

Original Study

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Perspectives for Network Analysis: Roman Roads, Barbarian Paths and Settlement Patterns in the Borderlands at the Limes Germanicus in the Main River Region

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Abstract: In contrast to the neighboring Roman Empire, no centralized sites in the sense of transregionally significant settlements are definitively verifiable outside of the Limes Germanicus in the research area at the middle Main River. However, some fortified hill forts do exist. Starting in late antiquity, these sites were temporarily occupied in times of internal and external conflict. Hill forts in the Babaricum were, without exception, sited on spurs at the Main or its tributaries. The course of the Main River constituted the primary transport route for the Romans into the Babaricum, although clear evidence of ship or harbor facilities has yet to be discovered for this period.

The well-known hierarchical settlement and road system in the Roman Empire is not apparent in the Babaricum although numerous sunken roads in multiple path networks were discernible. Precise dating of these features to the Roman Iron Age or Migration Period has not been possible due to heavy soil erosion in the vicinity. Particular stretches of this network of paths were only seasonally in use depending on weather conditions and soil moisture, and so it is not realistic to discuss roadways as usable year-round in the Babaricum as they are in the Roman Empire. Some of these paths were fortified, although the dating of these fortifications is not possible due to the continued use of some of these pathways into the Early Modern Period.

Nearest neighbor settlement relationships are methodically analyzed in network connection diagrams with the use of Delaunay triangulation in this GIS-based study. Probable routes by land and river are calculated with lost cost path analysis on the basis of digital surface models and compared with the local archaeological record.

Keywords: Network analyses, GIS, Roman borderlands, Barbaricum, settlement pattern, Roman Iron Age, Migration Period

1 Project Scope

This study follows on from a project considering the emigration of Germanic peoples from the Oder River in the inner Babaricum. Site factor analyses developed in that project will be applied to questions about

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reasons for migration, including the selection of potential destinations bordering the Roman Empire. It is of particular interest to link these observations with the apparent connection between a substantial population decline at the middle Oder in the heart of Germania libera in the late 5th and into the 6th centuries AD with contemporaneous climate extremes. This comparative perspective addresses how settlement behaviors developed from the Roman Period until the Early Middle Ages in this new research area around the middle Main River at the border of the Roman Empire. The methodology for this research includes the application of advanced site catchment analyses in a geographic information system (GIS) in order to classify the settlement sites based on their topographic features. A GIS-linked database of archaeological and geographical information provides the basis for this approach.

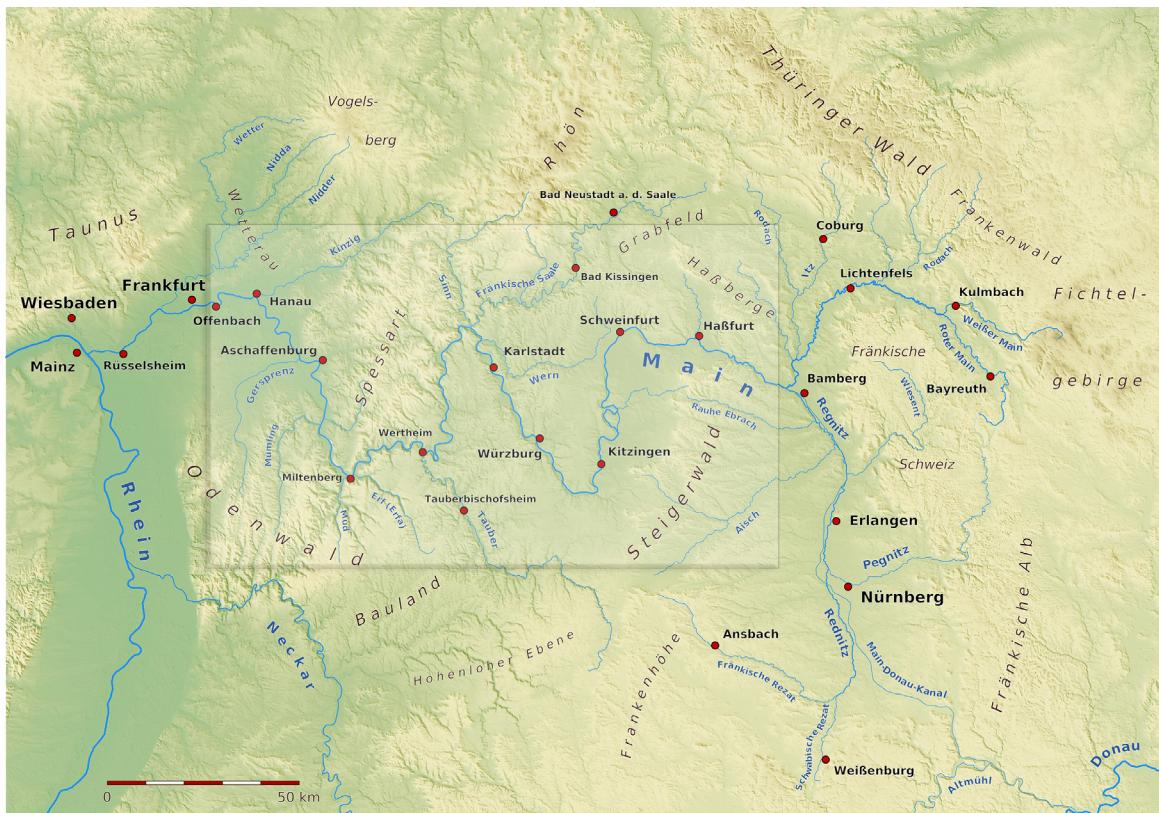


Figure 1. Location of the area under investigation at the Main River in southern Germany (open-source image with alterations by author).

2 Research Considerations

The Limes Germanicus forms the border between the Roman Empire and the Barbaricum in the research area at the middle Main (see: Fig. 4, attached). Settlement design within this area undoubtedly conformed to social, political, and legal factors and societal hierarchy. In the Roman Empire, in particular, settlement layout was much less dependent on a site's geo-ecological natural features than in the barbarian territories where settlers apparently preferred naturally favorable areas (see: Volkmann 2013, 111ff. and in English Volkmann 2016, 84ff.). Settlements in the Barbaricum are only rarely subdivided, if at all. Whereas clear functional differentiation in Roman settlement design between cities (*civitates*, *oppida*), towns (*vici*), and villages, estates, and rural industries allows for recognizable possibilities, transformations, and breakthroughs in settlement and economic development; though these are only somewhat apparent from the quite irregular and nonspecific settlement design in the Barbaricum.

Recently, indications against general regression to an exclusive system of small agrarian settlements south of the Limes following Roman occupation have been multiplying. Indeed, the continuity of certain urban functions is unquestionable in many cases, including almost all *civitates* and numerous towns which were partially appropriated by Germanic tribes like the Alemanni. The abandonment of urban settlements and early pre-urban regeneration also occurs from the beginning of the Merovingian Period into the Late Migration Period. The problem of extra-urban continuity (and discontinuity) is one in active discussion (e.g., Theune 2004; Reuter 2005). It is generally accepted that, at the end of development in these areas, rural estates (*villae rusticae*) disappear entirely and villages become the dominant settlement type, although the mechanism for this transition is interpreted quite differently (Nuber 2005, 270–281). The argument for a radical disruption in the development of agrarian industries is in opposition to the notion of a gradual transformation from estate to village.

Even at the intersection of the Limes and Babaricum, settlement does not appear to have exclusively consisted of small agrarian outposts, as the impressively large hill forts along the Main suggest (Haberstroh 2003, 201ff; Prien and Hilbich 2013, 19ff). Thus, it is possible to ask if settlement location was Roman-inspired in the Germanic Main River region, or whether these hill forts should instead be seen as adhering to Germanic settlement tradition, i.e., with placement based on geo-ecologically ideal sites (see: Gillich 2007).

Addressing this discussion through a comprehensive statistical analysis of settlement sites, of which this article represents a landmark first step, will amend this failing in current understanding. For all settlements where character and function are known, a multi-variable geographic-environmental spatial determination (with reference to terrain, hydrology, soil, path and road systems, etc.) is analyzed as part of a network to assess placement patterns of various types of settlements. Spatial determinations of settlements and, above all, how they change over time allow for the consideration of changes to economic systems (such as the adoption of the three-field system or transport systems), forms of social organization, and the environment.

In recent literature new hypotheses have been advanced which ascribe remarkable potential for technological innovation in agriculture to evidently smaller agrarian production industries in ecological borderlands, i.e., those Roman *villae rusticae* sited at the edges of more favorable areas (see: Jeneson 2011, 259–274). Comparatively, the dominant Roman estates in major river valleys and naturally fertile, extensive loess landscapes should be characterized by a rather extensive production profile. Ideally, these hypothetical suspected relationships would also be tested with the aforementioned GIS methodology and analyzed for their potential productivity backgrounds through various spatial development models.

It should be noted that, even well within Germania libera (particularly in the previously studied region around the Oder River), some settlements were intentionally sited due to specific economic and social hierarchical norms rather than on the basis of agricultural favorability (Volkmann 2013, 215, Fig. 229). It is of interest to research whether this phenomenon also occurred near the Roman border and, if so, whether both groups engaged in the practice or if it was demonstrably influenced by the external influence of the Romans.

3 Sources and Partners

At the middle Main River there is a quite advanced degree of detection and investigation of archaeological sites, particularly those from the Roman Period and Early Middle Ages, as is reflected in many large-scale publications (Hoffmann 2004, Pescheck 1978, and Obst 2012, among others). The status of such sites in this region is also apparent from the effort involved in the creation and completion of archive data by the Bavarian State Department for Sites and Monuments (Bayerisches Landesamt für Denkmalpflege). Conditions for scientific research on past environmental changes and climate developments are also ideal at the middle Main and so the Bavarian State Departments for the Environment (Bayerisches Landesamt für Umwelt) and Surveying and Geoinformation (Bayerisches Landesamt für Vermessung und Geoinformation) must also be named as partners.

The archaeological data from the aforementioned archive forms the basis for this GIS study and were systematically supplemented from catalogs and additional site data from publications. High-resolution

unpublished Light Detection and Ranging (LiDAR) maps (digital terrain model DTM1¹) were provided by the Department for Surveying and Geoinformation, which allowed for the systematic evaluation of the enclosed region under investigation. Because of its resolution, the assessment of the DTM1 provided numerous analytical possibilities with regard to topographic location of archaeological sites and ancient paths. Finally, numerous thematic maps (for soil or geology, for example) could be contributed to the GIS and systematically evaluated via the WMS (Web Map Service) server from the Bavarian State Department for the Environment.

4 Chronologies of the Roman Iron Age and Migration Period

The timeline in current use dates back to 1955 and was created by H. J. Eggers after comprehensive study. It is the standard upon which regional variations are based and with more precise phases identified in studies by K. Godłowski (1970). The Roman Iron Age in the Babaricum is divided into Phases A through D, although the lattermost is actually part of the Early Migration Period (Fig. 2) (see: Volkmann 2013, 40–45).

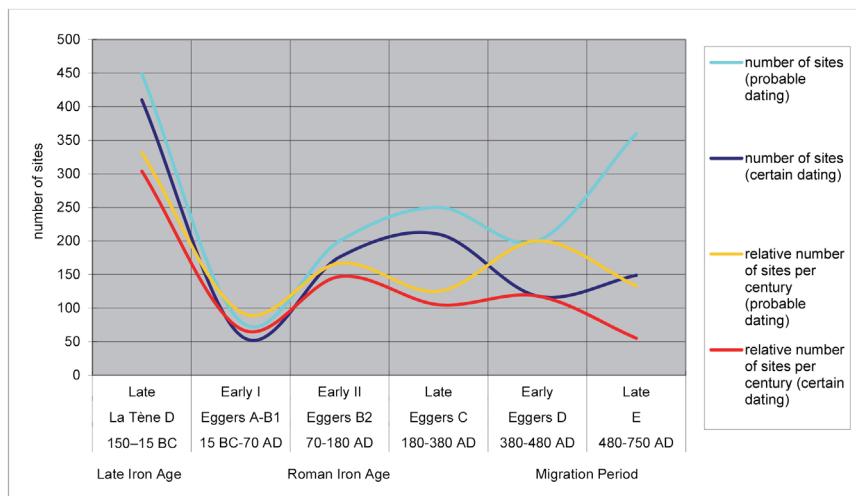


Figure 2. Graph showing sites in the Bavarian District of Lower Franconia in the research area at the Main River. Shown are the numbers of sites in the area under investigation at the Main from the Late Iron Age (La Tène D) through the Roman Iron Age Periods A–C to the Early and Late Migration Period D–E (author credit). Here the absolute numbers of sites are represented by the two upper curves (from definite and probability dates) which refer to the phases of various durations. The two lower curves represent the relative numbers of sites (similarly from definite and probability dates) in standardized and therefore comparable time intervals of 100 years (image author).

As in other parts of the inner Babaricum, like at the Oder River, a dramatic decrease in the number of archaeological sites is apparent, following quite intensive settlement during the Late Iron Age (see: Volkmann 2016, 93 Fig. 10.). These transregional effects of desettlement in Eggers Phases A-B1 in the Babaricum are not credibly attributable, as is mostly the case, to political reasons like the influence of the Roman Empire or Celtic-Germanic conflicts. Instead, climatic depression affecting many regions seems to have had a decisive influence on this process (see: Volkmann 2015). The de-settlement of this region as well as others in the inner Babaricum is clearly recognizable in the Early Roman Iron Age (Eggers B2). In contrast, the settlement intensity of the Late Roman Iron Age (Eggers C) seems somewhat unclear, probably because many sites in the research area dating to this period are not attributed to it as they lack definitively datable finds. This is indicated by the two upper curves representing actual numbers of sites. The far more

¹ The number following the acronym refers to the interpolated grid resolution per meter: in this case, point of distance for a 1 m interpolated grid.

meaningful relative numbers of sites established per century imply a decrease in settlement intensity in Eggers C. The same is true in the Early Migration Period (Eggers D) which, due to difficulties in dating sites from generic finds, is probably underrepresented in the curves depicted.

The relative curves indicate at least the stagnation of settlement intensity in the Early Migration Period and possibly even an increase in this region when compared to the Late Roman Iron Age. It is, difficult to determine site intensity in the subsequent Late Migration Period (Eggers E). The relevant curves for numbers of sites, regardless of the security of their dating, display a clear decrease in this intensity during the Merovingian Period in the Late Migration Period. Of particular note are sites dated to the Late Migration Period, which consist mostly of graves; the contemporary settlements that must have been associated with them are only rarely discovered. It is therefore probable that settlement intensity during the Late Migration Period was actually higher than indicated by either curve. This would be consistent with current theories of Merovingian expansion and accompanying planned settlement although not inferable from these data.

In general, it is difficult to date settlements in the Babaricum from the Roman Iron Age and Migration Period (1st to 6th centuries). In the Main River region, as in other parts of the Babaricum, the problem is typically one of unexceptional finds – generally settlement pottery storage vessels of similar types. Kumpf vessels are a good example as the production of this form persisted throughout several centuries. Some Germanic bowls, wheel-thrown pottery, and brooches, as well as imported Roman belt fittings and buckles in the forms of animal heads are rather easier to date stylistically. It can therefore be assumed that, for the Migration Period, a conditional hiatus exists based on largely imprecisely datable finds like pottery. There is the additional hindrance that the more easily datable finds from this period (brooches, coins, garment fittings and accessories, etc.) are typically seen as imported goods and not of local manufacture because of the spatial distributions of these finds within the archaeological record around the Main. This in turn generally hinders the date assignation to sites of this period because of the relative rarity of such finds. It is also conceivable that the use of wood vessels increased during the Late Roman Period until the Migration Period at the Main as is evidenced by preserved finds from the cemetery at Oberflacht, for example, and in southwest Germany, in general (Paulsen 1992). Due to geological conditions of drastically fluctuating groundwater levels in the research area and largely permeable, porous limestone bedrock; however, wood vessels are unlikely to have been preserved.

5 Methodology

Identifiable sites from relevant periods were methodically analyzed in a GIS. Next neighbor relationships of settlements to one another were calculated with Delaunay triangulation and depicted as a diagram with connecting lines (Fig. 4, attached) (see: Herzog 2012, 237ff.; Polla et al. 2013, 299ff.; Kline 2009, 26ff.). In the research area, hierarchical settlement orders (cities, towns, villages, etc.) could not be identified (cf. Nakoinz 2009 on research and theory of central sites). The methodology of diagram-based network studies (Brughmans 2013, 623–662; 2013a, 538–562; Knappett 2013; Sindbæk 2007, 59–74) therefore could and should not be applied here because such studies of geographic spatial relationships are not linked in a GIS and would limit further analytical possibilities. Instead network analysis is here depicted within the GIS.

The Germanic settlements in the Babaricum generally appear to be unspecialized. This is partly due to the state of research because no Roman Iron Age settlement has yet been completely or even extensively excavated and therefore only a few features from settlement centers were available for analysis. By comparison, a few cemeteries comprising some several hundred grave features from the Roman Iron Age, such as that at Kleinlangheim (Kitzingen District), have been documented because of the state of preservation of such feathers and the associated grave goods (cf. Pescheck 1978, catalog tables 150–153.).

For most settlements, only a few features allow for a general interpretation. The weighting of settlement importance was, possible through duration of activity. Settlements in use during a single phase were weighted with a factor of 1. Those in use for two were weighted with a factor of 2, and so on. In this way thematic maps could be generated in the GIS which indicated the probable importance of different settlement sites on the basis of length of occupation (Fig. 4).

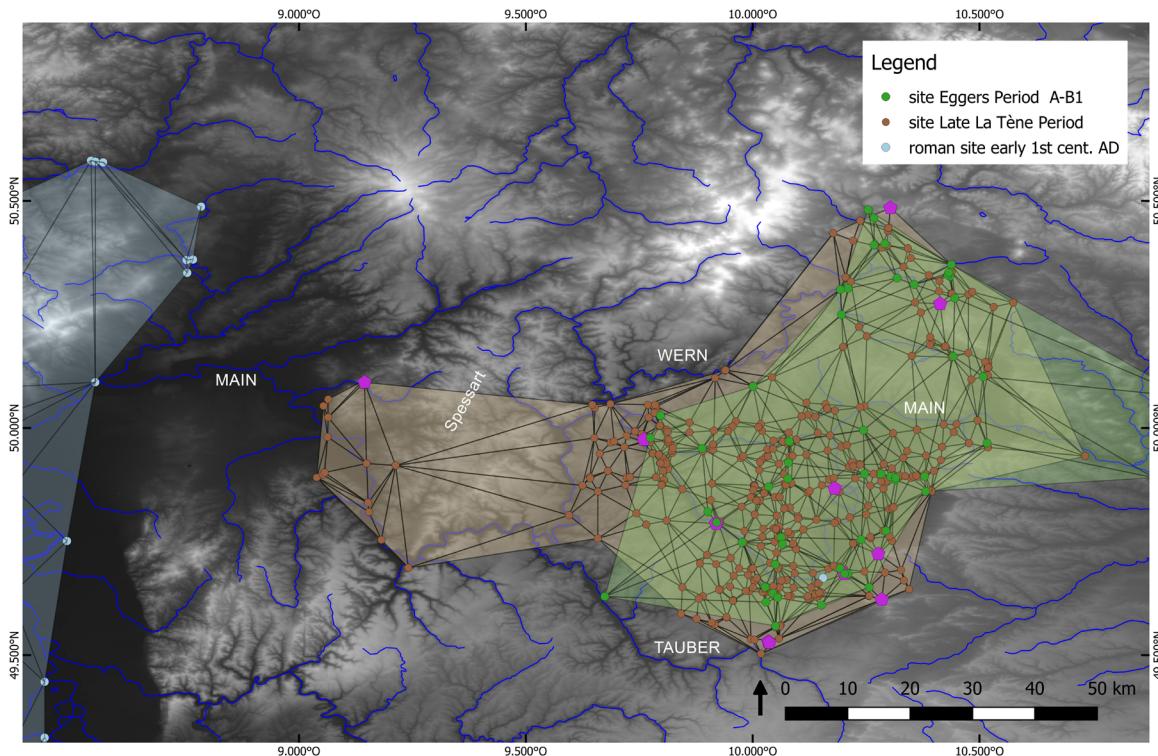


Figure 3. Late La Tène Period sites from the Late Iron Age in the late 1st century BC (approximately 85 to 15 BC) are in brown. Compare with sites dating to the Early Roman Iron Age I (Eggers Period A-B1, 15 BC to 70 AD) in green. Also depicted are Late La Tène hilltop settlements (purple pentagons) whose use did not continue into the earliest Roman Iron Age. In blue are marked the roman sites of the early 1st cent. AD. The Roman Empire is far away from the post-Celtic so called Germanic “Großromstedter” culture. Sources: Fundstellenarchiv Bayerisches Landesamt für Denkmalpflege, Hoffmann 2004, Obst 2012, Pescheck 1978, Schier 1990, darmc.harvard.edu, deutsche-limeskommission.de, and vici.org, among others. DTM200 from the Bundesamt für Kartographie und Geodäsie, GIS author.

6 Settlement Pattern in the Late 1st Century BC and Early 1st Century AD

The early Germanic settlement cluster from the early 1st century AD, in whose center the Roman fort at Marktbreit was situated (see: Fig. 4), was bordered by the peaks of low mountains to the north. No evidence of settlement within these mountains has been discovered and they are depicted as a lighter area on the topographic map (Fig. 3). The early Germanic settlements are, without exception, in the basin around the middle Main River and its tributaries. In the early 1st century AD the Roman area of influence and Germanic settlement cluster at the middle Main were divided by more than 100 kilometers (Fig. 4) and an uninhabited zone of the Spessart mountain range. This uninhabited boundary provided a natural barrier of topographically and agriculturally unfavorable conditions.

Important trade routes have been reconstructed within the Roman territory from historical sources and are represented by red lines.² With a least-cost path analysis the best possible extramural routes were calculated in the GIS based on geomorphological features. This was done in order to present a possible Roman route to the east into the Babaricum during the construction of the fort at Marktbreit. The fort was erected between 5 and 9 AD to the east of Roman territory in the course of a field campaign against the Marcomanni who resided still further east in the Babaricum (light blue dots in Figs. 4 and 7). Yellow similarly indicates a potential route used by the Romans during this construction. From these it

² According to DARMC – Digital Atlas of Roman and Medieval Civilization <http://darmc.harvard.edu/icb/icb.do>

is apparent that the middle Main River (*Moenus* in Latin) was an active route for mid-size Roman ships as early as the early 1st century AD as is already known for the Rhine and upper Main Rivers.³ According to written sources including inscriptions on stone construction elements, the Roman fleet “Classis Germanica” was deployed on the Rhine in 13 BC, in part to secure the river as a Roman border, in part as a base for expeditions east into the Barbaricum.⁴ Starting from the small Roman auxiliary camp at Frankfurt-Höchst on the Main, which was occupied with Germanic auxiliaries and dates from the turn of the millennium (Wolff et al. 1915), the 275 km river route to Marktbreit could have been reached in approximately three days by ship (see: Höckmann 2000, 267). As attested to by numerous reconstructions of Roman ships and experimental journeys on small and large rivers of central Europe, such ships could cover more than an impressive 100 km per day.⁵

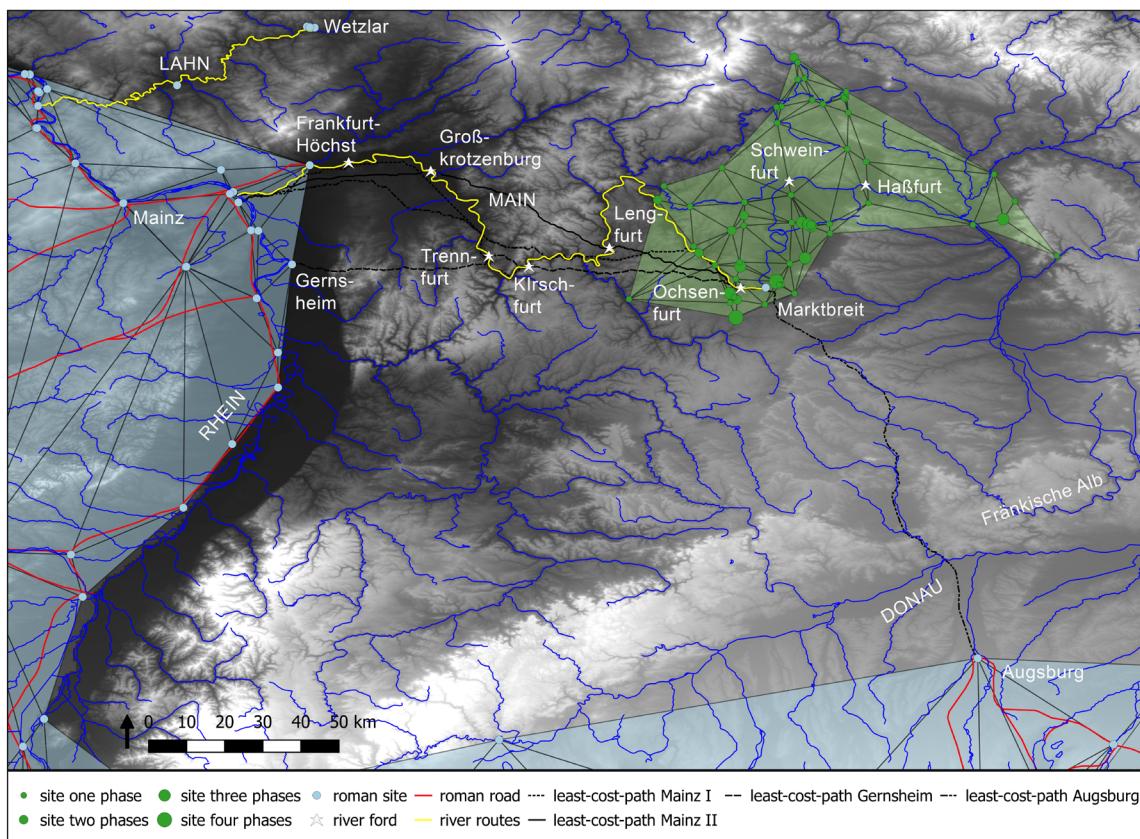


Figure 4. Research area in the Early Roman Iron Age (Eggers Phases A-B1, 15 BC-70 AD). The Germanic sites in the Barbaricum are indicated by green dots whose size corresponds to weighting based on duration of settlement usage. Natural fords on the Main are indicated by white stars; Roman sites are indicated by light blue dots and roads by red lines. Although not extant in the Germanic territories to the east, several roadways are known in the Roman territory to the west. For both areas settlement relationships with one another (next-neighbor relationships) were calculated with Delaunay Triangulation in the GIS, cleaned up and diagrammed. Yellow lines highlight Lahn and Main River routes for Roman incursions into the Barbaricum. Two potential overland routes to the Roman fort at Marktbreit in the inner Barbaricum are similarly highlighted with red lines. Sources: see Fig. 3, GIS author.

3 “Moenus – the ancient river Main” [sic] <http://www.museen-mainlimes.de/content/4-themen/theme.en.php?id=2>

4 Epigraphic Database Heidelberg from the Heidelberg Academy of Sciences and Humanities <http://edh-www.adw.uni-heidelberg.de/inschrift/suche> > search for “Classis Germanica”

5 As in Mainz, for example: the Museum of Ancient Seafaring, Mainz, a part of the Roman-Germanic Central Museum (RGZM): <http://www2.rgzm.de/navis/musea/mainz/aid.htm>

The overland route also seems realistic as potential access to the inner Babaricum, particularly as it was possible to cross the Main via natural fords during temporary periods of low water levels (interestingly, evidence for these fords can still be seen today at existing sites which all, with the exception of Großkrotzenburg, have the “-furt” suffix; see: Fig. 4.). Bases for a Roman expedition into the inner Babaricum include the aforementioned Frankfurt-Höchst but also the significant fort at Mainz⁶ as a bridgehead east of the Rhine. Mogontiacum, as Mainz was called by the Romans, was founded by Drusus in 13/12 BC. It later grew to become a significant provincial capital and administrative seat with urban infrastructure and monuments while continuing to serve as an important military base at the Rhine. So Mogontiacum became the gate to the Babaricum for routes on the Main River as well as overland ones.

A second northern overland route to Marktbreit from Frankfurt-Höchst ran over the flatlands around the lower Main and met up with a pre-existing Roman road in the west (Fig. 4). These lowlands ended near Großkrotzenburg where a natural ford facilitated the crossing of the river. A fort was constructed between 105 and 110 AD in Großkrotzenburg, and served as the garrison of the Cohors IIII Vindelicorum.⁷ Only in (no later than) 134 AD, at the end of Hadrian's reign, was a permanent stone bridge constructed over the Main, as confirmed by dendrochronological investigations of the archaeologically-documented thick log foundation.⁸

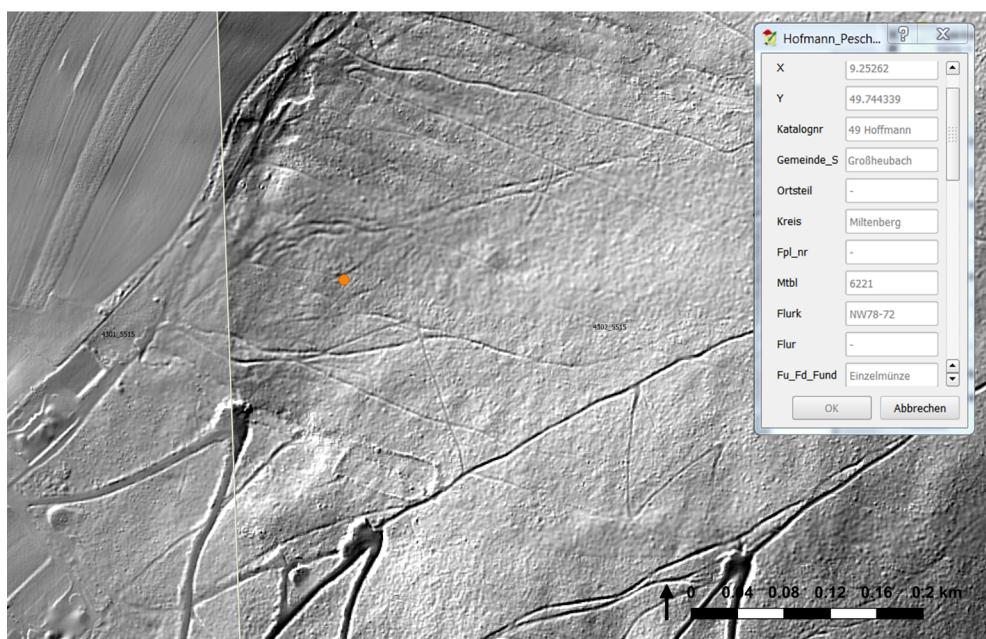


Figure 5. Sunken roads in a multiple pathway system with temporarily used sections running uphill from the flat fields (left) to a forested plateau (right), generally dated from the Iron Age to the High Medieval Period. These and many other archaeological features (such as grave mounds) survived particularly well in forested areas as they prevented plowing. Based on the discovery of a Roman coin from the Late Roman Iron Age (red dot) it is possible to precisely date the corresponding section of path; site data from the GIS-linked database is on the right. Subsequent geoarchaeological field studies should confirm this assertion and examine the multiphase nature of the pathway system in detail. Source: DTM1 from the Bayerisches Landesamt für Vermessung und Geoinformation, GIS author.

The fort and attached vicus (see: Becker and Faulstich 2000, 10–12) at Großkrotzenburg was on the eastern bank of the Main, exactly opposite of the small Numerus fort at Hainstadt, constructed in the 1st century

⁶ “Castellum Mattiacorum”, Latin for “Castle of the Mattiaci”

⁷ <http://www.museen-mainlimes.de/content/3-fundorte/fundstelle.en.php?id=13>

⁸ <http://www.museen-mainlimes.de/content/3-fundorte/fundstelle.en.php?id=18>

AD. On that eastern bank is also the edge of the forested Spessart range, the elevations and harsh climate of which left it virtually uninhabited until the High Medieval Period. In the vicinity of the least-cost path calculated from the GIS, much is recognizable from the high-resolution DTM1 (Fig. 5). The overland route from Mainz to Marktbreit continues beyond the Spessart elevations to a natural ford at modern-day Lengfurt (Fig. 4). To the east the terrain is less steep although still hilly due to local weathered limestone. The rest of the way to Marktbreit can be easily traversed mostly without steep inclines in the southern Main valley. This route is 168 km long, equivalent to a five-day march for Roman infantry or cavalry which could easily travel up to 30-40 km a day.

An alternative overland route begins at the fort at Gernsheim, the easternmost point on the border of Roman territory in this region (Fig. 4). This fort on the east bank of the Rhine was an important fleet base and dated from at least 30 or 70 AD (Hüssen 2000, 59; Kemkes 2005, 47). From this point it is 148 km, approximately four days' march, to Marktbreit, although one which passed over the Spessart range. The Main could have been forded at Trennfurt⁹ and Kirschfurt or, if this shortcut was avoided, Martkbreit could still have been reached entirely without crossing the river, a potentially dangerous prospect. Therefore, this route is decidedly the better and faster one. From Mainz or the fort at Frankfurt-Höchst it is far more likely that the three-day ship journey would have been preferred as a long (five-day), strenuous, and dangerous overland one seems unrealistic.



Figure 6. System of parallel, temporarily used sunken paths in the forest near Miltenberg. The image depicts the current appearance of a forested section of path represented in the DTM in Fig. 5 (image author).

⁹ Nearby the geologically caused ford of Trennfurt, a Roman fort was probably established in Wörth already in the first century AD: <http://www.deutsche-limeskommission.de/index.php?id=61&L=1> and <http://www.museen-mainlimes.de/content/3-fundorte/fundstelle.en.php?id=6>

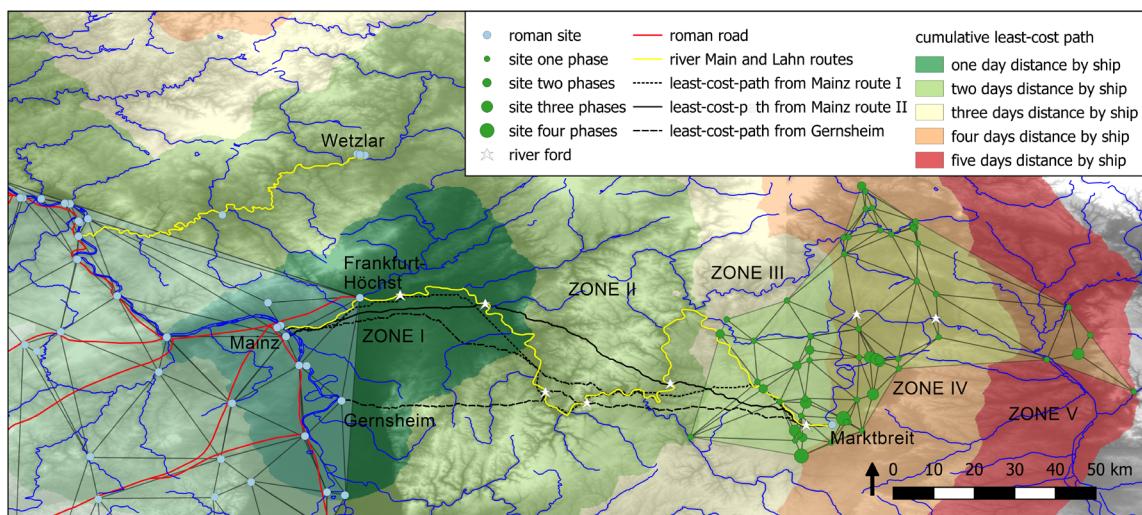


Figure 7. Roman point of view. Starting from the auxiliary fort at Frankfurt-Höchst, partly occupied by Germanic auxiliaries, Marktbreit lay just within the medium to well-accessible distance zone III. The five distance zones as equivalents of estimated travelling days by ship shown here display accessibility models calculated and visualized spatially in the GIS (GRASS) with cumulative least-cost path analyses from Frankfurt-Höchst (for method, see: Verhagen et al. 2013). Sources see: Fig. 3, GIS author.

The least-cost path analysis is based on the algorithmic evaluation of the digital surface model with slope gradient values for the calculation of aggregate zones of potentially good (green) to poor (red) accessibility. Zone accessibility is defined by effort expenditure so that well-accessible zones require little effort to access, and poorly-accessible ones a considerable amount (Verhagen et al. 2013, 359). Interestingly, all Germanic sites with a single exception lie in distance zones III-V. This indicates that, from the Roman perspective, the nearest-lying Germanic settlements at the Main were potentially difficult to access and the fort of Marktbreit was sited in the best-accessible and simultaneously most central location within the Germanic settlement cluster.

7 Settlement Pattern in the Late 1st and 2nd Centuries AD

The Limes Germanicus runs alongside a series of Roman features from the late 1st to 2nd centuries AD in the west of the research area. These features are indicated by light blue dots or, for vici, white squares in Figure 8. The Upper Germanic and Rhaetian Limes was constructed in 107/110 AD first as a cleared corridor through the forested Odenwald range between Roman territory and Germanic settlement regions. Roman expansion east of Gaul and the Rhine originated with Drusus' first expedition into the inner Babaricum along the Lahn River from 12 to 9 BC (Fig. 4, attached, top left) and ended with the defeat of Varus at Kalkriese in 9 AD. After this point Rome retreated to the west bank of the Rhine which served as the demarcating boundary for decades. In the late 1st century AD, Rome decided to annex agriculturally favorable areas with the systematic creation of a corridor ("Limes") guarded with wooden watchtowers to separate them from the Babaricum.

Simultaneously with the Roman expansion into the Babaricum, Germanic territory extended noticeably to the west, towards the Roman Empire. This is quite clear from new sites west of the natural barrier presented by the Spessarts and in the southwest at the Tauber River (Fig. 8). An early zone for direct Roman-Germanic contact is interestingly located directly at the end of a main Roman road near Großwallstadt (Nuber 2005a, 410–419). On the eastern bank of the Main, several new Germanic settlements were located directly across from Roman forts and their enclosed vici and so direct trade with the Romans is presumed although has not yet been proven from the archaeological record (Greiner 2005, 165–168). The core of the

Germanic settlement cluster remained in a previously-settled area. Because of its location in the center of the settlement zone, the natural ford through the Main at modern-day Ochsenfurt had great significance for communication and trade between the northern settlement cluster and those south of the Main.

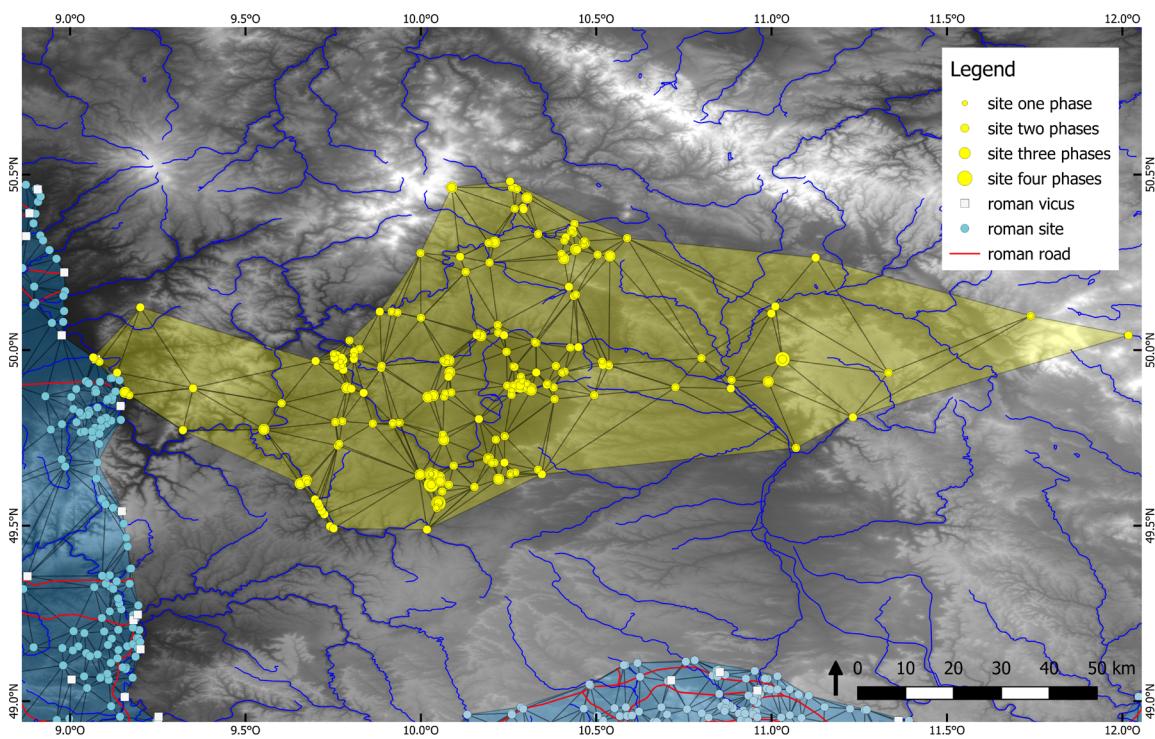


Figure 8. Sites dating to the Early Roman Iron Age II (Eggers Phase B2, 60-180 AD) in yellow. In contrast to the Early Roman Iron Age I (Eggers Period A-B1, 15 BC to 70 AD) in Fig. 3, now Romans and Barbarians are not divided by a settlement empty borderland in the hills of the Spessart region as before. The contact zone to the roman world is still very small indicated by new sites in the Barbarian west. Sources: see Fig. 3, GIS author.

Expansion from both the Romans and the Germans continued into the Late Roman Iron Age until both territories directly bordered one another. Between 159/161 and 165 in the south of the research area at the Odenwald Limes, Roman territory extended east into the previously uninhabited Roman-Germanic buffer zone which bordered both spheres of influence. At the Roman boundary, two settlement clusters emerged around modern-day Großwallstadt and to the south of Eberstadt. These consisted of numerous *villae rusticae* sited systematically for agricultural purposes in fertile high valleys (Fig. 9). Both clusters were physically separated from the numerous Germanic settlements along the Tauber to the east by the Odenwald low mountains. This range constituted a further 25 km wide uninhabitable border between the Romans and the Germans. The area of foreign contact is therefore limited to the lower Main on the banks of which Roman and Germanic settlements often lay in sight of one another.

New Germanic settlements to the south were neatly lined in the fertile western valley along the Tauber and many which had existed since the Early Roman Iron Age remained on the east bank. In general, most settlements founded in the Early Roman Iron Age continued into the Late Roman Iron Age, allowing for the postulation for general settlement continuity at the middle Main (Fig. 9). Although some sites were abandoned and replaced by new settlements, the total sum indicates an obvious increase in number of settlements in the Late Roman Iron Age. This increase can be plausibly explained by migration of other Germanic groups from the inner Babaricum, as illustrated by artifacts discovered at the Main of Elbe-Germanic provenance – coming from the northeast Babaricum (Schach-Dörges 2004, 79ff.).

When considering relative numbers of sites (Fig. 2) for the standardized period of 100 years, settlement intensity actually decreases in the Late Roman Iron Age because the two periods are not of the same length.

The apparent contradiction of increasing numbers of sites and relative decrease of settlement intensity is not necessarily irreconcilable. A population increase is also possible with a corresponding increase in settlement concentration and the foundation of well-planned structures in large settlements. These processes of consolidation into larger and larger settlements are also observable in the inner Barbaricum at the Oder River (see: Volkmann 2013, 240–241).

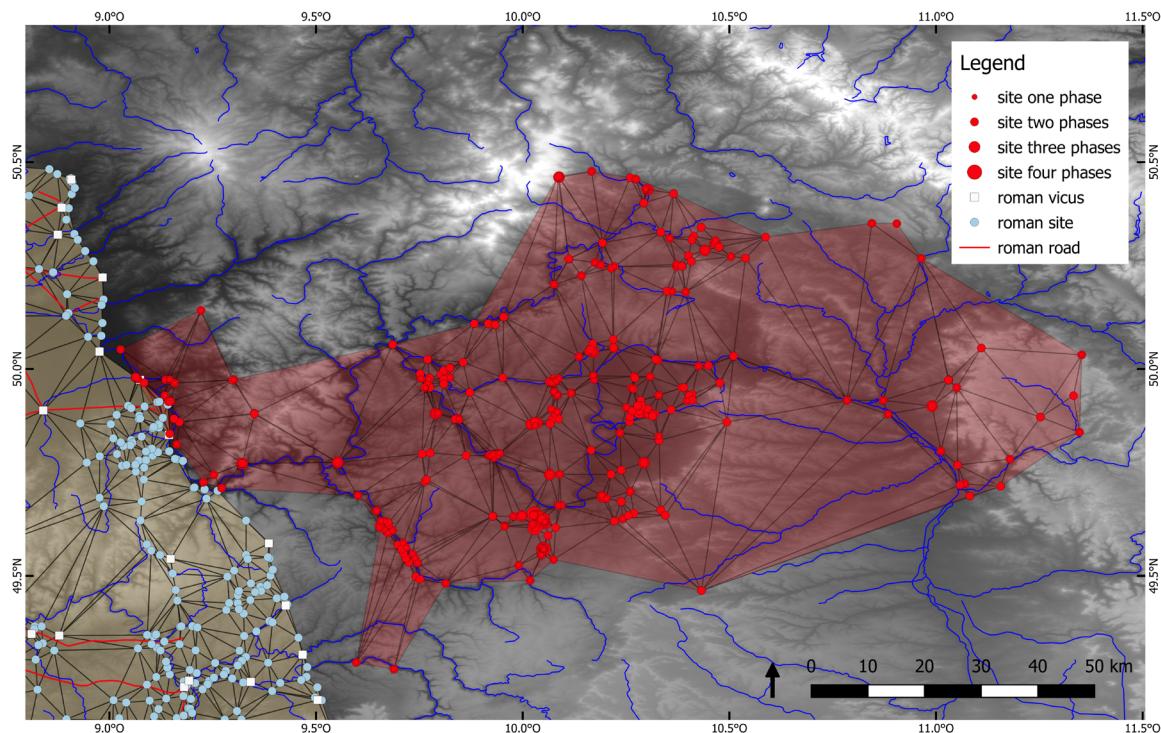


Figure 9. Sites dating to the Late Roman Iron Age (Eggers Phase C, 180–380 AD)–the settlement cluster at the time of its largest expansion with a large contact zone to the Roman Empire. Through the construction of the new eastern fortification line of the roman Odenwald Limes after 159/161 and 165 AD, the roman world comes closer to the Barbarian settlement cluster at river Main. Many sites in the inner settlement cluster date to three or four periods of the Roman Iron Age and the Early Migration Period. These were often in continuous use as settlements or cemeteries since the Early Roman Iron Age. Sources: see Fig. 3, GIS author.

Settlements condensed into approximately eight regional centers separated from one another by largely uninhabited, 10 to 20 km zones (Fig. 9). The highest degree of connectivity appears to be within each respective regional center. Transregional connectivity to neighboring centers is considerably less, corresponding to the spatial distances to one another. This means that the settlements in these centers were mostly in direct contact with neighboring ones within the same center, methodical investigation of transregional connections with Delaunay triangulation and next neighbor relationship calculations notwithstanding.

During the Early Migration Period, defensible hill forts were erected both directly on the plateaus at the Main River as well as in the hinterland, probably in response to an increased potential for conflict between Romans and Germans.¹⁰ The Wettenburg hill fort at the Main River was in use as a fortification in the Late Bronze and Early Iron Ages. During the Migration Period, specifically late 4th to 5th centuries, the ramparts were extensively renovated so that the fortification was essentially a large fortress with intramural settlement (Fig. 10) (see: Neubauer 2000). Aside from use as a fortification with affiliated settlement during

¹⁰ See the map of south German hill forts from the Late Roman Iron Age and Migration Period in Haberstroh 2003, 202.

the Early Iron Age, use of the Wettenburg site is also evidenced by finds dating to the Migration Period. Other hill forts in the research area at the Main were similarly active during the Migration Period (Fig. 10). These central places can be attributed exceptional significance from the concept of space even when they were not located centrally within a settlement cluster. Instead, they served as retreats at the edge of the settlement cluster during periods of conflict. Defensibility and a commanding view of the surrounding landscape were crucial to these sites steeply rising plateaus further secured by walls satisfied these qualifications.

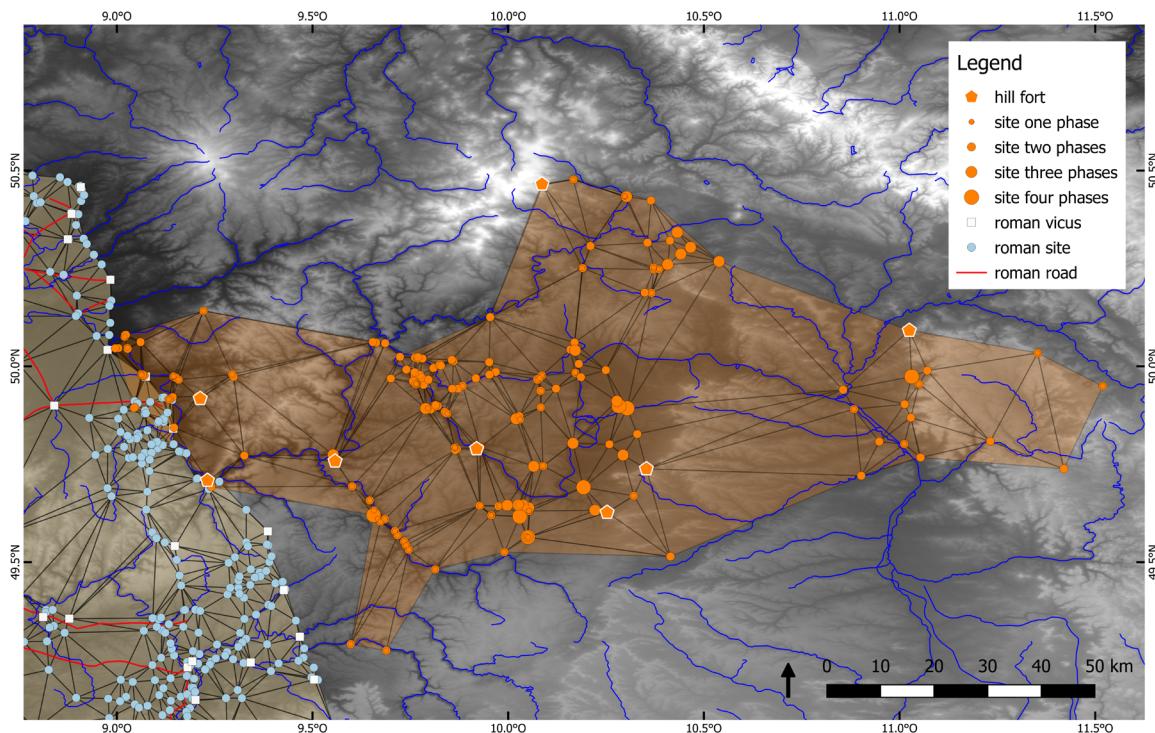


Figure 10. Sites dating to the Early Migration Period (Eggers Phase D, 380-480 AD). Some sites in the central settlement cluster date to three or four periods of the Roman Iron Age and the Early Migration Period. These were often in continuous use as settlements or cemeteries since the Late Roman Iron Age. Some cemeteries and settlements were abandoned. During the Early Migration Period fortifications, in the form of hill forts from the pre-Roman Iron Age, are re-utilized. That is the reason why the hill forts are not in the centers of the settlement sub-clusters. Sources: see Fig. 3, GIS author.

In approximately 260 AD, the Roman border retreated to the Rhine River (see map in Kemkes 2005, 51); the Limes was no longer under military guard and ceased being an impenetrable barrier to the Germans. Looting of the Roman frontier by small bands of Germans was frequent from the mid-3rd century; these were identified as Alemanni by historical Roman sources (e.g., Steuer 1997, 113). It cannot be assumed that the Roman populace, which consisted partly of “Romanized” Germans, those who had adopted a Roman identity throughout the course of Roman acculturation, completely abandoned the borderlands (see: Brather 2005, 150159; Hägermann 2004, 396ff.). This is supported by the archaeological record (Archäologisches Landesmuseum Baden-Württemberg 2004, 79–102). From the late 3rd century, it becomes difficult to distinguish between Roman and Germanic material culture in the archaeological record as the previously separate cultures mutual assimilation (see: Theune 2004, 381–389; Marti 2009, 291–307). In many Roman *villae rusticae*, for example, continued Germanic use is apparent from post-in-ground constructions. This does not argue against Roman abandonment as such features existed in the archaeological record both within and without the Roman-Germanic contact zone (Reuter 2005, 464–465).

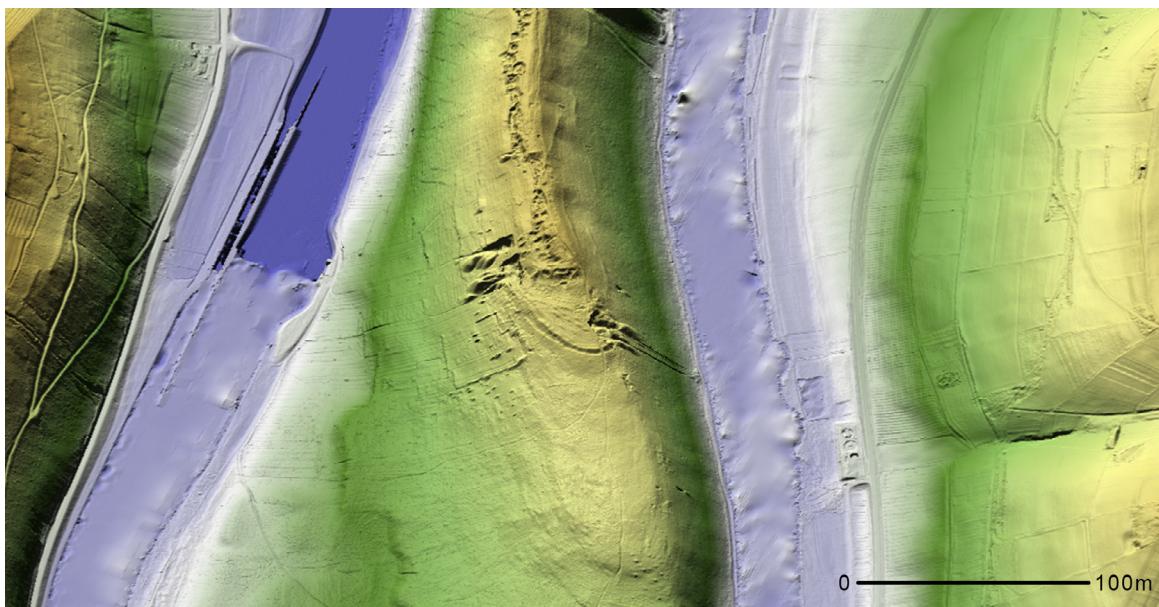


Figure 11. Three-dimensional terrain model of the Wettenburg hill fort at the Main River bend near Urphar. In the middle, sections of fortified walls are quite clear in the interpolated elevation model. Legend: blue–green–yellow–brown = from 138 meters (altitude above mean sea level) at river Main up to 234,19 meters at the highest point of the plateau. Source: see Fig. 5, GIS author.

8 Conclusion and Outlook

Many Germanic settlement sites were in continuous use throughout the Roman Iron Age and even into the Migration Period. With the beginning of the latter in the late 4th and 5th centuries AD, many settlements at the middle Main were abandoned and few new ones were founded. Due to difficulties in precise dating it is not possible to confirm whether settlement intensity, having continuously increased throughout the Roman Iron Age, also increased in the Early Migration Period. Through the identification of new sites, and comprehensive investigation of previously known ones from the Late Roman Iron Age, extensive changes to settlement structure in the Migration Period can be determined. Neighboring Roman-Germanic borderlands like the southern river Rhein region should be analyzed based on published comprehensive catalogues to accompany and support this research topic (Gillich 2007). These catalogues can be investigated with benefit as retro-digitalized sources in GIS data bases in order to investigate settlement patterns based on network, cluster, or density analyses.

The revolutionary processes of the Migration Period also led to drastic changes in settlement structure in other inner barbarian territories. The 5th to 6th centuries AD constituted a significant transitional phase in Germania libera. In the inner Barbaricum in river Oder region, an abandonment of settlements of the Migration Period has been identified. As the archaeological site analysis shows, the region was virtually uninhabited from 550 to 700 AD (see: Volkmann 2013). One majority opinion of some medievalists (see: Geary 2002 and Pohl 2005) has shifted in recent years to the idea of a rather static, predominantly locally rooted settlement and population development in the Roman and Migration Periods. However, the idea of gradual change is based on previous archaeological finds and probably only applicable for the Roman Period in the western border regions around the Limes Germanicus—during the Romanization of local groups, for example (Hägermann 2004, 396ff.). The finds of the areas in the Barbaricum indicate instead drastic processes of upheaval at the end of the Roman and Migration Periods, partially occurring within only a few decades or even years and inconsistent with a gradual transformation. Instead they suggest distinct breaches in the continuity of non-linear changes. These are the precise questions that need to be analyzed within investigations of our research in river Main region in context of transformation processes from late Antiquity to early Middle Ages (see: Hooper 2001).

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References

Archäologisches Landesmuseum Baden-Württemberg (Ed.) (2004). *Die Alamannen. Archäologie eines lebendigen Volkes*. Stuttgart: Konrad Theiss Verlag.

Becker, Th., Faulstich, E. I. (2000). Ausgrabungen im vicus des Kastells Groß Krotzenburg. *Der Limes* 4/2000, Heft 2, 10–12.

Brather, S. (2005). Acculturation and Ethnogenesis along the Frontier: Rome and the Ancient Germans in an Archaeological Perspective. In: F. Curta (Ed.), *Borders, barriers, and ethnogenesis: frontiers in late Antiquity and the Middle Ages. Studies in the early Middle Ages*. (pp.139–171). Brepols: Brepols Publishers.

Brughmans, T. (2013). Thinking through Networks: A Review of Formal Network Methods in Archaeology. *Journal of Archaeological Method and Theory* 12/2013, 20(4), 623–662, DOI 10.1007/s10816-012-9133-8

Brughmans, T. (2013a). Networks of Networks: a Citation Network Analysis of the Adoption, Use, and Adaptation of Formal Network Techniques in Archaeology. *Literary and Linguistic Computing* 28, 538–562.

Eggers, H. -J. (1955). Zur absoluten Chronologie der römischen Kaiserzeit im freien Germanien. *Jahrbuch RGZM*, 2 (Festschrift für E. Sprockhoff), 196–244.

Godłowski, K. (1970). *The Chronology of the late Roman and early Migration Periods in Central Europe*. Kraków: Nakładem Uniwersytetu Jagiellonśkiego.

Greiner, B. A. (2005). Die Kastellvici am vorderen Limes. In: Archäologisches Landesmuseum Baden-Württemberg (Ed.), *Imperium Romanum. Roms Provinzen an Neckar, Rhein und Donau*. (pp.165–168). Stuttgart: Konrad Theiss Verlag.

Gillich (Faustmann), A. C. (2007). Besiedlungswandel im südlichen Oberrheingebiet von der Römerzeit bis zum Mittelalter, *Freiburger Beiträge zur Archäologie und Geschichte des ersten Jahrtausends*. Dissertation an der Universität Freiburg i. Br. 2005. Rahden/Westfalen: Verlag Marie Leidorf.

Geary, P. J. (2002). *Europäische Völker im frühen Mittelalter. Zur Legende vom Werden der Nationen*. Frankfurt: Fischer Taschenbuch Verlag.

Haberstroh, J. (2003). Der Reisberg bei Scheßlitz-Burgellern in der Völkerwanderungszeit Überlegungen zum 5. Jahrhundert n. Chr. in Nordbayern. *Germania*, 81, 201–262.

Hägermann, D. (2004). Akkulturation. *Reallexikon der Germanischen Altertumskunde Ergänzungsband (RGA-E)*, 41, 396–435.

Herzog, I. (2012). Least-cost networks. Archaeology in the Digital Era. In: G. Earl, T. Sly, A. Chrysanthi, P. Murrieta-Flores et al. (Eds.), *Computer Applications and Quantitative Methods in Archaeology 2012*. (pp.237–249). Amsterdam: Amsterdam University Press.

Hooper, M. (2001). Alamannische Siedlungsgeschichte im Breisgau: zur Entwicklung von Besiedlungsstrukturen im frühen Mittelalter, *Freiburger Beiträge zur Archäologie und Geschichte des ersten Jahrtausends*. Dissertation an der Universität Freiburg (Breisgau) 1994: Alamannische Besiedlungsgeschichte im Breisgau. Rahden/Westfalen: Verlag Marie Leidorf.

Hoffmann, K. (2004). Kleinfunde Der Römischen Kaiserzeit aus Unterfranken. *Studien Zur Siedlungsgeschichte und kulturellen Beziehung zwischen Germanen und Römern. Internationale Archäologie*, Bd. 80. Rahden/Westfalen: Verlag Marie Leidorf.

Höckmann, O. (2000). Schifffahrt zwischen Alpen und Nordsee. In: L. Wamser (Ed.), *Die Römer zwischen Alpen und Nordmeer*. (pp.264–267). München: Patmos.

Hüssen, C. M. (2000). Sicherung der Reichsgrenze. In: L. Wamser (Ed.), *Die Römer zwischen Alpen und Nordmeer*. (pp.58–63). München: Patmos.

Kemkes, M. (2005). Vom Rhein an den Limes und wieder zurück. In: Archäologisches Landesmuseum Baden-Württemberg (Ed.), *Imperium Romanum. Roms Provinzen an Neckar, Rhein und Donau*. (pp. 44–53). Stuttgart: Konrad Theiss Verlag.

Kline, V. L. (2009). *Regional Network Analysis Situating Lost Valley in the Inter-Site Landscape*. Master of Arts in Anthropology. San Diego State University, San Diego.

Knappett, C. (2013). *Network Analysis in Archaeology: New Approaches to Regional Interaction*. Oxford: Oxford University Press.

Marti, R. (2009). Between ager and silva. Phases of the colonization and the use of land in Northern Switzerland from the 2nd/3rd to the 8th/9th century. In: J. Klápště, P. Sommer (Eds.), *Medieval rural settlement in marginal landscapes. Ruralia 7*. (pp. 291–307). Brepols: Brepols Publishers.

Nakoinz, O. (2009). Zentralortforschung und zentralörtliche Theorie. *Archäologisches Korrespondenzblatt*, 39, 361-380.

Neubauer, D. (2000). Die Wettenburg in der Mainschleife bei Urphar. Eine Höhenbefestigung des Jungneolithikums, der Urnenfelderzeit, der Frühen Eisenzeit und der Völkerwanderungszeit. Dissertation an der Universität zu Würzburg, Würzburg.

Nuber, H.-U. (2005). *Villae Rusticae*. In: Archäologisches Landesmuseum Baden-Württemberg (Ed.), *Imperum Romanum. Roms Provinzen an Neckar, Rhein und Donau*. (pp. 270–281). Stuttgart: Konrad Theiss Verlag.

Nuber, H.-U. (2005a). Zu Wasser und zu Lande. Das römische Verkehrsnetz. In: Archäologisches Landesmuseum Baden-Württemberg (Ed.), *Imperum Romanum. Roms Provinzen an Neckar, Rhein und Donau*. (pp. 410–419). Stuttgart: Konrad Theiss Verlag.

Obst, R. (2012). Die Besiedlungsgeschichte am nordwestlichen Maindreieck vom Neolithikum bis zum Ende des Mittelalters. *Würzburger Arbeiten zur Prähistorischen Archäologie 4*. Rahden/Westfalen: Verlag Marie Leidorf.

Pohl, W. (2005). Die Völkerwanderung. Eroberung und Integration. Stuttgart: W. Kohlhammer.

Polla S., Graßhoff G., Rinner, E. (2013). Explanatory Models in Archaeology: Are Least Cost Paths the Way to Go? In: F. Contreras, M. Farjas and F. J. Melero (Eds.), *Fusion of Cultures. Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology*, Granada, Spain, April 2010. Granada: CAA2010, pp.299–302.

Paulsen, P. (1992). Die Holzfunde aus dem Gräberfeld bei Oberflacht. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg 41/2*.

Pescheck, Chr. (1978). *Die germanischen Bodenfunde der römischen Kaiserzeit in Mainfranken*. München: Beck.

Prien, R., Hilbich, P. (2013). Zur Rolle von Höhensiedlungen in der spätantiken Siedlungslandschaft der Moselregion. In: O. Heinrich-Tamáska (Ed.), *Tagungsbeiträge der Arbeitsgemeinschaft Spätantike und Frühmittelalter 6. Zerstörung und Gewalt im archäologischen Befund*. (pp.19–53). Hamburg: Verlag Dr. Kovač.

Reuter, M. (2005). Germanische Siedler in römischen Ruinen. In: Archäologisches Landesmuseum Baden-Württemberg (Ed.), *Imperium Romanum. Roms Provinzen an Neckar, Rhein und Donau*. (pp.463–467). Stuttgart: Konrad Theiss Verlag.

Roymans, N. (2011). *Villa Landscapes in the Roman North: Economy, Culture and Lifestyles*, Amsterdam Archaeological Studies 17. Amsterdam: Amsterdam University Press.

Schach-Dörges, H. (2004). *Zusammengespülte und vermengt Menschen. Suebische Kriegerbünde werden sesshaft*. Archäologisches Landesmuseum Baden-Württemberg (Ed.), *Die Alamannen. Archäologie eines lebendigen Volkes*. (pp.79–102). Stuttgart: Konrad Theiss Verlag.

Schier, W. (1990). *Die vorgeschichtliche Besiedlung im südlichen Maindreieck*. Kallmünz: Lassleben.

Sindbæk, S. M. (2007). *The Small World of the Vikings. Networks in Early Medieval Communication Exchange*. Norwegian Archaeological Review, 40, 59–74.

Steuer, H. (1997). Germanische Heerlager des 4./5. Jahrhunderts in Südwestdeutschland. In: A. Nørgård Jørgensen (Ed.), *Military aspects of Scandinavian society in a European Perspective, AD 1–1300: Papers from an International Research Seminar at the Danish National Museum*. (pp.113–122). Copenhagen: National Museum.

Theune, C. (2004). Germanen und Romanen in der Alamannia. Strukturveränderungen aufgrund der archäologischen Quellen vom 3. bis zum 7. Jahrhundert. Berlin/ New York: De Gruyter.

Verhagen P., Brughmans T., Nuninger L., Bertoncello, F. (2013). The Long and Winding Road. Combining Least Cost Paths and Network Analysis Techniques for Settlement Location Analysis and Predictive Modelling. In: E. Graeme, T. Sly, A. Chrysanthi, P. Murrieta-Flores, C. Papadopoulos, I. Romanowska, D. Wheatley (Eds.), *Archaeology in the Digital Era, Volume II. e-Papers from the 40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology (CAA)*, Southampton, 26-29 March 2012, Southampton: CAA 2012, pp. 357–366.

Volkmann, A. (2013). *Siedlung. Klima: Migrationen: Geoarchäologische Forschungen zur Oderregion zwischen 700 vor und 1000 nach Chr. mit Schwerpunkt auf der Völkerwanderungszeit*. Studien zur Archäologie Europas 18. Bonn: Habelt.

Volkmann, A. (2015). Climate change, environment and migration: A GIS-based study of the Roman Iron Age until the Early Middle Ages in the river Oder region. *PCA Post-Classical Archaeologies*, vol. 5, 69–94.

Volkmann, A. (2016). An Archaeological Information System (AIS) for Digital Cultural Heritage management and research: identify settlement dynamics of the Late Roman Iron Age until the Early Middle Ages in the river Oder region. *Sektion für Slawische Archäologie beim 8. Deutschen Archäologie-Kongress 2014 in Berlin. Beiträge zur Ur- und Frühgeschichte Europas*. (pp.83–99). Langenweißbach: Beier & Beran.

Wolff, G., Schmidt, E., Ritterling, E. (1915). Das Kastell Höchst am Main. Die Kastelle Nr. 24–31. In: O. v. Sarwey, E. Fabricius (Eds.), *Der obergermanisch-raetischer Limes des Römerreiches*. Heidelberg: Universität Heidelberg.