

CULTURAL HERITAGE AND LANDSCAPES IN EUROPE
LANDSCHAFTEN: KULTURELLES ERBE IN EUROPA

CULTURAL HERITAGE AND LANDSCAPES IN EUROPE **LANDSCHAFTEN: KULTURELLES ERBE IN EUROPA**

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Christoph Bartels and
Claudia Küpper-Eichas

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Christoph Bartels/ Claudia Küpper-Eichas

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Contents

<i>Rainer Slotta/ Christoph Bartels</i> Preface/ Vorwort	9
---	---

<i>Almudena Orejas</i> Foreword	11
------------------------------------	----

Plenary session

<i>Ernst Theodor Rietschel</i> Greetings/ Grußwort	15
---	----

<i>Christoph Bartels</i> Introduction	21
--	----

<i>Horst Möller</i> Gottfried Wilhelm Leibniz and the European Enlightenment	34
---	----

<i>Ludwig M. Eichinger</i> Language and Regional Identity	43
--	----

<i>Laure Lévêque</i> Birth(s) and Rebirth(s) of Landscape	53
--	----

<i>Thomas Stöllner</i> Mining Landscapes in Early Societies - Imprinting Processes in Pre- and Protohistoric Economies?	65
---	----

<i>Rainer Slotta</i> Cultural Landscape and Identity	93
---	----

<i>Friedrich Jaeger</i> Räume in der Geschichte: Das Beispiel der Enzyklopädie der Neuzeit	101
---	-----

Workshop I: The Image of the Landscape

<i>Martin Knauer</i> The Image as a Source of Historical Evidence: Three Reflections on Image-based Research	115
---	-----

<i>Melanie Manegold and Frank Bode</i> Picture Postcards as Memories of Former Landscapes	119
--	-----

<i>Sigrid Schneider</i> Picturing the Landscape	127
--	-----

Michael Farrenkopf

'Coal : The myth' –

The Image of the Ruhr Area as Reflected in the Industrial Photographs of Mining Enterprises 145

Stefan Przigoda

Images of the Ruhr District in Films of the Mining Industry 169

Yvonne Zimmermann

Negotiating Landscape: Engineering Consent on the Exploitation
of Water Power in Swiss Corporate Films 180

Astrid Artner, Bettina Matzdorf

Future Landscapes – Scenarios of Landscapes of the Future 192

Workshop II: Describing Landscapes

Oliver Thaßler

Associative Cultural Landscapes on the Isle of Rügen 205

Wilhelm Marbach

'e.guide EMIL', the Electronic Medium for Interpretation of the Landscape 218

Bernd Brühöfner

Wahrnehmung und Darstellung von Kulturlandschaft und Heimat
in der deutschnationalen Literatur:
Das Raummodell von Hans Grimm im Roman 'Volk ohne Raum' (1926)
am Beispiel des ehem. Klosterortes Lippoldsberg a. d. Weser 222

Liliana Pop

Metaphors of Mining in the 'Bogland Poems' by Seamus Heaney 262

Tillmann Otto

Tools in Tourism for a Better Understanding of Cultural Landscapes 270

Workshop III: Colonisation Landscapes

Oriol Olesti Vila and Maamoun Abdulkarim

Syrian Cultural Landscapes: Roman Colonisation at Emesa (Homs) 279

Rainer Schreg

Before Colonization:
Early Medieval Land-Use of Mountainous Regions in Southern and Western Germany 293

Gisela Kangler

From the Bohemian Forests to the Bavarian Forest National Park –
the Change of Meaning of a Wilderness in Europe 313

<i>Markus Schwarzer</i>	
Mountain Wilderness – Cultural Aspects of the Modern Conquest of High Mountains	331

<i>Inge Schjellerup</i>	
La Morada, the Land of Canaan and Añasco Pueblo – a Case Study from the Eastern Slopes of the Andes as an Example of Settlement Formation	342

Workshop IV: Coastal- and River-Landscapes

<i>Hans-Peter Kuhn</i>	
Water Archaeology Indicating Changes in Landscapes: The Mid-Rhine Example	355

<i>Michael Fessner</i>	
Early Coal-Mining and Coal Shipping - The Example of the River Ruhr in the County of Mark	368

<i>Euphrosyne Rizopoulou – Egoumenidou</i>	
Kythrea – Kephallouyso (Head-Spring): A Paradise in the Past, a Distorted Landscape in the Present	385

<i>Norbert Fischer</i>	
Between Land and Sea: The Dike as an Important Element of the North Sea Coastal Landscape	393

<i>Ulf Ickerodt and Matthias Maluck</i>	
LancewadPlan – Towards the Integrated Management of the Wadden Sea Region's Cultural Heritage: A Consideration of Specific Processes in the Landscape Development of the Wadden Sea Coast	401

Workshop V: Mining Landscapes

<i>F.-Javier Sánchez-Palencia, Almudena Orejas and María Ruiz del Árbol</i>	
The Roman Gold Mines of Northwestern Hispania: Miners and Peasants	427

<i>Albrecht Jockenhövel, Michael Overbeck</i>	
Mediaeval Iron Landscapes, Traditions and Innovation – The Genesis of Early Modern Cultural Landscapes between the Rivers Maas and Weser	453

<i>Götz Alper</i>	
The Eastern Harz Mountains During the Middle Ages – the Impact of Mining and Metal Production	467

<i>Hans-Joachim Kraschewski</i>	
The Landscape of the Lower Harz	489

<i>Holger Schaaff</i>	
The Origin and Formation of an Industrial Landscape – The Ancient Quarry and Mining District between the Eifel and the Rhine	499

Luis M^a Gutiérrez Soler and Alejandro Casas Crivillé
The Centenillo Mine in the Eastern Sierra Morena Countryside 509

Christopher Smart and Peter Claughton
The Mining Community and the Landscape: the Impact of Silver Mining
on the Historic Landscape in South Devon 521

Workshop VI: Rural Landscapes

Raimund Rodewald
Historical Water Supply Channels in the Müstair Valley/Switzerland
and their Evaluation 547

Michael Link
Cultural Landscapes in Poland between Tradition and Modern Day –
Sustainable Development in the Conflict between Cultural Heritage
and Economic Demands 557

Hans Peter Jeschke
Die Historische Kulturlandschaft Hallstatt - Dachstein/ Salzkammergut im
Spiegel aktueller Tourismusstrategien 569

Oliver Bender and Kim Philip Schumacher
Periodisation of Agrarian Landscape Dynamics in Low-Mountain Ranges
of Southern Germany from Pre-industrial Times to Date 613

Daniel Salzmann, Matthias Bürgi, Martin Stuber
Cultural Landscape and Agrarian Modernization
in the Swiss Canton of Berne 1750-1914 639

Thomas Spohn
Farmhouses of the 17th to 20th Centuries: Mirrors of Cultural
Landscape Change in the Ruhr District 649

Contributors' Addresses 667

Albrecht Jockenhövel, Michael Overbeck

Mediaeval Iron Landscapes, Traditions and Innovations – The Genesis of Early Modern Cultural Landscapes between the Rivers Meuse and Weser



Fig. 1: Locations of archaeometallurgical research projects by the Seminary for Prehistoric Archaeology of the Westphalian Wilhelms-University of Münster:

- 1. Dietzhölzetal-project.*
- 2. Iron and Steel Production in the Märkische Sauerland. A Process of Production from the Bloomery Furnace to the Early Osemundfinery.*
- 3. Early iron production in Luxembourg.*

Since the 1980s the Department for Prehistoric Archaeology of the Westphalian Wilhelms-University of Münster has been carrying out different interdisciplinary archaeometallurgical research projects in three traditional iron production regions of West Germany and the southwestern part of Luxembourg. The aim of the projects was to examine the technological evolution from bloomery furnace (Rennofen) to early blast furnace (Floßofen) in connection with the structure of early iron producing landscapes. The interdisciplinary cooperation consolidating archaeological, metallurgical, botanical and geological data led to producing a significant amount of evidence that proves close connection between technological development, utilization of resources, and socioeconomic needs.

tion with the structure of early iron producing landscapes. The interdisciplinary cooperation consolidating archaeological, metallurgical, botanical and geological data led to producing a significant amount of evidence that proves close connection between technological development, utilization of resources, and socioeconomic needs.

The Dietzhölzetal-project

The first project (Dietzhölzetal-project, 1990-1995)¹ was located in an upland region (350-600 m above sea level) on the eastern edge of the Rhenish Massif/Rhenish Slate Mountains in the Hesse mountains (see fig. 1)². In comparison with the lowland areas, it is a densely forested upland region with typical natural disadvantages in soil, climate, and hydrology – but it con-

¹ The project was funded by Volkswagen Stiftung. Participants were the Institut für Geowissenschaften of the Johannes-Gutenberg Universität Mainz and the Institut für Geobotanik of the University of Hannover.

² Jockenhövel 1996, pp. 12 ff.; Jockenhövel/ Willms 1993, pp. 517 ff.; Jockenhövel/ Willms 2005; Willms 1995a, pp. 57 ff.

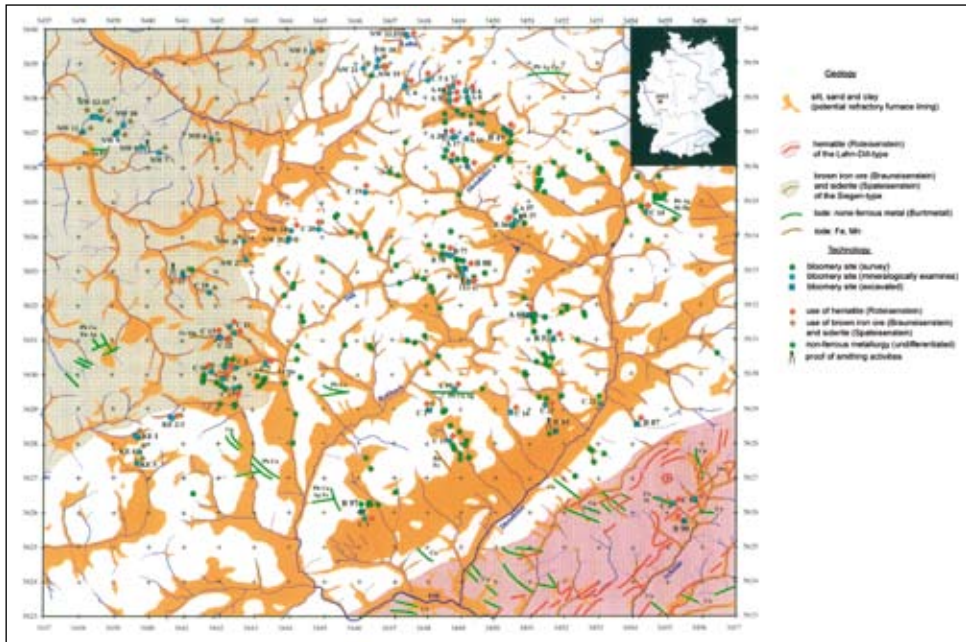


Fig. 2: Bloomery sites and ore deposits in the Dill/Dietzhölze area (after A. Kronz).

tains rich Devonian iron ore deposits (mainly consisting of hematite-Roteisenstein of Lahn-Dill type) and an abundance of Iron Age and Medieval sites and finds.

In the High Middle Ages the area became the nucleus of what later became the duchy of Nassau with the towns of Siegen, Dillenburg, and Herborn. Geological and mineralogical analyses gave evidence about the complete archaeometallurgical production chain (ore, furnace construction, charcoal as fuel, slags, blooms, semi-finished products). Pollen analysis and anthracology attested changes in the environment induced by iron production. Studies of local history and technological changes in iron production were done, too. The crucial part of the project was thorough and systematic fieldwork on some 80 km² around the rivers Dill and Dietzhölze resulting in the discovery of some 350 bloomery sites.

The bloomery furnaces on the excavated or probed sites are mainly of the same type, which was very common in Central Europe in the medieval times. The furnaces were low, stubby, thick-walled clay structures, sometimes with a stone reinforcement around the base. The inner diameter of the hearth was about 40 cm (15.75 in.). The furnaces had a sunk channel of about 1-1.5 m long (39.37 to 59.06 in.) on one of the sides to tap the slag. We can state that the self-regulating smelting process ran without any kind of bellows and forced air supply. The furnaces belong to the last type of bloomery furnaces developed in Central Europe over the period of almost 2000 years.

Mining and smelting were performed in different places (cf. fig. 2). The ore used in the Dill/Dietzhölze area is hematite (Roteisenstein), clearly distinct from the siderite (Brauneisen- oder Spateisenstein) of the neighboring Siegerland area in the Northwest. Some of the still traceable

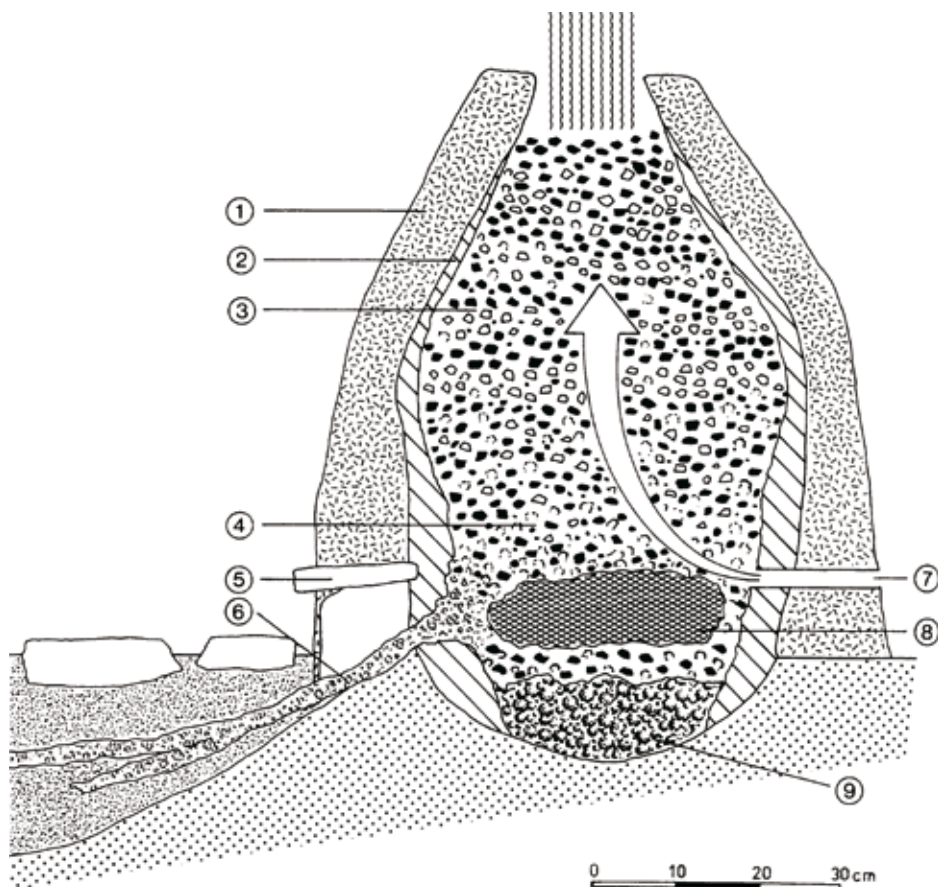


Fig. 3: Site B 88 Dietzhölztal, Ewersbach. Tentative reconstruction of a medieval bloomery furnace from the Dill/Dietzhölze area. 1. furnace wall (clay) 2. slagged and partly melted inner furnace lining 3. different layers of ore and charcoal (charge) 4. mixture of ore, charcoal and slag 5. stone reinforcement 6. tapped slag 7. air inlet 8. bloom or iron sponge (Luppe) 9. furnace bottom (Ofensau) (after D. Lammers).

deep cart tracks in the forests may belong to the period of early ore transport in two-wheeled carts. The distance covered by ore transport was up to 15 km, a days' journey one-way and back. In some cases ore was transported over even longer distances to the eastern and south-eastern parts of the Siegerland where hematite was also used.

The availability of wood for charcoal and the composition of the Lower Devonian clay used for furnace construction, or even matters of landownership may have caused the spatial separation of mining and smelting. Numerous round platforms for charcoal pitsteads (Platzmeiler) overlay bloomery sites in several cases and possibly date not earlier than from the 14th century. It is very likely that the smelters burned the required charcoal themselves.

Analysed charcoal finds show that any kind of available wood was used. There was no selection of certain trees or certain tree sections. The composition (birch, oak) of the charcoal found

on some sites indicates that coppicing (Niederwaldwirtschaft) was already practised to some extent. According to the principles of this special kind of woodland management, young tree stems are cut down to a low level. In subsequent growth years, many new shoots will appear; after a number of years the cycle begins again, and the coppiced tree is ready to be harvested again. However, the use of woodland in Dill/Dietzhölze may also have depended on how far from the contemporary settlements the sites were situated, and whether they were in repeated use. Excavations on the Kalteiche near Haiger show that during the High and Late Middle Ages charcoal for bloomeries was also produced in charring pits (Grubenmeiler)³. Wood carbonisation was completed in pits which were dug in the immediate vicinity of the bloomery furnaces.

Taking into account the amount of slag tapped in the process (25-35 kg per tapping) and the amount of slag found on the slag heaps (up to 25 tons) we can give a well-grounded estimate of the amount of iron produced at one site and in the whole region. The annual amount of iron produced per site equalled 5 to 20 tons.

The location of a bloomery site changed when the resources, especially wood, in the immediate vicinity were exhausted, but no large-scale deforestation was caused by the iron production in bloomeries. The medieval iron production in bloomeries in the Dill/Dietzhölze region remained seasonal. Unlike the production in the era of the first water-powered Stuckofen and high furnaces, it never became more than a small-scale industry. Additional studies were done on other subjects, including the technological shift from the direct (bloomery) to the indirect production process, which is connected with water-powered Stuckofen as the precursors of the blast furnace. Those much bigger furnaces made it possible to produce even more iron than in small bloomery furnaces. From the 11th to the early 14th century the demand for iron was increasing and at the end of the period the amount of iron produced exceeded the local needs.

The beginning of iron production in Luxembourg

The second project (The Beginning of iron production in Luxembourg, 2003 – the research continues)⁴ deals with a ‘missing link’ that explains the technological transition from the direct to the indirect method of iron production and the evolution from bloomery furnace to high bloomery furnace (Stuckofen) in the southern part of Luxembourg⁵. On the basis of metallurgical and geological analysis it became very clear how greatly the specific ores of this region influenced the development of a specific smelting technology during the Middle Ages⁶.

³ Verse 2003, pp. 189 ff.

⁴ Project participants were the Labor für Mikrosondentechnologie, Geowissenschaftliches Zentrum of the Georg-Albrechts-Universität Göttingen, the Institut für Geobotanik, Ökologie-Zentrum of the Christian-Albrechts-Universität Kiel and the Labor für Biophysik of the Westfälische Wilhelms-Universität Münster.

⁵ Overbeck 2004, pp. 62 f.; Overbeck/ Schiermeyer; Overbeck/ Kronz/ Nelle 2007.

⁶ Kronz/ Overbeck 2007.

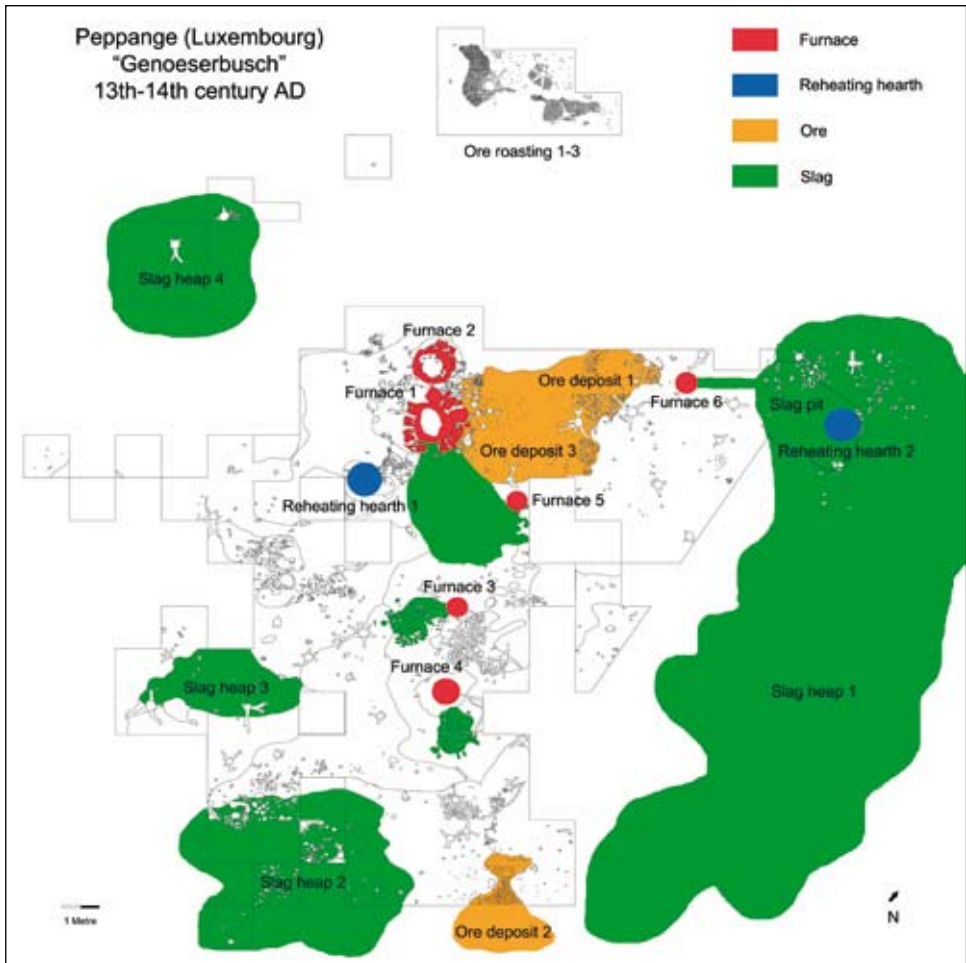


Fig. 4: The medieval ironworks from Genoesebusch/Peppange (after M. Overbeck).

Since 2003 a very well-preserved and unusually rich ironwork from the high to the late Middle Ages (13th-14th century AD) - which was used nearly for 50 years to produce iron - is being excavated. It is located in Genoesebusch, a forest near the villages of Peppange and Hellange, directly on the border with France (see fig. 1). The ironwork of about 2.000 m² (21.527 sq.ft.) in size was discovered by Norbert Quintus and Jos Spanier from the Peasantry Museum of Peppange in the year of 2000. The site comprises so far two reheating hearths, five small bloomery furnaces and one much bigger furnace (furnace 1) that differs clearly from the typical bloomeries of medieval or ancient times, and represents the transition from the direct to the indirect method of iron production. Moreover, nineteen roasting sites have been located.

Another outstanding archaeological find is a reheating hearth (reheating hearth 1), almost completely conserved. It is 80 cm (31.5 in.) in diameter with blooms, parts of an tuyere made of clay, reheating slags, hammer-scale and more. As a rule, excavations at medieval ironworks rarely reveal pottery or iron tools. The site of Genoesebusch is an exception even in this re-



Fig. 5: The largest furnace in Genoesebusch/Peppange (furnace 1, outer diameter 210 cm/ 82.68 in.), small bloomery furnace on the right side (furnace 2, outer diameter 120 cm/ 47.24 in.) and reheating hearth (reheating hearth 1, outer diameter 80 cm/ 31.5 in.) in the upper left corner.

spect. More than 2600 pottery shards (parts of more than 35 different pots) were spread all over the medieval living floor. The pottery dates back to the period from the 13th to the early 14th centuries AD. Many iron nails, rings and other tools gave information about wooden constructions that might have been connected with the bellows, for example. In addition to that, a storage for roasted ore, the associated slag heaps, and tapping channels give an exceptional amount of archaeological and metallurgical data that provide the opportunity to reconstruct this ironwork in Luxembourg.

The superstructures of the biggest furnace (furnace 1) were destroyed but enough details remained, which enables a tentative reconstruction. Furnace 1 is a thick-walled shaft furnace with a reconstructed height of at least 1.80 m (71 in.). The furnace with stone reinforcement at the base has a round shape with an external diameter of about 2,1 m (82.68 in.). The hearth has an oval shape with a max. internal diameter of about 80 cm (31.5 in.). The furnace was blown with bellows through obviously just one air-inlet. There is no evidence of water-power application. An iron tuyère was inserted into the shaft at right angles to the axis of the slag-tapping and 35 cm (13.8 in.) above the bottom of the hearth. The tuyère forged from iron, weighing about 4 kg (9 lbs.), is the connecting metal piece of 32 cm (12.5 in.) in length, located between the bellows and the furnace, in which the noses of the two bellows meet.

Charcoal analyses were done to reconstruct technological processes (fuel wood selection) and the impact on the environment. The results show that the charcoal used at the two reheating hearths and the six furnaces was of the same composition (mainly beech, hornbeam, oak) with very slight variations. The specific composition of the charcoal may indicate that coppicing (Niederwaldwirtschaft) was already practised to some extent. On the other hand, it is possible that only young trees or small branches were allowed to be used for charcoal burners while big logs were used for building houses and other constructions.

The medieval iron technology at Peppange/Luxembourg is characterised by extraordinary features, which clearly differ from the common bloomery iron making of ancient and medieval iron production, using fayalitic slag systems. It is also different from a cast iron production technology, which appeared at the same time (13th/14th century AD) in Europe. Iron production at Peppange can be regarded as a link between the two technologies, still producing a bloom, but avoiding getting liquid iron.

One possible reason for this phenomenon can be found in the specific geochemical composition of the ores: since high-grade ores of up to 90 % (calculated as FeO in dry matter) were still available, there was no necessity for the 'production' of a slag low in FeO and, hence refining of iron, too rich in carbon. Finds of a P- and C-rich cast iron are interpreted as accidental production⁷. Cast iron can be related to glassy slags. These slags, having less than 35 % FeO, play only a minor role in the overall composition of the typical slags of Peppange, ranging from 40-60 % FeO. The bulk chemical composition of the slags speak of a well-developed technology. Production parameters as well as ore sources were kept constant. Mass-balance calculations based on linear multiple fit models give evidence about the mixture of two ore types. The slag composition can not be derived from a unique ore source. Two types of ores that were found at the site were apparently used: an extremely high grade oolitic ore with Fe₂O₃- contents reaching 80 to 90 % on average, and a typical low-grade 'Minette ore' consisting of 45 % of CaO and 42 % Fe₂O₃.

In the medieval times the demand for iron was steadily increasing. The clearance of new land and increase in population resulted in the emergence of urban centres. Furthermore, a lot of iron was needed for the manufacturing of nearly all tools and instruments, as well as for military equipment. One way of achieving the required iron production level was to increase the volumes of furnaces - by building much larger furnaces than previously known. Up to the 13th-14th century AD iron was produced in bloomery furnaces in a direct, discontinuous process. Those furnaces were relatively small and mostly built of loam with only a few stones used in the construction. During the Middle Ages the furnaces became larger. Another important step in technological development was the combination of larger furnaces with the application of hydraulic energy and the use of water-power. These technological advances lead to the development of two new types of furnaces: the high bloomery furnace (Stuckofen) and the early blast furnace (Floßofen).

In the so-called Stucköfen water-powered bellows were already in use, while the smelting process itself remained unchanged. Still iron was produced as a bloom of wrought iron with only small amounts of pig iron (Graglach) that was not malleable at an early phase and therefore discarded as waste or probably added to the next furnace charge.

⁷ Kronz/ Keesmann 2003, pp. 259-274.

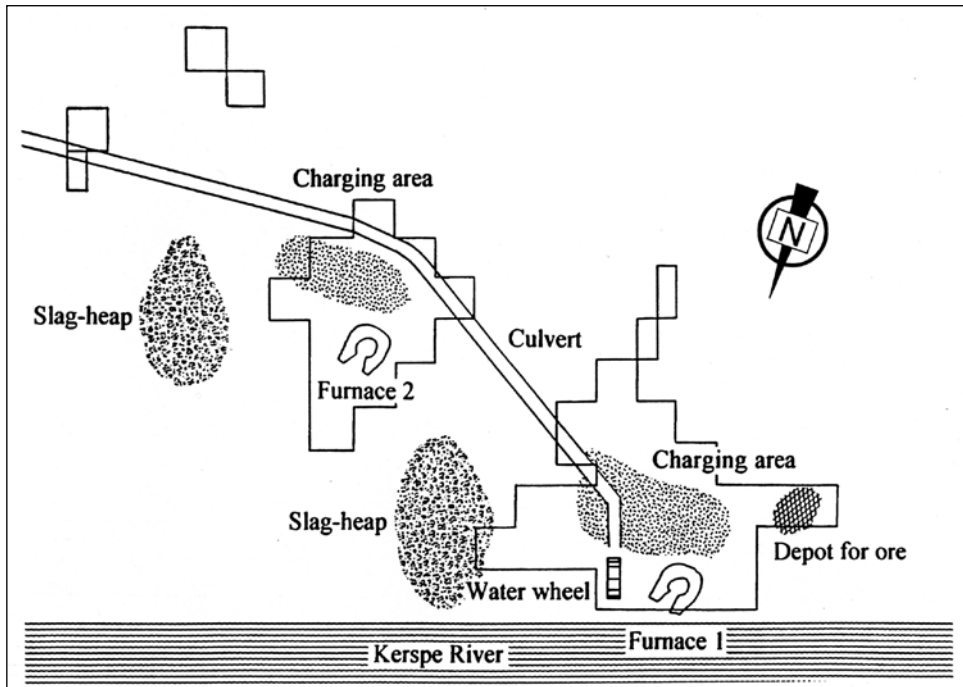


Fig. 6: Kerspe-valley, Märkisches Sauerland (site No. 105). Sketch showing the main features of the site (after M. Overbeck).

The new water-power-technology in the iron-making-process was also crucial for the invention of the blast furnace. It is not yet clear when and where in Europe the first water-powered blast furnaces were used. In such furnaces cast iron was produced during an indirect but continuous process. As the cast iron contained too much carbon, it had to be transformed into wrought-iron by the finery process which required a finery-hearth.

Iron and Steel Production in the Märkische Sauerland

The third topic of our research is iron and steel production in the Märkische Sauerland. (A Process of Production from the Bloomery Furnace to the Early Osemundfinery, 1994-1998)⁸. The Märkisches Sauerland, is located on the northern edge of the Rheinisches Schiefergebirge (cf. fig. 1). Historically this region is the southern core of the former county of Mark with the towns of Altena, Lüdenscheid, and Meinerzhagen. Together with the adjacent Bergisches Land with the world-wide known towns of Remscheid and Solingen it was one of the most important early iron production sites in Europe, the nucleus of the later Ruhrgebiet formed by Krupp, Hoesch, Thyssen, etc.

⁸ The project was funded by Volkswagen Stiftung. Participants were the Max-Planck-Institut für Eisenforschung GmbH (Düsseldorf) and the Institut für Geowissenschaften of the Johannes-Gutenberg Universität of Mainz.

Years of archaeological prospection and excavation have shown that this region has a very rich tradition of iron-metallurgy. Besides an impressive number of nearly 1900 bloomery furnaces, more than 100 blast furnace sites have been discovered by M. Sönnecken and H. L. Knau⁹.

Two of these sites (No. 105/ Kerspe-valley and No. 90/ Wipper-valley) were selected for scientific archaeological excavations. Beyond any doubt, indirect production process was carried out there¹⁰. Kerspe (Site No. 105) is located in the Kerspe water-reservoir. When the reservoir was emptied during repair works, it was possible to excavate two impressive furnace ruins. Both furnaces of the Kerspe-Dam dated as early as the 13th-14th century AD and are therefore the oldest known blast furnaces (Floßöfen) in Germany. They are probably the technological link between the traditional bloomery furnaces and the later blast furnaces in the Märkische Sauerland. This proves the active technological evolution in smelting iron over the centuries in this region. All early blast furnace sites in the Märkische Sauerland were situated in valleys near flowing water, the change of location obviously being connected with the new indirect technology of iron making. The water-powered bellows required water as an important pre-condition. The availability of wood/charcoal and ore was still important, but not as important as water. Nevertheless the consumption of charcoal in those new furnaces was enormous compared to earlier periods. The resulting deforestation caused serious environmental problems.



Fig. 7: Early blast furnace (Floßofen) from Kerspe-valley, Märkisches Sauerland. View into the totally preserved well (Gestell) of the furnace.

Both furnaces in the Kerspe-Valley were found in good condition. They were built mainly of loam and only a few heat resistant sandstones. So both furnaces were still built in the tradition of the bloomery furnaces construction. The inside walls, partly molten and slag covered, were still in their former places up to the height of 1.75 m (68.90 in.). Both furnaces had an outer diameter of nearly 2,7-3,0 m (106.3-118.11 in.) and an inner diameter of nearly 80 cm (31.5 in.). The former height of both furnaces could be estimated to equal approximately 3,0 m (118.11 in.). They were also smaller in size than the later blast furnaces of the 14th-16th centuries A.D. constructed in this region. Both furnaces were built with their backsides into the slope of the basin. On the one hand, the slope could be used as a natural charging platform; on the other hand, this kind of construction makes the furnace much more stable and helps to keep the heat inside the furnace in order to attain higher temperatures during the smelting process.

⁹ Knau/ Sönnecken 1994a, pp. 459 ff.; Knau/ Sönnecken 1994b, pp. 467 ff.

¹⁰ Abdinghof/ Overbeck 1998/1999, pp. 536-541; Abdinghof/ Overbeck 2000, pp. 128 ff.; Jockenhövel/ Willms 1998, pp. 131 ff.; Jockenhövel/ Overbeck/ Willms (preprint); Jockenhövel/ Willms/ Abdinghof/ Overbeck 1997, pp. 56 ff.; Jockenhövel et al. 1998 pp. 20 f.; Willms 1995b, pp. 132 ff.; Willms 1996, pp. 29 ff.; Willms 1997, p. 50; Willms/ Jockenhövel 1996, pp. 177 ff.

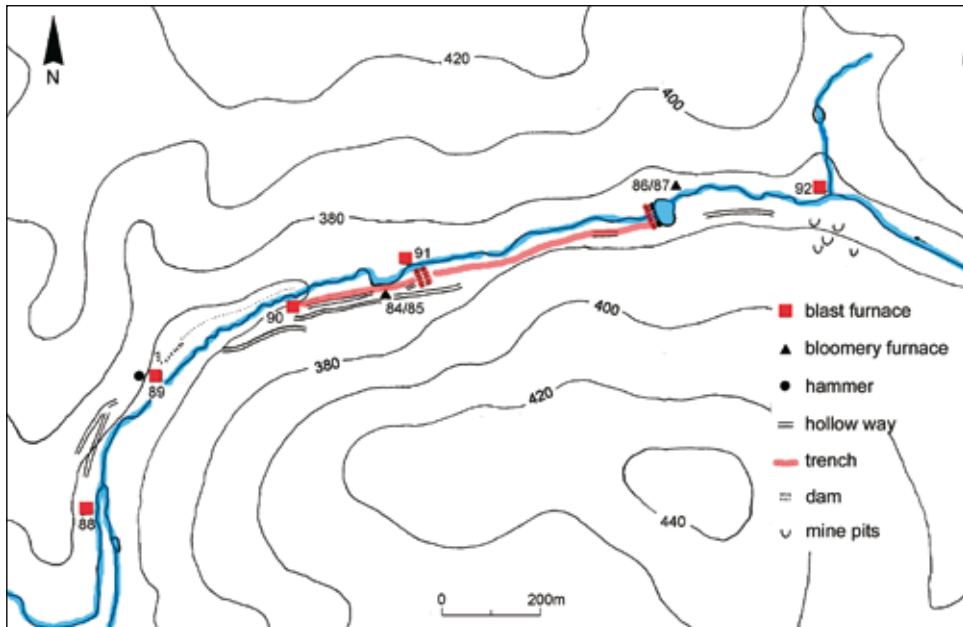


Fig. 8: Map of the Wipper-valley with different blast furnace sites along the river, Bergisches Land.

Unfortunately the frontside (Ofenbrust), which is important for studying the construction and operation of the furnaces, was badly damaged in both cases. However, it was possible to examine the totally preserved well (Gestell) of a typical shape, with a small rectangular hearth bottom about 80 cm (31.5 in.) long but only 30 cm (11.81 in.) wide (cf. fig. 7). Two bevelled side-walls form a narrowed hearth at the bottom which is slightly slanted, so that slag and liquid iron can easily run out of the furnace.

One furnace from the Kerspe-Valley had a preserved opening for the bellows or tuyre (Wind-form) in situ in the sidewall but there were no remains of the bellows or even the mill race. The bellows were driven by a waterwheel, its housing (Radstube) clearly identifiable, as well as the mill-trenches. Those trenches carried the water in a slight fall over a distance of several hundred metres (100 m=328.1 feet) along the sloping side of the valley. The technological necessity of keeping the opposite elements of fire (for smelting) and water (for driving the waterwheel) and moving the bellows to reach a temperature of well over 1300 °C in close neighbourhood required cleverly devised constructions. So as to keep away the groundwater from the interior of the furnace, a system of diverse draining channels was integrated into the foundation of the younger furnace. It can be assumed that most of the bigger substantial furnaces had similar kind of drainage. The first case when a drainage system under a furnace was discovered and later described dates back to the 16th century AD. The system was described about 100-200 years after its discovery by Georgius Agricola who called it the 'Abzucht'. This kind of drainage is normally unnoticeable from the outside, as it is totally covered by the furnace that was built on it. The small trench with only 12 cm (4.72 in.) in diameter was covered with huge plates of sandstone and constructed in the shape of a horseshoe beneath the furnace.

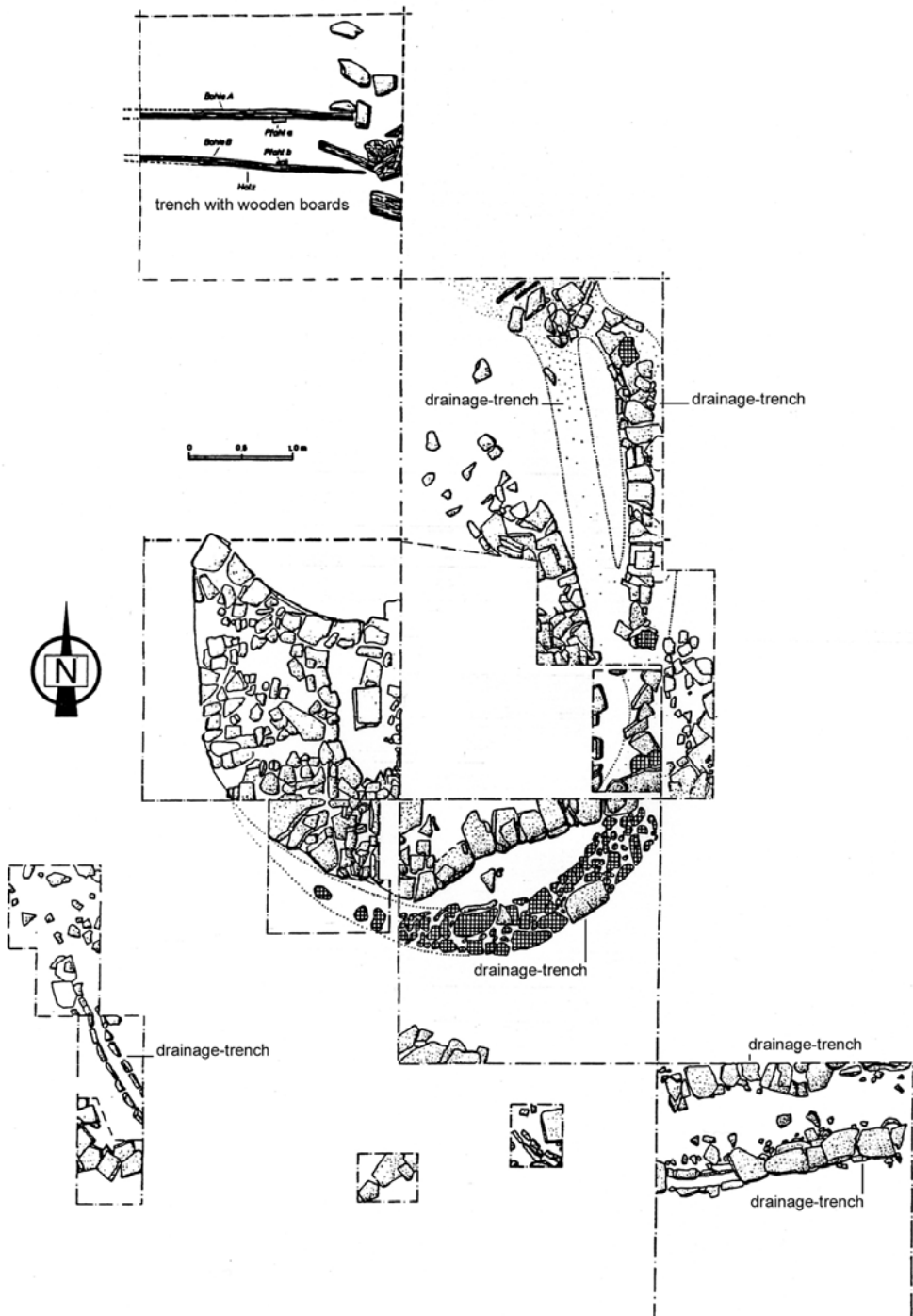


Fig. 9: Wipper-Valley, Bergisches Land (site No. 90). Plan showing the excavated structures of the site around the blast furnace.

Furthermore, the slag heaps and the depots for ore and charcoal could be located. It is interesting to see that there was clearly distinct space between the ore and the slag, which divided this site into exactly defined sections.

The second site (No. 90, Wipper-valley) is located on the northern slope of the Wipper-valley. Ceramic finds date the blast furnace back to the 15th century AD. No other objects (e.g. tools or iron-bars) were found. It is likely that people took all valuable things with them when abandoning this site.

The furnace was mainly built of stones which were found in that area. They were local varieties of sandstone with good heat resistance of up to 1580-1610 °C. The blast furnace measures nearly 3.5 m (137.80 in.) at the front, 3.6 m (141.73 in.) at the sides and only nearly 2.75 m (108.27 in.) at the back. The inside dimensions are 1.25 x 1.25 m (49.21 x 49.21 in.) but the inner furnace was completely cleared out or destroyed, so that no parts of the inner well (Gestell) were preserved. Only the stones of the side-walls remained. It seems that the blast furnace was burnt out and prepared for a repair that never happened. The furnace seems to have an open breast with a pig-iron-layer in front of it. It was built with its backside into the slope so that the furnace could be easily charged with ore and charcoal from the charging area on the slope. Drainage trenches, mostly made of stones and covered with a stone for protection against dirt were found uphill and on one side of the back of the furnace (see fig. 9). About 3.5 m (137.80 in.) downhill a trench with wooden boards on its side may have been the culvert of the waterwheel and/or the drainage. The waterwheel and bellows, although not excavated, were probably on the eastern side of the furnace because of the culvert and the distribution of stones forming the wall of the furnace.

Also, still partly visible on the surface near the excavation there were a 250 m (820.24 feet) long trench taking the water from the Wipper to the waterwheel and parts of gorges (Hohlwege) leading to/from this ironwork (cf. fig. 8). Unspecified mine-pits were nearby. The nearest pits were only about 1 km (3280.95 feet) away from the site, although a direct connection to the blast furnace site can not be traced.

As the charcoal fired blast furnaces (Floßöfen) were laid out for continuous operation over a period of at least some weeks or months, there had to be a crew sufficient in number for all activities during that time. Written documents claim that the blast furnaces of the 15th century AD provided the possibility to produce from 200 kg (Grottaferrata/Italy) up to 1000 kg (Fornovolasco/Italy) of cast iron per day. In the furnaces of the 16th century AD the production capacity increased to 1250 (Siegerland/Germany) - 2000 kg (Kärnten/Austria) of cast iron per day. Before starting iron smelting extensive preparations had to be made: water-channels and the wheel-housing had to be dug and lined with wooden boards, the waterwheel and the bellows were probably made by specially skilled carpenters. The construction of the furnace itself was specialized work of experienced iron-workers who were often hired for this task from farther away. Ore-miners, charcoal-burners and transport had to be organized in advance. The ironworks have to be organized and complex plants with sophisticated equipment. The new technology had a significant financial impact, because the size of the production sites grew together with the number of the workforce and the amount of raw materials needed. Therefore the foundation and operation of a blast furnace ironwork required considerable funds, contracts had to be made and sufficient capital was needed. Due to these factors, some time was

necessary to launch iron production itself and start getting profits. The records show that in many cases the ironworks pay-off stage was never reached because of numerous difficulties that could arise in the course of blast-furnace operation. Nevertheless, some of the lower local nobility engaged in the late medieval iron production.

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