

Analysing the Medieval Landscape of the German Palatinate

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Abstract

This paper presents work-in-progress, rooted in architectural art history and applied informatics, designed to draw new conclusions about the relationships of six medieval German Palatinate castles to the landscapes in which they were built. This is achieved through the integration of 32 geo-referenced historical maps (1540–1799 A.D.) of the German Palatinate and spatial analyses in Geographic Information Systems (GIS). The composition of the spatial analyses is based on terrestrial-laserscan (TLS) models of each of the castles, and 25-metre resolution airborne-laserscanning (ALS) data. This report is a subproject of the ongoing CITADEL project, which includes Structure from Motion (SfM) models in addition to the TLS ones, as well as a textual component comprising historical charters from the period 1174–1589 A.D. For the purposes of this paper, only the geo-referenced maps and GIS spatial analyses will be discussed at length.

Keywords:

QGIS, geo-referenced maps, medieval archaeology

1 Introduction

Architectural Art History has undergone a methodological revolution over the past 20 years with the application of 3D modelling techniques, such as terrestrial laserscanning (TLS) and Structure from Motion (SfM), to provide both precisely measured and photo-realistic models of historical buildings (Koehl et al., 2017). The CITADEL project (Computational Investigation of the Topographical and Architectural Designs in an Evolving Landscape) combines TLS and SfM models of six medieval castle sites with geo-referenced historical regional maps in order to conduct spatial analyses in GIS. An accompanying neo4j-based graph database derived from historical charters (1174–1589 A.D.) provides cultural and thematic contexts for the periods in which the sites were active. The combination of these components provides new insights into the political strategy behind the construction of the sites, as well as into the effect of the landscape on both their design and function. For the purpose of this paper, particular emphasis will be given to the GIS spatial analyses and historical maps, though not without reference also to the modelling and textual components, as they cannot be entirely separated from the discussion.

The case study sites are the former royal palace of Lautern (Kaiserslautern), the Teutonic Knight Commandry of Einsiedel (Einsiedlerhof), and the hilltop castles Beilstein, Hohenecken, Perlberg and Wilenstein, located in the southwest German region of the Palatinate (*Pfalz*), within an area of approximately 10x10 kilometres (Figure 1). All six sites were built/renovated within the period 1162–1253 A.D. based on a range of factors, namely: location within the landscape, visibility, access to water, proximity to roadways, and signalling of social status regarding both hierarchical rank and ambition (Untermann, 2007). These factors all impacted the design of each castle, underlining the necessity to treat each castle as a unique, individual, case, despite architectural similarities and their chronological and regional proximity to each other. We hypothesized that the six sites were well connected and within view of one another, to be determined by conducting least-cost-path and viewshed analyses.

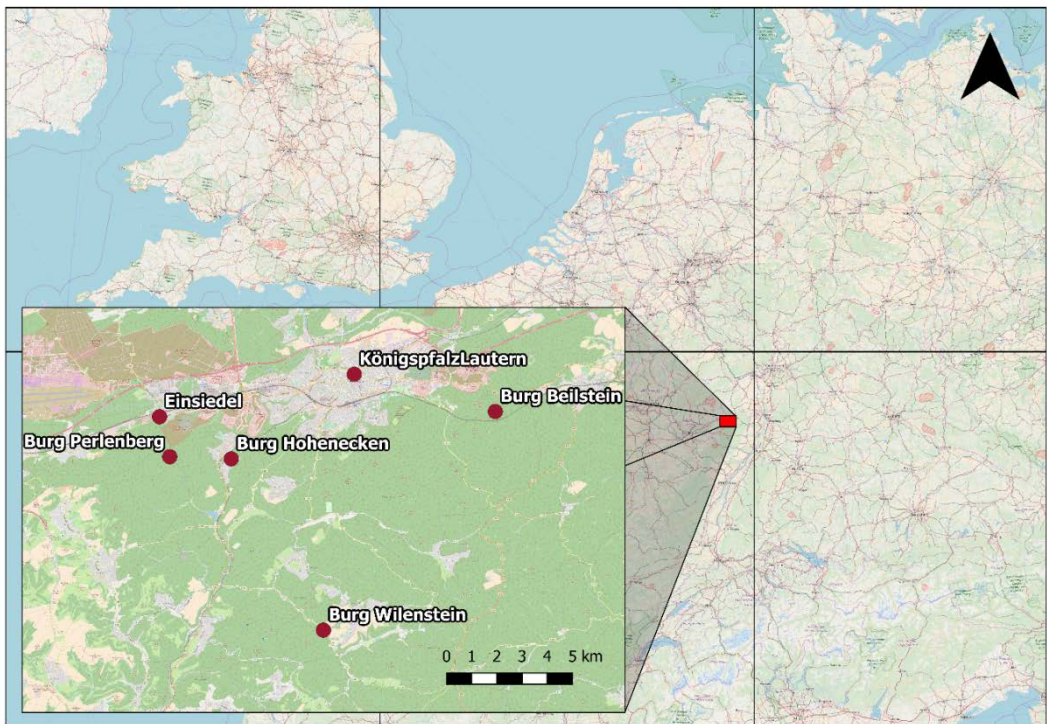


Figure 1: Locations of the six case study sites within Germany

2 Methodology:

Geo-referencing Historical Maps in QGIS

Thirty-two maps of the region, from 1540–1799 A.D., were chosen on the basis of the inclusion of Kaiserslautern. The maps were downloaded, free of charge, from the online

David Rumsey Map Repository hosted by Stanford University Library. The Thin Plate Spline algorithm of the Georeferencer plugin in QGIS was used to manually geo-reference each map based on 215 points of reference consisting of various cities, towns and castles named on the maps (Boùuaert et al., 2016). Although not every map provided all points, the key sites within the German Palatinate were marked on nearly every map (Figure 2). The specific reference points within the cities and towns were chosen because of their historical significance with regard to three hierarchical features: (1) presence of a castle, (2) oldest church (built prior to 1500), (3) marketplace (marketplaces became common in Germany in the 15th century).

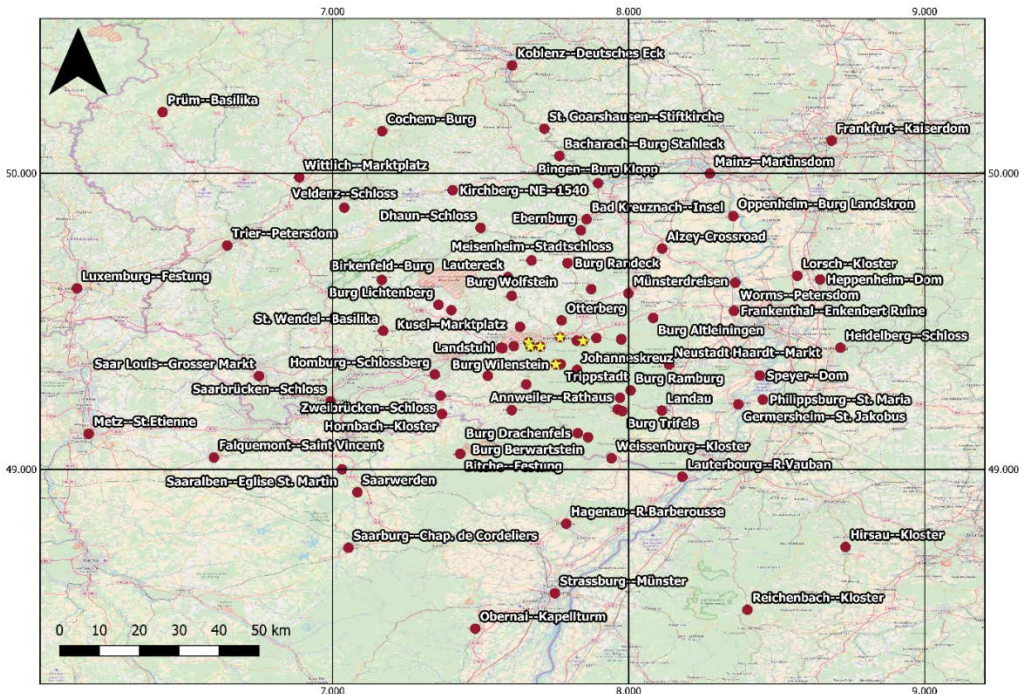


Figure 2: The key reference points of the *Pfalz* in Open Street Map (OSM). Note: the six case study sites are marked with yellow stars.

Maps of the region of the Rhine, the Electorate of the Palatinate, and the Palatinate Forest (*Pfälzerwald*) first appear in the first half of the 16th century. They are hand-drawn and often include geographical discrepancies as well as inaccurate locations for certain sites – particularly noticeable in the Palatinate forest – leading to distortions of local areas after georeferencing. Thus, a high level of survey and political uncertainty is inherently associated with the maps (Herrault et al., 2013). It must be taken into account that the patrons of the various maps sought to represent aspects most relevant to their own interests and perspectives (e.g. showing only fortified cities for the purposes of locating defensive sites during an invasion). Chronologically, the maps begin where the majority of the charters end, providing an excellent transition of primary sources until the early 19th century (Figure 3). The maps provide key data regarding land routes (i.e. frequently-travelled areas), roadways (fixed

features connecting two places), waterways, lakes and territorial boundaries (van Lanen et al., 2015). The historical boundaries were mapped as additional layers to trace the fluctuation of the borders of the Palatinate in relation to the positions of the six sites.

Historical Charters

The historical charters were obtained free of charge from the Institut für Pfälzische Geschichte und Volkskunde in Kaiserslautern (Institute for Palatine History and Folklife Studies), and the Deutsche Forschungsgemeinschaft’s (German Research Council’s) Regesta Imperii RI Opac (Literature Database for the Middle Ages) from the Bayerische Staatsbibliothek. Of the 310 charters, most date to the years 1200 to 1450, after which there is a sudden noticeable decline (Figure 3). This decline correlates directly to the decline of the political significance of the castles’ inhabitants, and the mid-fifteenth-century destruction of castles Beilstein and Wilenstein.

Developing a picture of the relationships that existed between the individuals mentioned in the historical charters will provide insight into the cultural contexts of the various periods, as well as into social phenomena that influenced the builders and renovators of the sites over time.

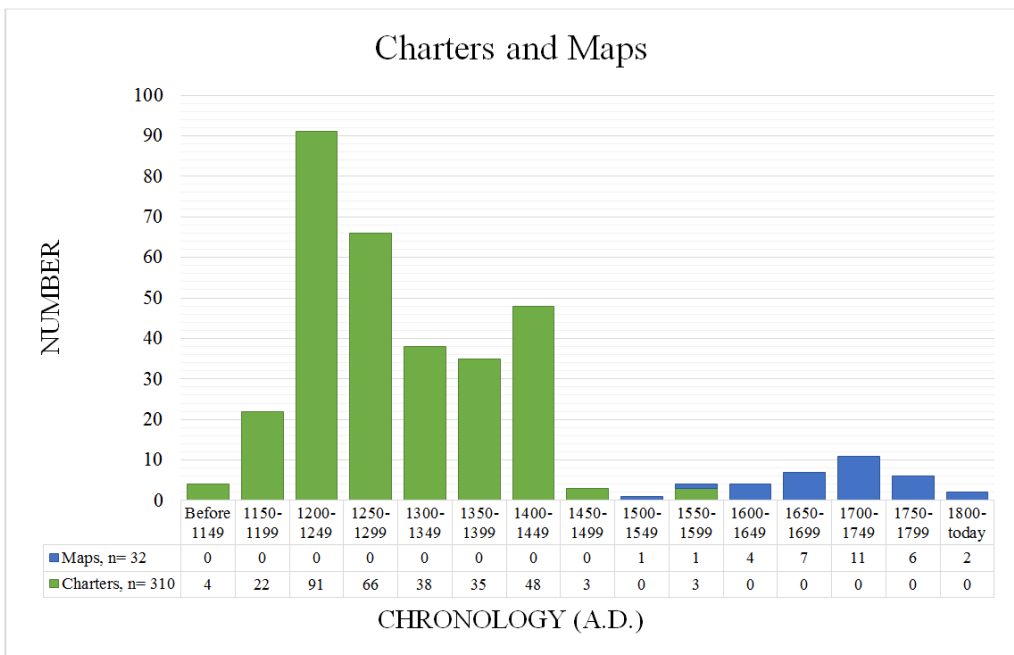


Figure 3: Corpus of written sources and maps

3D Modeling

The modelling procedure will not be discussed in detail here, although it is worth describing it briefly. So far, five of the sites have been recorded with both TLS and SfM techniques. The TLS scans were conducted using a Riegl VZ-400 laserscanner with a calibrated camera and were processed in RiSCAN PRO®. The SfM models were produced using a Nikon D3300 SLR camera and generated in Agisoft Photoscan Pro® with calibrated markers for accuracy (Sapirstein, 2016). The use of both techniques was dictated by their respective strengths: TLS is more suited to recording high-precision measurements, whereas SfM provides a superior texture (Figure 4). Together, the techniques complement each other, allowing models to be combined into a single model that is both precise and photo-realistic (Girelli et al., 2017). This was particularly useful in the case of architectural features that were too high to be captured by a TLS device (e.g. the tower of Burg Hohenecken), though readily captured by drone photography (Pattee et al., 2015).



Figure 4: The latrine of Burg Perlenberg (Left: TLS Model; Right: SfM Model)

Spatial Analyses in GIS

In order to determine the environmental influence on the six sites, Least-Cost Paths (LCPs) were generated between each site to determine possible roadways for comparison with modern roadways and those from the geo-referenced maps. Prior to generating the LCPs, theoretical connections were generated via a Delaunay Projection based on a DEM (Digital Elevation Model). Due to the lack of information in the corpus of primary sources (charters and maps) pertaining to the sites' mutual visibility, we generated viewsheds from the highest points of each castle provided by the TLS models, and from the estimated heights of towers for sites that no longer have towers. Thus far, the LCPs and viewsheds have been calculated using the ASTER Global Digital Elevation Model (GDEM) data provided for public access by the USGS (United States Geological Survey) in 25-metre resolution. The associated geospatial analyses were conducted in QGIS, in which the LCPs were calculated using the 'r.drain' processing-tool (algorithm from GrassGIS) for each site, based on a reclassified slope representing cost values (Table 1).

Table 1: Cost Values

| Slope | Weight |
|----------------|---------------|
| 0 thru 2 | 0 |
| 3 thru 5 | 1 |
| 6 thru 9 | 3 |
| 10 thru 13 | 4 |
| 14 thru 18 | 7 |
| 19 thru 25 | 9 |
| 26 thru 31.281 | 10 |

3 Results:

Historical Map Results

Geo-referencing the maps revealed a strong local distortion in the region around Burg Beilstein as far as Burg Frankenstein (Figure 5). The same area of distortion appears in all of the maps with the exception of the ones from 1637, *Palatinatus Rheni* (produced in London), and 1697, *Germania Parte Occidentale* (produced in Venice), primarily because neither map included either Burg Beilstein or Burg Frankenstein. Generally speaking, over time the distortions in the maps become ever fewer, or at least less pronounced, except for the aforementioned region. It is likely that it was measured in the late-16th or early-17th century and then copied by cartographers over the following centuries. From the early 18th century, map locations along the Rhine and in non-mountainous regions are fairly accurate when compared to modern maps. Analysis of the territorial borders between the Electorate of the Palatinate and the Duchy of Zweibrücken (the two dominions in which the six sites are located) reveals their constant fluctuation, demonstrating either mismeasurements of the terrain or actual seizures of territory (Figures 6 and 7). This is particularly relevant to the medieval castles because they are always located either near the borders or directly on the borders, suggesting that they served as physical boundary markers between the dominions, even after their destruction.

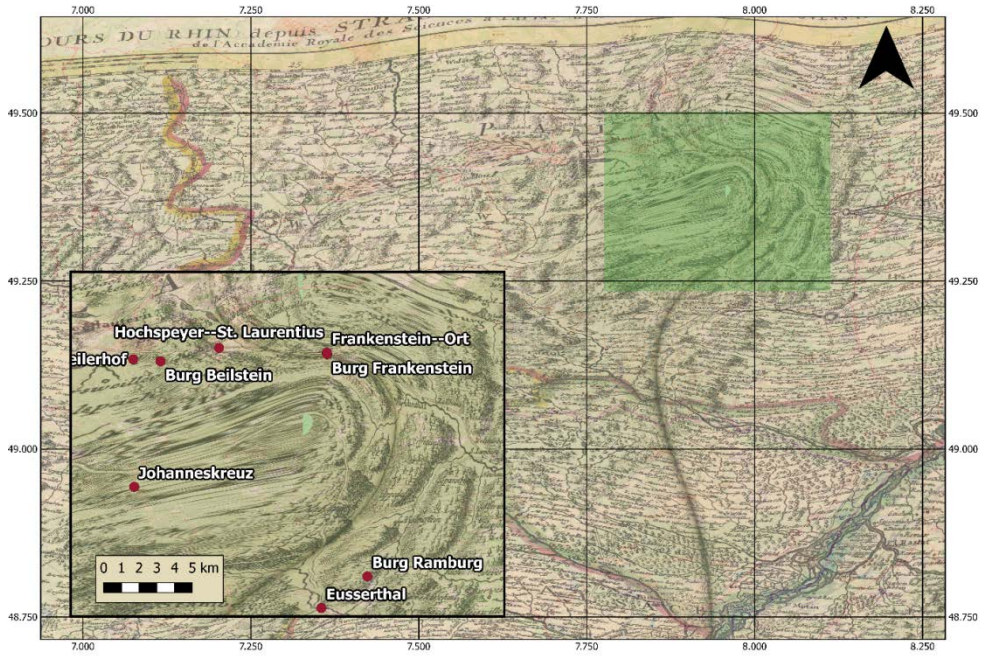


Figure 5: Extreme distortion, after geo-referencing, of the 1742 map in the region of the Palatinate

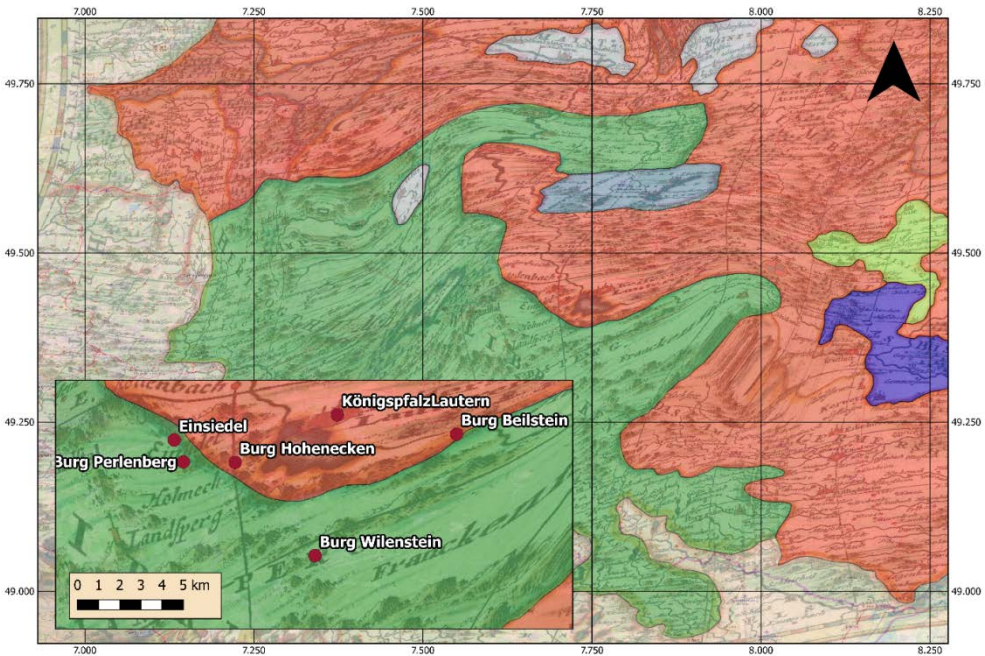


Figure 6: Territories of the Palatinate as outlined in 1682. Note: Electorate of the Palatinate = red, Duchy of Zweibrücken = green

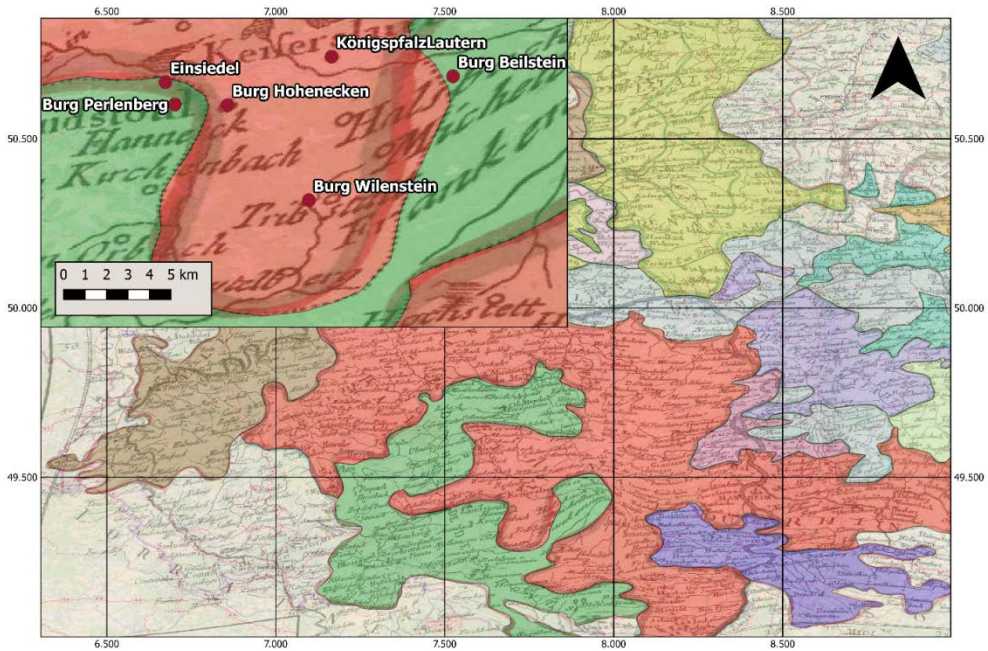


Figure 7: Territories of the Palatinate as outlined in 1777. Note: Electorate of the Palatinate = red, Duchy of Zweibrücken = green.

Geospatial Results in QGIS:

The resulting LCPs do not follow the theoretical direct connections from the Delaunay Projection (Figure 8). Rather, they coincide with many modern roads. The LCP from Burg Hohenecken to both Burg Perlenberg and Einsiedel follows a current forest path that is known to have been a medieval road. The roads from the geo-referenced 1742 map (*Le Cours du Rhin depuis Strasbourg, jusqu'a Worms et le pays adjacens*, by Covens & Mortier, Amsterdam) roughly overlay the generated LCPs, indicating the suitability of our approach to locate the historical roads prior to the 18th century, when three of the sites were still in use (Figure 9). The roads from the 1742 map go directly through two of the six sites (Einsiedel and the Königspfalz Lautern), which were active at that date, due both to their use as reference points and their position directly alongside the former imperial road that led from Metz to Worms.

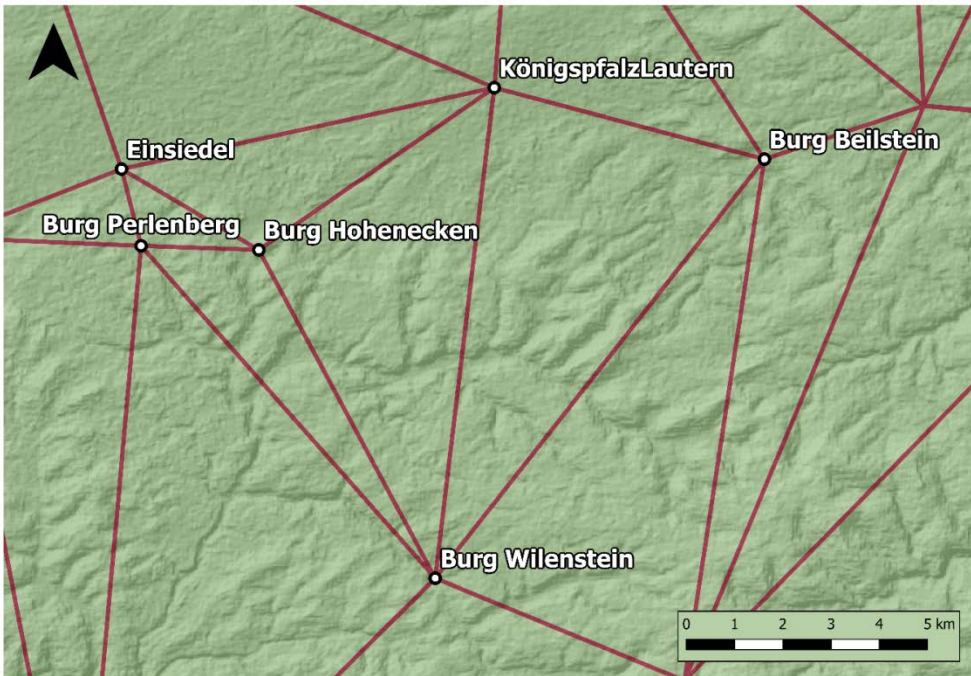


Figure 8: Theoretical connections between the sites based on a Delaunay Projection

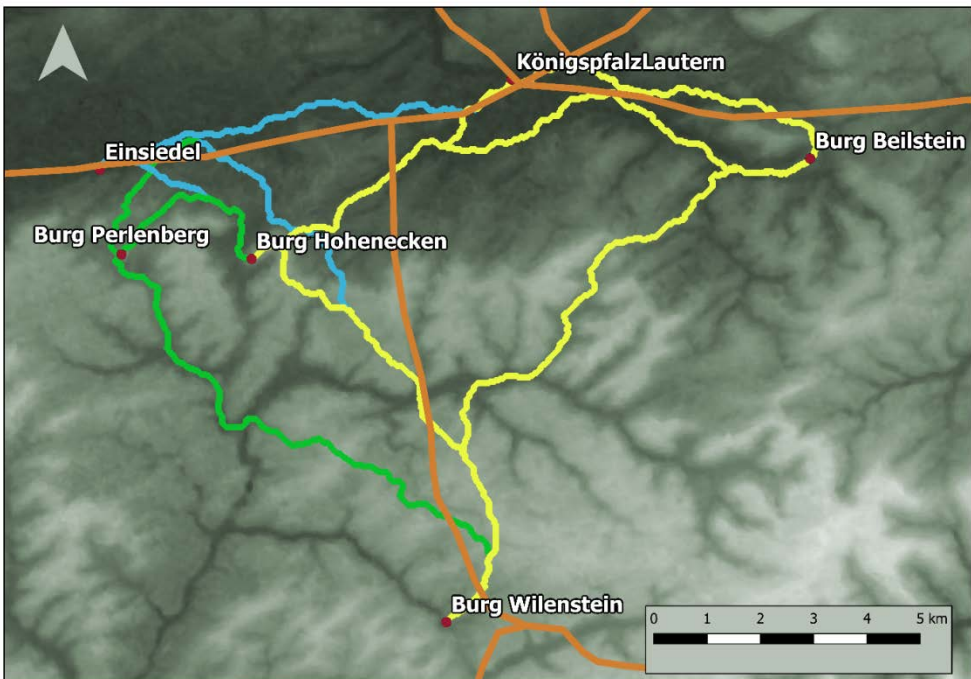


Figure 9: LCPs between the six case study sites, overlaid with the 1742 roads in orange

The viewshed analyses completely contradicted our initial hypothesis that the castles would be in sight of each other. Instead, using the known tower height of Hohenecken (32 metres) and the approximate height of Beilstein (10 metres) as the standards (Figure 10), the analyses demonstrated that there were no lines of sight between the castles. The only area of view shared by three castles was directly north of Einsiedel, where the imperial road was located, running along the shores of a former lake.

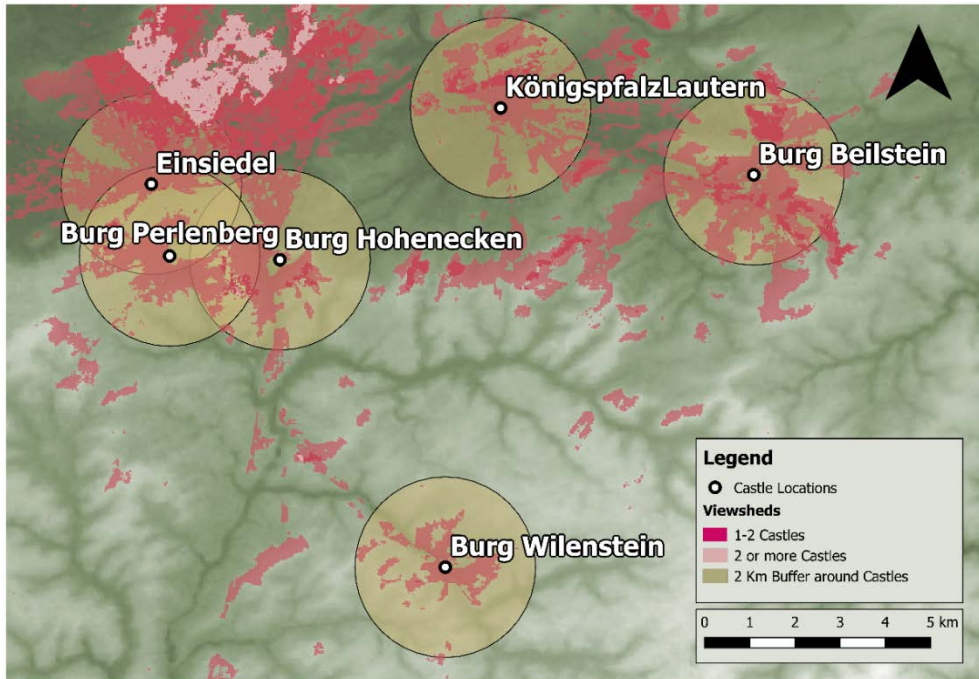


Figure 10: All six sites are invisible to one another

4 Conclusions and Outlook:

The mode in which the castles of the Palatinate operated with one another needs to be reassessed based on the results of the spatial analyses, particularly the viewsheds. None of the castles could view each other, despite having been built within 100 years of one another. The LCPs generated take into account neither the variation of vegetation (height of trees) nor the existence of historical lakes present in the historical maps, both of which will have a profound impact upon future LCPs. GrassGIS-based watershed analyses of the various valleys in the immediate vicinity of the sites will be generated to determine the historical locations of the lakes and rivers. Digitization of the roads and geographic features from the historical maps still needs to be completed for their incorporation into the GIS, as does a segmentation of land regions from the cadastral maps of the 1840s (Kim, 2014). This project demonstrates the effectiveness of using both open-source and free tools for digitizing and interpreting historical geospatial data.

Acknowledgements

CITADEL is supported in part by the Heidelberg Graduate School of Mathematical and Computational Methods for the Sciences (HGS MathComp), funded by the DFG grant GSC 220 in the German Universities Excellence Initiative. We thank the Institute of Geography, and the Digital Humanities and Cultural Heritage research group at Heidelberg University, in addition to the David Rumsey Map Repository at the Stanford University Library.

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