19th International Congress
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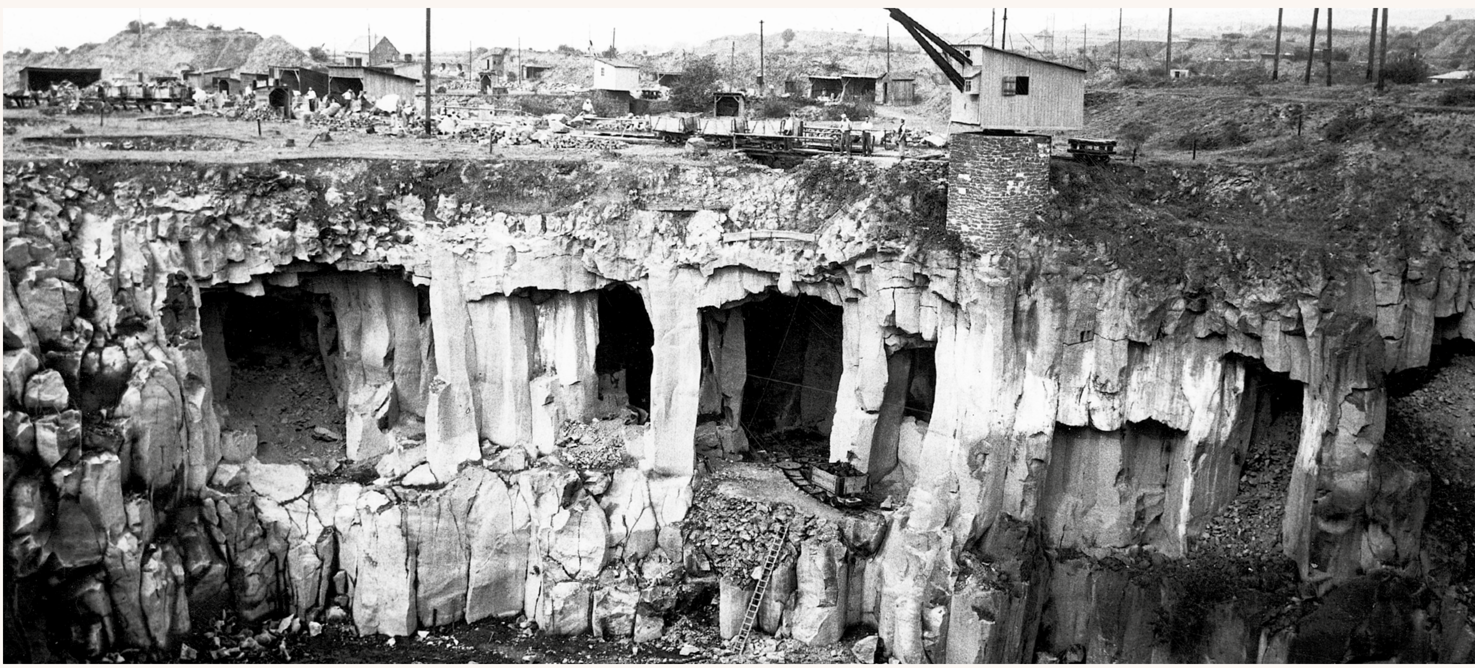
Cologne/Bonn
22–26 May 2018

ICCA XIX AIAC

Archaeology and Economy in the Ancient World



14

Pre-modern Industrial Districts

Panel 3.12

Michael Herdick
Angelika Hunold
Holger Schaaff (Eds.)

Propylaeum
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Proceedings of the

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Volume 14: Pre-modern Industrial Districts

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Edited by

Martin Bentz and Michael Heinzelmann

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Cover illustration: Open-cast mining in the Mayen basalt pit field around 1930 with a section of an underground mining of the Early Modern Period. (Photo: Geschichts- und Altertumsverein für Mayen und Umgebung e.V.).

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PREFACE

On behalf of the 'Associazione Internazionale di Archaeologica Classica (AIAC)' the 19th International Congress for Classical Archaeology took place in Cologne and Bonn from 22 to 26 May 2018. It was jointly organized by the two Archaeological Institutes of the Universities of Cologne and Bonn, and the primary theme of the congress was 'Archaeology and Economy in the Ancient World'. In fact, economic aspects permeate all areas of public and private life in ancient societies, whether in urban development, religion, art, housing, or in death.

Research on ancient economies has long played a significant role in ancient history. Increasingly in the last decades, awareness has grown in archaeology that the material culture of ancient societies offers excellent opportunities for studying the structure, performance, and dynamics of ancient economic systems and economic processes. Therefore, the main objective of this congress was to understand economy as a central element of classical societies and to analyze its interaction with ecological, political, social, religious, and cultural factors. The theme of the congress was addressed to all disciplines that deal with the Greco-Roman civilization and their neighbouring cultures from the Aegean Bronze Age to the end of Late Antiquity.

The participation of more than 1.200 scholars from more than 40 countries demonstrates the great response to the topic of the congress. Altogether, more than 900 papers in 128 panels were presented, as were more than 110 posters. The publication of the congress is in two stages: larger panels are initially presented as independent volumes, such as this publication. Finally, at the end of the editing process, all contributions will be published in a joint conference volume.

We would like to take this opportunity to thank all participants and helpers of the congress who made it such a great success. Its realization would not have been possible without the generous support of many institutions, whom we would like to thank once again: the Universities of Bonn and Cologne, the Archaeological Society of Cologne, the Archaeology Foundation of Cologne, the Gerda Henkel Foundation, the Fritz Thyssen Foundation, the Sal. Oppenheim Foundation, the German Research Foundation (DFG), the German Academic Exchange Service (DAAD), the Romano-Germanic Museum Cologne and the LVR-LandesMuseum Bonn. Finally, our thanks go to all colleagues and panel organizers who were involved in the editing and printing process.

Bonn/Cologne, in August 2019

Martin Bentz & Michael Heinzelmann

The Ancient Quarrying and Mining District between the Eifel and the Rhine – a Summary of Research

Angelika Hunold – Holger Schaaff

The district between Mayen on the edge of the Eifel and the river Rhine in the federal state of Rheinland-Pfalz has been of outstanding economic significance since prehistoric times. The products – primarily basalt lava saddle querns and later on millstones (fig. 1), tuff stone for building, and pottery – were traded throughout much of Europe. Therefore, the district has been the subject of research by the Römisch-Germanisches Zentralmuseum (RGZM) in Mainz and Mayen since 1997. A comprehensive research programme named "The origin and formation of an industrial landscape – the ancient quarrying and mining district between the Eifel and the Rhine" was launched to examine the wealth of evidence about the ancient mining economy in the region and its effects on settlement structure. At the same time the Vulkanpark Osteifel was created, which was devised both to protect and investigate the local heritage and to present it to the public.[1]

Fig. 1: Roman hand mill in use.

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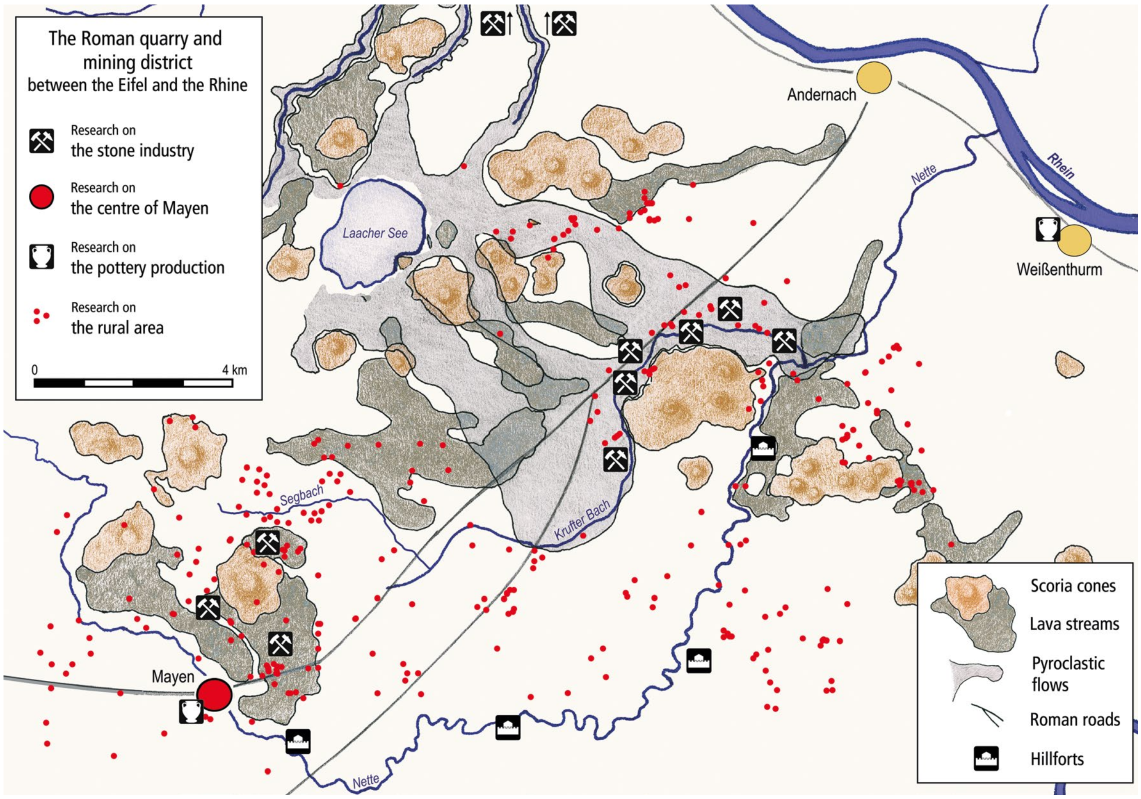

Fig. 2: The ancient quarrying and mining district between the Eifel and the Rhine.

Formation of the Raw Materials

The area west of the confluence of the rivers Rhine and Moselle (fig. 2) comprises much of the quaternary Eastern Eifel Volcanic Field with approximately 100 volcanoes.[2] Most of them are scoria cones that erupted about 400.000 and 200.000 years ago. Some produced molten lava streams. These cooled to form basalt lava deposits.

The highly explosive eruption of the Laacher See Volcano approximately 13.000 years ago is thought to have been the largest in the recent geological history of central Europe. During the eruption pyroclastic flows filled the bordering Brohl and Krufter Bach valleys. They cooled to leave tuff deposits up to 35 m thick. Wherever the powdery tuff subsequently came into contact with water, it solidified as tuff stone.

The region also possesses equally significant non-volcanic raw materials. The bedrock of the region is Devonian slate.[3] It is well suited for roofing and has been exported from the region ever since Roman times. Iron and lead ores are also of economic significance. Clay deposits[4] are mainly found on the left bank of the Rhine[5] and in the Mayen basin.[6]

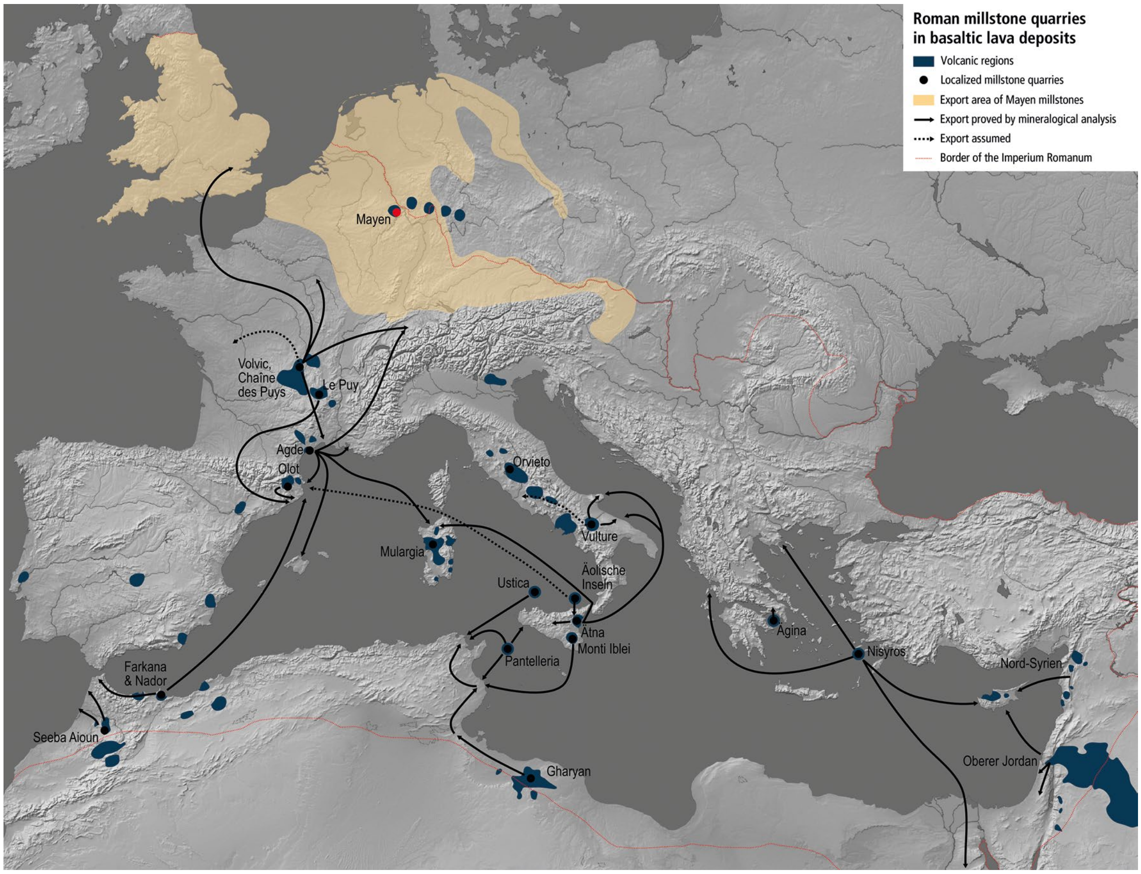

Fig. 3: Export area of basalt millstones in the Roman period, after F. Mangartz.

Ancient Industries

Among the branches of the stone industry, basalt quarrying has the longest tradition. Neolithic farmers were the first to detect the special quality of the basalt lava for the essential task of preparing cereals for consumption.[7] Some 7000 years ago, the first grain grinding stones were produced from the lava flows of the Bellerberg volcano near Mayen (fig. 2). The quality of the stone and the proximity of the river Rhine meant it was traded outside the region from an early date on. The introduction of the rotary mill during the Iron Age led to further expansion.[8] This technology transfer had an immense impact on the development of the mining district.

So, in the Roman period Mayen millstone became a leading export[9] throughout much of northwestern Europe (fig. 3). The Roman quarries around the Bellerberg volcano developed into the largest millstone production works north of the Alps. They were worked as opencast mines and systematically separated into parcels. In the years 1999–2000, Fritz Mangartz excavated one of the rare parcels, which are still preserved amid the modern mining areas. Both the estimated output and

Fig. 4: The so-called Ubiermoument in Cologne was part of the Augustian city fortification.

numbers of workers soared between the Late Iron Age and Roman times.[10] One reason for this was that the Roman state wasted no time in adopting the high-quality Mayen millstones.[11] Mineralogical analyses of millstones from the forts on the river Lippe and from the Augustan town of Waldgirmes in the federal state of Hesse reveal they were ordered to supply the Roman army during Augustus' Germanic campaigns.[12] This means the district received a major order, which promoted its economic development noticeably.

Another significant raw material is tuff stone, which was used as a building stone.[13] Since north of the Alps there is no pre-Roman evidence of it, it is likely that the tuff stone deposits were detected by specialists of the Roman army, who easily recognized the tuff as a stone known from the Vesuvius region. Again it was the emperor Augustus who impelled the economic use. Stone analyses[14] reveal that the local tuff stone was used to build the "Ubiermonument" in Cologne (fig. 4). This

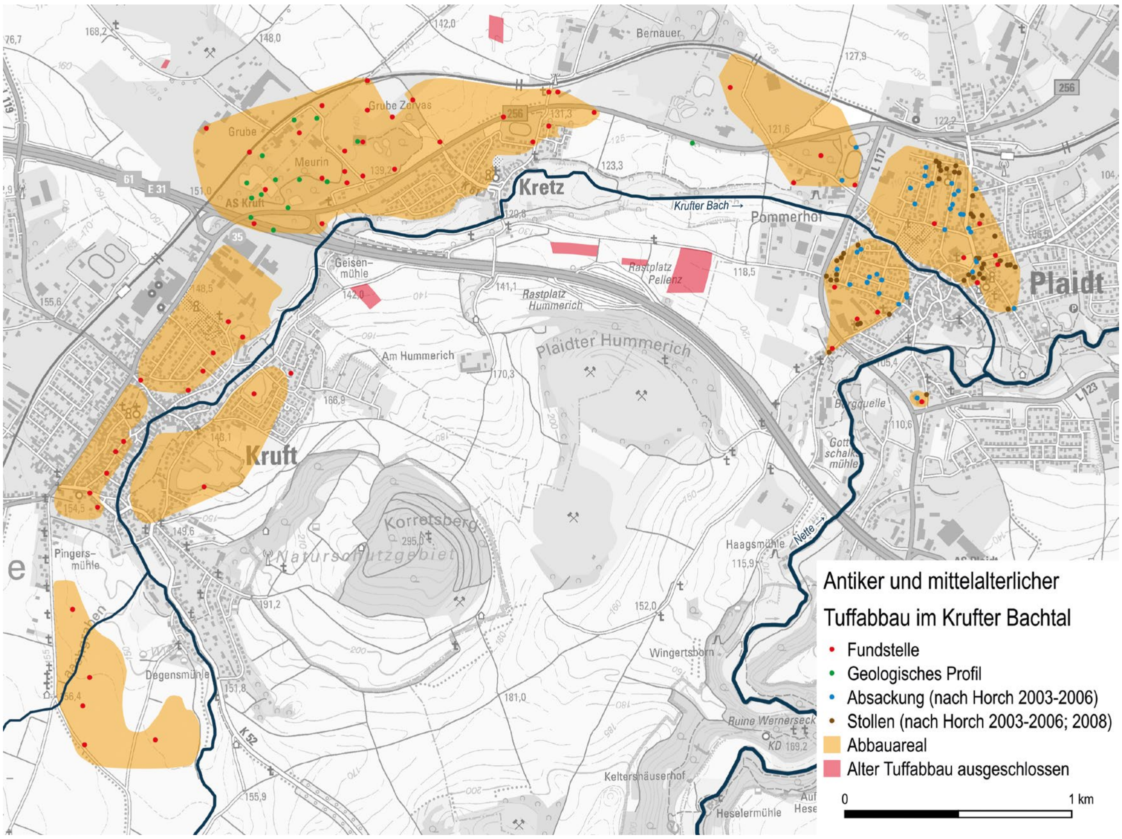

Fig. 5: The tuff mining area of Krufter Bach valley in detail. The red dots mark archaeologically confirmed mining sites, after Schaaff 2015.

tower was erected about 4–6 AD and is thought to be the oldest stone building in Roman Germany. It was part of the city wall of the *oppidum Ubiorum*, the earliest settlement on the site of what was later to be Cologne.[15] So the working of tuff stone marks the introduction of stone architecture north of the Alps. Later in the Roman period, the tuff stone of the Laacher See volcano was used in towns and forts along the Rhine, e.g. in the *Colonia Ulpia Traiana* near Xanten or in the Late Roman fort of *Divitia* in Cologne-Deutz. Total tuff production in the Roman period is estimated at approximately 2 million metric tons.[16]

Tuff stone was mined and the workings of the Krufter Bach valley have been examined in detail (fig. 5). Holger Schaaff excavated an area of 2500 m², which today is presented to the public under the name of Römerbergwerk Meurin (fig. 6). In many cases the military was in charge of its extraction. So, along with the tuff stone quarrying came the arrival of numerous quarry workers from the ranks of the military. Up to the times of Hadrian they left a great number of dedication inscriptions in sanctuaries amid the quarrying areas (fig. 7).[17] Besides the military mines, civilian enterprises were producing cremation ashes boxes made of tuff at the latest in the Tiberian era.[18]

Fig. 6: "Römerbergwerk Meurin", Roman tuffstone mine.

Comparing the basalt and tuff productions, several differences become clear. While basalt quarrying looks back on an indigenous tradition from the early Neolithic, tuff mining was unknown until the Roman occupation. The required knowledge about tuff stone came via technology transfer from the Mediterranean. Basalt was worked by civilian workers, tuff in most cases by the Roman army, at least in the beginning. The products as well differ very much from each other. The basalt saddle querns and millstones were essential for every-day use. That is why the production in the basalt quarries was ongoing. Tuff stone was a building material, which had to be provided at any time when building projects required it. Therefore the tuff mining was dynamic, performing a "just in time" production.

Pottery production is another significant ancient trade branch. The clay deposits had been exploited locally since pre-Roman times but it was not until the Roman period that they took on importance beyond the region. The potter's workshops at Weißenthurm on the Rhine (fig. 2) produced Urmitz Ware that supplied numerous forts on the *limes* in *Germania superior* until the middle of the 3rd century AD. The discontinuation of the production used to be attributed to the decline of the *limes*. Recent research[19], though, has shown that production continued at least into the first half of the 4th century. In the potter's workshops of Mayen, production increased from the Late Roman period onwards and long-distance trade developed which persisted to the Middle Ages.[20] Mineralogical analyses now make it possible to define the area over which the products were exported.[21]

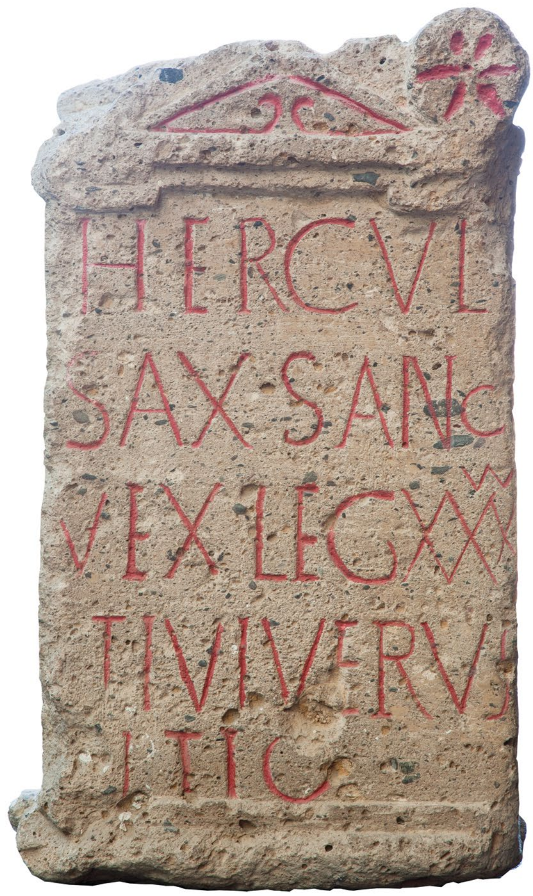

Fig. 7: Tuffstone altar dedicated to Hercules Saxanus.

The Mayen *vicus* – the Economic Centre of the District

From the Late Iron Age, the economic centre of the region was the *vicus* of Mayen.[22] It was located in a shallow basin astride the small river Nette. The nearest Roman basalt quarries lie at a distance of 500–800 m.[23] A group of seven millstone workshops was found within the *vicus*, where the half-worked millstones were brought for finishing.[24] The location of the millstone workshops on the opposite riverside from the quarries seems surprising at first. But on closer inspection, it becomes clear that they were concentrated in a limited area near the river Nette. So it is likely that after being transported from the quarries and completed in the *vicus*, the millstones were carried down the river Nette for sale.[25] The Roman potters' workshops are located east of the river Nette.[26] Metal processing and other crafts are represented locally.

The transformation of the indigenous settlement into a Roman *vicus* took place at the same time as the surge in millstone sales triggered by Augustus' Germanic campaigns. In order to handle the increasing workload, the population must have increased as well. In the Mayen *vicus* cemetery, Martin Grünewald observed the arrival of a group practicing Mediterranean burial rites for the early Flavian period.[27] The population of the *vicus* may be estimated, by comparison with the 19th century situation and with regard to the number of workers in the stone industry, at approximately 2000 or 2500 inhabitants.[28] That number remained stable until the 5th century at least.

In Late Antiquity, pottery production became a significant factor of the economy, especially after the warring incidents of 355 AD.[29] At this time the river Nette was protected by a string of four military hill forts (fig. 2).[30] Upstream, the string ends with the hill fort on Katzenberg, approximately 2 km southeast of the *vicus*. From about 300 AD to the middle of the 5th century, this fortification guaranteed the continuing production and distribution of the export goods.[31]

Rural Settlement in the Mining District

Two studies have been undertaken in order to determine whether the particular industrial character of the region influenced the rural settlement pattern (fig. 2). One compiles the Roman settlement sites in the vicinity of the basalt quarries and the Mayen *vicus*;[32] the other focuses on Roman settlement in the vicinity of the tuff stone mines.[33] In addition, the Segbach valley north of Mayen was explored as a case study, in order to find out how Roman agriculture enabled the industrial booms and what the effects on the environment were.[34]

Viktoria Baur found that the architecture and the grave finds indicate remarkable prosperity around Mayen. There is especially an extraordinary density of rich *villae*[35], which would be unusual in other regions.[36] Among them is the so far unexcavated axial *villa* of "Fraukirch". Known exclusively from aerial views, it has a walled courtyard area of 5.7 ha. The main building faces at least 12 adjoining buildings arranged in two rows. But *villae* of ordinary size as well show features which indicate prosperity, such as mural paintings, mosaics and plasterwork. In general, the rural settlement grew continuously from the Late La Tène period to the 2nd century AD. During the crisis in the 3rd century, the rural area around Mayen appears to have been only marginally affected by destructions. As in the Mayen *vicus*, there are indications of continuous development into the Early Middle Ages.[37]

Not far away, Segbach valley lies on the northern edge of the millstone quarry area amid the lava flows of the Bellerberg volcano. Prospecting and excavation focused on the "Lungenkärchen" and "Im Winkel" *villae*. The well-known settlement site of "Lungenkärchen" (fig. 8) has been recognised by Martin Grünewald as another axial *villa* that attests to considerable prosperity.[38] The complex consisted of a 73 m-long main building with a 40 m-long water basin in front and six outbuildings. Tomb monuments of the landowners were found nearby.[39] Surface finds range from pottery of the late La Tène period or early Imperial times to the second half of the

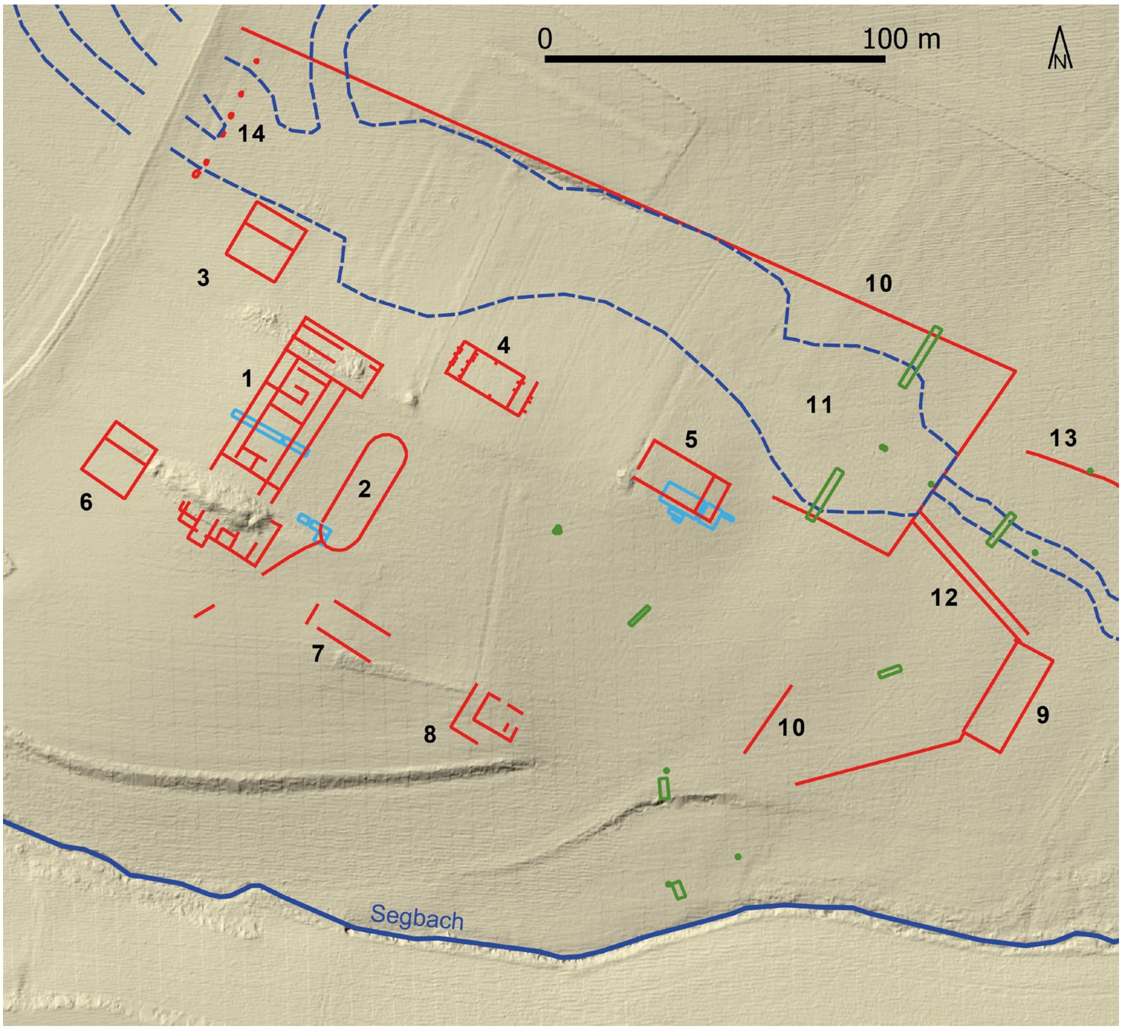

Fig. 8: Mendig, “Lungenkärchen”, plan. Archaeological trenches (blue), geoarchaeological trenches (green). 1 main building; 2 ornamental pool; 3-8 annex buildings; 4 *horreum* (?); 5 stabling; 9 mill (?); 10 courtyard border; 11 reservoir (?); 12–13 mill channels (?); 14 aqueduct (?).

5th century. The *villa* worked an area of 100–120 ha.[40] As the proportions of the *pars urbana,* the *pars rustica* and the agricultural land indicate,[41] agriculture was not the sole economic basis of the *villa.* The owners had access to the rubble of the millstone quarries, which they used for construction. This suggests that the *villa* owners were also owners of millstone quarries.

The medium-sized “Im Winkel” *villa* was located just north of the millstone quarries.[42] Here, Stefan Wenzel determined an economic area of 46 ha.[43] The settlement existed from the Early Imperial period to the second half of the 5th century. 21 quern roughouts from the cellar of the main building show that its inhabitants, too, had access to the rubble of the quarries outside their front door. Stone waste from the quarries with discarded Late La Tène and Roman quern rough outs were found close to the settlement site.[44] This means the inhabitants of the *villa* were involved in the production of millstones. The *villa* burnt down in the second half of the 3rd century, but settlement on the place continued.

Around 300 AD,[45] a *burgus* was erected on a hill nearby and drains were created on an area next to that. According to the architecture and finds of military equipment, the *burgus* was a defensive structure with a military occupation;[46] at the same time it was a *horreum.*[47] Inside, a purified stock of dehusked spelt has been found.[48] Approximately 80 t of spelt could be stored in the *burgus*. So it could store far more cereals than the holding of the former *villa* could produce. If the per capita consumption was 1 kg spelt per person per day, as assumed for wheat,[49] this stock would have been sufficient for the daily rations of 218 people for one year. Presumably, the *burgus* secured the supplies for the workers of the nearby millstone quarries. Accordingly, millstone extraction must have continued at least up to the first third of the 5th century.[50] Extracted millstones could be stored on the drained area next to the *burgus* before being transported on the Segbach.[51]

A particularly striking connection arises also between other *villae rusticae* and the millstone quarries. Millstone roughouts occur at the well investigated sites of "Narrenborn", "Steinrütsch", and "Fraukirch", where they are used partly in the buildings' foundations.[52] This suggests that especially the more wealthy estates were inhabited by the quarry owners or quarry administrators.

As Ricarda Giljohann found, the fertile basin landscape in the vicinity of the tuff stone quarries was continuously inhabited from the late La Tène to the 5th century. Expensive tomb monuments made of Lorraine limestone indicate extraordinary wealth and a high degree of Romanization already in the middle of the 1st century AD.[53] Prestigious mansions are recognisable from the presence of tomb monuments, Jupiter's giant columns, *tumuli* with *dromos*[54] and also from qanat water conduits. For the most part, the water pipelines were found near the mining area and the rich graves were found directly within the mining area, so it is obvious that the extraction of and trade in tuff stone was the basis of the economy alongside agriculture. Two settlement sites, which are surely related to the processing of tuff stone, were excavated.[55] In the southeastern part of the Neuwied basin, *villae* are invariably simpler than in the tuff mining area.[56]

The region was affected by the political crisis of the 3rd century, but there was no final break-up of settlements. In the times of crisis and in years with crop failures, grain had to be imported from Britain. In the middle of the 4th century, large storage buildings were erected in Andernach, which ensured the continuity of the ceramic and stone industry.[57] The rural settlement returned to prosperity from Valentinian times onwards. The richest sarcophagus burials are found again in the mining area.[58]

How to Define Pre-modern Industries

Finally, we should turn to the question which criteria are characteristic for pre-modern industries. Undoubtedly, the first feature is a high quantity of the production. Millstones, building material and ceramic vessels were manufactured in an amount distinctly exceeding the local or regional demand. Furthermore, a standardised production process can be observed. Millstone manufacturing followed a determinate chaîne opératoire, beginning in the quarries and continuing in special workshops. Tuff blocks were produced in a technique, which is clearly visible by the working traces in the Roman mines. The third criterion is a supra-regional distribution of the goods. In the Roman period Mayen millstones provided a marketing area, which extended from Britain to the Alps. Along with the mills, in the same cargos pottery vessels seem to have been transported. Tuff stone from the district was used for building projects especially in Germania inferior where there was a lack of rocks. In the Middle Ages tuff stone trade reached to northern Germany and Denmark.

Certain preconditions are necessary to make an industrial development possible. The first, of course, is the availability of high-quality raw materials. The district's mineral deposits, volcanic and non-volcanic, guaranteed an enduring supply. But deposits and production sites also must be located in a favourable position. This is the case here in an open landscape close to the confluence of the rivers Rhine and Moselle. Further, to benefit from the above-named preconditions, a good infrastructure is essential. Besides the waterways, several important Roman roads run through the district.

In combination these criteria and preconditions can produce a development that leads to pre-modern industries. As we have seen, several factors reinforce the development, such as technology transfers, cultural change and, last but not least, the involvement of economy and power.

Notes

[1] Hunold – Schaaff 2010; Hunold 2011a.

[2] Steingötter 2005; Schmincke 2007; Schmincke 2008.

[3] Steingötter 2005, 301; Hunold et al. 2004.

[4] Steingötter 2005, 297.

[5] Friedrich 2012b.

[6] Redknap 1999, 52.

[7] Holtmeyer-Wild 2000; Mangartz 2006; Mangartz 2008, 6–10. 24–29.

[8] Mangartz 2008, 40–52; Wefers 2012a.

[9] Mangartz 2008, 52–107. 196; Mangartz 2012.

[10] Mangartz 2008, 93–97.

[11] Schaaff 2010.
[12] Gluhak 2010; Gluhak 2012; Wefers 2012b.
[13] Schaaff 2012; Schaaff 2015.
[14] Gluhak et al. 2012; Geisweid 2018.
[15] Trier 2014.
[16] Schaaff 2015, 193–199.
[17] Schaaff 2010; Schaaff 2015, 165–183. 201–211.
[18] Giljohann 2017, 140–141.
[19] Friedrich 2012a; Friedrich 2012b; Friedrich 2015; Gluhak et al. 2012, 40–45; Sibylle Friedrich in this volume.
[20] Grunwald 2012; Grunwald 2015; Grunwald 2016; Lutz Grunwald in this volume; Gregor Döhner – Michael Herdick – Anna Axtmann in this volume.
[21] Gluhak et al. 2012, 40–45.
[22] See Lutz Grunwald in this volume fig. 2; Oesterwind 2012; Glauben 2012; Köstner 2012.
[23] Mangartz 2012, 2–4.
[24] Mangartz 2008, 74–75; Glauben 2012, 89–90.
[25] See Stefan Wenzel in this volume.
[26] Redknap 1999, 23; Glauben 2012, 92–94; Grunwald 2012, 112–116.
[27] Grünewald 2011, 140–141. 199–201; Glauben 2012, 92.
[28] Hunold 2011b, 274–275.
[29] Grunwald 2016.
[30] Hunold 2011b, 284–294.
[31] Hunold 2011b; Hunold 2012.
[32] Baur 2012; Baur 2014.
[33] Giljohann 2012; Giljohann 2017.
[34] Giljohann et al. 2017.
[35] Baur 2012, 242–243; Grünewald 2012, 170–174.
[36] Henrich – Mischka 2012, 334–335 fig. 6.
[37] Baur 2014, 145.
[38] Grünewald 2012; Giljohann – Grünewald forthcoming.
[39] Grünewald 2012, 162; Oesterwind – Wenzel 2012, 358 No. 43; Giljohann – Wenzel 2015, 25–27.
[40] Grünewald 2012, 171–172.
[41] Roymans – Habermehl 2011, fig.1; Grünewald 2012, 172–173.
[42] See Stefan Wenzel in this volume fig. 5.
[43] Wenzel 2012, 154 fig. 17; Wenzel forthcoming.
[44] Dotterweich et al. 2012, 198 fig.12; Wenzel et al. forthcoming.
[45] Wenzel – Zerl 2014, 184; Chameroy 2012, 227.
[46] Wenzel 2012, 144 fig. 12, 1–6.
[47] Ferdière 2015, 25 no. 99.
[48] Zerl 2012; Wenzel – Zerl 2014, 186–192.
[49] Rothenhöfer 2005, 56; Junkelmann 2006, 66.

[50] Cf. Henning et al. forthcoming.
[51] Wenzel 2012, 146–150; Wenzel 2014; Dotterweich et al. 2012, 193–198; Stefan Wenzel in this volume.
[52] Baur 2014; Giljohann et al. 2017.
[53] Scholz 2012, 39.
[54] Henrich – Mischka 2012, 328–329.
[55] Giljohann 2017, 11–13. 35.
[56] Giljohann 2017, 15–17. 157–158.
[57] Brückner 1999, 131.
[58] Giljohann 2017, 145–151. 158.

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Pottery Production for the European Market – the Roman Potter's Workshops of Weißenthurm

Sibylle Friedrich

On the left bank of the Rhine, in the middle of the Neuwied basin the modern village of Weißenthurm is located between the cities of Koblenz and Andernach (fig. 1). Through its fluvial location, the place is perfectly connected to the long-distance trade network. In Roman times the so-called Urmitz ware was produced there. From the Roman potter's *vicus* almost 20 pottery kilns are known up to now. Its extension was recorded by compiling all the finds from the past decades (fig. 2).

In this production centre of supra-regional importance high-quality coarse ceramics were made. Particularly plates, bowls and pots for daily use were produced there, which differ clearly in appearance and design from other ceramics. Characteristic features of this ceramics are a hard firing, a rough surface in varying shades of colour and a leafy break with a reddish tempering (fig. 3). These characteristics make the Weißenthurm products easy to recognise in other localities.

When in 1914 Franz Oelmann worked on the pottery from the Niederbieber fort, he noticed that he knew the ceramics from a production site that was then located in the Urmitz district. Consequently, he called these vessels "Urmitzer Ware".[1] Due to territorial shifts, the site lies now in the municipality of Weißenthurm. In research, nevertheless the naturalised name "Urmitzer Ware" remains because it has been an important name in archaeology since a long time.

Still today the type classification of the Urmitz ware submitted by Oelmann is used to characterise Roman vessels. Furthermore, up to the most recent literature this product has been considered a chronologically guiding fossil of the so-called Niederbieber horizon (end 2nd to the second third of the 3rd century).[2] The production has been supposed to have ceased with the so-called "Limes decline". However, according to my results, the traditional research opinion, which regards the Urmitz ware as a criterion for dating is no longer sustainable and needs to be reviewed. The same applies to the product range.

In 1974/75 the largest contiguous *vicus* surface, of 220 × 110 m, was excavated by the "Staatliches Amt für Vor- und Frühgeschichte" Koblenz (fig. 4). Pottery kilns and cellars of buildings are scattered throughout the area. In the southwest of the excavation area pottery kiln 1 was found. The rectangular kiln, of standing type, was filled with municipal waste, including numerous animal bones and the demolition debris from the kiln. Even if the ceramics recovered from the kiln filling were not the last load of the kiln, by the quantity and similarity of the potsherds it can be considered that the waste of previous fires was thrown into the kiln. The ceramics are typical Urmitz coarse ware (fig. 3). From the ash layer remaining in the oven, four samples were taken for scientific analysis. The samples had to be cut with great force because the burnt fragments were extremely hard and sharp-edged. As the finds from the ash layer indicate, the production span

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Fig. 1: Location of the Weißenthurm potteries.

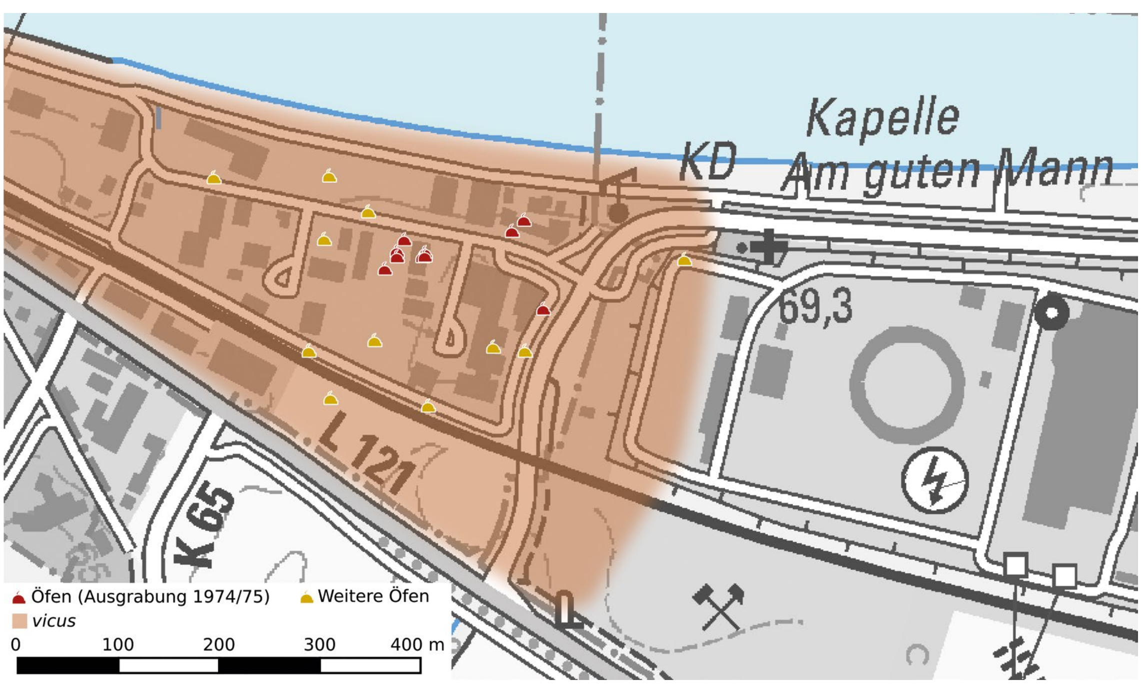

Fig. 2: Extension of the potter's vicus of Weißenthurm.

Fig. 3: Appearance of the typical Weißenthurm coarse ware.

of kiln 1 was middle to second half of the 2nd century.[3] This means the Weißenthurm production started earlier than it was expected before.

New information on the product range yielded the double kiln 2/3 on the western edge of the excavation area (fig. 4). The production span of the double kiln cannot be dated more precisely than second half 2nd / beginning 3rd century. While in the larger kiln 2 the typical Urmitz ware was fired, the later added smaller kiln 3 was used for the production of fine, thin-walled vessels (fig. 5). A total of 15 waste potsherds of both productions were selected for sampling. In both cases the sherds were so hard that the samples had to be broken off with the pliers. We found out that, despite the significant macroscopic differences, the compositions of the coarse ware and the fine ware are identical.

The fact that the production of the Urmitz ware did not end in the middle of the 3rd century is shown by finds from the backfilling of cellar 6, to the east of the excavation area (fig. 4) from which kiln debris could be recovered. The mineralogical analysis of two fragments of pots Alzei 27, fused with the remains of the kiln, proved a production of that late Roman type in Weißenthurm.[4] Altogether, all the samples taken from the kilns and the vicus area can clearly be classified in a group called “Weißenthurm” (fig. 6). On the basis of this result, a continuation of production is documented until the beginning of the 4th century.

As the Weißenthurm sherds could be clearly classified chemically and mineralogically, samples were also taken from the right bank of the Rhine. During the investigations, the author had the opportunity to see sherds from sites in the Barbaricum, whose macroscopic aspect pointed to Weißenthurm. By the samples taken in Leverkusen-Rheindorf, Leverkusen-Schlebusch, Niederkassel-Lülsdorf, Düsseldorf-Stockum and Kamen-Westick,[5] capturing the export area of the Urmitz ware turned out to take a completely new direction in time and space. In the cemetery of Leverkusen-Rheindorf

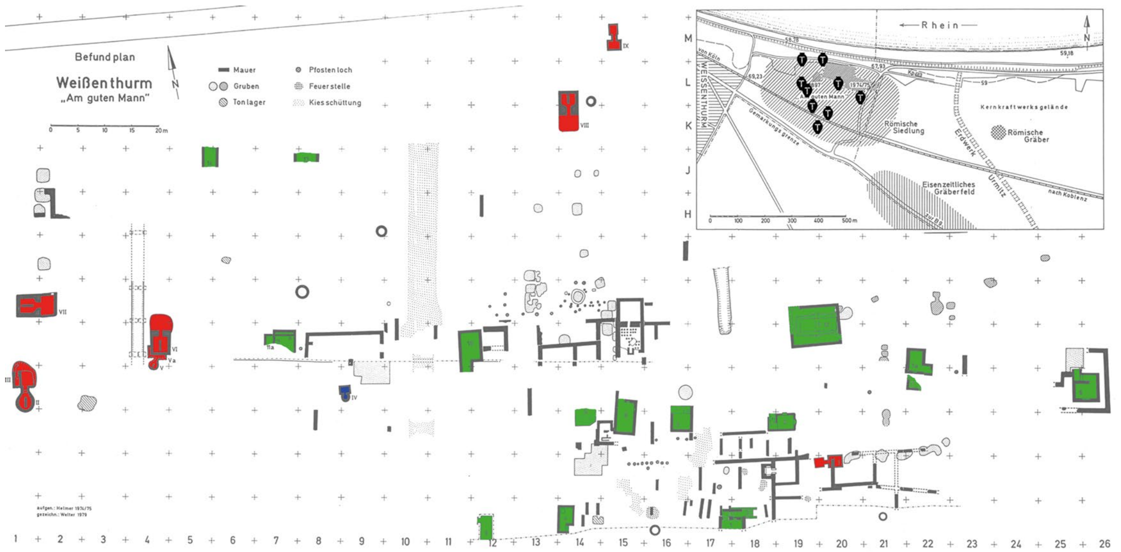

Fig. 4: Plan of the Weißenthurm excavation area 1974/75. The pottery kilns are marked in red, the cellars are coloured in green.

Fig. 5: Fine ware from Weißenthurm kiln 3.

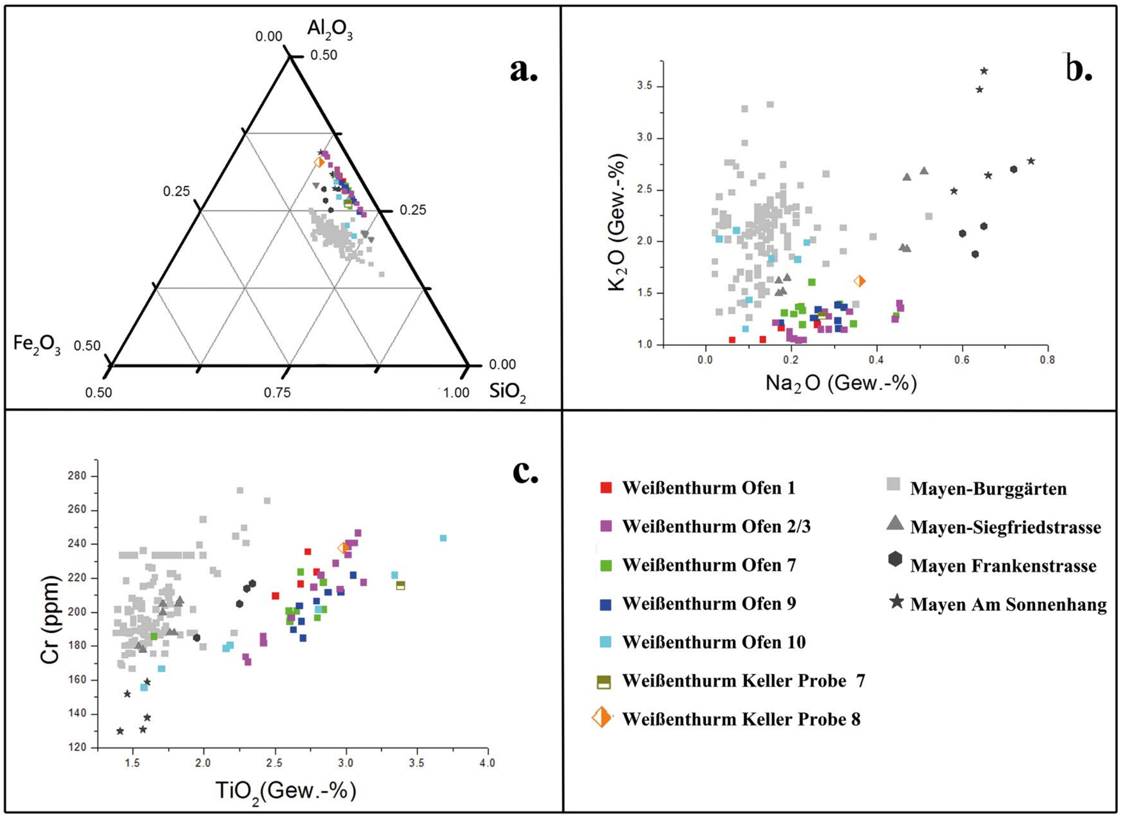

Fig. 6: Chemical analysis of Weißenthurm samples in comparison with Mayen sample.

Fig. 7: Sherd from Leverkusen-Rheindorf.

Fig. 8: Pottery waste from Koblenz "Bürresheimer Hof".

a sample was taken from grave 35, which dates to the first half of the 4th century (fig. 7). But in contrast to all the samples taken in Weißenthurm, the sherds of the jar from Rheindorf were so soft that the sample could simply be broken off by hand.

This fact leads to a recent excavation in the city of Koblenz. For a couple of years, voices became louder that doubted the exclusivity of the production site of Weißenthurm.[6] However, a review of the surrounding Roman settlements revealed no indication of further production sites in the Neuwied basin.[7] Then at the "Bürresheimer Hof" in the old town of Koblenz below the late antique city wall a pit filled with pottery waste was excavated. The ceramics, coin-dated in the years 275, resembled the classical Urmitz ware (fig. 8). Because of this similarity, the author initiated a sampling of the sherds.[8] To take the samples, again it was not necessary to use a pair of pliers. The soft consistence of the sherd is reminiscent of the sample from the grave 35 from Leverkusen-Rheindorf.

The sherds from Rheindorf and Koblenz could be distinguished from Weißenthurm only haptically and not macroscopically. For this reason the question arises once again whether Weißenthurm was the only production site for the Urmitz ware. Therefore, it was decided to expand the sampling radius in order to create a comprehensive database. Samples were also taken in Andernach and Bonn down the Rhine.[9]

Especially the last facts show how cautious we should use the term "Urmitz ware" and its use as a dating criterion in the future. The results of the pending mineralogical analyses will show whether we can talk about THE "Urmitz ware" at all.

Notes

[1] Oelmann 1914, 70

[2] Doubts in this regard: Heising 2010, esp. 65–66

[3] Friedrich 2015

[4] Xu 2015

[5] I would like to thank all the contacts for their extensive support. Leverkusen-Rheindorf, Leverkusen-Schlebusch, Niederkassel-Lülsdorf: Erik Classen and Klaus Frank, Landschaftsverband Rheinland, LVR-Amt für Bodendenkmalpflege im Rheinland – Außenstelle Overath; Düsseldorf-Stockum: Michael Schmauder and Katarzyna Kus, LVR-LandesMuseum Bonn; Kamen-Westik: Michael Baales, Eva Cichy, Robert Fahr, LWL-Archäologie für Westfalen, Außenstelle Olpe.

[6] Kiessel 2008, 399–407; Brüggler 2009, 143

[7] Friedrich 2012

[8] I like to thank Peter Henrich, the head of the Generaldirektion Kulturelles Erbe Rheinland-Pfalz, Direktion Archäologie, Landesarchäologie Koblenz (GDKE Koblenz) and his staff for the rapid implementation of this project.

[9] Special thanks to Peter Henrich, GDKE Koblenz (Andernach), Michael Schmauder, LVR-LandesMuseum Bonn and Erik Classen, Landschaftsverband Rheinland, LVR-Amt für Bodendenkmalpflege im Rheinland – Außenstelle Overath (Bonn).

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Pottery Production for the European Market – the Roman and Early Medieval Potter's Workshops of Mayen

Lutz Grunwald

In the landscape around Mayen in the Moselle and Rhine region clay deposits from the tertiary occur. They formed the basis of the pottery found here. Between the early 1st and the first half of the 4th century AD nearly every larger settlement possessed its own pottery workshops (fig. 1).[1] In the first half of the 4th century AD in Mayen there existed two pottery areas. South of the *vicus* and west of the late antique fortification on the Katzenberg on today's Polcher Straße a smaller production site of local importance can be found (fig. 2, 1). An extended pottery area was located within the *vicus* of Mayen in an area called "Eich" (fig. 2, 2), where the so called Mayen ware was produced in large numbers serially for the long-distance trade.

Both from coin-dated destruction layers in the settlements as well as through the written tradition we know that in 355 AD the Alemanni came from the south and devastated the Moselle estuary.[2] The raids most likely also destroyed the export-oriented pottery of Mayen and Weißenthurm. At least since that time, our region was one of the areas of interest of the Alemanni, which led in the second half of the 5th century AD to an Alemannic immigration into this area. After about 360 AD the Caesar Julian secured the Rhine region, only in Karden and Mayen potteries can be observed. All other locations have now been abandoned at the same time. The potter families who fled from Andernach, Weißenthurm, Koblenz, Kobern, Büchel and Mayen-Polcher Straße did not return to their homes. Where did they go?

They may have come to Mayen. Here the potteries in the area called "Eich" (fig. 2, 2) were reused and expanded. In addition, a large pottery area was founded along today's Siegfriedstraße (fig. 2, 3).[3] Very different qualities and in their chemical composition different clays were used at these sites. Mayen seems to have seen a rise in population around 360 AD. It is hard to imagine that such a pooling of a business in one place and its massive expansion took place without state knowledge and coordination. Rather, the state response to a crisis here becomes visible.

According to the historian Elena Köstner the area between the Vinxtbach stream and the river Nahe belonged to the *ager publicus* since early Roman times and thus was directly subordinate to the Roman state and its administrative organization.[4] In the originally Roman *pagus* of Mayen, which is mentioned in written sources already in 620 and 634 AD, a state-controlled lease system was the basis of economy. This *pagus* stretched between Vinxtbach in the north and Moselle in the south and was coordinated from Mayen. Thus in the *vicus* of Mayen there was – after Köstner – in Roman times and, in administrative succession, probably also in the early Middle Ages, a seat / *officium* of a administrator / *procurator*. It is assumed that trade and goods export by prior arrangement with the administration from the big tenants

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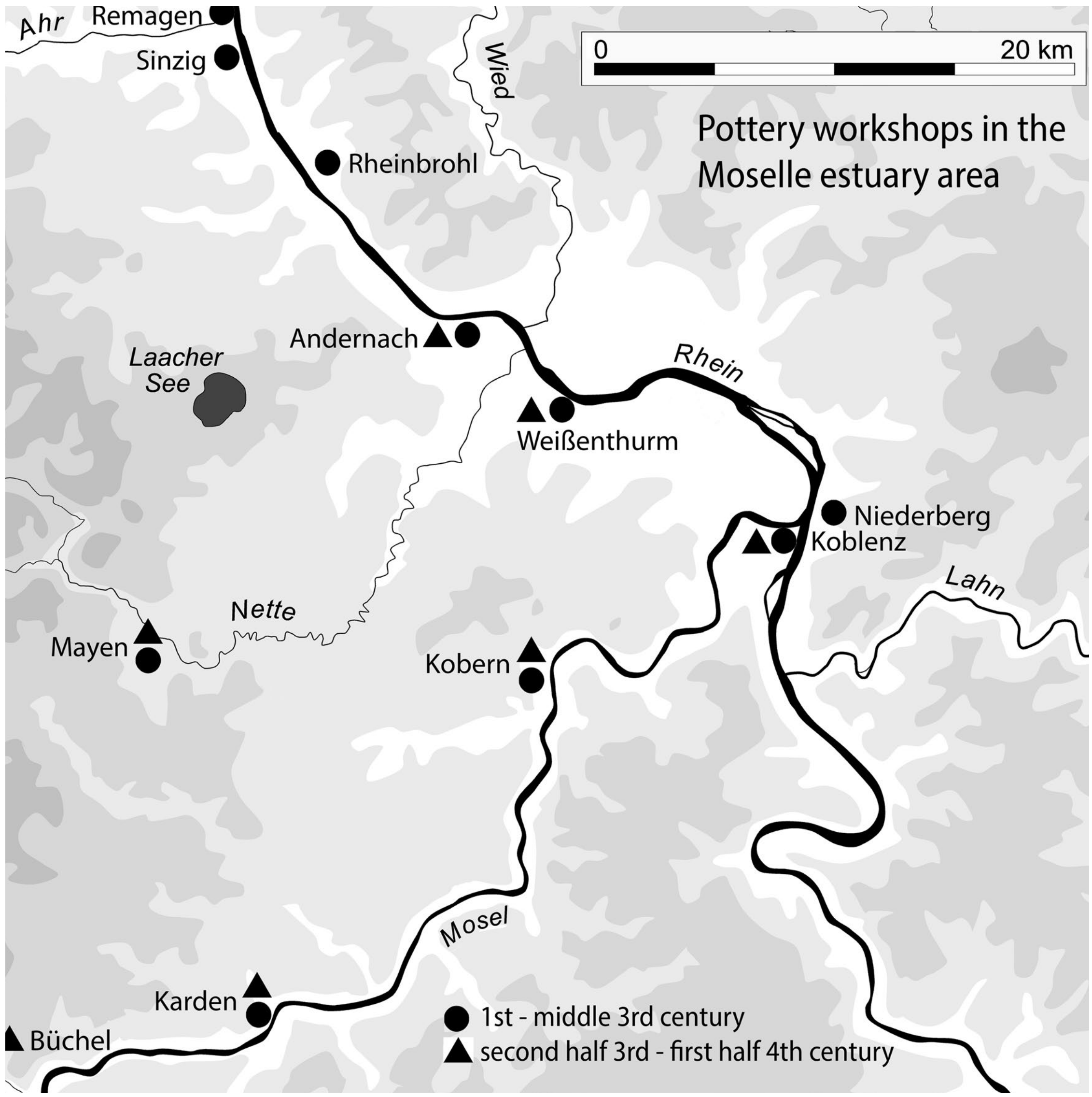

Fig. 1: Landscape around Mayen. Settlements with pottery production. Dots 1st – middle 3rd century. Triangles second half 3rd/first half 4th century.

– for whom the simple potters / *figuli* worked as small tenants – in their role as wholesalers was coordinated and controlled nationwide. Certainly fixed travel routes were used during the export.

Like the millstones made of basalt, the Mayen pottery was transported both over the road network and over the river Nette to the Rhine and then brought to the central shipping port of Antunnacum / Andernach. From here, the Mayen ceramics reached the export regions via the water network. In the export regions, the pottery vessels came to the customer from the central market towns via streams and roads.[5] One can therefore

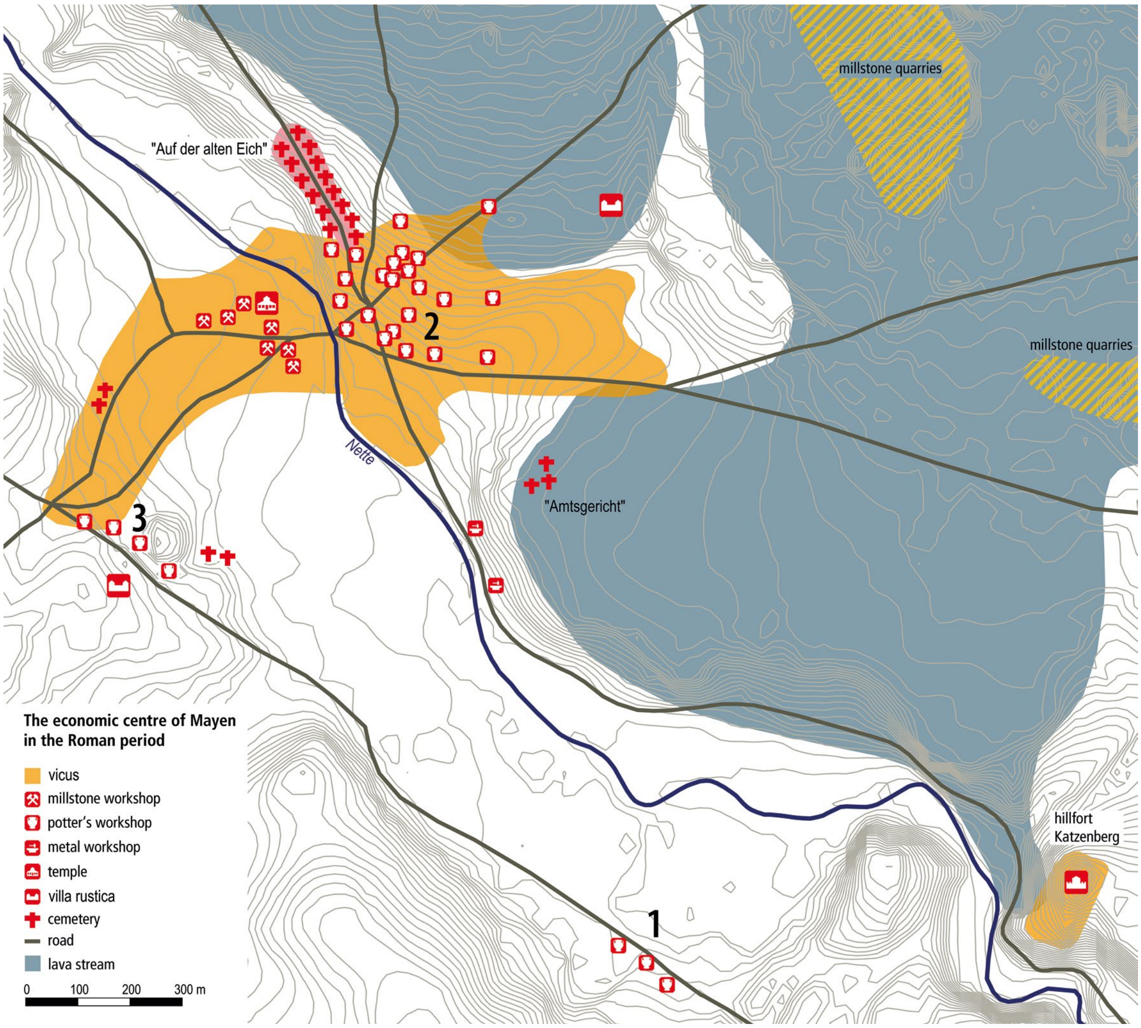

Fig. 2: Map of the roman vicus of Mayen. Ceramic production areas: 1 = Polcher Straße. 2 = Eich. 3 = Siegfriedstraße.

imagine that Mayen vessels reached the French territory from Cologne via the Tongern – Bavay – Cambrai highway.

A new distribution map to late antique Mayen pottery shows that the image has not only condensed, but the export area has also expanded massively, for example to Belgium and France up to the Champagne (fig. 3). But also in the east, for example on the Ruhr and Lippe rivers and on the Main and Neckar rivers, the number of sites has significantly increased. Empty areas on the lower reaches of the Meuse north of Maastricht or between Trier and Karden on the Moselle should be research gaps. In addition, in certain regions Mayen goods were imitated in late antiquity. Such “Mayen imitations” especially occur in the more distant export regions like the Paris basin in the west.[6]

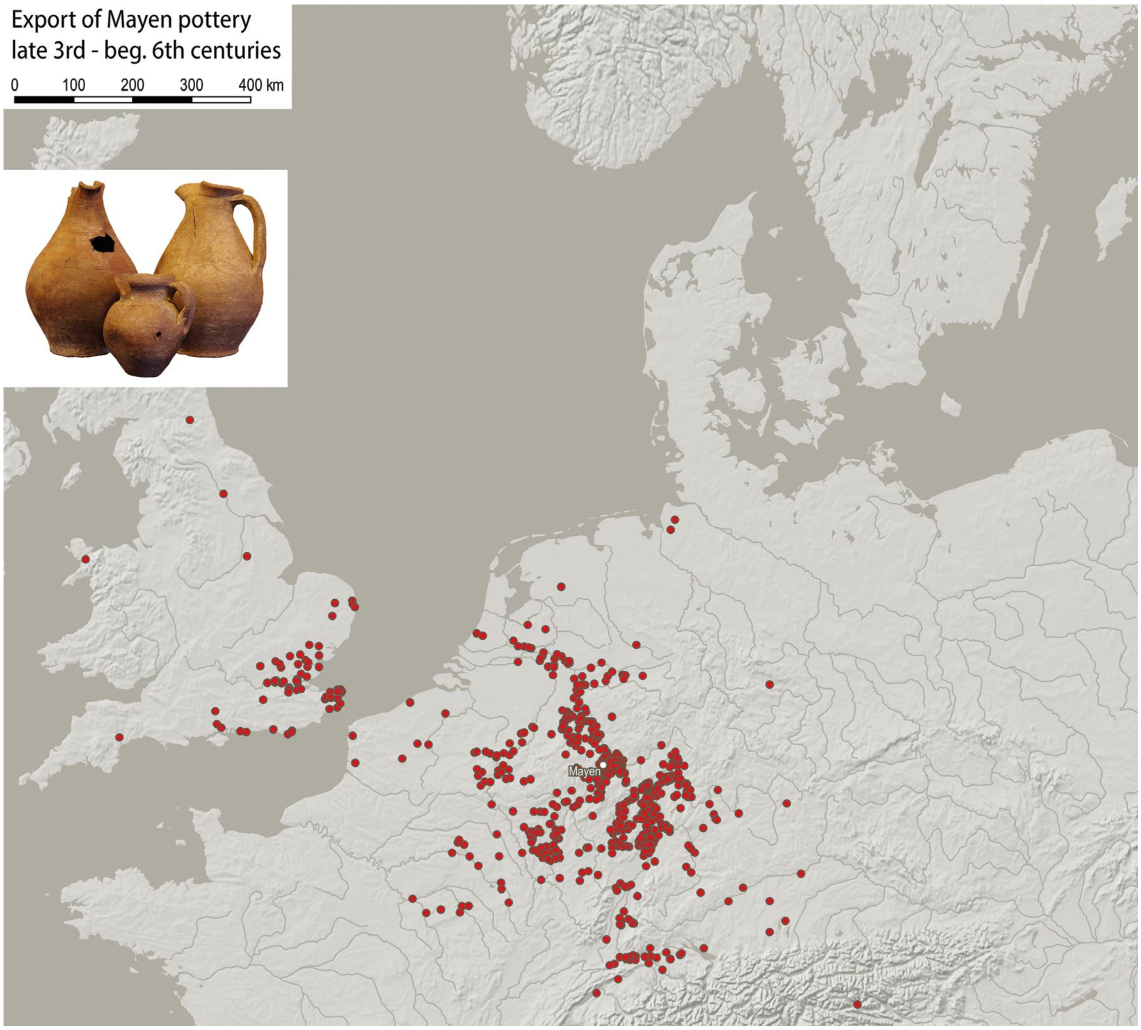

Fig. 3: Distribution map of the late antique Mayen pottery (late 3rd – beginning 6th century).

Like the pottery of Mayen, the workshops of the Argonne with their Samian ware in late antiquity shaped large parts of the Roman export market. This also affects the Moselle estuary region. The surroundings of Mayen were supplied with Argonne Samian ware until the second quarter of the 5th century. After the middle of the 5th century, this import broke off in the Moselle estuary area as in most parts of the Rhine region. Do we notice here the effects of the Hun's destruction of the year 451 AD?

It appears to be so. The supply with Argonne Samian ware went down severely in the Germanic provinces of the Roman Empire after 451 AD. But the import did not stop completely. For example two sherds of the second half of the 5th century were found in Andernach. In addition, according to the well-founded studies of the INRAP-pottery-science-group in Metz[7], the share of imported Mayen ceramics in Lorraine in the third

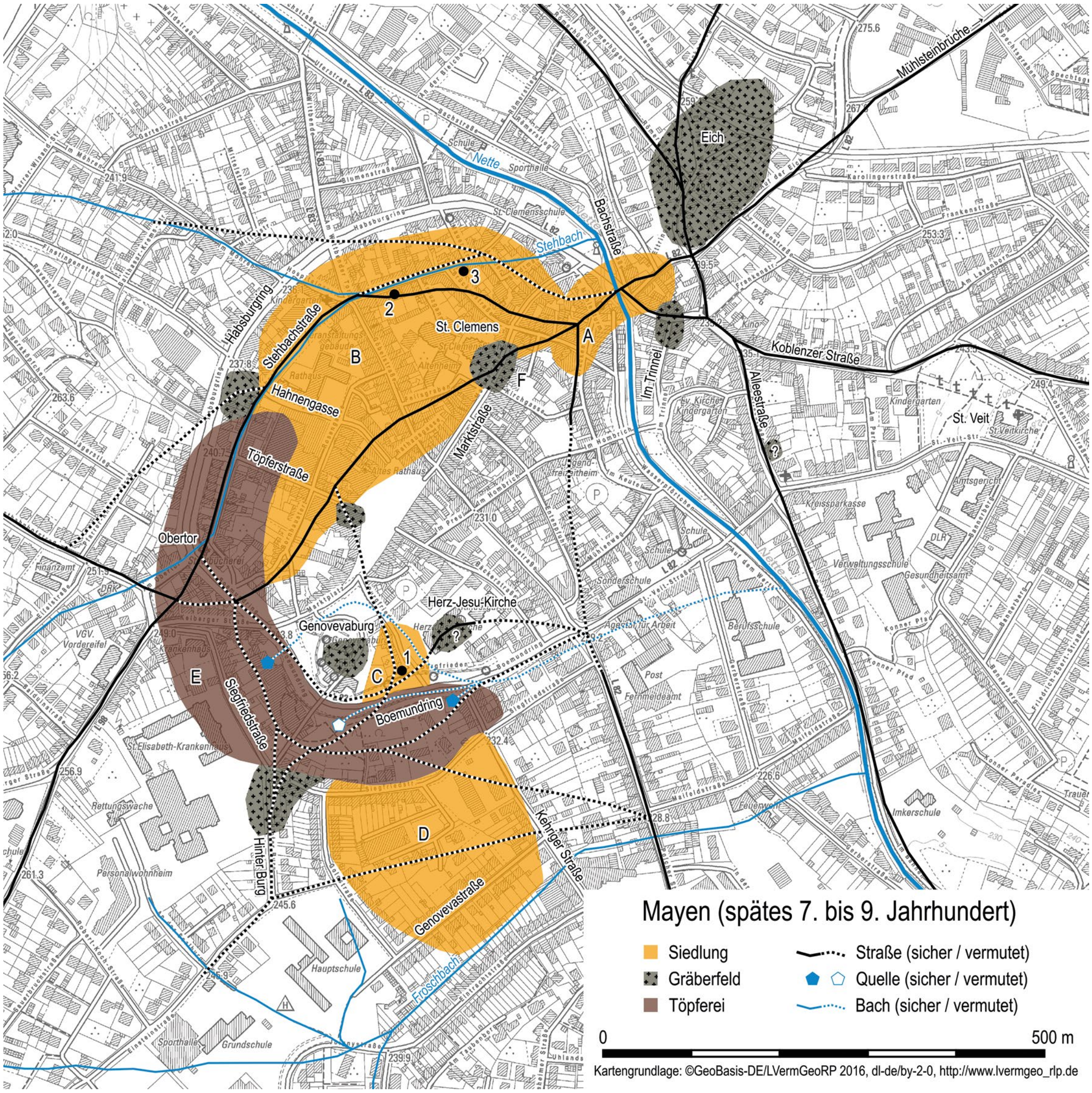

Fig. 4: Map of Mayen (late 7th–9th century). A–D population centres; 1–3 early courts; brown = potteries; grey = graveyards.

quarter of the 5th century is more than 30% of settlement ceramics and is still on a high level in the beginning of the 6th century. Thus the trade relations did not collapse. But the production of the Argonne ware seems to have declined dramatically. Perhaps the absence of the Argonne Samian ware in the Mayen area also indicates a change of power relations. Between 450/460 and 496/497 AD (battle of Zülpich) our region – like large parts of the Rhineland – probably belonged to the Alemannic dominion. Perhaps the new rulers promoted the production of red engobed ceramics in Mayen and by that prevented the importation of Argonne ware in the Alemannic area.

Fig. 5: Examples of the red engobed Mayen ware MA (left) and Mayen ware MD/ME (right).

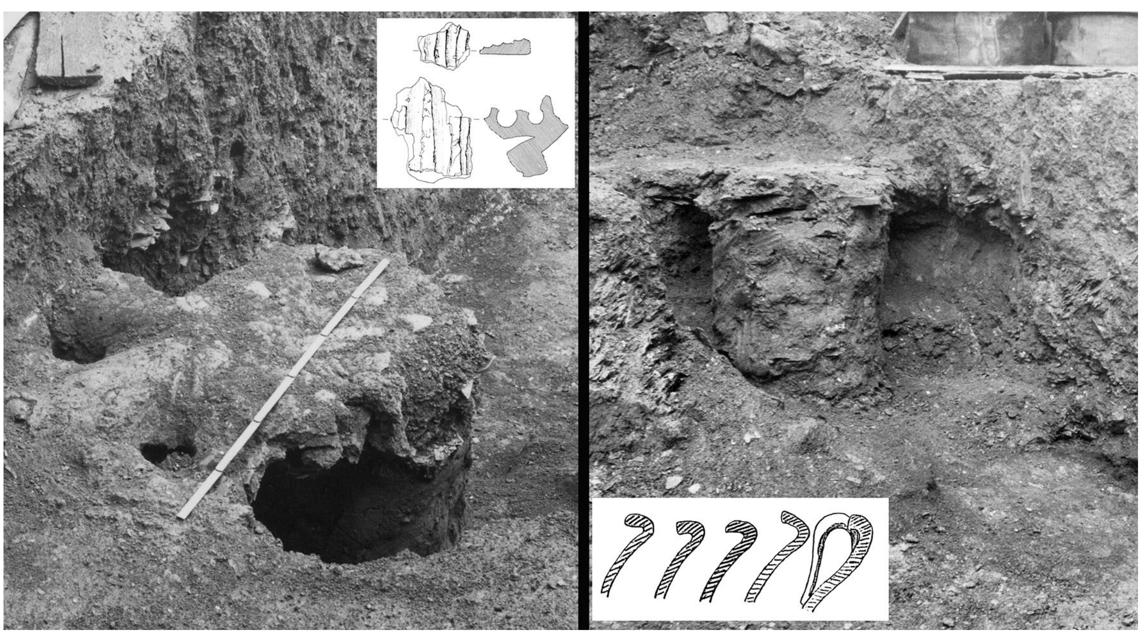

Fig. 6: Updraft kiln found 1953 at the property Siegfriedstraße 6–8. In this kiln ball pots of the Mayen ware ME had been produced.

At the latest around 480 AD, in Mayen the pottery area 2 "Eich" as well as the fortification on the Katzenberg were abandoned and the pottery area 3 "Siegfriedstraße" expanded (fig. 2, 3). Due to the pottery kiln fillings in Mayen continuity into the early Middle Ages can be proven. Between the late 7^{th} and 9^{th} centuries, Mayen's pottery area expanded immensely, especially to the north (fig. 4).[8] This expansion was accompanied by a significant increase of production. The Mayen potters acted very traditionally and

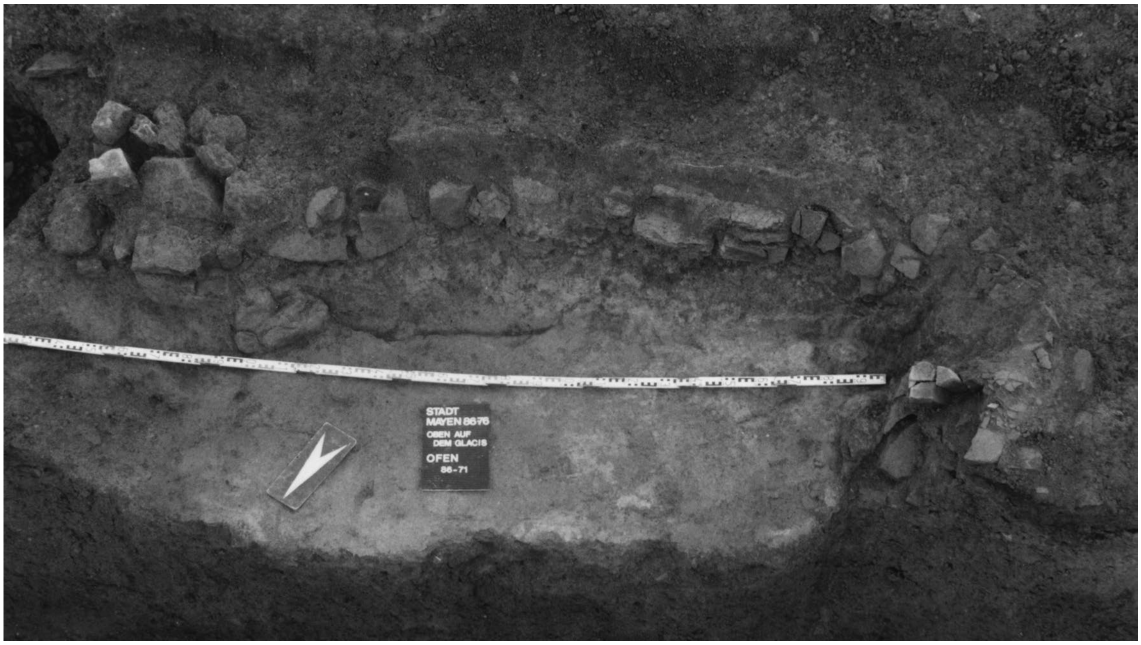

Fig. 7: Lying pottery kiln 9 found 1986 in the production area Siegfriedstraße.

produced ceramics rooting in Roman wares – such as the red engobed Mayen ware MA (fig. 5, left side) – up to the 9th century. During the Carolingian period, they continued to produce all the ceramic goods which were common in the Merovingian period[9]. This sense of tradition is also evident in the vessel shapes.

Generally one can note that so-called Wölbwandtöpfe (fig. 5, right side) and late, shallow shamrock jugs with ever more spherical vessel bodies are characteristic of Mayen-made ceramics of the 8th century. They are usually made of the product type MD / ME which is typical for the period around 700 AD to around 800 AD. This means a proto-stoneware, which lies between the coarse product type MD and the nearly-stoneware type ME.

At this time standing, circular firing systems in updraft kilns of late Roman origin still remained in use.[10] A good example of this was discovered in 1953 on the property Siegfriedstraße 6–8 in the expansion of the timber shop Orth. Here, classical Carolingian ball pots, a type emerging around 800 AD, had been burnt in the then arising Mayen ware ME (fig. 6). The established forms in late antique / Merovingian tradition were pushed out of the production in the course of the 9th century.

However, in the 9th century, also new kiln types appeared in Mayen. So the kiln principle of the horizontal furnace was introduced. An example of this construction principle is kiln 9 which was documented 1986, unfortunately detected unobserved by a trench section (fig. 7). Built of rubble and clay, this unit, used in the first half / middle of the 9th century, can be assigned to the lying pottery kilns. Its content includes mostly reducing burnt vessels of Carolingian nearly-stoneware ME and oxidizing burnt earthenware (fig. 8).

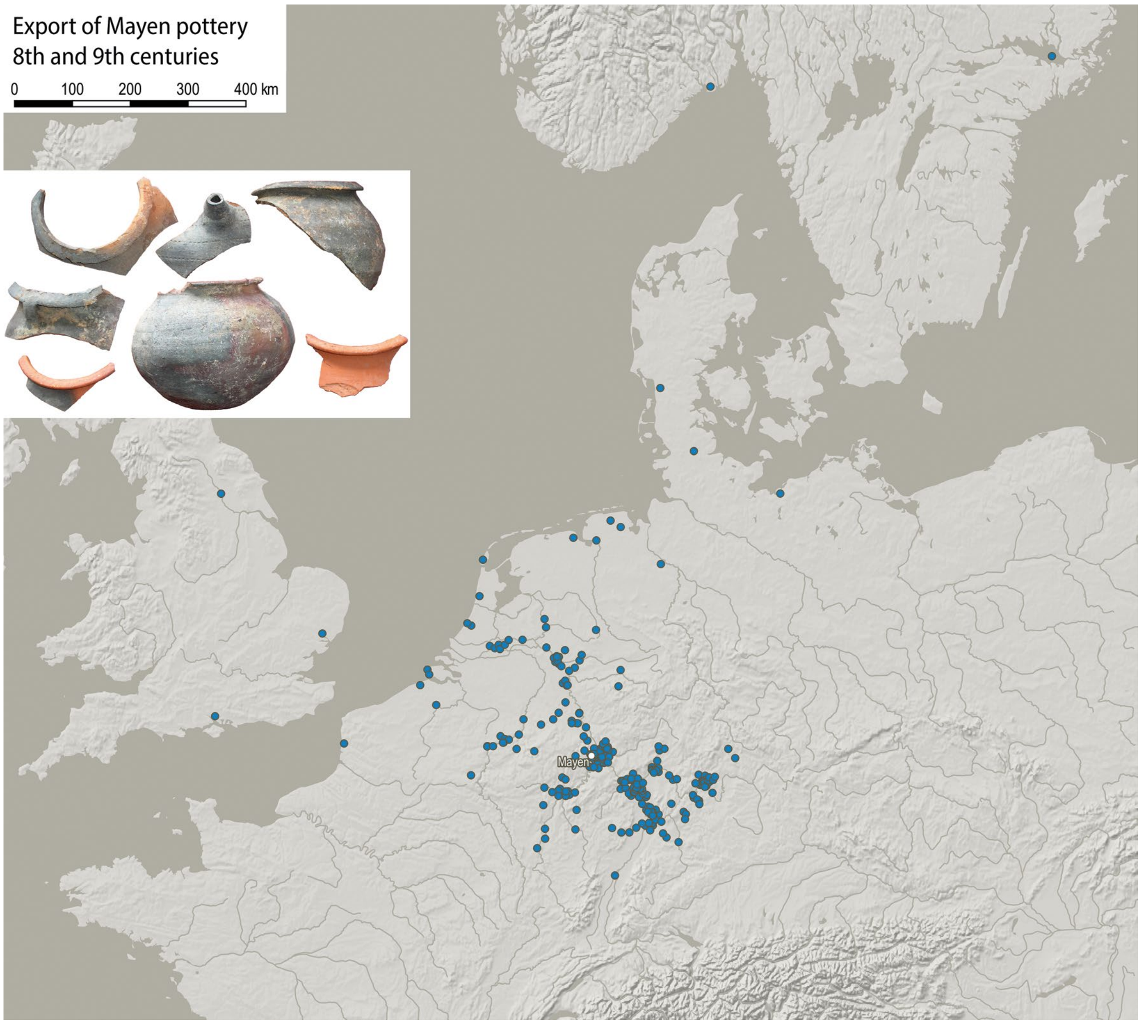

Fig. 8: Distribution map of the Mayen pottery from the 8th/9th centrury.

Also for the Mayen ceramics of the 8th and 9th century the author created a new distribution map (fig. 8). Compared to 1999's mapping by Mark Redknap[11], there is not only a consolidation of evidence, but also an extension of the sales area both to the west to Belgium and France as well as to the east, for example into the Main-Neckar region.

In research, the distribution of the Mayen pottery in the 8th and 9th centuries was associated with the possessions of the Eifel monastery of Prüm. In the core zone of the possessions of the Prüm monastery between Euskirchen and Trier, however, hardly any Mayen ceramics can be detected until today. A distribution of Mayen vessels on the possessions of the Prüm monastery does not seem to have been substantial. However, if one adds to the distribution map the settlement areas of the Frisians and other evidence for Frisians – for example Frisian coins (sceattas), Frisian trading posts, graves or found objects – they correspond well to the dissemination image of Mayen ceramics. It is very probable that in the 8th and 9th centuries the Mayen vessels were distributed by Frisian merchants. Whether they acted on behalf of the Carolingian authorities, thus acting as agents who had to pay taxes in the state budget, remains to be clarified in the future.

Notes

[1] Grunwald 2012b, 111–112 fig. 1; Grunwald 2019.

[2] Grunwald 2016, 345–345 fig. 1.

[3] Grunwald 2016, 347–349.

[4] Köstner 2012; Köstner 2013; Köstner 2015.

[5] Compare: Grunwald 2015; Grunwald 2019.

[6] Petit 1975.

[7] Bressoud et al. 2015a; Bressoud et al. 2015b.

[8] Grunwald 2018.

[9] Grunwald 2012a, 150–153.

[10] Hanning et al. 2016; Hanning et al. 2019; Döhner – Grunwald 2018.

[11] Redknap 1999, 351 fig. 102 B.

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Technical-Historical Comparison of Pottery Districts: Desiderata and Experimental Archaeological Research Prospects

Gregor Döhner – Michael Herdick – Anna Axtmann

The study of industrial landscapes holds great potential for the development of experimental archaeology. Connecting the three following research areas yields both advantages as well as challenges:

- The reconstruction and technological evaluation of production processes and production facilities
- The contextualization of the applied techniques within the pottery industry and the strategy of use for resources which were available in the region
- The development of transparent documentation standards which would allow for the comparison of the applied techniques and material properties of products from different industrial areas

This research approach is a clear negation of any technological deterministic view of history. Instead, technological acts – understood as the capability to use and change material as a means to solve problems – are examined as aspects of human behaviour. Accordingly, they can be analysed only while taking into account further components, especially those that are social and economic in nature. Furthermore, the interrelations with the environmental conditions of an industrial area must also be kept in mind.

The challenges which result from this, especially for the examination of pottery areas, can be summarized as follows:[1]

- With every year of excavation, the number of archaeologically documented production facilities from pre-modern periods is multiplied.
- Despite a multitude of experimental archaeological test firings in reconstructed kilns, up until now there is no valid performance data for even one European industrial area with supra-regional markets which would allow tracing kiln technology diachronically.
- Even today, extremely subjective characterisations are being used for the description of functional features of pottery products, for example 'robust, heat resistant kitchen pottery'. The same is true for the classification of wares. The classification as 'proto' or 'almost' stone ware is not only ill-defined from a material scientific point of view, but there are also no equivalent terms in the pottery profession.

This stocktaking shows an urgent need for the development of methodological procedures. A transparent data base would allow for a comparison between the ceramic technologies of different pottery areas.

The ceramic technology of the pottery workshops in Mayen is especially suitable for a model study in this field of research:[2] From about 300 AD, the potteries of Mayen

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Fig. 1: Shaft kiln, type B 1c after Redknap, excavation plan. Red circle: a slate plate marked the height of the kiln wall.

produced more and more wares for export and were able to assert their markets until the Middle Ages.[3] Thanks to large-scale excavations during the 1970s and 80s, a broad stock of archaeological material is available. A series of comparatively well or very well preserved pottery kilns is especially suitable for reconstruction.[4] Also, the current state of research can be described as above average compared to other European pottery centres. Therefore, this area fulfils the ideal prerequisites for a diachronic experimental archaeological study.

The research approach of this study was defined as follows:

a) The reconstruction and technological evaluation of kiln types which, according to the current state of research, mark a technical historical evolutionary step and/or appear in a transition period of social or economic history.

b) The determination of the maximum spectrum of uses for the available raw material in terms of their ceramic technological properties in relation to the practical usage of materials during the respective operation period. For this, the analysis data from raw

Fig. 2: Construction of the firing chamber using upside down pots.

material and material studies has to be connected to the actual forming, drying and firing behaviour of the plastic masses. The objective is the development of generally applicable methodological tools which can be used to deduce the possible spectrum of vessels (for example their probable form, size and function) by looking at the ceramic technological analysis of raw materials.

During the first phase of the project, an updraft shaft kiln with a spoked floor – Type B1c after Redknap[5] – was reconstructed and subsequently fired. The kiln was reconstructed based on finds[6] which had been uncovered in Mayen, Siegfriedstr. 53 (fig. 1).

The kiln was in use from ca. 500 AD until around 520/30 AD.[7] Its height was 1.70 m; the diameter at the upper end of the firing chamber was 1.60 m. The walls of the firing chamber were erected using whole and/or broken bottoms of so-called Wölb- and Wölbwandtöpfe, which were stacked upside down in rows and embedded in clay (fig. 2).[8] The basic construction principle of this kiln type was known in the Mayen region as early as the beginning of the Common Era.[9] However, starting in the second half of the 5th century AD, the shaft kiln with spoked floor began to replace the formerly dominant elongated oval or rectangular kiln types.[10] The early appearance of the wheel-like spoked floor supported by a central pillar in Mayen and the duration of use seem to be unique for the German-speaking area.

Two elements which influence the function of the reconstructed kiln will be presented here: the way of stacking the firing goods and the dome.

Fig. 3: Stacking the pots.

Only two small stacking props, which probably served as spacers for engobed goods, are known from late antique contexts in Mayen.[11] The coarse ware pottery vessels which were produced primarily for export during the operating period of the kiln could be stacked directly on top of each other without additional support (fig. 3). This stacking technique requires a high level of experience so that flames and fuel gas are conducted through the kiln in a way that ensures an even temperature distribution and prevents the vessels being damaged due to stacking pressure. This stacking pressure also limits the height to which vessels can be stacked and thus provides a further indication for the reconstruction of the kiln.

In some archaeological contexts in Mayen, a slate plate can be seen at the top of the wall of the firing chamber. This has been suspected to mark the upper rim of the furnace wall. When taking this height into account, around 550 vessels of the contemporary variety of shapes could be stacked in the furnace. As a rule of thumb, particularly for this type of kiln, the stacking technique is as important as the construction of the kiln for the physical processes which occur during firing.

The original hypothesis of the excavators was that the furnace was constructed with a permanent dome. However, there were no indications of this in the archaeological context. Following general ceramic technological considerations, such a dome is also not necessary for the production of the export pottery preferred during the operation period and therefore a temporary dome was chosen for the reconstruction. From historical and

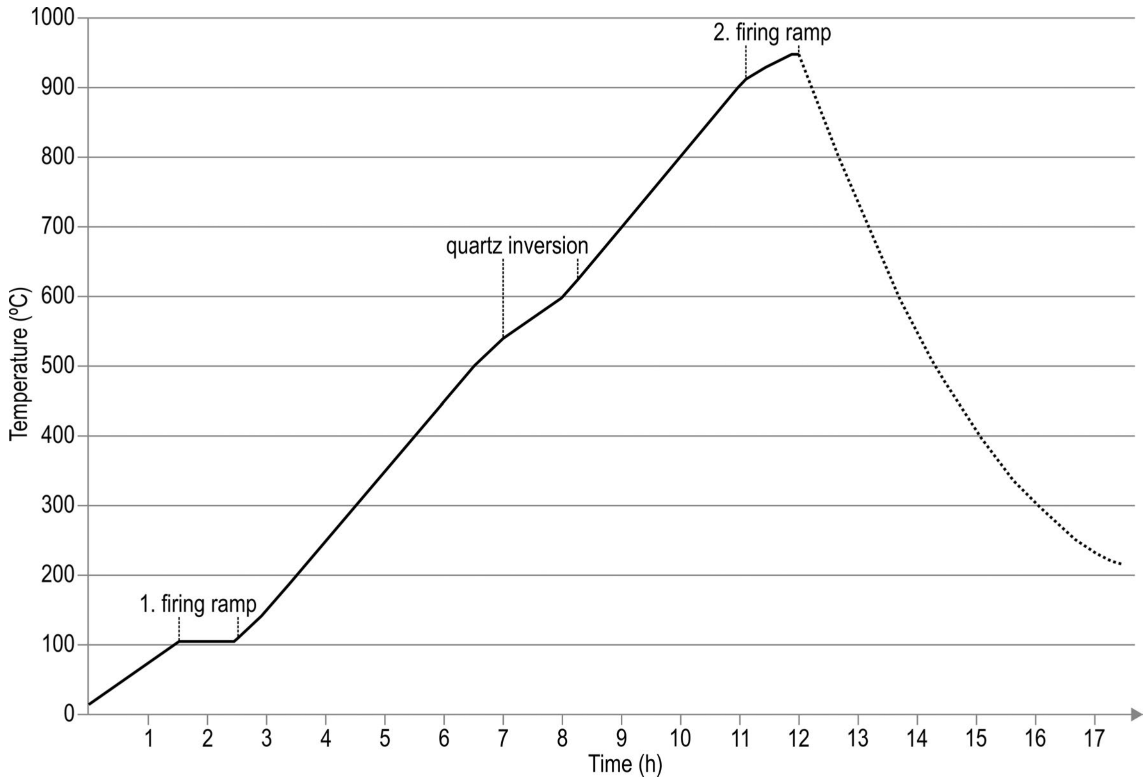

Fig. 4: Ideal firing schedule for the production of Mayen export wares from 500 AD. First firing ramp is to allow for the evaporation of mechanically bound water, the second firing ramp is critical for the quality of the ceramic in that enough time elapses before the final temperature is reached.

ethnoarchaeological analogies, a temporary dome can be constructed by covering the loaded chamber with large shards from the pottery's waste dump.[12] We decided on large, shallow, unglazed ceramic bowls and fragments thereof, which fulfilled the same purpose as large shards.

A final judgement concerning the technological efficiency of the reconstructed shaft furnace of Mayen, which is based on the experiences gained during the test firings between 2014 and 2016, must take into account the type of products which was produced in this type of kiln around 500 AD. The robust, rough-walled domestic ware was fired in an oxidizing atmosphere and intended for export. The evaluation by means of experimental archaeology has proven that for this usage, the kiln construction principle was robust and comparatively unsusceptible to faults. A worker could have gained the experience needed for the management of the furnace quite quickly within a training period of several months. This was made possible by the nearly linear combustion process, which shows retention times only at 80 to 120℃ and at the intended final temperature between 800 and 900℃ (fig. 4; fig. 5).

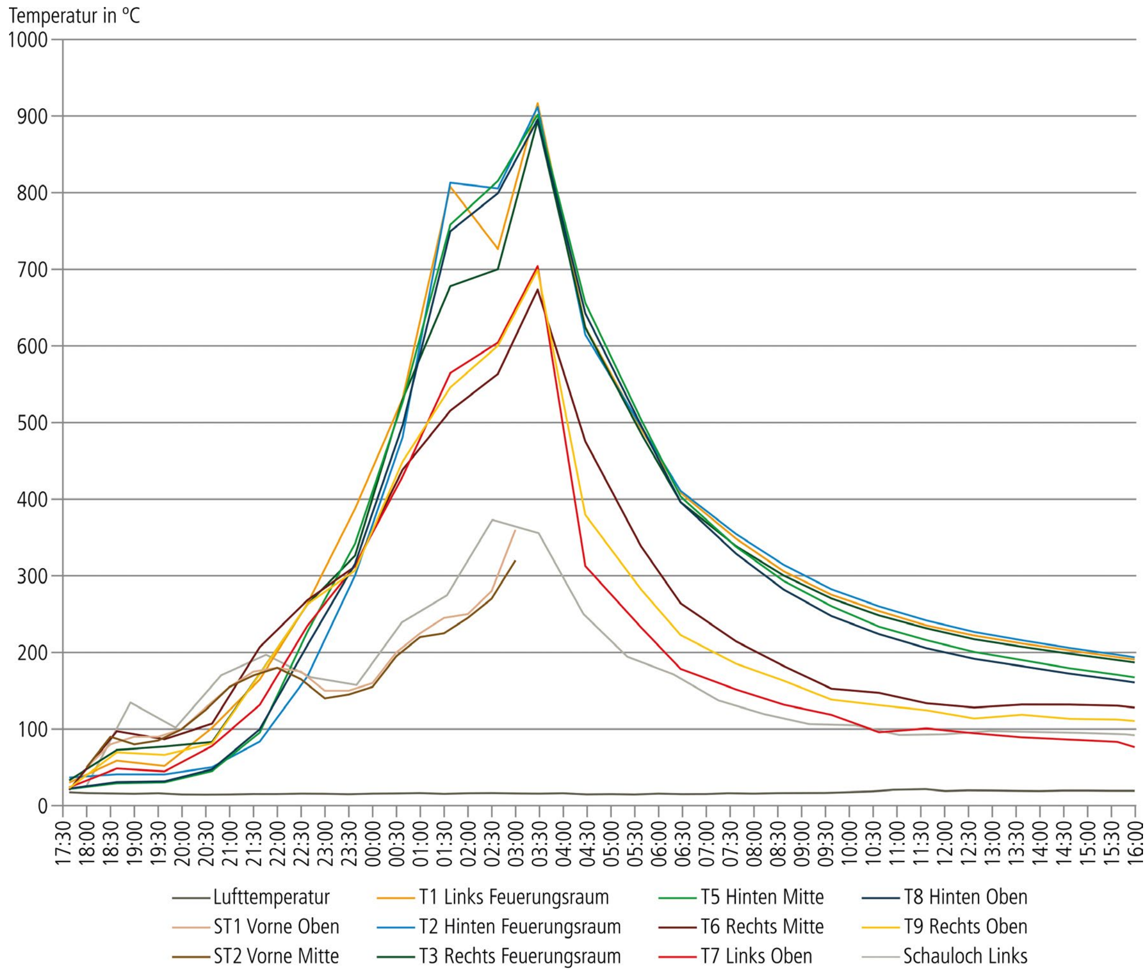

Fig. 5: Pottery firing in 2016 – Temperature curve: measurements taken at 12 fixed points.

The following observation can be made about the energy balance of shaft kilns for pottery production:[13] Shaft kilns are less energy efficient at higher temperature ranges. The retention of temperatures at higher ranges, especially over 800℃, is directly connected to high fuel consumption in the combustion chamber (fig. 6). In this state, firing systems are subject to extremely high thermic strain. This is due to the fact that a raise in the quantity of the combustion material (in this case wood) only leads to a delayed rise in temperature, but also to an increased reducing atmosphere within the furnace. This is caused by the construction principle of shaft kilns, and that two types of energy loss decrease the firing efficiency of wood-fired systems:

- Thermic loss due to heat emission
- Chemical loss due to incomplete burning

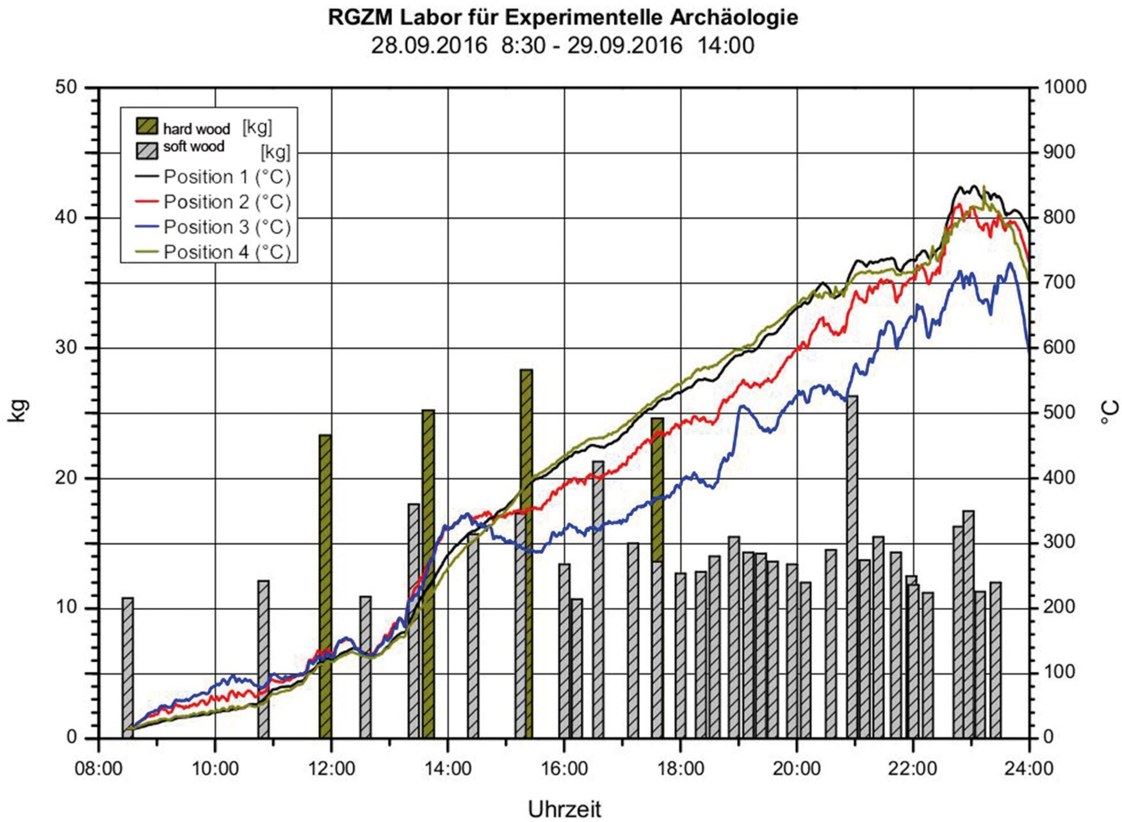

Fig. 6: Fuel diagram. Additional wood did not lead to a notable increase in temperature when the temperature in the kiln was above 800°C.

The thermic loss due to heat emission to the environment occurs at the opening of the firing chamber and can only be partially reduced because otherwise the draught behaviour of the furnace would be affected. But the dependence of the firing temperature on the oxygen level within the kiln, as well as on wood humidity (which is around 12 to 14%), is of more importance for limiting the final burning temperature of shaft furnaces. Covering the fired goods causes a lack in sufficient oxygen supply in the firing chamber which would be needed for raising the temperature. But not covering the goods would lead to a high thermic loss due to heat emission and at the same time to such a large surplus of air that it would induce additional cooling. The relation between supplied combustion material and usable performance increases disproportionately, even with longer retention periods or a slight raise of the final firing temperature.

Around 500 AD in Mayen, shaft kilns with spoked floors were a perfectly suitable installation type for a clearly defined purpose: the production of coarse ware export ceramics. The potters relied on proven construction principles for their kiln installations which allowed production that exceeded their personal need. When needed, new personnel could be trained for the firing process with relative ease.[14] The building material for the kilns could be acquired from local raw material sources. As long as the distribution channels were open, supra-regional markets could then be steadily supplied. The challenge was to develop a product based on the available raw materials that could be sustainably established on supra-regional markets.

Determining the maximum ceramic technological spectrum of uses of the available raw material is necessary to make qualified assumptions about how far the success of a pottery area was dependent on conscious decisions and not only on resources.

In Central European research and publications, there are several single-case studies and observations that broach the issue of clay gathering, the usage of different clays or their mixture at one production location.[15] For Mayen, archaeometric studies have provided hints for the mixture of clays used to generate materials for pottery production.[16] Nevertheless, when investigating the intentional processing of clay batch compositions and their development in a diachronic perspective, natural scientific and ceramic technological methods are still too rarely applied to ancient and medieval potters' workshops in Central Europe.[17] Anglophone studies are more often based on ethno-archaeological and archaeometric approaches. This systematic research focuses on the extraction of raw clay and its processing into ceramic raw material and can contribute to the understanding of human behaviour and the development of working models.[18] Incentives for such research have often come from representatives of archaeometry.[19] Against this background, in 2015/2016 ceramic technological experiments with clay from the Mayen area were started to determine the maximum spectrum of uses of the available raw materials and the differences between individual clays for usage in pottery production.

A single clay deposit can contain several different clay types. Thus, it was possible to gather different clays from the city area of Mayen which were visually distinct from one another in terms of colour, texture, and macroscopic composition. Vulcanites have been mentioned by other authors as a tempering element for pottery from Mayen,[20] but could not documented in any of the shards and clays that were recently examined.[21]

Testing of Raw Material

Extensive ceramic technological tests are still ongoing, but preliminary results concerning the suitability for engobes and the thermal shock resistance of pottery made from Mayen clay are given below.

Even though they were well-known throughout the Roman Empire, engobes were of minor importance for the decoration of export wares from Mayen during the time period of this study. However, the ceramic technological analysis of certain clays from Mayen led to remarkable results: Clays 0002 and 0003 proved to be

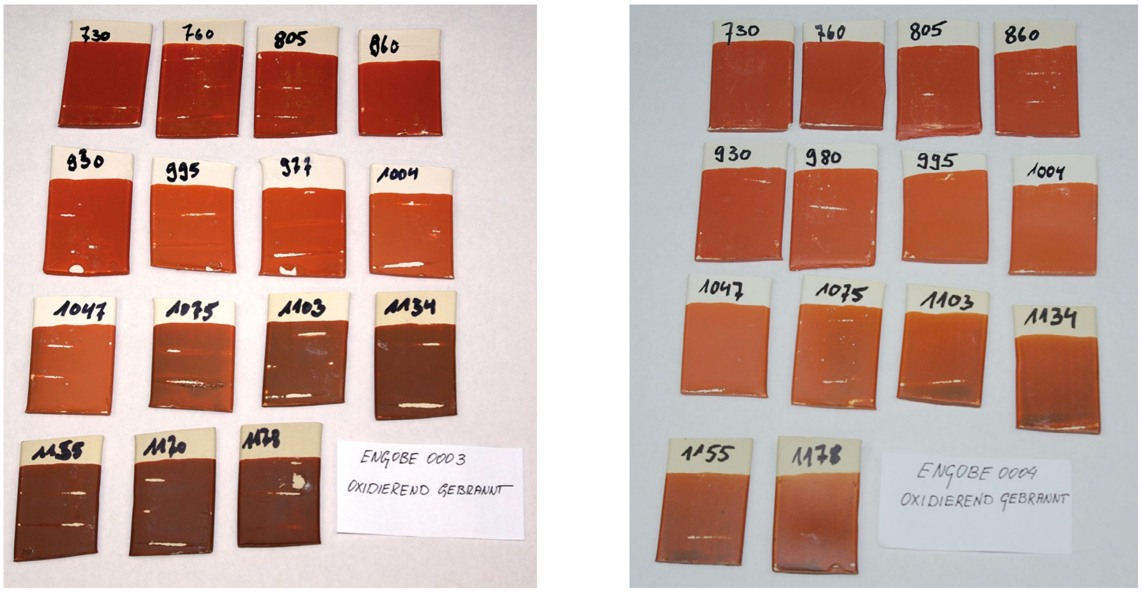

Fig. 7: The firing plaques from the laboratory tests. Left: Clay 0003 (Geishecker Hof), right: Clay 0004 (Eichenweg)

suitable for the production of engobes.[22] In 2016, another type of clay was gathered during construction work.[23] Natural scientific analyses of this strikingly red clay are ongoing, but first engobe tests have already been finished. After being fired at a temperature range from 1050°C to 1100°C, the clay forms an extraordinarily thick, glossy coating (fig. 7).

Quartz sand was used as tempering agent for the batch composition of clays from Mayen. This mixture proved robust against temperature fluctuations during firing, as well as during the use of the vessels.[24] Thermal shock resistance is of utmost importance for the firing of the pottery as well as for its usage as cooking vessels. The experimental pots underwent a series of laboratory tests: Individual vessels were heated up to 500°C in an electric laboratory kiln, and then quenched in a 20°C water bath. This procedure was repeated ten times for each vessel and vessel form. All vessels made from the tempered batch composition passed this test series without damage (fig. 8).

The results of the engobe tests clearly show that around 500 AD a conscious use of the available raw material potential was made. The possible spectrum of uses therefore did not comply with the actual spectrum of production. Instead, there was a conscious decision to focus on one product group with properties that turned into a standardised product feature, i.e. production of robust coarse wares that were resistant to thermal shock. The studies on thermal shock resistance show that conscious material design based on the available raw material was used to increase a single quality feature.

Fig. 8: Experimental pot after going through ten rounds of thermal shock testing. Inv.-Nr. 2016-075, Clay: MV4/ White 50% – Red 50%.

There are two possible explanatory approaches for the conscious development of the pottery production of Mayen in order to reach standardised exports: collective decisions or singular power control of the production. Settlement archaeology in combination with experimental archaeological analyses will be used to determine which of the two is more likely.

Notes

[1] Basic: Herdick 2015.

[2] See also Hanning et al. 2014, 342.

[3] Grunwald 2011, 25–34; Grunwald 2012; Grunwald forthcoming; Glauben et al. 2009.

[4] Döhner – Grunwald 2018, 61–79.

[5] Redknap 1999, 34. 38.

[6] For a current interpretation of the kiln findings see in detail Hanning et al. 2014, 342–347. – Hanning et al. 2016.

[7] Grunwald 2016, 355–356.

[8] Hanning et al. 2014, 347. – Cf. Hampe – Winter 1965, 192–193.

[9] Grunwald 2012, 111.
[10] Döhner et al. 2018, 72.
[11] Grunwald 2016, fig. 6, 6–7.
[12] Hampe – Winter 1965, 186 kiln type A.
[13] Döhner et al. 2018, 74–76.
[14] Döhner et al. 2018, 76.
[15] e. g. Historic England 2015, 44; Schmid – Grolimund 2001; Sorge 2001, 23; Schwedt – Mommsen 2004; Hancock 1984; Winter 2010. – On the relevance of the mixture of clays for archaeometry: Mommsen 2017, 182.
[16] Xu 2012, 41; Kritsotakis 1986, 779.
[17] Döhner et al. 2018, 79.
[18] Exemplary: Arnold 1985; Arnold 2000; Arnold 2006; Arnold 2011; Arnold 2017; Harry 2011. – Further: Costin 2000; Gosselain 1994; Hegmon 2000; Stark 2003.
[19] e. g. Buxeda et al. 2003; Cau Ontiveros et al. 2014; Neupert 2000; Polito et al. 2015; Sillar 2000.
[20] Schneider – Rother 1991, 189–223.
[21] Xu 2012, 34–35. – But consider Döhner et al. 2018, 80–81.
[22] Döhner et al. 2018, 81–83.
[23] Döhner et al. 2018, 82–83.
[24] See in detail Döhner et al. 2018, 82.

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Transport of Heavy Loads on Inland Waterways

Stefan Wenzel

Transport connections are an important factor for the success of an industrial area. This applies all the more if its products are heavy products such as stones, where the transport costs significantly define the price for the final user. But even with bulk goods such as ceramics, the transport costs co-determined the attractiveness for the customers. Transport on water is more favorable in energy terms than transport on roads, it is faster and offers the possibillity to bundle large cargos. Large blocks of marble can be transported with teams of 16 oxen,[1] difficult to manage and costing considerable expanses for fodder. On the other hand, two horses can easily pull a big boat[2]. The Edict on Maximum Prices of Diocletian states that fluvial transport of goods costs the sixfold of transport on sea, while the expanses of transportation on land are sixty times that of carriage by sea.[3] Therefore the proximity to the Rhine as a major transport route was undeniably a location advantage for the millstone and tuff quarries[4] as well as for the potteries between Mayen and the Rhine (fig. 1). The first stage of the transport from the raw material deposits to the Rhine could be covered both by land and on the river Nette[5].

Land Transport as an Alternative to Fluvial Transport on the Nette

Between Mayen and Andernach two Roman major roads met, which were well-researched by Josef Hagen[6] and whose course has since been confirmed by new observations (fig. 1). The Roman road Mayen – Andernach was detected during the excavation of a cemetery of the Early Iron Age near Mendig[7] exactly where Hagen supposed it, under and right next to the current federal highway B 256. Apparently already the prehistoric burial mounds were lined up at the side of a path. Traces of the second arterial road were in places recognizable very recently in the fields between Mayen-Hausen and Fraukirch, where the route is not under modern agricultural roads.[8] Road transport was of crucial importance in modern times. The Nette was obstructed by several mill weirs then and considered not to be navigable[9] apart from its lower course, where building material was shipped upstream in 1727.[10] Around 1846, each year 1060 two-horse wagons and more than 20.000 one-horse wagons went with products from the quarries around Mayen in the direction of the Rhine.[11]

The Nette as a Waterway

The fact that especially heavy loads can be transported much easier and on a cheaper rate on the water than on land caused Josef Röder and Martin Eckoldt to suspect that in

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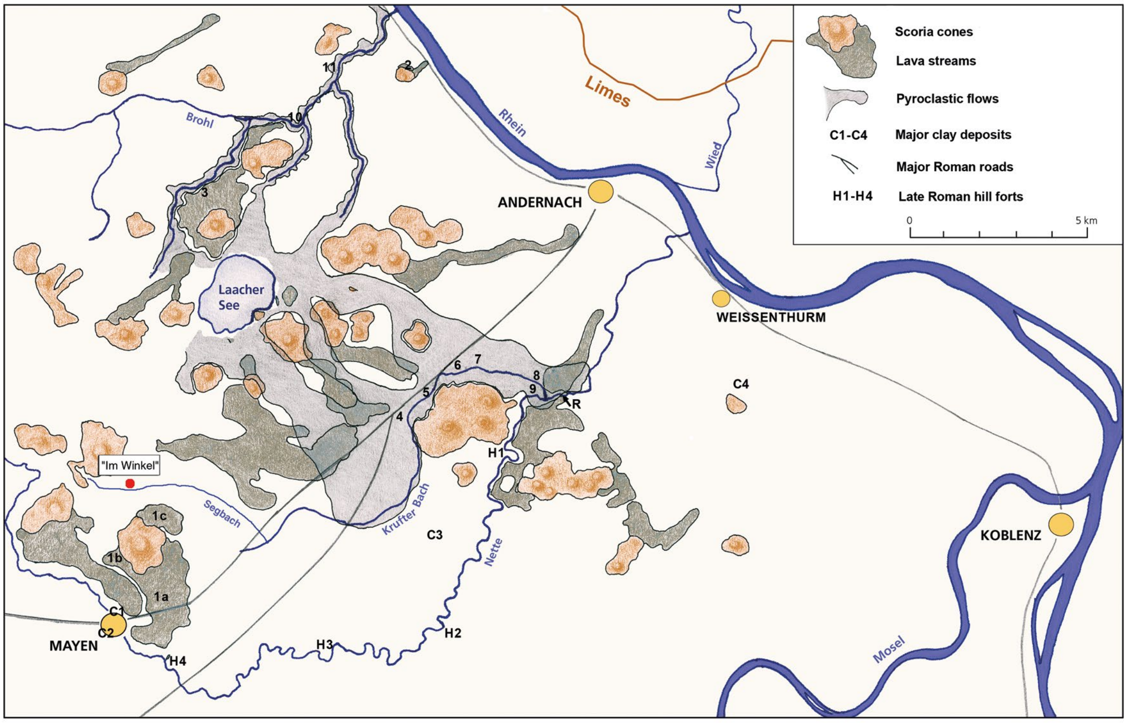

Fig. 1: The ancient quarrying and mining area near Mayen in the Eastern Eifel. Roman quarry districts: 1a–c Lava streams of the Bellerberg volcano (basalt-like lava, millstone quarries); 2 Andernach, Hohe Buche (basalt-like lava); 3 Wassenach, Mauerley (basalt-like lava); 4 Kruft, Hohe Straße (tuff); 5 Kruft, Ratskaul/Grube Idylle (tuff); 6 Kretz, Meurin 1 und 2 (tuff); 7 Kretz, Steinacker (tuff); 8 Plaidt, Sportplatz (tuff); 9 Plaidt, Kretzer Straße (tuff); 10–11 Brohltal zwischen Schweppenburg und Nonnsmühle (tuff). – Clay occurence: C1 Mayen, Alte Eich; C2 Mayen, Siegfriedstraße; C3 Kruft, Sibelco clay pit; C4 Kärlich, Mannheim clay pit. – Late Antique hill forts: H1 Ochtendung, Wernerseck; H2 Polch-Ruitsch; H3 Trimbs/Welling, Burgberg; H4 Mayen, Katzenberg. – R Rapids of the Nette stream at Rauschermühle.

Roman times the river Nette was also used as a waterway. Tuff blocks of 1.9 tons found in Cologne could only have been transported on the water[12].

The Nette has its source at Hohenleimbach in the High Eifel and flows after 55 km between Andernach and Weißenthurm into the Rhine.[13] The Nette is characterized by floods in winter and spring and low water in late summer and autumn (fig. 2). The mean water supply is around 2.5 m^3/s. According to Martin Eckoldt, in Roman times the Nette would have been 48 cm deep and navigable in "good maintenance".[14] The depth would have been sufficient for flat bottomed logboats or prams.[15] Yet smaller streams were used for transportation in modern times. Wood was floated on the small tributaries of the Nette[16] and there was a wood yard between Brückentor and Vogelsturm of the city walls of Mayen.[17] In the 18th century tuff was transported on rafts on the Brohlbach to avoid the ruined streets.[18]

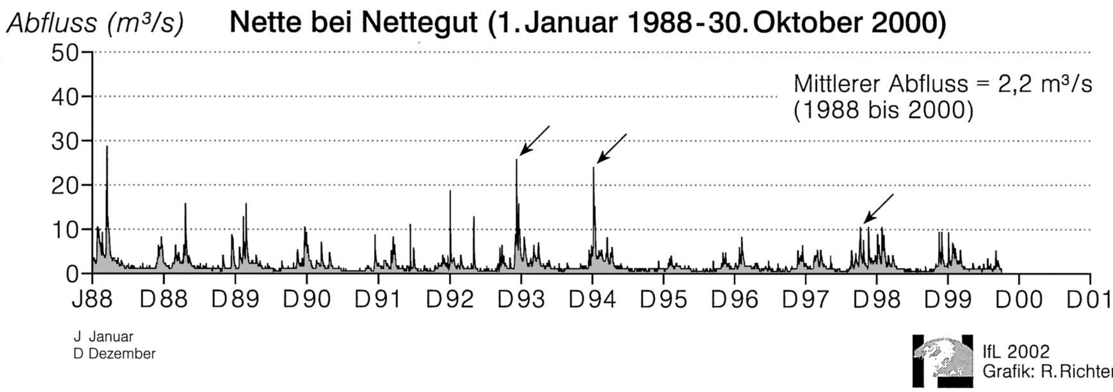

Fig. 2: Runoff regime of the Nette stream at Nettegut (January 1, 1988 – October 30, 2000, according to Beck 2003, Fig. 7).

In antiquity even water courses were used for navigation, which were so small that this was not permanently possible. Pliny the Younger reports that goods from his manor near Tifernum Tiburinum[19] could only be transported by water in the cool half of the year: »This river, which winds through the middle of the meadows, is navigable only in the winter and spring, at which seasons it transports the produce of the lands to Rome: but in summer it sinks below its banks, leaving the name of a great river to an almost empty channel … «[20].

There are rapids of the Nette at Rauschermühle at Plaidt (fig. 1, R), where the Nette crosses a lava flow of the Wannen volcano group. A simple answer to obstacles like this was to unload the cargo, transport it a short way on land, and to bring it on a ship downstream. Alternatively it is possible to lift the ships on a slipway with a winch.[21]

The use of the Nette for inland navigation is indicated by the position of millstone workshops within the *vicus* of Mayen, by the location of late antique hill forts as well as by the alignment of villas and grave monuments along the Nette at Andernach-Miesenheim.

In Mayen since the early imperial period a bundle of measures was implemented, which indicates on the one hand a possible influence of the state on the millstone production, and on the other hand the use of the Nette as a transport route for the millstones made of lava of the Bellerberg volcano. This program may have included to parcel out anew the quarries,[22] to relocate the settlement of Mayen into the valley and to establish separated quarters with potters and stone workshops,[23] to shift steps of quern production to the newly formed *vicus* on the river[24] and to establish new quarries on the side of the lava flow towards the Nette. In Roman times, new quarries were opened on all lava flows of the Bellerberg, but a particular large number on the southwestern flank (fig. 3). If one wanted to bring the millstones to the transfer site in Andernach, one extracted them just on the side facing away from Andernach and made a detour, if one brought them first down to finish them

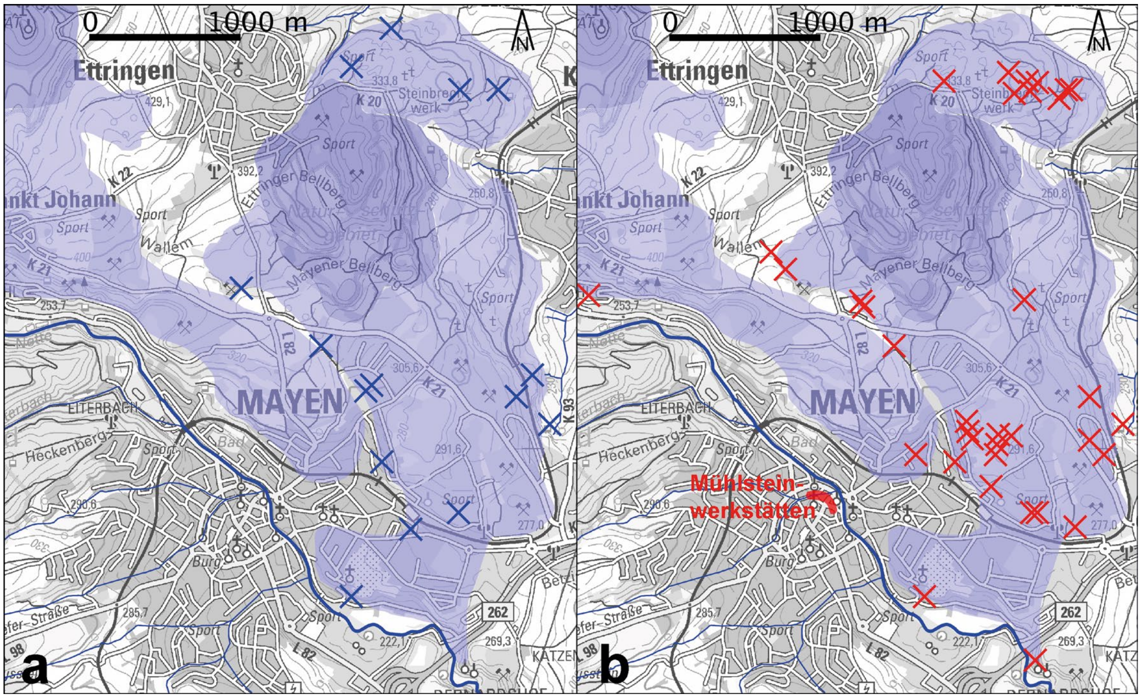

Fig. 3: Distribution of the millstone quarries in the lava streams of Bellerberg volcano in the Late Iron Age (a) and in Roman times (b).

in Mayen. But both was just then advantageous if one transported the millstones on the Nette. A bank stabilization of unknown age with horizontal oak logs was found near one of the stone workshops »Im Keutel«, next to it was a Roman road with a remarkable coating, 75 cm thick and ›hard like concrete‹, and vertical wooden pecks on the side towards the Nette.[25]

Late Roman hill forts were preferably sited on traffic routes such as rivers and roads. The presence of a whole chain of hill forts along the Nette (fig. 1, H1-H4) indicates the use of this river as a waterway.[26]

In addition, at the lower course of the Nette near Miesenheim a large villa and several grave monuments are orientated towards the river (fig. 4, a-c). Such a line-up is also known from other areas, where merchants and landowners preferred to build their elaborate mansions and tomb monuments along waterways, sometimes right next to stone quarries.[27] At Miesenheim there are some larger pillar monuments of Lorraine limestone next to the Nette[28] (fig. 4, c), as well as a burial chamber made of large tuff blocks[29] (fig. 4, b), which certainly had a considerable superstructure. Since no major Roman roads are known in this area, the monuments were designed to be seen from the Nette.

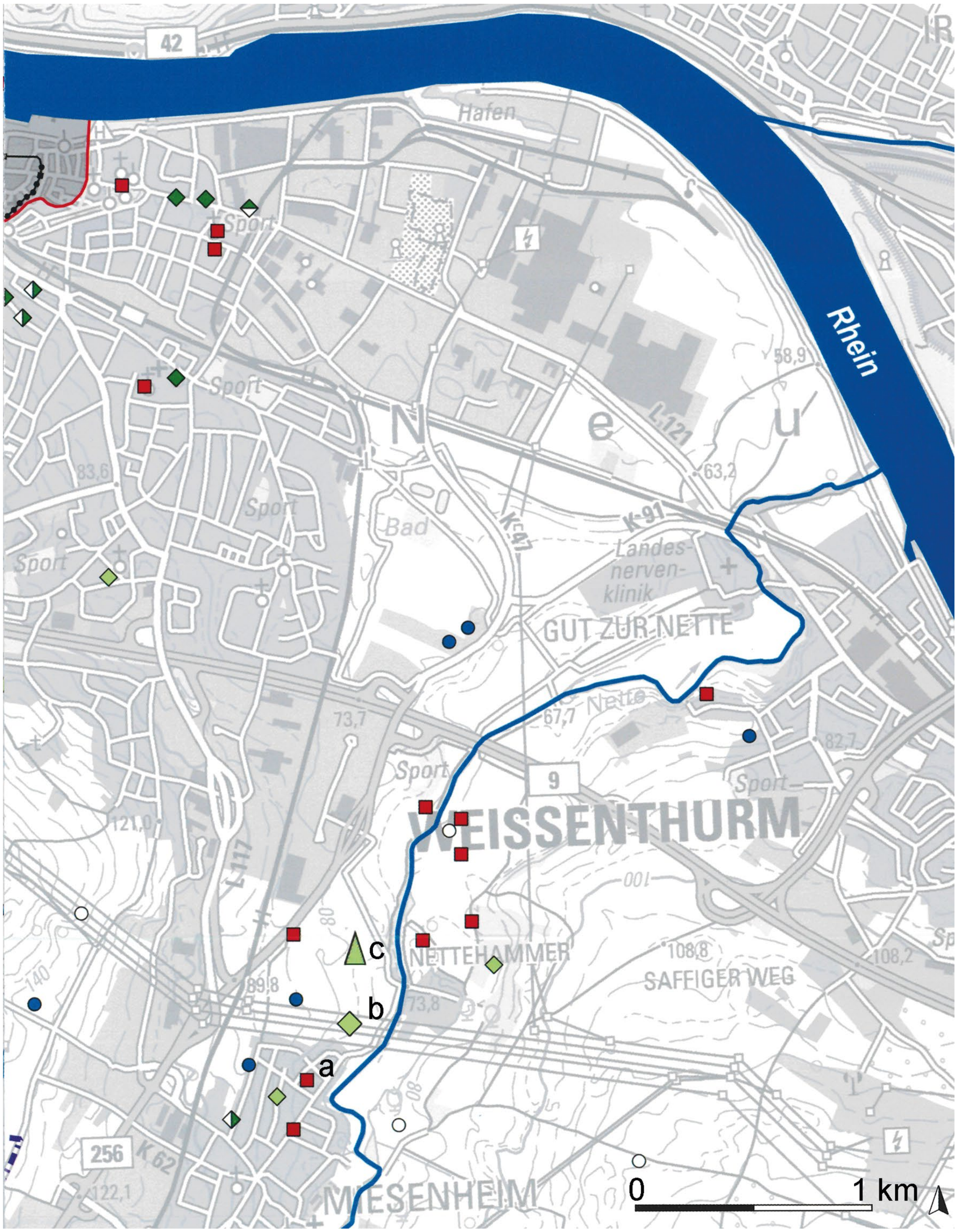

Fig. 4: Lower course of the Nette stream near Miesenheim with villas and grave monuments (settlements: in red, graves: in green, water pipes: in blue).

Possible Use of the Segbach as a Waterway

There is evidence that even a small tributary of the Nette could have been used as a waterway, even if a watertight proof for this is still outstanding. It is the Segbach, which could have been connected the northern edge of the quarry area wih the *villa* and the *burgus* »Im Winkel« to the Nette via the »Krufter Bach« stream.

The residents of the *villa* produced querns, proved by more than 21 rough outs found in the filling of a cave in the main building (fig. 5, 2), and quarry rubble found close to the settlement site (fig. 5, 10)[30]. After destruction of the main building, a *burgus* was built around 300 AD as a presumably fortified granary (*horreum*) (fig. 5, 5). Below the *burgus* was a surface drainage.

The granary could contain the annual supply in cereals for more than 200 persons. Six ballista bolt heads and further militaria suggest that it was protected by armed forces. The ceramic findings imply that the state ascertained supply and protection for the quarry workers until the 5th century.

Adjacent to the Segbach, the drainage system dewatered an area of almost 1000 m^2 from a parabolic tip through two sewers connected by transverse gutters towards the northeast. The drainage sewers cut clay layers with samian ware of the early to middle imperial period. Ceramics from the filling of the drainage and from their overlying strata date this installation to the Late Antiquity. It seems reasonable to suppose that the drain dried up a reloading site, where large quantities of grain were delivered and heavy millstones were shipped. Walls crossing the flood plain of the Segbach (fig. 5, 6.7b) or forming a funnel shaped structure (fig. 5, 7c) could have served to guide the water. A wall now intersected by the Segbach (fig. 5, 7a) has bounded a kind of basin cut into alluvial clay from the Early to Middle Imperial period. The alluvial clay is dated by a sherd of a bowl Dragendorff 29 and by sherds of ›Iron Age fabric‹, the trenched structure contained pottery of the third century and a group of five terracotta figurines (Cybele and four matrons).[31] Walls bordering the Segbach have the appearance of bank revetments (fig. 6). A Roman origin of these walls is plausible because only building structures of Roman age are known from this site. Next to the illustrated section a wooden half-round gutter dendro-dated to around 208 AD was found.[32]

Outlook

Although fluvial transport has left few traces, it must have been of great importance in Antiquity. In the Segbachtal it may be possible to gain insights on the use of a small stream by examining the presumed hydraulic structures that are today partly located in the groundwater range.

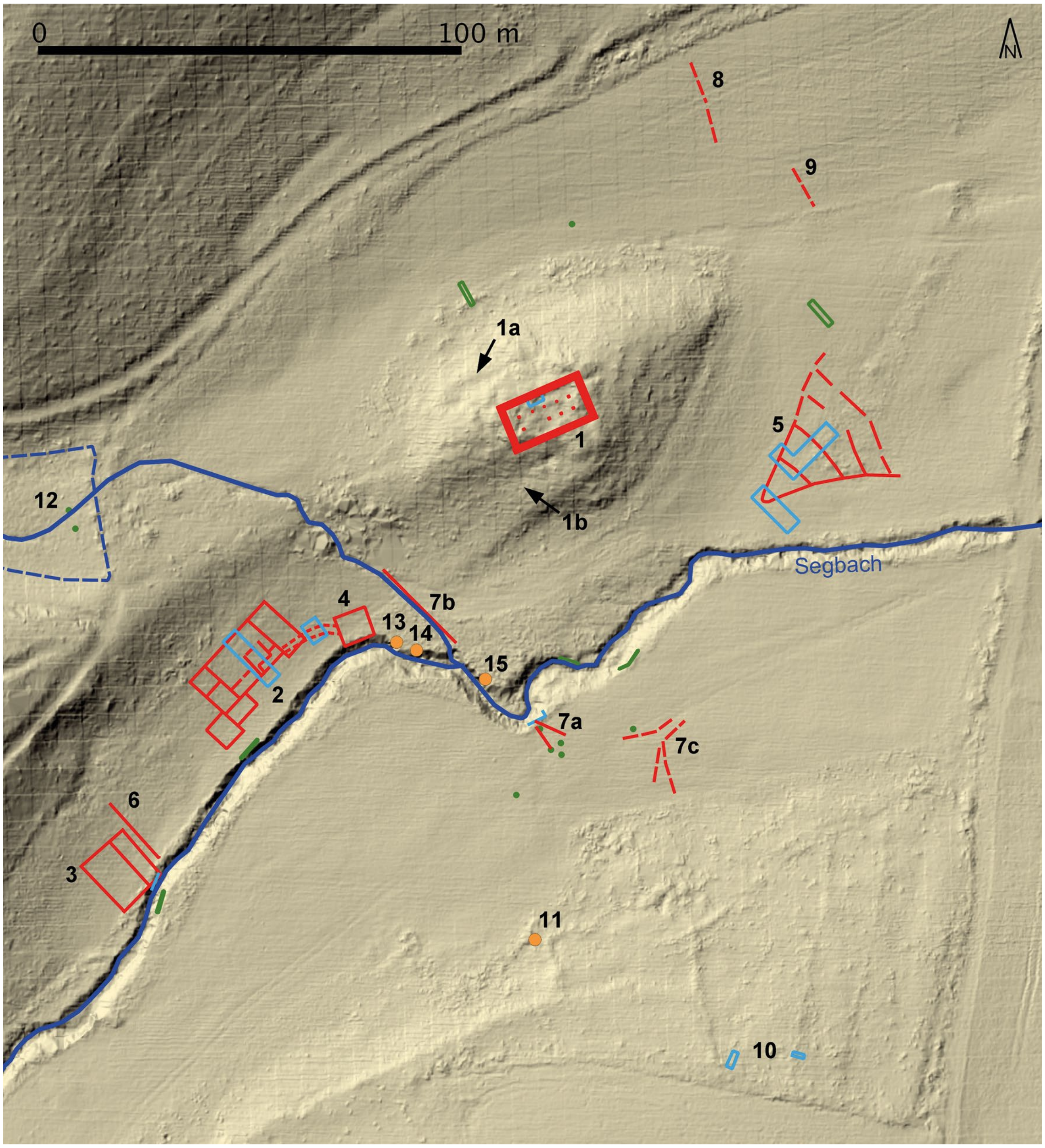

Fig. 5: Mendig, »Im Winkel«, plan. Archaeological trenches (blue), geoarchaeological trenches (green), walls and drains (red) clearly visible on the georadar. 1 burgus; 1a step in the terrain; 1b possible entrance; 2 main building; 3 secondary building; 4 small stone building; 5 drains; 6-9 walls (the findspot of the matrons is at 7a); 10 linear stone heaps / buried quarry rubble; 11 presumed location of a building; 12 possible reservoir of unknown date.

Fig. 6: Mendig, »Im Winkel«. Wall bordering the Segbach.

Notes

[1] Smerdel 2006, fig. 1

[2] Descombes 2007, 88 fig.

[3] Kunow 1983, 53–54 fig. 5; Wefers 2012, 168 fig. 62.

[4] Mangartz 2008, 97–106; Schaaff 2015, 210–211; Geisweid 2018, 37.

[5] Redknap 1987, 90.

[6] Hagen 1931, 287–290.

[7] Brücken 2009, 77 fig. 22. fig. 43.

[8] von Berg 1995, 5.

[9] Meesen – Meesen 1998, 74.

[10] Weidenbach 1923, 59.

[11] Prößler 1991, 17.

[12] Eckoldt 1980, 89. 116 note 242.

[13] Wenzel 2014, 231–232, with earlier references.

[14] Eckoldt 1980, 89.

[15] Slightly smaller vessels than those described by De Boe – Hubert 1977, 24; Bockius 2004, fig. 10.

[16] Schmitt et al. 1997, 16.

[17] Schüller 2005, 42.

[18] Pohl 2012, 55.

[19] Braconi – Uroz-Sàez 2008, 93.
[20] Plin.epist. 5, 6, 12.
[21] Voß 2011, 40. 43; Weski 2014, 103–104.
[22] Hörter et al. 1955, 12–13 fig. 4; Mangartz 2008, 91 fig. 27; Mangartz 2012, 14–15.
[23] Oesterwind 2000, 37–38; Hunold 2002, 81; Glauben 2012, 89–90 fig. 3; Giljohann et al. 2017, 130; Hunold – Schaaff, this volume.
[24] Mangartz 2008, 73–74. 90.
[25] Hunold 2002, 75–76 fig. 2.
[26] Hunold 2011, 370.
[27] Beal 2006/2007, 2; Paulke 2010, 55 fig. 7.
[28] Schröder 2016, 15 note 22; Giljohann – Wenzel 2015, 24.
[29] Eiden 1977, 59–60; Noelke 2010, 480–481 fig. 55.
[30] Wenzel 2012, 135 fig. 6. 139.
[31] Dotterweich et al. 2012, 88–193; Wenzel 2012, 139–142; Wenzel forthcoming.
[32] Dendro-dating by Thomas Frank, Cologne.

Image Credits

Fig. 1: Graphic A. Hunold, RGZM. – Fig. 2: after Beck 2003, Fig. 7. – Graphic R. Richter, IfL. – Fig. 3: Location of quarries after Mangartz 2008; Hörter 2005; Hunold 2011; Oesterwind – Wenzel 2012. Base map: TK50 L5708 © Geo-Basis-DE / LVermGeoRP (2018), dL-de / by-2-0, http://www.lvermgeo.rlp.de. – Fig. 4: Modified after Giljohann 2017, supplement 1. Base map: TK50 L5708 © Geo-Basis-DE / LVermGeoRP (2018), dL-de / by-2-0, http://www.lvermgeo.rlp.de. – Fig. 5: Georadar S. Seren, ZAMG; LiDAR. ©GeoBasis-DE/LvermGeoRP 2017, processing A. Cramer, RGZM. – Fig. 6: Photo: S. Wenzel, RGZM.

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The ancient quarrying and mining district of the Eastern Eifel has been the subject of research by the Römisch-Germanisches Zentralmuseum (RGZM) in Mainz and Mayen since 1997. The products – primarily basalt lava millstones, tuffstone building material, and pottery – were extensively traded throughout much of Europe for many centuries.

An extensive research programme was launched to examine the wealth of evidence about the ancient stone industry in the region and its significance for the political establishment of Rome north of the Alps. The main subjects were the basalt and tuff stone industries as well as the Mayen vicus, the most important economic centre. Another subject is the pottery production, which is researched by material studies as well as by experimental archaeology. Other studies deal with the preconditions for the economic success, focussing on the infrastructure and the rural settlement conditions.

Being an industrial district of supraregional importance, the quarrying and mining district of the Eastern Eifel turned out an excellent case study for the investigation of pre-modern industrial districts in general, providing a model for the study of ancient industries: these need to be investigated with a long-term view and with a holistic approach, taking into account economic, social and settlement aspects.

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