site at Oss-Schalkskamp (prov. Noord-Brabant/NL)

The study of iron production during the Iron Age in Northwestern Europe has attracted a great deal of research, especially in Germany, Great Britain, and Scandinavia. Yet little is known about the Iron Age production of iron in the Netherlands, because of the scarcity of known production. This article attempts to rectify this through an in-depth study of an assemblage of nearly 200 iron slags found at the Late Iron Age settlement of Oss-Schalkskamp, just south of the river Meuse. The study aims to determine the nature of the iron activity that took place at this site, placing the results in a micro-regional and macro-regional context. The investigation of the find context shows that the slags were discovered in and around a hearth that had been used for iron forging. The results of this site and nearby settlements point to the existence of small-scale domestic iron production in places difficult to find, probably at the fringe of settlements.

Le potentiel des débris métalliques: un site de réduction du fer de la fin de l'âge du Fer à Oss-Schalkskamp (prov. Noord-Brabant/NL)
L'étude de la production de fer dans le Nord-ouest de l'Europe à l'âge du Fer a généré de nombreux travaux, particulièrement en Allemagne, en Grande-Bretagne et en Scandinavie. Toutefois la production de fer des Pays-Bas reste mal connue pour l'âge du Fer à cause de la rareté des productions connues. Cet article tente de rectifier cet état de fait en étudiant par le détail près de 200 scories de fer mises au jour sur le site de Oss-Schalkskamp, juste au Sud de la Meuse. L'étude vise à déterminer la nature de l'activité métallurgique du site et de replacer ses résultats dans un cadre micro- et macro-régional. Le contexte indique que les scories proviennent d'un foyer et de ses alentours qui a servi de forge. Les résultats concernant ce site et ses voisins pointent l'existence de petites productions domestiques de métal difficiles à identifier, probablement en bordure des habitats. Traduction: L. Bernard

Schlüsselwörter / Keywords / Mots clés

Niederlande / Eisenzeit / Latènezeit / Eisenproduktion / Schmieden / Metall / Schlacken / Schmied
The Netherlands / Iron Age / La Tène period / iron production / forging / metal / slags / smith
Pays-Bas / âge du Fer / période de La Tène / production de fer / forgeage / métal / scories / forgeron

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