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Iron and Consequences of the Introduction of its Technologies in Northern Central Europe

Summary

This paper deals with the introduction of iron technology in Northern Central Europe and discusses two major aspects. On the one hand, it asks to what extent we are able to trace the process of the introduction of iron and how it might have taken place. On the other hand, intended and unintended consequences of the introduction of this new technology are investigated. Can we spot ‘collateral processes’ that accompany the introduction of iron? To what extent do these processes enable such innovation, are an integral part of it, or are triggered by it?

Keywords: Iron production; innovation; Iron Age; technology; archaeology.

Der Beitrag behandelt die Einführung der Eisentechnologie im nördlichen Mitteleuropa und diskutiert zwei wesentliche Aspekte. Zum einen wird der Frage nachgegangen, in wie weit es heute schon möglich ist, den Verlauf des Einführungsprozesses zu rekonstruieren, und wie dieser ausgesehen haben könnte. Zum anderen wird der Einführungsprozess auf intendierte und nicht intendierte Folgen hin untersucht. Welche ‚Kollateral-Prozesse‘ begleiten die Einführung, inwieweit ermöglichen sie die Innovation, gehen Hand in Hand mit ihr oder werden durch die Innovation angestoßen und hervorgerufen?

Keywords: Eisenverhüttung; Innovation; Eisenzeit; Technologie; Archäologie.

I Introduction

The wonderful book *The History of the Railway Journey* by Wolfgang Schivelbusch uses the example of the introduction of the railway to show which conscious and subconscious accompanying effects and after-effects an innovation can have. The question of intentionality will be addressed below by looking at a very central innovation: the beginnings of iron smelting. The specific region in focus is the northern part of Central Europe. This is not about the territory of the invention of iron smelting, but rather concerns a region in which iron was not introduced until more than half a millennium later.

Stefan Burmeister has pointed out in his introduction that archaeologically identifiable innovations are normally obtained from an accumulation of individual observations. Depending on the available data, these processes can be reconstructed in a high or – as is the case here – in a low temporal resolution. The very heterogeneous evidence in Northern Central Europe makes it necessary to employ the concept of innovation for a long time period of several centuries.

Two questions should be addressed. The first concerns the extent to which it is already possible today to reconstruct the innovation process and how this process could have proceeded. The second concerns the ‘Schivelbusch aspect.’ Which ‘collateral processes’ accompanied the beginnings of iron technologies? To what extent do they enable the innovation, go hand and hand with it, or are triggered and caused by iron technologies? To answer these questions, the instrument of ‘technology assessment’ is available and is used to predict side effects, to identify opportunities and risks, and ways to seize opportunities of the new technology and make it manageable. The focus is not only on technical, but also societal and social aspects that are not restricted to the development of – not always unproblematic – acceptance strategies, but make, for example, changes in the perception of people a subject of discussion.¹ In reversing the chronology, the second question attempts a form of retrospective technology assessment. It is in the nature of the archaeological evidence that this section is in many areas speculative.

Production of iron is not very complicated, but it requires some specific knowledge (Fig. 1). This has to do with space-related knowledge – where raw iron occurs and how one can procure it – as well as knowledge of technical processes in order to perform a successful smelting. In the case of Northern Central Europe, it is usually bog iron ore that occurs near to the surface in low-lying land and can be dug easily. The ore is subjected to a first cleaning, generally by roasting and then crushing it, before the furnaces are loaded with it. The other raw material that is needed in the furnace is fuel. Most likely – even if the use of wood was possible – this would have been charcoal. What

1 Grunwald 2010; see here especially p. 212–215.



Fig. 1 Chaîne opératoire of the smelting of bog iron ore in the shaft furnace with slag pit. 1 – quarrying the bog iron ore; 2 and 3 – roasting and crushing the bog iron ore; 4 – charcoal production; 5 – construction of the shaft furnace above the previously dug out slag pit; 6 – pre-firing of the furnace shaft; 7 – filling the furnace initially with temporary filling material for the slag pit, then with charcoal and crushed iron bog ore; 8 – breaking the shaft furnace; 9 – removal of iron bloom; 10 – reforge the still hot iron bloom.

the various types of early furnaces had in common was that they were built of clay and had an air supply. Often it was a shaft furnace with a slag pit below the shaft in which the slag was collected. In a successful furnace campaign, the slag is then formed into an iron bloom². The still glowing bloom is compressed at the end of the smelting process by hammering.

2 Furnace campaign refers to the course of the smelting process in the smelting furnace; the iron bloom

is the outcome of this process in the form of concentrated iron.

It is important to know that in the Late Bronze Age and Early Iron Age, other fire-based innovations in Northern Central Europe were in use. Although the production of charcoal is presumed since the beginning of copper smelting, this can currently be determined archaeologically only for the Pre-Roman Iron Age in Northern Central Europe.³ This is likely due to the fact that simple kilns set on the surface are hardly preserved, so that potentially older evidence is untraceable today. In any case, the amount of charcoal burning grew significantly through iron smelting. Also, the burning of lime can at times be traced archaeologically since the Late Bronze Age⁴ and becomes an important technology in the Iron Age. Among the challenges that arise in overseeing the process, this procedure is quite comparable to smelting. Salt boiling experienced an upswing in the Iron Age. Although, here we already have secure evidence from the Neolithic, for example from Central Germany, salt production experienced a boom in the Late Bronze Age and the Iron Age.⁵ Iron production is not isolated as a new process, but forms part of a number of other fire-based production processes, which are also new or now gaining enormous importance.

2 The innovation of iron smelting in Northern Central Europe

The reconstruction of the beginnings of iron technology has to draw an important dividing line. Iron smelting and forging of iron have – as far as we know today – different innovation patterns. It all starts with the transfer of regional forms, traditionally crafted from bronze, to a new material – iron. The iron scythe from Gánovce in Slovakia, according to Furmánek the oldest iron object in Central Europe, references regional models made of bronze and was supposedly made at the beginning of the Middle Bronze Age, long before any indication of smelting activities.⁶ In Northern Central Europe around 600 BC, traditional bronze objects like razors and gooseneck needles are made from iron (Fig. 2). Obviously, artisans resorted to imported iron before autochthonous iron production started. The archaeological evidence for iron smelting is excellent as iron slag hardly weathers and is easy to find even after 2500 years.

However, as it turns out, slag can be dated only with the aid of C14 samples from adhering charcoal, a complicated process that has so far only rarely been carried out. It depends on the specific context in which slag was found and on relative dating of the finds from these contexts. This requires the implementation of archaeological excava-

3 Brumlich (unpublished); for the evidence of late pit kilns in late Bronze Age cp. Eibner 1991, 215–216.

4 Uschmann 2006.

5 Nebelsick 2007; Saile 2000.

6 Furmánek 2000.

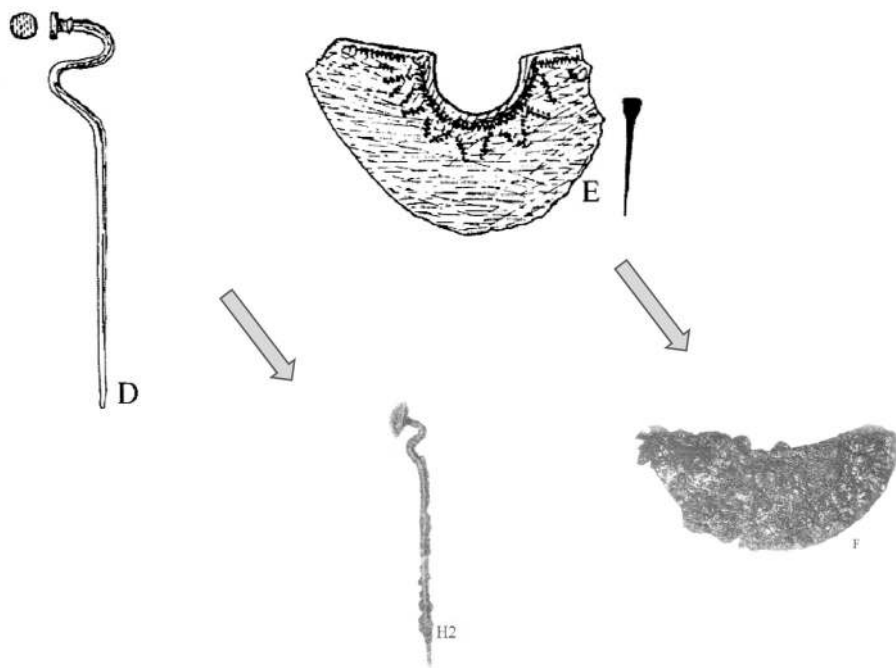


Fig. 2 From Bronze to Iron: gooseneck needles and razors in bronze and the new material iron. Above: Astofte, Ribe Amt, Denmark; bottom left: Heitbrack, Kr. Uelzen, mound 4, grave 2.; bottom right: Heitbrack, Kr. Uelzen, mound 4, grave 3.

tions. In the still poor state of research on Iron Age settlements, especially in the area of Jastorf Culture, currently all statements are based on a very small dataset.⁷

There are three key suggestions for the course of the emergence of iron smelting (Fig. 3). Based on the systematic review of sites with slag finds in Denmark, L. Nørbach⁸ developed a three-stage model with an “introduction phase” (ca. 500 to 300 BC) and a “consolidation phase” (ca. 300 BC to 200 AD), followed by a “centralization phase” (ca. 200 to 700/800 AD). The phase sequence is characterized by an increase in the number of sites and the total weight of slag from each site. However, it is uncertain whether the slag from the introductory period derives from the smelting process; bloom furnaces⁹ do not exist in this period.

In Scandinavia and Schleswig-Holstein, C. Zimmermann identifies four phases.¹⁰ After a first phase of iron objects (ca. 1200 to 500 BC), the second phase is characterized by slag finds and the third phase by insignificant settlement-bound iron smelting with

7 Meyer 2010.

8 Nørbach 1998; see most recently Olesen 2010 with new discoveries from the early Iron Age.

9 Simple clay furnaces made for smelting iron.

10 Zimmermann 1998.

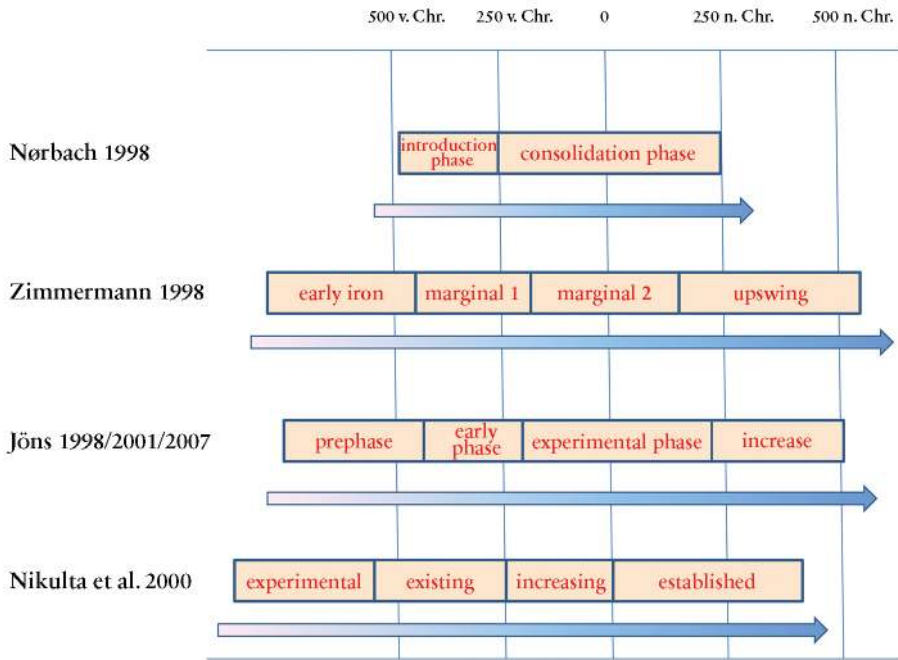


Fig. 3 Comparative presentation of important models for the introduction of iron smelting in Northern Central Europe.

first definite bloom furnaces, whereby the development shows regional patterns (500 BC to 200 AD). It is only with the fourth phase that we see a massive rise in production (ca. 200 to 750 AD). Other turning points are delineated by F. Nikulka et al.;¹¹ they see an experimental phase (Late Bronze to Early Iron Age), a phase with evidence for the existence of iron smelting (Early and Middle Pre-Roman Iron Age), a third phase with increasing technological experience (Late Pre-Roman Iron Age), and a phase with a generally established knowledge of smelting procedures (Roman Iron Age).

After a critical review of older ideas from H. Hingst, H. Jöns was right to emphasize that secure evidence for independent iron smelting in Northern Central Europe exists only after the transition from Late Pre-Roman Iron Age to Roman Iron Age.¹² The iron supply was here based mainly on the import of iron blooms. He later presented a modified model that was already based on the data from Teltow.¹³ Relying on the early datings

11 Nikulka, Bartels, and Augstein 2000.

13 Jöns 2007, 58.

12 Jöns 1998.

of E. Hjärthner-Holdars, he defines a preliminary phase (1500 to 500 BC) with iron objects accompanied by a very early onset of smelting in Scandinavia. This is followed by an early phase (550 to 300 BC) with iron slags as evidence of the start of iron production, although reliable traces are still rare. The first bloom furnaces are present during the experimental phase (ca. 300 BC to 200 AD), while in the expansion phase (200 to 500 AD) a significant increase in production takes place.¹⁴

Against the backdrop of such sparse evidence, it is currently almost impossible to develop more detailed models.¹⁵ Only an insufficient amount of datable findings are available from the beginnings of iron smelting. The necessary generalization of the models due to the naturally rough phasing can, however, cause us to detect a linear development even if the above-cited authors have made clear through the use of words such as ‘experimental phase’ or ‘introductory period’ that the development does not proceed uniformly.

It should therefore be emphasized that linear concepts implicitly included in the above scenarios are rejected by modern innovation theories mainly developed in Economics and Sociology. Rather, reviews of different stages of innovations and their re-evaluation, as well as the results of the concurrent introduction into the market, lead to many changes in the course of innovation, which can be described only with non-linear models.¹⁶ Although the archaeological evidence does not support these yet, it is still important not to look only for common trends, but to assess non-linear elements such as time delays, repairs, disruptions, and disjunctions.

This indicates two important aspects which are closely intertwined and promote or ‘trigger’ an innovation. First, it is the combination of innovation and optimization that makes an innovation attractive; second, social assessment is key, because it exerts a strong influence on the success or failure of an innovation. How were technical changes evaluated? Who profits from an innovation or suffers disadvantages? Are scenarios conceivable in which innovations were sanctioned as deviations from the norm of behavior?¹⁷

It is therefore exceptionally interesting to examine when developments began and end, and why people living in different regions behaved differently. In the well-studied region of Teltow, where evidence exists for intense iron smelting activities after the 4th century BC,¹⁸ the question remains unanswered as to why settlements in the area of Glienicke Plate were abandoned at the latest in the 1st century BC and why for centuries after that iron smelting is no longer detectable, while the inhabitants of other settlement areas moved on to small scale iron production and to using a different type of furnace. In addition, we do not yet understand why a large number of smelting areas, especially in the younger Pre-Roman Iron Age, are present in Teltow while comparable findings are

14 Brumlich, Meyer, and Lychatz 2012.

15 E.g. Nørbach 1998, 56.

16 Details on this e.g. B. Braun-Thürmann 2005, 30–33.

17 Cf. Braun-Thürmann 2005, 14.

18 Brumlich, Meyer, and Lychatz 2012.

missing in the neighboring regions. Was the supply of iron through exchange systems simple and reliable enough in these regions? Or did the residents not see the benefits of iron to be important enough to learn and organize the new technology?

Comparable questions were raised for the start of iron smelting in Sweden. The Late Bronze Age iron production proposed by Hjärthner-Holdar cannot yet be connected with the Late Iron Age smelting.¹⁹ Has a previously known technology been forgotten here?

Apparently, it took quite some time for the new iron objects to be seen as an improvement in Northern Central Europe. Only then was imported iron used as raw material for autochthonous production. The step towards production of iron does not happen simultaneously, varying from one region to another, and it is not necessarily maintained permanently. If it was possible to understand the reasons for this, we could obtain a deeper insight into the social dynamics of these times.

3 Iron and its consequences

By now it is possible to ask how this innovation – the mastery of iron production – affects the individual and the society of the Pre-Roman Iron Age.

3.1 Individuals and individual skills

In fire-based production, success or failure depends on assessing time intervals and temperatures, and also on the ability to determine the quality of the raw material in reliable ways. Basically, the mastery of pyrotechnics – a knowledge that includes the combined properties of fire and matter – was nothing new. Time, temperature, and quality were equally important parameters in preparation of food as in bronze processing, lime burning, and salt boiling. Iron smelting, however, was a long process of twelve hours or more, which was performed by supplying oxygen, charcoal, and iron ore, and which was dependent on viable bog iron ore with low silicate content. Additionally, the smelting furnace was closed during the smelting process so that the activities in the furnace could only be assessed from the outside.

Today we use measuring instruments such as thermometers and chronometers as well as analytical methods, like X-ray fluorescence, to determine the iron and silicate content of bog iron ore, which helps to make the knowledge of the process an explicit knowledge. The Iron Age metalworkers had to use their senses for these purposes. Whether bog iron ore was usable could be seen and felt in its grain and color. The temperature

¹⁹ Hjärthner-Holdar, Kresten, and Lindahl 1993;
Hjärthner-Holdar and Risberg 2003.

was felt during the blooming process and changes during the process could be determined from the color of the smoke. The beat of the bellows was kept constant with a sense of rhythm, and with the sense of time the duration of the smelting process was assessed.

All of this was based on experience – the reproduction and application was done through a sharpening of the senses; the body was used as a measuring instrument. Together with other fire-based innovations, iron smelting led to a new targeted use of certain body skills.²⁰ With the beginning of iron production and processing, people who have a seemingly unimaginable ability became visible: people who were able to turn stones into malleable objects. In Northern Central Europe, where no copper and tin deposits had been exploited, and bronze had arrived only in ingots or as finished products, this must have caused an overwhelming impression.

This impression can be seen indirectly in a number of tombs. Occasionally, forging tools are present in graves and so the buried person was supplied with the attributes of this craft.²¹ The special position of the metallurgists and forgers is more clearly visible through a series of tombs, in which construction slag was used or where slag or ore pieces were added (Fig. 4).²² Unfortunately, this slag is generally no longer preserved today, so whether they were byproducts of forging or smelting cannot be investigated.²³ Nevertheless, the waste products can be seen as a symbol of the transformation of the raw stone to the objects with which the deceased were connected. Since all of these tombs date to the Early Pre-Roman Iron Age, it can be ruled out that this was an accidental use of slag. The early dating shows instead that the mystic properties of this process were apparently lost when the technology became a commonplace.

Unfortunately, we know very little about the organization of smelting and blacksmithing processes. An exception is the Late Iron Age settlement of Hodde in Jutland. Here we have evidence of one homestead that, over the entire settlement period of about 150 years (Fig. 5), shows concentrations of forger's slag.²⁴ This finding is remarkable: not only is a specialization recognizable here, but also the passing on of this task over generations. In other words, the process of learning and the transfer of knowledge are

20 See e.g. Borić and Robb 2008. – This aspect, however, is not the focus of the current trend on the body as a subject of analysis.

21 Brumlich 2005. – They presumably worked during their lifetime as blacksmiths. It is also conceivable that – as discussed, for example, for bronze casters by Bartelheim 2007, 207 and Bertemes 2004, 148 – the objects of metal craft served as a status indicator, without the buried having actively performed this craft.

22 Brumlich 2005.

23 According to Bartelheim 2007, 207, in the Bronze Age the blacksmith would have been more likely than the miner or metallurgist to be honored in graves by the gift of professional utensils. “It is conceivable that in this way, similar to the modern relationships, it is expressed, that more prestige (and probably also profit) was associated with the processing of raw materials into high quality products and their distribution than with the extraction of the raw materials themselves.”

24 Hvass 1985, 168–170, 215.

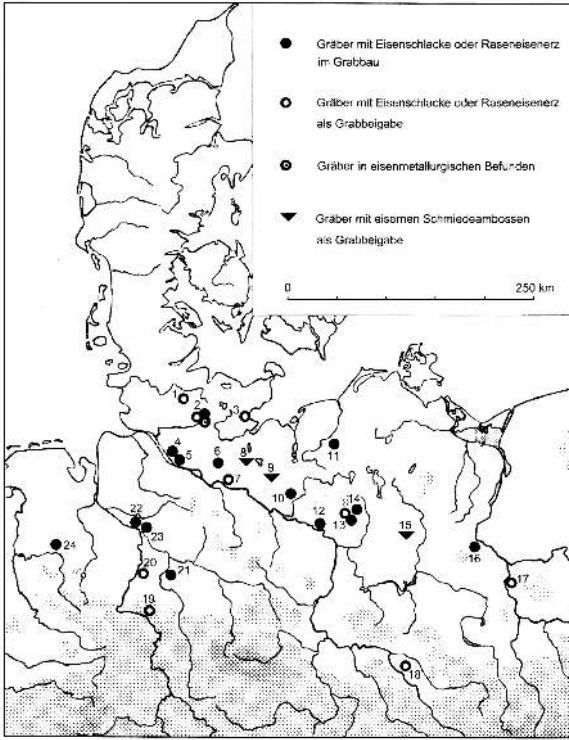


Fig. 4 Graves with iron slag, bog iron ore, anvils and burials dug into iron metallurgical findings.

recognizable here without written tradition. It is probably limited to one family, embedded in everyday life, and introduced in childhood. It does not otherwise differ from the other homesteads of the settlement that are fenced in by a stockade and from which only one farmstead stands out over the entire duration of the settlement. This place, to its unusual size and the fine ceramics that were found only here, is considered the place of the leading family of the village community.

An important insight about the people, who mastered iron smelting, is presented by the Iron Age settlements of Teltow located south of Berlin. Here, in more than 20 settlements, the smelting of iron can be detected in a very specific type of furnace, which was apparently used at all of the sites. As the experience and knowledge necessary for smelting can only be maintained by continuous practice – something that cannot be identified in any of the settlements here – Brumlich et al. recognize specialists at work that did not exercise their craft – potentially for generations – in a fixed location, but rather at a regional level.²⁵ If one accepts this model, another process of knowledge

25 Brumlich, Meyer, and Lychatz 2012.

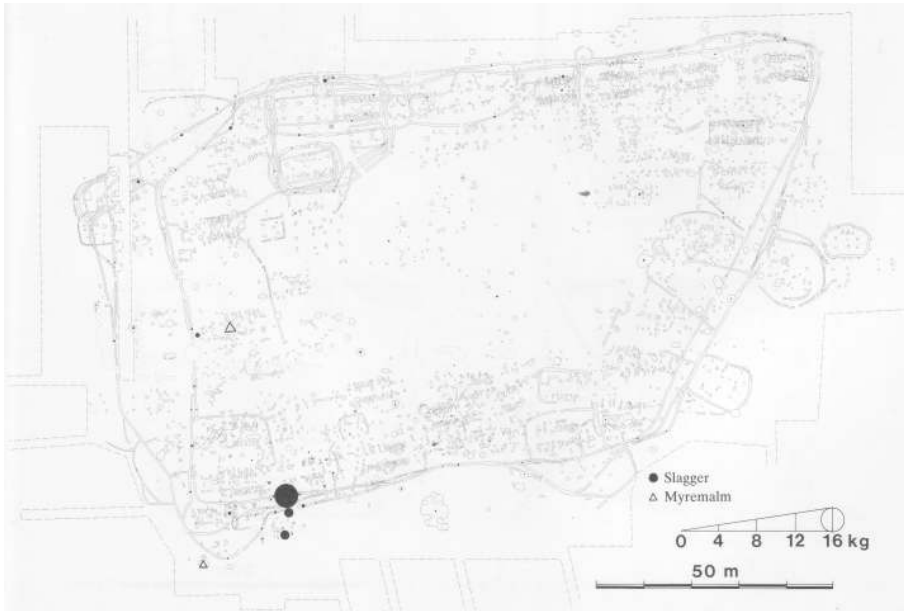


Fig. 5 The concentration of slag finds in the Late Iron Age settlement of Hodde indicates the location of the smithy.

sharing is also visible: The knowledge was dispersed into the individual settlements, where it could be taken up and further developed.

3.2 Perception of the landscape

While the specific technical skills, but also the awareness of the body as a measuring instrument, are initially bound to individuals so that their influence on society may have been indirect, the production of iron changed the collective perspective of the landscape.

The lowlands are now seen as potential or real deposits of bog iron ore; aside from the soil and its quality, the plants and the indigenous wildlife, the mythical significance of the landscape, its everyday use at first and later its special use, a new aspect is now added. A treasure lies in the lowlands that can be extracted and utilized. It can be used for the production of weapons and military strength, for improved tools, and for more lavish jewelry. This meta-level can now resonate if the environment of the settlement is recognized and valued.

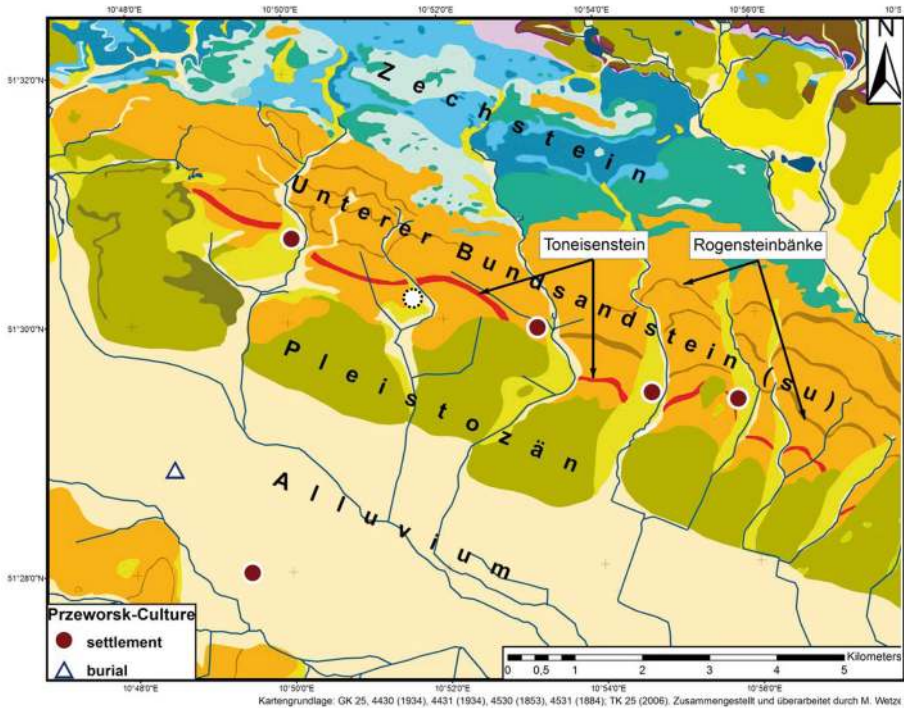


Fig. 6 Location of settlements of Przeworsk culture on the northern edge of the ‘Golden Meadow’ (Southern Harz foothills) and their relation to clay ironstone deposits.

3.3 Settlement and resources

The relation of Pre-Roman and Roman Iron Age settlements to the deposits of bog iron ore demonstrates that this new view can also be action-conductive. Seyer described this in 1982 for the Teltow,²⁶ and this is confirmed by current investigations.²⁷ This connection is also clear in Holstein, where settlement concentrations in the Roman Iron Age mainly occur within the vicinity of iron ore deposits.²⁸ A very particular example is the location of settlements of the Przeworsk Culture in the Southern Harz foothills.²⁹ Apparently, migrants from the area of the southern Polish Przeworsk Culture settled here. Four of these settlements were founded at the periphery of the “Golden Meadow,” an ideal agriculturally zone, which is clearly linked to a rich horizon of clay ironstone that stretches out across a narrow strip (Fig. 6).

26 Seyer 1982, 35–37; cf. also Kossack 1997.

27 See Brumlich, Meyer, and Lychatz 2012.

28 Jöns 1997, Fig. 33; Hingst 1983, Fig. 1; Michel 2005, Map 25–29.

29 Meyer 2013.

3.4 Society

The Iron Age society of Northern Central Europe is not extremely stratified when it comes to burials and settlements. Only at the end of the Iron Age do graves appear in a significant number, which stand out due to a broad spectrum of grave goods found in the majority of the burials. While some speak of a segmentary lineage society,³⁰ other authors also see evidence of power structures that cover at most a local or regional area.³¹ The idea that society was differentiated regionally may be inferred from significant clothing accessories and ceramic finds.

It is conceivable that this reflects the new possibilities of the procurement of metal. In the Late Bronze Age, bronze was used as the only metal the continuous use of which could be obtained solely based on extensive trade or through exchange networks. In contrast, in the Iron Age, the need for the new metal resource could be satisfied either on site or at least directly out of the region.³² Although bronze was then still used and obtained from the outside, there did no longer exist a strong dependence on this commodity, so exchange networks did not play a decisive role here. One can see in this a prerequisite for a more regionally-based society.

3.5 Ritual and society

In Southern Scandinavia, we can witness a very interesting use of weapons in two periods, which corresponds to developments in iron production. In the Early Iron Age, a ship including the equipment of many warriors was sunk in a lake in Hjortspring on the island of Als in Southern Denmark (Fig. 7). Most of the weapons (swords, lances, spears) found are made of iron; only a number of lances, whose tips are made of bone, show that not enough iron was available at that time to make all of the weapons out of iron. The intensely debated dating of the finds can be narrowed down by two C14 dates to the 4th/3rd century BC.³³ This is exactly the time when, along with the findings of Glienicke and the cluster of sites on the Teltow, intensive iron smelting is first detected in the Jastorf zone in the Pre-Roman Iron Age. If we apply this observation to Holstein and Southern Jutland, it appears logical that there would be a connection between the offerings of large amounts of iron and the availability of the new metal.

30 Brandt 2001.

31 Martens 2009.

32 For the Hallstatt period see also Bartelheim 2007, 220.

33 Martens 2001, 141. – Dating from the wood of the ship: K-5015 – Radiocarbon Age 2240 ± 50 ; 1 sigma ranges: [cal BC 385; cal BC 351] 0,283358; [cal BC 300; cal BC 227] 0,61182; [cal BC 224; cal BC 210]

0,104823; 2 sigma ranges: [cal BC 397; cal BC 196].

– Dating from a lance shaft: K-5016 – Radiocarbon Age 2290 ± 70 ; 1 sigma ranges: [cal BC 406; cal BC 349] 0,418941; [cal BC 311; cal BC 209] 0,581059; 2 sigma ranges: [cal BC 724; cal BC 694] 0,013482; [cal BC 540; cal BC 170] 0,986518; calibration with Calib Rev 6.1.0.



Fig. 7 Selection of finds from Hjortspring.

Offerings of weapons begin again in large numbers at the turn of the second and third century AD. This is the time when, according to Nørbach,³⁴ we experience a significant intensification of iron smelting – a phase in which iron was available in larger quantities than before. When mapping the weapons offerings together with the distribution of bog iron ore deposits, it is clear that – although they almost never lie directly within the vicinity of larger deposits of raw materials – they are almost never very far away from them (Fig. 8). Therefore, because iron was easy to obtain, the weapons of defeated enemies no longer had to be used or reused as source of raw material. Both examples show how the knowledge of iron smelting and its subsequent intensification had an impact on rituals.

34 Nørbach 1998.



Fig. 8 Weapons offerings and ore deposits. Roman Iron Age and Migration Period war booties from bogs in Denmark and Southern Sweden, and distribution of bog iron deposits.

4 Concluding comments

The comparison of different explanatory models for the introduction of iron smelting in Northern Central Europe shows that currently no clear, supra-regional picture can be sketched. This reflects the still insufficient state of research. However, it is also conceivable that differences and regionally divergent development rhythms will begin to emerge, as is to be expected in an innovation process. Therein lies great potential for research: The regional differences in innovation provide an opportunity for researchers to identify regional structures more clearly and to develop new approaches for their interpretation.

This paper distinguished different levels of innovation processes, which can be seen in the context of emerging iron production. For the successful implementation of the smelting process, a new use of the body as a 'measuring instrument' has been suggested,

and we can witness a change in the perception of the landscape. The relationships indicated here – between new possibilities of extraction of raw materials and changes in social organization, including the religious sectors – are certainly not to be read as clear causalities, but they open our eyes to the social aspect of technological innovations.

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Illustration credits

1 Jöns 1997, Fig. 60. 2 Schneider 2006, Taf. 20, D.E; Taf. 2, F.H2. 3 Michael Meyer. 4 Brumlich 2005, Map 1. 5 Hvass 1985, Pl. 112. 6 Meyer

2013, Fig. 15. 7 Kaul 1988, Fig. 17. 8 Ilkjær 2003; Zimmermann 1998, Fig. 1.

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