

# **Modelling Spatial Interaction during the Early Iron Age**

Reconstructing and Modelling Ancient  
Infrastructure, Interaction and Distribution  
Systems in Southwest Germany and the Alsace

Dissertation

zur Erlangung des Doktorgrades

der Mathematisch-Naturwissenschaftlichen Fakultät

der Christian-Albrechts-Universität zu Kiel

vorgelegt von

Franziska Faupel

Kiel, 2021

Erster Gutachter: PD. Dr. Oliver Nakoinz

Zweiter Gutachter: Prof. Dr. Rainer Duttmann

Tag der mündlichen Prüfung: 29.03.2021



## Acknowledgements

I wish to express my sincere appreciation to my supervisor, PD Dr. Oliver Nakoinz: he convincingly guided and encouraged me to be professional and do the right thing even when the road got tough. Without his persistent help, the goal of this project would not have been realized. I am grateful to the DFG for supporting and funding the project *Modellierung und Rekonstruktion ältereisenzzeitlicher Interaktions- und Distributionssysteme in Südwest- und Westdeutschland sowie im Elsass* (NA 687/3-1).

Further, I would like to thank my colleagues at the Institute for Pre- and Protohistory at Kiel university for the numerous fruitful discussions. Thank you Christoph Rinne, Martin Hinz, Hendrik Raese, Daniel Knitter, Martin Furholt, Ingmar Franz, Clemens Schmid, Wolfgang Hammer, for your help when a fresh perspective was needed.

Also, Jamsin Rauhaus-Höpfer deserves my appreciation for sharing her excellent and unique knowledge of Salem's cemetery (Baden-Württemberg) and the Early Iron Age of the Lake Constance area.

I want to thank Laurie Tremblay-Cormier and Remy Wassong for sharing their data with me. Without the source of your knowledge, the data acquisition on the French side would not be at the current high level. I want to thank Loup Bernard for his friendly support in all matters relating to this project in Strasbourg.

I want to thank Nicole Grunert for the challenging work of proofreading from the bottom of my heart. You have been a lifeline. Finally, I wish to acknowledge the support and great love of my family. You kept me going on, and this work would not have been possible without your support. I would like to recognize the invaluable assistance that you all provided during my study.



# Contents

<b>1</b>	<b>Introduction</b>	1
1.1	The Phenomenon of Princely Seats	6
1.2	On the Research History of the Early Iron Age	10
1.3	The Hallstatt Culture - a Problematic Term	11
1.4	Chronology	13
<b>2</b>	<b>Theory</b>	17
2.1	Definition of Cultures, and the Archaeological Culture	17
2.2	Interaction in Prehistory	19
2.2.1	Artefacts and Interaction	23
2.3	Infrastructure	25
2.3.1	Archaeological Evidence of Infrastructure	28
2.3.2	Evaluating the System of Infrastructure	29
2.4	Bottleneck Situations in Prehistory	39
2.5	Theoretical and Empirical Models	40
<b>3</b>	<b>Geographical Area: Baden-Württemberg and the Alsace</b>	41
3.1	Subareas	44
3.2	Digital Elevation Model	44
3.3	Landform Classification	47
<b>4</b>	<b>Archaeological Data</b>	51
4.1	Source Criticism	51
4.1.1	Evaluation of Possible Source Critical Filters	53
4.2	Early Iron Age Sites and their Characteristics	55
4.2.1	Graves	59
4.2.2	Settlements	64
4.3	Artefacts	66
4.3.1	Vessels (B1)	67
4.3.2	Ring Jewellery (B2)	72
4.3.3	Remains of Costumes (B3)	78
4.3.4	Weaponry (B4)	82
4.3.5	Means of Transportation (B5)	90
4.3.6	Tools (B6)	93
4.3.7	Art and Jewellery (B7)	97

<b>5</b>	<b>Method</b>	101
5.1	Classification of Material and Collection of Data	101
5.1.1	Classification of Artefacts	102
5.2	Reproducible Research	104
5.3	Reconstructing Infrastructure	106
5.4	Modelling Parameters of Infrastructure	108
5.4.1	Pedestrian Walk and Driving	113
5.4.2	Visibility	114
5.4.3	Lowlands and Mountain Ridges	115
5.4.4	Archaeological Models	117
5.5	Model Patterns of Interaction	117
5.5.1	Type Spectra	118
5.5.2	Distance Diagrams	120
5.5.3	Profile Diagrams	121
5.5.4	Histogram of Cultural Distance	124
<b>6</b>	<b>Results</b>	125
6.1	Baden-Württemberg and the Alsace	125
6.1.1	Reconstructing Infrastructure	125
6.1.2	Identification of Infrastructural Important Parameters	130
6.1.3	Interaction alongside Corridors of Communication	132
6.2	Hagenau	147
6.2.1	Reconstructing Infrastructure	148
6.2.2	Identification of Infrastructural Important Parameters	149
6.3	Breisach Münsterberg	150
6.3.1	Infrastructure	150
6.3.2	Interaction	151
6.4	Swabian Alb and the Heuneburg	154
6.4.1	Infrastructure	154
6.4.2	Interaction patterns of the Heuneburg	157
6.5	Ipf and Hohenasperg	159
6.5.1	Infrastructure	160
6.5.2	Interaction patterns of the Ipf	162
6.5.3	Interaction patterns of the Hohenasperg	165
<b>7</b>	<b>Synthesis</b>	169
7.1	Infrastructure	169
7.1.1	Parameters of Infrastructure	171
7.1.2	Infrastructure alongside the Rhine	172
7.2	Patterns of Interaction	175
7.3	Communication Corridors	178
7.4	Bottleneck Situations of Princely Seats	181
7.5	Perspectives	182
<b>8</b>	<b>Summary</b>	185
8.1	Summary	185
8.2	Zusammenfassung	187
	References	189
<b>A</b>	<b>Classification of Artefacts in SHKR Database</b>	215

# Chapter 1

## Introduction

The Early Iron Age is one of the best-studied periods in prehistoric Europe. Partly due to its long research history — beginning with the excavation of the Hallstatt cemetery (Austria) in 1824, but also due to the monumental character of so-called princely burials and seats. Besides fascinating burial monuments and hilltop sites, fundamental technological and social changes characterise the Early Iron Age. However, covering mainly entire Europe, expressions of the so-called Hallstatt Culture differ, sometimes drastically, but with many standard features connecting this enormous spatial area. For examples, the sun-centred iconography of Bronze Age depictions changes to the display of human bodies in the Early Iron Age iconography. Besides changes in burial habits, settlements and hoards, these circumstances indicate tremendous changes in belief and religion [394]. These circumstances, not yet understood completely, together with further significant changes, frames the Hallstatt phenomenon, which fascinates researchers for generations.

They were beginning with focussing on graves; during the second half of the last millennium, the research foci shifts to settlement structures and the importance of hilltop sites. With more knowledge on so-called princely seats, more questions on the Hallstatt culture's socio-political development arises. During the 1980s, spatial properties, together with theoretical studies, improve the understanding of princely seats' political and social structure, although the discussion is still ongoing (chap. 1.1). For example, the dynastic character of "princes" buried in so-called princely burials genetically related to another <sup>1</sup>. Additionally, rich child burials (Bettelbühl, Baden-Württemberg, or Bourges, France) indicate ascribed and inherited rang, and status [113]; [116]; [250].

An extensive collection of artefacts, sites, and monuments are available to illustrate the Early Iron Age living conditions. For example, detailed studies on burial habits [253]; [523], studies on the structure of the Early Iron Age society [464] or settling of the Heuneburg [252] highlights individuals, society and areas. Regardless, an overarching analysis of interaction patterns, distribution systems and the infrastructure across the European Early Iron Age is still missing.

Nakoinz [345] showed in his analysis of Baden-Württemberg the cultural heterogeneity of the Early Iron Age. The applied method aims to identify territorial structures as cultural areas in order to be able to reconstruct possible areas of influence of central places, like princely seats. Increased interaction occurs within cultural territories, which in turn leads to cultural adaption. Based on type spectra, calculated at evenly distributed sample points, two successive cluster analyses identify reoccurring cultural boundaries, as demonstrated by Nakoinz [341] for the Hunsrück Eifel Culture. Despite assumed territories, Nakoinz [345] shows that cultural segments overlap only partially, resulting in a polyhierarchical cultural structure. Each social group depicts its own interaction area. The second cluster analysis allows Nakoinz to identify the most dominant borders, however, indistinct and overlapping. More compact units characterize northern, middle and southern zones. The

---

<sup>1</sup> Genetic analyses indicate the maternal relationship of the so-called *Dame* of Ditzingen-Schöckingen and the *Fürst* of Hochdorf [199]. Evaluating only a part of the DNA, the relation and the number of generations between the individuals remain unanswered [505].



Rhine, Neckar and Main - Danube are three corridors — elongated interaction zones, seeming to function as interaction channels, meaning higher and wider-reaching interaction networks.

Later, Nakoinz [347] used the existing data to illustrate the concept of interaction analysis, define interaction, distance and models, show the spatial aspect in interaction patterns, and present possible interpretations using some selected type combinations. Costume components, vessel shapes, and decoration describe interaction relationships over shorter distances. Even if the analysis has a more didactic reference <sup>2</sup>, exciting results are nonetheless to be mentioned. Nakoinz determined a global interaction threshold at around 200 km. An attempt was made to optimize, which can be seen from a slight drop in the interaction friction before reaching the threshold. Topographic obstacles and transport systems are also visible in interaction relationships. Results of specific type combinations show that the dispositional context (i.e. settlement or grave) inherits different interaction patterns. Parts of costume components seem to be particularly tied to traffic routes, whereas prestige goods, pottery and ring jewellery suggest long-distance connections [347].

A different temporal and spatial frame defines the analysis of Schneider [442]. Schneider differentiates the transition from the Bronze Age to Iron Age into two main networks with a higher internal interaction rate. The northern network overlaps with the *Nordischer Kreis* and the southern pendant with the so-called *Westhallstattkreis*. In combination with temporally overlapping Bronze and Iron Age communities, the large spatial extent forces Schneider to reduce the considered artefacts in his analysis to two categories assumed to show large scale connections. Needles and razors serve as markers to reconstruct interaction networks between the northern Bronze Age and the Early Iron Age in the southern study area.

The two networks differ in the distribution of sites and their relation to water. Sites and artefacts accumulate near water drainage dividings in the southern network. Schneider interprets this as an indicator of supra-regional communication, while in the northern area, sites and artefacts occur near larger streams, an indicator of local economic organisation. However, due to the more pronounced topographical relief of the southern network, water drainage dividing is a distinct landscape marker. Preference of passes, valleys and natural passages benefit from interaction and environmental properties. The southern network shows an interesting main communicational route. From the Rhône, the route follows the Swabian Alb along the Danube towards the next large stream, the Main and then via Nahe and Altmühltal into the northern network. In contrast, the topography of the northern zones allows for more evenly distributed sites [442].

Furthermore, later emerging princely seats are located at those pre-existing main communicational routes. Which proves, according to Schneider [442], the extension of these location bases on so far unknown pre-existing economically predisposition, besides their convenient location for long-distant connections. Unfortunately, due to the reduction of artefact categories, the results of Schneider display only a segment of interaction. Therefore, the network represents only specific relations between these areas and only a part of interaction — namely, exchanging goods.

Again, a different temporal and spatial frame defines the interaction analysis subjects by Tremblay-Cormier [495]. It aims to understand the cultural and economic dynamics in eastern France, south-western Germany and western Switzerland at the end of the Bronze Age and the Early Iron Age. The methodological framework is based mainly on the principles of “cultural geography” and economics. The various forms and dispositional context of metal artefacts depend on cultural phenomenon, behaviour or technical knowledge. Her data collection <sup>3</sup> allows addressing to define groups of familiar forms and deposition contexts in the study area to determine their geographical extent and interactions. Based on Jacob-Friesens *Formenkreise*, facies describe typical artefact combinations. The facies, combined with dispositional behaviour from regional zones. The term territory is avoided as it implies borders and political control, which is a delicate topic without direct evidence from written sources or boundary stones.

The results on a Factorial Correspondence Analysis show statistical groups of indicators, named facies, and their affinities. When given a spatial extent, these facies became entities. In combination with other material cul-

<sup>2</sup> The present work uses most of the methods developed and described by Nakoinz, or develops new forms of representation based on the theoretical and methodological foundations (see chap.: 2.2).

<sup>3</sup> Stored in a relational database, which is now integrated into the SHRK database structure.

ture parts like funerary practices, cultural groups could finally be put forward. She supposes for Ha C following cultural groups: e.g. alongside the Upper Rhine valley, which persists from the Late Bronze Age, western Swiss, Burgundy, France-Comté and Rheinland-Pfalz. During Ha D, more groups emerge and split the larger Upper Rhine entity into a northern and southern Upper Rhine group, Swabian group and one on the Swiss Plateau. Already during Ha C, contacts of the Upper Rhine valley to Württemberg and Bavaria is represented by wagons, harness and ceramic artefacts. Contacts to Northeastern Swiss are visible for ring jewellery, like type *Bern*, *Schötz* and *Tschugg*, lance heads or tweezers (chap.: 4.3). More intensive contact to Lothringen from the Upper Rhine Valley occurs in Ha D1, besides intensive interaction to Württemberg and alongside the Danube valley. With Ha D3, Tremblay-Cormier differentiated two groups for the Upper Rhine valley. The northern group intensifies its contact to Württemberg, e.g. decorated belt plates or pins with small spherical heads of coral and amber. The southern group has a more intensive connection to the Swiss plateau.

Besides investigating the entire population, Tremblay-Cormier also addresses the interaction among assumed elites. Based on a corpus of more than 200 graves in France, she investigates common structures in elite burials of the early Iron Age [496]. The main characteristics of elite graves are proposed: the dominance of weapons (swords) and *ad hoc* presence of wagons, harness equipment and metal vessels. However, the result is a homogeneous set with a general differentiation of the eastern border going from Alsace to the Jura and the extreme southwest (Languedoc). The Upper Rhine might also be linked to a group centred on southern Bavaria, where wagons and metallic vessels have a more critical role in the funerary set. The sharing of practices and ideas by individuals of the same social status, over such a vast geographical extent, leads to the identification of a strong interactions network between the elites and a sense of belonging to a privileged group [496].

As a central drive for cultural, social and technical change, interaction is the central theoretical focus. Exchanges with others create needs or at least make them more transparent. Of course, the natural and social framework must not be disregarded, but it is primarily these needs that demand innovations, adaptations and solution strategies. The transfer of ideas urgently needed to satisfy the needs triggered is also only possible through interaction. Nakoinz [343] emphasises the dynamic connection between the development of societies and interaction in his methodology for analysing interaction patterns as an essential key term in research. This dynamic relationship continues in various aspects characterised by interaction, such as infrastructure, communication network or exchange system. Interaction between people or groups, directly or through an intermediary, is only possible through communication. Communication is, therefore, an essential method of interaction, as it facilitates the exchange of information (chap.: 2.2). Communication is not a modern invention, which increases with new technology. Humans have been connected and communicated across large geographical distances in prehistoric times, as proven by trade goods. Interaction always leaves traces in artefacts, technological development or societies. Decor, material and shape of artefacts depict those influences and contacts, enabling archaeologists to retrace sender and recipient.

Early in the research history, with the discovery of foreign goods, questions arise on origin and meaning, the covered distance, and the exchange or even trade organisation. There are various alternative routes to reach a destination, although knowing the road system. Especially considering an artefact has not reached its destination directly. Since the Early Iron Age paths are paved only rarely, there are few markers to reconstruct a route (chap.: 2.3.1). Therefore, numerous reconstructions of the Early Iron Age's trading network or exchange system base on the mapping of imported goods, topographical features (Alpine passes) and considerations of ideal routes.

The reconstructed supra-regional connections based on Mediterranean import goods — found mainly on princely seats — by Pauli [375] is highly influencing, which results in various reprints [406]; [445]. Pauli considers those sites, which — besides Mediterranean import — located near rivers are reloading points to switch means of transportation. Therefore, Pauli assigns river systems high importance and reconstructs trade routes along large navigable rivers connecting princely seats with a short cul-de-sac. From Ha D 1 onwards, more long-distance routes develop connecting the Mediterranean world via first the Rhône, later in Ha D2 across the western Alpine passes, and in Ha D3, eastern Alpine passes, passing the Dürrenberg.

The reconstruction presented by Pauli is criticised for being monocausal, neglecting routes across land and, as only Mediterranean imports are used to reconstruct connections, Pauli's maps record only trade or exchange

routes of these artefacts [101]. Furthermore, the connection to the Golasseca culture in Upper Italy proven by small bronze artefacts depicts a contradicting chronology of southern routes. Pare [358] and Egg [76] state that the central Alpine passes are in use before the Rhône routes develop in Ha D2/3. Hauser [171] criticises that other sites are excluded as not fitting to the assumed topographical location, although archaeological evidence would allow their consideration.

Stary reconstructed long-distant connections between northern and southern Germany based on artefact distributions [463]. Former eastern connections from northern Germany move to more western connections during Ha D. Changes indicate non-stable conditions, especially in northern Germany. Therefore, Stary reconstructs different routes for long-distant exchange. During Ha C, three main routes lead northwards from Bavaria following the Elbe and Baden-Württemberg following the Main. The routes branch in the Central German Uplands. During Ha D, only two main routes connect Baden-Württemberg to the north. One follows the Danube, Regen, Saale and Elbe. The other begins at the Upper Rhine and follows the Main until reaching the first route. These schematic reconstructions of routes depict interaction connections rather than realistic path reconstructions. Salač [421] criticises that the realistic route may lay distinctively dislocated from the markets. Moreover, river systems play an essential role in locating connections without proving their significance for transportation systems.

Koch and Scholz [234] points, that the route from Breisach to Heuneburg across the valley of the river the Breg was impassable for wheeled vehicles until 1770 AD. Therefore, they suggest using the Magdalenenberg as a landmark for this long distant connection instead of Paulis [375] suggestion. For reconstructing the route, Koch and Scholz use the google navigator in pedestrian mode resulting in one optional route passing Buchenheim and Villingen. They assume that this transect was — at least in summer — a possible day trip based on the estimated travelling time by google of 12 h [234]. As Herzog states, the construction of the Least Cost Path is not an easy task [183]. Koch and Scholz, however, does not evaluate the cost surface generated by google, the applied cost function or the method for calculating travel time. Their results are fascinating, but missing discussion on method and data reduce the significance.

Early Iron Age stone-paved road and bridge constructions connect the Franconian Alb with the Danube Valley via the valley of the Schwarzach, Anlautertal, and Wellheimer valley [445]. However, these favourable connections for transport are not considered in the previous reconstruction of prehistoric exchange like presented by Pauli [375]. Schussmann states that import good are present at sites on the Franconian Alb, although not very numerous. The function as a transit area to provide the central place Ehrenbürg with goods may explain the stone-paved road (e.g. Großhöbing (Roth, Bavaria) or Enkering (Eichstätt, Bavaria)) and wooden bridge construction (Kränzelstein (Eichstätt, Bavaria)) dating to the Early Iron Age, used later in La Tène also.

The importance of river systems for the transport system also becomes apparent when evaluating the interaction areas of the Early Iron Age by Nakoinz [344]. Here, rivers emerge as essential corridors for communication, although this supra-regional approach does not make any statements about the actual location of the path or the use of waterways. Princely seats locate at borders of zones with higher interaction and nearby communication axes, indicating a position near intersections of communication and possible control. Nakoinz calls this a gateways function with princely seats having a high network centrality, with a low Christaller centrality.

This project focuses on interaction in different spatial scales and perspectives while reconstructing and modelling with a broad interdisciplinary tool-set. Global trends in interaction processes in contrast to local interaction relationships will increase the understanding of the complicated system forming the Early Iron Age's heterogeneous cultural area. Short distance interaction, which is usually problematic to approach with traditional concepts, is retraceable using the cultural distance approach developed by Nakoinz [347]; [348]; [349]; [337].

For a better understanding of the Rhine Valley as a factor for communication and interaction, the area of Baden-Württemberg is enlarged, including the Alsace (France) 3.1. Now, the central area (Baden-Württemberg) is connected to both main European river systems — Rhine and Danube, resolving edge effects due to political borders (chap.: 3). The Rhine and Danube serve here as reference areas, as they allow to investigate commu-

nicational corridors, different environmental settings and different primary orientation. The new perspective of analysing cultural distance results in new distance diagrams.

Besides river systems and their role in interaction patterns, global trends, indicated in distance diagrams, describe the system of interaction during the Early Iron Age. By investigating different cultural distance segments, range, thresholds and relationships are identified for different social segments.

In contrast to the overarching supra-regional perspective, several local evaluations consider local dynamics, differing geographical settings and allow detailed studies for aspects with unbalanced data coverage. The integration in terms of the interaction of so-called princely seats into their hinterland is illustrated based on the spatial representation of interaction friction.

Several subareas are selected to understand better local dynamics, representing different environments, geographical settings or gateway positions in *sensu* Nakoinz and evaluating integration into the interaction system. Nakoinz [345] could identify a gateway position for the Heuneburg, the Ipf and Hohenasperg. The Breisach Münsterberg is located too close to the modern political borders of Baden-Württemberg for robust estimation. Although overcoming the modern political border, testing for the location at a gateway position is not the focus of this analysis. The integration of so-called princely seats into the system of infrastructure and interaction highlight differences in local and supra-regional connections will be fascinating as this may allow concluding the organisation of infrastructure, exchange and preferred interaction partners. Using the Breisach Münsterberg as a viewpoint for interaction analyses will illustrate connection into the Belfort Gap and alongside the Rhine. In contrast, the Heuneburg as viewpoint will integrate the Danube with an east-western direction into the interaction analysis. Besides interaction processes, the integration of so-called princely seats in infrastructure and distribution systems is investigated to understand these sites' formation better.

Barrows in the Haguenau Forest provides detailed data of cultural material and precise geographical data. The rich equipped burials and a potential wagon-grave at Maegstüb (Haut-Rhin, France) [495] arise questions on potential princely seats. So far, Battert [25] and Seltz [169]; [504]; [509] are in discussion as possible locations<sup>4</sup>. Until today the Haguenau Forest is covered with woodland due to unfertile soil, which conserves barrows. Recently, Wassong documents the current state of barrows, including precise GPS data of spatial organisation and infrastructure analysis locations. Linear aligned barrows with regular spacing, ostentatious barrows near the Rhine, and long chronologies of necropolis close to the Rhine compares Wassong to the meaning of barrows describes in the saga of Beowulf [508]; [509]. Regarding infrastructure, based on an intuitive approach Wassong identifies five main routes directing to the Rhine (chap.: 6.2.1). Although the data recording is outstanding and the shared GPS data highly precise, the topographic analysis and path reconstruction lacks reproducibility and proper statistical and geographical methods. The precise locations of single barrows combined with the well-published archaeological material enable us to analyse the local infrastructure by reconstructing the path systems. Especially the connection to the Rhine as a supposed communicational corridor is interesting.

Although the significance of transportation for the Iron Age is well-known [117]; [421], the reconstruction remains an open issue [337]. So far, mainly theoretical models based on partial data (import goods) and an emphasis on river systems outline possible connections while neglecting alternative routes, cultural effects or the exact location of the path. Although river systems are important networks for infrastructural systems, terrestrial connections need to be considered likewise.

This study aims to reconstruct the Early Iron Age path system using pattern recognition based on path associated features for the infrastructural analysis. The Repath method, a density approach, was successfully applied for a Bronze Age case study in Schleswig-Holstein [111]. The reconstructed path system also enables us to evaluate the princely seat's location within the infrastructural system. Furthermore, relevant parameters influencing the location of the path system are evaluated for a better understanding of the system of infrastructure. Again, both scales are addressed. Supra-regional conditions might mask local effects. The disadvantages of covering a sizeable heterogeneous area will be overcome with a local evaluation of path parameters.

---

<sup>4</sup> Leutenheim/Hexenberg revealed only Bronze Age settlement structures [2]; [276]. Further settlements locate at Brumath [3], Klosterberg [276], Hügelsheim, Iffezheim, and Sinzheim [509].

Focussing on interaction patterns, especially the combination with infrastructure and exchange systems, leads to a better understanding of communication, the emergence and decline of regional cultural groups. Therefore, interaction, infrastructure and exchange relate mutually, integrated into overarching methods and combined interpretations. Based on the analysis of so-called princely seats in terms of interaction pattern and infrastructure, bottleneck situations in controlling trade and exchange flows occur, which might explain these sites' location and the possible accumulation of wealth.

## 1.1 The Phenomenon of Princely Seats

The ongoing discussion on the phenomenon of princely seats in south-western Germany and eastern France is still influenced by Kimmig's model of a Mediterranean reflex of living conditions and his "check-list approach" with a fortified hilltop site, rich aristocratic burials, and the presence of Mediterranean imports [224] even though criticised several times [103]; [99]; [212]; [330].

In Kimmig's perspective, princely seats resulting from an established nobility, retracing Caesar's description of leaders [224]. The political position of these leaders and the social structure of their groups evolved gradually, resulting in nobility, as Kimmig interprets it, is rather unlikely. In contrast, Caesar's rarely mentions leaders or the Celtic social structure. In those cases, he describes the rivalry between leaders or emphasises the personal strength of individuals (Caesar bell. Gall.: I,3; V,3; VII, 76). This points to a chiefdom structured society, which Kimmig rejects as taken from modern ethnological comparisons [224].

Furthermore, Kimmig does not explain why a nobility can be assumed between the Early Iron Age and late La Tène without indicating artefacts, while no nobility is assumed for the periods before the Early Iron Age, despite also missing proof. Besides this vague reconstruction of nobility, Kimmig understands princely seats as a barbaric reflex of Mediterranean living conditions. The construction of a fortified *acropolis* and a surrounding *suburbia* represents the idea of a polis in a rather planning and constructing sense than in a socio-political one [224]. As hilltops have limited space, with a growing population, suburbia develops naturally.

Hence, this phenomenon appears as convergence. However, if princely seats indeed imitate Mediterranean living conditions, Jung points to missing further adoptions, like the Etruscan adopted writing [212]. For Kimmig, another critical indicator of nobility are imported goods representing spending capacity [224]. Princely seats are usually conveniently situated for trade. Hence, they may have more available access to imported goods and derived wealth from their trading position. The chronological discrepancy between princely burials within one necropolis indicates dynastic cemeteries [224]. The central burials of the four grave mounds of the Gießhübel-Talhau (Baden-Württemberg) necropolis near the Heuneburg indicate successive funerals, although all artefacts are dating to Hallstatt D2 [431].

While Kimmig focuses on princely seats as indicators of nobility, Härke [166] emphasises economic reasons for changing settlement structure. During Hallstatt C dominates the agricultural economy. Caused by increasing contacts to the Mediterranean in Hallstatt D1, settlements are reorganised and displaced towards natural long-distance paths. Social stratification arises and declines shortly after Ha D during the following decades. In contrast to Kimmig or Pauli (see below), both placing the foundation of Massalia before the changes northern the alps, Härke orders the events differently. Hence, after establishing an elite that could profit from contacts to the Mediterranean, contacts were intensified [166]. The shift of settlements combined with an increase of settlements, the hierarchy of settlements and the spread towards the North attributes for Härke the "phenomenon of princely seats". "Voluntary urbanisation" matches the discontinuity in settlements size of princely seats like the Heuneburg, while "mandatory urbanisation" would result in more stable settlement growth. Princely seats lost their advance, perhaps because they lost their political or economic power [166].

Aside from a chronological shift towards princely seats in the northern periphery, those sites have a larger enclosed area. Even though Härke could not exclude natural causes like more extensive plateaus, he suggests an economic reason: Pastoral economy and animal breeding require larger fortified areas to protect cattle [166].

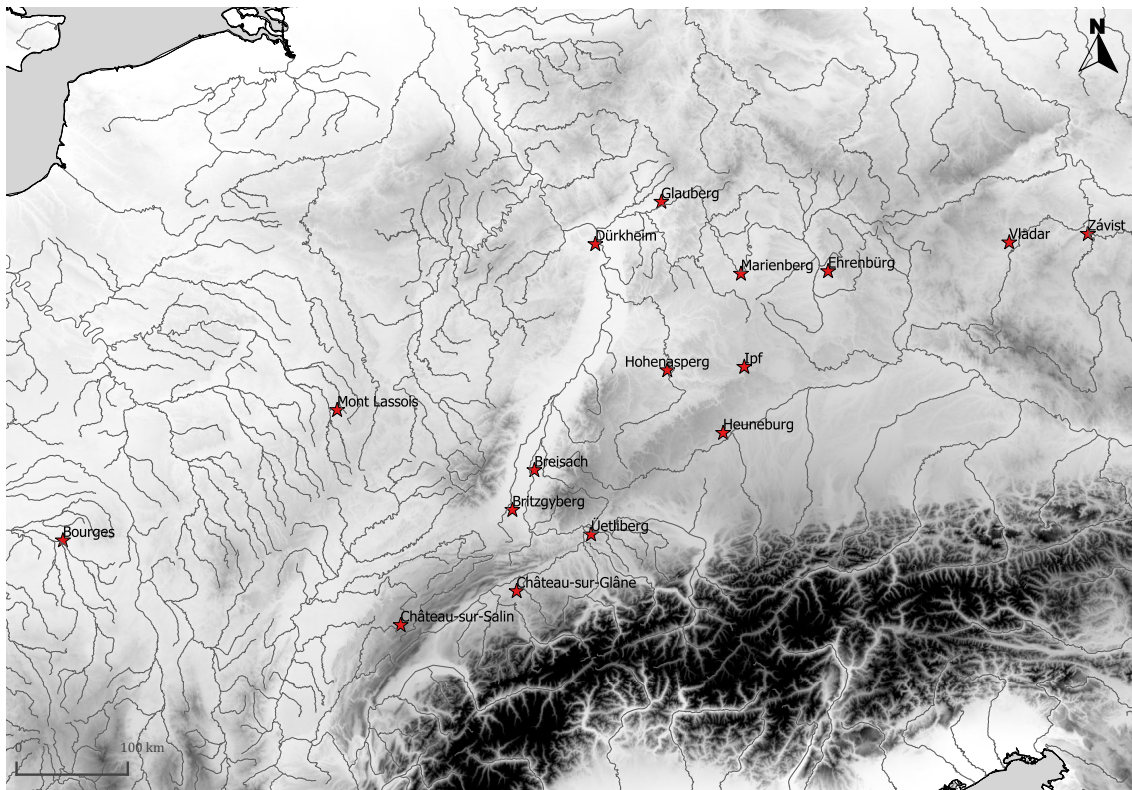


Fig. 1.1: Early Iron Age princely seats in Europe (DEM: SRTM 90 m).

Further, Härke reconstructs the settlement hierarchy and the size of primary territories of 20 km around princely seats using the distribution of settlements [166]. His theoretical model of territories is sensitive to the definition of settlements and their hierarchy and the basic assumption of an existing hierarchy and territory. However, Biel tries to use empirical data for reconstructing territories. Therefore, he uses needles from spruce in badger coats of the cline of Hochdorf to reconstruct a large hunting ground for a nobility extending until the Black Forest [33]. Pollen extracted from the beak-spouted ewer at Glauberg indicates a territory up to 90 km. However, these two exceptional examples only prove existing contact and no depending territories because several mechanisms are possible for the existence of these features [103].

In contrast, Pauli rejects all approaches before 1978 as using historical sources in an unreflective manner resulting in *bibulous potentates* imitating Mediterranean conditions [372]. Pauli formulates a model in which Hallstatt D and La Tène A are contemporaneous. Princely seats had to compete against the Early La Tène culture focussing more on natural resources, while princely seats focus on trade [372]. According to Pauli's model, conditions and events taking place in the Mediterranean influence the evolution of the Hallstatt Culture. Despite his rejection of the *bibulous potentates* imitating Mediterranean living conditions, his model is based on a *barbarian elite* only capable of warfare. Additionally, Pauli's approach connects the princely seats to the Mediterranean world system neglecting independent developments.

Parzinger [369] criticises the implied social dependency indicated by the term nobility. As Kimmig lists some evidence for nobility, e.g. rich grave inventories (princely seats), monumental building, and import goods (princely seats), Parzinger tries to retrace these indicators from periods with known social dependencies. Therefore, comparing settlements structures with known social dependencies show overbearing domestic buildings

as a standard indicator. This difference in domestic buildings is unknown at the best-studied princely seats, the Heuneburg. Rich grave inventories indicate an elite, however not necessarily social dependencies. Furthermore, lacking evidence for dominant domestic buildings, the concentration of precious or imported goods inside the settlement does not support the interpretation of the social structure based on dependencies like the term *Fürst* indicates.

The model of concentration of power by Pare [358]; [360] base on a reduction of signs of powers (daggers, swords, wagon or harness) with a contemporaneous incline in their exclusivity and political meaning from Ha c to Ha D2/3. Pare combines this with a model for the social and political role of the individuals and the elite located at a princely seat [361]. However, this approach is again sensitive regarding the absolute dating of the phases Ha C and D. Maise [299] points out that the subphases decrease in their duration and a false reduction in signs of power occur. Assuming 475 BC as End of Ha D3, the described trend by Pare indeed shifts. Maise draws a different picture for the Breisgau: Several hilltop sites dates into the Early Iron Age spreading with a primarily regular distance of 4-5 km. Therefore, during Ha C and D1, the southern part of the Upper Rhine valley lacks a supra-regional political organisation. Power seems not to be institutionalised. In contrast, a supra-regional political centre is erected in late Ha D at Breisach. The settlement structure changes from equal rural settlements to a hierarchical structured regional organisation positioned at a representative and conveniently situated hilltop.

Eggert's critic bases mainly on Kimmig's opinion that archaeological empirical analysis has sufficient material indicators to reconstruct past realities and terminological problems are of less importance. Eggert emphasis that due to a lacking theoretical background and missing rigour in Kimmig's concept, Kimmig's approach is not applicable [103]. However, Eggert notes that Kimmig tried to induce a discussion instead of giving a list of needed features to be fulfilled by a princely seat. Naturally, Eggert criticised those archaeologists using the criteria in such a manner. In light of increasing data on princely seats, Eggert aims to develop a general pattern of the phenomenon by interweaving different sources on a social and economic basis.

Regarding subsistence strategies, two general patterns can be identified. First, at princely seats, reduced spectra of crop plants are documented while a broader spectrum is found at rural settlements [103]. Second, comparable to botanical studies, the spectrum of faunal assemblages from princely seats differs from rural settlements. At princely seats, pigs dominate, while in rural settlements, cattle is dominant. These proportions do not support elite consumption: Breeding of pigs in densely settled areas is more manageable than cattle, and pigs produce meat quicker. On the contrary, cattle provide more advantages for rural settlements because of secondary products and labour exploitation [103]. Another economic factor often connected to princely seats is craftsmanship on a high level of specialisation with mass production.

This degree of specialisation and productivity is an essential aspect for central places (see below). Unfortunately, at Heuneburg, indicators of this kind are lacking. All remains of craftsmanship at the site are of little volume, proving only local manufacture. For the social structure of the Early Iron Age, Eggert concludes a segmentary society with chiefs or *Big Man* as leaders. Princely burials might have served as funeral places for these individuals. The subdivision of the suburbia at the Heuneburg can be interpreted as settlement areas of different lineages [103].

A different approach supports the Priority Programme SPP 1171 "Early Processes of Centralisation and Urbanisation - Studies on the Development of Early Celtic princely seats and their Hinterland"<sup>5</sup> to understand the *phenomenon of princely seats*. Princely seats were assumed to be centres *sensu* Christaller [60]. Hence, not only economic but also cultural and religious centres inhabited by a noble family. Factors supporting the process of centralisation are favoured climatic conditions, distribution of iron technologies, and contacts to the Mediterranean world [251]. Central places can fulfil diverse centrality functions like sovereignty, protection, trade, craftsmanship and religious functions [151]. Evidence of most functions are rare at princely seats; on the one hand, because they are unverifiable, and on the other hand, some functions are proven by the existence of only one feature [386]; [387]. For example, fortification can be a function of protection or useless fortifications, a function of power [345]. As one criterion of princely seats is a fortification, all princely seats have in common

<sup>5</sup> founded by the German Research Foundation

to fulfil this function. The second most frequent functions are trade and craftsmanship. Especially for trade, often single imported objects are used to verify this function. Of course, retrieving such an object is strongly linked to taphonomic processes and excavation activity. As Eggert [103] pointed out, the degree of specialisation in craftsmanship does not support a central function. As a central function, religious proposes is properly verified for the Glauberg [387]. Princely seats display not enough central functions allowing to be addressed a central place. However, as princely seats do fulfil some central functions, they can be identified as complex settlements.

Nakoinz uses cultural geography approaching the organisation and territorial structure of princely seats and their surrounding settlement area. Dependency between rural settlement and princely seats/graves existed with present distinct cultural borders. However, Nakoinz demonstrated a heterogeneous cultural pattern of the Early Iron Age in Baden-Württemberg without a clear relation between princely seats and territories. These results do not support the interpretation of princely seats as central places [345]. Interestingly, Nakoinz analysis on cultural areas suite Eggert's interpretation of a segmentary society; as these segmentary units are socially, politically and economically independent, clannish behaviour is not strongly pronounced [103], which would lead to diffuse borders and vague zones on higher interaction. Princely seats seem to appear near the margins of diffuse cultural zones and communication corridors. Nakoinz suggests that they are located at "gateway positions", controlling and enabling trade and exchange.

Results of geographical studies by Posluchny can support the gateway model by Nakoinz. Princely seats occur in distances of 5 km to physical geographical borders or navigable rivers [386]. Hence, princely seats have a convenient position within their landscape. That these positions are as well convenient from a communicational point of view is evident by Nakoinz analysis. Regarding economic subsistence, Posluchny calculated catchment areas for princely seats and rural settlements. An agricultural subsistence is unlikely, as catchment areas of princely seats are distinctively smaller than of rural settlements [386]. They are indicating a prominent location in order to control the surrounding landscape. Indeed neither the Heuneburg nor the Glauberg has good visibility based on viewshed analyses. The neighbouring Mount Bussen next to the Heuneburg has a significant larger viewshed. Hence, they are not centrally placed in their landscape, which does not mean that they have no central meaning. Emphasising princely seats' diversity, Posluchny points out that each princely seat might have only reasons for its growth and wealth. Trying to find one model fitting all princely seats will fail [387].

Fernández-Götz emphasis two distinct zones — North of the Alps and the Mediterranean — evolving parallel and in close contact, rather than a dependency of the North from the South. His definition of *city*<sup>6</sup> recognises variations in urban traditions and defines a city as a "numerical significant aggregation of people permanently living together in a settlement which fulfils central place functions for a wider territory" [112].

North of the Alps first urban or proto-urban centres developed between the seventh and fifth centuries BC between Závist (Bohemia) and Heuneburg (Germany) due to demographic growth, hierarchisation and centralisation. Princely Seats are heterogeneous in layout, occupied area, function and lifespan, but for Fernández-Götz, they represent focal settings for tribal polities [114]. Low-density urbanisation characterises Heuneburg and Bourges<sup>7</sup>, while other princely seats show other signs of urbanism<sup>8</sup>. This ephemeral phenomenon follows a period of crisis, abandonment of central places, and a more decentralised settlement pattern [116]. Resulting in a more decentralised settlement pattern, without major agglomerations and a reduction of social inequalities between the fourth and early third centuries BC [50]. Fernández-Götz points out that contacts with the Mediterranean played a role in cultural change, however, mainly due to and not the cause for the emergence of princely seats. Moreover, he understands the development during the Early Iron Age as a similar and mostly parallel social trend triggered by demographic growth, social hierarchisation and production intensification. Climatically favourable conditions, populations increase, and new areas for agriculture and other economic resources are the basis of the wealth of this new social elite [116].

<sup>6</sup> Posluchny criticises the concept of urbanism. He suggests not to define urbanism in a way fitting to Early Iron Age circumstances, instead of using the concept of centralisation [387].

<sup>7</sup> Recent examples for low-density urbanism are Angkor, Cahokia or Great Zimbabwe, prehistoric examples are Trypillia mega-sites from Ukraine, princely seats, and *oppida* [116].

<sup>8</sup> Mont Lassois: large apsidal buildings, Ehrenbürg: storage pits, Glauberg: religious function [116].



Assuming the existence of a hierarchical organisation and a somehow common "Celtic" culture centres the critic of Hill [189] on the interpretation of hillforts as central places. Early and Middle Iron Age hillforts in Wessex (Britain) do not support the interpretation of hillforts as centres of production, exchange, or elite residences. Hill states that hillforts seem to complement the settlement system rather than dominating it. The absence of marked social inequalities in settlements, combined with only sporadically occurring hillforts, does not attest to centrality or dominance. Hillforts are not concerned with defence and warfare as generally assumed.

Furthermore, they do not represent a coherent monolithic class of monuments. Hill denominates hillforts as "not farmsteads". Although this evaluation bases on data from Britain, analogies to the Central European Early Iron Age are evident. Princely seats are not evenly distributed, proof for central function varies, and marked social inequalities in settlements are missing — however, very pronounced in grave assemblages.

Recently, Rieckhoff exposes the narrative motives for interpreting cultural change between Hallstatt and Latene explicitly for Kimmig, Pauli and Guggisbergs work [407]. Cultures are narration communities with open and hidden narratives [11]; [130]; [131]; [518]; [519]. The first level of narration, the indigenous story being told using images or language, remains unknown. It is conserved in archaeological artefacts with symbolic character. The second level of narration is constructing narrative patterns that are embedded into the next levels of so-called master narratives. All three narratives tell the transition from the so-called Hallstatt to the La Tène culture based on the same narrative pattern: The story of progress. While Kimmig lets the underdeveloped "Hallstatt Celts" become more or less civilized Europeans through the *completely new* Latène art. At the same time, Pauli has stylized the *radically new* art as a symbol of the revolt against the Hallstatt princes. In contrast, Guggisberg [153] interprets the same artefacts as an expression of a continuously increased consciousness for tradition among a conservative elite, which at a certain point in time derives its new identity from the recourse to images of a bygone era <sup>9</sup>.

Rieckhoff illustrates well possible interference of archaeological interpretations by narrative patterns, which naturally are affected by the current zeitgeist. The above-presented interpretations of princely seats' emergence and decline display this affection of zeitgeist and narrative patterns. In the end, it is possible to identify some common tendencies. The economy seems to be more relevant than geographical or cultural centrality for the location of princely seats as supposed earlier. Princely seats show individual adaptations to local circumstances, which leads to individual reasons for their emergence and wealth. A monocausal trigger seems unlikely, which does not neglect southern influences. Still, princely seats' political role and importance remain unclear, while further questions arise on the interplay of politics and economy.

## 1.2 On the Research History of the Early Iron Age

Compromising the long history of Early Iron Age research on a few pages is impossible. That would not do justice to the fascinating story of single researchers, excellent work of previous generations of archaeologists, or exciting results of more extensive research activities. Therefore, the following chapter limits and summarizes research history to giving insight and background for the planned work <sup>10</sup>.

Systematic excavations driven by a specific research question started in Europe around 1820 to 1860, trying to discover the past, mixed with romantic and patriotic understanding [218]; [244]; [524]. During the following decades, research activities increased, especially excavation activities on burial sites in eastern France and

<sup>9</sup> The problematic temporal shift between so-called textitkeimelia and the beginning of the La Tène art might be solved if the proposed hypotheses by Trachsel [494] with an early beginning of Lt A is accepted [407].

<sup>10</sup> Generally on research history in Baden-Württemberg see Paret ([366], Schiek [433] or Dauber [71]).

Baden-Württemberg<sup>11</sup>. The early focus of research<sup>12</sup> on grave mounds do not surprise, as these monuments are visible, and numerous artefacts can be expected [213]; [354]; [441]. In both regions, it took several years from the beginning of research activities until synoptic publications were released (e.g., [351], [503]).

Shifting research interest or a strong bond to single personalities might cause some incline or decline of excavation activities. Kurz's section on research history seldom describes fluctuating activities without giving further explanations [262]. Certainly, triggers for numerous beginning excavations are crucial for the composition, understanding and evaluation of recovered material culture<sup>13</sup>. Economic and political circumstances influence immensely archaeological activities. Whereas declining activities during cross-national conflicts appear logical, fluctuating activities during peaceful times need further explanations. More recently, Müller-Scheeßel used his data collection on burial sites in Bavaria and Baden-Württemberg to investigate economic and political influences on archaeological activities. He differentiated 4 phases of high excavation activities (1825-1845, 1880-1910, 1920-1939, 1950-2000), two phases of low activities can be linked to both World Wars, while the earlier reduction between 1845-1880 correlates to several more minor conflicts, political turnover (revolution in 1848/49) and social-economic development (industrial revolution) [333]. Furthermore, fluctuating activities during phases of high activity correlate with economic development<sup>14</sup>. Surprisingly, during phases of disfavour inclining, Baden-Württemberg explains best by incidental income supported with the excavators' profession [333].

Shifting research interest after 1950 moved research activities towards settlement structures and dominantly towards princely seats (chap.: 1.1). Although most of them are known earlier today, only a few are excavated to a greater extent, which is caused by later reuse of the hilltop sites. For example, large scale excavations on the hilltop site Heuneburg (Baden-Württemberg) between 1950 and 1979 recovered a third of the plateau. Due to the fortification, imported goods from the Mediterranean and the artefact assemblage, the site is one of the most important princely seats in Europe. Further excavations in the following decades integrated the hilltop fortification into a densely settled area. More recent research activities focus on the surrounding areas of princely seats, like at Heuneburg, where new results revealed a heavily fortified lower town and exterior settlement of approximately 100 ha comprising dense groups of farmsteads [112]; [252]; [263]. Similar, recent excavations at Bourges (France) revealed another princely seat at an enormous scale [116].

### 1.3 The Hallstatt Culture - a Problematic Term

Like the chapter on research history, a detailed study of the term Hallstatt Culture is beyond the scope of this work. Regardless, it is necessary to highlight some important facts for the interaction study of the Early Iron Age in Central Europe.

Difficulties defining a culture are manifold, beginning with a discussion on what culture is (see 2.1), how to identify properties, and how to draw spatial outlines. The existence and spatial differentiation of the so-called *Westhallstattkreis* and *Osthallstattkreis* serve as an example of the problems we are facing with defining a uniform culture while heterogeneous groups apparently dominate [238]; [328]; [217]; [486]. A uniform Hallstatt culture cannot be defined; it is rather a conglomerate of regional groups who share some commonalities and are contemporaneous. These commonalities might be supported by an elite with widespread, highly specialised and related appearing expressions [241]; [368]. What is left to characterise the Hallstatt culture is a kind of Hallstatt

<sup>11</sup> The term Baden-Württemberg refers to the modern (post 1952) German state of Baden-Württemberg mainly composed by the former kingdom of Württemberg and the Grand Duchy Baden.

<sup>12</sup> Lacking a better description of this mixture of excavation and pure collecting of goods. Research, in this case, is more comparable to a treasure hunt with romantic and patriotic motivation and finding valuable artefacts.

<sup>13</sup> Deliberately searched and excavated archaeological sites have to be evaluated differently as accidentally recovered sites due to rescue excavations (chap.: 4.1).

<sup>14</sup> Other influencing parameters are increased engagement of the intellectual bourgeoisie, equipping newly founded museums, founding cultural heritage agencies, and licensing required excavations [333].

lifestyle with its intermediate role between the Mediterranean world and the European periphery. Dividing the Hallstatt complex of the Northwest Alpine area into regional groups by Parzinger provides an approximation to understand the heterogeneity of the phenomenon, like the northern and southern Württemberg group, Forest of Haguenau group, Middle Rhine and Saar-Palatine group [367]. Lately, Nakoinz [345] analysed the cultural structure of Baden-Württemberg and pointed to a complex and heterogeneous cultural phenomenon with no distinct cultural borders.

A perceptible, distinct or abrupt cultural change from the late Bronze Age to Hallstatt C is not visible in the archaeological record (chap.: 1.4). However, the development of types continues at the transition from Ha B to Ha C, a change in settlement behaviour took place, indicating significant socio-economic changes [49]; [313]. These internal transformations might respond to social tensions, and long distant exchange [313]. Moreover, climatic changes might enforce reorganisation of territory [36]. As the introduction of iron as new material does not precisely mark the chronological change either, there are notable changes visible in the elite' graves with new burial habits <sup>15</sup> (grave chamber, prestige goods like swords, metal vessels or wagon) and the end of depositing hoards or weapons [494]. To summarise some Hallstatt C burial characteristics are a four-wheeled wagon, so-called *Vasenkopfnadeln*, *Schwanenkopfnadeln* and typical Hallstatt swords (type *Gündlingen* and *Mindelheim* (for a detailed description of artefacts chap.:4.3). While during Hallstatt D Hallstatt daggers are characteristic [452] and lance heads for the Upper Rhine valley and Rheinland-Pfalz [161]; [195]; [208], as well as *Schlangefibeln* and *Tonnenarmbänder*. The amount of jewellery in funeral contexts increases significantly due to high-status female burials and changes in burial habit. In Ha D1 *Paukenfibeln*, during Ha D2 *Fußzierfibeln*, *Doppelpaukenfibeln*, *Armbrustspiralen* and two-wheeled wagons during Ha D3. The following period La Tène can be described by its unique La Tène style and again arising swords (La Tène types). At the End of Ha D, opulent burials with gigantic grave mounds [382], precious metal and Mediterranean imports indicating the adaption of Greco-Etruscan banquet habits appear [47]; [248]; [355].

The gradual development from Ha D into the La Tène period is evident in the grave of Vix, where artefacts dating to Ha D3 and early La Tène attributes are combined. As the cultural development did not stop at the transition from the Early to the Late Iron Age, most types show an ongoing typological development. Admittedly, some new types develop during Lt A, like La Tène fibula. Most dominant is the newly developed La Tène art with more organic and curvilinear motives. Again, the changes are first traceable in elite graves, and a changed burial habit (flat graves) [494].

The end of the Hallstatt culture is more distinct regarding the reduction of population, violent destruction of central places (princely seats), and a more decentralised settlement pattern [116]; [50]. A vivid discussion on possible reasons is still ongoing [48]; [116]; [299]; [489]. They vary from climatic changes, which first supported or facilitated the rise of princely seats and then cause their decline/fall as the temperature drops [299], to Celtic migration, which caused social and political crisis [489]; [513]. Also, a shift of power towards the north, causing the end of the Hallstatt period, seems a possible scenario. However, the reasons causing the decline of the Hallstatt period remain unknown. Complex systems like societies and economies are unlikely to collapse due to a particular reason. Therefore, a more complex model explaining these circumstances is needed (see, for example, [116]: They propose a combination of climatic changes and internal social and political tension due to demographic growth.). Before such a model is developed, a better understanding is necessary of the cultural complexity (socially and spatially), interaction patterns and systems of exchange and distribution.

What might have triggered the cultural changes at the transition from the bronze to the Iron Age? Was it a passive reaction to Mediterranean influences as Kimmig [224] suggests, or was it triggered by favourable climatic conditions resulting in population growth and early urban centres as lately supposed by Fernández-Götz [116]? As Parzinger points out, contacts to the Mediterranean change the appearance of an elite, but this does not imply a change of the entire society [369]. This matches Trachsel's observations of new types and changed burial habits first occurring in elite graves, while most of the population sticks to older traditions [494]. As time goes by, the changes permeate into a bigger part of the population. Fortified hilltop sites with rich

<sup>15</sup> Trachsel supposes eastern France and southern Germany as the earliest regions with new burial habits. Interestingly, the regular population carried on the old burial habit into Ha C [494].

burials in the surrounding is another characteristic of the Early Iron Age, and those princely seats are widely understood as either a manor (*Herrschaftssitz*) or a central place (chap.: 1.1 for more details).

Besides these changes, the introduction of iron is another change with indeed a significant impact. Iron ores are more widespread in the Hallstatt area, as, for example, the raw material for copper and tin. Distribution routes for bronze, which were established during the Bronze Age, stayed important during the Iron Age, as those metals were still needed [362]. Pare suggests a western trade route for bronze based on the distribution of Hallstatt swords, bronze vessels, harness and parts of wagons [358]. The distribution of amber can draw an eastern trade route.

Interestingly, amber might be a trade good, especially for the Mediterranean, where it comes into use much more often than in the Hallstatt area [494]. However, the internal trade may have been influenced strongly by the introduction of iron as the new material. The general trade routes for bronze and amber based on the distribution of finds has often led to the suggestion of regional trade routes along with rich graves [46]; [360]; [463].

The heterogeneous and complex structure of Early Iron Age groups in central Europe combined with only a few connecting commonalities shared mainly by an elite, cause a rejection of the term Hallstatt Culture and leads to the use of a more neutral term of Early Iron Age, which is in use further on.

## 1.4 Chronology

Problems in establishing an archaeological chronology is a method inherit dilemma as Stöllner describes it [477]. Cultural change is a continuous development, while archaeology needs to scheme, classify and divide. Mutually contradicting, cultural change does not fit into chronological frameworks. With more material cultural, and synchronised parallels, the chronological picture tends to become more blurred instead of clear. Additionally, chronological schemes depend highly on the underlying material used to establish, like well-defined small cultural areas, comparability in inventory, value and social status, and type classification. Some types and attributes react with different temporal pace to cultural changes. Pottery seems to be more traditional compared to fibula, which subdues fashionable and fast changes [477]. Therefore, persistent types or attributes will create a blurry picture, while particular types "atomise" the chronological scheme. These atomised chronologies appear to be precise, but when synchronising with other areas, delayed deposition of artefacts is more problematic [477]. Another significant influence on chronology has the archaeologist himself, his knowledge of artefacts, his theoretical background and current research history. As a chronological framework always depends on the present knowledge, each generation of researchers will naturally establish their schemes, which will be outdated in a few years. For the Early Iron Age with its long research history - beginning in 1846 with systematic excavations at Hallstatt by Ramsauer, several different chronological frameworks are known, each influenced by the current state of the art, theories and methods [238]; [367]; [396]; [492]; [494]; [531].

Tischler differentiated an Early and Late Phase of the Hallstatt Culture based on fibula linking the earlier phase with swords and the later phase with daggers [486]. Reinecke subdivided the Hallstatt period into four sub-phases (A to D) based mainly on grave assemblages from southern Germany [396]. However, Hallstatt A and B are phases of the Late Bronze Age, while Hallstatt C and D refer to the Early Iron Age. Reinecke's scheme is still widespread in Europe, although developed for southwest Germany. The application of this chronology in other regions remains difficult. For France, Joseph Déchelette developed the First ('Première Âge du Fer') and Second Iron Age with less emphasis on continuous development, while the first corresponds to German 'Hallstattzeit' [72]; [73]. Kossack and Zürn again subdivided Reinecke's phases C and D into C1 and C2, and D1 to D3 [238]; [531]; [532].

Via bronze typology, the synchronisation of local chronologies is done under the assumption that single types are characteristic for sharply defined chronological phases [362]; [363]; [367]. As Collins points out, chronologies correlate different categories of finds and practise that follow different trajectories, aiming to create a 'package' of features appearing in a synchronised fashion, which, of course, remains unrealistic [63].

This problematic assumption was also criticised by Torbrügge [492]; [493]; [494] because of synchronised areas with little use of metal, where those few datable complexes may contain not locally produced artefacts, which were probably in use for long periods. Trachsel emphasises a temporal difference of production and deposition of artefacts, especially for those connected to individual identities such as jewellery, dress elements, or arming. Age of individuals and biography of individual artefacts both need considering dating assemblages containing artefacts acquired throughout a person's lifetime [494]. Furthermore, not forget the deposition of reused, repaired and recycled objects [394].

Trachsel re-evaluated the existing chronological system based on a seriation of harness and parts of wagons (see tab.: 1.1, [494]). These two artefact categories show a supra-regional distribution, often occur in closed features, and are deposited from Hallstatt B until La Tène A. Nevertheless, they are restricted to one social group and not gender-specific <sup>16</sup>. Besides those periods between producing a type and individual deposition of an artefact, metal artefacts are acquired during a lifetime, while ceramic objects are often much younger. Trachsel differentiated a relative chronological stratification including the following phases: Ha C1, Ha C2, Ha D1, Ha D2, Ha D3, Lt A. Often, a subdivision into an early, middle and late phase is possible. As only a small part of material culture is found in the same assemblages as those well-dated supra-regional types, a significant part of material culture remains roughly dated. For instance, jewellery remains complicated to incorporate into detailed chronological phases caused by strong regional deviating types and regional fashion, especially during Hallstatt C. With well-excavated data assemblages like the Magdalenenberg, a more detailed, however spatially restricted chronology is obtainable for Hallstatt D.

Relative Phase	Absolute Dates (after Trachsel)	Absolute Dates (after Krause)
<b>Ha C1</b>	<b>810 BC</b>	<b>750</b>
<b>Ha C2</b>	<b>before 700 BC</b>	
<b>Ha D1</b>	<b>650 BC</b>	<b>650</b>
<b>Ha D2</b>	<b>590 BC</b>	<b>575/550</b>
<b>Ha D3</b>	<b>570/560 BC</b>	<b>525</b>
<b>Lt A</b>	<b>520 BC</b>	<b>480/450</b>

Table 1.1: Relative and absolute dating of the Early Iron Age after Trachsel [494] and Krause [246].

Both transitions from Bronze Age to the Early Iron Age and the Late Iron Age show a continuous cultural development with ongoing typological development from the preceding period marked with changes in burial habits of the elite [494].

Due to the so-called Hallstatt plateau in the <sup>14</sup>C curve, radio-carbon dating can only date before and after this plateau precisely. Wiggle-Matching improved the radio-carbon dating slightly, but in between 800 to 400 BC, that method is not reliable [494]. Only in the 1980s, the dendrochronology curves from German oak-tree rings could be synchronised with Irish curves [21]. Thanks to corrections of German oak-tree ring chronologies in the 1980s, dates published before had to push back 500 BC by 70 years [135]. Combining results of the seriation with dendrochronological dates, Trachsel estimates for Hallstatt C1, the beginning of the Early Iron Age, 810 BC (see tab. 1.1), but pointing out that there was no sharp cultural change. According to Trachsel, the transition from Hallstatt C to Hallstatt D dates somewhat around 650 BC, and the end of Ha D3 took place around 520 BC. Too early for some researchers, as some Ha D3 artefacts from grave 352 from Dürrnberg (Austria) dated by dendrochronology to 464 BC [456]. Krause connects Mediterranean import at the Ipf and surrounding *Rechteckhöfe* Zaunäcker and Bugfeld, which dates to the second half of the 5th century BC with

<sup>16</sup> Trachsel contradicts Torbrügges assumption on Ha C is no chronological phase but only male assemblages [491]; [494].

the transition from Ha D3 to Lt A ([246], tab.: 1.1). Future research might lead to an agreement on absolute dates.

However, as this analysis focuses on long-term developments in interaction, infrastructure and distribution, high precision of dating is unnecessary and would lead to an unwanted selection of material culture. The precision of dating varies with the artefact type; hence, for better precision in chronology, some artefacts have to be excluded, which on the other hand, will result in an unclear pattern of interaction. Accordingly, in this analysis, all material culture is included, which dates from Hallstatt C to Hallstatt D. Artefacts, which originate from later or earlier epochs, will not alter the result drastically. Assuming the interaction pattern is an ongoing development from the late Bronze Age onwards.



## Chapter 2

### Theory

Büchschütz describes culture as a polythetic entity in space and time, which separates or converges to neighbouring cultures or that of earlier generations [51]. On the one hand, this illustrates the complexity of culture, as it may be similar but also dissimilar to others; and on the other hand, it highlights the potential of reconstructing cultural groups.

Wir wissen, dass jede Kultur eine polythetische, bewegliche Gesamtheit im Raum wie in der Zeit ist, die sich von der benachbarten Kultur oder der früherer Generationen durch einige Züge unterscheidet oder näert (O. Büchschütz [51]).

The distribution of artefacts, the imitation of decoration, or the rejection of new behaviour, are retraceable between regions or generations using distribution maps, displaying characteristic Early Iron Age phenomena. After Kossinna's abuse for nationalistic ends, using the distribution of artefacts to reconstruct cultural areas was discredited. Despite Kossinna, distribution maps of various artefact types, phenomenon or properties have a high potential for understanding, explaining and reconstructing prehistoric cultures [51]; [345]. Traditional distribution maps showing only some, presumably significant types, do not meet the modern requirements of cultural geography. The use of predefined types of artefacts to distinguish cultural groups leads to circular reasoning, as those presumably significant types result from former analyses. Therefore, Nakoinz developed a method incorporating all possible information towards a holistic analysis [345].

This chapter describes the theoretical background of cultural geography. First, the definition of culture supports the method developed by Nakoinz and *vice versa* [345]. Second, interaction as a key term is introduced, including specification for prehistoric contexts. After introducing these two main building blocks, links to infrastructure and distribution, highlight the dimensions of an interaction study.

#### 2.1 Definition of Cultures, and the Archaeological Culture

Although this work does not try to discuss all possible definitions of culture [163]; [259], culture is essential for understanding interaction patterns. How do cultures, or more neutrally certain groups, express their belonging and affiliation to another? Which implications do cultural differences trigger? How can archaeologist distinguish and understand cultural groups? All these questions require a practical definition of culture, which is comprehensive and fuzzy enough to fit the archaeological record.

Hansen provides one such clear, comprehensive and flexible definition of culture [162]; [163]. Culture, in his definition, incorporates all standardisations, which are valid in a collective. Contrasting culture against nature means culture is everything humans create: materially, technically or mentally. Standardisation mediates content understood within a collective, creating coherence. Signs are agreed upon to facilitate communication, while no causality exists between the medium of meaning and the meaning itself [426]. For example, the word tree is not



caused by the actual tree; therefore, other languages know different words for a tree, like *Baum* in German or *arbre* in French.

Collectives may appear with a distinctive border, but they need to be permeable to allow for interaction. Individuals are multi collective, meaning they belong to several collectives at the same time. A young woman belongs to the collective of the youth, but as a mother also to the collectives of motherhood and her cultural group's collective. Primary collectives are understood as basic collectives, like the collective of motherhood. Secondary collectives are groups of collectives enabling interaction and communication between their primary collectives. An archaeological culture is, in this sense, a secondary collective. If standardisation is valid for a secondary or a primary collective, it is crucial to define properties of archaeological cultures but challenging. Whether a standardisation is valid for the complete community can serve as a useful indicator<sup>1</sup>. For a cultural group, more than one standardisation is needed to incorporate the variability within collectives. Therefore, defining culture means focussing on regularities, which are followed by the members willingly. Culture accentuates similarities, and for this reason, highlights individual and singular incidents. Relations between standardisations means either similarities or dissimilarities. A similar artefact, for example, connects two spatial points. If the similarity does not occur randomly, a cultural relation is likely. Intuitively, dissimilarity might be interpreted as no cultural relation, but the social differentiation of collectives might cause it.

Nakoinz emphasises the advantages of Hansen's formal definition as it enables us to combine facts from several theories concerning culture. Those theories each focus on specific points and complement each other. Combined they create an integrative theory of culture *sensu* Nakoinz [346]. For example, Huxley's decomposition of culture into artefacts, mentifacts and sociofacts [201], which are indeed strongly interrelated. Based on Huxley's components, artefacts enable us to define cultural groups with smooth spatial borders and as entities that are not spatially bounded, like cultures of elites, craftsmen or gender.

A similar definition of culture is given by Clarke [62]. Based on the point of view (ethnological, linguistic or archaeological), culture is an ensemble of infinitive characteristics of the material or immaterial. These characteristics are relevant for language, material culture, world-view, social norms and territory [62].

The complex nature of human beings and culture, as created by humans, results in complex systems of identity and culture — a suitable method to reconstruct archaeological culture respects this complexity. Using the method of cultural geography described by Nakoinz [345], a holistic approach reduced restriction by the complexity of culture.

Addressing archaeological culture often begins with Kossinna, as an early researcher<sup>2</sup> to define and subdivide archaeological culture. The firm spatial reference of Kossinna, which distinguishes him from contemporary colleagues, originates in the attempt to retrace the origin of the Germanic tribes [243]. Nakoinz points out that his influence rests upon criticisms of this work rather than his research itself [345]. Most influential — though indirect — are the critics by Jacob-Friesen [204] and Eggers [98]. Both strictly reject the equation of type "locality is equal to culture is equal to ethnos"<sup>3</sup>. Eggers attempt to improve cartography and the analysis of distribution maps leads to a now routine source critic.

Further, from a theoretical point of view, Kossinna's work is strongly biased as he understands cultures and ethnic units as actors resulting in a powerful narrative. Cultures or ethnic units cannot act as an individual. Only people can act [346]. Kossinna's understanding of culture as crisp spatial units defined by some characteristic types excludes many aspects and results in a limited interpretation of cultural change (namely migration). His construction of identity and ethnicity being — as usual in this time — relatively static. Whilst nowadays, as Stoddart points out, the researcher emphasises dynamic and fluid constructions [475].

As a result of the so-called *cultural turn*, the new cultural geography emerges based on meaning-oriented cultural models [11]. Nakoinz criticises the increasing loss of the geographical component due to the strengthened focus on sociological issues and humanities [345]. Furthermore, political aspects are the new focus [22]; [200];

<sup>1</sup> All citizens of Germany understand German, so German is a property of secondary collective Germany. However, not all German-speaking people belong to Germany.

<sup>2</sup> Nakoinz summarises the research history of archaeological culture briefly in [346] and more recently in [337].

<sup>3</sup> Additionally, Kossinna's interpretations is rightfully rejected due to his cultural concept, including valued races.

[319] ; whereby - according to Nakoinz - a methodological error occurs, because here, cultures acting as units. Culture is nothing other than the standards assigned to collectives. Identities and collectives are often, but not necessarily, correlated with one another. Abbreviating the equation "culture equals ethnos" to "culture equals identity" is wrong. Besides, Nakoinz criticises that the previous cultural geography is neither improved nor presents a better alternative but merely expands it.

For Nakoinz, archaeological cultures are a specific type of culture. Perceptible crisp borders with a social meaning, which most contemporary people regard, is characteristic of archaeological cultures. If borders reoccur when using different segments of material culture, an archaeological culture is observed. The spatial closeness of clusters resulting from type spectra serves as an indicator for dependency or independence of components. Therefore, no spatial closeness means that no archaeological culture is evident, but maybe a culture *sensu* Clarke. However, Nakoinz emphasises that it is not admissible to assume the existence of archaeological cultures generally or that cultures can act instead of people [346].

In his research, Nakoinz mainly focuses on archaeological cultures, so he chooses a specific facet enabling settlement archaeological conclusions [345]; [341]. Based on type spectra calculated from a predefined classification, Nakoinz tries to recognise recurring boundaries in order to be able to infer crisp boundaries of the archaeological culture. However, in the present work, the interaction patterns based on particular points in the landscape and specific social segments are focused. Therefore, considering another facet of interaction analysis.

## 2.2 Interaction in Prehistory

Establishing regional chronologies, analysing regional phenomena, or identifying supra-regional relationships require the analysis of interaction processes. The distribution of cultural similarities and their temporal development reflects interaction patterns, which are tightly bound to historical processes [342] — based on the before-mentioned definition of culture, cultural geography emphasises reconstructing cultural fingerprints. Using so-called type spectra (chap.: 5.5.1), shared or indeed not shared components of material culture enable us to investigate entities from collectives to archaeological cultures [345]; [346].

Interaction is the main driver for historic and cultural processes [347]; [348]; [349]; [337]. Hence, interaction is the fundamental process of all social relationships since negotiation is an interactive process. Wandering craftsmen, the direct exchange of goods or exchange down the line are only some interaction segments in prehistory. Interaction is not only understood as targeted transport of goods but also, and most probably, on a much larger scale, as moving and conveying ideas and technologies [442]. Historical events are based on the interaction of remarkable people or, in a long term perspective, of groups of people. Although deviating definitions of culture exist (see above), e.g. rules, common knowledge, technique and styles define culture. Spatial interaction uses cultural distance to define interaction areas, avoiding the circular reasoning found in traditional approaches using predefined cultural markers. Finally, interaction facilitates economic processes whose task - basically - is to cover one's own needs with surpluses elsewhere [347]; [337].

The exchange of artefacts or innovations over large distances came into the focus of archaeological research comparatively early [321], as this allows correlating different areas chronologically. Various aspects of the exchange, such as trade [149]; [323], the spread of ideas [7] or migrations of peoples [243] are anchored early in the archaeological discussion. Therefore, people, goods, and knowledge are moveable objects, whereby special cases [347]. The more neutral term of interaction, which allows considering different forms of simple exchange, gains more interest [231]; [258].

Since interaction, due to the high degree of abstraction, enables us to describe concrete exchange relationships<sup>4</sup>, Nakoinz extends this theory and methodology to evaluate identities, and their interplay with cultures [348] and also hierarchies and centrality of settlements [337]; [347].

---

<sup>4</sup> Apart from the spatial aspect of interaction [337].

Nakoinz defines interaction as the joint action of at least two partners. Actions or an event of interaction includes several activities but not necessarily a common intention. Thus an act of war is an interaction, although the interacting partners have contrary intentions. Communication facilitates the exchange of information, which is a particular case of social interaction. Communication is also possible through visual phenomena of any kind, not only through language [11]. In visual culture theory, an image or visual phenomenon only becomes a symbolic meaning through cultural differences in perception [54]. Although most interaction processes accompany communication, it is impossible to reduce interaction only to communication [347]. Also, concerning the concept of culture developed above, interaction functions as the basis for developing common standardizations. Culture is the outcome of the interaction; thus, it depicts interaction.

Further on, a crucial parameter of interaction is the distance, if abstracted, covers several aspects. The relation mainly rests on the assumption that the interaction intensity is distance-dependent. The probability of interaction increases with decreasing distance and decreases with increasing distance. There is more probability of meeting an interaction partner near the settlement than, for example, on the border of the territory [347]. Spatial interaction connects locations by movements of people, goods or knowledge as in prehistoric times the distance needed to be overcome physically [347]. Random processes certainly play a significant role in short-distance interactions, especially in everyday life. Nevertheless, deliberate interaction at short distances increases the intensity of the interaction. Nakoinz points out that a similar process occurs in preferred interaction with partners of the same culture, so culture represents a self-stabilizing system [347].

Nakoinz also approaches the interplay of identity and culture through interaction. The interaction causes culture, whereas identity intends interaction [348]. Expressing identity and group membership is more pronounced when a demarcation from others is needed, either because of similarities or crisis. Elwert points out that identity can only exist in contrast to others [108]. The human capacity to know 'who is who' and 'what is what' describes for Richard Jenkins [207] identity. This concept involves a multi-dimensional classification of the environment and collectives. Fernández-Götz states that identity is a process of something one does, not a static label of something one owns [115], which seems like a contradiction to the previously described definitions of identity. However, wearing a sign and communicating the affiliation to a group is an action someone does.

The problem in analysing identities is the information singularity expressing individuality, which is difficult to analyse based on similarities, patterns or structures in the database. However, they must be differentiated from random data that fall into the noise category. Since neither identities nor cultural groups focus on the present work, the evaluability and methodology for recording identities are of less interest. However, in addition to structured information and incidental noise, there is also individual information related to an identity expression and is therefore valid data relevant for understanding all factors of cultural distance.

The relation between interacting partners can be described as an interspace or a distance, whereby this can be geographic, sociologic, economic or cultural. The metric and calculation (chap.: 5.5) also depend on the underlying data. Sociological or, more general, cultural distances can be understood in terms of dissimilarity in material culture. Meaning that social distance is a segment of cultural distance since material culture embeds social differences [347]. Since interactions are events, they are countable. In archaeology, however, we can only infer indirectly from their effects. Parameters that are causally related to interaction serve as proxies, such as import finds or material culture. Since the interaction itself is not measurable, the imported good indicator serves as a proxy. Employing calibration transform the indicator into a proxy. In order to be able to measure interaction, three components are necessary: a measure of interaction (events), an indicator (effect or result) and the calibration function [337].

Whether the imported object itself or the knowledge of its manufacture occur in remote cultural areas, both processes are fundamentally based on interaction. The economic term import has specific implications which are unprovable in archaeology, as stated by Fischer [122]. The implied trading neglects other processes of exchange, such as gifts. If considering a more neutral definition of import, namely a commodity from a foreign region, it applies to archaeology. On a more general level, spatial interaction regards an imported good without economic implication. Before evaluating interaction relations, import goods need to be identified. A threshold defining local and far-distance connections might be applied if the origin is known. Another approach defines objects

from different cultures as imports. Distinct archaeological cultures enable us to identify import goods, locate borders and outsiders. However, this is not the case for the Early Iron Age in Baden-Württemberg and the Alsace. The cultural heterogeneity complicates the definition of imports, which means that such goods usually only describe large-distance contacts, while shorter interaction relationships remain undetected. Although imported goods are countable events of interaction, the number of import goods in archaeological assemblages are not a proxy for interaction, as this depends on research intensity, excavations or publication status. The proportion of imported goods to all artefacts transfers the indicator into a proxy. The comparison of proxies deriving from different imported goods must be based on sound theoretical assumptions, as different processes of interaction result in the distribution of bronze vessels and fibula [337].

Fall-off curves are a well-known approach to model interaction based on imports, originally developed for obsidian exchange ([402]; [401]). Renfrew, Cann and Dixon identify types of exchange and describe theoretical distance decay functions based on the proportion of distance to the number of imports. A comparison with empirical fall-off curves reveals well adapted theoretical models<sup>5</sup>. The distance to the raw material source is the abscissa and the number of imports as ordinate. The intensity of interaction or the probability of interaction decreases with increasing distance and shapes the fall-off curve. Comparing only two factors for understanding exchange systems is an advantage of Renfrew's approach. Reproducing results and applying the method to other artefact categories is possible without knowledge of specific software. Using the Euclidian distance between site locations and counting artefacts do not require computing-intensive calculations. However, it is only a particular case dealing with imported artefacts and the known origin of raw material. This detailed information is mostly lacking in archaeological studies trying to evaluate trade or exchange.

The assumed direct connections to calculate distance does not necessarily reflect the cost of moving the items. The least-cost distances respect topographical properties and result, therefore, in more accurate distance calculations. However, this does incorporate complex computation calculations and profound knowledge on specific software or programming (advantages and disadvantages of least cost path modelling in chap.: 2.3.2.2). Also, different regional find densities are problematic (see above). Relative amounts instead of total numbers level these effects.

Additionally, depositional habits manipulating the archaeological assemblages must be considered as they influence the total amount of artefacts deposited and recovered by archaeological research (chap.: 4.1) [337].

Since similarities - or standardisations - are caused by interaction, the inverse cultural distance is a proxy for interaction. Based on material culture, cultural distance enhances the understanding of the relationship between people, and historical or economic processes, which is criticised because of the problematic correlation of material culture and behaviour [337]. Nonetheless, research in different disciplines leads Nakoinz *et al.* [337], to the assumption that material culture corresponds to the degree of interaction between two entities, and this correlation is a general rule. Increasing interaction, however, does not necessarily lead to similar material culture. Contradicting the alignment process, like group markers, may also communicate using material culture [337]. This concept is restricted, as material culture is not sufficient for understanding culture, in general; however, it allows for identifying different cultures and measuring the cultural distance [347]; [337].

Cultural distance is a measure of dissimilarity of material culture and the most robust approach to investigate interaction. The Euclidian distance of two sets of archaeological assemblages, represented by relative amounts of each archaeological type, yield the cultural distance (chap.: 5.5) [337]. The interaction friction, i.e. cultural dissimilarity, increases with increasing distance, while in turn, the interaction intensity decreases. Interaction friction and interaction intensity relate inversely to each other, which is why a transformation for the representation (but not the interpretation) is unproblematic [347]. Cultural distance - or the proxy of imported goods - does not correlate linearly with the intensity of interaction, making it difficult to compare different proxies.

In contrast, comparisons within a proxy are admissible since they are based on the same non-linear correlation [347]. Nakoinz understands cultural distance in two ways. Namely as an influencing factor, on the one hand, and as a proxy, on the other. When interpreting, careful attention must be paid to which of the numerous segments relates the interaction and which variable is included in the representation, influencing factor, or proxy [347].

<sup>5</sup> Chapter 2.5 deals detailed with differences of empirical and theoretical models.

It is necessary to differentiate between the relative chronological dating of artefacts and the moment of events taking place regarding chronology and the order of events. For the latter, Nakoinz points to the theory of relativity [347]. Event and perception cannot coincide: The velocity of propagation limits the contemporaneity to at least the velocity of light. Especially in prehistoric times, the velocity of propagation is most probably much slower regarding travel speed. Besides uncertainties in absolute dating, biases of the relative dating of artefacts are, e.g. a delay in the deposition of artefacts and the velocity of propagation (chap.:1.4). Beinbauer states that the weaponry clock then ticks at a different speed to the ceramic clock [477] <sup>6</sup> Uncertain chronologies and problematic synchronisation between areas are unproblematic regarding long-term patterns of interaction. However, a chronological framework is still necessary to define the temporal border of the investigated phenomenon and select material culture. For example, Steffen [464] uses subsets of material culture to retrace chronological changes during the Early Iron Age, focusing on social interaction.

Simple distance models only consider distance as an influencing factor, the dominant factor, according to Nakoinz. The course of the curve, for example, of the cultural distance against the geographical distance, can be represented using various mathematical formulas. According to Nakoinz, decreasing interaction with increasing distance mostly confirmed, with deviations being particularly interesting. He describes, for example, abruptly increasing distances as caused by borders or natural obstacles. Expansion phenomena, economic issues, trade relationships or social and cultural structures also influence interaction. These influences might explain disturbances in the curve's course, which adds certainly to the interpretation of interaction relations [347].

If the empirical model deviates from the simple theoretical model defined above, the monotonically rising curve, additional components can be used to explain such disturbances [347]. Nakoinz interprets sudden rising levels as boundaries <sup>7</sup>, barriers or standard distances. Topographical obstacles such as rivers, mountains or cost-influencing aspects such as daily travel distance or a specific range of means of transport can explain such gradual disturbances [347].

Mountains in friction curves (corresponding to depressions in interaction curves) can be interpreted as foreign colonies or settlements, hard-to-reach places, an undesirable distance just below the maximum possible range, or just above the maximum possible range. Accordingly, depressions in friction curves can be interpreted inversely, as possibly an affiliated colony or settlement, stations in the distribution system or maximum ranges. The friction curve in a trading system with fixed relay stations would have a toothed course. Because starting from the intermediate station, which is culturally closer to the starting point, the distribution occurs in the area, whereby a higher cultural dissimilarity remains [347].

When interpreting disturbances, one must also pay attention to whether one is looking at a singular reference point or evaluating all observation points averaged. In the latter case, topographical obstacles would not be a plausible explanation for the disturbances since it cannot be assumed that a topographical obstacle occurs at every reference point, for example, at a distance of 30 km. However, a threshold may be reached, which can relate to transport costs or travel time [347].

In addition to distances and respective metrics, different forms of representation illuminate relationships. Distance diagrams, as defined by Nakoinz *et al.* [337], map the likelihood or intensity of interaction displayed by the inverse cultural distance over spatial distance. Distance diagrams are based on the correlation between connection, and spatial distance, Tobler's first law of geography [487]. A mathematical function can map a connection, e.g. interaction, if it depends on spatial distance <sup>8</sup>. Theoretical distance decay models accompany the empiric model of distance diagrams. According to the defined starting point (viewpoint) and targeted point (focus), distance diagrams offer a wide range of applications. Nakoinz *et al.* define 9 main classes dd1 to dd9 [336]; [337].

---

<sup>6</sup> It is, therefore, possible to compare more traditional, cultural aspects and more fashionable interactive aspects of material culture. This distinction is essential, comparing time slices.

<sup>7</sup> Boundaries are to be understood here in the sense of interaction boundaries and do not necessarily refer to territorial boundaries or of an archaeological culture [347].

<sup>8</sup> The fall-off earlier curves, as mentioned, are a variant of distance diagrams.

Starting from a singular viewpoint <sup>9</sup>, cultural distance can be mapped along with selected profiles (dd1) or averaged cultural distances against geographical distance classes (dd9). The different definitions of viewpoint and focus mutually lead to different interpretations. Simultaneously, diagram type dd1 allows us to connect interaction to topographical features, dd9 depicts more general trends determining the interaction likeliness as a function of the direct spatial distance [337].

Nakoinz suggests that different forms of representation should be placed side by side and compared for a comprehensive interpretation. In this way, it becomes possible to identify the different dimensions of interaction in different social groups and spatial relations [347]. This interaction study develops a new distance diagram - profile diagram- to display the interaction friction emanating from river systems, supposed communicational corridors [345]. At regularly spaced viewpoints parallel to the river and profiles with an orthogonal orientation to the main direction map the hinterland's cultural distance (chap.: 5.5.2).

When considering the princely seats, it is evident that global representations (dd3) and those according to cardinal directions (dd2) do not consider the frequency of the occurring cultural distances. To achieve a better assessment of the interaction structure of these sites, another type of distance diagram was developed: the distance histograms (chap.:5.5.4).

To summarise the basic concepts of interaction, the term allows for abstract central driving forces in cultural developments. Interaction facilitates ways to satisfy the needs of a population. These needs are economical, as well as social, like communicating the affiliation to a group. Interaction also allows for transferring knowledge, which leads to spreading innovations. Distance is the main factor influencing interaction. With increasing distance, the likelihood for interaction, interaction intensity declines. The relation of interaction and distance refers not only to spatial interaction; likewise, the likelihood of interaction of two interacting partners declines with increasing social distance.

Further influencing factors are the attraction of large sites or remarkable persons, expansion phenomena, and economic, social and cultural structures. As mentioned above, interaction and distance shape the simple distance models with only distance as a factor. However, real-life systems are complex systems. Non-linear relationships and strange phenomena, like the emergence of new patterns or butterfly effects, may interfere with the concept of piecing together a mosaic of interactions [337].

### ***2.2.1 Artefacts and Interaction***

Exchanged items, e.g. imported goods, livestock or people, are direct evidence of an interaction. With known provenance, connections between origin and destination can be drawn; however, a transfer might be not direct or straight. The adaption of ideas, new decoration, technique or innovations are indirect evidence of an interaction. This section highlights some artefacts or types of sites to evaluate their potential influence in the interaction analysis. Although all aspect of material culture relates to cultural, economic or social exchange and contact, some artefacts are better suited to answer the question concerning interaction. Nakoinz compares <sup>10</sup> cultural distances from type spectra of settlements and graves, and different artefacts categories [347]. For example, with the Heuneburg as viewpoint, ceramic from graves show the Black forest's anomaly less pronounced than ring jewellery or ceramic from settlements. In contrast, the cultural distance of type spectra from garb separated into grave and settlement shows similar minimal distances at the same geographical distance, reaching the Neckar.

To summarise, artefacts show different scales of interaction because of their meaning for society, the use, the character of deposition, the preservation, the production and the spatial distribution. When choosing subsets of

<sup>9</sup> A detailed description and discussion of the types follow in chap.:5.5.2.

<sup>10</sup> Nakoinz [347] states that the presented distance diagrams and selected type spectra serve didactic purposes, and further investigations are necessary for a cultural-historical interpretation.

type spectra to analyse social segments, considering the potential and limits of the archaeological assemblage (chap.: 4.3) will improve the interpretation and prevent over-interpreting or circular reasoning.

Components of costumes, like jewellery or garb, are understood traditionally as a marker of group identity. The German term *Tracht* (traditional costume) describes a particular kind of markers for group identity. Biel states [35] that traditional rules fix signs of group membership and a person's social status. They could not be changed at will or according to personal taste. A costume change affected all members of a community [35]. This static understanding of garb originates in the developments after the Thirty Years' War. There was a division into Catholic and Protestant areas, and the strictly religious and medieval rules dissolved. So it happened that the rural population dressed in traditional costumes, while the bourgeois population deviated from it. Biel [35] indicates that strict rules prohibit the individuality of costumes, which contradicts a wide variety in grave assemblages and often occurring foreign artefacts.

Heynowski [187] points out that these particular type of markers for identity refer to a specific historical and cultural setting. Circumstances certainly differ in the Early Iron Age. Additionally, the strict rules and spatial distinctiveness indicated with the term *Tracht* do not reflect medieval reality. Overlapping distributions of markers are evident, especially in border zones. Moreover, one should bear in mind that *Tracht* has a strong notion to textiles and patterns. Nonetheless, as Heynowski states, jewellery is used to express a group membership [187]. The garb deviated according to social status, marriage status, age, gender, and occasion [5]; [464]. Those rules, however, are negotiated within social and regional groups.

For instance, fibula, being personal items (chap.: 4.3.3.1), are locally produced with a high degree of individualisation and probable underlying fashionable trends. The distribution of fibula types indicate regionally differing groups, but also some types with supra-regional connections. Interestingly, Kurzynski [268] points out that the number of fibula in graves might be an indicator for the dress, which differs during the season, and not as a social marker [303].

In contrast, swords (chap.: 4.3.4) are personal items of a social elite; hence, they are an indicator for the interaction of only a small segment of the population. Further, preservation restricts, in many cases, a detailed typological classification. For instance, Daggers are highly individualised artefacts [452], similar to the fibula. Their low abundance, however, restricts the potential influence of these artefacts on the entire assemblage. The restriction must be considered when choosing a segment with these types of artefacts.

Fibula, semi-circular husk needles (*Zweischalennadel*) or daggers show southern influences with the area of Switzerland as intermediate region [453]. For Sievers, numerous everyday objects and products of the Early Iron Age show foreign influences proving large-distance interaction connections.

Depositional habits influence assemblages, and in the case of voluntary depositions (e.g. graves or hoards), includes a process of interaction. The grave inventory is chosen by the community [167]. Negotiation and selection are only possible when communicating and interacting. Therefore, the resulting assemblage is an indicator of this interaction process, as well as the artefacts themselves.

To contrast, these artificial collections, a comparison with a randomly accumulated collection like settlements, show deviations and intended or strengthens connections willingly displayed by the selecting community. Settlements display the actual set of used artefacts. Sievers [453] describes that iron needles occur more often at the Heuneburg than in graves. The hairstyle was draped with small spheric needles in the grave, while iron needles for everyday life. She notes more deviation of artefacts categories in settlements and graves, like sling-shots and toiletry in settlements, or bronze cauldrons in graves [453].

Technical innovations also display interaction. In the case of so-called Hallstatt wagons (chap.: 4.3.5), the production took place locally, while technological influences connect large areas. Pare demonstrates that the felloe construction of so-called Hallstatt wagons how fast technological advances transmit over large distances and that the detailed history of contacts or influences can hardly be reconstructed. The felloe construction from Großleibstadt (Bavaria) can indicate either an Italian influence or a continuation from urnfield constructional techniques [360].

In contrast, the physical properties of lance heads and arrowheads restrict varying types [95] (chap.: 4.3.4.2). However, the shape is not useful for interaction analyses, the habit of placing these objects in a grave in combination with the amount, indeed, as value for interaction analysis.

The provenance of some artefacts is in some cases foreign, as the raw material does not occur naturally. Jet or lignite artefacts, beads (chap.: 4.3.7) and ring jewellery (chap.: 4.3.2.2), are often imported goods; however, a certain identification of the origin is still missing [414]; [18]. Baron notes that the Early Iron Age jet artefacts might not originate from the Swabian Alb and Great Britain. For so-called *Haguenauer Perlen* and small glass rings, the production is assumed in Haguenau based on the distribution [173].

Brosseder [45] uses the decoration on ceramic vessels for identifying signs as markers of identity and regional groups. She decomposed the decoration into elements, ornaments and pattern (chap.: 4.3.1). Larger regional groups more often seem to share ornaments instead of complete patterns. Distribution maps of ornaments, patterns and single motives generate the impression of alternation between demarcation and integration. The combination of signs is not arbitrary, although not deciphered. They were understandable for the contemporary and socially related population. Signs can be used to differentiate groups within one cemetery up to linking long distant regions. A common sign may be shared within a region and shows their connection, but this sign alters slightly to distinguish subgroups within these regional groups. Even more uniquely designed decoration occurs in high status (mostly male) graves, showing long distant relations (like Schirndorf: a bowl with decoration known from southern France). The signs' system shows several levels: individual, social status, cemetery groups, and regional groups [45].

From a chronological viewpoint, ornaments on ceramic vessels show changes as visual expressions of at the beginning of Ha C. High-status burials are earliest with ornamented ceramic. With Ha D, less ceramic occurs in graves. Instead of showing foreign signs, foreign objects display these connections instead, [45].

The presented concept of interaction does not use cultural markers; however, this short section illustrates possibilities and limits in retracing interaction relationships. Predefined types, often used as cultural markers [495], are not used to evaluate interaction relationships. Correctly identified structures in the archaeological data need to be separated from predefined biased types. The method used for classifying the Early Iron Age artefacts (chap.: 5.1.1) includes the underlying structure mutually while decomposing the artefacts into material, shape, technic and decoration.

## 2.3 Infrastructure

Understanding infrastructure is essential on its own, as it allows us to study communication, trade networks or landscape use. However, it is also needed while interpreting interaction systems or other socio-cultural phenomena. As stated above (chap.: 2.2), every interaction is based on communication. The mutual relationship between infrastructure and interaction is strongly connected because, besides transmitting acoustic or optic signals that can overcome relatively short distances, a prehistoric protagonist has to overcome the distance physically. If a third person realizes this communication or takes places directly, it is for the formation of infrastructure irrelevant [343].

The importance of such systems is self-evident, as they influenced the development of past societies, enhancing trade dynamics and affecting the prosperity of civilisation. For medieval roads, Hindle states that roads form the backbone of a transport system, which cause and supports economic growth [190]. Interaction serves to satisfy people's needs, like trade goods, passing on innovations that trigger adaption, change, and development. The wish to interact is the cause for traffic and transportation system the outcome [336].

The path system canalises interaction, while the interaction system induces modifications to the system of transportation [336]. Cultural and environmental factors furthermore influence the dynamic relationship between interaction and infrastructure. Based on the systems' dependency, the infrastructure is a mirror of interaction systems [337]. With changes in the interaction relations, the transportation system will adapt (for de-



tails, see below). Intensive interaction induces intensively used paths, resulting in a higher optimisation degree than sporadically used routes (chap.: 2.3.2.2).

Reconstructing the path system, combined with identifying the influencing parameter, enables us to deduce routes, exchange structures and connections (chap.: 2.3.2). The comparison allows for a better understanding of exchange, travel and contacts between prehistoric protagonists. Overwhelming evidence - material culture, genes or artistic styles (chap.: 4.3) – prove that the Early Iron Age Europe was highly interconnected.

The physical route between two points results in a limited, albeit a high, number of possible passages. Ignoring relief-related costs is rejected as unrealistic. Therefore, unnecessarily high costs reduce possible passages. Here, however, the size of the detour to be accepted must be taken into account.

Besides, some other factors will have influenced the path's location, such as cultural factors (chap. : 2.3.2.3). These can be based on relief-independent costs, such as the location of production sites. A route from settlement A to settlement B could head for different raw material extraction sites. If a deposit is no longer profitable, careful considerations decide whether the establishment (search, protection and creation) of a new route justifies the detour along with the abandoned site.

Paths are multi-scale and multi-temporal phenomena. Since assuming a high level of spatial consistency of paths, once established paths will have been used for a long time, like Danish economists showed with Roman Road System [68] which still influences an uneven distribution of economics in Europe. However, Denecke [81] urges caution when backdating path relicts and the basic assumption of long-existing long-distance routes. A delay in path formation's dynamic process can be attributed here (see discussion on pedestrian movements in chap. : 2.3.2.3). On the other hand, especially in landscapes with more complex relief, the number of ideal paths is limited by topographical circumstances. Steep mountains or impassable rivers are barriers that are not influenced by cultural or political changes. Their influence on a route remains constant<sup>11</sup>. Topographical constraints in hilly terrains ease the reconstruction of paths [528]. According to the landscape, a shifting river's influence will also remain constant because paths move on a small scale. Haupt [170] indicates that routes that have been optimally adapted to the terrain only have more inadequate alternatives. Haupt refers here primarily to topographical aspects, which is why his statement is in principle correct. However, the transport system is influenced not only by the topography but also by the interaction system, i.e. the dynamic connections between people, settlements, and regions. Hindle [190] gives another example of the formation of alternative routes. Multiple tracks show the most comfortable path up a slope.

The restriction on convenient routes is correspondingly higher as the topographical restrictions decrease. Denecke [81] describes that this "free" choice of paths leads to fan-shaped paths and possibly also to a deep impression in the landscape (sunken lanes). Multiple tracks document this choice and result in widening of the path of up to ten times [190]. Lewis predicted Roman roads in Britain, in lowland and highland area, while hilly areas with more topographic constraints Least Cost Path predicts sufficiently Roman Roads. This declines with topographic freedom in lowlands, here social processes more influential [279].

Furthermore, climatic conditions lead to different routes. In winter, the use of sledges can lead to an increased avoidance of steep slopes, whereas frozen streams or rivers were preferred [81]. Interestingly enough, Hindle describes that the winter months did not necessarily bring medieval traffic to a standstill [190].

Changes in the interaction pattern will also affect the infrastructure because of mutual dependency. This process is comparable to a chemical equilibrium reaction (fig.: 2.1). The ratio of product to educt, i.e. the equilibrium, can be changed by external influences. The interaction pattern, i.e., the educts' composition, is changeable so that equilibrium establishes again. Such changes can break off sales markets, open up new sources of raw materials, change cultural relations or even technical innovation, to name just a few illustrative examples. The composition of the products, the infrastructure adapts to the new circumstances. The changed interaction pattern requires an adapted and, therefore, newly optimised infrastructure. New routes can arise, and older routes may no longer be used. The speed of such an adjustment is the reaction speed, which catalysts can accelerate.

---

<sup>11</sup> This applies with one restriction. Denecke [81] states that the wagon's use and, thus, critical inclines only influenced the route's location from the Middle Ages onwards. Here, an unchanged landscape parameter becomes a relevant influencing factor later, opening up new routes.

The interaction intensity of a new interaction relationship will have influenced the establishment of a new route; likewise, the cost differential between the new and the old route.

The cost differential, the amortisation level, ultimately determines whether a new route is created. Not only relief-dependent costs are meant here, but the entirety of all possible costs, including cultural ones. The finite number of possible passages through a landscape mentioned above is another catalyst. Alternative routes are easier to find in a landscape with a lower cost difference. The effort to look for a new route is less in a flat region than in a mountain range. Catalysts cannot influence the position of the equilibrium, only the reaction rate. In this way, the new equilibrium, i.e., the path system's adaptation, is established faster. In contrast, buffers change the position of the equilibrium, hindering absolute extreme values. Above all, topographical obstacles should be considered here. However, the actual equilibrium establishes after exceeding the buffer.

This indolence also describes Helbing, Keltsch and Molnár [177]. In the sense of adapting to new circumstances, direct path systems only develop if the direct connection is more comfortable than using existing trails<sup>12</sup>. A path system is an optimal compromise between convenience and shortness. The contrast between long-existing paths and dynamically adapting path systems in particular harbours exciting approaches to interpretation. When does a path survive that has been in use since the Neolithic? Is it due to environmental conditions, the terrain, or the connection between favourable areas? At what point is a path system modified to suit new circumstances?

Nakoinz [343] identifies, for a case study of Neolithic and Bronze Age path systems in Schleswig-Holstein, changing parameters defining the location of the path due to changing properties in the path system. Higher need for security from Funnel Beaker to Bronze Age induces increasing visibility as an influencing parameter.

A distinction between interaction network and path system makes sense here: The interaction network represents those connections between sites without making a statement about the actual physical path connections. There will be different routes to get from one interaction partner to the next. In this sense, route means a sequence and selection of possible transects or passages through a landscape. Which routes represent path is subject to certain factors, for example, an expected reduction in costs. However, which costs are decisive has yet to be determined. To avoiding cultural dissimilarity, a detour along more similar interaction partners may have been chosen.

The transport system is understood as the routes' physical expression and refers to the paths' actual location. With changed interaction environments or changing sales markets, connections in the interaction network will shift, and the intensity will increase or decrease. To what extent the paths (physical representations of routes, see below for detailed definition) have to adapt to these new circumstances? Attempts must be made to estimate using theoretical models (chap.: 2.3.2.3).

Paths<sup>13</sup> are tracked, maintained or built traffic lanes of land transport, regardless of the means of transport. A street, on the other hand, describes a paved or expanded route. In the present work, the path is the physical representation of a connection. Of course, it cannot be assumed that there was only land traffic, but that traffic also took place along sea routes or *ad hoc* paths [343]. In contrast, connections with no direct reference to the

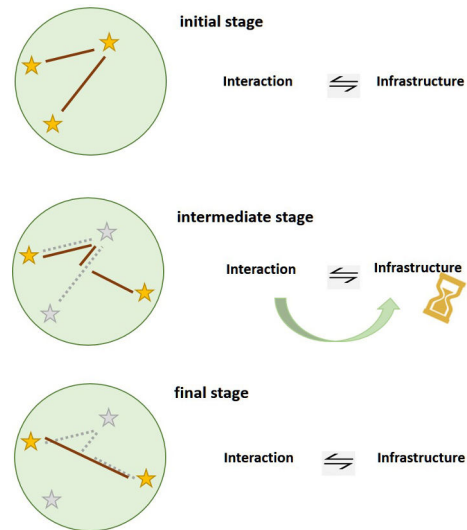


Fig. 2.1: Dynamic relationship between interaction and infrastructure.

<sup>12</sup> Howey [196] also emphasises that already existing paths improve a path calculation.

<sup>13</sup> The terminology of historic roads differentiates between relief, the type of fortification or fixed legal relationships, such as *via regia*, *via publica* or *via privata*) [81].

path's localisation are networks that reveal possible relationships. This representation primarily relates to spatial relationships, such as the exchange of goods and cultural transfer.

### 2.3.1 *Archaeological Evidence of Infrastructure*

With the search for Roman roads in the 17th century began the research history of ancient paths. Many relicts of roads are wrongly assigned with this epoch, which continues until today [81]. Alpine passes were also in the focus of path research early on, as they concentrate traffic, represent bottlenecks and seldom require consolidation [81]. The reconstruction of a path along aligned barrows is an approach developed by Sophos Müller in 1904 [327]. Kerstens [221] describes in 1946 old and rarely used paths that are still visible in northern Germany's landscape. To estimate the importance of a path, Kerstens suggests the width and several parallel wheel tracks as parameters. He contrasts the prehistoric path as a thoroughly chosen path avoiding all obstacles (terrain, marshy areas, or ridges) to the artificial Roman roads, which follow straight lines through the landscape. Import goods and precious metal in barrows occur closer to the main routes, and decrease in frequency towards the hinterland [221]; [297].

In the 1960s and 1970s, well-founded geographic-historical path research was developed within the research framework into the emergence of cultural landscapes focusing on the Middle Ages and modern times [81]. Better knowledge of pre-medieval paths exists only in isolated cases, such as the *Ochsenweg* or *Hellweg*, the Alpine passes [528] or bog roads [174].

Evidence for infrastructure divides into direct and indirect features. Those direct evidence are relicts of a path, river crossings, bridges, or harbours [81]. Relicts of prehistoric paths are preserved only under specific conditions, and they leave slight traces in the landscape. Additionally, their recovery, if not inside a larger settlement, is quite unlikely.

Sunken lanes are caused by linear erosion, especially on slopes and soft ground. During the path's use, deepening occurs, and after the path abandonment, began these "hollow ways" become filled [80]. Traces from paths in the terrain, used for a long time or very intensively, lead to the overprinting of older traces, which makes dating the beginning of the path difficult [81]. It is not easy to ascribe a date to a path that was not actively built but came into use. Moreover, paths disappear if not continuously used [190]. According to Denecke, sunken lanes in German forests go back primarily to the 15th and 18th centuries. The construction of the Chaussees in the 18th century and early land consolidation has removed many earlier relicts of the unpaved nature trails.

Agricultural land use makes the archaeological proof of an ancient path nearly impossible [81]. In those rare cases, when a path's preserved, it usually can only be traced on a short distance, often connected to specific conditions like bog roads [174], Alpine passes [528] or at other topographically specific locations [445]. Although most paths were unpaved nature trails, since the Neolithic, there have been repeated measures to strengthen or improve certain areas [81]. These transects allow a highly detailed analysis of path location. However, the parameters defining such a path's location restrict individual circumstances at the specific site. Transferring these results onto other transects remains difficult as information is missing regarding how routes emerge on deviating circumstances.

For Roman roads, which are sometimes solidly constructed, the evidence in the area of question is better [40]; [156] (chap.: 7.1). For the area in question, several Roman path, roads, river crossings and bridges are documented in excavation, artefacts, or crop signs [156]. Surprisingly, pedestrians walked beside Roman roads on more comfortable and softer ground [190].

Early Iron Age paths are most likely field path or country lane only paved under specific circumstances [344]; [445]. For example, in Manching, wheel tracks are still recognizable in profiles as evidence of wagon traffic [81]. For an analysis of a connected transportation system, this direct evidence is too scarce for a coherent reconstruction of a regional path system. Therefore, other features associated with infrastructure with better preservation are used to reconstruct prehistoric path.

Additionally, indirect evidence may be settlements, monuments, barrows, or landmarks [6], specific domestic buildings, like pubs, inn, harbourage, market places or towns [81]. The existence of those features is, in some cases, bound to specific socio-historical settings. For example, a customs post provides indirect evidence of a path as there is no need for customs without traffic. However, such a facility can only be established under certain political conditions. The written and archaeological sources reveal much more details on settlements and buildings' use and function for medieval periods. For example, since 1290 *Steinau an der Straße* (Hesse) was an essential waypoint from Frankfurt via Fulda to Leipzig. Besides its name, a fortification and economic surplus resulting from the location next to the *via regia*. However, with modern means of transport, Fulda is reached within hours. Today, only the occasional tourist spends a night in *Steinau an der Straße*.

Path associated features fulfil various functions, such as communication, maintenance and control of the paths. Here Denecke also sees a connection between the so-called princely seats concerning their function and location on traffic axes [81].

Artefacts such as wagon parts, horseshoes, nails from shoes, coins, tools or goods indicate indirect evidence of path, and, if possible, for dating [81]. In this context, the deposition of artefacts may also indicate passages across a river. Logel uses symmetrical depositions on both banks of the Rhine <sup>14</sup> [293]; [294], which is criticized by Schmid-Merkl [436] due to the lack of differentiation between relocated and intentionally deposited circumstances (chap.: 6.1.1).

Path related features can serve specific features related to travelling or transportation. Other indicators need identification before. Monuments, e.g. barrows, form linear structures or are lined up straight towards important topographical points, is described as path associated feature by Sophos Müller [327] for barrows in Denmark. The row of burial mounds on high trails in Haglebuvatn (Norway) or accessible areas in necropolises of the Bronze Age and Iron Age also indicate crossing paths (Wederath-Belginum). Further examples for the connection between monuments and paths are runestones from the immigration period or the Wendel period in Scandinavia [81].

### 2.3.2 Evaluating the System of Infrastructure

Nakoinz [344] developed besides a theoretical background, methods to reconstruct path systems and evaluate possible influencing parameters (see chap.:5.3 and 5.4). He differs in a first step three scales for investigating infrastructure. The supra-regional scale depicts more global trends for evaluating exchange systems, interaction patterns, and long-distance transport. For this scale, the connections between areas focus on evaluating which connections existed, are necessary or extensively used. On an intermediate scale, the regional perspective focuses on transportation systems and the evaluation of significant traffic routes. In comparison, the local scale focus on the exact location of the path. A clear and explicit definition between empirical reconstructions and theoretical constructions increase the understanding of infrastructural systems and networks [344].

The development of paths depends on various, sometimes contrary, factors. In addition to terrain-related costs, other cultural costs can lead to an alternative path that may appear to be less optimized at first glance. Influences such as vegetation and ground on the formation processes of paths must also not be ignored. Other dynamic influences include changing baselines of interaction relations, moving markets, political instability, and environmental changes.

Theoretical models should apply various parameters and create an idealized network. This ideal network is compared with the empirical data to estimate the most critical parameters (see below for a detailed discussion of influences and modelling chap.: 2.3.2.3). Based on the theoretical assumption, modelled cost surfaces serve as friction raster to calculate idealized path systems. Besides avoiding a deterministic and global view (chap.:2.3.2.2), accumulated cost surfaces facilitates for identifying alternating decisions and results in path bundles. However, the development of a path differs from that of a planned route. Modern path planning evalu-

<sup>14</sup> Bonnamour shows similar results for the Saône [42].

ates e. g. relief, geology, existing infrastructure, potential needs in the future and accessibility of land—global knowledge on all these factors influence the planning. In contrast, the development of a path based on everyday movements respect other factors and more importantly, only limited global knowledge exists.

To understand the mechanism influencing the path construction, relocation and usage, important aspects concern the life on the road [421]. The means of transportation, accommodations along the route, length of the daily journey, control and defence of routes and reloading or storage points influence not only the exchange but also interaction rate and intensity<sup>15</sup>.

Those transects of connections longer than the length of a daily journey need station or accommodation in-between. In areas where the terrain restricts those locations, as Salač [421] suggests, there are possibilities to establish control. He illustrates Bohemia's route to Saxony, which passes through a settlement unfavourable area, small settlements occurring near the path as accommodations [421]. For later periods, evidence exists, indicating that exchange follows in stages from producer to consumer [105]; [484]. Groups of traders organise transects or paths, especially in more complex terrain or areas where local knowledge increases safety.

Communication axes belong to the supra-regional scale and consider the approximate course of traffic routes. The evaluation of contact and flow of goods between regions is made possible by knowing the communication axes. Ideal communication axes, i.e. constructed, theoretical models, consist of traffic-favourable connections whereby no obstacles should block the route, the route should be mastered with little effort, and if possible, spanning supraregional networks [344]. The works of Stary [463] and Pauli [375] come closest to this category.

To reconstruct real communication axes, empirical data identify important traffic routes [344]; [344], e.g. imported artefacts [38]; [375] (chap. : 2.2).

Mapping the distribution of artefacts to connect origin and contact zones does not suit the paths' reconstruction, as Salač [421] points out. Such a map illustrates the contact; however, the real physical path remains unknown. The regulating mechanisms can only be evaluated and understood based on realistic physical routes. Salač notes that besides Alpine passes, there are only little indications for reconstructing ancient paths. Additionally, only a small proportion of exchanged goods are evaluated. Often luxurious items, jewellery or weapons, while a much larger part of exchange remains unknown, like salt [476], food, slaves, cattle, textiles or fleece [421]. Further on, artefacts follow several detours until reaching the final deposition. Besides deviation of a direct straight connection from origin to destination, proprietor changes elongate the travel of artefacts [106]; [400]; [421]-, [471]; [484].

Nakoinz, therefore, proposes to reconstruct communication axes from the mapping of culturally identical areas based on cultural distance (chap. : 2.2) [344]. If there is an intensive exchange, there is also a certain degree of cultural alignment. Nakoinz can locate these elongated cultural spaces on the river systems Rhine, Main, Neckar and Danube [345].

Denecke [81] names some fascinating aspects of long-distance traffic. It seems to prefer mostly remote routes running on high-altitude trails, therefore far from settlements connected through a cul-de-sac. Denecke believes that alternative routes are likely; it was not until the Middle Ages that he counted on a concentration of the lines. Long-distance routes arise first in regions with low population density because otherwise, one would explicitly bypass settlements to reach the destination. The example of Salač [421] in Bohemia shows that settlements have emerged along long-distance routes. However, it remains questionable when long-distance traffic uses regional paths and when alternative routes.

The transportation system focuses on connections, and the evaluation is used more likely [344]. Here, settlements are used to construct a network using straight lines, as the exact location of a path is not yet concerned. The system depicts connections by nodes and edges — a graph [83]. The weighting of edges, connections between sites is weighted by specific parameters reflecting, e.g. likelihood of interaction and exchange. Nakoinz suggests a Delaunay graph [79] which connects every natural neighbour<sup>16</sup>. From origin to destination,

<sup>15</sup> For the Roman epoch exists more evidence on these aspects of travelling [23]; [24]

<sup>16</sup> Using an MST (Minimum spanning Tree) connects all nodes with the lowest total sum of edge weights. A tree is a specific graph that does not include any circles. However, as Nakoinz shows, such a theoretical system seems only realistic if travel time

a route passes through different nodes. Not all connections existed; a weighting helps to identify those more probably important<sup>17</sup>.

A transportation system's construction assumes three aspects: First, paths connecting neighbouring points – necropolis or isolated barrows. Edges of a Delaunay graph represent all realistic connected paths. Second, a string of short Delaunay edges indicates a path. The shortness of edges serves as an indicator for the likelihood of existing routes. Third, the route is an efficient connection between origin and destination. Circling or meandering is less likely than straight and stretched routes. Edge betweenness is an appropriate method for creating a subgraph that excludes unrealistic connections [344].

Using settlements to construct a transportation system has some disadvantages. The contemporary of the settlements considered must be guaranteed. Settlements are often poorly preserved, often only partially excavated and not entirely published. The exact dating of the duration of a settlement depends mainly on these factors. Combined with the problems in absolute dating during the Early Iron Age (chap.: 1.4), it is not easy to determine which settlements existed simultaneously.

Furthermore, proving which settlements exchanged with another is necessary if one does not want to apply theoretical models such as the Sphere of Influence, Nearest Neighbourhood, or Delaunay graphs [336]. Direct evidence of interaction is already difficult to do at the supra-regional comparison because of the factors described above (chap.: 2.3.1) that affect the transfer of artefacts or also the provenance. Also, a network based on settlements is prone to missing settlements because missing nodes can impact the entire network.

Besides the problematic dating of a settlement and their relation to another, a settlement's relative location to a path system may be influenced by moving settlements within a settlement area. The assumption that settlement moving around a virtual centre of a settlement chamber is also strengthened by the connection between the accumulation of burial mounds and settlement areas [109]. Shifting settlements, differing functions and indicated settlement hierarchies is also evident in the area around the Heuneburg [267]. Open rural settlements moved in a radius of 1 km at Entzheim-Geispoldisheim (Alsace, France) [125].

Finally, the geographical distance – as the crow flies – deviates from the actual path. The calculated optimizations of the transport system, therefore, may be based upon flawed data.

For example, with a different temporal perspective, Filet [117] investigates the transportation system based on commercial interaction<sup>18</sup>. She attempts to explain the influence of economic flows to urbanisation processes between the end of the fourth and the middle of the first century BC. Considering the urbanisation process as an internal evolution contemporary with intense economic, technical, demographical, social and spiritual changes, Filet could demonstrate the urban response and commercial interaction are mutually connected. However, the commercial interaction is not the monocausal reason for urbanisation, but with detailed knowledge, other factors can be investigated separately [117].

Path networks focus on the exact location of paths. A distinction is made between ideal path systems, theoretically constructed, and actual path systems, empirically reconstructed. Posluschny [387] lists three main assumptions when considering ancient paths' reconstruction. First, ancient roads show immense continuity from the Neolithic onwards, even partially throughout the Roman periods. The use of bridges or crossings of swamps begins at least in the Bronze Age. Second, ancient paths run along crests of hills and mountains to avoid crossing streams, rivers and difficult ground such as swamp and wetland in river floodplains. Moreover, third, prehistoric

---

is irrelevant. Reaching a destination includes large distances. Nakoinz [344] also tested the density clustering proposed by Herzog [182] stating that this method is not well suited for constructing transportation systems.

<sup>17</sup> Nakoinz uses edge betweenness, a value which describes how many shortest paths cross an edge. First, the geographical distance between each connection defines the weight of an edge. In a second step, the shortest path from each node to each node bases on the before calculated geographical distance. The edge betweenness counts each shortest path through an edge and uses this for weighting. The result is a subgraph depicting more important routes based on the used parameter — here geographical distance.

<sup>18</sup> Filet applies the Rihll and Wilson [411] model to estimate flows circulating between sites and extracted benefits. It aims to suggest a hierarchy of links and locations, although excluding any interaction between the actors. This model's major factor is the sites' location and the distance between them, which calculates Filet on cost surfaces for wheeled transport. Initially flow spread uniformly over the network. Each site gathers parts of the incoming flow, depending on its weight (importance) and location, and redistributes it again. With increasing income, the more a site is attractive, the model suggests the relative importance of agglomerations. [117].

routes follow lines of barrows or attracted their construction. In his understanding, the long-term use of path tends to overcome the friction provided by the cost surface, differing from more short-term people's movements, which might have responded more readily to such factors.

### 2.3.2.1 The Local Path System

For the ideal path systems, the connections must first be determined. The same restrictions apply to the use of the settlements as already described for the transport network. Dating, relationships to one another and integration into the local path system are unknown in most cases or too imprecise. The connection between barrows and paths [81]; [327]; [343]; [344] (more details below in chap. : 2.3.2.4) and settlement centres [109] is used to extract settlement centres or junctions from the location of groups of barrows. A density approach to detect local maxima in locations of barrows makes it possible to identify possible centres of settlements or important junctions of a transport system (chap.: 5.4). The approach compensates for two disadvantages in using the settlements. The contemporary of barrows is less sensitive, as they are recognizable as monuments in the landscape after their construction (see below). The relative location of settlements to the local path system resolves by assuming that the currently used settlement is connected to the road network by a cul-de-sac.

Only the creation of the network, i.e. the construction of the existing connections, remains problematic. A Delaunay graph [79] depicts all connection of natural neighbours, without allowing unrealistic bypass situation by skipping a settlement centre (for advantages and disadvantages of Delaunay triangulation see below) [336].

Since here, unlike when considering the transport system, the exact paths are examined, various parameters (chap. : 2.3.2.3) are used for the construction of the path system to model actual paths. A Least Cost surface provides a path system including alternative routes, modelled upon predefined assumptions whilst considering a certain degree of optimization (chap.: 2.3.2.2). Parameters relevant for the emergence of a path can be determined and highlight the usage of a path system [343]. For Denecke [81], relevant route parameters are constraint points of a passage, intended direct connections and a slight gradient loss. The parameters mentioned are incorporated into the theoretical models' development and compared with the empirical path system.

As mentioned above, direct evidence of prehistoric paths is rare. The particular evidence, which also dated in the Early Iron Age [445], is too rare to reconstruct a coherent network of paths. Also, they refer to extraordinary locations, so transferring the parameters to the entire investigation area is inadmissible. Therefore, the local path system must be reconstructed from path associated features. For this purpose, the density-based method developed by Nakoinz is applied to barrows.

Monuments have a central meaning for infrastructure, as assumed to be located next to the prehistoric path. Following the assumption that barrows are path associated features (see 2.3.2.4), their location reconstructs prehistoric path. Naturally, the connection did not exist between barrows but with the population living nearby. Barrows only serve as landmarks to orientate the reconstruction of the prehistoric path.

Path systems are often reconstructed as connections of nodes respecting topography. An intuitive approach uses the distribution of barrows in combination with the topography. However, additional knowledge on other archaeological sites, such as a presumably large settlement, influences the reconstruction subjectively. The results are, therefore, not reproducible, as they depend on the researcher's background. Sophos Müller [327] assumes that barrows are located next to the path and uses their distribution to reconstruct Bronze Age path systems in Jütland (Denmark). Since then, the intuitive approach to reconstruct path systems is widely applied [221]; [304]. With linear aligned monuments, an intuitive approach reconstructs a path system without applying complicated methods. However, denser distributed monuments cover linear alignments and an intuitive reconstruction results in more random path systems.

Network analysis for investigating roads systems, transportation and exchange networks are an essential sub-discipline of geography, which provides several tools. Nodes and edges are mapping elements of an infrastructural network. As network analyses focus on relations of elements, it describes connections based on graph theory [83]. Neighbourhood graphs allow drawing connections between nodes if fulfilling specific requirements

of the spatial properties. A Delaunay graph [79] connects all-natural neighbours. A Delaunay graph draws a triangular if no other point occurs inside a circle crossing all three triangular points. The resulting graph consists of triangular connections. For a transport system, a Delaunay graph created too many connections. A sub-graph reduction is the Gabriel graph, SOI or relative Neighbourhood graph resulting in more realistic transport systems. However, the reduction assumes an optimized system [336].

More recently, Mette Lovschal [296] reconstructs path system using the Delaunay triangulation. She was able to identify corridors for communication and mobility — however, the reconstructed path system crosses barrows directly, which seems unrealistic and unnecessary detours. As a result of the Delaunay graph, the reconstructed path has straight lines contradicting realistic routes. A graph-based approach allows identifying connections on a regional scale, while the exact position of a path remains unknown.

A significant disadvantage of the intuitive approach is the unreproducible result. Each reconstruction differs depending on the researcher and the additional individual knowledge, theoretical preferences, and archaeological training. Moreover, problematic identification of linear alignments closely connects to the non-reproducibility of this approach. A Delaunay graph has reproducible results, which can be tested, modified and redone. However, it is better suited to draw possible connections - a theoretical system. Further disadvantages of this method are the high amount of possible connection, reduced in a second step by creating a subgraph. Caused by directly crossing monuments, detours elongate the route significantly. Besides an unrealistic amount of connections, that path following straight lines through a relief, disregarding mountains, vegetation, rivers or other obstacles is unlikely [343]. Therefore, a density-based approach is applied developed by Nakoinz [343] (detail in chap. 5.3).

The model assumes that monuments, e.g. barrows, are located near the path (chap.: 2.3.2.4). Nearby monuments lay at the same path, and monument clusters indicate traffic junctions [344]. Naturally, not burial sites are connected. Settlements in the surrounding connect to the path system via a cul-de-sac, similar to necropolis [133].

Furthermore, zigzagging of the path is rejected [343] as resulting in a high amount of detours. The path is near the monuments, as being in sight of the monument suffice for orientation. However, for better orientation, a prehistoric protagonist might use a higher position on a barrow.

A case study in Schleswig-Holstein for Bronze Age path systems shows the potential of combining the reconstruction of a path system based on Nakoinz density approach to evaluate influencing parameters [111]. Main routes running north-south and integrating the hinterland by access routes characterise the complex path system, thus enabling effective route guidance in the region. Particularly view-seeking parameters seem to have been essential for the path system. Relief-dependent models show a worse fit to the empirical data. The preference for the sight-seeking models is interpreted as a high need for security and better control of the routes. Against the background of competition and distribution of the bronze, the path system has been reconstructed as an effective distribution system with the central importance of safety [111].

### 2.3.2.2 Path Optimisation

Numerous archaeological studies apply Least Cost Path analyses on path reconstruction [279]; [479]. A Least Cost Path analysis calculates the optimal connection between origin and destination based on distance and effort needed to cover that distance [500]. Missing sections of a known route or complete routes are calculated in order to be able to make a statement about the prehistoric route. The Least Cost Path method is often criticised because of its environmentally deterministic character [286]; [517]. This section questions how a Least Cost Path analysis is admissible because of the optimisation and which conditions influence the quality of the results.

The principle of least effort [529] assumes that humans economise their behaviour by using all available knowledge of a given area or task. Moving through a landscape, humans will naturally choose the path of least resistance [479] as Herzog states [184] the real world equivalent of a Least Cost Path.



The optimisation of a route is a process that is controlled by various variables. At the beginning of the process, the path also consists of numerous random components since the ideal route is unknown [420]. In the course of use, unfavourable path sections are replaced by better, more convenient ones. The catalyst in this process forms the inconvenience of the known route. Such costs can, for example, depend on the relief, be triggered by weather conditions, contain a safety aspect, or consider the availability of drinking water. When choosing a route, human behaviour flows into the routes' formation and the costs that stretch from the continuity of known path, curiosity to the desire for optimisation.

However, when does optimisation even come about? Trade routes, routes for daily use, or frequently travelled routes between interaction partners make the urge for optimisation likely. Trade routes, or neutral exchange routes, should transport goods from the manufacturer to the consumer quickly and without great effort [155]. In addition to time and effort, security and communication will certainly also be essential parameters for optimisation. The path reaches a well or the nearest settlement will have been optimised primarily through knowledge of the surroundings and the frequency of use.

In contrast, some circumstances do not enable or allow for optimisation. Processions are subject to specific religious ideas. The path may run by important places, take a certain amount of time, or not the way, but the procession's common act was of central importance. A crusade also follows other laws since, for example, the area is not well known, and the path is only used once. Travel and once-a-lifetime travel also make it unlikely that the route will be optimised. When investigating such a movement through the landscape, an Least Cost Path analysis is not the right choice [183]. A random walk approach suits better. In addition to relief-dependent costs, they enable us to model ignorance through a random variable [420].

With a suitable archaeological setting that makes optimisation likely, the optimal route can be calculated. Herzog [183] states that the calculation of a Least Cost Path is by "no means trivial" and von Leusen [499] reflecting that the wide variety of parameters used to calculate Least Cost Paths, in general, is a "sign of the immaturity of the field".

The knowledge of the relevant parameters, namely the environmental properties and cultural costs, is not given. Cultural or social effects are assumed to be too difficult within Least Cost Path calculations Herzog [183]; therefore overemphasising environmental factors [517].

Herzog criticises that very few case studies try to validate the results of the Least Cost Path method [185], such as the necessary variables, calculation of costs, use of the software<sup>19</sup> and also the results. If the relevant costs can be identified and modelled, an appropriate method for combining the individual components must be found [520] and a cost function that calculates the actual costs for crossing a cell [183]. Herzog points out that the weakest component determines the overall performance; therefore, all factors and parameters have to be chosen carefully [186].

The criticism of Least Cost Path analyses, especially the deterministic character with the singular path, as a result, leads to new approaches and methods. Howey suggests using circuit theory modelling combined with Least Cost Path to produce richer models of past movements by appreciating the importance of multiple pathways and scenarios with priority to optimum single travel routes [196].

The global knowledge of topography, vegetation, watercourses and other costs cannot be assumed for pre-historic times. Even with a good knowledge of these parameters, it is questionable whether the optimal route corresponds to the real-world equivalent because how should a personal preference be calculated. If there is only a minor improvement, the familiar path was likely continued. It is possible that a route was not optimised sufficiently because the reference points changed too often, such as changes in the interaction structure or shifting fords in the river. Methods that enable us to determine alternative ways with only a slightly lower degree of optimisation improve the disadvantages of the global deterministic of the Least Cost Path analysis (chap. : 5.4).

---

<sup>19</sup> The accuracy of Least Cost Path also depends on the correct implementation of Dijkstra's algorithm [84]. Herzog [183] states that os is incorporated differently in software. Gietl *et al.* tested ArcGIS, GRASS GIS and IDRISI with unreproducible results [148].

### 2.3.2.3 Modelling Costs for Infrastructure

Assuming a certain degree of optimisation, a reference model uses direct straight lines between the nodes to evaluate parameters. Natural and cultural parameters are ignored; therefore, a better fitting to the empirical data is expected for the following parameters [343]. This section highlights the various parameters theoretically that can have influenced a path system by assessing the influencing variables such as vegetation, slope or navigability of rivers on the various means of transport, besides cultural parameters, such as visibility.

Besides means of transportation, Salač [421] points out that transported goods need specific requirements, like large items, the number of goods, sensitive goods in the sense of shock, the vibration of spoiling. Livestock, e.g. cattle or slaves, need a constant supply of food or water, which increases the organisational demand for such trading goods.

The most straightforward mode of transportation is a pedestrian walk, as other technological equipment is unnecessary. Although cost surfaces incorporate energy exposure or walking speed<sup>20</sup>, slope, aspect, terrain, geology, climate, and vegetation are interlinked physical properties that affect possible passages through a landscape.

Helbing, Keltsch and Molnár [177] demonstrates the formation of trail systems show interesting collective effects of pedestrian motion, for example, the emergence of lanes uniform walking direction and oscillatory changes of the passing direction at bottlenecks. For their model, to predict human trail systems in urban grass areas (parks), they incorporated two antithetic effects: The formation of trails by human footprints easing making progress and the regeneration of vegetation leading to a restoration of the natural ground. Humans tend to move toward the largest increase of ground attraction without a visible connection to the destination. However, the walking direction is influenced not only by the destination but also by existing trails. The influencing parameters are used to simulate existing trail systems, which results in a prediction of the trail system and unexpected islands in the middle of the trail system. First, humans chose direct connections. Later, they use already existing trails as it is more comfortable to follow. Second, frequently used trails are more attractive than others, which reinforces them being even more attractive. Weathering destroys rarely used trails, and trails began to bundle. Therefore, pedestrians use and produce common parts of the trail system, although having different destinations.

The pedestrian move is the simplest way to interact, with slope, vegetation, and barriers to the landscape influencing the path formation. Additionally, a preexisting path had a particular influence [177] which leads Howey [196] to include a dynamic approach using circuit theory.

In the Early Iron Age in Europe, wagons are well documented in numerous graves [360]. That their usage only connected to burial practises [72]; [128] is unlikely due to wagon parts' discovery in a profane context [453] (chap.: 4.3.5). A wagon is suitable for transporting numerous goods at once but above all heavy or bulky goods.

Denecke [81] in particular questions the extent to which the use of the wagon influences the formation of the path network. He assumes that the wagon's use only influenced the location of paths from the Middle Ages onwards. Similar evidence proves the location of Roman roads, which were adapted to the movement of pedestrians [155]. However, due to the design of the wagons, Herzog [184] proposed a cost calculation based on the slope of the landscape and a critical slope value of 8 % (chap.:5.4.1).

Additionally, draught animals restrict daily travelling duration. The care of the animals and the supply of feed also influence the speed of transport. Also, dangers from accidents or delays due to bad weather are expected [81].

During the Early Iron Age, cattle were the essential draft animals because of their constant pulling power and less demanding eating behaviour than horses. With 5 to 10 hours of work and a maximum distance of 33 km, the cattle cover significantly less distance than horses that are significantly faster and can cover between 50 and 110 km per day. Donkeys were often used as pack animals. The speed of a group of travellers depends on the weather, region, the load of the animals, and their state of health [19]. Ellmers [105] describes an upswing

<sup>20</sup> details in the calculation of cost surfaces, their combination and appropriate cost functions in chap.:5.4.1).

in terrestrial transport in the Early Iron Age through the horse's introduction, which facilitated quick and easy locomotion on land.

Movements within a landscape can be influenced negatively and positively by rivers [517]. Rivers separate and connect landscapes and people alike. The river system naturally well suites the requirements of a traffic axis. Schneider suspects that rivers are particularly useful as traffic arteries when there was no road network [442]. The use of rivers as traffic routes can either mean the direct use of the river, i.e. through boats or rafts, or following their course as an aid to orientation. Early on in research, it was assumed that paths often run alongside rivers; even if they were not navigable, paths were cut along them through the dense forest [323].

According to Ellmers [105], waterways are better suited for reconstructing transport systems than backdating ancient paths since the European river landscape has developed since the last Ice Age and - taking local conditions into account - has not changed significantly. The waterways system was used differently in different epochs, and the navigability of a river varies not only with the size of the boat but also with the respective climatic conditions.

Navigable rivers particularly well connected in central Europe. Except for mountainous regions, all areas are only a few day trips away from navigable rivers. With the excavations in the pile dwellings in 1854, the logboat proves inland shipping for prehistory<sup>21</sup> [105]. Most boats or rafts can carry out passenger traffic or the transport of most goods. The development of explicit ship types for trade is initially unnecessary unless, for example, transporting wagons.

The comparison of the transport costs over land or water will, according to Ellmers [105], clearly show that river transport is in most cases much easier to manage until the development of railroad systems [106], although the costs for a transport upstream are assumed to be about ten times higher than downstream [105]. The boats can also be driven upwards with oars or stakes, which is why Ellmers [105] does not rate the importance of towpaths so highly. For example, despite the towpaths laid out and maintained by the Romans, [105] punting was still done. Besides defining which river is navigable, the different cost for upstream and downstream movements complicates the construction of cost surfaces for this mean of transportation [118].

The high organisational effort to carry out river transports is only taken into account by Ellmers [105] to a small extent. Port, pier, towpaths or transshipment points with storage facilities and the associated work must be considered for river transport. Following rivers, one moves along a slight gradient, drinking water is always available and bypasses barriers in the landscape, but one also follows a noticeable detour, especially with meandering rivers like the Rhine. Ellmers repeatedly emphasises the importance of rivers in transport systems<sup>22</sup>, above all he criticises their neglect in research on ancient roads [106]; [105]; [107]. However, he assumes a trade network and takes little account of the daily exchange between settlements. Apart from the direct transport on the river, the overland route along the rivers is also suitable because it includes the same topographic advantages as rivers, including the signpost and orientational aspect, but reduces the organisational costs. Neither port facilities, moorings, nor transshipment points are necessary [344].

Additionally, the dividing character of rivers should not be ignored either. Larger rivers like the Rhine, the Danube or the Neckar are difficult to pass. Swimming to the opposite side is risky. River crossings are therefore of particular importance for infrastructure systems. To infer a passage from artefacts' location can be criticised [107]; [436], if it is not differentiated whether the artefacts were deposited there naturally (chap.: 4.2 on river finds and 6.1.1 on the reconstruction of river passages). When crossing a river with a wagon, two aspects are central, the suitable place, a passage, has to offer a sufficiently solid ground and has to be maintained to a certain extent, since the bank area is washed out [107]. The use of transport along rivers is not denied, although direct riverine traffic is not assumed central for the Early Iron Age.

The preference for high altitudes is often mentioned, especially concerning long-distance traffic [81]; [170]; [344]. Once reaching the top level, the route runs over small altitude differences and avoids crossing streams

<sup>21</sup> In addition to logboat, hide boats, bark boats and plank boats are in use from prehistory to modern times. A technical solution that was found to be good has been used unchanged for centuries. Ellmers genealogy of the boat building tradition is strongly influenced by an evolutionist basic idea [105].

<sup>22</sup> see also fluvial transport systems in [59]; [61]; [227]; [459]; [463]; [345].

or rivers. The altitude allows for better orientation, which, similar to the river systems, is often addressed as an important parameter for long-distance traffic. However, this concept can be very problematic, especially in Uplands. The use of ridges is particularly advantageous in narrow and meandering river valleys and regions with pronounced humid lowlands. In this context, the climatic conditions naturally also play a central role [343].

Of course, high Uplands can also represent a barrier in a landscape. For example, the Alps represent a topographical obstacle, which certainly has a culture-dividing character. The Alpine passes<sup>23</sup> represent critical points and mark the few possible passages that could be used during the summer [53]. The altitude as a parameter can therefore test for two different aspects of the routing. On the one hand, the preference for mountain ridges or lowlands is mostly also of river valleys (details on calculation and limitations in modelling elevation related cost surfaces in chap.: 5.4.3).

In addition to assessing which route represents a cost-effective or convenient connection, the preference for high altitudes usually also has a higher safety potential. Paths along high altitudes are usually in a well-visible area. Viewshed analyses can calculate which areas of a landscape were visible (chap.: 5.4.2). Good visibility ensures an increased safety aspect. Besides, visibility increases communication and interaction with the surrounding population. Lee and Stucky [275] stating that public roads were built with high visibility in mind. Avoidance of visibility is mostly seen in connection with conflicts or avoidance of communication or interaction [275]. In connection with security, Haupt [170] points out that an ambush is easier on the best routes, similar to critical landscape points.

For example, the case study of Rahn [391] concerning Middle Iron Age sites (broch) on the Orkney islands investigates besides visibility transportation costs. Finding that the Least Cost Path based on visibility coincided with the path of least resistance, suggesting that the location of broch sites were either chosen to make travel between sites as visible as possible or to make the easiest route, whilst ensuring they were also exposed to outside observation.

On the one hand, the example illustrates the possible influence of visibility, and on the other hand, the formation of the path is not monocausal depending on terrain-related costs. Besides visibility, several other social or cultural costs might be relevant [275]; [287].

#### 2.3.2.4 Reconstructing Infrastructure

Barrows are a widespread phenomenon in north-western Europe. In some regions, they remain visible in the landscape; in other regions, these monuments disappeared due to agricultural activities or erosion [405]. As a specific type of funeral monuments, Barrows occur in similar shape throughout several cultures like North America, Scandinavia, and the Scythians. Indeed, a barrow signals a grave and helps keep the memory, and maybe secondly to mark paths. A traveller approaching a barrow uses these landmarks to orientate and "experiences the presence of the monument" and remembrance of the buried [508]. In rural legends, a barrow exists in collective memory as a funeral monument. For example, in Haguenau (Bas-Rhine, France), some barrows are told to be Attila's grave (king of the Huns) or Siegfried's grave, the hero of the *Nibelungenlied*. Still recently, these mythological names occur in street names of the region [508]. The following section highlights the location of barrows within a landscape, in respect of visibility or orientation will highlight their doubled role for communication and as landmark structuring the cultural landscape.

At the beginning of the 20th century, Sophos Müller and Xavier Nessel suggest dependencies between necropolis and path systems or communication axes. In 1904 Müller first published a paper indicating dependency of barrows and paths. There he criticises the focus on settlements and graves of contemporary researchers, while paths and locations are neglected [327]. Müller describes the location of barrows regarding infrastructure as follows:

- Barrows occur in linear axes suggesting paths.

<sup>23</sup> One could include such points in a cost surface, similar to the procedure for rivers with bridges [279], by low costs. However, since the Alps are outside the working area, this approach will not be pursued any further.

- They are well-visible.
- Barrows following the local topography and occur in relation to, or nearby to waters.
- A pass is often marked with a barrow.

More recently, Klassen compared the reconstructed paths by Müller with historical maps and confirmed Müller's results [229]. Furthermore, Klassen shows that monuments of different epochs (TRB, Single grave) can be used in combination to predict paths.

Although Müller does not cite Beowulf's saga, it is highly probable that he knew it and used it as inspiration (19th and 20th century strengthens nationalism in Denmark) [27]. According to the saga of Beowulf, a barrow should be ostentatious and on prominent location, well visible from waters for seeing and saluting [509]. For example, a viewshed analysis of 400 Bronze Age barrows in Scania (Sweden) shows preferred locations offering views over the sea. This preference may relate to the cosmological beliefs of Bronze Age communities [270]. The result also fit the described location by Wassong [509] and other examples proving the relation of barrows and visibility [123]; [516]; [527]. In contrast, Posluschny demonstrated that barrows are not necessarily well-visible regarding the settlement area [385], which is undoubtedly correct.

Nonetheless, that does not contradict a barrow's position next to a path that helps to orientate in the landscape. If the path was not intended to be well-visible from a global perspective, a barrow next to it would not be either. Nevertheless, it will have been seen quite a lot by people passing by.

Kurz [262] describe various locations for Early Iron Age barrows like in valleys, next to riverbanks, on mountain ridges, between hills, on infertile soils and slopes facing different orientations. He assumed that a necropolis location depends on the accessibility of areas not needed for agriculture. Preferred necropolises locations are neither provable nor expectable; for Kurz, individual solutions are more likely to explain the location. A tendency close to paths is declared with the communicational character of visible monuments, which is for Kurz insufficient to reconstruct paths; however, this is contradicted by several studies [16]; [111]; [234]; [344]; [343]; [449]. He interprets the closeness to water as a side effect caused by settlements near water [262]. However, Kurz does not conduct a geomorphological analysis of the location of barrows.

The distribution of barrows within a landscape is not random, and although individual solutions occurred, locations are prominent [6]; [127]; [165]; [405]. Fontijn points out that deliberate selection indicates a barrow's importance to structure a landscape. Newly erected barrows will increasingly structure the landscape for contemporary, and later generations [127]. De Reu demonstrates that the choice of appropriate methods for identifying the position affects the archaeological interpretation immensely [405]; [404].

More recently, Balzer [16] summarises that a barrow is a landmark, marking a river passage (Remseck-Neckarrens, Baden-Württemberg) or a long-distance path (Magdalenberg, Baden-Württemberg), which does not contradict a border marker or regional ownership as a representation of power and a symbol of ancestors worship [16]. Llobera [288] investigates the relationship between monuments and the location of movements. He could demonstrate that monuments in the Barbanza mountains reinforce corridors' location, not determine them, as indicated in [67]. Moreover, Llobera shows that monuments are located on a "privileged crossroad" offering the most choices in travel direction [288].

The meaning of burial mounds as a symbolic marking of a border [399] does not contradict the burial mound's position on a path. The above-ground construction of a monument that is visible from afar makes the communicative character clear. It can communicate a border and at the same time, serve as a signpost and orientation in the landscape. If the monument's original meaning was to mark a settlement area, a path could still be oriented towards it. Assuming that initially there was a path, the monument may have been deliberately erected near this path to communicate a borderline [344]; [343]; [404]. A border marking that is not visible cannot serve its purpose [111].

The unmistakable communicative character of barrows is conveyed by the aboveground structure and the sometimes enormous dimensions. The barrow of human-made tombs is certainly known by the contemporary population and is evidenced by the monuments' frequent reuse as a funeral site. The dating of barrows was presumably unknown to a prehistoric society; all grave mounds erected before (a specific temporal point of view) are valid for reconstruction as part of the cultural landscape and perception of the contemporary population.

Incorrectly dated burial mounds also have no profound influence on the results since a density-based method is used that has proven to be highly robust (chap.: 5.3) [111]. Nonetheless, careful source criticism is equally needed to estimate biases in the original number and distribution of barrows (chap.:4.2.1).

## 2.4 Bottleneck Situations in Prehistory

The definition of political power by Earle and Spriggs [92] is the ability to manipulate a group to act in the leader's interest, although conflicting with other interests. Individuals or groups try to access sources of political power to enforce their interests. Earle and Spriggs, in *sensu* Marx [307], every social evolution can be understood as a power struggle between social segments in manoeuvring decentralized fields of power. Elemental powers derive from the economy, a warrior might, and religious ideology [93]; [301] by control of the means of production, of coercion, and symbolic legitimation. They describe political power as a process which may dissolve or be augmented likewise [92]. Power strategies involve different power sources as none is dominant to reinforce the others. Political economy uses the surplus to expand all powers by channelling resource flows to finance power strategies. An analysis of political power requires the identification of conditions responsible for emergent social stratification and political control. Since Marx's historical materialism is not applicable in prehistoric times due to a lack of evidence, a deliberate approach must be pursued. Therefore, Earle and Spriggs emphasize that central power and social stratification are based on circumstances that allow bottlenecks.

Bottlenecks are points in the commodity chain, offering limited access, thus creating ownership over resources, technologies or knowledge. As a result of unintended consequences of environmental conditions, like fertile soil, or intended consequences of strategic actions, like the construction of fortifications overlooking exchange routes, bottlenecks emerge. For an analysis using the political economy approach, identifying bottleneck situations and their dynamics needs to cross the societies' whole spectra. To gain surplus from a bottleneck situation, control at any point of the commodity chain — trade, production or land — is necessary. The consumer gets access in return for *corvée*, rent or other payments. If the costs to move away or establish their access are higher than the payment, consumers will stay. A mutual relationship between leader and consumer from a dynamic bond, whereas the consumer remains not powerless [92].

First, a political economy approach identifies the general economy, like subsistence, trade, and commodity chains; secondly, it identifies essential commodities for societies to examine its commodity chain for potential bottlenecks. Besides the centralizing potential of bottleneck situations, the evaluation needs to consider the contrary opportunities for commoners acting free from elites control. Thus, the political economy approach allows for the consideration of early dependency systems since free movement is possible. The dependency system is of particular interest concerning the Heuenburg, where there is a rapid loss of population without the system collapsing completely. If assuming a medieval nobility, the princes should exercise more personal power over the commoners. So far, the origin of the wealth of princely seats remains unknown (chap.: 1.1). As defined by Earle and Spriggs [92], political economy provides a new perspective to identify the wealth of those leaders, chiefs, Big Man or princes. Although the Early Iron Age is a rather short period, identification of bottlenecks seems possible.

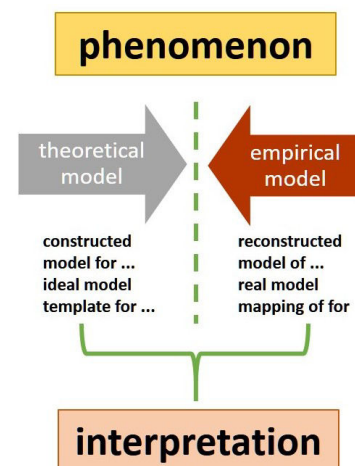


Fig. 2.2: Theoretical and empirical models (after Nakoinz [336]).

## 2.5 Theoretical and Empirical Models

The definition of a model is just as diverse as the definition of culture [338]; [336]. The core idea of a model is dealing with particular objects and ideas. Therefore, it comprises certain features of the original object or ideas selected for an individual purpose and allows to communicate, reveal, and compare some aspects of the phenomenon of interest. As connected to particular methods, theories and assumptions, the range of application of a model is determined [482]. In this sense, models are a reduction to display relevant features of a selected phenomenon. Two fundamental models have differentiated (fig.: 2.2): a theoretical model constructed based upon specific rules and an empirical model, which retrieves the model based on empirical data. While the empirical model depicts a phenomenon, the theoretical model represents the ideal case considering specific rules. No theoretical model can contribute to knowledge about the past until it is compared to an empirical model. Without comparison with empirical data, a theoretical model is an educated intellectual game. If the theoretical model fits the past reality, the rules for constructing the model may be transferred onto the empirical data for interpretation. Although the theoretical model does not fit, this may exclude the rules and assumptions from the interpretation and develop new, more comprehensive interpretations [347]; [337].

Empirical models depict the reliability more or less well in a reduced form, but the developing phenomenon's explanation remains unclear. Only by comparing it with a construct, of which we know the rules and conditions exactly, can we draw conclusions that explain the empirical model.

Since they represent a reduction of reality, models span a wide field between simple and complex models. The distance model mentioned above is simple, the theoretical course representing the distance dependence of the interaction. Simply because it only takes the distance as a factor and differentiates disturbances from a continuous course. The modelling of the infrastructure parameters is a more complex model because different weighted factors are considered.

## Chapter 3

# Geographical Area: Baden-Württemberg and the Alsace

Topography, geology, soil quality or aspect are only some geographical parameters influencing human behaviour in selecting settlements, burial sites and location of paths <sup>1</sup>. Although this analysis does not aim to reconstruct or model the past landscape or landscape formation, these properties relate closely to the interpretation and understanding of infrastructure and interaction pattern. Therefore, a brief introduction to the geographical properties of Baden-Württemberg and the Alsace will be helpful to gain an overview.

Geographers use the term landscape to describe an "area made up of a distinct interrelation of forms, both physically and culturally" [424]. As Haupt states, the landscape <sup>2</sup> is a defined space based on the negotiation of its definition [170]. Cultural landscape describes the state of a landscape influenced and changed by human impact. Anthropogenic processes potentially influence every single element of a landscape, and static conditions or natural balances do not exist and are not preservable are two main assumptions on cultural landscape [170]. In this section, a past landscape refers to a landscape term fitting for geo-archaeology; hence the history of the interrelationship between humans and the environment, focusing on landscape reconstruction [336].

The German federal state Baden-Württemberg was founded in 1952 and merge mainly the Kingdom of Württemberg and the Grand Duchy Baden. It covers the south-western part of the *Bundesrepublik Deutschland*; hence it shares borders to France and Switzerland (fig.: 3.1). The Alsace is a landscape, and former administrative region in eastern France, meaning the departments Bas-Rhin and Haute-Rhin, covering the south-western part of the Upper Rhine Valley reaching northwards to the plateau Lorraine.

Baden-Württemberg divides into seven main macrochores of third-order <sup>3</sup> (Upper Rhine Valley, Black Forest, Neckar-Tauber Valley, Swabian Keuper-Lias Region, Swabian Alb, Danube-Iller-Lech Plateau, Foothills of the Alps). Moreover, 66 macrochores of fourth-order illustrating the complex and heterogeneous topography and geography of Baden-Württemberg [460]. Different parameters of land use, climate, landscape features and river systems characterise these macrochores. Ideal climatic conditions combined with good soil qualities define the macrochores of Upper Rhine Valley, Neckar and Tauber Valley, partially Danube-Iller-Lech Plateau and Foothills of the Alps. The Upper Rhine valley is a sediment-filled rift valley. Bordering mountains on its eastern river banks, the Black Forest and Odenwald consist of granite, gneiss and bunter sandstone. Their north-south orientation collects most rainfalls; hence their western waters have cut deeply into the surface of the Black Forest. The highest mountain of the Black Forest is the Feldberg, with 1493 m above sea level and the highest of the Central German Uplands. The south-west German escarpment landscape, the Neckar and Tauber Valley, consists of vast hilly terraces separated by several steps creating subregions like the *Baar*, *Obere Gäu*, *Stromberg*, *Kraichgau* and further on. Loess covered areas, and mild climatic conditions allow intensive agriculture, which results in a still exceptionally densely settled region. The Swabian Alb, forming a separate part of the Central

---

<sup>1</sup> More recently, Doris Mischka developed a methodology for reconstructing prehistoric settlement structures regarding the landscape formation in Baden [318].

<sup>2</sup> On the etymology of the term landscape see [129]; [170]; [277].

<sup>3</sup> Additionally, three other macrochores border Baden-Württemberg and cover only minor parts [460].



German Uplands, is a water-poor karst area. As the largest swallet in Europe, the White Jura swallows the Danube around Immendingen and Friedingen. Additionally, low temperatures, high rainfall rates and minor soil qualities, especially on the *Hohe Schwäbische Alb* and *Mittlere Kuppen Alb* restricts modern agriculture mainly to grassland. The impact crater of the *Nördlinger Ries* limits its eastern border. The Swabian Alp counts as a barrier for transport, trade and, in general, traffic. Four possible passages allow to overcome the 300 m high stepped rim: *Pforte von Immendingen*, *Reutlinger Pforte*, *Geilinger Steige* and *Pforte von Aalen*. *Oberschwaben* and *württembergisch Allgäu* are parts of the foothills of the Alps with low hill country, the Lake Constance and former volcanos in the area Hegau [261]. As a result of the hilly topography, rivers and valleys have been highly relevant for settlements, land use, and traffic. The rivers Danube, Iller and Lech form another favoured macrochore. Grassland and agriculture dominate, and woodland cover only higher areas [460].

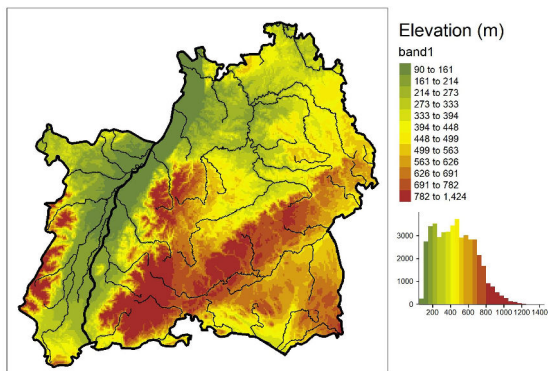


Fig. 3.1: Digital elevation model of Baden-Württemberg and the Alsace (incl. histogram of elevation, DEM: SRTM 90 m).

values of 626 m have a comparable frequency of only 214 to 273 m and 448 to 499 m occur more often. Although only depicting elevation, the macrochores mentioned before are recognisable.

Two large river systems cross the study area: the Rhine and the Danube, connecting the study area with large parts of western and eastern Europe reaching the North and Black Sea (fig.: 3.2). These two river systems connect the North Sea following the High Rhine and Lake Constance into Württemberg and the Black Sea following the Danube. A south-western passage to the Mediterranean Sea follows the Belfort Gap and the Valley of the Rhône.

The Upper Rhine Valley is approximately 300 km long and 30 to 40 km wide. Here, the Rhine cuts through a sandy surface with a low gradient, which results in a densely branched zone of countless, always moving branches and more than 1500 islands. Behind Strasbourg these branched zone changes to a meandric river with also constantly changing sinuous curves [312]. Confluence rivers like Elz, Feuerbach, Dreisam<sup>4</sup>, Neumagens, Möhlin, Eschbach, Sulzbach, Glotter, Fliederbach, Klemmbach and Neumattbach transported debris and pebbles from the Black Forest, creating alluvial fans [318]. On both riverbanks, during the Würm glaciation formed terraces rising to 10 m above the modern river. The western Rhine terrace is cut through by confluence rivers like the river Ill. In northern Alsace, this terrace is up to 10 km away from the modern River bed, between the rivers Zorn and Moder, which generated marshy areas, the so-called Ried [293]. Further alluvial terraces formed during the End of the Neolithic and Bronze Age, creating a coherent terrace in central Alsace, while in northern Alsace, these terraces are less coherent and forming islands [293]. Three phases divide the restruc-

<sup>4</sup> The alluvial cone of river Dreisam is probably part of traffic route indicated by Iron Age settlements [318].

Nowadays, the Rhine in the East, the ridges of the Vosges in the West, the *Pfälzer Wald* in the North, and French Jura and the Belfort Gap in the South limit the Alsace. Through the southern part of the Upper Rhine Valley - the so-called Alsacian Plain - flows the Ill. Notably, the confluences of the Ill in the western areas of the Alsace form broad river valleys with alternating meadows and forests. Larger Forest areas occur in the vicinity of Haguenuau (Haguenuauer Forest) and the Harthwald in the South. Besides these vast plains, around Strasbourg and at the borders of the Alsace, a hilly landscape occurs. The Grand Ballon (Große Belchen) is the highest mountain of the Vosges, with 1424 m only slightly lower than the Feldberg.

Fig 3.1 illustrates the described heterogeneity of the area in question. Large parts are covered by flat areas, mainly river valleys; however, the Black Forest, Vosges and Swabian Alb contrast. The histogram of elevation represents the global trend of elevation. Besides an initial step (until 90 m), the elevation

turing of the Rhine by anthropogenic activities<sup>5</sup>. Starting in the 16th century by building dykes to tame the *wild* river Rhine. A second phase in the 1890ths, channelling of the Rhine, changed the landscape of the Upper Rhine Valley drastically: The branched zone disappeared, the small Rhine islands, and the groundwater level dropped influences erosion and created new marshy areas. And thirdly, the recent modern channelling of the Rhine [284]; [293]; [312]. More recently, Schmid-Merkl describes the Upper Rhine with its morphological and hydrological properties, modern channelling, and influences on the deposition of archaeological material [436].

The Danube rise in Baden-Württemberg at the confluence of the rivers Brigach and Breg, both rising in the Black Forest, quickly develops to the second-largest stream in Europe. Like the Rhine, modern building activities force the Danube into her current river bed; former marshy areas with regular occurring high water have vanished<sup>6</sup>.

The European watershed reaches its western extent in the Black Forest with the Danube and, on the other side, the Rhine and their confluence rivers. Rainfall, which collects at the Black Forest, generally flows towards the Rhine. In contrast, rainfall that collects at the Swabian Alb tends to flow into the Danube [144].

Generally, the climate in Baden-Württemberg and the Alsace favours from its southern location, and the Upper Rhine Valley with its yearly average 10°C is one of the warmest regions in Germany. Naturally, other valleys have similar high temperatures, but the yearly average temperature declines with increasing elevation. With a yearly average 4°C one of the coldest areas of Germany is the Black Forest. Regardless, documentation shows extremely cold winter for the *Baar* due to stationary temperature inversions. Demonstrating briefly how different the climatic conditions in the study area are: Warm and mild climate along river valleys contrast cold average temperatures in Central German Uplands.

Additionally, extreme climatic conditions occur, which influence local vegetation and settlement behaviour. Agricultural societies are firmly bound to their surrounding nature, and therefore climate changes affect these societies. Nevertheless, socio-political change triggered only by climate change is unrealistic, as many stress-reducing scenarios are possible. Nevertheless, the climate is an influencing factor for the prosperity or decline of societies and civilisations. During Ha D1 until Ha D3, good climatic conditions induce agricultural upswing, rising population and economic upturn, which corresponds well with the prosperity of princely seats [299]. Falling average temperatures from Ha D3 to Lt A result in a reduction of the vegetational area, resulting in a reduction of agriculturally usable land [465]. Only slight changes in the annual temperature have immense consequences for the hilly region of the Swabian Alb, possibly resulting in a crisis for food supply (see. fig. 5 in [465]). This effect is less dramatic for favourable climatic regions like the Kraichgau or the Neckar valley. A detailed and regional study of vegetation and land use of the Nördlinger Ries (Baden-Württemberg), close to the Princely Seat Ipf (Bopfingen, Baden-Württemberg) by Stobbe proves the decline of forests with the increasing impact of cereal production from the Early Iron Age onwards. The intense agricultural land use is explicitly visible from 800 to 625 BC with reduced fallow phases. Longer fallow phases took place between 652 and 350 BC when a drastic increase of cereal pollen shows an intensive cereal production [473].

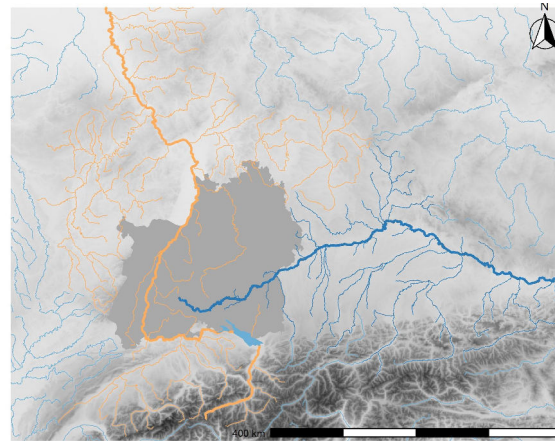


Fig. 3.2: River systems of Rhine and Danube (DEM: SRTM 90 m).

<sup>5</sup> Reconstruction of historic river beds, topography and hydrology of the Upper Rhine [284]; [293]; [334].

<sup>6</sup> Drastic changes happened during the correction of the Danube between 1806 and 1867 [460].

### 3.1 Subareas

For regional case studies, three subareas are located at the Haguenauer Forest (Bas-Rhin), *Breisach Münsterberg* (Baden-Württemberg) and at the Swabian Alb (Baden-Württemberg) (fig.: 3.3).

The first subarea covers an area from Gougenheim (Bas-Rhin), southwest of Haguenau, to Drumersheim, north-east of Rastatt (Baden-Württemberg) resulting in a rectangular area of 50 to 25 km. The Haguenau Forest is the largest continuous forest in Alsace, covering 13,400 ha and extends from Pfaffenhoffen to Bischwiller and Seltz. Several rivers run through the area (La Zinsel, Eberbach, Halbmiehlbach, Klostergraben or Seltzbach) and flow into the Rhine. Those rivers transport and deposit pebbles from the Vosges while Moder and Le Sauer are forming alluvial cones. The mountain regions of the Vosges in the west and the Black Forest in the east form a natural border for this area, and the Rhine terraces rise 10 m above the Rhine valley. The Haguenau Forest itself is situated on a Würm glacial terrace and has infertile and sandy soil not suited for agriculture. Claypits from Soufflenheim or Betschdorf might have been visible and exploited in prehistoric times. Still today, a strong ceramic tradition is present in those two vicinities [508]; [440].

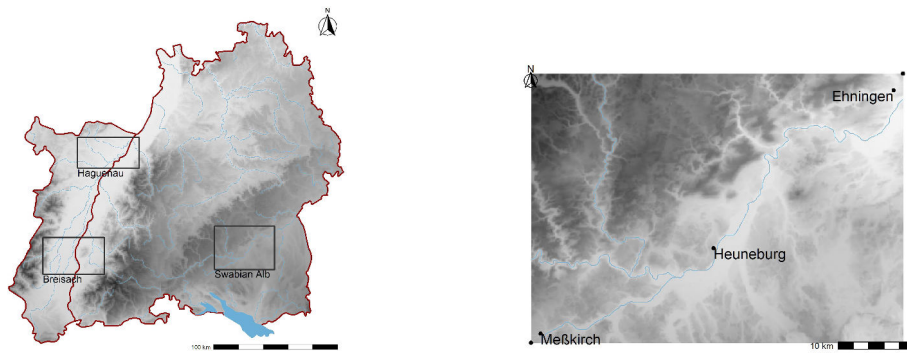
The prominent topographic location of the Münsterberg in Breisach (Baden-Württemberg) next to the Rhine centres the second subarea, which extends from Guebwiller (Haut-Rhin) to Schweighausen (Baden-Württemberg) in the Black Forest resulting in an area of 50 to 30 km. The Vosges and the Black Forest - again bordering mountains, the Rhine corridors in a north-south direction, connecting the Belfort Gap and the Lower Rhine. Several macrochores occur in this subarea, like the Freiburger Bucht, Kaiserstuhl, Markgräfler Rheinebene und Hügelland. As mainly three rivers Glotter, Dreisam and Elz, form a massive fan and cut deeply into the Black Forest, the transported pebbles form the elevated area (200 m) of the Freiburger Bucht. Towards the Rhine Kaiserstuhl and Tuniberg limit this macrochores. The Kaiserstuhl, a small volcanic mountain of the Central Uplands, rises 377 m above the Rhine. Together with Tuniberg, Nimberg, Schlatter Berg, and Lehner Berg characterise this landscape. Besides the Rhine, channelled rivers are Dreisam and Elz. Viticulture and the reallocation of agricultural land shape the most recent natural scenery [230].

The well-known archaeological site Heuneburg centres the third subarea. The two modern villages Meßkirch and Ehningen (Danube), serve as limitations of the 35 km to 49 km large area. The Swabian Alb declines towards the foothills of the Alps. The *Mittlere Flächenalb* and the *Donau-Ablach Platten* form the main macrochores divided by the river Danube while Ablach and Lauchert are two confluences of the Danube. The subtle relief of the Danube-Ablach plateau contrasts with the mountainous relief of the Swabian Alb. The modern land-use of the Swabian Alb is characterised by meadows and dryland farming and consists mainly of woodland, while in the Danube-Ablach macrochore, only near the Federnsee woodland is preserved [460].

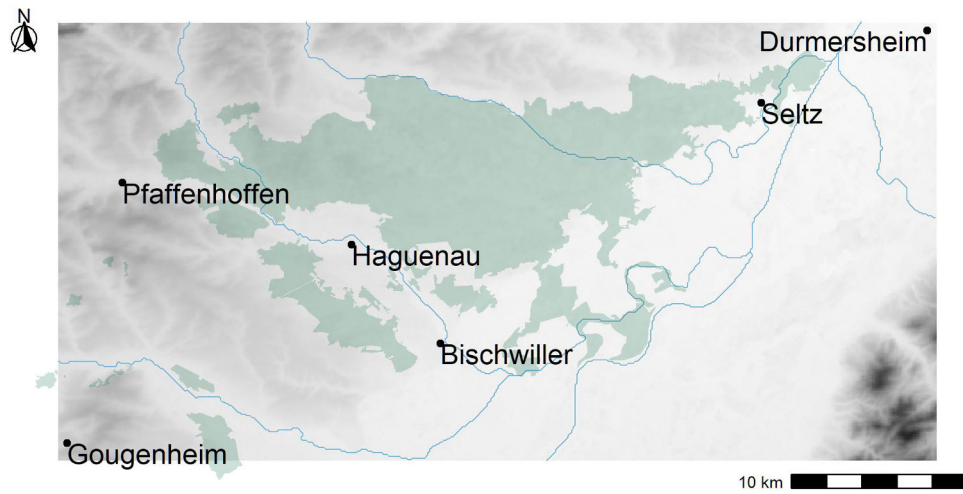
### 3.2 Digital Elevation Model

Naturally, landscapes change continuously [146]; [269]. There are times when changes happen fast caused by anthropogenic or climatic influences, such as when changes are slowing down. Therefore, there is no unique past landscape; it depends on the considered period. Its reconstruction needs to combine several disciplines like hydrology, geology, and of course, archaeology. Besides naturally and continuous change of landscape, e.g. moving river beds and channelling rivers, this section discusses the re-allocation of agricultural land and other modern building activities and their influences on the topography. Although landscape reconstruction is out of the scope of this study, working with geographical data forces to assess modern data critically. Moreover, to estimate which data precision is necessary. The choice of DEM and its raster size depends on planned analysis, landscape, availability of data and archaeological framework (meaning behaviour of past societies in selecting sites).

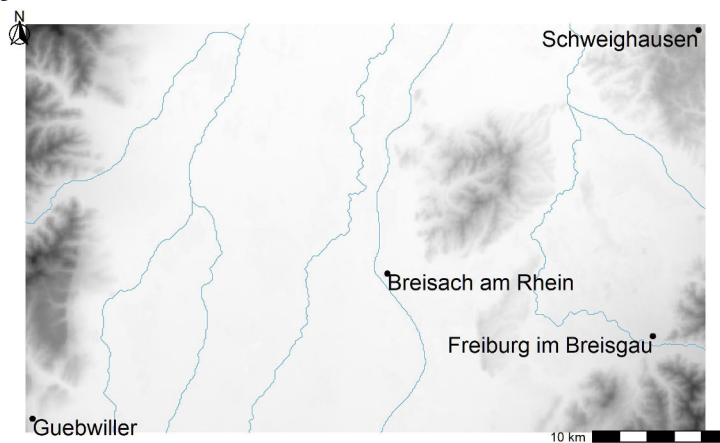
During the last 200 years, anthropogenic activities, mostly building activities and raw material extraction, rapidly changed some Baden-Württemberg and the Alsace areas. The channelling of rivers, straightening parts



(a) Location of Subareas within geographical area (b) Subarea Swabian Alb



(c) Subarea Haguenau (light green: Forest of Haguenau)



(d) Subarea Breisach Münsterberg

Fig. 3.3: Digital elevation models of subareas (DEM: SRTM 90 m).

of them is one of the more extreme examples <sup>7</sup>. Straightened rivers obscure older river beds, resulting in the lowering of groundwater levels, which has a significant impact on a complete landscape. For example, the Rhine channel forced the river into a 200 m broad and straight river bed, instead of a dense and widely branched 2 to 4 km wide river. Besides positive effects, like more agricultural land, fewer risks of high water in this particular region and the elimination of malaria, some confluences cannot reach the Rhine anymore and created new marshy areas [312]. Additional canals in the study area are the Grand Canal d'Alsace and the *Leopoldkanal*.

Furthermore, re-allocation of agricultural land after World War II, for example, for viticulture in the area around the Kaiserstuhl and *Vorbergzone*, often involves massive earth movement. The re-allocation of former small parcelled fields, construction of access roads and in some areas installation of rain retention basins for water management results in the recovery of many archaeological sites and reshaped the local topography drastically [119]; [120]; [121]; [308]. Although the re-allocation of agricultural land changed the local topography, and in the case of Baden, a reconstruction of the former landscape is impossible, the tendency of location did not change [318].

For several analyses, models of human behaviour using the topography of a landscape contrast archaeological observations as empirical data. Therefore, a sufficient Digital Elevation Model of the geographic area needs to be selected. Recently, archaeological studies use either open-source Shuttle Radar Topography Mission (SRTM) data in 90 or 30 m raster size [350] or commercial DEMs with higher precision, like LIDAR (light detection and ranging). Mischka points out that elevation values gathered from topographical maps using interpolation of two isolines cannot be assumed to be more precise in general, as most data on the creation of topographical maps are missing [318]. Requirements for topographic maps to study catchment areas of single settlements differ naturally from requirements of cross-regional infrastructure analysis, such as for a Least Cost Path analysis. Both ends of the scale (90 m raster size to 10cm) inherit different obstacles: From missing topographic elements, like the pronounced structure of the Breisach Münsterberg [318] or so-called *Bücke* <sup>8</sup> of Upper Rhine Valley to overprinting of modern building activities [181].

As airports, highways, rain retention basins or re-allocation of viticulture changes topography drastically, and in some cases, reconstruction of past relief is impossible, the global trend preserves [180]; [186]; [269]; [318]; [425]. Furthermore, knowledge of the method-inherent error and possible errors occurring by interpolation should guide the model selection. For this study, the SRTM of 3-arc-second (90 m, [350]) has a sufficient resolution to depict the global topographic trend of the study area while not pronouncing modern building activities. Rademaker states that SRTM provides a more accurate representation of the landscape than similar DEMs [390]. Generally, accuracy for SRTM-C band data (90% confidence intervals [416]) is 8.8 m absolute geolocation error and a 6.2 m absolute elevation error <sup>9</sup>. Nevertheless, these errors depend on several factors and can increase drastically. Eineder and Holzer reported higher elevation errors reaching over 30 m for alpine regions due to an increasing slope of 50°, changes in aspect towards the north and northwest (due to radar shadow effects), and vegetation [104]. Mouratidis *et al.* also suggested that slope was the dominant factor controlling SRTM accuracy, with the critical value at 18°; above this value, the errors may increase dramatically [325].

---

<sup>7</sup> That river systems are in a constant state of change is part of their nature [146]. Modern maps often depict static, channelled and straightened rivers, hence a wrong impression. Only an interdisciplinary study combining geomorphology, hydrology and archaeology might reconstruct a river system of a particular period. Therefore, Mischka suggests using historical maps to get an impression on the width and behaviour of a water system [28]; [318].

<sup>8</sup> Those slightly elevated sites might not influence the macrochore but are relevant regarding settlement structure [271].

<sup>9</sup> Using a provided function `add_dem_error` of the R package "leastcostpath" by Joseph Lewis corrects the SRTM data [280].

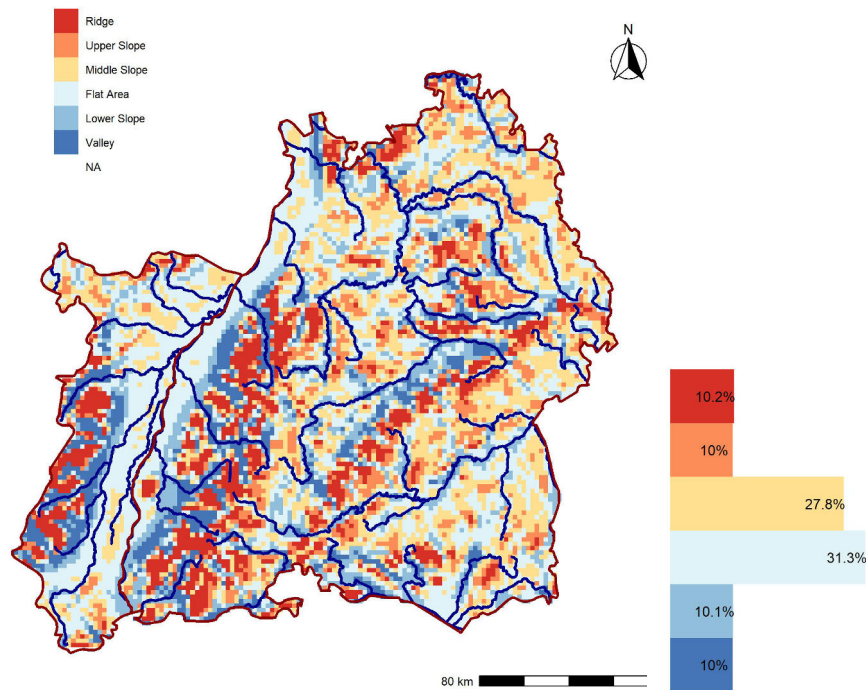


Fig. 3.4: Landform classification of Baden-Württemberg and the Alsace (method: DEV, DEM: SRTM 90 m, neighbourhood size 1 km radius).

### 3.3 Landform Classification

The topography of the study area is composed of Central German Uplands and large fluvial plains; therefore, it can be described as a heterogeneous relief. A landform classification following De Reu's approach<sup>10</sup>, presented in figure 3.4, highlights the heterogeneity with high ridges and low river valleys. The alternating occurrence of these two landforms, clearly visible at the Swabian Alb or the Black Forest, intuitively depicts the topography better than elevation values. Like the Neckar-Tauber Valley or the Danube-Iller-Lech Plateau, areas with a more subtle relief show much less abrupt changes in landform classification and appear more homogeneous. The main landform is characterised by flat areas (31%), followed by a middle slope (28%). Ridge, upper slope, lower slope and valleys each landform represented with 10%.

Comparing the three subareas (fig.: 3.7) illustrates their topographical differences. The Haguener Forest is characterised by fewer ridges and valleys and more flat area as the complete area. The Rhine Valley, which appears entirely levelled in a DEM, reveals in the landform classification several features as the Rhine terraces or small, slightly elevated areas. The slopes of the Black Forest in the southeastern part of the subarea occur as an abrupt change from the flat area to ridges crossed by valleys. However, the dominant landforms are flat and lower, while other landforms occur much less frequently. The frequency of landform in the subarea of Haguener resembles that of the complete area in question.

Nevertheless, the bordering mountains are visible, and the meandric rivers Le Sauer and Moder. The second subarea, around Breisach, illustrates the extreme topography in this region. The Vosges and the Black Forest restrict both sides, while the flat Upper Rhine Valley has only subtle relief. Lower slope and flat area are the

<sup>10</sup> For a detailed description of the applied method and its limitations see 5.4.3.

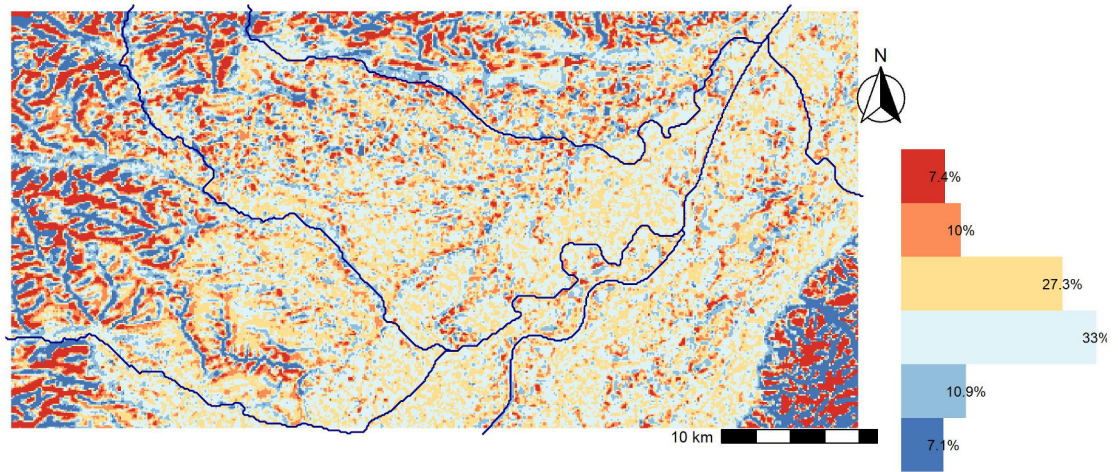


Fig. 3.5: Landform classification of the Haguenau Forest (method: DEV, DEM: SRTM 90 m,  $r = 1$  km).

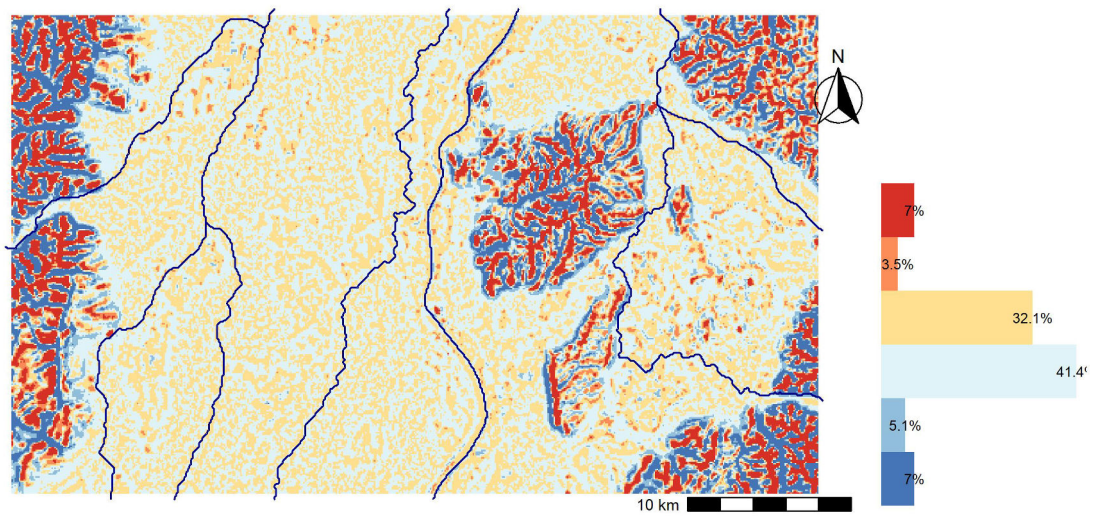


Fig. 3.6: Landform classification of around the Breisach Münsterberg (method: DEV, data: SRTM 90 m,  $r = 1$  km).

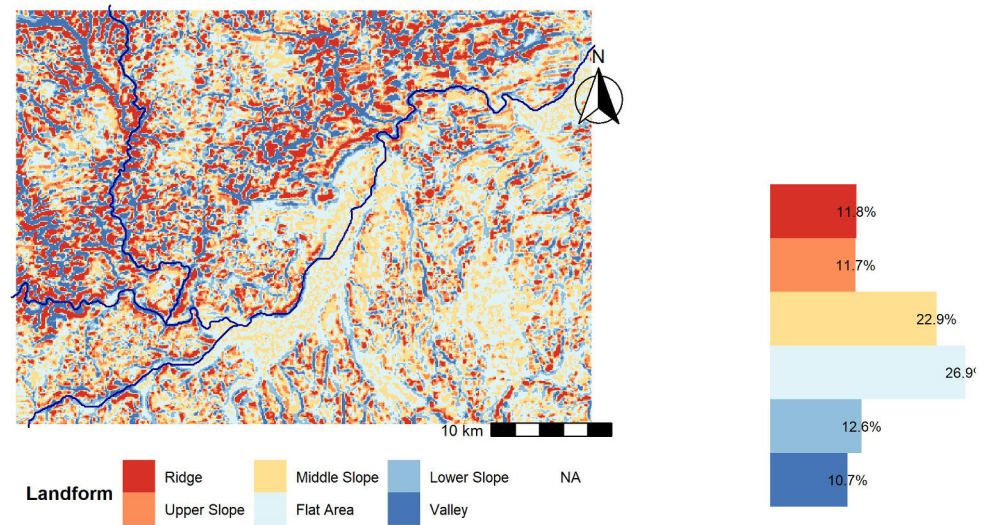


Fig. 3.7: Landform classification of the Swabian Alb (method: DEV, data: SRTM 90 m,  $r = 1$  km).

dominant landforms, which contrasts to Baden-Württemberg and the Alsace proportions. The third subarea centres the Heuneburg next to the river Danube at the edge of the Swabian Alb. The slopes of the Swabian Alb split by valleys are well visible in the landform classification and the more flat relief of the Danube-Ablach plateau. In this subarea, dominating landform classes are lower slope and middle slope, while other landforms occur equally. However, the abrupt changes from ridges to valleys in the north-western part of the subarea illustrates a heterogeneous landscape.





## Chapter 4

# Archaeological Data

During decades of research history, the term Hallstatt Culture <sup>1</sup> comprises common practises and tendencies that can be observed throughout the Early Iron Age in Europe. These tendencies do not occur evenly in the entire region. In fact, the regional deviation is a crucial characteristic of the Early Iron Age in Europe and a major reason for this analysis. Even if those regional phenomena are not named explicitly, and some are more important for the analysis than others <sup>2</sup>, their sources — archaeological artefacts — are mutually integrated (chap.: 2.1).

### 4.1 Source Criticism

Source-critical factors and effects like formation processes, taphonomy, recovery likelihood or research history reduce possible obtainable information about past reality. Moreover, additional filters transfer the deposited material culture due to cultural effects (e. g. burial habits), recycling, re-use, or break down of artefacts. For statistical analysis, a critical evaluation of those factors and effects is crucial to estimate the potential influence and evaluate whether statistical tests are admissible.

Schier's model [434] of an archaeological process is broadened by O. Nakoinz to a concept of reduced information <sup>3</sup>. According to Nakoinz, several more levels of reduction, which alter between selection and transformation, until interpreting the material culture takes place (fig.: 4.1, [345]; [340]). Artefacts undergo a first transformation (c-transformation according to Schiffer [435]) by usage, abrasion (wear), break down or secondary usage, removing them from circulating material culture. Other artefacts will not be deposited but may be recycled. Those artefacts might leave no trace for archaeological investigations. Surely, this first transformation may involve several phenomena like deposition due to burial habits - a cultural transformation. Another cultural transformation is different social systems (e. g., graves of political leaders), which condense material culture differently. These two examples illustrate the possible tendentious character of prehistoric sources [102]; [167]. Especially, graves and depots are specific types of archaeological sites. The deposited assemblage is rather a result of choice than chance [102]. Considering prehistoric sources as *unconscious evidence*, [380] may lead to a miss evaluation of their possible meaning.

---

<sup>1</sup> Constraints with uniformity implied by the term Hallstatt culture is described in 1.3.

<sup>2</sup> For example, differences in settlement behaviour, like fortifying hilltop sites or building of *Herrenhöfe* dissect West and East. The social status of individuals, which is often derived from their grave inventory, is of less importance, as cultural consistency is focussed in this study.

<sup>3</sup> Eggerts concept of inner and outer source criticism helps to structure available data [102]. To understand the formation, selection, and transformation that archaeological data undergoes, a more detailed description of the ongoing process is needed.

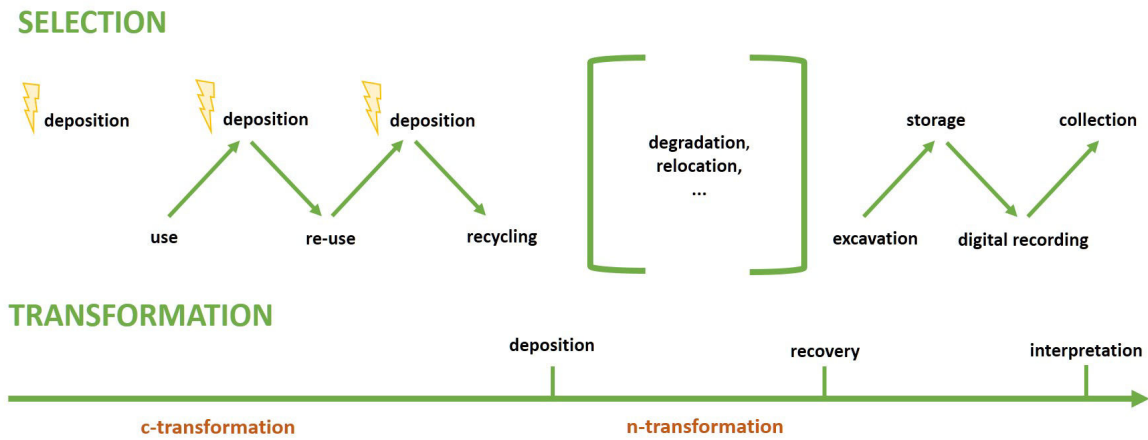


Fig. 4.1: Scheme of selection and transformation of material culture.

Additionally, deposited artefacts undergo another transformation: degradation and relocation (n-transformation [435]). After deposition, manipulation of features can have several reasons: contemporaneous cult or religious activities, grave robbery or re-use. However, this transformation may destroy the original feature or parts of it. Besides, physical factors may cause spatial patterns of artefacts by affecting the preservation of certain artefacts or material categories. Furthermore, the geographical properties of an area affect the preservation of a site, like better-preserved barrows on woodland. Apart from that, the preservation of a site is also affected by political conflicts, like World War I / II or the French-German War. Especially in areas next to political borders.

Several factors influence the possible recovery of a deposited artefact: Is the site covered with a thick layer of sediment or is it well visible (like a barrow), is the recovery linked to construction or due to any destruction or moving of earth (e.g. bomb craters of World War II). The quality of site information depends on other circumstances, like a planned research excavation or private collections. Urban areas reveal different reasons for recovering archaeological sites. Especially rescue excavations of planned constructions along a highway, for example, have to be evaluated critically. A highway, for instance, follows a specific path, planned and calculated. Therefore, analysis of the topographic location of those sites is biased. On the other hand, the excavation technique and quality of data are excellent. Private collectors are of specific interests, as they usually prefer a particular material type or epoch and are somewhat restricted in their spatial extent. Natural, the likelihood of recovery has a substantial impact on archaeological research, but factors influencing the recovery are known and, therefore, assessable.

The excavation technique influences the knowledge of contextual finds, layers and depositions and the kept artefacts<sup>4</sup>. Besides causes of recovery, the time of recovery has a substantial impact on information as well. Especially for the Early Iron Age, many grave mounds have been excavated quite early in research history, resulting in documentation ranging from moderate to poorly [262]; [333]. Following excavation, two possible transformations follow the restoration and storage. Often artefacts of uncertain excavation conditions or site information are found in museum collections<sup>5</sup>. Studying social structure may lead to dismissal because information on the closeness of the feature is crucial. While — as in this case — a cultural study does not rely on artefact combination, if the location is undoubted, the object is admissible.

<sup>4</sup> It was common to practise to throw out broken or fragmented pottery.

<sup>5</sup> When newly founded, museums and other collections (at universities) ordered excavations or bought assemblages from excavations. Before the foundation of State Offices for Cultural Heritage (around 1907), the quality of these excavations varied drastically, from grave robbery to proper research excavations. Hence, the quality of documentation varies accordingly.

The second to last transformation is describing the material culture and adding information to a database. The description also reduces information from possible to actual information (here, digital information), as never all aspects can be recorded or seem to be relevant. Mostly, dealing with several assemblages collected regarding different research foci, either the requirements have to overlap, or it is necessary to add specific data. Merging data collections, another transformation of data inherits additional possible filters. Mischka compared site catalogues from several publications in Baden and surprisingly detected a depletion of sites. Perhaps the dating or other information on the site was too vague for some researchers, and sadly, as not commented, the circumstances remain uncertain [318]. Another factor selecting archaeological data is the choice of chronological framework, publication and work balance (chap.: 5.1). Now, reaching the data collection process, the data undergoes a final selection and transformation resulting in a map, cluster analysis, or any other statistical analysis [288]. To illustrate, the interpretation of the selected data (of that analysis) is chosen to refer to their prehistoric meaning.

Naturally, obtained data allows only restricted conclusion on prehistoric reality <sup>6</sup>, because of the before-mentioned source-critical and taphonomic effects. Finally, what may lay underneath the surface, remains guesswork [102].

#### 4.1.1 Evaluation of Possible Source Critical Filters

After identifying possible filters and effects, appraising their influence follows. Does the obtained data reflect the original prehistoric spatial pattern, and how much does it reflect present source-critical factors? How to make those effects visible without knowing what is missing? Several approaches to appraising influences and possible distortion are available. Depending on the research design, the spatial and temporal scale of the planned analysis, geographical data and available data on source-critical effects guide the choice of an appropriate method.

Kristiansen's approach to estimating the effect of source-critical factors tests whether recent recoveries are frequent or alter the pre-existing pattern. He uses geographical representativity maps to show how the distribution of data reflects the original prehistoric activity. Nevertheless, this approach is highly sensitive towards shifting research foci. After a phase of intensive research activity, according to Kristiansen, the distribution reaches a "satisfying representativity" [257]. That may be true for the specific type of sites but misleading when considering archaeological sites in general. Furthermore, the spatial extent of such intense research activity has to be carefully taken into account.

For example, Doris Mischka uses two types of maps - the situation of sources (*Quellsituation*) and the potential of macrochores (*Naturraum-Potential*), to evaluate and interpret the current knowledge [318]. Based on detailed data, the reason for recovery and circumstances and private collectors' behaviour makes a precise estimation of problematic or over-represented areas possible. For Baden <sup>7</sup>, no distortion is visible, neither in the type of site nor circumstances of discovery [318].

For the Alsace, Tremblay Cormier evaluates the confidence and quality of obtained data based on criteria like the reason for recovery (planned or rescue excavation), modern or ancient research activity, and data availability. Her confidence map shows moderate reliability and representation of archaeological sites for the Alsace, with few areas with better evaluation like the Haguenau Forest [495].

Existing evaluations, as in Baden [318], Breisgau [230] or Alsace [495], are useful to gain an overview. Each region has a unique research history. That heterogeneity, combined with the different landscapes, taphonomic phenomenon, recovery of artefacts/relicts by chance, unbalance the quality of available information. Never-

<sup>6</sup> See for instance Binford's Middle-Range theory [37] and its critic (e. g. [389])

<sup>7</sup> Mischka recorded the reason for discovery in her study of human landscape formation in Baden. Although she recorded all Neolithic sites dating to the End of La Tène period, her results serve as a comparison. 37 % of all sites are single finds, 25 % of sites have been discovered in connection to building activity, 4.5% through agricultural activity and same by raw material production (mostly gravel pits), 3% re-allocation of agricultural land (mostly viticulture) and 8.5% unknown circumstances. Depending on macrochores, the reason for discovery varies. Surprisingly, only 16 % of graves have been discovered due to agricultural activities [318].

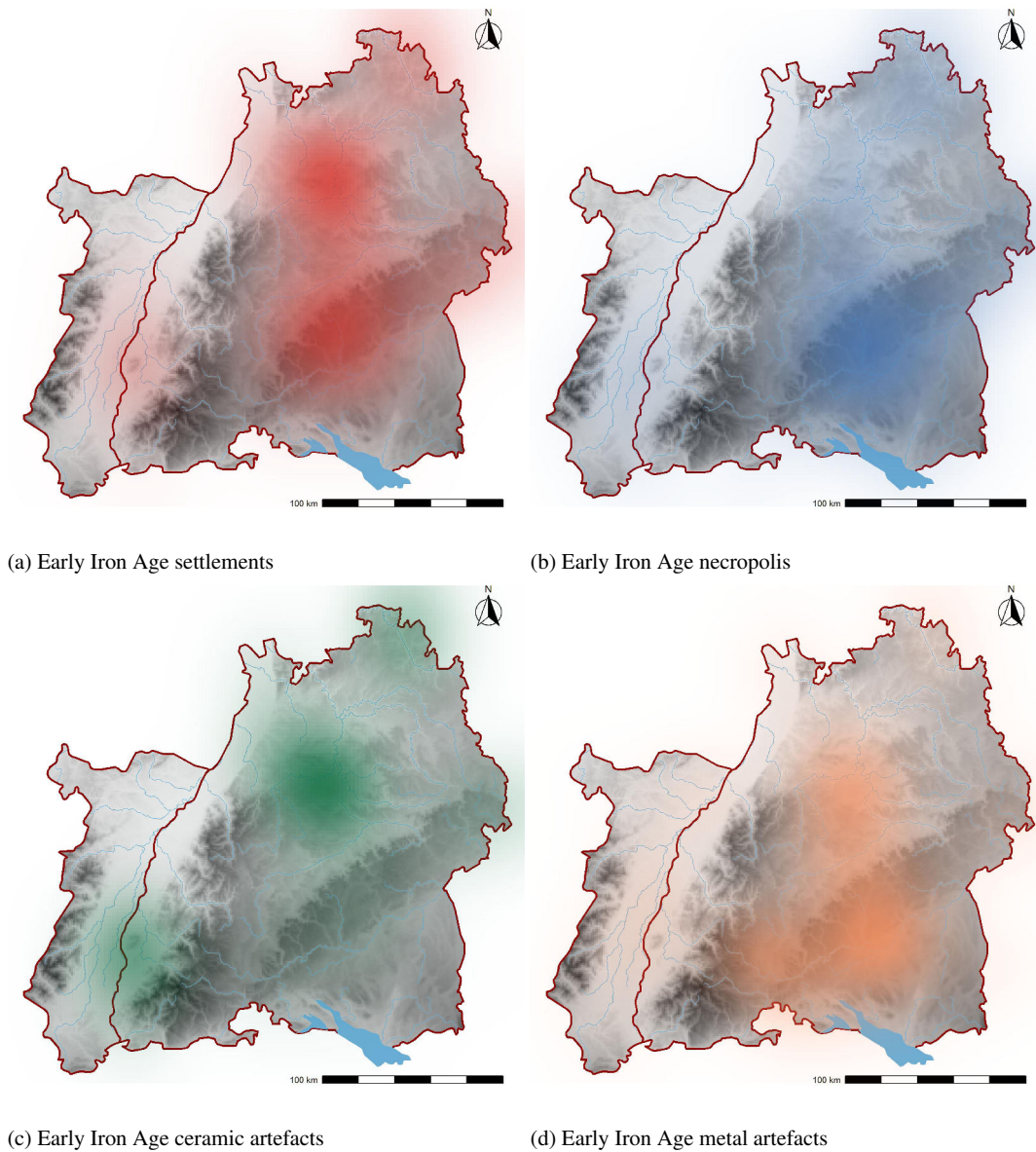


Fig. 4.2: KDE of Early Iron Age sites and artefacts (method: KDE with sigma 20 km and Gaussian kernel, data: SHKR20, mode: presence or absence).

theless, a coherent estimation of the large spatial area of Baden-Württemberg and the Alsace is necessary. A consistent set of data with a comparable quality throughout the entire area are the type of site and artefact. A density approach, presented by Nakoinz [345], of type of site and material of artefacts, illustrates the spatial distribution of source-critical factors - the geographical representativity. Theoretically, settlements and necropolis should have a similar distribution. Although settlement and necropolis have different preferred topographic locations, a burial site can be assumed to be close to a settlement on a regional scale. Hence, source-critical effects

may occur in areas with deviating patterns. A Kernel Density Estimation (KDE)<sup>8</sup> with 20 km bandwidth and a Gaussian kernel shows regional trends while blurring local variations. A KDE of sites illustrates the recovery likelihood and preservation of the type of site. Here, research intensity at a site does not influence the distribution pattern. Thus large and extensive excavations, for example, at the Heuneburg, does not distort the evaluation. Similarly, the presence of ceramic or metal artefacts (instead of quantities) illustrates the preservation and recovery likelihood of these material classes.

Settlements seem to dominate in the Neckar Valley, while burial sites often occur on the Swabian Alb. That illustrates the widespread phenomenon of better preservation of barrows on the Swabian Alb and more building activities in valleys resulting in a higher discovery likelihood for settlements. Not surprisingly, the presence and absence of ceramic and metal artefacts indicate an equal distribution of settlement and necropolis, as metal artefacts dominate in burial sites and ceramic in settlements. Metal artefacts have a slightly deviating distribution from burial sites, which the state of research may better explain than cultural differences.

A comparison of the distribution of ceramic and metal artefacts dating to either Ha C or Ha D might highlight cultural effects (fig.: 4.3). For this evaluation, the quantities of artefacts may reveal not only these. An interpretation of these maps has to consider also possible effects of research intensity. Further on, the before calculated KDE of geographical representativity serves as a monitor to detect the effects of preservation and recovery likelihood. Knowledge of largescale research projects will help differentiate cultural effects from research intensity (e.g. Heuneburg, Magdalenenberg or Haguenau Forest). The deposition of ceramic dominates during Ha C in the Swabian Alb necropolis (fig.: 4.3). Changing depositional behaviour during Ha D is visible in fig. B, when settlement and ceramic pattern overlap precisely. The distribution of metal artefacts of Ha C dating is similar to the distribution of necropolis, which illustrates the known phenomenon of metal artefacts occurring dominantly in graves. The Ha D's deviating pattern might be caused by changing depositional behaviour, state of research or less accumulated artefacts due to a shorter period (chap.: 1.4).

The distinct separation of the material classes like ceramic and metal has a strong influence on interaction analysis. Ignoring this pattern would result in false identification of two cultural groups — a separate analysis of material classes levels affects deviating quantities. For a combined analysis of material classes, an adequate interpretation considers those effects mentioned before.

## 4.2 Early Iron Age Sites and their Characteristics

Traces of ancient civilisations, or more general settlement activities, are diverse and range from different types of settlements (from villages to central places) or cemeteries (e. g. well visible barrows) to infrastructural sites (paths, river crossings) or production sites. Summarising the most common Early Iron Age sites focuses on relevant aspects for infrastructure and interaction patterns.

Fig. 4.7, 4.5 and 4.4 show the distribution of sites in Baden-Württemberg and the Alsace<sup>9</sup>. Besides settlements (n = 2,112) and necropolis (n = 1,566), which will be described in detail below (chap.: 4.2.1 and 4.2.2), other types of sites are of less abundance (fig.: 4.1): cult or religion (n = 21), hoards (n = 18), single finds (n = 190)<sup>10</sup> or infrastructure (n = 6).

<sup>8</sup> KDE allows a Gaussian kernel as a membership function. Therefore, the distance to a sample point weights the density. Many events, here sites, next to a sample point results in high weights, while those more distant having a lower influence on the resulting value (see [336] for more details).

<sup>9</sup> Although the SHKR database records sporadically archaeological sites outside Baden-Württemberg and the Alsace, this study only respects those sites in the defined geographical area. Further on, sites dating to the Bronze Age or later Iron Age are sporadically recorded and excluded from the analysis.

<sup>10</sup> This evaluation regards only sites with dating (see below for more details on the category "single finds". Therefore, the total number of recorded single finds in the SHKR database is much higher.

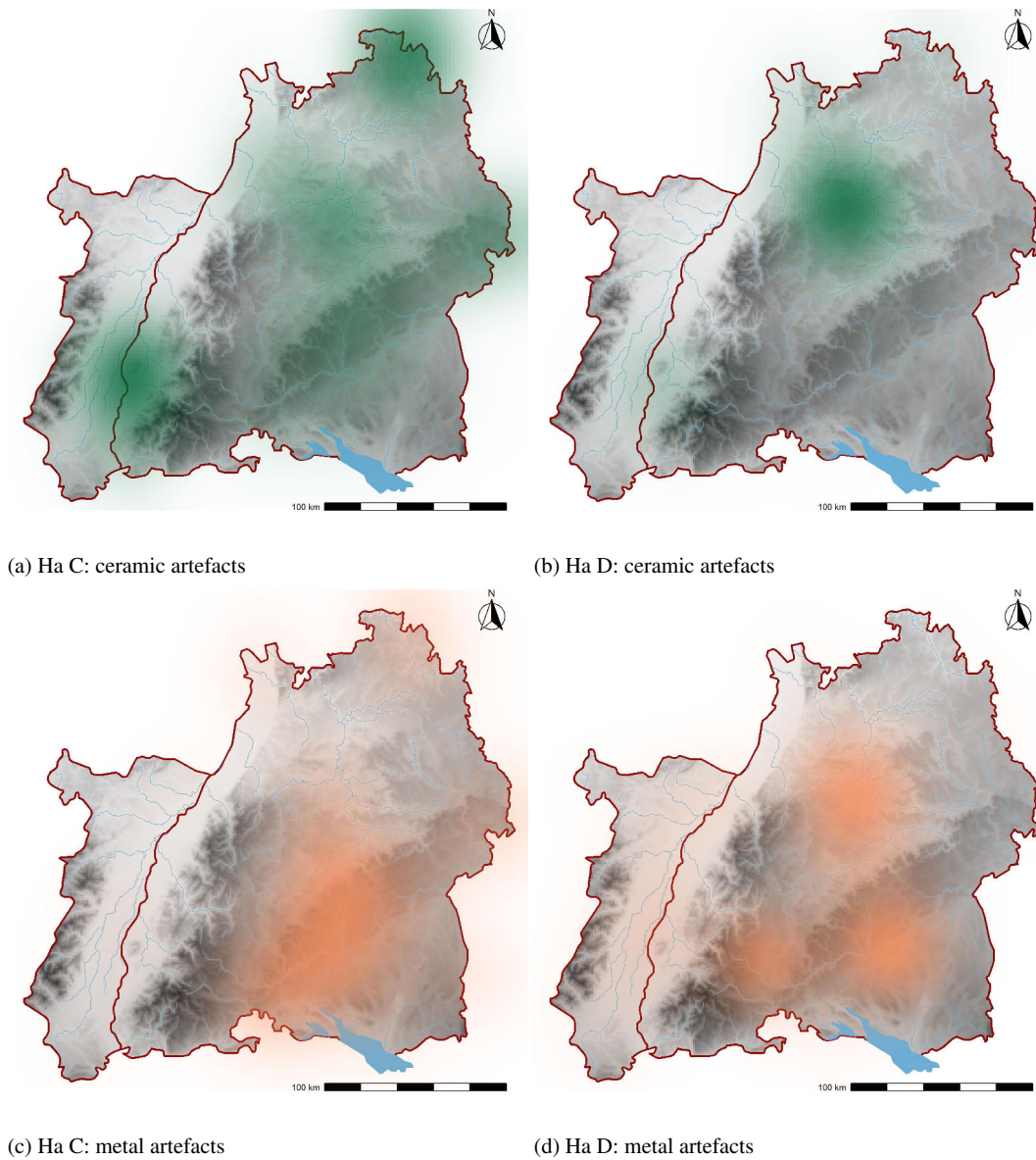


Fig. 4.3: KDE of ceramic and metal artefacts dating to Ha C or Ha D (method: KDE with sigma 20 km and Gaussian kernel, data: SHKR20, mode: quantity).

The total number of sites depends on the definition of a sites spatial and temporal imitations; therefore, this number requires critical evaluation <sup>11</sup>. For example, in fortified hilltop sites, spatial limitations are naturally pre-defined, while continuous settlement activities may be obscure. Alternatively, barrows in the Haguenau Forest, often spreading over a larger area, complicate a necropolis definition. Where does a new necropolis begin? Or is this barrow isolated? Further on, the definition of temporal limitations, *hiatus*, may alter the number. Fluctuating quantities and site definitions hinder comparisons between publications and illustrate the source-critical effect

<sup>11</sup> The before mentioned quantities are serving as rough proportions to illustrate the dominant type of sites.

Type of Site	Iron Age	Hallstatt	Ha C	Ha D
<b>Settlements</b>	<b>2112</b>	<b>1201</b>	<b>93</b>	<b>353</b>
<b>Burial sites</b>	<b>1566</b>	<b>1291</b>	<b>102</b>	<b>237</b>
<b>Hoard</b>	<b>18</b>	<b>4</b>	<b>1</b>	
<b>Infrastructure</b>	<b>6</b>	<b>2</b>		
<b>Cult or Religion</b>	<b>21</b>	<b>10</b>	<b>3</b>	<b>2</b>
<b>Single Finds</b>	<b>485</b>	<b>190</b>	<b>9</b>	<b>49</b>
<b>All</b>	<b>4229</b>	<b>2727</b>	<b>209</b>	<b>669</b>

Table 4.1: Number of recorded sites in SHKR database (excl. Bronze Age or undated sites).

of data transformation. Neither the number of sites nor the spatial or temporal limitations of sites influence the modelling of interaction patterns (chap.: 5.5). In contrast, the reconstruction of infrastructure depends on the location and density of archaeological sites. Therefore, the definition of a site might bias the data selection for such analysis.

For archaeological interpretations, like social differentiation, cultural differences or settlement structure, sites and their corresponding artefacts need to be categorised into predefined types. Naturally, lacking information complicates categorising sites. Mischka points out that to positively identify a grave, a single urn is sufficient; while in contrast defining a settlement, a single vessel is not enough [318]. Also, some types of sites are more sensitive to preservation conditions<sup>12</sup> to be classified correctly, like a workshop area (like at the Heuneburg). A dominance of easily identifiable types of site and the associated artefacts influences the composition of collected data. It may be more meaningful to categorise the artefacts found at a location into voluntarily deposited artefacts or lost items. Furthermore, the predefined types might not meet prehistoric reality; intermediate types occur, like settlements including graves and production sites or sacral areas or sporadically distributed sherds found in caves, which might indicate transhumance or single events [34]. An interpretation as a regular settlement may be over-interpreting this archaeological evidence. Additionally, sites with an uncertain character are often categorised as sacral or as single finds, limiting the potential and relevant information.

Sites with a sacral character do not frequently occur in the SHKR data collection, reflecting problematics in defining sacral sites rather than prehistoric reality. For example, the site Heidendor (Egesheim, Baden-Württemberg) appears to have a sacred character indicated by many offerings found in a hole [513]. Another similar example is a hole at the Alteburg (Langenslingen, Baden-Württemberg) with remains of human skeletons [266]; [266]; [267]. Without written sources, religious belief and practice are complicated to reconstruct from archaeological sources. Moreover, it may be not identifiable. One should bear in mind that a strict separation between profane and sacred, as typical today, may not have existed in prehistoric societies [513]. What an archaeologist understands or interprets as sacred might be only a tiny part of the religious sphere.

Likewise, single finds to interpret is complicated, as randomly deposited, dropped or lost; or deposited out of specific instances unknown to us. Their circumstances of discovery are often inexplicit, like collected from a surface, and no further investigations took place. This type of site combines different archaeological sites, those of lost items [206], truly isolated finds [260], or undiscovered settlements, graves or production sites [318]. Therefore, the category of single finds is a conglomerate of potential meaningful archaeological sites; however, they are lost for most archaeological investigations due to lack of knowledge. Objects deposited voluntarily without a funeral or domestic context, as described by Kubach [260] are often not differentiated from those of uncertain context. Tremblay Cormier states that, likewise to objects deposited in rivers, these - truly isolated finds show significant topographic locations, like rock wall/cliff, earth fissure, or mountain pass [260]; [495].

<sup>12</sup> Besides preservation, all other source-critical parameters such as excavation technique, extend, research focus, or documentation influence a site characterisation.



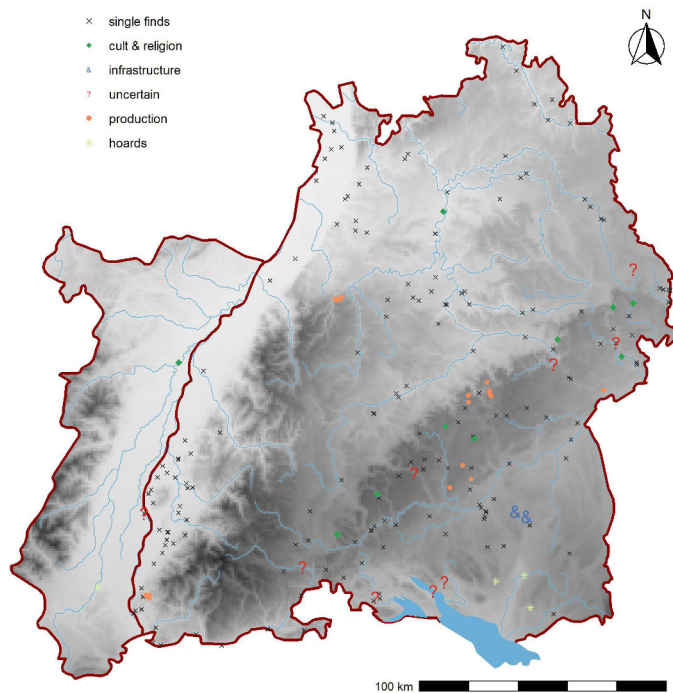


Fig. 4.4: Early Iron Age sites in Baden-Württemberg and the Alsace without settlements and necropolis (data: SHKR20, DEM: SRTM 90 m).

Like isolated finds, a distinction of river finds between voluntarily deposited artefacts and lost items remains complicated or impossible. Ideally, discovery and sediment circumstances reveal the nature of deposition: whether it was deposited during settlement activities or intentionally deposited into a river bed. This differentiation is crucial, as paleochannels of rivers sometimes have a significant distance to the modern river bed (up to 7 km [293]; [274]). Therefore, single or isolated finds include an unknown number of wrongly categorised river finds [293]; [294]. Further on, river finds are displaced based on flow velocity, settling velocity and portability of the artefact [510]. Assuming a single motive in the deposition of river finds is unrealistic, indicated by the heterogeneity of river finds concerning quantity and quality of artefacts [490]. Generally, weapons and bronze artefacts are overrepresented because of their recognisable shape and preservation [490]. However, recent channelling or channel enlargements increasing the frequency of small objects like fibula or needles [41]. The deposition of artefacts in rivers began

during the Neolithic and continued into the Bronze Age. Much lower frequencies of river depositions characterise the Early Iron Age and La Tène period [510]; [490]. Wegner [510] lists several possible factors for an interpretation: disruption/interruption of shipping traffic, reduction of the importance of river cult or hiatus of settled places and general reduction of traffic. Recently, Schmid-Merkl [436] critically evaluates river finds, deposition factor, and interpretation for the Upper Rhine. More river finds at the middle and northern Upper Rhine in contrast to the southern Upper Rhine, which Schmid-Merkl interprets as consequences from more vital Urnfield traditions [436]. River finds accumulating at sites over several epochs indicate voluntary deposition. Especially if those depositions occur on both river banks, as Logel demonstrates for Bronze Age depositions along the Upper Rhine Valley [293]; [294]. He assumes that these depositions appear at specific landmarks, e.g. river passages. On the contrary, Schmid-Merkl points out that single finds do not prove the location of river crossings as long as not excluding other accumulative circumstances [436]. However, she recorded a drastic incline in artefacts dating to the Early Iron Age in context to river finds. Considering more problematic preservation conditions for iron objects, smaller artefacts, and population growth during the Bronze Age does not explain this abrupt change.

Likewise, hoards and production sites are recorded much less often in the SHKR data collection. That displays their lower actual abundance and source-critical effects regarding preservation, discovery likelihood, and classification. While hoards<sup>13</sup> are common during the Urnfield culture, this practice is nearly unknown during

<sup>13</sup> On function, interpretation and location of hoards see [43].

Hallstatt C<sup>14</sup>. During Hallstatt D, hoards are again more common, however not reaching the high frequency of the Urnfield Culture [513].

Production sites range from raw material production to handcraft and artisanry. Naturally, raw material production can only take place at specific locations. For example, extraction happens only at an ore deposit, while metal processing can happen in any settlement or at any location. Considering economic or political structures, producing artefacts where and by whom is undoubted of importance. And, at some settlements, metal processing sites or quarters (like at the Heuneburg) are known<sup>15</sup>. Raw material supply, like iron extraction, left traces in the landscape but often missing chronological indicators make an evaluation problematic. Wieland and Gassmann investigate sources, exhaustion and smelting in the northern area of the Black Forest, which seems to had a large supply region [140]; [142]; [141]. Especially the area around the ore district of Neuenbürg revealed several iron production sites like stockpiles close to raw material sources. In later stages, stockpiles occur in greater distances; hence ore deposits are intensively used, so transportation costs were acceptable.

### 4.2.1 Graves

Large barrows with richly equipped graves and several secondary burials grouped with smaller barrows forming the necropolis of a nearby settlement depict our image of the Early Iron Age. Generations of researchers investigated, excavated and evaluated the social structure, various cultural aspects, burial habits or even genetic relations between buried individuals. The following section places general trends and behaviour overviewing the geographical area (for an extensive description of facets and fascinating details see, for example, [394]; [262]; [253]).

At the beginning of the Early Iron Age, a new burial habit appears inhumation graves. Although cremation graves, known during the Bronze Age, are still common in the Early Iron Age. Changing from a focus on the body's transformation during cremation, now the burial centres on displaying the human body; expressing social status seem increasingly necessary. Furthermore, a range of different options emerges, which Rebay-Salisbury adds to the list of Hallstatt phenomenon besides ostentatious funeral display, the introduction of Mediterranean ideologies and technologies. Additionally, various burial patterns across the European Early Iron Age show a possible choice to conduct burial rituals [394]. She points out that with changing burial practises, the importance of burial monuments increases [394].

Graves combine assemblages of artefacts and features intentionally created by the community in a complex burial rite process. Burial habits, as well as the intentional selection of artefacts, reveal insights into idealized images of society: the image of the burying community, their social structure and an image of the deceased [167]; [?]. While this context is crucial for socio-political analyses, differences between individual assemblages are less critical in interaction studies. Nevertheless, as the burying community selects those items meant to them, potential influence on interaction patterns might occur. For example, import goods are found more often on burial sites than in settlements. Therefore these artefacts, often interpreted as prestige goods, might dominate in grave assemblages because of a preferred selection by the society. Regardless, dominating import goods throughout a whole necropolis is unlikely and potential distortion of interaction patterns reduced. Additionally, an imported good serves as proof for interaction not necessarily to the origin but to foreigners in general. Moreover, integrating settlement data levels the effect. Nevertheless, a critical evaluation of these distorting effects is part of the interpretation and discussion of results.

<sup>14</sup> Hoards dating to Ha C: Alsenbron (Rheinland-Pfalz, Germany), Bingen (Rheinland-Pfalz, Germany), Worms (Rheinland-Pfalz, Germany) and Mulhouse (Haut-Rhin, France) (uncertain).

<sup>15</sup> Whether these settlements somehow controlled the production or served a broader market is a fascinating question, but beyond the scope of this study.

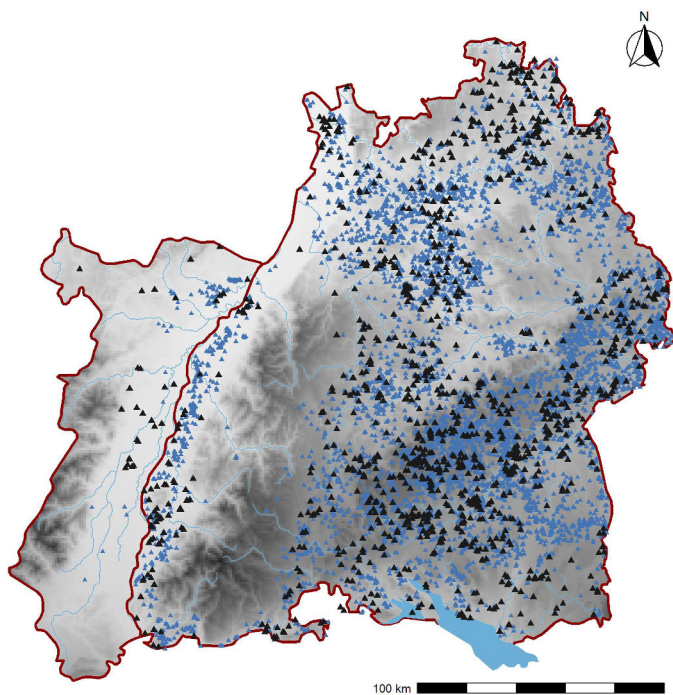


Fig. 4.5: Early Iron Age necropolis in Baden-Württemberg (n=1,195) and the Alsace (n=96) (data: SHKR20, DEM: SRTM 90 m).

Figure 4.5 gives an impression of the densely spread necropolis in Baden-Württemberg. A clear contrast is visible regarding the Alsace. The available data collection of the vicinity Haguenau [508] results in a comparable data resolution as covered by the SHKR database. However, the mapping of necropolis indicates lacking data, especially in Haut-Rhin (France). Undated or Bronze Age barrows are illustrated in light blue. In the Early Iron Age, most Bronze Age barrows presumably still existed and are well visible. They are part of the landscape and have been reused as burial monuments during the Early Iron Age. The intensity and extent of erosion on barrows and necropolis depend on several factors, like size, height, building material, grouped barrows or isolated barrows, cover with woodland and current land use. Besides natural erosion, barrows are vulnerable to several human interferences, like building activities<sup>16</sup>, agriculture, raw material extraction and further on. As barrows were meant to be seen, they have been visible for centuries and naturally attracted some

attention, not only by the former contemporary population. Grave robbery documented for various cases; only seldom the act of robbery is dated<sup>17</sup>. Estimating to which extend artefacts, especially those made of precious metal, are missing remains difficult. To assume better preservation of barrows on woodland might be misleading, as Kurz stated in 1997. In a footnote, he describes that bigger or higher barrows are related to the edges of forests. Due to modern agriculture after World War II, smaller or lower barrows do not constrict ploughing, and clearing of forests took place until reaching a higher individual. Accordingly, a wholly levelled necropolis, if existing of only low barrows, might be more common. However, the effect of ploughing on the height of a barrow is not a modern phenomenon; its intensity changed with modern techniques<sup>18</sup>. More recently, aerial photography has proven that many nearly levelled barrows occur on agricultural land. Even in areas with no known barrows, e. g. in Sandy Flanders, intense aerial photography reveals more than a thousand barrows from 1984 until 2012 [405]. Another kind of destruction happens during both great wars, not only dugouts or bombing destroy archaeological sites and monuments. For example, for an airfield levelling of barrows from the necropolis of Gäufelden-Tailfingen or Dormettingen (both Baden-Württemberg) [262].

Sadly, but noteworthy is early research activities with limited documentation (before 1920), only in some cases, following a clear research interest, mostly a mere fascination initiated these antiquarian excavations. Lacking documentation, antiquarian excavation techniques and intention reduces the potential information on burial practises, artefacts and individual assemblages in most cases drastically, in comparison with modern

<sup>16</sup> Medieval chapels built on top of barrows (Maria-Buch-Kapelle in Neresheim) might have been more common [262]. As a chapel is protected cultural heritage, excavations remain scarce.

<sup>17</sup> Some instances are known for Roman interference in barrows, e.g. Schafisheim, Valangin-Bussy or Rüttenen [262].

<sup>18</sup> In Northern Germany, Sprockhoff records during 100 years (1838 to 1938) a reduction to 6% up to 16% of stone cist graves [459]. Reuse as a building material might increase this destruction. However, it demonstrates the potential loss of monuments.

excavations<sup>19</sup>. Additionally, only late in respect of the research history, systematic excavations of a good technique evolved. For example, if the basis of the barrow remains untouched by an antiquarian excavation, this barrow, declared as excavated, might reveal several secondary burials and possible simple cremation graves in the area around the barrow remain undetected. Therefore, the moment of discovery and excavation is crucial for the amount and quality of data. Müller-Scheeßel shows for research activities on Early Iron Age necropolis in Bavaria and Baden-Württemberg alternating phases with a dominance during 1880 and 1920 (more pronounced in Bavaria) [331]. Surprisingly, the spatial distribution of necropolis reveals a significant agglomeration of data from 1980 to 2000 in both areas<sup>20</sup>. If only using results of these research activities, a distortion is most likely [331].

Size, height, construction of barrows, and size and spread of necropolis are essential for their preservation; therefore, crucial source-critical factors for infrastructural analysis and cultural distance calculations. These constraints are omnipresent in archaeological studies and included interpreting the results of each analysis.

While usually, barrows grouped together<sup>21</sup>, some barrows, especially huge ones, appear separately [262] (SHKR20: 385 of 1,413 sites). Kurz used for his study nearly all published necropolis (until 1997), while the SHKR data includes all registered barrows of the Cultural Heritage Management of Baden-Württemberg. That includes a high amount of barrows identified by aerial photography. More barrows, less well preserved, might have existed in the surrounding of these - so far isolated monuments. In figure 4.6 necropolis are marked by circles representing the size - the number of barrows - of each necropolis using size classes according to the method described in [332]. As expected, with the increasing size of a necropolis, the frequency of this size class is decreasing<sup>22</sup>. Some regions characterized by large necropolis with smaller "satellite" necropolis in the surroundings (Eastern part of Swabian Alb). However, the small necropolis is common. During early Ha D barrows are more frequent in southern Baden-Württemberg than in northern Baden-Württemberg with a proportion from 3 to 1. This shifts during later Ha D towards northern Baden-

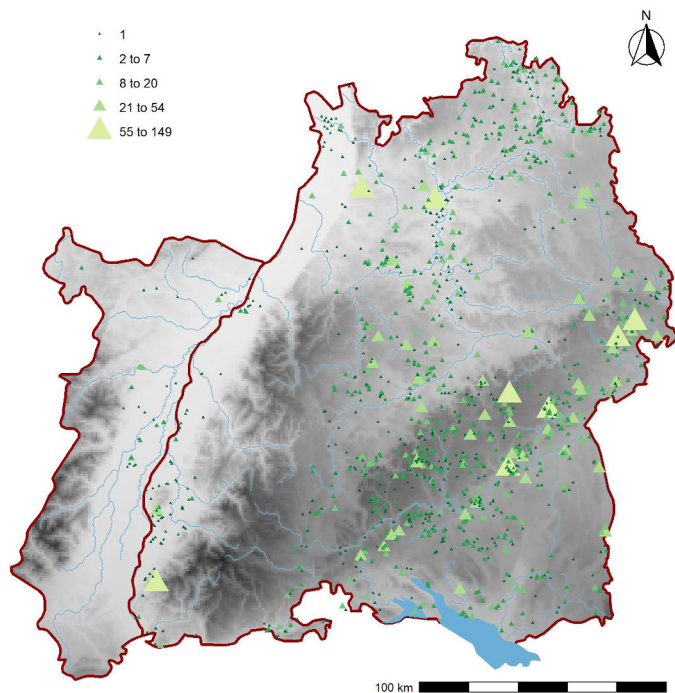


Fig. 4.6: Size of necropolis in Baden-Württemberg and the Alsace (size of necropolis in size classes proportional to size of point Müller-Scheeßel [329]).

<sup>19</sup> More recently, the excavation of the so-called Keltenblock [253], shows impressively the potential data and knowledge obtainable from a barrow with excellent techniques, time and money.

<sup>20</sup> Müller-Scheeßel used the Mantel index, a place-time correlation to estimate whether during a specific period - the activity of individual researchers - an agglomeration in space took place [331].

<sup>21</sup> If smaller barrows erected separately but then ingrown during the necropolis development, can only evaluate in retrospective when the dating method is precise enough.

<sup>22</sup> See above a discussion on the dominance of single barrows in this data collection.

Württemberg [52]. Intensive agricultural land use on fertile soils and better climatic conditions in northern Baden-Württemberg might reduce the total number of barrows compared to unfavourable conditions in southern Baden-Württemberg, resulting in pastoralism. Similar subsistence strategies in each region can be proven for early medieval times [446]. However, agriculture does not destroy monuments selectively from one specific epoch. Hence, this proportion (more barrows in southern Baden-Württemberg) seems to depict the prehistoric reality.

Mutually, burial habit and the size of the necropolis are interlinked. In some areas, secondary burials are more common; hence fewer burial monuments erected, as in areas where only seldom secondary burials took place [178]; [332]<sup>23</sup>.

Continuous use of necropolis from the Bronze Age onwards is known for several sites, like in Haguenau (France), [509]. Indeed, the practice of barrows is very dominant for the Middle Bronze Age and continues during the late Bronze Age in several regions (Eastern France, Hessen or Bavaria) [364]. Caused by the visible nature of grave monuments, re-use as burial monuments in later times is not surprising<sup>24</sup>.

As erosion and preservation influence the size and height of barrows, the shape might also alter, elongated or stretched. The original spread can only be known if a limitation like a ditch is documented. As the original size remains unknown, many archaeologists give a size range. Neither the maximum nor the minimum serves as a sound criterion. Regardless, barrows between 10 to 20 m in diameters seem to be dominating, while more prominent barrows decline in frequency<sup>25</sup> [262]. The preserved height of most grave mounds ranges between 0.5 to 1.5 m [262]. The construction material depends on locally available material, often a combination of stones and earth. Further features sometimes occur like a circular or rectangular ditch, pole circles, enclosures or coverages of stone, stone packing of central graves possibly as protection or stele, or palisade [262]; [508].

As mentioned above, with the beginning of the Early Iron Age, besides cremation graves<sup>26</sup>, inhumation graves reappear. The earliest inhumation graves documented in Eastern France of a so-called social elite [393]; [506]. This habit spread towards Germany, where early inhumation graves<sup>27</sup> cluster around Breisach and Colmar, at Hegau and Middle Swabian Alb [478]. Inhumation graves in those western areas are associated with separate barrows disconnecting sword-bearers from the rest of the community. Secondary burials are uncommon, or a later phenomenon [478]. For both Upper Rhine and Neckar Valley, no early inhumation graves are documented [9]; [395].

Regarding the number of barrows and graves in them, a larger part of the population is missing;<sup>28</sup> more recent studies suppose chronological reasons, excavation technique and preservation causing this lack of archaeological evidence [331]; [295]; [137]. Fries [137] lists 117 necropolises with a bi-ritual burial habit since 2007 with

<sup>23</sup> These two studies are an excellent example of the heterogeneous character of burial habits and their influence on statistical analyses. Rank-Size-Rules of necropolis sizes indicates a settlement structuring according to Christaller's central places. While this approach is prohibited by the habit of secondary burials in Baden-Württemberg, it results in an exciting conclusion of the settlement structure for Bavaria. Necropolises sizes based on the number of barrows do not correlate with population size in Baden-Württemberg [332].

<sup>24</sup> Müller-Scheeßel cites a recent example for re-using grave monuments, even without cultural or temporal continuity: Settler's and African slaves buried in prehistoric barrows in Northern America [329].

<sup>25</sup> Giving rounded ratios of barrow sizes resulting in a weird dominance of 5, 10, 15 and 20 m in a diagram. Kurz excludes those "imprecise and irritating" values [262]. However, including this data does not change the overall trend. Giving a rough estimation is still valid information, as the precision is vague due to preservation effects. By excluding this information, Kurz may generate a false precision.

<sup>26</sup> Summarizing the variety of cremation graves in barrows shortly: deposition of burned bones with or without pyre deposits, in a vessel or without a vessel (or possibly in an organic container), in a pit (mostly secondary burials), on ancient surfaces (as primary and central burial) or elevated above ancient surfaces, with covering stone or stone chamber, with a wooden covering or wooden chambers (for a more detailed description see [262]).

<sup>27</sup> Like cremation graves, an inhumation grave can either be placed on the ancient surface, in a pit, with a wooden or stone covering, a wooden or stone chamber (for more details see [262]).

<sup>28</sup> Additionally, burials in settlement contexts do not show typical characteristics of regular Early Iron Age burial habits, e. g. in a pit without grave goods like at Glauberg (Hessen, Germany). Possibly, these individuals had no right to be buried as a member of the society; the possible reasons are manifold [262].

simple cremation burials in those areas in-between barrows. Mainly occurring at the Swabian Alb, Hegau, Upper Franconia and Oberpfalz <sup>29</sup>. These areas between barrows are often not excavated systematically by antiquarian excavations; hence the archaeological evidence lacks a larger part of each necropolis. Furthermore, constructing a new barrow, older burials might be destructed [331]. However, cremation graves in close area around contemporary barrows seem to be a regular Early Iron Age burial practice, <sup>30</sup>, perhaps indicating a social relation to those buried in the barrow [52]. These so-called simple cremation graves are problematic in dating as they have a low frequency on grave goods, mainly metal objects. This type of graves might explain the lack of children and woman graves in Ha C. According to Fries, it seems to be a common practice during Ha C and D, with dominance in Ha C [137]. Regardless, in some areas - with sufficient modern excavations, those simple burials are still missing, like in Eastern France and other areas of Baden-Württemberg [137]. A chronological shift is also visible regarding the number of burial sites: An incline of necropoleis from the older to the younger Early Iron Age reflects changing burial ritual and inclining population [331].

A distinction of goods deliberately produced for funeral context and artefacts attain over a lifetime is crucial to differentiate in chronological and chorological studies. Personal items, often metal objects like weaponry or jewellery, might be decades older than ceramic vessels of the same grave assemblage. Furthermore, some vessels produced for funeral context only, such as mortuary vessels [523], might reflect a different social or political reality. Nevertheless, this distinction might highlight the discrepancy between an individual's interaction pattern and that pattern intentionally shown by the community <sup>31</sup>.

A canonical set of grave inventories cannot be identified throughout the geographical area, although some artefacts <sup>32</sup> tend to be found in pairs or sets. As personal items, fibula, bracelets, anklets, temple rings, torques or belts are found in Early Iron Age graves regularly. They deduce a vague common practise in grave inventories, ceramic vessels, nutrition's <sup>33</sup>, bronze vessels, weaponry, horse's harness and wagons vary regionally, and with social status [52]. Rich grave inventories of so-called Princely Burials are exceptional burials and contrast drastically to regular or typical grave assemblages.

Ceramic assemblages vary enormously in composition and amount between individual graves <sup>34</sup>. Furthermore, compositions of ceramic assemblages differ regionally. In the area of the so-called "Alb-Hegau" ceramic, similar decorated stepped bowls often occur in pairs (Ebingen (Albstadt) - Schmiechatal, [533]) in graves with a more considerable amount of grave inventory. In contrast, conical-necked vessels, or bowls, are found often in pairs, while neither their decoration nor their size needs to be similar [262]. However, the positioning of bronze vessels, found in much lower frequencies, in graves are closely correlated to ceramic vessels.

More recently, Steffen [464] uses grave inventories from Ha C until Lt B to evaluate gender dimorphism, age differences in burial assemblages of Baden-Württemberg to address social hierarchies and changing differentiation within the Early Iron Age. He could demonstrate a substantial difference between male and female representations in the burial context by pronouncing reproduction for female and feasting for male individuals. When removing tendencies from gender, no age differentiation occurs. After Steffen identified tendencies by

<sup>29</sup> For example, at Albstadt-Ebingen (Zollernalbkreis), Albstadt-Truchtelfingen (Zollernalbkreis), Berghülen-Treffensbuch (Alb-Donau), Ellwangen-Röhlingen (Ostablkreis), Enstingen-Kleinengstingen (Reutlingen), Burrenhof-Grabenstatten (Reutlingen) or Heidenheim-Schnaitheim (Kr. Heidenheim) [137]; [295]

<sup>30</sup> Furthermore, Fries proves the existence of separate cremation necropolis [137].

<sup>31</sup> Comparing those two patterns throughout the necropolis might reveal fascinating deviations. However, this study aims for regional interaction patterns.

<sup>32</sup> A description of artefacts, their usage and characteristics are given in the following section (see 4.3).

<sup>33</sup> Nutritions, like animal bones and meat or beverages, are known in grave contexts, however, due to preservation and excavation techniques not well documented. Stadler investigates better-documented excavations and could demonstrate that the burying community select comparable food in respect to quality and selection as found in settlements. Furthermore, differences in quantity and quality indicate gender and social differentiation [461].

<sup>34</sup> Problematic association of inventory to individual graves of antiquarian excavations are frequent. Some marked without any context despite the necropolis or the barrow; others have a depth given, indicating at least further burials. Sievers suspects only 10 % of excavated artefacts during the 19th century have a particular assignment to an individual grave [452]. Noteworthy is the habit of not collecting broken or undecorated ceramic vessels in antiquarian excavations.

biologically determined factors, he investigated social structures. Zones with broad spectra and horizontal social differentiation alter with higher social complexity [464].

Summing up, a chronological shift is visible from primarily ceramic grave inventories in Ha C, except rare sword graves, towards more bronze vessels, declining ceramic assemblages, and inclining metal objects, like personal items and weaponry in Ha D [38].

#### 4.2.2 Settlements

Like the ostentatious barrows and richly equipped graves, impressive princely seats shape our Early Iron Age image in Europe. The drawn picture of a nobility inhabiting overbearing hilltop sites with large fortification walls still influence our understanding of the Early Iron Age society and settlement structure. The before discussed political and social meaning of princely seats (chap.: 1.1) summarises theoretical aspects without detailing archaeological evidence. Therefore, this section summarises archaeological evidence of not only princely seats, but more generally on hilltop sites and rural settlements (fig.: 4.7, as well as the structure of settlements and artefact assemblages).

In general, princely seats are, in summary, fortified settlements on hilltop sites with usually densely settled interiors, surrounding suburbia and imported goods from the Mediterranean [224]. They serve as political and economic centres [112] showing signs of proto-urban settlements [116] (see chap. 1.1). A more detailed compilation of those so-called princely seats will show large differences in archaeological evidence [387]. Consistent common features are the topographic location and some extraordinary evidence which contrast to other regular rural sites. For example, the Heuneburg<sup>35</sup>, with the impressive mud-brick wall, a rampart, Mediterranean import and ostentatious barrows nearby is the model of the Early Iron Age princely seat [113]; [253],[116]. Mostly the mud-brick wall serves as a defensive structure and as emblems of community identity acting as internal and external points of references in the landscape and society [64]; [408]. However, as Posluschny points out, such a building's visibility would be much higher on the nearby Mount Bussen [387]. The hinterland's recent investigations revealed a dense system of rural settlements dating from the Bronze Age up to late La Tène. Most of these settlements are located on small ridges, restricting each hamlet's size and reducing the preservation. However, evidence (iron slag, bronze casting mould, semi-finished lignite bracelet) documents an economic differentiation contemptuous with the mud-brick wall [264]. Other so-called princely seats are the Ipf [245] or the Marienberg [188] (Bavaria), both sites with imported Greek ceramic. For the Marienberg, situated above the Main, with undated fortification probably dating to the Early Iron Age, agricultural surplus from the settlement itself is unlikely. Therefore, Posluschny [387] supposes the function as a trading point. The Glauberg, the most northern and youngest princely seat, has an unfinished rampart, large barrows nearby and possible calendar structures. Its central function might lay in the religious sphere [387]. Again, this site is not situated well visible in the global landscape.

The term hilltop site is neither regionally nor culturally limited. This type of site occurs during the Urnfield culture, although other plateaus are settled in Ha C and D. In the simplest definition, it describes a settlement in a prominent topographic location<sup>36</sup> [34]; [230]. Several other terms like hamlet, castle, hillfort, princely seat, or manor include a functional interpretation, often without a critical evaluation of the definition and archaeological evidence<sup>37</sup>.

The reason to settle on such prominent locations might clarify the functionality of hilltop sites. Often a higher need for security combined with an additional fortification along the not naturally secured side seem coherent

<sup>35</sup> More recently Balzer [16] and Posluschny [387] summarising recent research and excavation results on princely seats.

<sup>36</sup> Biel defines the relative difference in elevation as a criterion for hilltop sites. Additionally, he defines several types of hilltop sites.

<sup>37</sup> Osterwalder Maier criticises this creativity in cultural-historical reconstructions as storytelling and romanticisation of the past [357].

[34]; [? ]; [451]. However, Klug-Treppe points out that warfare reflects the zeitgeist of older literature. Several factors might guide the choice of a location besides elevation, like conveniently situated next to long-distant routes, next to waterways or overlooking large areas [451]. Trade, economy, social or climate changes, or the before mentioned need for security illustrating diverse — although incomplete — possibilities for settling on a hilltop site. It is unrealistic to name one factor to explain the broad diversity of Early Iron Age hilltop sites. Each site needs a separate evaluation [230]. This fact, the diversity in hilltop sites (already evident in a small area like the Breisgau [230]) fit well into the general picture of the European Early Iron Age: a conglomerate of sites, artefacts and common behaviour. Partially similar, so archaeologists try to unify and draw an overall picture, but dissimilar enough to complicate general trends' identification.

However, Early Iron Age hilltop sites are not necessarily a particular type of settlement proven by Schlatt, Mauchen, and Ihringen [230]; [299]. Open rural settlements, and hilltop sites often differ only by fortification and topographic location [230]; [175].

For Baden, some hilltop sites indicating processing of raw material, e. g. production of jet bracelets. Probably these sites are craftsmen settlements [423]; [230]. Further extraordinary evidence is missing, partially due to lack of excavations. A diachronic comparison shows no preference for hilltop settlements during the Iron Age in Baden as suggested by Dehn [318]; [78].

The spectrum of rural settlements ranges from pit and pit houses, small farmsteads or single houses to villages. As Early Iron Age settlements are mainly rural, the requirements and customs of a farming society determine its architectural characteristics. Buildings are constructed using material ready at hand, easy to work, and long experiences rather than complex technology. However, the variety of buildings throughout Europe show perfect adaption to climatic conditions, the environment, and the functions assigned to them [8]. These mostly unfortified small settlements located in plains only evident by single finds, or smaller pits, often remain unpublished [230]; [423]. The location of a site depends on its character, settlement behaviour and possible locations. A detailed case study of Baden reveals a preference for settlements in warmer south-eastern and south-western expositions, while barrows are located on soils of lower quality<sup>38</sup>. Noteworthy, 3% of Early Iron Age settlements are in a 750 m radius to modern villages [318]. In lowland macrochores, like the Freiburger Bucht, fewer settlements developed, as in Upper Rhine Valley near Offenburg (close to Strasbourg). Mischka suggests that the Freiburger Bucht's marshy district reduces possible settlement area [318]. In the Kraichgau, a second example, crucial parameters are climatic conditions and the growing season's length. Mostly only good

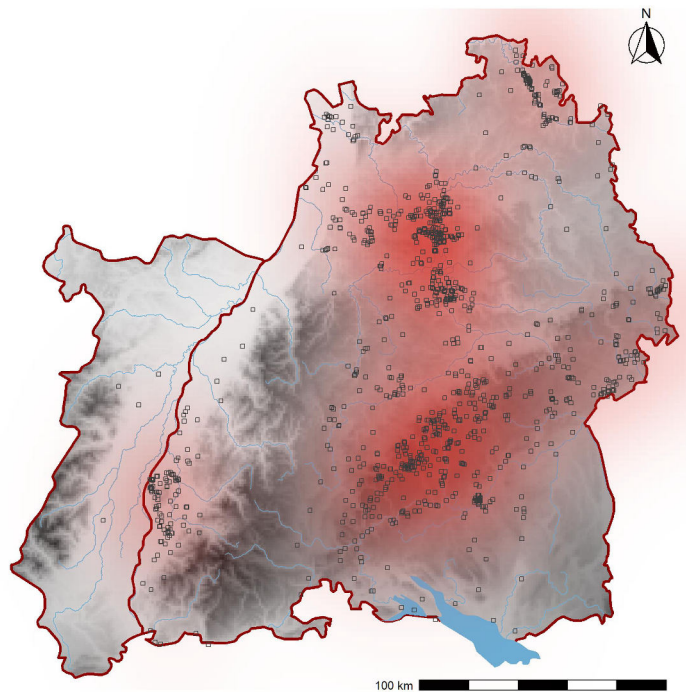


Fig. 4.7: Early Iron Age settlements in Baden-Württemberg (n=1,169) and the Alsace (n=32) (data: SHKR20, DEM: SRTM 90 m).

<sup>38</sup> This result relies on modern soil mapping [318]. For the Kraichgau, Steffen notices a similar behaviour in locating barrows protecting farmland [466].



soils exist in the Kraichgau; therefore, soil quality has less impact. However, the settlement preferably locates on the outskirts of favourable areas [466]. These briefly summarised examples depict tremendous variations in geological parameters for settlement locations. Hence, from a methodological point, an overarching examination of Baden-Württemberg or the Alsace will fail due to regionally varying macrochores (chap.: 3 for details on macrochores in Baden-Württemberg and the Alsace). Furthermore, identifying a set of factors for such a culturally diverse area might overrate common trends and neglect local adaption.

Similar to the necropolis, settlements underlie specific source-critical effects. Besides drastic differences in the depositional behaviour at settlements and necropolis, differing recovery likelihood, frequency of depositions, preservation conditions, and relocation of artefacts are all to be considered. The function of a settlement, frequency of deposited remains, slope, construction of buildings, and settlement activity duration regulates condensation of features and artefacts. Further on, the preservation depends on following settlement activities, preservation condition and redistribution [434]. Artefacts found in settlements are usually dropped, lost or broken. Their deposition is either random or intended as a broken artefact. Hence, most artefacts are highly fragmented and in bad stages. Additionally, as mentioned above, small settlements represented by only a few features often remain unpublished. Single artefacts might indeed refer to a settlement, which remains unrecognised. In combination, these effects reduce the number of known settlements and the knowledge of details.

### 4.3 Artefacts

An archaeological object is a source of intrinsic and extrinsic information. Its appearance, shape, decoration or material, without further context, reflects, however, limitedly the living culture [138]. Observing the object reveals the intrinsic information directly: technique, manufacture, decoration and shape. In the end, it is needed to place the object into its archaeological, chronological and spatial context - the extrinsic information to, e.g. reconstruct cultural groups [455].

The willing deposition of an artefact counts as the last use of it (see above chap.: 4.1), which is assumed in burials, hoards or on waste disposal sites. A deposition is a deliberate, voluntary action. Therefore, objects of a domestic context are objects which got lost. Differences in assemblages occur based on these depositional characters [495]; [88]. Both circumstances of deposition — voluntary or lost items — are relevant to understand a society. For example, in a burial context, a society pronounced deviating aspects from daily circumstances documented in a settlement. However, interaction — intentionally or not — left traces in artefact assemblages or shape and decoration on an artefact. The reconstruction of the interaction pattern does not differentiate between different depositional characters and does not value the importance of one deposition over another.

Besides, changes in settlement structure and depositional behaviour, like decreasing deposition of hoards, iron as new working material, characterises the Early Iron Age. Recently Dubreucq [88] evaluated the proportions of metal used during the Early Iron Age from burial and settlement contexts likewise. Iron artefacts occur at the beginning of Ha C in connection to an elite, which seems to hold a monopoly on iron. A change is visible in Ha D1, also still fewer items, but the weight of artefacts produced in iron changes. The weight of iron found at settlements doubles from Ha D1 until Ha D3 and multiplies by 9 to Lt A. However, the amount of bronze remains more or less stable. The proportion of bronze and iron objects varies between hilltop sites and enormous open settlements. Partially due to research bias, it also reflects differences in socioeconomic activities at the sites.

Additionally, bronze is suited well for small objects, while iron is adequate to produce large solid objects that connect to the material's physical properties. Based on a study by Dubreucq, the Heuneburg (outer area) and Crest (France) have more bronze objects than iron. The distinct differences in frequency between iron and bronze objects may be explained by different function, difficulties in the recycling of iron and different social value of iron artefacts [88].

Most artefacts with a Ha C dating originate from the burial context. In contrast to the Bronze Age, fewer axes, cavalry and toiletry are documented [495]. Similar to the decline in hoards, combined with changes within the depositional behaviour from the Bronze Age onwards and intensified by missing settlements, tools are less frequent than before during the late Bronze Age. Likewise, for Ha D, most artefacts occur in burial contexts. The habit of rich grave assemblages — vibrant jewellery in female burials — are more common. While sets of ceramic vessels are frequent before, now metal artefacts dominate with mostly jewellery, followed by arming and tools [495].

Early Iron Age artefacts are described based on a functional differentiation used in the SHKR database (chap.: 5.1). Vessels (B1), ring jewellery (B2), garb (B3), weaponry (B4), mean of transportation (B5), tools (B6), art and jewellery (B7) are summarised based on relevant aspects like production, phenotypes, decoration, distribution and chronology. The category of construction and production (B8) and others (B9) reveal little information on interaction patterns, as the available information does not allow differentiation.

### 4.3.1 Vessels (B1)

The most common material of vessels is ceramic as preservation is, under most circumstances, quite well. However, in so-called princely graves, metal vessels appear in inclining proportions from Ha C onwards. Usually lost for archaeological investigations are organic containers probably used in much higher proportions, as evident from archaeological sources. Wooden boxes from the so-called "Keltenblock" (Bettelsbühl, Baden-Württemberg) are an excellent example of this missing artefact category and its decorative appearance [254].

Besides its importance for subsistence, pottery serves as a display for styles, fashion and other expressions of identity. Generally, Early Iron Age ceramic is decorated mainly with linear geometric pattern <sup>39</sup>, while anthropomorphic or zoomorphic figures are rare. The phenomenon to decorate pottery with geometric signs in rhythmic repetition develops at the transition from the late Bronze Age to Ha C and disappears rather quickly again [44]. The fast development of this specific type and its distribution across the complete "Hallstatt area" is undoubtedly one of the fascinating aspects of the European Early Iron Age. Decoration, either painted, applied or incised, can be understood as a system of signs <sup>40</sup> as Brosseder suggests for red-and-black painted pottery, so-called *Alb-Hegau* ceramic [44]; [45]. Ornaments are understood as a visible expression of changes at the beginning of Ha C when ornamented pottery occurs suddenly and densely decorated [44]. Hence, pottery is more than a rare functional container for food as Rebay-Salisbury states; it "also mirrors world-views, aesthetic conventions, changing attitude towards standardisation and creativity" [393]. Stockhammer emphasises a broader invest-

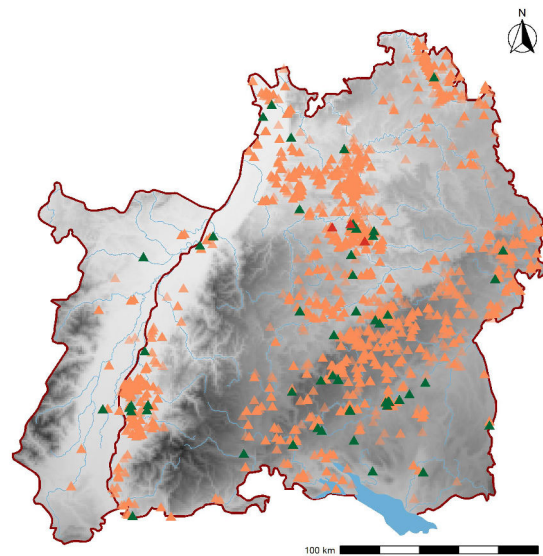


Fig. 4.8: Early Iron Age vessels (B1) in Baden-Württemberg and the Alsace (orange: ceramic, green: bronze, red: precious metal, data: SHKR20, DEM: SRTM 90 m).

<sup>39</sup> Kossack points out that geometric signs show similarities with Greek and italic contemporaneous art, north of the Alps exists own style of decoration [242].

<sup>40</sup> Ornaments or decoration implies only a decorative aspect, which has to be denied for this ceramic [45]

igation of ceramic beyond chronological and typochronological evaluations. A holistic approach to understand vessels should address three main topics: production including *chaîn opératoire* and community of practice, a dynamic concept of usage and function, and the deposition of these artefacts [474]. Production, provenance, style and use involve interaction at several stages, and therefore those aspects may reveal interaction relationships.

A large fraction of prehistoric artefacts (fig.: 4.8) is made of ceramic (n = 28,965 recorded ceramic vessels in the SHKR20), mostly pottery (n = 28,650). However, especially in rich equipped burials of the Early Iron Age, metal vessels (n = 178) may display a political and social elite (for details on distribution and production see below in chap. 4.3.1.1). Although only 15.74 % of vessels (n = 4,560) occur in a funerary context (fig.: 4.9), this artefact group will have a significant influence on the analysis of interaction pattern. Often, ceramic found in a funerary context is densely decorated (see below), well-published and kept (during some antiquarian excavations, undecorated pottery was, if recorded, not kept). In contrast, pottery found in settlements are in a more fragmentary stage, exposed to different taphonomic processes, less often decorated and less well-published — the information of funerary pottery is potentially higher to better documentation and data availability.

Most pottery dating to Hallstatt C and D originates from grave contexts <sup>41</sup>. Primarily because of the habit of rich pottery assemblages as grave goods during Hallstatt C. The unbalanced state of research between settlements and cemeteries indeed influences this pattern <sup>42</sup>. Especially, considering that mostly higher status individuals have been buried within grave mounds, the known pottery does not reflect average settlement assemblages. Decorated pottery from settlements is rare. More recently a new chrono-chorological evaluation of ceramic found in recently excavated settlements in the Alsace give an insight into profane pottery [272]; [3]; [75]; [273].

Wagner defined *Alb-Hegau* ceramic after he discovered Salem (Baden-Württemberg) cemetery ([502]). Therefore, Schumacher named this type of ceramic *Alb-Salem* ceramic in 1921. Nevertheless, in 1939 Keller ([220]) demonstrated a larger distribution of this ceramic type and formed the term *Alb-Hegau* which is still in use today. *Alb-Hegau* ceramic is characterised by geometric decoration with rills, chip carving and stamps. Keller could distinguish several regional groups with the Alb-Hegau area (Heidenheim, Ries, Ostalb and Middle Alb) and a Korberadter group <sup>43</sup>. More recently, Rauhaus [392] points to the problematic differentiation of these ceramic styles, as intermediate groups occur, which have been in contact and interaction with the before mentioned groups.

*Alb-Hegau* ceramic distributes on the Swabian Alb, its surroundings, western of Lake Konstanz, Bayrisch Schwaben and Switzerland. Rhombic strips, *Wolfszahn* strips, filled spaces and star motives in bowls decorates densely *Alb-Hegau* ceramic [44]. As mentioned above, stamps chip carving, polychrome painting, mostly red and graphite, and white incrustation characterises this type [468]. Stegmaier differentiates three groups within the distribution area of the *Alb-Hegau* ceramic, indicating not only workshops but also spatially limited cultural areas [470].

Red slipped (or engobe) vessels with graphite or black paint characterises pottery of type *Ostalb*. In contrast to type *Alb-Hegau*, plastic decorations like rills or stamps occur only as frames [468]. Zürn defined the term *Ostalb* to describe pottery distributed in eastern Swabian Alb, Nördlinger Ries and southern Frankenalb [530]; [194]; [136].

In contrast to pottery of type *Ostalb*, graphite painting on dark surfaces characterises pottery of type *Koberstadt* <sup>44</sup>. The pottery fired in reducing atmosphere differ from the firing of *Ostalb* ceramic, which is done in oxidising atmosphere. *Koberstadt* pottery distributes from north-western Baden-Württemberg northwards to Wetterau (Hesse) and Lower Main Valley towards Heilbronn (Baden-Württemberg) [468]; [230].

<sup>41</sup> Therefore, most assumptions following are based on cemetery assemblages.

<sup>42</sup> Naturally, source-critical filters (depositional habits and research bias) reduces potential information on small scale interaction. However, decorated ceramic seems to allow for identifying local identities and large scale interaction based on signs, as Brosseder showed (see [44]).

<sup>43</sup> Others differentiated other groups and defined regional specifics like Zürn [533], Hoppe [194], Baitinger or Bauer [20]

<sup>44</sup> More on research history, spatial distribution and decoration of *Koberstadt* ceramic see [444]; [13]; [511].

Ceramic found along with the Upper Rhine Valley show strong similarities to that found in Baden-Württemberg [300] and Switzerland [419]. Graphite painting forming strips on a red surface, chessboard decoration, space-filling motives, triangular, crossing lines and doubled St Andrew's cross is expected during the Early Iron Age [230]. According to Brosseder, patterns and motives show strong connections to southern Germany, but especially in terms of technique (graphitisation) and ornamentation of filled spaces deviates. Some rare vessels of this type occur outside its main distribution area of southern Baden, eastern France, and northern Switzerland [44]; [467].

More recently, Brosseder compiled a catalogue of decorated Early Iron Age ceramic in central Europe and analysed the decoration to understand the Iron Age system of signs [44]. For an interaction study, signs across larger areas can be used instead of the usual provenance. Handmade ceramics make exact analogies unlikely, but decoration, technique and shape are indicators for temporal and spatial comparisons [247]. Comparable to provenances of metal object, defined by characteristics linking to workshop traditions (see, for example, the definition of workshop areas for fibula 4.3.3.1), signs combination, ornaments and patterns retrace relationships, connections and communication on local and regional levels.

Brosseder deconstructs the decoration of the Early Iron Age into the pattern, ornament and motives on a hierarchical basis where motives are understood as the smallest units <sup>45</sup> [44]. Furthermore, she differentiated motives or signs from the structure of decoration like strips, sequences or spaces. As composed of at least one motive, signs have been used more conservatively, while it can vary in detail and technique. Rhombic strips, for example, are a common sign, which was in use from Ha C to Ha D. In detail, rhombic strips can appear very differently. Brosseder assumes that signs represent a more conservative part of Early Iron Age culture and appear mutually on funeral goods.

The distribution of signs show different levels and sizes of circles:

- individual decoration in each grave
- similar decoration within a cemetery
- the variation between cemeteries and regional groups in commonly used pattern and ornaments

Being not restricted to a regional group, the syntax of single motives and signs differentiate regions [44]. Chip carving is known on ceramic from southern France dating to the End of the Bronze Age and contemporaneous sites in southern Germany. Surprisingly no such decoration is known in the area in between, the Rhône Valley. This link is also supported by several motives known in both areas, like triangles, H-motives, sequences or rows of triangles. On the other hand, other motives show overlapping distribution showing more local connections like circular stamps and simple chessboard strips [45].

Decorated Early Iron Age ceramic seems to be produced deliberately for funeral purposes [154]; [44]; [45]. Poor clay quality and firing, unhandy vessel types with a small base or old-fashioned vessel types indicating

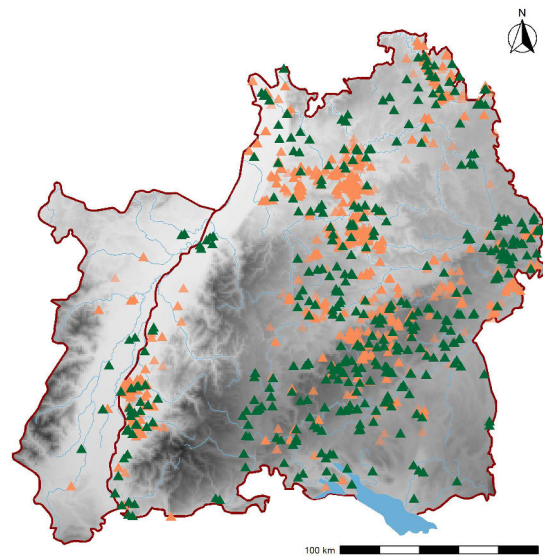


Fig. 4.9: Early Iron Age Vessels (B1) in Baden-Württemberg and the Alsace (green: funerary context, orange: settlement context, data: SHKR20, DEM: SRTM 90 m).

<sup>45</sup> Simple decorations like dents, rills or lugs are not evaluated by Brosseder, as she assessed this decoration as less informative value. Part of the SHKR philosophy is to record this information unbiased.

production as grave goods. Besides, some specific shapes are only known in grave contexts, like stepped bowls [44]. Recent residue analysis of a conical-necked vessel from Speckhau mound group (Baden-Württemberg, next to the Heuneburg) proves the usage of this vessel as a mortuary vessel <sup>46</sup> [523].

Some factors indicate a local production and most probably a household production. For decorated ceramic, the used ornaments make a production for a larger, regional market unrealistic <sup>47</sup>. Varying clay quality and composition within a closed assemblage (grave) indicate household manufacture [44]. Furthermore, if the decorated Early Iron Age ceramic is deliberately produced as a grave good, a household production is more likely.

Ceramic typologies diversify not only in regionally distributed shapes but also in the style of decoration. Trachsel states that different temporal trajectories hinder a synchronization of metal objects and ceramic vessels [494]. Generally, decorated pottery dominates in graves in Ha C. Already in Ha C2, fewer vessels and less decorated vessels occur in graves. This trend continues during Ha D1 and D2/3 when mortuary vessels have a subordinate role in burial rites. In contrast, jewellery with ornaments show a contradicting development: In Hallstatt D, jewellery seems to display ornaments and signs formerly displayed on pottery. Brosseder explains this change of habit not with inclining importance of ornaments and signs, but with a changed medium to demonstrate [44]. This phenomenon develops further to the famous La Tène art with its outstanding decoration.

Brosseder differentiated four chronological groups (A to D <sup>48</sup>) of decorated ceramic and tried to connect these with the chronology of the Heuneburg and with metal objects. She could demonstrate that ceramic with stamp and chip carvings are contemporary and do not allow separation into *Alb-Hegau* ceramic and *ceramic in Alb-Hegau tradition* as suggested by Dämmer [70]. Moreover, this style of decoration continues into Ha D [44]. Dark surfaced ceramic with a rich and dense stamp and chip carving decoration connects to swords type *Gündlingen*. Ceramic associated with iron swords are bicoloured and decorated with stamps. Moreover, black-and-white ceramic in Baden-Württemberg found together with Mindelheim swords [13]; [44]. While ceramic with incision or rills are dominant in graves with daggers, hence, younger [44]. Stegmaier states that no stamps and chip carving decoration on ceramics date to Ha D1 complexes, except grave XI from Hohenmichele, which is contradicted by Brosseder [44] and Dämmer [70]. For Stegmaier, Alb-Hegau ceramic dates to the older Early Iron Age and channelling decorated ceramic and ceramic with cross hatches in Alb-Hegau style dates to end of Ha C and beginning of Ha D. White backgrounded ceramic with red painting dates to late Hallstatt [468]. The Heuneburg seems to be the centre of distribution for the latter ceramic type [470]; [469].

Although archaeologists tend to classify ceramic vessels according to their shape; and afterwards address usage, this deduction remains a suggestion until proven. Nowadays, some organic residue analyses describe the individual usage of a vessel [523]. A fascinating insight into burial practise is visible thanks to these investigations, but transferring these results to other vessels of the same type has to be dismissed until a satisfying number of cases are known.

Stepped bowl, concave bowl and conical-necked vessels are typical shapes in Ha C graves contexts. Stepped bowls occur from the beginning of Ha C and have their origin most probably in shapes of Urnfield culture, while concave bowls might begin slightly later but indeed continuing into Ha D1 [468]. Conical-necked vessels have a blurry range in the form of shoulder and position of vessel carnation. Those vessels with a high positioned carnation can be dated to beginning Ha C, and they are in use until Ha D1. In contrast, vessels with lower carnations are younger, those with high and long necks dating to late Hallstatt and not later than Ha D2 [468].

Besides these specific shapes, several others date into the Early Iron Age, like cambered bowl, pots or bottle-like vessels <sup>49</sup> [273]; [230]; [498]. Cambered bowls with graphite decoration, for example, date to Ha D2 [14].

<sup>46</sup> Whether this result can be transferred to all conical-necked vessels remains uncertain. Regardless, the results strengthen Brosseder's hypotheses of travelling high-status individuals [44], as this individual got infected with a haemorrhagic fever somewhere in the Mediterranean [523].

<sup>47</sup> A regional market cannot explain the alternation of signs within a cemetery [44]. However, as Nagy points out, the production by a local potter is indeed possible [335]. Perhaps with more data on contemporary settlement ceramic, these questions can be answered.

<sup>48</sup> Her groups A to C dates into Ha C, and group D refers to an early Hallstatt D1 now with fibula [44].

<sup>49</sup> Bowl no. 2200, vessels no. 6210 and no. 6220 dates to Ha C, continues into Ha D3/Lt A with a morphological development. In Ha D bowl no. 1200 occurs sporadically until Lt A. And, in Ha D2 bottle no. 9100 appears [273].

In the 6th century, unfamiliar pottery — made on the potter’s wheel — appears in small numbers at so-called princely seats like Breisach/Münsterberg, Heuneburg or Châtillion-sur-Glâne (Switzerland) [15]. This “new” pottery has dark-brown to black surfaces, which differentiates from the regular lighter-brown hand-built traditional Early Iron Age pottery; it is thin-walled and evenly made. The zoning of the pottery core indicates controlled firing conditions. The well-smoothed surface reveals nearly no traces of production. However, the shape of vessels resembles hand-built bowls, bottles and jars. First, this pottery was assumed import due to the low frequency and presumable exclusive appearance at princely seats. However, Balzer’s study of the Breisach/Münsterberg [14] changes this image drastically. At only five sites, this ceramic was known in 1974, Pare counts nine sites in 1991, and 2010 Balzer lists 50 sites in France, Germany and Switzerland. With these changes in research assemblage, detailed results on this ceramic are made possible. Thin-section analysis of artefacts found at sites in and around Breisach and Britzgyberg proves local productions at five of those sites. Although slow rotating turntable used in pottery production since the Urnfield Culture continues into the wheel-made pottery, Balzer sees most probably influences from southern France. She suggests that mobile craftsmen or mobile potters can explain the distribution. Form, decoration and firing are spreading in a wide-ranging region between Bourges and Ipf. Therefore, Balzer shows that princely seats were neither exclusive producers nor consumers of wheel-made pottery. Princely seats are gateway or conduits and indeed consumer of this foreign style pottery, supported by a beginning regional differentiation of wheel-made pottery with the decline of princely seats at the end of the Early Iron Age.

Table A.2 illustrates the classification (chap.: 5.1.1) of a vessel, ceramic or metal, by a description of its profile, rim, base and outlet<sup>50</sup>. Some classifications will confirm better with these materials than the SHKR, especially concerning types and chronology. However, for a regional comparison, the used classification has crucial advantages: The SHKR classification overcomes uncertainties by definition of types or an only vague description of types. Using interval scaled features, like size or height to width index combined with nominal scales features, like shape (rounded, shoulder, 3-parted (conical-necked vessel) allows to describe and classify a large proportion of artefacts independently from their predefined type or fragmentary stage. Furthermore, recording decoration independent from type allows evaluating relations between ornaments or signs without biases in the type definition.

#### 4.3.1.1 Metall Vessels

With 178 metal vessels recorded in the SHKR, those artefacts occur not regularly but quite often (see fig.: 4.8). According to Tremblay-Cormier during Ha C they serve for representation and consumption of solid and liquid food in grave contexts [249]; [58]; [76]; [248]. Therefore, the assemblages contain dipper (*Schöpfkelle*), tankard (*Krüge*) and accessory for sieving/filtering, and most artefacts are plates, bowls, goblets, phials and mugs. In contrast, in Ha D1, vessel types for presenting or serving food dominate, like a cauldron, situla, cist, followed by those for consumption [495]. An adaption of a Mediterranean habit for the banquet is strongly visible during Ha D2/3 in graves of the presumed elite [76] showing a Mediterreanisation of the elite [248]. During the Early Iron Age, this group of artefacts connects a social group — may be a political elite, across Baden-Württemberg and the Alsace. Especially for the interaction pattern of these social segments, metal vessels may influence the results; also, the total number remains low compared to all vessels.

Metal vessels are containers made entirely of metal, usually a metal sheet of bronze, copper or gold. Therefore, this definition excludes composite containers for examples of metal fittings as on rhyton. Due to the thin-walled metal sheet, they preserve only fragmented, and the original shape only preserves with appropriate excavation and restoration. Jacob assumes more unidentified metal vessels from settlement excavations are stored unrecognised in museum archives [203].

As these vessels dominate in richly equipped burials, most artefacts originate from antiquarian excavations, which missed especially smaller objects as proven by modern investigations. First regional comparisons are con-

<sup>50</sup> A similar system applies Nakoinz for the HEK [341]

ducted by Lindenschmidt [283] and Reinecke [396] and a compendium by von Tröltzsch [497] from 1884. Montelius investigated the trade connections from Scandinavia to southern regions and supposed an italic provenance of metal vessels found north of the Alps [322]. Although Reinecke and Lindenschmidt suggested a local production, Montelius' assumption prevails until the 1940's assuming missing technology and knowledge for local production. In 1952 Gero von Merhart considered types of Bronze Age and Early Iron Age metal vessels independent from chronological aspects and noted a local production from the Urnfield Culture onwards [310]. Regional evaluations follows [223]; [238]; [491]; [472] and Jacob covering Germany (excluding the former German Democratic Republic) [203].

Jacob provides a classification of metal vessels based on the shape and functional features. A handle, for instance, characterises a cup and a narrow neck a jug. Further, functional groups are subdivided by shape, decoration and handle [203]. She uses explicitly different terms to differentiate her classification of those pre-existing to avoid biases. The recent classification of Jacob resembles the SHKR classification the most; therefore, her system structures this section, although older classifications are still in use.

Bronze cups with a high looped handle (*Beckentasse* according to Mehrhart), bronze mugs with undecorated rim zone, bronze jugs or plates occur in low frequencies in Early Iron Age graves. Dehn differentiates the terms of *oenochoes* from locally produced bronze jugs [76]. Bronze bowls are the group with the widest variety of subtypes: type (*Hohmichele*, bowls with embossed decoration, bowls with foot or bowls) ladle-like with attached handle. In contrast to a more restricted distribution in southern Bavaria, the Upper Danube valley and Rhine-Main region during the Urnfield Culture, in the Early Iron Age jugs, occur at the Jagst Kocher confluences, the Upper Pfalz, southern Bavaria and along the Neckar [203].

Bronze basins and cauldron are the most common metal vessels in Early Iron Age grave contexts. Jacob differentiates the two types by their proportion of width to height. Further differentiation bases on handle attachment for basins and position of carnation of cauldrons. Triangular handle attachments distribute at the Main and in Bavaria, cross-shaped attachments striking close to rivers Rhine, Danube and Neckar. Cauldron with cross-shaped attachments (type C) have a central distribution south of the Alps; however, some examples occur in Ha C complexes near Rhine Valley and the Upper Danube [310]; [58]. Generally, bronze basins show a large distribution from Baden-Württemberg to southern France [77]; [248]. Dehn and colleagues differentiated five types of cauldrons based on morphological markers. Of those occur the types of (*Kappel*, *Herbertingen* and (*Kissing* during the Early Iron Age in the area of question. The most eastern location of type *Kappel* is at the Rhine. Type *Herbertingen* concentrates on the Swiss plateau during Ha D1 and D2, and in Rheinland-Pfalz in Ha D3. Type *Kissingen* occurs in Ha D2/3 on the Swiss plateau, French Jura and southern Württemberg [76]. The chosen names for types based on well-known sites implies a misleading concentration of this type around the eponym site location.

Other essential types are bronze situla, like so-called *Rheinische Situlen* defined by Kimmig [223] distributed mainly in the northern periphery and corrugated situla with a broader distribution reaching northern Germany.

### 4.3.2 Ring Jewellery (B2)

The category of ring jewellery summarises personal items like well-known bracelets, anklets or torcs. The habit of ring jewellery is a long tradition from the Bronze Age and continues into the La Tène period. Therefore, some archaeological types show overlapping typological developments across the epochs. Furthermore, the plastic or incised decoration, different shapes, and production depict a regionally varying distribution [57]; [90]; [353]; [382]; [437]; [195]; [495]. In combination with the high frequency of these artefacts in archaeological assemblages, ring jewellery seems suitable for interaction analyses.

Likewise, other personal items, ring jewellery in archaeological collections, mainly originates from grave contexts, which is even more dominant with changing depositional habits at the beginning of the Early Iron Age [495]. Noteworthy, some types of ring jewellery are sets of pairs while torcs occur singly. This habit influences

the proportion of artefacts (bracelets are more frequent than torc, see below); however, it does not explain the dominance of bracelets and anklets.

The category of ring jewellery lists 5'248 artefacts dating between Ha C and Ha D. Most artefacts are bronze objects (n = 4'189), followed with an almost same ratio by gold objects (n = 181), iron (n = 161) and jet or lignite (n = 141). These numbers are always bearing several taphonomic effects. Primarily, iron ring jewellery might be underrepresented due to degradation of iron and possibly miss classification into other categories like parts of a garment. The spatial distribution of material (see fig.: 4.10) does not show significant preferences, although jet objects are more frequent on the Swabian Alb and in the southern Alsace.

The wide variety of types and decoration lead to the division into numerous types and subtypes with a more or less restricted distribution [506]; [314]; [187]; [398]; Hornung.2008. More recently, Tremblay-Cormier summarises relevant types and the distribution for the area in question [495]. Therefore, only some types and their aspects illustrate the significance in interaction analysis, although the SHKR classification does not use these pre-defined types. All aspects of an artefact, like material, shape and decoration, are recorded precisely but independent of the artefacts category. Also, the pre-defined type is recorded but excluded from the analysis.

Table A.3 summarises ring types of the SHKR classification with possible additional descriptive levels. First, they are differentiated according to the way of wearing, and secondly, on specifics of their shape, like solidly made bracelets having a round cross-section (B2311). As many artefacts originated from antiquarian excavations, their position in respect to the deceased is unknown. Hence the way of wearing is assumed by their diameter, appearance and in comparison to better documented objects. This functional division [341] by using the diameter may obscure the actual wearing. However, costumes and habit of wearing are not the focus of this analysis.

Nonetheless, this functional division has — although simple — some disadvantages. Differentiating anklets (B24) from bracelets (B23) and fingerings from earrings (B25) remains complicated due to overlapping diameters. Rings of an undefined type, or fragmented artefacts, are recorded as "B29 Other"<sup>51</sup>. If possible, the artefact is described with the before mentioned levels. Additional levels describe closed or open shapes, modes of connection, fastening and appearance of the end section. Material, the technique of decoration and decoration itself is registered in separate facets of the SHKR classification (chap.: 5.1.1).

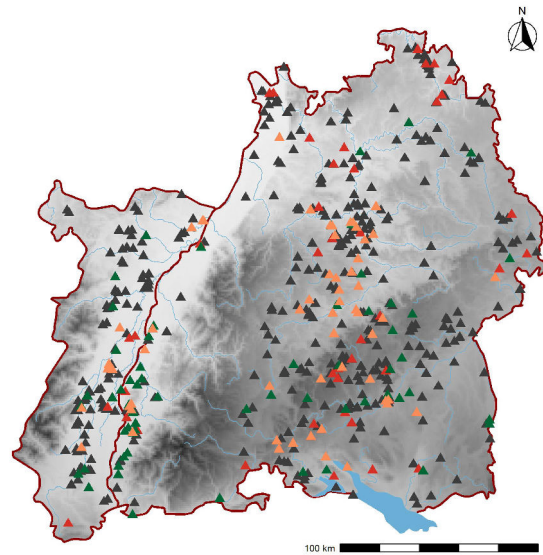


Fig. 4.10: Early Iron Age ring jewellery (B2) in Baden-Württemberg and the Alsace (grey: bronze objects, orange: gold objects, red: iron objects, green: jet/lignite objects, data: SHKR20, DEM: SRTM 90 m).

<sup>51</sup> The category of "other rings" (B29) with 1,426 artefacts shows problematics in differentiating rings into functional types.



### 4.3.2.1 Torc (B21) and Temple Ring (B22)

Torcs mainly occur in grave contexts during the Early Iron Age<sup>52</sup>. Torcs seem to occur mainly in the graves of women, considering the age and sex determinations. Except for the golden torc, which, apart from the Lady of Vix, occur in typical so-called princely burials. Moreover, age groups do not differ [515].

In Ha C, mostly almost all neck rings (torcs) occur in the Rhine-Main area and Saarland [187] and not in Baden-Württemberg or the Alsace [515]. At the beginning of Ha D, Hollow torcs [86] occur in Haguenau, south-eastern Baden-Württemberg and less often at the Swiss Plateau and French Jura [382]. Hollow torcs with a pintle shaped fastening distributed during Ha D2/3 in Upper Rhine Valley [235], Swiss Plateau [382] and spreading into Saarland [397], Lothringen and Burgundy [57].

At the beginning of Ha D2/3, a type of closed, solid torcs with a circular cross-section, without decoration and sometimes with casting residues occurs the area of the HEK [187], Pfalz, northern Alsace [367]; [449] and Châtillonnaise [57]. Only at the end of Ha D1 torcs occur more often in funeral contexts of Baden-Württemberg, and the Alsace, with a diameter ranging between 20 to 25 cm indicating that they are put on in during early childhood [495]. This simple type disappears at the end of the Early Iron Age [495]. Westhausen points out that objects with small diameter in Ha D1 context (Kappel-Grafenhausen, St. Johann-Würtingen and Hohmichele), where these torcs are still relatively rare to occur dominantly in male graves [515]. Westhausen disagrees Dehn [76], who interprets these artefacts as symbols for a leader as a rule breaker. The type does not adopt female garb; instead, it is a different type of torc that develops into a symbol for an elite's social status of an elite [515].

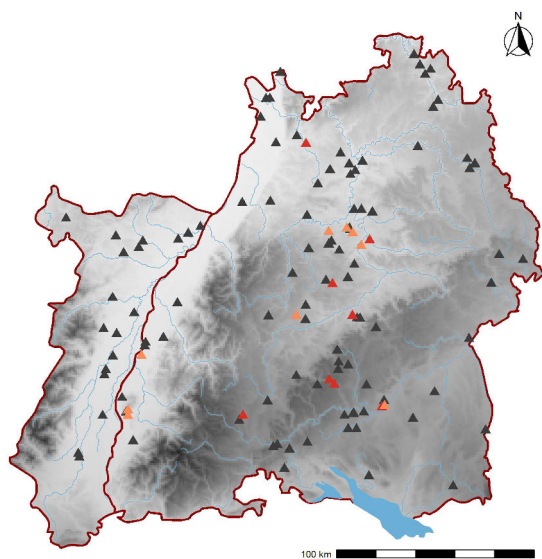


Fig. 4.11: Early Iron Age torcs (B21) in Baden-Württemberg and the Alsace (grey: bronze objects, orange: gold objects, red: iron objects, green: jet objects, data: SHKR20, DEM: SRTM 90 m).

Torcs with single or groups of eyelets or eyelets in a row are produced in a cast, occasionally with casting residues, and probably more items attached to them [160]. Three to nine eyelets are characteristic for funerals on the left side of Rhine, Saarland and Pfalz [397]; [235]. At Ohlungen and Maegstub (Bas-Rhin), attached items are glass objects and other organic material [495]. For the Alsace, applied snakes on bracelets and torcs are typical during Ha D1 [235]. (*Wendelringe* [160] with a square cross-section originate most probably in the area of the HEK spreading into the northern Alsace [495]. Likewise, during HaD1, torcs are concentrated in Rheinland-Pfalz, along Upper Rhine, in Châtillonnaise and less strongly in southern Baden, Swiss Plateau and Jura massif during Ha D2/3 [495]. Golden Torcs divide into hollow torcs with an oval cross-section and pintle closing and sting-shaped decorated (or not) gold sheets. The latter type shows a strong connection to so-called princely seats as found nearby [196].

Regarding signs of an elite, Kurzynski [268] points out, golden torcs indicate a particular social position, understood within a supra-regional community, without implying similar social positions or similar social structures, but a common understanding of this sign.

Temple rings are characteristic artefacts of the HEK and show connections to the northern periphery again. They are divided by diameter, amount of changes in twist direction and possibly used in connection with he-

<sup>52</sup> Noteworthy, Sievers points to problematic differentiation between large neck rings from supporting rings of metal vessels in settlement contexts [453]

address [195]. However, the definition remains complicated if the position in the grave does not indicate the usage.

For category B21 (torcs), 317 artefacts are listed with a significant dominance of bronze (83%). In comparison, gold and iron are less frequent. Temple rings occur only rarely in the area of question. Nonetheless, 79 artefacts are recorded as B22 in the SHKR database.

#### 4.3.2.2 Braclet (B23) and Anklet (B24)

A wide variety of types and decoration showing different regional distributions characterises bracelets and anklets. This fact might cause the lacking synoptic typology for the central European Early Iron Age. Regional typologies exist for eastern Switzerland [437], Rhine-Main and Palatinate region [237]; [187]; [449] or central France [314]. Tremblay Cormier tries to close the gap between these regions and links the artefacts to the typology of Milcent [314]. She adopts the structure of Milcent's typology and describes the jewellery by morphological aspects of the ring body, fastening and technique of decoration. The ring body differs in either solid rings with regular cross-sections, with knobs or regular hollow cross-sections. Three main techniques for fastening divide into closed rings, open rings, and a mechanism to close [495]. Finally, the decoration is described in a combination of technique, decor and position of decoration. All these criteria are easily transferred into SHKR structure, except the position of decoration.

The SHKR database lists 2,016 bracelets (B23) and 353 anklets (B24). In both categories bronze is the dominant material (fig.: 4.12 and fig.: 4.13. For bracelets, records show a higher amount of lignite or jet objects ( $n = 114$ ). Gold and iron are also present, however, in lower frequencies.

During Ha C, the primary production (and distribution) of bracelets and anklets lay outside of the area in question in the Rhine-Main area [187] and on the Swiss Plateau [437]. An intersection of both areas is evident in type 3 with discoid endings (XIV, a variant of type *Schötz* and *Tschugg*)<sup>53</sup>. Some specimen of this type also occurs in Baden-Württemberg and the Alsace (type 3 XIV, XIII, XIX, type 26) [495].

With the beginning of Ha D, type *Großaffoltern* originally from the Swiss Plateau [437] also occurs in south-eastern Germany and the area in question [495]. Types *Eich-Schenk* and *Hemishofen* concentrated on Swiss plateau and France Comté, spreads sporadically into Burgundy and Rheinhessen, but not along Rhine Valley [495]. Which contrasts to the distribution of type *Thunstetten*, that indeed occurs also in the Rhine Valley [381]. The so-called *Tonnenarmbänder* links the Swiss Plateau with Baden-Württemberg (here especially type Baden-Württemberg [437]) and the Alsace [384]. Local production in Baden-Württemberg seems likely. A very restricted distribution shows type *Magdalenenberg*, which occurs besides its eponym site only once near Tübingen (Neuenstetten-Wolfenhausen, Baden-Württemberg) [533]. The type *Baden-Alsace* is characteristic for the Upper Rhine Valley during Ha D1 [495]. Variants 1 and 2 show

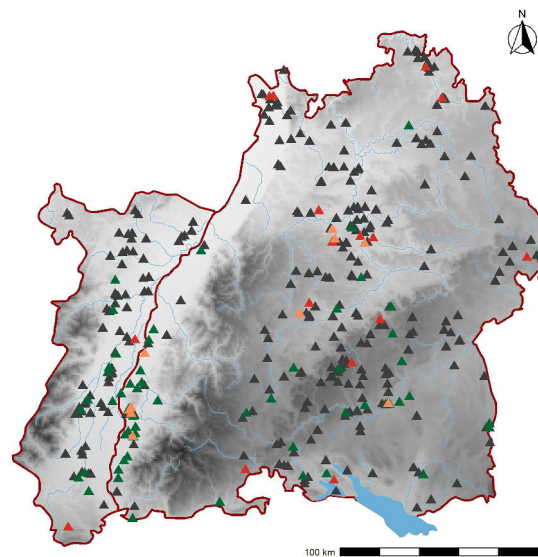


Fig. 4.12: Early Iron Age bracelets (B23) in Baden-Württemberg and the Alsace (grey: bronze objects, orange: gold objects, red: iron objects, green: jet objects, data: SHKR20, DEM: SRTM 90 m).

<sup>53</sup> In the Pfalz, intersecting types are visible in type 31 [237].

two different spatial distributions, which, according to Plouin, indicates two regional groups. At Herrlisheim (Bas-Rhin, France) occurs a golden object of variant 1 [526]. However, zones with overlapping occurrences of these types show commingling and exchange [383]. Variant 3, although concentrated around Colmar (Bas-Rhin, France) spreads sporadically northwards to the Pfalz [495]. Similar to torcs, simple, solid and closed bracelets and anklets without decoration, but casting residues are characteristic for the Upper Rhine Valley as well as Württemberg [367]. This type continues during Ha D in the Upper Rhine Valley [235]; [237]; [449]. Bracelets and anklets with varying numbers of eyelets concentrate in the periphery of the area in question: the Saarland, Pfalz and Main Valley [449]; [398].

Iron bracelets with thickened endings originally distributed in Burgundy and Lothringen spread along the Rhine. Bronze and iron anklets occur combined in graves at Schirrhein (Haut-Rhin, France) and Königsbrück (Haut-Rhin, France). Reinhard reports of poorly preserved iron bracelets in sword-graves on the eastern banks of the Rhine [398]. Another concentration of these artefacts occurs in the Palatinate [237]. However, establishing a typology is naturally restricted to preservation conditions.

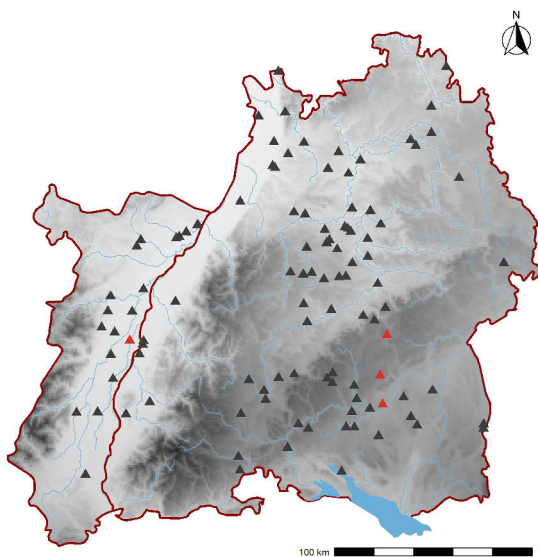


Fig. 4.13: Early Iron Age anklets (B24) in Baden-Württemberg and the Alsace (grey: bronze objects, orange: gold objects, red: iron objects, green: jet objects, data: SHKR20, DEM: SRTM 90 m).

Bern, Côte D'Or and a middle Rhine group. The distribution of the lignite armrings from the Swabian Alb overlaps with that of small jet rings. Around the group between Kaierstuhl and Tuniberg, middle high lignite bracelets occur as a periphery. Lower lignite bracelets (up to 4cm) locate mainly around Bern and Basel; however, some artefacts occur also in the Breisgau, Hageunau Forest until Lothringen. Middle high lignite bracelets (between 4 to 6 cm) spread across the entire Alsace, Departement Doubs, Côte D'Or, Baden, Swabian Alb, Upper Danube and Switzerland. High bracelets (6 to 6,8 cm) concentrate southern the Swabian Alb between Staffelsee and Ammersee with two outliers in the Alsace. For western Switzerland, several high lignite bracelets seem to dominate the distribution. However, outliers occur in the French Jura, at Hageunau and Karlsruhe [414]. Rochna supposes the large lignite bracelets being a lining for bronze *Tonnenarmbändern* [414], which is contradicted by Kimmig [226].

During Ha D2/3, new types like type *Muttenz* spread from the Rhine-Main area into the study area. The Rhine-Main area characterises a wide variety of types. Solid and closed bracelets or anklets with a plano-convex cross-section (type 4.I.a [495]), and varying decoration, also spread into the Saarland and Alsace. Decoration with groups of lines is characteristic for northern Württemberg, the Swabian Alb, while an example found in the Rhine-Main area underlines connections [195]. A solid, closed and undecorated bracelet or anklet with a circular cross-section (type 3.I.a [495]) and type *Thunstetten* are characteristic for Bas-Rhine, especially the Hagenau Forest [235]. The relation between the Alsace and the Swiss plateau is evident, e.g. in the distribution of type *Trüllikon*, type *Aubonne*, type *Bülach* or type *Cordast* [437], [495]. While type *Rance* and type *Schupfart* connects the Alsace with Châtillonnaise and Franch-Comté [495].

Rochna [414] classifies lignite armrings by their height into armrings and bracelets, which he again subdivides into low, middle, high and very high bracelets and barrel bracelets (*Tonnenarmbänder*). For the distribution of armrings, he defines six locally concentrated groups: Swabian Alb, a group between Kaierstuhl and Tuniberg, the northern Alsace, around

Rochna suggests that lignite and jet artefacts in the Early Iron Age context in Baden-Württemberg and the Alsace originate from raw material sources in Jurassic deposits spreading across south-western Germany. Which is supported by semi-finished products from the Heuneburg settlement [415]. A petrographic and chemical provenance study of lignite objects by Baron [18] highlights our knowledge of the exchange system. She analysed European raw material sources and archaeological artefacts from 20 different sites dating to the late Iron Age. During the Early Iron Age, carbonate sediments are preferred, which changes later Iron Age to silicate sediments. Baron suggests that mainly Kimmerdigs (Cornwall, Great Britain) serves as a source for raw material during the Early Iron Age.

Nonetheless, the south-western German sources are also likely; however, she could not identify an artefact originating from one of her samples raw material sources. Another possible source might be Whitby (York, Great Britain). In respect to the low number of samples, Baron attested the same raw material, although found at different sites. Only a few raw material sources are exploited to produce this jewellery and strengthen an excellent interconnected European image.

The distribution of jet rings<sup>54</sup> describes Rochna as more punctual near the Swabian Alb. Real jet originates from the Swabian Alb and has been exploited until the 15th century AD in Bad Boll and Balingen. The exposition of jet is more exhausting than lignite, which occurs in outcrops quite often across Baden-Württemberg and the Alsace. Rochna suggests that the problematic exploitation of jet might cause the earlier and more extensive exploitation of lignite sources in Ha C2 and Ha D1. The numerous jet artefacts located in the Alsace have been traded in from the Swabian Alb [414].

#### 4.3.2.3 Ear- and Fingerring (B25)

Similar to torcs, bracelets and anklets, types of earrings and finger rings indicate differing regional groups [495]. It is so far unknown how these small rings have been worn. However, they are usually found near the head, which indicates the usage as a headdress, or earrings [311]. Most artefacts of this functional category are bronze objects (n = 598). Gold objects are frequent with 12%. The high ratio of gold objects might be caused by the better visibility of gold than other materials, like bronze or iron. Further on, the preservation of gold objects exceeds that of other metals besides bronze.

The most frequent type is a hollow, half-moon shaped ring without decoration made of bronze sheet, so-called *Hohlblechring*. By the position in graves, this type has been worn on both sides of the head [458]. It occurs in a large area from the confluence of Rhine and Main to the Swiss Plateau [86]; [449]; [238]. Besides in France-Comté and at the Swiss plateau, this type is likewise characteristic for the Upper Rhine [367]; [235]. In Ha D1, artefacts of this type made of gold seem to be restricted to the Upper Rhine Valley [495]. Later, golden earrings of this type show three distribution areas in central Europe, the Upper Rhine, Württemberg and Swiss Plateau [495].

Bronze filament earrings, so-called *Spiralringe*, occur in the Rhine-Main area, Baden-Württemberg, Alsace, Pfalz and Switzerland [449]. The position in graves varies; it seems that these artefacts serve different functions within regional groups. Golden Earrings of this type are common in the Upper Rhine area at the end of the Early Iron Age [495].

*Bandohrringe*, bronze ribbon-shaped earrings, occur mainly as pairs in female burials. Mansfeld notes that it remains uncertain whether these artefacts are earrings or temple rings [302]. He defines two types of production and additional variants of fastening. The distribution of type A1 (bronze sheet bent to a ring) with socket and needle fastening occur at the Neckar, Swabian Alb, Upper Rhine to northern Switzerland. The other variant, A2, is more restricted to the Alsace, eastern France and middle and western Switzerland. Type B, a ring cut out from a thin circular bronze sheet, has a more western distribution than type A1 [302]. With the more recent discovery at the so-called *Keltenblock* a local production of type A1 near the Heuneburg (Baden-Württemberg) seems likely [94].

<sup>54</sup> See also the discussion of so-called (*Haguenaue Perlen* in Havernick [173] and below in chap.: refsubsec:2art.

### 4.3.3 Remains of Costumes (B3)

A garb does not only consist of metal artefacts or other durable materials, although these preserve most likely. Textile components, with colourful ornaments or hair dresses, were undoubtedly essential for identification with an ethnic or regional group and identity in general [393]. Textiles, mostly being lost to archaeological research, archaeologists have to focus on durable artefacts, mostly made from metal, to distinguish different gender, social status or region. Especially for interaction studies, regional differences - and local similarities - in garb have a high potential for reconstructing interaction patterns (chap. 2.2.1). Foreign influences indicate at least some kind of connection to the artefact's provenance.

Remains of textiles and other fibres are drastically underrepresented in the archaeological context (n=4 of 2,860 artefacts listed in B3). However, Kurzynski [268] states that these remains occur quite often corroded onto metal artefacts, poorly preserved and removed within an unqualified restoration. Textiles found in Austrian salt mines (Hallstatt), in so-called princely burials and bogs indicate that textile production during the Early Iron Age produces several weaves and patterns. From the Bronze Age onwards, new technologies in weave construction and sewing of clothes indicate a bloom of textile production [268].

In contrast, metal artefacts like fibula (n = 1,539), pins (n = 676) or belt plates (n = 574) frequently occur in Baden-Württemberg and the Alsace. Primarily, grave contexts yield most artefacts (70%), secondly settlements. Indeed, depositional behaviour at different types of sites influences these proportions. Additionally, the burial habit varies regionally and the individual assemblage with status, gender or age.

Interestingly, a temporal shift is visible in methods used to fasten garments. Besides pins, typical from the Bronze Age onwards, in Ha D, a new type of garment fastening occurs fibula. However, pins are still in use, assumable in connection to hair dresses (chap. 4.3.3.2). This phenomenon is merely a tendency, not a rule, is evident when considering grave context from the northern periphery of Baden-Württemberg. Here, fibula occurs in Ha D2; hence, rather late [13].

#### 4.3.3.1 Fibula (B31)

As mentioned above, Ha D marks the emergence of fibula north of the Alps [358]. Portion and number of fibula found in a grave are used to reconstruct the way of wearing. Fibula often occur in pairs or sets of three and four. Mansfeld shows that this represents a habit that differs from Bavaria to Baden-Württemberg and the Alsace. While a pair of fibula is found mostly in graves of women in Bavaria and their male counterparts had one fibula, sets of three fibulae are characteristic in Baden-Württemberg, and the Alsace with sets of 4 in male burials [303]. Kurzynski states [268], that differences in fibula sets found in burials might depend on the season of deposition. A dead might be dressed and equipped differently during summer than during winter. The deposition of the deceased in a pall can be denied by the high amount of fibula found in function position. Surprisingly, those sets do not have to be of one fibula type but could be a combination of local and foreign, or modern and old fibula [371]; [303]. Besides graves, fibula are found in settlements in much lower frequencies, as deposited not deliberately but lost or broken.

Mansfeld [303] developed a classification based upon phenotype and the combination of components, as fibula are composites of the foot, a needle holder, a bow profile or ornament shape, the spring and additional decoration<sup>55</sup>. Early Iron Age fibula show a high variation in their appearance. On the one hand, Mansfeld classification respects the technological aspects of fibula production and, on the other hand, highly individualised personal items. Following his classification of primary phenotypes and additional components allows to describe each fibula without constraints of classical typologies, and more importantly, allows to identify of shared features across different phenotypes [303]. He defined 7 phenotypes, each has several variants (see A.4). *Bow fibula*, *Kahn fibula* and *Pauken fibula* may be grouped together. In contrast, *doubplepauken fibula*, *foot fibula* and *doublezier fibula* are characterised by a second decorative part attached to the foot. By definition,

<sup>55</sup> Based on Mansfeld's phenotype classification, fibula are recorded similar in the SHKR database (see tab.: A.4).

a *serpentine fibula* has no spring, but this phenotype has the most variants (S1 to S6). All other fibula types share a set of 3 technologically different springs (x,y and z). Because of the composite nature of fibula, most components fit several phenotypes and their variants. Phenotypes of *arch*, *serpentine*, *Kahn* and *Pauken* share a set of interchangeable foot decoration (A to E), while phenotypes of *doublepauken*, *foot fibula* and *doublezier* share another but assimilable set of foot decoration (A to G). The cross-section of a fibula arch divides into the shape and technique (cast or toreutic) [303].

Due to separately produced components, the same artefact might combine different techniques. Local workshops produced in their community of practice and imitated foreign, differently produced fibula (fig.: 4.14). As imitations are the norm, trading fibula are the exception. But some phenotypes show a supra-regional distribution, like *serpentine fibula S1-P*, *arch fibula B1* with bird application and *foot fibula G1*. Mansfeld hypothesises a French origin for this *serpentine fibula*, the *arch fibula* might originate from Baden-Württemberg and the *foot fibula* from Slovenia. In each possible provenance, the presence of a princely seat can explain the distribution. The frequent occurrence of a fibula type (respecting all its attributes) at numerous sites marks its origin, or primary occurrence [303]. The distribution of some phenotypes indicates an area of provenance, while others show a broader distribution indicating interaction<sup>56</sup> [303]; [495]. The *serpentine fibula S5*, for example, is restricted to the Rhine valley and Swiss Plateau, while the Rhine-Main area and Haguenau Forest represent the most western and northern distribution [495]. According to Sievers seems a local production at the Heuneburg likely [453]. For the *arch fibula B1* a local production in its central distribution area, southern Württemberg seems likely. In Ha D2/3 this fibula type also occurs in Haguenau (Bas-Rhin), on the Swiss Plateau and Haute-Saône [495]. Furthermore, local production in Württemberg seems likely for type K2. In contrast, type B2 concentrates in Bavaria and on the Balkans, though some individuals in Haguenau (Maegstüb, Schirrhein, Hatten) and Britzgyberg indicate long-distance relationships between both areas [495]. The combination of production and origin shows different workshop traditions, implying local workshops and no travelling craftsmen, low long-distance trading and production for the local population [303]. For other artefacts casting moulds can be used to differentiate workshops<sup>57</sup>.

As mentioned above, sets of fibula found in one grave do not have to be of the same type or phenotype. Naturally, a certain degree of contemporaneity cannot be denied [303]. Nevertheless, the tradition to wear older fibula combined with the great variety and low technological development complicates the chronological differentiation of fibula immensely [303]. Additionally, a temporal shift from a fibula type origin to a site in its periphery has to be assumed. Mansfeld highlights some general trends, observable across different phenotypes, like reducing fibula length, a temporal shift within feet from A to D, or the technological development of springs

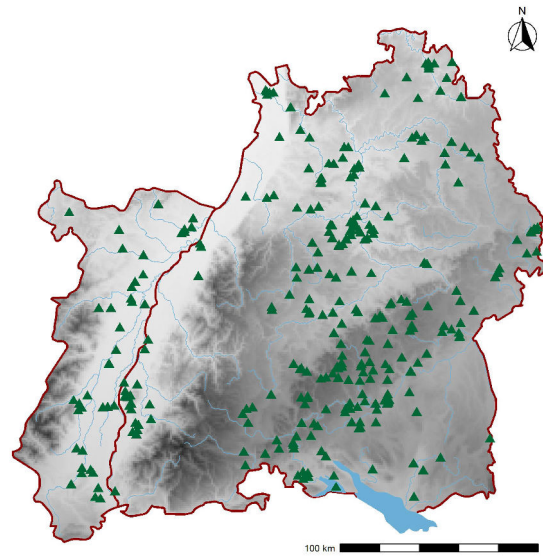


Fig. 4.14: Early Iron Age fibula (B31) in Baden-Württemberg and the Alsace (data: SHKR20, DEM: SRTM 90 m).

<sup>56</sup> Supposedly imported italic fibulae have to be dealt with care when their recovery date is in the 19th and early 20th century. Museums and collectors have bought fake artefacts. This circumstance makes provenance studies of these rare objects much more complicated [226]; [315].

<sup>57</sup> The process of reworking cased components, combined with highly individualised artefacts, creates a high variation of fibula by a low frequency of finds [303].

from x to z to y [303]. The vague relative chronology of fibula is discussed intensively and controversially in combination with the periods of the Heuneburg [70]; [147]; [453]; [265]. The before mentioned temporal delay towards the North (into the periphery) is also evident in grave inventories. While the South already used fibula, and as personal items, they are buried together with the deceased, in northern Baden-Württemberg (especially the Tauber Valley), contemporaneous grave inventories have significant less fibula. Apparently, the new fashion/behaviour/ garment did not permeate [13].

#### 4.3.3.2 Pin (B32)

Similarly, using pins to fasten a garb connects the Early Iron Age with the previous periods (Urnfield culture). Reinecke defined particular types referring to Ha C [396], while more recent research shows that these types rarely can be connected to Ha D contexts [13]. Pins have also been used as hairpins, either supporting a headdress or pinning a veil or hood. Apart from a documented position in grave context, which is often unknown due to poorly documented excavations, the length of a pin can indicate the use as a hairpin. Firstly documented during the excavation of grave mounds in the 1840's at Trüllikon (Switzerland) and Hallstatt (Austria)<sup>58</sup>. Pins often found surrounding the head (1 to 3 pins), in the position of use or a half-circle around the deceased head. Alternatively, when used to fasten a garment, lying on the chest. The likelihood of recovery depends on the excavation technique and preservation. Due to their small size, they are easily missed and decay faster until they are not recognisable anymore. For example, if only the shaft of the pin preserves, it may be indistinguishable from the needle of a fibula. As personal items and not deliberate grave goods, pins getting lost during daily life<sup>59</sup>. Therefore, not surprisingly, they are the second most artefact found at the Heuneburg. Additionally, semi-finished products proving the Heuneburg as a production site [453]. Amount and value of pins, supposedly female jewellery, are considered a marker of social status [5]; [326], profession or provenance [422]; [278].

Besides defining typical Ha C types (*Spiralkopfnadel mit Achternschleifen*, *Schlingenkopfnadel*, *Schwanhalsnadel* or *Vasenkopfnadel*), Reinecke used the length to develop a chronological shift; shorter pins are common during Ha D<sup>60</sup> [396]. After this early chronological evaluation, Schaeffer [428] and Naue [351] divided pins by their heads and shafts into types. *Kolbenkopfnadel* and *Spatenkopfnadel* (both Ha C to Ha D1) show in their later development a swan-necked shaft, possibly to drape a garb in a specific manner [302]. More recently, M. Schmidt [439] uses existing terminology for his typographic classification of hairpins in group, type and variation. Schmidt defines three groups based on the material of pinheads, with seven types like *Kugelkopfnadel* (pin with circular head), *Kugelkopfnadel* with a moulded shaft or head, *Zweischalennadel* (pins with two semi-circular husks), pins with amber heads and those with coral. Caused by reduced weight, the size of heads increase from *Kugelkopfnadel* to *Zweischalennadel* to coral and amber. The type *Kugelkopfnadel* is subdivided into six variants differentiating the shape of the head. Most common are simple roundish pin (variant 1) and half-circular pin (variant 2). The massive circular is made mostly of bronze and much less frequent of iron. In contrast, the type *Zweischalennadel* is made of two semi-circular husks and subdivided into three variants based on the husk material: bronze, iron or gold. Bronze and iron *Zweischalennadel* are undecorated, while golden *Zweischalennadel* are densely decorated with geometric patterns. Pins with an amber head subdivided into three variants based on the construction of the pinhead: undecorated, decorated, and composed of 3 disks. Apart from the undecorated variant, drilling supposedly increased the lustre of amber. Coral<sup>61</sup> headed pins have only one variant and are relatively rare (tab A.5 for details of the classification in the SHKR database).

<sup>58</sup> With the End of the 19th century, the documentation of the position is more frequent [439].

<sup>59</sup> Using hairpins every day, or only occasionally does not matter in this context.

<sup>60</sup> This observation matches changing garb habits in Ha D. As during Ha C, more pins are manufactured in iron, Trachsel supposes preservation effects also causing the reduction [494].

<sup>61</sup> The material is interesting for distribution patterns.

The distribution (fig.: 4.15) of the most common type, *Kugelkopfnadel*, and its variants allows some regional differentiation<sup>62</sup>. For example, variant 2 (pinnacle head) is unknown in the Alsace, while variant 5 (flattened head) is found dominantly in the Neckar region [439]. Although - or maybe because of - *Kugelkopfnadel* with a moulded shaft or head is found with a low frequency but widely spread; differentiation of central area and periphery is therefore complicated. During Ha D1 on both riverbanks of the Upper Rhine, *Kugelkopfnadeln* and *Zweischalennadel* are common and possibly used as hairpins [428]; [457]. *Kugelkopfnadel* with no metalhead, like amber or coral, remain as well characteristic for Upper Rhine Valley [235]. The type *Zweischalennadel* (bronze and gold) connects the Alsace with the region of the upper Danube. Semi-finished products at the Heuneburg indicate a local development [69] and production. The iron variant of the *Zweischalennadel* occurs in the region of the Hunsrück and Tauber valley (Germany) [495]. A similar connection as the bronze variant of *Zweischalennadel* shows the undecorated variant of amber heads, which occurs from Ha D1 onwards. The composited variant is widespread and dates into Ha D2 [439]. Pins with a coral head occur in the Alsace, and southern Baden-Württemberg, which local productions indicated at the Heuneburg and Mont Lassois [439]; [236].

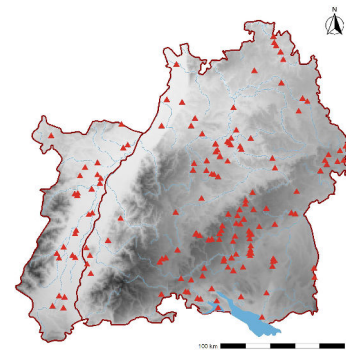


Fig. 4.15: Early Iron Age pins (B32) in Baden-Württemberg and the Alsace (data: SHKR20, DEM: SRTM 90 m).

#### 4.3.3.3 Belt (B33)

Likewise, fibula and pins, parts of belts (see tab. A.5) are found in grave context mainly. Moreover, parts of belts are complicated to recognise in settlement contexts as they occur mainly fragmented, or small rings and fittings are not characteristic enough assigning them indeed as parts of belts [453]. Traces of usage or repairs indicate belts as personal items rather than grave goods. Belts can be composed of a decorated or undecorated plate, belt hook, fastening rings, link chain, counter fitting, organic matter, decorative or technical rivets.

At first, Schaeffer [428] describes belt plates and their various decorations. More recently, a typological and chronological study by Kilian-Dirlmeier [222] sub-classifies belt plates according to their decoration into several types, like: plain belt plates (types *Magdalenenberg*, *Bitz* or *Ohnastetten*), horizontally finned belt plates (type *Neuenegg*, *Rixheim* or *Hundersingen*), belt plates with engraved decoration (types *Nebringen*, *Ins*, *Veringenstadt*), belt plates with punched decoration (types *Geigerle*, *Cudrefin* or *Brumath*), and others. Furthermore, Kilian-Dirlmeier identifies stylistic groups by subdividing decoration and significant punches, like intricate patterns or figurative motives. For western Europe, she defines seven groups: decorated with humps, figural punches, geometric and curvilinear pattern, a combination of humps and figurative punches and other mixed styles. Arrangement of pattern, technique and distribution indicates the location of workshops with dominating local markets. Those seven groups reflect two main stylistic variants: additive sequencing of punched motives with workshop areas in Württemberg, western Switzerland and French Jura, and geometric figures with simple sequencing in northern Switzerland, southern Baden and the Alsace. Although some types tend to be more dominant for one gender, belt plates seem not specific for certain groups of society [222].

Like fibula, the distribution of belt plates reconstructs workshop areas (fig.: 4.16). A centre region corresponds to the local market; the periphery shows its sphere of influence and interaction patterns. While most types have a rather regional distribution, Hallstatt (Austria) 's cemetery proves long-distance interaction and movements of items. Interesting interaction relationships are visible for types *Wohlen* and type *Singen*. Both indicate contact from Rhine Valley to Franken (Bavaria) across the Pfalz, avoiding the Black Forest. Possibly, the same workshop produced several types related to another by production technique or style. Type (*Hossin-*

<sup>62</sup> Mansfeld hoped in 1971 [302] with better knowledge of the material, a distinction of workshops will be possible. Schmidt recently contradicts that still, no workshops could be differentiated [439].



gen and *Bitz* share the same distribution area (southern Baden and Alsace) and are contemporaneous. Despite the before mentioned well-articulated distribution areas, other types like *Königsbrück* show a broad and vague distribution with no clear indication of a workshop area [222].

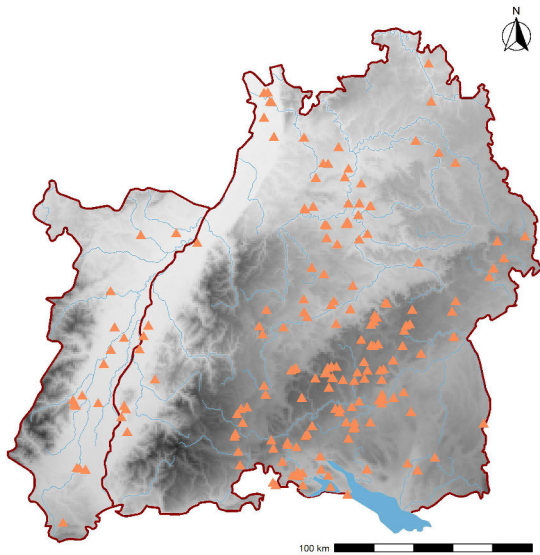


Fig. 4.16: Early Iron Age belt (B33) in Baden-Württemberg and the Alsace (data: SHKR20, DEM: SRTM 90 m).

are often severely preserved due to their small size; nevertheless, a simple system fixes most applications, categorised into three types: One common in Burgundy, Franche-Comté and Haute-Marne, the second found at Magdalenenberg (Baden-Württemberg) and a last one at Königsbrück (Hagenau, Bas-Rhin). Those metal fittings are especially characteristic of the Upper Rhine Valley in Ha D1, and this habit continues into Ha D2/3 [428]; [495].

Confusingly, belt plates of the same type belong to different stylistic groups (see [222]). That illustrates problematics using classification systems on highly individualised artefacts. Each plate is unique, although common tendencies are visible. However, these tendencies might be a common understanding, favour, fashion and technique, show an intricate pattern of interaction within one plate. This information, crucial for analysing interaction patterns, would be lost using Kilian-Dirlmeiers classification. The fractioned manner of artefact description in the SHKR database respects an artefacts individuality and shared commonalities (see tab.: A.6).

#### 4.3.4 Weaponry (B4)

In general, arming subdivides into two significant groups: defensive and offensive weaponry. Helmet, shield and other armoured protection are found relatively rarely in Early Iron Age contexts. Offensive weapons are more common, especially swords in Ha C and daggers in Ha D. Due to lacking hoards, most weaponry from the Early Iron Age originates from burial contexts as this artefact category is somewhat unusual for settlements. The decline to nearly only swords in Ha C<sup>63</sup> and daggers during Ha D and reoccurring swords again in La Tène

<sup>63</sup> In Bronze Age, hoards types of weapons and quantity vary widely.

Belt plate types differ slightly in dating, ranging from Ha D to more precisely dated types, like type *Wangen* dating to Ha D1. Moreover, it seems that style and decoration technique are already developed with the beginning of the belt plate production [222]. In Ha C, belt hooks are restricted to the area of the Swiss Plateau. In the following decades, they spread into Burgundy, Franche-Comté and along the Rhine valley. Willow-leave shaped belt hooks found along the Rhine valley connect to the Swiss Plateau and Burgundy. More to the north, in Rheinland-Pfalz and Saarland, belt hooks remain unknown. In Ha D2/3 belt, hooks are now dominantly made of iron; their preservation is therefore quite bad, which makes distinguishing and differentiating types complicated. However, belt hooks with rivets are characteristic for the Hagenau Forest, Burgund, and Franche-Comté [495]. During Ha D1, simple rings indicate a belt if they occur in a functional position within a grave. Hence, in this case, the position in a grave implies the artefact function [381].

Furthermore, decorative metal fittings on organic material like birch bark, leather or tissue are known for Early Iron Age belt assemblages. Those fittings

indicate selecting only a small part of arming for burial context. Therefore, preserving all types of arming is unlikely.

806 artefacts are recorded in section B4 as weapons in the SHKR (see tab.: A.7). This number subdivides into 160 parts of swords (including 116 swords, 44 chapes and scabbard), 182 arrowheads, 237 parts of lances (lance heads and ferrules), 120 daggers, 23 axes and 14 of defensive arming like helmet or shields — this category of artefacts source mainly from burial context, followed by settlements.

Necropolis with weapon inventory distribute unevenly throughout Baden-Württemberg and the Alsace<sup>64</sup> (fig.: 4.17) [452]. Some areas had weapons (Swabian Alb, Oberschwaben, around Tübingen and Stuttgart), others not like northern Baden, eastern Württemberg (Göppingen and Schwäbisch Gmünd) and the Black Forest<sup>65</sup>. However, the Black Forest is an unfriendly settlement area; others need further explanation. Results this pattern form different depositional habits, social structure, wealth or political organisation?

Sievers criticises the reconstruction of weaponry based on grave inventory and depictions on situla while neglecting settlement inventory like slingshots from Heuneburg. Furthermore, she criticises the supra-regional analogy, for example, by Kimmig [225] of a regional phenomenon [453]; [452]. Therefore, she analyses the habit of depositing weapons with a regional scope. In 5 areas of Baden-Württemberg (Oberschwaben, Ostalb, Zollernalb, Tübingen and Nordwürttemberg), she could demonstrate that lances are dominant in the later Early Iron Age, while daggers are rare compared to other weapons<sup>66</sup>. A combination of dagger and lance is characteristic for Swabian Alb, while on the Ostalb, many arrowheads are found. At the Magdalenenberg, a weapon bearing grave is unique by the weapon itself, not by accompanied artefacts. Usually, weapon bearing graves are outstanding in their cemeteries. These examples illustrate the diverse habits of weaponry as grave goods and differences between regions. Regardless, Sievers observes a continuity from Ha C to Ha D. A supra-regional character is visible in equipping a deceased with a status symbol (or sign of power), and not in the combination of artefacts [452]. Wamser [506] highlights the connection in burial habit between eastern France and Baden-Württemberg. In contrast, Sievers points to strong urnfield traditions visible in sword graves. Interestingly, those graves with many sword graves (for example, Burgundy) have no daggers later in Ha D [452].

Early chronological classification by Reinecke [396] used swords and daggers to differentiate Ha C from Ha D. This strict subdivision by Reinecke's *Leittypen* contradicts daggers in Ha C contexts [443] and swords in Ha D<sup>67</sup>. Daggers occur in grave assemblages not much later than Hallstatt swords, but only with missing swords, daggers are more prominent in the assemblages [494].

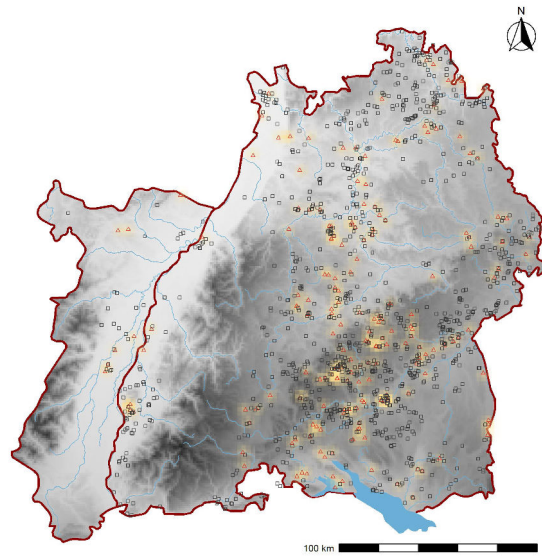


Fig. 4.17: Necropolis with weapons (red) in Baden-Württemberg and the Alsace (data: SHKR20, method: KDE (5 km), DEM: SRTM 90 m).

<sup>64</sup> Some separate weapon graves occur south of the Danube and east of Lake Konstanz [452].

<sup>65</sup> The more recent resubmission of the Salem cemetery (Baden-Württemberg) by Rauhaus [392] results in identifying a second dagger.

<sup>66</sup> A different depositional tradition is known for Switzerland, where swords and daggers occur in waterbodies [452].

<sup>67</sup> Like a late sword grave at Maegstüb (Tumulus 2 grave 3 (Bas-Rhin)), dated by other artefacts to Ha D [495].

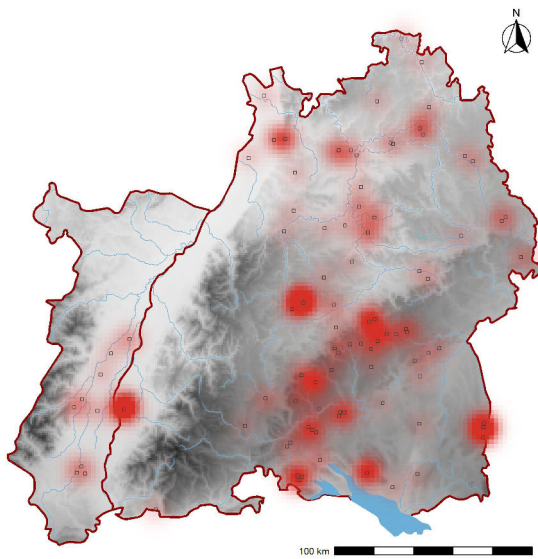


Fig. 4.18: Early Iron Age swords in Baden-Württemberg and the Alsace (data: SHKR20, method: KDE (5 km), DEM: SRTM 90 m).

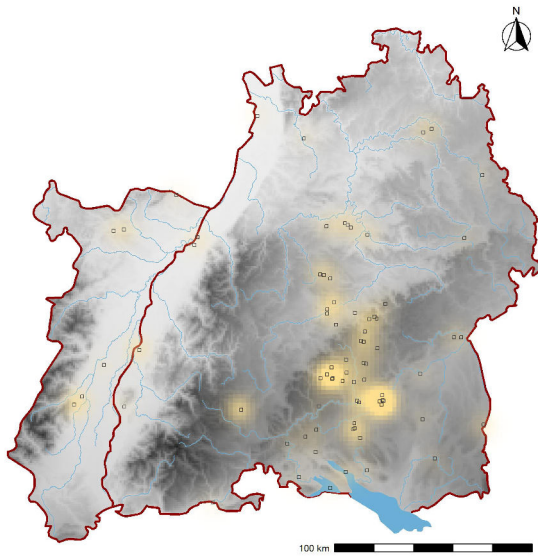


Fig. 4.19: Early Iron Age daggers in Baden-Württemberg and the Alsace (data: SHKR20, method: KDE (5 km), DEM: SRTM 90 m).

The transition from swords to daggers triggered many discussions on how to interpret these changes in burial habits. Is a more peaceful epoch responsible for the reduction of swords while trade and exchange dominated? However, this contrasts with signs of destruction in fortified hilltop settlements (like at the Heuneburg). Already early, in 1942, Rieth supposes that missing swords in Ha D graves does not indicate a reduction in feistiness [409]. Kossack estimated an increase of weapon bearing graves for southern Bavaria (increasing from 10 to 20%) in Ha D, combined with a sudden increase in lances by reducing the number of swords. According to Kossack, changes in burial habit reflect changes in combat strategy, similar to introducing the phalanx and civil army in Greece. A dagger serves as a weapon and to display power [238]. For Bavaria, Kossack states that lance bearing graves are relatively poorly equipped and interprets these individuals as simple lance bearer. For Baden-Württemberg, Sievers contradicts that lance bearing graves are not poorer equipped and points out that generalisations over more extensive areas are problematic [452].

Nellissen suggests that the sword never was out of use; only changing burial habits reduce swords in our archaeological record. Images on situla do not depict realistic combat strategies, as swords are also missing on Greek pottery <sup>68</sup>. Based on different archaeological material in northern Baden, Nellissen concludes that daggers are a sign of wealth in general [352]. Sievers points out that it seems unrealistic to suppose the exact meaning of daggers across the western Early Iron Age due to its heterogeneous character. Nevertheless, a character as a sign of dignity for daggers based on richer equipped graves seems likely [452].

The reduced frequency of slingshots (B44) onwards to defensive arming (B49) might not reflect realistic combat strategies or warrior equipment (see above); more likely, a depositional behaviour is visible. Due to their low frequency and often bad preservation, no description of slingshots, mace, and defensive arming follow. However, a few interesting remarks on axes are possible. Simultaneous to the drop in the frequency of hoards, the amount of axes declines in Ha C drastically [495]. In Ha C, the dominant type is socket axes with round or quadratic sockets. Axes of type *Ärmchenbeil* are standard during the

<sup>68</sup> Sievers adds that defensive weapons are only depicted on situla in western Hallstatt area [452].

Urnfield period and occur in the Early Iron Age. They are sometimes associated with *Mindelheim* swords [359]. In Ha D some socket axes made of iron replicate a winged axe (*Lappenbeil*) [370]; [495]. Later, in Ha D2/3, axes occur in princely graves, probably in symbolic meaning like in Gieshübel, Hundersingen or Hochdorf [374]; [382]; [57].

#### 4.3.4.1 Hallstatt Swords (B41)

As mentioned above, swords are considered to be typical of Ha C dating. However, the continuous development of sword types from the late Bronze Age onwards highlights continuous cultural development. Nevertheless, swords are familiar during Ha C and much less common during Ha D. This circumstance might be caused by changing burial practises. Swords as grave goods reflect instead a symbolic meaning than militant character, as no other weapons, shield or helmets are common in Ha C graves [145]. This symbol might have changed into a dagger in Ha D, or a dagger might transport a different meaning. Regardless, missing swords in grave context do not mean that swords are out of use during Ha D. Indeed, some rare cases of Ha D dating are known (Maegstüb, Bas-Rhin and Polling-Etting, Bavaria) [494].

Sword bearing graves are usually the primary burial in a burial mound; only occasionally are secondary burials in much older burial mounds. A common practice across the distribution of sword graves (see below) is the deposition of ceramic vessels. All other artefacts vary in regional dependencies, like daggers, other weapons, wagon, harness, ring jewellery, pins or fibula. Pare names 600 swords found in grave context and 50 found under other circumstances [365]<sup>69</sup>.

Early Iron Age swords are composed of a sword blade, handle plates mostly of organic matter (wood, bone, horn), and sometimes a knob (*Griffknauf*). Often a scabbard is associated with swords, mostly made of organic material (wood) and sword chape. In general, sword chape as part of swords are neither separated from swords in the SHKR<sup>70</sup> database nor this chapter.

Reinecke differentiates two series of sword types: type *Gündligen* and type *Mindelheim*. Both of them are manufactured in bronze and iron and are so-called *Griffzungenschwerver* (flange hilted swords). A third type is defined by Corot, type *Magny Lambert* which is distributed in eastern France and a typological development of type *Gündligen* [66]. Differences between blade lengths are one noticeable difference. Swords of type *Gündligen* are 10 cm shorter on average. Schauer [429] subdivided type *Gündligen* into 5 stages, based on sword handle, chape and length of blade. The pommel tang, the blunt trapezoidal point, and the shoulders of the hilt are characteristic for type *Mindelheim* [359]. He subdivides type *Mindelheim* into two series with five stages each. *Mindelheim* series 1 has wide blades which have a larger middle ridge towards the handle, while several engraved lines at the middle ridge characterise series 2<sup>71</sup>. In Ha C1 to C2 more regionally restricted types develop like type *Magny Lambert* [365]. For typological classification of iron swords, the preservation is very problematic, which is evident regarding 300 unprecise classified swords [365]. In those cases where preservation is good enough, they show many similarities to bronze swords and, in general, their common relationship/origin [82].

Generally, fewer chapes are known than swords, often explained with wrapping the sword in textile or scabbards made entirely of organic matter. Chapes are made of bronze<sup>72</sup> [145]. Kossack [238] subdivides chapes

<sup>69</sup> Gerdson counted 45 swords (of 567 as mostly found in grave context) not found in grave context until 1976. Of those were 36 deposited in water, mainly in the periphery of so-called sword-graves, only six are found in hoards, and three in late Celtic settlements [145].

<sup>70</sup> The class B41 refers to swords in general (see tab.: A.7), B411 sword, B412 chape B413 scabbard. Swords can be differentiated by types in class B4111 (type *Gündlingen*) to B4114 (type *iron Hallstatt sword*). Chape is similarly differentiated by phenotypes and then into types known by literature.

<sup>71</sup> So-called Hallstatt swords mostly refer to swords with insufficient classification due to preservation.

<sup>72</sup> Gerdson mentions one chape made of iron [145].

into two groups based on phenotypes of wings (A: stretched wings, B: rolled wings). Later, Schauer <sup>73</sup> assigned types with site names but used mainly Kossacks classification [429]. Types *Prüllsbirkig* and *Neuhaus* are always associated with bronze swords, types *Dottingen*, *Büchenbach* and *Frankfurt-Stadtwald* are mostly associated with bronze swords. The proportion is more or less equal for type *Beratzhausen* and shifts towards iron swords for types *Oberwaldbehrungen* and *Freihausen* [145].

The spatial distribution of swords covers mainly the distribution of other Ha C artefacts with some dominant regions (see fig.: 4.20), however in no distinct spatial pattern: From Bohemia in the East crossing south Germany and eastern France until central France as the maximal western extend, Belgium in the North and southern France in the South. The habit of placing a sword in a grave counts as one common feature of the Early Iron Age: a unique expression of a social group shared over a broader area. The definition of a consistently social position of these people throughout the entire area neglects dominant regional variations. Therefore, the social position must be evaluated regionally in respect of local burial habits. It states a somehow common understanding of this symbol - a sword - placed next to the deceased. Additionally, due to chronological effects, duration of a necropolis, burial habits or social structure, frequencies of sword-bearing graves within a necropolis vary regionally [145].

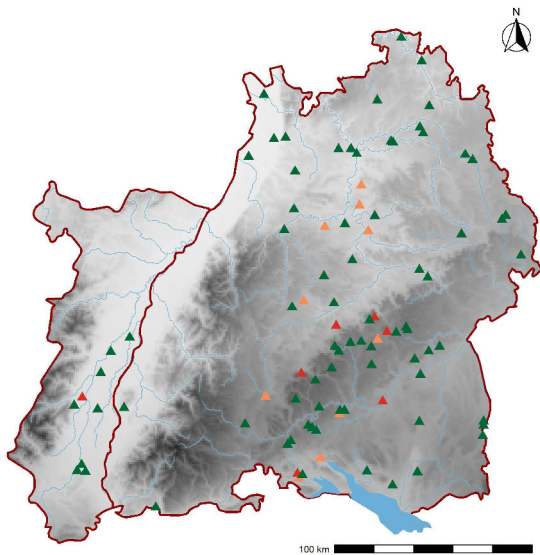


Fig. 4.20: Distribution of swords (n=116) and chapes (n=44) in Baden-Württemberg and the Alsace (green: sword, red: chape, orange: scabbard, data: SHKR20, DEM: SRTM 90 m).

Sword chapes are found mainly eastwards of the Rhine with a core area in Bavaria. Types *Prüllsbirkig*, *Neuhaus*, *Büchenbach* and *Frankfurt-Stadtwald* distribute more or less equally across the sword grave distribution, while types *Oberwaldbehrungen* and *Freihausen* are found mainly east of the Rhine. Besides their impotence for chronological questions in Ha C, an interesting spatial distribution shows two main zones: One in Burgundy and Franche-Comté, characterized by types *Beratzhausen*, *Büdenbach*, *Prüllsbirkig* and *Neuhaus*, and a second in southern Hesse and northern Baden with types *Frankfurt-Stadtwald*, *Oberwaldbehrungen* and *Dottingen* [495]. Concerning central Europe, iron swords have three main distribution areas: Burgundy and Franche-Comté, Hesse and Upper Danube [31].

When dating an assemblage containing a sword, a temporal shift may occur between the sword and other artefacts. A sword most probably is in use for a lifetime; hence, it may appear older than later acquired personal items. Beginning in Ha B, swords of type *Gündlingen* started their development and continued to be used and produced during Ha C. No temporal partition between both types occur. Trachsel [494] estimates 100 years for the complete duration of production and typological changes of type *Günd-*

*lingen*. Stage 2 can be dated to Ha C, and type *Gündlingen* stops before 750 BC. Production and use of types *Gündlingen* stage 4-5 and *Mindelheim* stages 1-2 are contemporary. The duration of production and typological changes of type *Mindelheim* lasts 150 years and begins in Ha C2 around 675 BC. Oldest types are found in Bavaria, as a typological development of type *Gündlingen* stage 3 [494]. Chapes begin in Ha B with wings pointing to the top, to the side, pointing down and finally are rolled up in Ha C [429].

<sup>73</sup> In 1989 Hein established a more nuanced typological sequence for chapes, which is incorporated in the SHKR database classification [176].

Early Iron Age swords registered in the SHKR database in Baden-Württemberg and the Alsace are overall 116 (see fig. 4.20). The 44 chapes found in the AI are recorded based on the classification by Hein [176].

#### 4.3.4.2 Lances and Arrows (B42)

Bow and arrow are precisely produced tools needing specific physical properties to achieve accuracy and penetrating power. Every archer needs an individualised bow fitting individual physical properties. Furthermore, the shape of arrowheads, the length and diameter of the shaft define the distance and function of an arrow. A reconstruction of use and intention - as a weapon or for hunting - is theoretically possible with sufficient preservation [95].

Eckhardt [95] divides arrows into ten basic ten types, mostly iron, and adds special types of organic matter. Base type 1-5 have a broad or narrow tang, sockets and leaf-shaped arrowheads. Base type 6-10 summarises Scythian arrowheads, hence eastern types. Further on, Eckhardt differentiates several variants having deviating shapes of blades, like leaf-shaped or with a barbed hook. A typological development of the western base types (1 to 5) decelerates over a longer period. The existing types are sufficient for the intended use - hunting, and serve the purpose for combat [95]. As Eckhardt suggests, development is unnecessary. Following the types defined by Eckhardt [95], 183 arrowheads subdivided into six types (B4221 to B4226), besides quiver (B4227) are recorded in the SHKR database. A detailed differentiation in *Grundtyp 1* to *Grundtyp 10* is possible in a next level of classification (fig.: 4.21). Ethnological comparisons and experiments help to differentiate between hunting tool and weapon. In case of danger, a hunting weapon will most certainly be used as a weapon likewise; however, preferring specific properties in each case. The vital properties of an arrowhead for hunting are a deep cut resulting in high loss of blood. Additionally, barbed hooks prevent an animal from stripping off the arrow. Arrowheads used as a weapon need a high penetration power; therefore, tower-like shapes or three-bladed shapes are most efficient. According to Eckhardt, at the Heuneburg<sup>74</sup>, arrows were used as weapons, while most western arrowheads were better suited for hunting with a wide blade and sometimes barbed hooks [95]. Krauß-Steinberger [256] highlights the continuity from Urnfield culture to the Early Iron Age in selecting arrowheads and quivers. Only the quiver found in Hohenmichele fulfils military needs with high arrow capacity and easily extractable arrows based on the box-shaped quiver. Other quivers in Early Iron Age graves contain no more than 20 arrows and are simply tube-shaped. Furthermore, the selection of conservative arrowhead shapes, thin leaf-shaped arrowheads, instead of arrowheads for military use, indicate equipment of the deceased with a weapon for hunting. Krauß-Steinberger interprets hunting weapons as showing a higher social status [256]. Sievers [453] understand arrows in grave context as a sign of power than

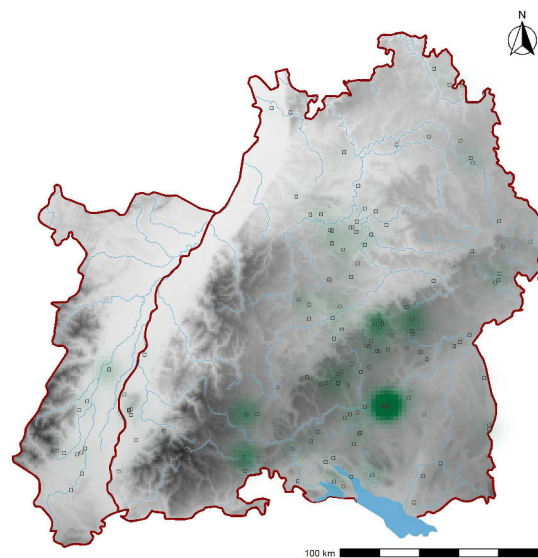


Fig. 4.21: Early Iron Age arrows and lance heads in Baden-Württemberg and the Alsace (n = 425, data: SHKR20, method: KDE (5 km), DEM: SRTM 90 m).

<sup>74</sup> Some bronze and bone arrowheads occur at the Heuneburg. Three-bladed arrowheads, the Scythian type, also known from settlements in eastern France [495], may indicate Scythian activities, direct Mediterranean contact [225] or, however, long-distance interaction.

a weapon, depicting a hunting tradition of nobility. However, these interpretations do not explain arrowheads in poorly equipped graves.

In combination with arrows, quiver occur as grave goods during the Early Iron Age [95]. Made mainly of organic material, wood, leather, textile or bark, only occasionally quivers outlast like at Villingen, Hochdorf or Mont Lassois [57]; [33].

In contrast, the use of lances seems univocal. However, a lance head is either used as a spear (javelin) or lance. Kossack, Kimmig and Frey [238]; [225] understand lance heads as a lance, which are only helpful in combat formations like a phalanx proven by the depiction on situla. The length of the shaft defines the balance point, which defines the use as spear or lance. A lance should not be too heavy at the top in contrast to a spear. The range and variety of shapes and proportions in lance heads point to the use as an all-purpose weapon with no clear standardisation [452]. Rieth [409] defines four groups based on shape and proportion of lance heads: long and slim, long and broad, lozenge shapes, small. More recently, Sievers [452] differentiates long-slim and short-brads lance heads in Baden-Württemberg. Although, she doubts the usefulness of such a classification [452]. Since lance heads are made of iron <sup>75</sup>, which is unfavourable for their preservation, a more detailed typology is not obtainable [495]. Most likely to be preserved of a lance are lance heads (B4211) and ferrules (B4212). Their shape can differentiate lance heads into three types: stepped, long and narrow or asymmetrical (see fig.: 4.21).

During Ha C, arrowheads occur in graves more often than lance heads, although decreasing arrows indicate a change. Arrows occur in richly equipped dagger-bearing graves and simple graves, mainly in northern Baden-Württemberg and at the Ostalb. Here, often the arrow is the supposedly only weapon in a grave [256]. Reducing numbers of arrows and increasing numbers of lance heads intensify the impression of a changed combat strategy [95]. The preference of lances as arming begins with Ha D and is very popular at the Upper Rhine Valley, Rhine-Main region and Hunsrück-Eifel area; however, few cases of lances dating to Ha C <sup>76</sup> [495]. Similar to Ha D 1, during Ha D2/3 lance heads occur dominantly in the Hunsrück-Eifel Culture [161] spreading along the Rhine Valley and slightly more frequent on Swiss plateau [495].

#### 4.3.4.3 Hallstatt Daggers (B43)

As mentioned already above, daggers are characteristic of Ha D but not strictly. Hence, daggers occur in late Ha C or early Ha D in graves northern the Alps. Until the 1880's archaeologists erred in dating them to the Roman period, only Tischler and later Reinecke separated daggers and swords chronologically, giving crucial directions for forthcoming researchers [485]; [396]. Déchelette divided daggers by shape of the antenna and pommel [74], but unfortunately mixed regions and epochs [452]. Rieth expands Déchelette's division and defined five groups [409], which are still in use <sup>77</sup> [452]. Zürn and Kossack try to date daggers more precisely in Hallstatt D [531]; [238]. More recently, Sievers sorted middle European Early Iron Age daggers by technological aspects. A pheno-typological classification fails due to the highly individual daggers [452].

Early in research history, Lindenschmit [283] and Déchelette [74] suppose a connection of antenna hilted swords of the Urnfield culture and Etruscan swords as origins for Early Iron Age daggers. Reinecke [396] and Rieth [409], in contrary, strengthen a north alpine development of daggers. Sievers differentiates two sources for daggers and dagger-knives (see below for differentiation of thrusting), those of one-bladed knives and two-bladed swords, however in Ha D, both types merge into daggers and dagger-knives. She suggests a regional development of daggers originating in Urnfield tradition and influenced by southern contacts, while Switzerland serves as a communicator. During Ha D1, in southern Germany, daggers begin to occur in graves, while antenna hilted swords are rare and transitional antenna hilted weapons to enforce the impression of a typological development [452].

<sup>75</sup> In the Hunsrück-Eifel culture, some rare examples of lance heads made of bronze exist [161].

<sup>76</sup> Like the uncertain hoard of Mulhouse (Haute-Rhin, France) with a bronze lancehead [495].

<sup>77</sup> Only the typological dependency of iron from bronze daggers is outdated by now [452].

During the Early Iron Age, daggers occur mainly in a grave inventory of mostly male inhumation. As mentioned above, they are positioned centrally on the body, indicating a personal item [452]. There are no daily use items, although multi-purpose objects in between weapon and tool [393], daggers rarely belong to settlement assemblages<sup>78</sup>. Outside Baden-Württemberg and the Alsace, daggers occasionally occur in rivers in Switzerland, and along the banks of the Saône (France) [452]. Besides grave good, a depiction on a stele as a funerary marker, like *warrior of Hirschlanden* shows an Early Iron Age dagger [533].

The highly individual character of daggers, their low frequency and compositional construction complicates the definition of types. Therefore, Sievers uses technological aspects combined with broad typological tendencies to define types. Type names are descriptive, instead of using site location, as one dagger usually is not suited to be exemplary for one type; site locations name only variants of daggers [452]. Furthermore, the reconstruction of a workshop area or definition of workshop traditions is impossible based on the present data. Several contemporaneous dagger types are characteristic of Early Iron Age daggers [452]. Additionally, daggers have to be differentiated from short swords, dagger-knives and so-called *Hiebmesser*. Rieth supposes a differentiation by length and one- or two-bladed weapons between sword, dagger and all types in-between [409]. As no exact step occurs in a histogram, Sievers correctly states that the objects themselves do not give this differentiation. Using the length and width to differentiate these artefact classes is strictly biased by preservation and conservation [341]. Kimmig suggests to differ daggers and dagger-knives according to one or two blades, and connects dagger-knives to hunt and therefore, as a knife, not a weapon [225]. Sievers points out that dagger-knives are typologically and based on their construction closer to daggers than to regular knives, and in graves, dagger-knives show similar characteristics as a sign of power. Furthermore, the position in a grave indicates personal belonging, as dagger-knives lay next to the deceased and not next to the food like *Hiebmesser* [452]. The discussion of how to classify sword, dagger and other knives illustrates a method-inherent bias: how to classify if no classes have existed or if the classifying features remain unknown? Regardless, Sievers points out that all these weapons are thrusting [452]; and differentiation by types seems highly artificial.

Two types of iron weapons (with cylindrical handle or compositional handle, bronze antenna hilted weapons (like type *Hallstatt*<sup>79</sup>), and iron daggers with spindle-like handle) belong to a first larger group, sometimes with an early dating to late Ha C. Daggers of type *iron antenna hilted weapons with cylindrical handle* occur in eastern France and Switzerland in Ha D1. *iron antenna hilted weapons with compositional handle* mainly distributed in Bavaria and Upper Italy demonstrate southern influences as in Italy an early Ha C2 dating is possible. Iron dagger with spindle-like handle and shortened antenna (including variant *Mauenheim* and *Magdalenenberg*) have a western distribution with a centre in Baden-Württemberg. The type of *iron daggers and dagger knives with wrapped pommel* has two variants: *Etting*, which dates to Ha D 1 and 2 and occurs mainly in Baden-Württemberg, and *Estavayer-Le-Lac*, which dates to Ha D1 and spreads from the Alsace across to Bohemia, interestingly in Baden-Württemberg only southern the Danube. The construction of the handle allows several variants of *daggers and dagger-knives with bronze wire wrapped scabbard* type: variant *Neuenegg* are mostly dagger-knives with the main distribution in upper Italy, but also in Switzerland and rarely in Baden-Württemberg; variant *Hoffenheim* with a northern distribution mainly northern Baden-Württemberg and Alsace; variant *Sulz* summarises only daggers found in Baden-Württemberg and Bavaria; and variant *Obermodern* distributed in the Alsace, Upper Rhine Valley and western Württemberg. The type of *bronze daggers and dagger-knives with developed pommel and scabbard* are challenging to subdivide due to their rich decoration and various combinations. Variant *Ludwigsburg* dates to Hallstatt D2 and D3 and occurs mainly in Baden-Württemberg. Those individuals found in Bavaria and Hallstatt (Austria) indeed depend on those in Baden-Württemberg. The variant *Aichach* dates similar and occurs mainly around the probable production site Heuneburg [452].

Often typology and chronology are connected, and problems defining a type usually have substantial implications on these objects' dating. In those cases, other contemporaneous artefacts serve for dating. This method works fine for closed assemblages as in graves; however, depositional habits during Ha D complicates the case

<sup>78</sup> Sievers lists daggers from the Heuneburg and Mont Lassois, and two possible daggers from Dürnberg [452].

<sup>79</sup> One dagger from Eugisheim (Haut-Rhin, France) belongs to type *Hallstatt*. Unfortunately, the context of this artefact is unclear [495].



of daggers. They dominantly occur in supposedly male graves, which are often outstanding in their equipment, but precisely dated types, often jewellery, occur dominantly in rich female burials [452]; [494].

Sievers shows that daggers do not evenly spread across the western Early Iron Age, indicating a general understanding or need for being equipped with a dagger. In Baden-Württemberg, the concentration of daggers alternates with areas of no daggers and without weaponry in a grave context. Those areas with daggers are at the Swabian Alb, the Hegau, around Tübingen and Stuttgart and less often between Danube and lake Constance (see fig.: 4.19). Similar alternating patterns occur in Bavaria and Austria. In France daggers occur in Haguenauer Forest (Bas-Rhin), French Jura and along the river Saône. In the northern periphery, fewer weapons are deposited in graves [452].

Although daggers are fascinating artefacts, their individualized character combined with a low frequency of finds restricts possible obtainable knowledge drastically. Therefore, only the dagger (n = 120) is recorded in the SHKR, besides possible decoration, as the shape does not inherent regional differentiation.

### 4.3.5 Means of Transportation (B5)

Means of transportation are crucial for trade, exchange, or an expression of social status and everyday tasks like moving goods and people to the next village. By what means of transportation a destination is reached bears information on the relationship between origin and destination. Does the interaction occur on a regular, perhaps daily basis or rather a once in a lifetime event? Do economic or political reasons initiate a trip? These are some central question concerning the means of transportation for a study on infrastructure and interaction. It is necessary to separate artefacts linked to transportation from those artefacts, which location indicates travel (like small finds at river banks [294] or imports in settlements). Therefore, this chapter deals with parts of wagon, horses, horse-gear and boats<sup>80</sup>.

In 1860 Lindenschmit recognised wagons in Early Iron Age graves<sup>81</sup> and published the first survey of wagon-graves, including nine in Germany and five in Switzerland. The collection of French wagon-graves by Déchelette [72] and the reconstruction of the wagon from Ohnenheim (Bas-Rhin) by Forrer [128] are other essential moments for the research history. Undoubtedly, the collection of 228 wagon graves and the typological definition of wagon types by Pare are crucial for the current data collection and study<sup>82</sup> [360]. More recently, after restoration, Tremblay-Cormier identified spherical elements from grave 6, Tumulus 4 at Maegstub (Haut-Rhin, France) comparable to those found at Hochdorf [233]. Therefore, this grave can be assigned to wagon graves, and prestige graves in general [495].

Hallstatt (Early Iron Age) characteristic four-wheeled wagons occur in graves, so-called wagon-graves northern the Alps with concentrations in southern Germany and along the Danube (see fig.: 4.22) [360]. During Ha C, the wagon-grave rite begins north of the Alps, possibly originating from the Middle Danube region. Not only evident in types of Ha C harness, by a new horse race and new method of wagon construction. Kossack suggests that during Ha C, the higher social status of an individual is expressed via wagon burial, while this rite changes in Ha D, when quantity and quality of grave good represent the social status [238]; [239]; [240]. Pare points out that historical or quasi-historical sources in ancient literature strongly influence many interpretations of a wagon in graves. Déchelette [72] and Forrer [128] seem to be influenced by Roman literature and depictions when reconstructed wagon from Ohnenheim as a throne bearing wagon. The Iliad may serve as source material for the interpretation of the wagon as a funerary hearse. Moreover, G. Rieck and L. Wamser doubt whether the wagons were steerable, therefore produced only for the burial (after Pare [360]). Schauer, in contrast, suggests that the

<sup>80</sup> Pedestrian leaves very few traces. Perhaps shoe nails from Roman soldiers (*caligae*) might fall into this category. Or so-called *Stäbchenanhänger* interpreted as shoelace [157]; [32].

<sup>81</sup> Early excavators misinterpreted iron tyres as rims of wooden shields ([514] at site Leberberg, Bavaria).

<sup>82</sup> Parts of the wagon recorded in SHKR Database in section B (shape) divided into the wheel, box and yoke. Section E (type by literature) records defined types according to Pare [360] and is used to generate maps in this chapter.

wagon is involved in the transport of the corpse [430]. However, broken parts of wagons at the Heuneburg prove the regular use daily [453]. The provision of a wagon in a grave was part of a special burial rite in Early Iron Age Central Europe, limited to a particular social group. These graves stand out almost always in their cemetery and their rich grave goods or elaborate construction. Associated goods give little information on the role of the wagon itself. The wagon was fully functional, but neither was it designed for speed nor heavy transport. The very elaborate decoration of the wagon box or naves, underlining the importance and the prestigious role the wagon took within the burial rite. Nevertheless, it is without a doubt that the Early Iron Age four-wheeled wagon is no pure funerary hearse or that they have been produced deliberately for the burial. These vehicles are constructed and fitted for travel and transport over long distances [360].

The characteristic construction of a four-wheeled wagon again emphasises the connection to the previous Urnfield culture. However, advanced technologies from central Italy are adopted, although developed for two-wheeled chariots [360]. A wagon is a complex compositional construction of wooden parts and metal fittings, like tyre, nails, felloe clamps, nave, spoke fitting, axel claps and often decorative wagon-box fittings. Naturally, most wooden elements do not preserve; in some cases, the wood grain or kind of wood survived imprinted with iron oxide. Iron tyres are an innovation in Early Iron Age Central Europe, also influencing the felloe construction. With iron tyres, doubled layered felloe, like type *Großeibstadt* allowing replacement of outer wooden layer [97], become obsolete. Iron tyres were fixed with nails, defined by shape and position to the surface of the tyre. The wide variety of naves often provided with bronze or iron fittings suggests that this part was critical for the vehicle's functioning and required constant development. Therefore, naves are very interesting from a typo-chronological perspective and allow recognising regional workshops. In contrast, box-fittings serve a more decorative purpose. Nevertheless, they also allow the recognition of workshops and regional preferences [360].

Pare defines wagon types as a recurrent association of wagon fittings, which results in a combination table and seven wagon types [360]: The wagon from grave Hexenbergle, Wehringen (Bavaria) represents the only example of wagon type 1. This grave has to be dated very early in the Early Iron Age, as a transmission between Urnfield and the Early Iron Age, evident by parallels of nave fittings to those from Bad Homburg group. Open worked bronze plaques, nailed circular or squared frames, nailed wheeled-shaped ornaments and nails with triangular heads represent box fitting type ii; and are characteristic for wagon type 2, which distributes across Bavaria and the Swabian Alb with some outliers in Austria. Only nave type *Breitenbronn*, besides nave-head rings characteristic for wagon type 3, allow the recognition of individual workshops or workshop groups. This wagon type has a broad distribution covering southern Germany and central Bohemia, while nave type *Breitenbronn* is mainly restricted to Bavaria. According to Pare, wagon type 3 has foreign technological influence, which can be traced back to Etruscan Italy, especially evident for nave type *Breitenbronn* [360].

Wagon type 2 and 3 are both contemptuous and overlap in their distribution. Their representation does not indicate a deviating function in grave context; therefore, Pare suggests that wagon type 2 represents local wagon making tradition while type 3 shows foreign influences and novel furnishings [360]. A more western distribution

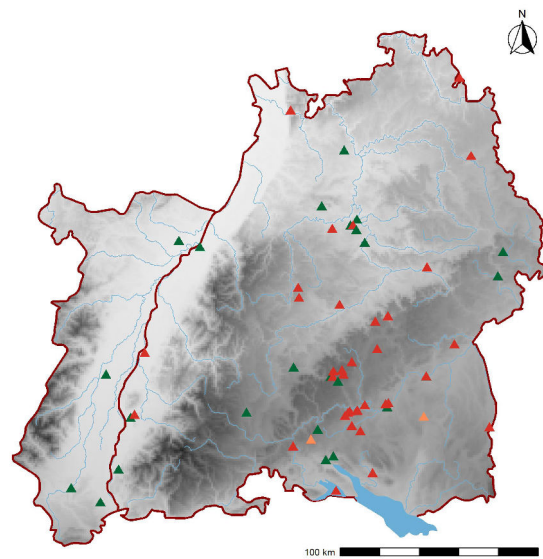


Fig. 4.22: Early Iron Age means of transportation (green: horse, red: wagon, orange: boat, data: SHKR20, method: KDE (5 km), DEM: SRTM 90 m).

has wagon type 4 with distinct box-fitting type iii and nave type *Ins* in Switzerland, France and Netherlands. Wagon type 4 has apparent links to the south, shown by naves of type *Ins*, reaching central Italy<sup>83</sup>. Excluding an import of type 4 from Italy, Pare suggests imitation of Italic fashion and technology. Therefore, new wagon-making workshops occur in later Ha C in Upper Rhine valley and eastern Switzerland, producing wagon type 4. Nave-heads with conical nave-necks, nave-heads type *Erkenbrechtsweiler* or *Emerkingen* are typical for wagon type 5. Box-fitting type iv seems to be exclusive for this wagon type.

Wagon type 5 concentrates on Swabian Alb and has outliers in Lorraine and Bohemia, Upper Bavaria and Upper Rhine (Hügelsheim and Kappel-Grafenhausen). The new popularity of wagon burials on Swabian Alb during Ha D1, dominantly wagon type 5, indicates local production. With wagon type 6, four distinct nave types subdivide nave type *Repperndorf* which distributes in the Main area, nave type *Grandvillar* found in western Switzerland, eastern France and northern Baden-Württemberg, nave type *Kicklingen* concentrated in Bavaria and nave type *simple iron nave*. Nave type *Cannstatt*, tyres type VII and box-fitting type v characterise wagon type 7. This wagon type occurs in Rheinland-Pfalz, Burgundy, Switzerland, Baden-Württemberg and Bavaria. Various types and variants of fittings of wagon types 6 and 7 indicate the existence of several workshops. For wagon type 7, two possible workshops could be visible in local concentrations around Heuneburg and Hohenasperg [360].

As mentioned above, a wagon is a complex compositional construction combining different kind of wood and metal fittings. Pare assumes the existence of specialised workshops combining the skills of several craftsmen. Not alone for wood selection and storage, wagon-making workshops must have been sedentary [360]. Schiek supports this; he points out that wandering craftsmen would have had difficulties finding enough consumers as the ceremonial wagon is not needed in large quantities [432]. If those workshops are sedentary, wheelwright craftsmen and associated bronze and ironsmiths needed to be supported by their community; therefore, by a community with a relatively high level of social differentiation [360].

Horse-bits in Ha C are primarily of iron; their preservation and typological differentiation are in some cases difficult [359]. Pare differentiated seven types of two linked forms A to F: simple, straight shanks, shanks with plaited thongs, shanks are loosely twisted, shanks are tightly twisted, shanks angular in cross-section, and shanks are round in cross-section and decorated with an engraved herring-bone pattern. Types A and B are often associated with swords type *Gündlingen* and have a broad distribution. Pare suggests chronological reasons for the association of types A and B associated with *Gündlingen* swords instead of regional workshops, because types A to C are similar to Urnfield examples types D and E are found in wagon-graves [359].

As already mentioned in 1.4, wagon and horse-gear typologically developed from Urnfield culture onwards and is often used in chronological comparisons [494]. Using wagon types defined by Pare, the following order outlines the chronological progression: Wagon type 2 to 4 are typical for Ha C, type 5 and 6 occur in Ha D1, while type 6 continues together with type 7 into Ha D2/3. In later Ha C, the habit of wagon-graves arrives at the Rhine valley, Switzerland and the Netherlands. The traditional funeral depositing of a wagon continues during Ha D1 in southern Württemberg and along the Danube Valley. While the habit of wagon-graves spreads westwards, those are lacking in Ha D2/3 in old wagon-grave centres like on the Swabian Alb or in Bohemia and Oberpfalz. Pare explains this change with an increase of exclusivity of wagon graves. This widespread habit of wagon-graves or the deposition of a *pars par toto* of linchpins or paired horses during Ha C seems not restricted to a small social group. With the beginning of Ha D, *pars par toto* of wagon-graves vanish and in later Ha D wagon-burials are relatively rare [360].

Wagon and horses are the dominant evidence of means of transportation (322 parts of wagons and 204 horses or harness recorded in the SHKR database), followed by seven artefacts indicating the use of boats. Parts of the wagon can be recorded in SHKR divided by their component: wheel (B5111 to B5115, further divided into 2/or 4 wheeled, tyres, nail, felloe and naves), box and box fittings (B5121 to B5124), joke and accessories (B5131 to B5134) (see tab.: A.8).

<sup>83</sup> Pare points out that direct contact between craftsmen is highly possible [360].

### 4.3.6 Tools (B6)

Besides clothing, items for body care, grooming and objects used for everyday activities or habitual practices belong to personal items. Knives, grindstones, razors and toiletry (tweezers, nail cutter and ear spoons) assumedly belong to a male toolset, as occurring dominantly in male burials. The already mentioned changes in depositional behaviour from the late Bronze Age also reduces the number of tools in the archaeological assemblage [495]. In general, during Ha D2/D3, tools made of iron have a peak in frequency due to the many objects found at fortified hilltop sites [88]. During the Early Iron Age, settlement sites reveal most tools, while funeral contexts are traditionally underrepresented. However, Tremblay-Cormier describes a wider variety of artefacts compared to Ha B2/3 [495].

Tools can either be classified by material, presumed usage, or the material they rework, like metalworking, wood or ceramic [410]. The low degree of specialisation of craftsmen, as Modarressi-Tehrani [320] shows, make a classification based on specifics of production less suited. Probably, most tools are used for several purposes. The following section summarises tools (n = 1,280 of 49,936 artefacts in SHKR20) in categories of presumed usage like knives (n = 171), which include razors (for details see chap.: 4.3.6.1), toiletry artefacts (n = 102), instruments for barbecue, heavy tools (n = 147) like drill, saw, anvil and hammer, textile production (n = 433), small tools (n = 203) and tools for agriculture (n = 201), like milestone, sickle or plough (see tab.: A.9).

Besides bronze (n = 261) or iron (n = 266), tools can also be made of bone or antler (n = 29), like a bone awl, stamps of antlers for metalworking or pottery production. Tablet weaving utilises open-worked antler discs. Several semi-finished products and part of antler at the Heuneburg indicate the production of bone and antler. Undoubtedly, one has to conclude that this was more widespread also in other smaller settlements. Another raw material for tools is ceramic (n = 417), mainly used for loom weights and spindle whorls, and stone (n = 244) — not only as grindstones [453].

Kurzynski [268] describes a blooming of textile production during the Early Iron Age, with the introduction of new variants of weave and patterns and documents also tablet weaving. Tools for textile production, such as loom weight, spools, sewing needles and spindle whorls, occasionally occur in burial contexts [393]. Besides loom weights and spindle whorls, tools for textile production that most likely preserve, rare cases of sewing needles occur as semi-finished products at the Heuneburg [453] and a bronze needle in the settlements at Strasbourg-Koenigshofen [495].

The function of a knife ranges from cutting tool, a hunting weapon, carving knife, weapon to a sacrificial knife. Pauli concludes that knives found in graves mostly belong to beverages; therefore, in their function as a carving knife [374]. Regardless, one has to assume that knives serve as multipurpose tools [13]; [341]. So-called *Hiebmesser* describe a type of knife with at least 30cm long and 5cm high blade. Often, associated in burial context with animal bones, which indicate the usage as a cutting or boning knife. However, Sievers does not exclude the use as weapon [452] (see above for a discussion on differentiating dagger and knives 4.3.4.3).

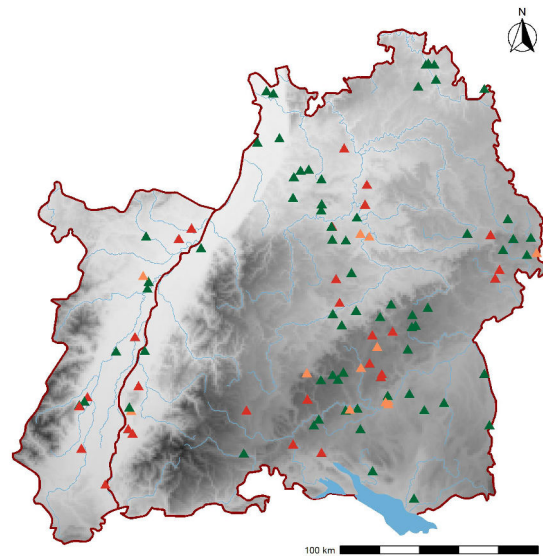


Fig. 4.23: Early Iron Age knives in Baden-Württemberg and the Alsace (green: knife, red: razor, orange: *Hiebmesser*, data: SHKR20, method: KDE (5 km), DEM: SRTM 90 m).

With the beginning of Ha C, knives occur in burial contexts in the Rhine-Main region, Saarland, Upper Rhine Valley, along the Danube from southern Baden-Württemberg to Bavaria and on the Swiss plateau (fig.: 4.23). The distribution of iron knives spreads towards the Hunsrück-Eifel culture [195]; [208] and into France Comté [495]. Knives with languets are made of iron, with a rare exception of a bronze knife at Hoenheim (Bas-Rhin, France), which originates from a cremation grave. Some *Hiebmesser* complement the collection showing no preferable geographic distribution in Ha D2/3 [495].

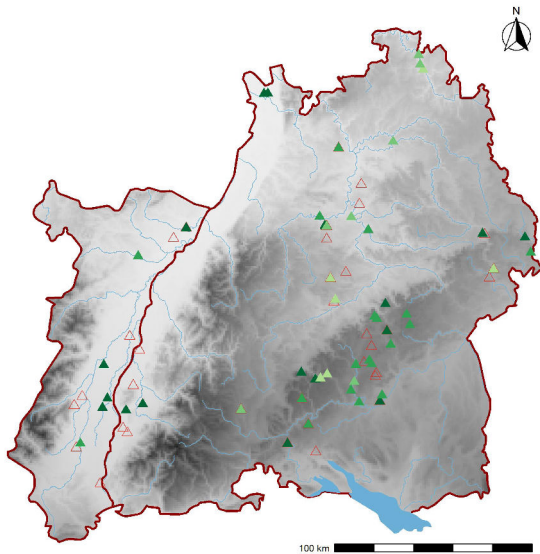


Fig. 4.24: Early Iron Age toiletry (dark green: toiletory, green: tweezers, mid green: nail clip, light green: scoop, yellow: etui, red: razors, data: SHKR20, method: KDE (5 km), DEM: SRTM 90 m).

Knives are made mostly of iron, therefore, poorly preserved. In combination with the heterogeneity of this artefact, defining group types is complicated. Nakoinz states that for the Hunsrück-Eifel culture, only one-third show enough details for a typological definition [341].

Equipment for personal hygiene, like razors or metal toiletry tools, assumedly complete with organic consumables, like oil in miniature vessels [341]. Razors and tweezers show a different distribution during Ha C; however, they may indicate the same use: controlling hair-growth [398]. Razors occur in France, while tweezers are more common in Baden-Württemberg. During Ha C, tweezers and toiletry artefacts occur in the Rhine-Main region and Rheinland-Pfalz. Later, this partial separation between these artefacts becomes blurred and indistinct [495]. Only a few artefacts of type toiletry occur during Ha D2/3, both at funeral context or in settlements (for example Wolfgantzen (Haut-Rhin, France) [495]), Heuneburg [453]).

Miron [317] investigates those toiletry objects which are bound to another with a so-called *Scharnierkonstruktion*. This construction is a simple pintle connecting the single artefacts instead of suspending them onto a ring or binding them with organic matter.

The five types he defined differentiate in decoration and construction of the hinge-joint. Type A (*Rebbio*) with a frame-shaped holder and type B (*Hochdorf*) with a bell-shaped holder have their main distribution area in Upper Italy — the area of the Golasseca culture. Three artefacts of type B found at Pfaffenwäldle (Eberdingen-Hochdorf, Baden-Württemberg) are, according to Miron, import goods and not local imitations. Type C (*Altforweiler*) has a broad distribution across Central Europe, excluding Upper Italy. Type D (*Basel-Gasfabrik*) does not fit into the category of *Scharnierkonstruktion* in a strict sense, as a simple rivet connects these artefacts. Type E (*Moselländischer Typ*) and F (*Wederath*) are temporal and spatially in the periphery of this study. Toiletry with hinge-joint is usually a set of the same three single tools like toiletory bound with a simple ring: Nail clipper, tweezer and scoop (for functional definition see [302]) [453]. Toiletry artefacts are dominantly bronze objects; iron is less frequent. As mentioned several times, this proportion probably alters due to the preservation conditions of these relatively small objects.

#### 4.3.6.1 Razor (B612)

Jockenhövel [209] describes razors as thin, one- or two-bladed knives. The thin metal sheets are often made of iron, resulting in bad preservation conditions. Perhaps many artefacts have degraded completely [494]; [495].

These artefacts occur dominantly in grave assemblages during the Early Iron Age, which indicates a personal item. Although they belong mainly to male burials, some grave assemblages indicate female individuals<sup>84</sup>. The position of razors in inhumation graves does not indicate a standard wearing. Jockenhövel, therefore, suggests storage in houses [210].

Jockenhövel [210] suggests, at reaching adolescence, a male individual receives a razor during an initiation rite. Furthermore, the ratio of razors to swords in the necropolis of Maillhac-Moulin indicate a symbol as patriarch [210]. More recently, Schneider [442] uses razors to detect and depict changes in interaction and communication during the transition from the Bronze Age to Iron Age in northern Germany.

While during the late Bronze Age, handy and straightforward shapes of razors are common, during Ha C, more types and shapes develop. The increase in types is contemporaneous to shifting depositional behaviour from settlements to burial context in Ha C [495]. In contrast, at the beginning of Ha D variety of shapes reduces drastically [57] reinforced by production in iron. The bad preservation of iron razors identifies or establishes a typology impossible, likewise decoration unrecognisable. Most iron razors occur along the Rhine Valley and Rheinland-Pfalz [367].

In southern central Europe, this artefact type is known since the excavation of the necropolis of Amberg in 1821. Based on the Villanova necropolis (Italy) [150], Keller assumes the use as razors for two-bladed artefacts [219]. The term razor for this artefact type spread quickly, as applied in the so-called *Pfahlbauberichte*. Flouet contradicts the use as a razor and suggests using a knife to cut leather, sacrificial or surgical knife [126]. Until 1870 problems with the nomenclature are solved [483]. In 1871 Bertrand maps the distribution of razors in Europe starting from rich equipped burials in Burgundy and notes missing razors in western France, but concentrations in Upper Italy, western Switzerland, East France, western Germany and Belgium [29]. Déchelette divides Early Iron Age razors into two basic types: one- and two-bladed razors [74]. In his understanding, razors in combination with swords in Burgundy belong to an "aristocratic warrior" elite<sup>85</sup>. However, Henry's [179] typology is closer related to Reinecke, especially according to chronology.

Jockenhövel summarised in 1971 [209] and 1980 [210] bronze razors in central Europe. Besides typology and distribution, he also includes a functional analysis. Relicts of hair on razors serve as proof for cutting hair, like in Winterlow [209]. However, attached hair on continental artefacts document hair corroded onto the metal surface in one direction indicate storage in a case lined with fur. Although accepted by the majority, rarely the attribution as razors by Jockenhövel [209] has been disagreed on [449].

Razors are either cast or forged. Those produced by the cast needed reworking to remove the cast surface and waster. Additionally, the blade needs sharpening. Casted errors rarely occur on these thin artefacts (between 0.2 and 0.3 cm). The decoration is created by open-worked ornamentations already included in the casting model. For razors with a languet, Jockenhövel [209] assumes a handle made of organic material. Several artefacts document repairing, mostly between handle and blade or suspension ring and handle using wire or cast.

The need for reworking and sharpening of razors change the shape and ankle of blades. Razor and grindstone found occasionally associated in graves, while it remains uncertain whether these artefacts belong to another. Although several artefacts may originate from one mould, manipulation in combination with poorly preservation reduces the likelihood to identify two artefacts of the same mould. Jockenhövel [209] defines static aspects as features for a typology of bronze razors, like a handle, position of the handle, open-worked decoration and transition between handle and blade<sup>86</sup>. Iron razors are again problematic to fit into a typology due to their poor preservation and low frequency. They seem to distribute in northern Burgundy and the Rhine Valley [495].

The artefacts summarised as razors may subdivide into two broad groups — one-bladed and two-bladed razors. For the Early Iron Age relevant types are *Wiesloch* and *Minot* of the two-bladed group and type *Endingen*, *Flörsheim*, *Cordast* and *Ins* of the one-bladed group. Type *Wiesloch* has a long blade, a small v-shaped transition between handle and blade richly decorated with circles or triangles as open-worked. The eponym artefact from *Wiesloch* is deposited non-reworked, indicating a production shortly before the burial or in the context of the

<sup>84</sup> Feldkrich-Hartheim, Baden-Württemberg [209].

<sup>85</sup> See Wamser [506] for a more recent evaluation on razors in Burgundy.

<sup>86</sup> Blade reverses not to the cutting edge, which changes during usage.

burial rite. Type *Minot* relates closely to type *Wiesloch*; however, the circular bent blade with a rounded transition towards the handle has decorative bracings. This type originates in razor types of the Urnfield culture [209]. Likewise, type *Gramat* is related to type *Wiesloch*. It is elongated to the circular shaped blade has a small transition to the handle with suspension ring and circular shaped open-worked decoration [210].

Type *Endingen* belongs to the one-bladed razors and has a trapezoidal-shaped blade with a straight cutting edge and concave back with a suspension ring at each end. A ridge strengthened the back. The open-worked blade facilitates the definition of two variants with either circular or rectangular decoration. Type *Flörshheim* also has a trapezoidal-shaped blade with a concave back whose suspension rings connected at each end. Of type *Cordast*, only a few documented artefacts exist. However, they are characterised by a semi-circular blade with a strengthened back that has three indentations. Similar, type *Ins* has a semi-circular shaped blade with a parallel back [209].

In principle, cast moulds allow identifying a series of produced artefacts and the location of workshops. As mentioned above, the reworking, sharpening, low artefact frequency and bad preservation conditions such identification was not yet successful in the case of razors. Jockenhövel [209] lists cast moulds occurring in the periphery of the distribution of that type. He suggests missing data and not dislocation of cast moulds.

Type *Wiesloch* spreads across a large area from northern Germany to Perigord in southern France. Some variants show concentrations; however, a production area is not identified. Jockenhövel suggests [209] several well-connected workshops. The related type *Gramat* occurs from the western Languedoc to the northern Upper Rhine and southern England [210].

Type *Endingen* has no particular area of concentration. It spreads along the eastern Upper Rhine, southern France, Westphalia, Belgium, until southern England. In contrast, type *Cordast* has more restricted distribution spreading from Switzerland into Baden-Württemberg. Local production in Switzerland is assumed for type *Ins*; however, this type occurs more often during Ha D in western-central Europe [209].

Several types and variants develop during Ha C, indicating provenances, primarily found in Eastern France in association with Early Iron Age swords [495]. In Burgundy, the distribution induces local production of types *Dampierre*, *Magny-Lambert*, *Mauvilly-Sundhofen*, *Unterstall/Poiseul* and probably *Flörshheim*. Type *Minot* also occurs in the area of question, while type *Basile* and *Tremblois* have more restricted distributions in France not reaching the Alsace. During Ha D, razors occur more often in the Haguenuer Forest [210].

In the periphery of the area in question, only a few examples occur in Neuwieder Becken, at the Lower Rhine or Westphalia, which contrasts drastically to neighbouring southern areas. However, frequent "Hallstatt" artefacts indicate contacts, Jockenhövel names only one bronze razors in the Mosel-Saar region [210].

Razors occur from the Middle Bronze Age onwards. The western area of the Early Iron Age continues the use of razors, while in eastern central Europe, razors disappear. Jockenhövel assumes no missing artefacts but a decline in the importance of razors in burial contexts. Probably, tweezers substitute razors [209].

Similar to other artefact categories (like daggers), the numerous variants in combination with a relatively low frequency results in only a few artefacts per type and variant. Trachsel [494] supposes four groups combining the defined types by Jockenhövel to allow for chronological comparisons. Group A correlates to type *Magny-Lambert*, *Saint-Pierre-Eynac*, *Clayaures*. It summarises one-bladed razors with two suspension rings. These types of origin in the Bronze Age and prolong into the Early Iron Age. Group B consists of open-worked, two-bladed or ring-shaped razors with suspension rings. Therefore, types *Baisle*, *Tremblois*, *Minot*, *Wiesloch*, *Gramat* and *Havré* belong to this group which dates comparable to group A. Similar, group C, one-bladed razors with indentations on the back summarises types *Unterstall/Poiseul*, *Flörshheim*, *Feldkirch/Bemissart* and *Endingen*. Group D, which includes semi-circular razors, date to Ha C with a typological development until Ha D3 [494].

### 4.3.7 Art and Jewellery (B7)

Akin to other artefacts in connection to dressing, art and jewellery visualize cultural aspects. The meaning and interpretation of such artefacts enable us to understand the cultural framework, imaginary world and mental ideologies. Jewellery expresses individualism and, nonetheless, belonging to a social or cultural group being more than aesthetic adornment. The meaning of art and jewellery for contemporary society remains unknown to us. Also, the differentiation between a functional artefact and jewellery is only possible within a social group [462]. However, similarities in shape and decoration and regional differences contain valuable information on interaction patterns (chap.: 2.2.1).

The category art and jewellery summarise large and small sculptures (B71 and B72), pendants and amulets (B73), beads (B74), fittings and other decorative artefacts (B75 to B79) (see tab.: A.10). Especially pendants (see below a more detailed description of pendants 4.3.7.1) and beads belong to the category of personal items and, therefore, occur mainly in grave assemblages (5,749 of 49,936 artefacts in total). Sculptures occur likewise not very frequent (n = 31 artefacts).

Most beads are non-metallic, probably connected to bad preservation conditions for small metal objects (n = 49) besides a lower recovery likelihood, which might explain the low frequencies, especially iron beads in grave assemblages. Amber (n = 622), coral (n = 39), glass (n = 2,129), ceramic (n = 34), bone (n = 50), lignite (n = 119) and jet (n = 2,390) were used for manufacturing beads. Quantity varies largely in grave assemblages from one artefact up to 200. Additionally, the exact number of beads is often not named in older documentation [495]. The size and possible degradation of beads reduce the meaning of quantities; however, specific material serves as an indication for interaction.

For glass, two variants are relevant for Baden-Württemberg and the Alsace. Circular glass beads, so-called *Haguenauer Perlen*, are dark brown coloured glass beads often interpreted as an imitation of jet beads [173]. Havernick [173] identifies the Haguenauer Forest as the main distribution area for those glass beads and suggests a local production. However, glass beads have wide-spreading distribution without specific shapes of types [453]. The other variant is glass rings found attached to chains or colliers of other beads. The colour ranges from light blue to light green. However, the range in colour is small, and each ring is formed out of a round rod, which Havernick [173] supposes a western workshop. Those glass products occur at the end of Ha D in the transition to Laténe A.

#### 4.3.7.1 Pendants (B73)

Pendants are mainly bronze artefacts with a holder, often a lug attached to fibula or torcs as jewellery. Only occasionally, bone, amber or coral are used to manufacture pendants (n = 33). The diversity in shape combined with deviating regional distribution enables us to identify areas of possible origin [507].

257 of the 5'749 jewellery items are pendants in the SHKR database. According to Warneke [507] until 1999 nearly 40% of pendants deviate from antiquarian excavations (before 1900). Primarily, those artefacts recovered by excavations lead by Naue were only assigned to groups of barrows. Similar, for excavations initiated by R. Ulrich in Switzerland, excavators mixed inventories of a poorly equipped burial with mostly later dating fibula from other burials to increase the price [507]. These manipulations influence the assemblages of individual burials and might affect the assemblage of an entire necropolis. However, these constraints occur in several artefacts and need to be considered carefully in interpreting archaeological data.

Kossack uses pendants to identify the possible eastern cultural influence on the middle European Middle Bronze Age, and Early Iron Age. While he could prove influence during the Urnfield culture, the Early Iron Age groups in Baden-Württemberg, Bavaria and Eastern France show limited Danubian influence, as in bronze belts and bird sculptures [238]. His comparison serves as fundamental for typology and chronological fitting. In contrast, Frey uses Etruscan import goods, like beak-spouted ewer or pendants of south alpine origin (*Körbchenanhänger*, *Schuhanhänger* or *Dreipässe*), to illustrate trading connections across the Alps parallel to



a later connection to Massilia [134]. Although different geographical scopes, Kossack and Frey only referred to specific shapes without presenting pendants in general. Drack presents the earliest regional classification for Switzerland of *Körbchenanhänger*, decorative rings and plates and bronze rattles [87]. Mansfeld adds spherical needles (*Kugelkopfnadeln*) and spherical pendants [302]. Pauli [373] addresses pendants, among other artefacts, in graves as amulets. Starting from grave assemblages at Dürrnberg, Pauli considers only those grave assemblages with an "evident amulet character". He subdivides pendants based on their character as an amulet into several groups like noise causative (*Klapperbleche*, *Tonrasseln*), obvious amulet shape (*Schuhanhänger*, *Dreiecksanhänger* or *Stäbchenanhänger*), curiosa and by their material (tooth of a boar, serpentine, parts of a human skull) [373]. However, his data collection is irregular, resulting in unequal coverage. This unbalanced, and mostly unmentioned, selection reduces his analysis of amulet and his interpretations likewise. Besides other critical aspects (see Torbrügge [491]), the classification by Pauli seemed influenced by Pauli's understanding of amulet in grave context, namely fear of the dead or so-called dangerous dead, neglecting alternative interpretations like talisman [507].

More recently, Warneke [507] disclaims the classification by Pauli. However, he uses older existing classifications to define stylistic and technological features rather than types<sup>87</sup>. Variants may subdivide shapes, while groups of features summarise shapes on a higher level. Warneke defines 14 groups of features, where 10 of them are documented in Baden-Württemberg and the Alsace. These ten groups are further subdivided into 18 shapes, while six groups only have one shape each. *Hohlblechanhänger* (hollow sheet pendants) form the largest group of shapes<sup>88</sup> with spherical husks (*Kugelanhänger*, shape 1), two semi-circular husks (*Zweischalenanhänger*, shape 5) and capsule pendants (*Kapselanhänger*, shape 6). Spherical husks, also known as *Blechbommeln*, or *flachrundlich gewölbte Pommeln*, are toreutic semi-circular husks connected by a narrow fillet often with an additional ring as suspension. These artefacts are mainly undecorated; those decorated have concentric circles or humps (*Punkt buckel*). These shapes are differentiated from semi-circular husks (*Zweischalenanhänger*) in the orientation of the joint, which is horizontal for shape 5. A central pin ties both half-shells together and often forms a ring suspension. These pendants are also primarily undecorated. One exception is a hump decorated pendant in Villingen-Schwenningen (Baden-Württemberg). If found in a functional position, these pendants (spherical and semi-circular husk pendants) are suspended at torcs, ear, or temple rings singular or as a set of up to four pendants. These jewellery artefacts occur mainly in female burials. Capsular pendants are cylindrical shapes with a lid and sometimes preserved organic matter inside.

*Stäbchenanhänger* (rod pendants, shape 8) have a cylindrical shape with a pointed or rounded bottom and often a ring as suspension. They are dominantly found in settlements in eastern France, indicating a profane use, not an amulet character [157]. Sievers suggests that these artefacts have been used as a kind of shoelace, which would also explain their position in graves near legs or feet [453].

The feature group ring pendants summarises simple ring pendants (*Ringanhänger*, shape 9), rings with an appendage (*Ring mit Fortsatz*, shape 10) and two shapes located just outside the region in question, namely toothed ring (*Zahnring*, shape 11) and trefoil rings (*Dreipässe*, shape 12). Simple ring pendants have either a directly connected ring-shaped suspension or are connected via a fillet. The cross-section is rhombic and, in the case of the Heuneburg circular.

Jingles (*Klapperbleche*, shape 13) are the most frequent pendants and have triangular or trapezoidal shapes, while the base is either straight or slightly convex. Often a perforation or an intermediate ring serves as suspension. Some of the bronze jingles are decorated with humps or concentric circles. Fibula, vessels or cult sceptres have jingles as pendants. Iron jingles are associated with the wagon and harness.

Dovetailed pendants (*Schwalbenschwanzanhänger*, Shape 14) subdivide into two variants (14A with down tipping edges and variant 14B bended up). The use is similar to shape 13 at fibula or vessels.

The feature group of figural pendants combines sheeted anthropomorphic pendants (shape 15-17), massively cast anthropomorphic pendants (shape 18) and zoomorphic pendants (shape 19). Only shape 18 and 19 occur in

<sup>87</sup> Warneke explicitly rejects the term type [507].

<sup>88</sup> Three other shapes locate outside the region in question.

the area of question. The anthropomorphic pendants have a casted ring as suspension either attached to the head or back. The depicted animals in zoomorphic pendants are horse, stag, cow, ram and cox.

The classification by Frey [134] defines the subdivision of basket-shaped pendants. The term refers to a modern analogy of baskets without implying a similar meaning. Two semi-circular husks combined vertically form the so-called basket. Shoe shaped pendants (shape 23) is cast and often decorated with grooved lines. A differentiation between the right shoe and the left shoe is often possible. They occur in female burials. Wheel shaped pendants (*Radanhänger*, shape 24) are circular disks with open-worked fellow, and at least four spokes occur only once in the area of interest. However, it concentrates on French Jura and Burgundy. Miniature tools (shape 25), namely knives and axes, often occur in pairs in burials. While miniature knives occur in Baden-Württemberg and Tessin, axes dominate in Bavaria. Framework pendants (*Rähmchenanhänger*, shape 26) have a triangular or squared shape, often with thickened edges.

The distribution of spherical husk pendants (*Kugelanhänger*, shape 1) covers the Upper Danube, Swabian Alp, Lower Franconia, Slovenia and Oberpfalz, although in the Upper Pfalz artefacts are smaller there and probably later (Ha D3) [507]. The spherical husk pendant of the Tumulus 5 in Maegstub (Bas-Rhin) represents the most western point of distributing this shape. The semi-circular husk pendants (*Zweischalenanhänger*, shape 5) concentrate at the Upper Danube, especially around the Heuneburg and spread into the western Rhine area and to the lower Main.

Technical similarities and distribution pattern of shape 6 and semi-circular needles (*Zweischalennadel*, chap.: 4.3.3.2) make a local production at the Heuneburg probable [507]; [69]. As capsular pendants are relatively rare, the distribution of the artefacts is not very informative. However, they occur in separate areas at the Upper Danube, in Slovenia and Tessin. *Stäbchenanhänger* (shape 8) distribute loosely across Baden-Württemberg and the Alsace. Simple ring pendants (shape 9) are characteristic of Baden-Württemberg and occur in the main and northern Alpine regions. Shape 10 (rings with appendage) have a more restricted distribution. It occurs more concentrated at the Upper Danube and along the Neckar Valley and spreads loosely across Baden-Württemberg and the Alsace. Jingles occur across the entire area of the Early Iron Age, surprisingly rare in Switzerland and France. Iron jingles are only documented north of the Alps. Dovetailed pendants (*Schwalbenschwanzanhänger*, especially variant 14 A, occur northern the Alps and only rarely southern. Anthropomorphic pendant occurs only rarely in Baden-Württemberg and eastern France, where Warneke supposes the workshop. Zoomorphic pendants spread from Baden-Württemberg across Bavaria into Slovenia. Basket pendants with a rounded base (*rundbodige Körbchenanhänger*, shape 20), pointed baskets and profiled baskets occur mainly southern the Alps and occasionally spread into the area of question. Framework pendants, if triangular-shaped, distribute at the upper Danube, Swabian Alb into Franconia, or if squared shaped in Switzerland and Upper Danube [507].

The endogenous cultural product of the western Early Iron Age is semi-circular husk pendants (*Zweischalenanhänger*, shape 5) the distribution of pendants and needles. No regional differentiation is possible for jingles and spherical husk pendants (*Kugelanhänger*, shape 1). Exogenic pendants, hence imports, in the western Early Iron Age are trefoil and basket pendants from the Golasseco culture, dovetailed pendant variant 14B from Upper Italy and anthropomorphic pendants variant A2 from Hallstatt cemetery (Austria). However, pendants allow identifying endogen and exogenic influences.

Compared to the fibula, which has a fast typological development, pendants are less devoted to fashion [507]. Therefore, the typological development is reduced or not recognisable in the preserved data. Spherical husks and semi-circular husk pendants (shape 1 and 5): Ha D1/2 similar to hollow *Kugelkopfnadeln*, latest Lt A [507], slightly earlier than Mansfeld (Ha D2 to D3 [302]). Shape 9 and 10 dates to Ha D1. Shape 13 dates to Ha C2 until Ha D1, hence relatively early. Figural pendants date to Ha D. Shoe pendants dates comparably late into Ha D2. Early Iron Age pendants do not prolong into La Tène A.



## Chapter 5

### Method

The data basis and the research question determine the choice of methods because both have limitations and requirements that significantly reduce the choice of possible methods[345]. Those methods refer only to the unique compilation of questions and data and do not provide any information about which methods are generally preferable.

#### 5.1 Classification of Material and Collection of Data

The classification of material and a data collection strategy are mutually connected and form the backbone of every archaeo-statistical analysis. Detailed information is necessary for data gathering, standardised data recording, and artefacts classification. Otherwise, neither the results nor an interpretation resist critical evaluation or fulfil standards of reproducible research. A similar data collection is naturally needed to conduct an interaction study similar to Nakoinz' approach [345]. As mentioned before, Nakoinz focuses on reconstructing archaeological cultures using interaction pattern as a key term; his developed database suites the needed requirements for this analysis. Additional data needed for other projects (e.g. details on individual burial assemblages [464]) are not integrated into the analysis. SHKR10 expanded spatially, and some additional sites extend for version SHKR20.

During four years (2005 until 2009), all so far known sites in Baden-Württemberg dating between Hallstatt C and La Tène B were recorded with a focus on site description and artefact classification. Not only published sites but also those recorded by the State Office for Preservation of Baden-Württemberg <sup>1</sup> were included in SHKR10. This overarching data collection is unique, not only due to the enormous labour amount <sup>2</sup> but also its holistic character. Especially at the beginning of the data recording, not specially trained employees, often no archaeologist, installed primary data on sites. During several steps of data revision, the quality of data recording improved immensely until reaching a satisfactory stage [345]; [464].

Additionally, two other data collections <sup>3</sup> are added to the SHKR database from 2014 to 2019 resulting in 4229 sites (chap.: 4.2). R. Wassong surveyed the region of Haguenau Forest (France) to record the current state of preservation of known barrows and recorded so far unknown monuments [508]. The precise GPS coordinates

---

<sup>1</sup> In total 9052 sites are recorded until 2009 (archaeological object (n= 566), depot (n=20), grave (n=7758), settlement (n=666), infrastructure (n=8), cult or religion (n=5), others/unknown (n=29)).

<sup>2</sup> Nakoinz calculated that one single researcher would have needed 25 years collecting this amount of data ([345], 27).

<sup>3</sup> I am very grateful to R. Wassong and L. Tremblay-Cormier for sharing their data collections. Their expertise enriched the data classification. Both databases are published on the ArkeoGIS website [26] which proves to be an excellent tool to share spatial data among researchers (arkeogis.org).

of individual barrows allows detailed local analysis. Further, Wassong was able to identify most of the excavated barrows by Nessel, which was published in high quality by Schaeffer [427]; [428].

L. Tremblay-Cormier conducted the second data collection to study cultural identities in an area between Rhône and Rhine [495]. Her collection focuses on metal artefacts from all types of sites dating to the Bronze Age onwards until Ha D. Although she selects one material for her analysis, she also recoded other precious artefacts like amber, glass or coral. Further, existing ceramic is named, and for Haguenau added based on Nessel (using the journals stored in the Haguenau Museum) and Schaeffer [427]; [428]. The covered area excels the departments Bas-Rhin and Haut-Rhin. However, integrating all sites, a detailed classification adapted to the SHKR structure of artefacts has only been done for those areas under investigation. Outside those areas, artefacts are at least recorded correctly in terms of material and shape <sup>4</sup>.

Although both databases are excellent work and provide a large amount of detailed, high-quality data, the difference in site frequency is visible from Baden-Württemberg to the Alsace. Archive and inventory of the State Office for Preservation of Baden-Württemberg exceed published information of sites. To reduce these different resolutions, and in order to gain comparability, other sites and artefacts are added <sup>5</sup>. Based on the different nature of data collections, some areas were recorded with the highest standard (mainly Baden-Württemberg), some have additional information (vicinity of Haguenau), and others were recorded sufficiently. These three stages of data quality will be considered while interpreting the results.

Besides site information and artefact classification, the SHKR database stores context information as well. Ten levels structure the SHKR database. The first five levels (loc 1 to loc 5) describe the administrative location from the state (Federal Republic of Germany) to the municipality. Each site is located explicitly in one element of each level, enabling to filter for federal states or departments. The second 5 levels (loc 6 to loc 10) stores additional archaeological data. The level of sites (loc 06) followed by objects (loc 07), feature (loc 08), deposit or layer (loc 09) and finally artefacts (loc 10). All relevant data concerning an archaeological site belongs to level 6 (loc 06). Besides name and coordinates, this includes the type of site, description, literature and comments — this enables us to address and classify sites often required for analyses. Additional information, e.g. on centrality aspects of settlements, append the site information. An archaeological site is composed of objects like houses in settlements or barrows in a necropolis — relevant information for the archaeological objects provided in loc 07. Moreover, again within those objects (loc 07), other complexes may occur like burials (loc 08) specifying the type of burial (inhumation or cremation) and the buried individual. Similar layers, the next level (loc 09), are often only documented in settlements. The last level (loc 10) represents archaeological artefacts (see example in 5.1). Here, each artefact is classified based on Nakoinz hierarchical method [341]; [345] (for details see below, chap.: 5.1.1). During the duration of the SHKR project and the cooperation with several subprojects [465], the original SHKR database from 2004 stores irrelevant data for the present analysis like preservation status of monuments, elements of settlements, grave inventories. However, this information does not disturb the workflow in any way. Moreover, another project might use it later. In order to enable us to reproduce the results presented by Nakoinz [345] and Steffen [465], a new version of the SHKR10 provides all recent changes: SHKR20.

### 5.1.1 Classification of Artefacts

The core of the data collection is the SHKR classification system developed by Nakoinz [341]; [345]. Based on Orton's [356] concept, a classification has to meet four basic requirements: First, artefacts of the same type should appear similar; second, artefacts of different types should appear dissimilar; third, a type needs a clear

<sup>4</sup> For each affected site, a comment reminds of the preliminary state of recording.

<sup>5</sup> Like metal artefacts and ceramic assemblage is recoded for the sites Entzheim and Rosheim [272]. For better coverage of ceramic assemblages, sites and artefacts recoded by U. Brosseder [44] fill those gaps. 19 sites added from the database of C. Morel published on the ArkeoGIS website [324]. Additionally, iron production sites identified by Gassmann [143] on the Swabian Alb and in the ore district of Neuenbürg (Black Forest) completes the SHKR data collection. The Bronze Age passages across the Rhine identified by Logel added as sites of type infrastructure [293]; Logel [294]

<b>loc01</b>	<b>loc02</b>	<b>loc03</b>	<b>loc04</b>	<b>loc05</b>
11 Federal Republic of Germany	19 Baden-Württemberg	82	172: Reutlingen	23541: Römerstein
<b>loc06</b>	<b>loc07</b>	<b>loc08</b>	<b>loc09</b>	<b>loc10</b>
7967: In der Au	3996: Grabhügel	2364	2364	28177: Kegelhalsgefäß

Table 5.1: Example of recorded sites in SHKR database (In der Au (loc 06: 7967)).

and distinct definition; enabling reproducibility of classification; and fourth, new artefacts have to merge into the existing classification. An archaeological classification compares several aspects to biological taxonomy, relativising evolutionary aspects as not presuming strict hierarchies. A degree of similarity expresses limited typological relations [403]; [450]. However, biological speciation (taxonomy) differs from archaeological technological and typological taxonomy. Similar constraints in defining chronological phases (chap.: 1.4) apply for classifying archaeological material likewise. Most archaeological artefacts, especially in the Early Iron Age, are handcrafted, or those produced using models are reworked. Deviations occur, therefore, naturally resulting in nearly continuous spectra of variants. Defining classes always requires existing fractions. Continuous variables depend on assigning observation to a class. Near the transition to a new class, the assignment results in possibly false class allocation — a method-inherent bias applying to every archaeological classification. However, a high amount of possible features, elements and attributes enable us, on the one hand, to describe each artefact precisely and, on the other hand, prevent arbitrary selections.

Requirements for a classification serving an analysis of interaction patterns record the archaeological material completely, registering similarities at all levels of description, maximising recorded information, including similarities of assemblages, and weighting degree of specialisation [342]. Six fundamental attributes describe an artefact on a first and basic level (tab.: 5.2). This polythetic division of material (A), shape (B), technique (C), decoration (D), type named in the literature (E) and dating of type (F) follows a hierarchical classification whereby levels indicate the degree of specialisation or availability of data. Inside each attribute, features are hierarchically organised, allowing maximising recorded information.

Traditional classification systems have one disadvantage in common: their strict and inelastic order in material, shape, type and variant is unsuited to describe entirely all found archaeological artefacts. Due to preservation (destroyed or incomplete), or publication (drawing or description), many artefacts are indistinguishable throughout all levels of classification. These objects should and need to be included in the analysis. Therefore, the sorting of features follows availability. Preservation and frequency are mutually integrating, however, rare but highly characteristic features. For vessels (tab.: A.2), the basic shape (either open or closed) represents the first level of classification.

Further on, basic profiles differentiate the second level, while the following levels describe the shape in detail (rim, shoulder and base). Complete vessels up to single sherds can be recorded concerning their potential information. Each subdivision is represented by a cypher ranging from 1 to 8, while 9 always represents indifferent features. Every different further level of features adds another cypher, again ranging from 1 to 9. Artefact descriptions of complete or highly specialised individuals result in long Chiffre codes. The example illustrates the strength of the present classifications: fibula (tab.: A.4) subdivide by their phenotype, like *Hallstatt fibula* or *La Tène fibula*, followed by fibula types for example an arc fibula (*Bogenfibel*). Composites of the fibula are classified in additional feature levels as foot, needle holder, or spring construction. Naturally, complete vessels retrieve more data than rim fragments; a weighting is reached by transforming the Chiffre code into a so-called type spectrum (chap.: 5.5.1).

The artefact shape does not always determine material or decoration and *vice versa*. The distinction into attributes (material, artefact or decoration technique) allows quick classification and reduces redundant attrib-

utes. Especially features of the decoration attribute are similar in different artefact shapes, like ceramic or metal vessels and belts. Each artefact might be decorated with triangles forming a horizontal band referring to D241 for triangular and D22 for a strip. Therefore, an overarching analysis of functionally similar artefacts but with different materials or different functional artefacts with similar decorations can be realised quickly without further data revision. As Schneider [442] points out, these aspects are of great importance when investigating influences, adaption or transfer within interaction patterns in contemporaneous living groups.

loc10	A	B	C	D
28177 Kegelhalsgefäß	A111 ceramic, fine,	B11224 Vessel, closed, pronounced neck,	C1C41C233C321 C1 profiled,	D26D241D239 D26 decorated:fields,
conical-necked vessel	handmade	conical necked, flat base	C41 depression: punched,  C233 relief: notches,  C321 painted: graphit	D241 deccroated: triangulars or arcs: triangulars, D239 decorated: lines: others

Table 5.2: Example for classifying archaeological artefacts (conical-necked vessel "Kegelhalsgefäß" found in "In der Au", Römerstein (loc 06:7967)).

The high performance of such a classification is evident, as it allows for differing types, distinctively defined, while it preserves alternative combinations of typed elements. Reusing existing material classification, e.g. of the ware definition of pottery (fine to coarse), either requires an evaluation and adaption or rejecting limiting the present method, as only rough classifications may remain. The case of the ware definition of pottery is complicated, as deviating classifications occur numerously. However, assuming a shared understanding of coarse or fine ware still reduce the informative value of such uncertain definitions.

Numerical and hierarchical classification are well designed for computer-assisted analyses [191]; [341]; [465]; [442]; [345] however, not generally accepted in archaeological research. Schneider [442] suggests that a Chiffre code is less intuitive and less informative as a term like *Bogenfibel*. In order to overcome biases by research history, personal perception or knowledge of researchers, artefacts are described based on phenotypes, not on defined types named in the literature. Nevertheless, these types are recorded separately in attribute E, prohibiting loss of information as not all previously defined types are biased, allowing for selection of known archaeological types and trace differences between existing classification and the presented numerical variant. Therefore, six Chiffre codes describe each artefact entirely. In tab. 5.2 a conical-necked vessel (so-called Kegelhalsgefäß) serves as an example to illustrate the artefacts classification and description in the SHKR database. Besides site information (see tab.: 5.1) the following Chiffre code describes the artefact 28177 (loc 10) entirely: A111B11224C1C41C233C321D26D241D239. Additionally, E and F occur. For convenience, columns store one attribute each.

## 5.2 Reproducible Research

Ongoing debates on openly available data, reproducible research and new guidelines for good practice has already reached Archaeology [306]. Besides a paper, two main components are needed to reproduce scientific results: data and method. This section briefly introduces the costs and benefits of reproducible research, the programming language R and the "RRtools" package developed by Marwick and colleagues [438].

As Ben Marwick states, if different researchers can reproduce the results of numerous investigations, those results are trusted to approximate the true account - for archaeology - of past human behaviour. Therefore, earlier

published results need to be tested and reproduced to reach that approximation or, if necessary, do changes [305]. In Archaeology, it is increasingly common to produce complex computational results, but reproducing statistical results or figures usually fail cause of lacking information; for example, data is rarely openly and fully provided or unrecorded data cleaning, tidying and visualising happened [305]; [202]; [377]. Furthermore, if the conducted method is noted underspecified, the likelihood for reusing, inspecting and approving reduces [4]; [85]; [448]. Although, it is challenging and time-consuming for others to benefit [305]. Marwick names four general principles derived from software engineering and computational intensive fields, making any research a reproducible one [305].

The first principle is to *openly share and archive both data and code*. For Marwick, this is similar to the archaeological principle of artefact provenance. Without context information, an artefact is nearly meaningless; hence without data and code, results are diminished [305]. Making both available enables us to inspect and evaluate the reliability of the results. Due to the diversity and wide variety of archaeological data, one single approach to make data openly available is difficult [228]. Furthermore, copyright limitations, cultural sensitiveness (e.g. protection from vandalism) or technical limits complicate data sharing.

Secondly, commonly used commercial software with a point-and-click interface hinders reproducibility and constrains the transparency of research (Hatton and Roberts 1994). As mouse gestures leave little traces, sharing steps of the conducted analysis remains complicated. Additionally, details of data analysis are not available for inspection or modification because of the proprietary code of the software [202] [501]). The most convenient and efficient solution is to use *scripting tools* [211]; [305]. A script is a plain text file containing instructions composed in a programming language with a very high-resolution record of the research workflow. It allows reusing and inspecting used methods with great flexibility to choose either traditional or cutting-edge algorithms [305].

Thirdly, *version control systems* ease the documentation. Instead of keeping multiple copies with appending dates for different versions, a version control system separately saves each change to a version control database. Each change is assigned with a commit, creating a high-resolution record of research history. Furthermore, creating branches allows exploration of new ideas, documenting dead ends, and merging allows to incorporate successful explorations. For Marwick, version control is a key principle for reproducible research because of the transparency it provides [305].

Finally, providing the *computational environment* to prevent workflows from failing [305]. Trying to reproduce results with a different operational system, version of R, or available packages may fail immediately, or time-consuming troubleshooting is needed. RRtool creates and saves the computational environment for better reproducibility using a virtual machine and the service Docker.

Schmidt and Marwick recently investigate the influence of reproducible research on archaeology and ecology (sharing data, sharing code and its influence on citation rates). While a clear trend is visible for ecology based on the programming language (here R), only a slight trend is visible in Archaeology. Nevertheless, the number of papers using R and incorporating principles of reproducible research increase, similar to their citation rates. Schmidt and Marwick acknowledge the high barrier to learn a programming language but encourage to spend the effort for better scientific practice <sup>6</sup> [438]. Besides the time-consuming process to learn programming and getting used to working with scripting tools, the reuse of code to redo the same analysis, for example, with a new dataset, is much easier.

R was originally developed by two academic statisticians in the 1990s [305]; [55]; [521]. It is a free open source complete programming language customised for data analysis and visualisation. Because of its free, open-source nature, user-contributed packages save a substantial amount of programming effort <sup>7</sup>. For example, the RRtools package developed by Marwick and colleagues [438] provides functions to create a research compendium following the before mentioned principles. Hence, it separates data and method, raw data and data

---

<sup>6</sup> Schmidt and Marwick themselves made both code and data openly available.

<sup>7</sup> In February 2020 more than 15,000 packages are available on CRAN (<https://cran.r-project.org/web/packages/>).



created by analysis, connect to a version control system, and provides an R Markdown document to write and render a publication right away.

In total 2,727 sites with 49,936 artefacts are recorded in the SHKR20 database. Although most statistics can be calculated manually, this vast amount of data needs to be processed using computational approaches. Following the guideline for reproducible research, this study uses the R scripts to enable us to reproduce, inspect and use the code and data. Additionally, further user-contributed packages help to filter, tidy and analyse data to conduct the planned study. While describing the method, the used packages will be cited for further information on code, data and used function <sup>8</sup>.

### 5.3 Reconstructing Infrastructure

Possible methods to reconstruct path systems based on empirical data summarise in intuitive approach, graph-based and density-based approach. Here, the reconstruction of the path along density of monuments (chap.: 2.3.2.4) based on an empirical density model created by Nakoinz [343] results in reproducible and detour avoiding path systems. Only in a second step, the comparison with theoretically constructed path systems enables us to estimate probable path planning parameters.

Besides the location of barrows (fig.: 5.1), a regular spaced grid will store resulting kernel density estimations (KDE). A KDE calculates a density value by weighting the influence of observations regarding its distance to the grid cell origin. The shape of the kernel, the membership function, defines the weighting. It regulates the influence of distance on the density value. The bandwidth controls the width of the membership function and regulates the resolution of the KDE. At each sample point, a Gaussian kernel with a dynamically defined bandwidth calculates density values. The dynamically determined bandwidth regards local density at a point producing more details across dense areas. The weighted density values stored in the provided grid illustrate a density relief with ridges along with aligned monuments.

In a second step (fig.: 5.1), this density relief enables us to identify paths along density ridges. Ridges not only occur along with the global maximum density values but also on locally density maxima reconstructing a path in an area with fewer monuments. Preservation, state of research, less settlement or interaction activity might cause a reduction of monuments. Additionally, this procedure results in the calculation of residuals at the borders of the monument distribution. Both effects must be regarded when interpreting the results. Finally, using the Peucker-Douglas algorithm [378] reduces zigzagging line constructions and creates a path system near a monument density.

A R script (RePath.R <sup>9</sup> documents the described workflow [388] <sup>10</sup>. Furthermore, it provides all necessary functions from the used R libraries (shkrdata [339], sp [39], spdep [39], rgdal [417], raster[413], spatstat [12], tidy [159], ggplot2 [158]) and directories for data to reproduce results. The resulting path system can either be exported as a lines object (fig. f: 5.1) or as a grid object. For plotting, a line object results in well-illustrated path systems. However, density ridges may have a significant width, especially near traffic junctions. The width of a density ridge corresponds to possible path bundles. For further analysis, e.g. cultural distance diagrams, the grid prevents a rounding error.

Often critic on reconstructed path systems address the incompleteness of data collections, doubting the plausibility of the entire model as— preservation, recovery and state of publication influence the quantity and quality of data available on prehistoric monuments. A critical evaluation of possible distorting source-critical effects always precedes conducting an empirical analysis (chap.: 4.1.1). The precision of coordinates defines the res-

<sup>8</sup> Besides raw data, scripts are stored in a git repository to reproduce and inspect results (<https://gitlab.com/FFaupel/analyse>).

<sup>9</sup> <https://gitlab.com/FFaupel/analyse>

<sup>10</sup> R script for the local path system in the subarea Hagenau; RePathHag.R.

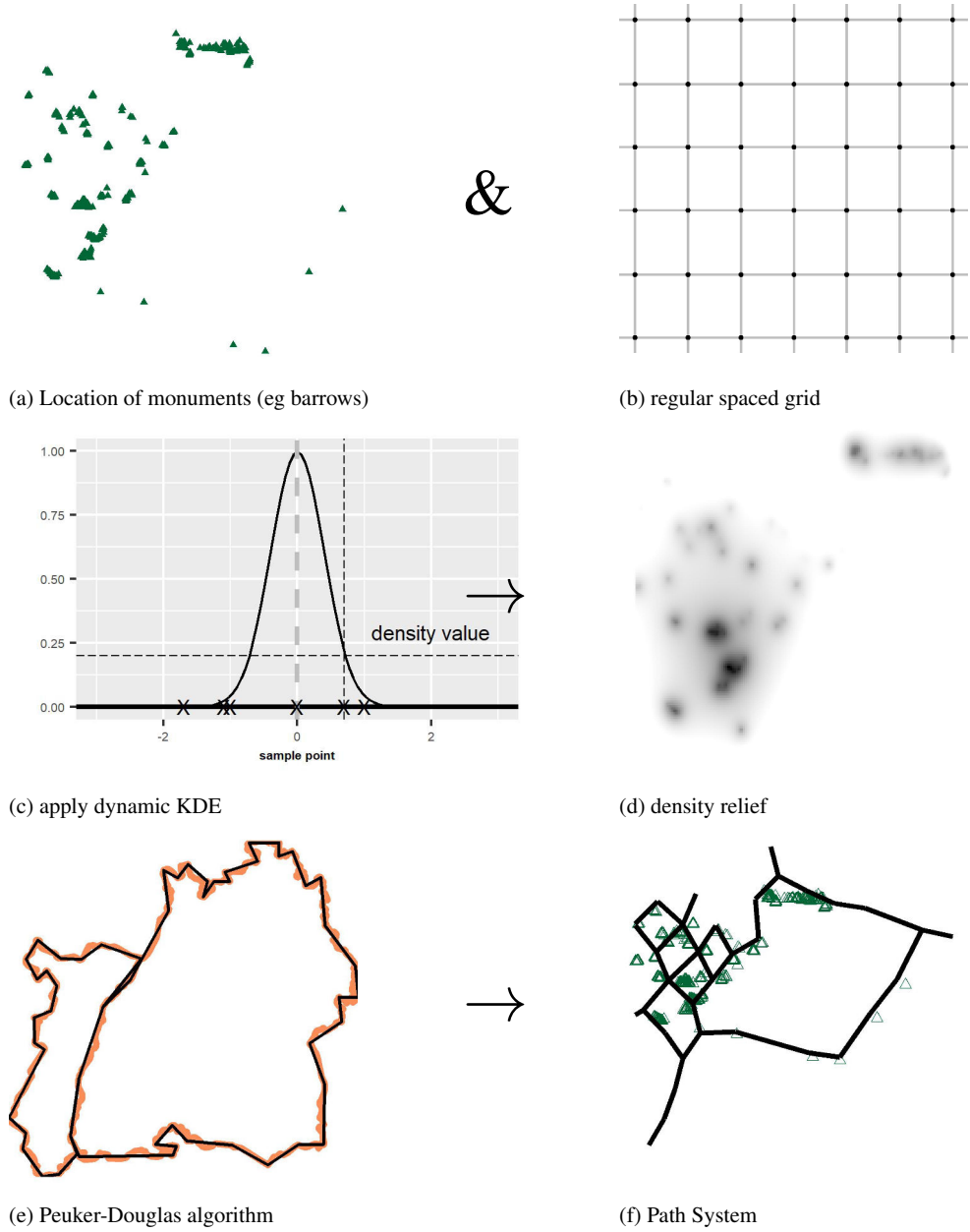


Fig. 5.1: Reconstruction of path systems along monument densities (RePath method).

olution of the reconstructed path systems. An area with only insufficient data on the location, like up to 5 km deviation, might not serve the requirements of a locally reconstructed path system but a regional path system.

However, testing robustness in reproducing a reconstructed path proves the plausibility of the model [111]. A Bronze Age path system in Schleswig Holstein (Germany) repeatedly reconstructed with randomly reduced monuments results in comparable path systems until a reduction to 60%. The deviation occurs especially at borders of the testing area. The central axis is correctly reconstructed until 20% reduction, while further deviation occurs for traffic junctions and the connection of the hinterland. Although effects on preservation and recovery likelihood do not follow a random distribution, this test illustrates the method's robustness as it reconstructs path systems along locally determined monument densities.

## 5.4 Modelling Parameters of Infrastructure

To understand path systems, identifying those parameters crucial for the prehistoric population is necessary, which needs the creation of theoretical models designed to evaluate a specific aspect (chap.: 2.3.2.3). The comparison with empirical data will evaluate those parameters possibly influencing the path system. Herzog [185] suggests validating Least Cost Path calculations compared to remnants of old routes or route indicator sites, e.g. barrows. As mentioned before, barrows are path associated features serving as monuments displaying path systems in a landscape. If a theoretical model fits the prehistoric reality, the modelled path system has short distances to monuments, e.g. barrows. Fig. 5.2 and 5.5 illustrate the workflow from creating theoretical models to their evaluation.

To model theoretical path systems, locations spanning theoretical networks are crucial to define origin and destination (fig.: 5.2). Phillips and Leckman [379] used archaeological artefacts representing residential sites as locations. Others used locations in gentle terrain [198], or medieval villages to predict Roman roads [500]. As stated earlier, using the location of settlements for infrastructural studies is biased by several effects (chap.: 2.3.2). High local density centres of barrows indicate junctions and settlement centres. Therefore, based on barrows density, a theoretical network is constructed connecting settlement centres [111], while connecting individual settlements via cul-de-sac. A dynamic KDE, similar to the method described above (chap.: 5.3) detects locally occurring densities of monuments in a given spatial extent. As no information is available on actual connections, a Delaunay triangulation depicts natural neighbourhood connections. For evaluating the theoretical models, the distance to the nearest monument serves as an indicator of model fit; nevertheless, no circular reasoning occurs. The method to detect settlement centres uses the same data; however, path systems are modelled independently.

A theoretical model is designed to test the influence of one specific parameter on the location of paths (see discussion in chap.: 2.3.2.3). For each model, a cost component depicts either high or low costs of one factor (fig.: 5.2). Availability, precision or method for simulation directs the selection of parameters in creating theoretical models. Environmental aspects, like topography, viewshed or preferred movement along mountain ridges are generated based on elevation values (see below for details on the creation of cost components 5.4.1 to 5.4.4). Social influences or political influences remain challenging to model [183] [269], as they often cannot be derived from geographical parameters. Different meanings and values assigned to locations by different people [291] complicate modelling social cost components. Here, two archaeological models illustrate a simple creation of theoretical models using site locations.

The creation of cost components inherits transfer costs of a parameter onto the spatial extent of a given landscape (fig.: 5.2). Cost components unaffected by the direction of movement are isotropic, like vegetation, crossing large rivers or visibility [184]; [65]. In contrast, anisotropic costs result in deviating costs depending on the direction of movement. Walking downhill is generally more comfortable than the opposite direction [185]. Therefore, slope or movement along rivers are anisotropic costs. After modelling (chap.: 5.4.1 to chap.: 5.4.4 for details), a combination enables us to construct more complex, and therefore more realistic models.

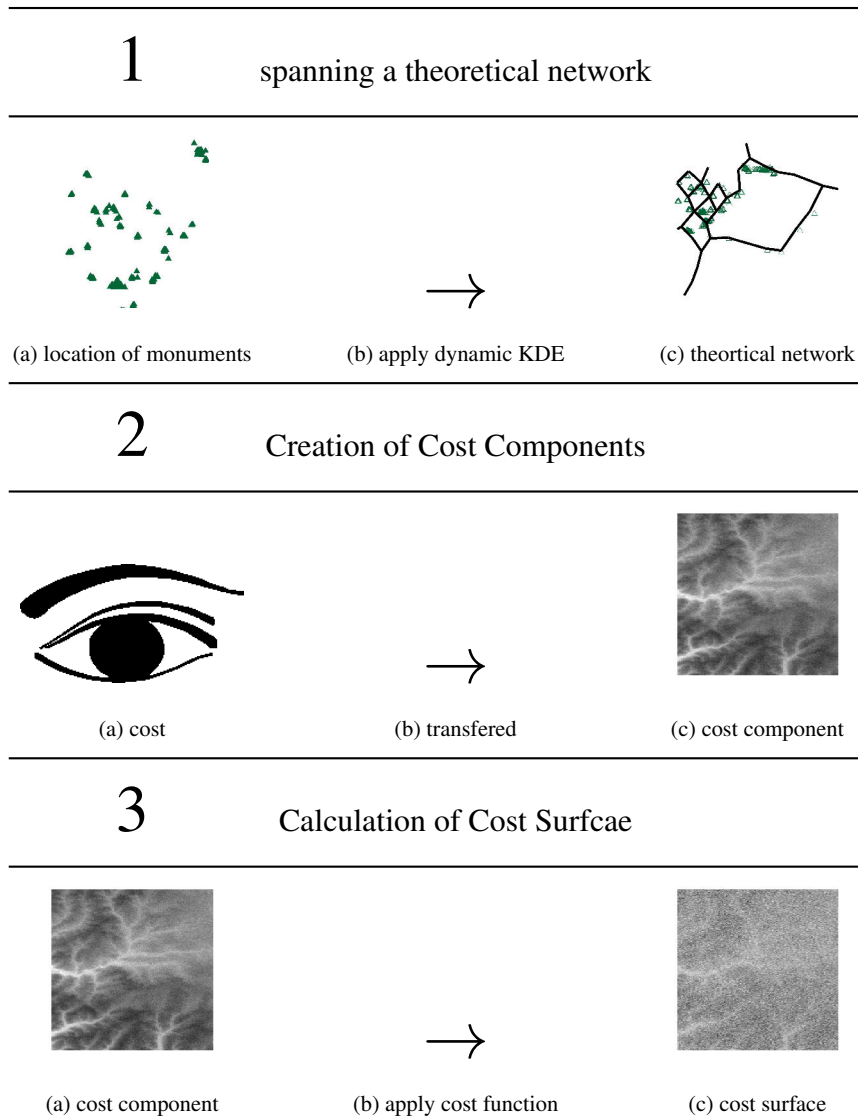


Fig. 5.2: Modeling parameters of infrastructure: Steps 1 to 3.

For constructing Least Cost Paths, Surface-Evans and White [479] state that the more variables included in the model, the better it potentially captures the representation of the past. Combining numerous models might correspond better to reality; however, the heuristic value does not improve. Here, the models are designed to identify the influence of parameters.

As planning no Least Cost Path reconstruction, three modes of each theoretical model tests the influence of each parameter in different settings. Mode a neglects topography by only respecting the additional cost component, mode b weights pedestrian movements and the additional cost component equally, and mode c pronounce the additional cost component. However, the first two theoretical models test either pedestrian movement or wheeled vehicles simulating no other modes.

Cost components are transferred into cost surfaces by applying a particular cost function (fig.: 5.2). Herzog [185] states that the cost function is fundamental in the Least Cost Path analysis, as it calculates — and therefore regulates — the costs moving from one cell to its neighbours. The cost functions define the effort of moving a certain distance based upon the values of a particular parameter; for instance, the slope [336]. Depending on the applied function, costs refer to speed or energy consumption. Kantner [215] criticises that no evaluation is available to choose which cost function models best real human movement. Toblers [488] Hiking function is often applied in archaeological studies, although Herzog criticises the unscientific data from which the function results from [185]. Minetti et al. [316] developed a function based on energy expended by runners walking and running at different slopes. The sixth polynomial approximates the energetic costs while eliminating unrealistic negative values for steep downhill slopes [184]. This function is applied to slope values to create cost surfaces modelling pedestrian movements. To approximate the cost for wheeled transport Herzog [184] provides a symmetrical function based on LLobera and Sluckin [290] cost function to approximate metabolic energy expenditure. Using the gravity approach to modelling attraction of site locations reduces terrain costs in TM 7 and 8. After defining a zone of attraction and the mode of reduction, the cost function for pedestrian movements models these cost surfaces. For additional cost components modelled for TM 3 to TM 6 summing the costs to conduct a movement respects inserted costs (chap.: 5.4.2 and chap.: 5.4.3 for details). An additional cost function is not necessary. However, the algorithm in R expects conductance values [205]. Conductance is reciprocal cost; therefore, inverted costs are simulated for TM 3-6.

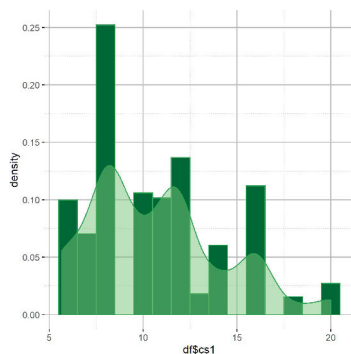


Fig. 5.3: Histogram of cost stores in cost surface of additional component (TM3).

Some cost components result in highly detailed cost surfaces, depending on the local variation of inserting values. This can be observed in TM6 (chap.: 5.4.3). Other cost components with less deviating values will smooth the slope depending on the cost surface, which is evident for both archaeological models. This effect is visible when comparing different cost components (see below). Multiplying cost components preserve the variation of both components [186], which is important for constructing a Least Cost Path. The additional cost component, e.g. not slope, of theoretical models TM3 to TM6 is examined under different theoretical backgrounds. Instead of searching for the best fitting cost curve (combined cost components), different settings test each cost component. Hence, the cost components are combined by addition, not multiplication. Fovet and Zaksek [132] combined slope and visibility by adding theoretically no dependency between these two parameters. Visibility is not more important on steep hills than on flat terrain. Addition acquires both cost components being comparable to cost dimensions; otherwise, influences are not measurable. Fiz and Orengo [124], for example, added slope and a factor of wetness after normalising the cost values. The range of cost values for each model checked separately by creating a cost surface within a randomly chosen spatial extent. Histogram of cost values compared with results in rescaling of one component. Fig.: 5.3 depicts the range and frequency of cost values calculated for TM 3 (avoiding visibility). Visibility costs vary from 5 to 20, while the cost for pedestrian movements in the same area range from 0 to 0.020, as shown in fig.: 5.4. Rescaling is explicitly mentioned in the construction of theoretical models below.

Besides choosing an appropriate cost function, allowed movements into neighbouring cells regulate the path construction. Moving in cardinal directions (4) results in a so-called "elongation error" [168]. The difference between the length of Least Cost Path (following cells of a raster) and optimal straight line reduces with increasing neighbourhood kernels [197]; [180]; [186]. However, larger neighbourhood kernels as 8 (connecting all-natural neighbours) allow for skipping cells with higher costs, e.g. barriers. If not ensured, that barriers are wider than skippable cells by proposed 24 movements [180] smaller neighbourhood sizes respect those cost barriers better.

The two last steps are the calculation of the optimized path and the evaluation of results. To avoid environmental determinism and allow searching for alternative path instead of a Least Cost Path, a so-called Least Cost Path corridor analysis calculates areas of preferential movement based on accumulated cost surfaces (chap.: 2.3.2.2). Accumulated cost values, from several origins to destinations, illustrate and evaluate a cost relief (fig.: 5.5). Cells with low costs are assumed to be crossed more likely, than those with high accumulated costs. The accumulated cost surface enables us to evaluate alternative routes restricted by Least Cost Path calculations. Cost values of accumulated cost surfaces range between 0 for being optimal to 1 for the least acceptable. Accumulative cost surfaces avoid the use of randomizing factors as in the "passage" function of *gdistance* [205]; [420]. One accumulated cost surface is calculated for each theoretical model and its modes, resulting in 18 different representations of Least Cost Path corridors within the area in question.

These areas of preferred movements, stored in the accumulated cost surfaces, inhabiting several alternatives optimised paths, serve as a comparison with the empirical data (fig.: 5.5). An accumulated cost surface stores a cost value for each cell, selecting those most likely part of an optimised path. 10% of those values with the lowest costs serve as possible alternative routes. The distance to the nearest neighbour from each cell to locations of barrows depict the model fit. The median distance is an expression for confirmation of archaeological reality. The median is appropriate due to outliers, which occur in areas with lower data coverage.

As a reference, a simple basic theoretical model uses direct connections. These paths, "as the crow flies", are unrealistic. A theoretical model should result in lower distances than the basic reference model; otherwise, it is unrealistic. Additionally, the following five nearest neighbours indicate the robustness of the model fit. The median represents the global model fit of each mode of the theoretical model. Therefore, the evaluation results in five values (five medians of nearest neighbourhood distances) and three modes per theoretical model. Assuming that the best model fit is where the distances to monuments are lowest, the best performing model has the lowest median distance values.

A R script (TheoPath.R<sup>11</sup>) documents the described workflow [388]. Furthermore, it provides all necessary functions of the used R libraries (*leastcostpath* [280], *gdistance* [205], *sp* and *spdep*[39], *rgdal* [417], *spatstat* [12], *raster* [413], *shkrdata* [339] and *tidyr* [159]) to reproduce results. First, a KDE estimation of monument locations estimates the nodes within the theoretical network. The resulting local maxima are used to construct a Delaunay triangulation representing connections to all-natural neighbours. This theoretical network also serves as the basic reference model. Location of origin and destination and coordinates of subareas for each cost calculation are stored in a data table. Several theoretical models required a complex calculation of cost components documented in separate R scripts. The resulting cost components are loaded for further steps. Cropping the spatial area into smaller subareas is necessary to facilitate fast computation. However, a large buffer added around each location ensures adequate coverage for cost calculations. Additionally, as accumulated cost surfaces are combined to represent a global cost surface, a smaller raster transaction has no disadvantage. Each theoretical model, and each mode, is calculated successively. Therefore, an empty raster is provided to store accumulated costs calculated within a loop. Inside this loop, an accumulated cost surface is calculated for each theoretical network connection in both directions. Besides creating spatial points for origin and destination, the DEM is cropped by the present subarea's extent. A function [280], creating a sloped surface and applying a cost function to calculate a cost surface allows conveniently for conducting several separate steps described by [205]. The accumulated cost surface for each transect accumulates from origin and destination. Finally, this accumulated cost transect is transferred into the global raster.

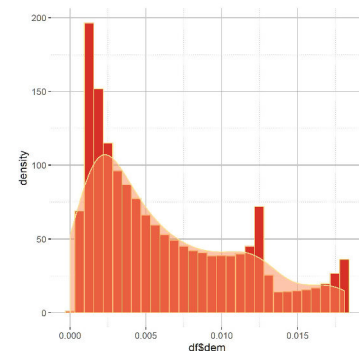


Fig. 5.4: Histogram of costs for pedestrian movements (TM1).

<sup>11</sup> <https://gitlab.com/FFaupel/analyse>

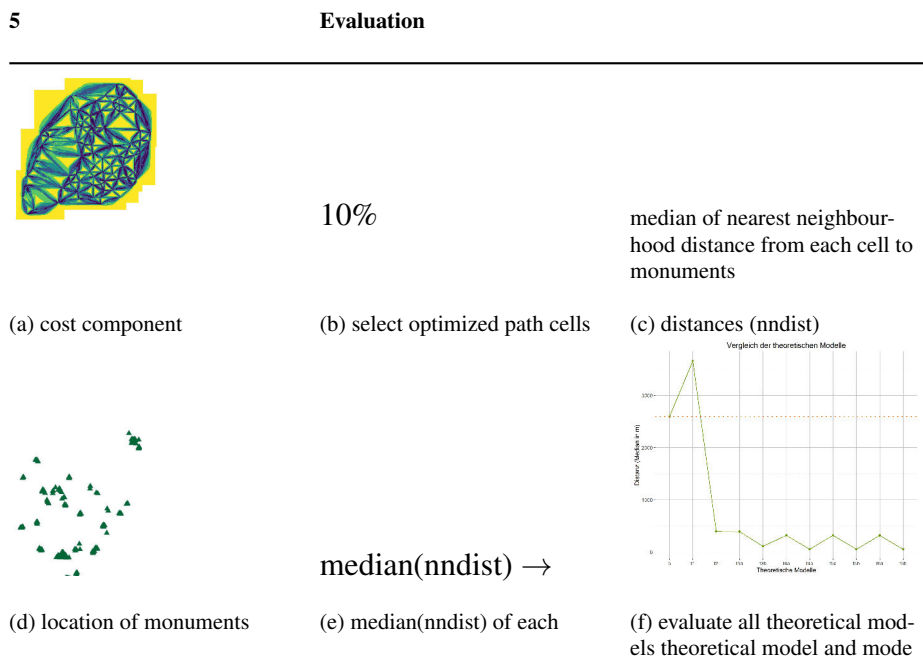
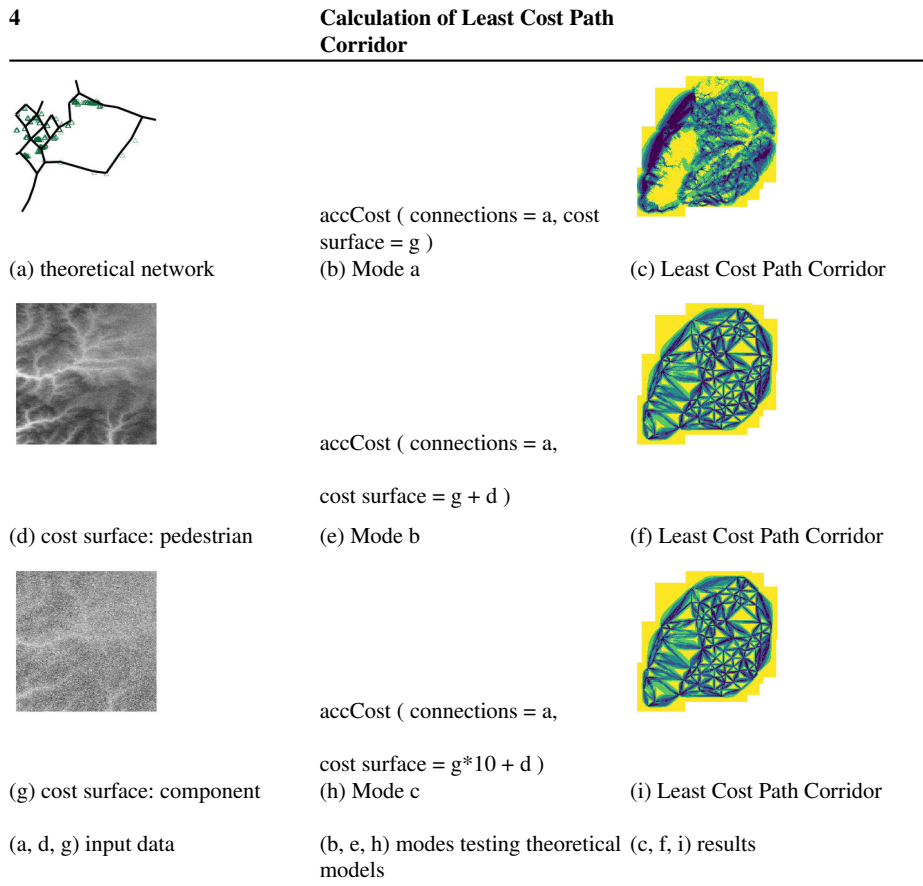


Fig. 5.5: Step 4 and 5

TM	Mode	Cost A	Cost B
TM 1	none	pedestrian walk	none
TM 2	none	wheeled vehicle	none
TM 3	a	none	avoiding visibility
TM 3	b	pedestrian walk	avoiding visibility
TM 3	c	pedestrian walk	avoiding visibility *100
TM 4	a	none	preferring visibility
TM 4	b	pedestrian walk	preferring visibility
TM 4	c	pedestrian walk	preferring visibility *100
TM 5	a	none	preferring lowlands
TM 5	b	pedestrian walk	preferring lowlands
TM 5	c	pedestrian walk	preferring lowlands *100
TM 6	a	none	preferring ridges
TM 6	b	pedestrian walk	preferring ridges
TM 6	c	pedestrian walk	preferring ridges *100
TM 7	a	none	attraction of settlements
TM 7	b	pedestrian walk	attraction of settlements
TM 7	c	pedestrian walk	attraction of settlements *100
TM 8	a	none	attraction of production sites
TM 8	b	pedestrian walk	attraction of production sites
TM 8	c	pedestrian walk	attraction of production sites *100

Table 5.3: Theoretical models with mode and cost components.

Another R script [388] (EvalPath.R<sup>12</sup>) documents the evaluation of theoretical models (rgdal [417], raster [413], spatstat [12], sp and spdep [39]; FNN [30], shkrdata [339], tidyr [159] and ggplot2 [158]). Besides loading archaeological data, all theoretical models, including the basic reference model, are reduced by those smaller than the second quantile. The coordinates of the corresponding cells are used to calculate the nearest neighbourhood distances for five neighbours. The median of each theoretical model mode illustrates the model fit. For each regional evaluation, a separate R script documents the performed steps. The process is similar to the above-described process, the spatial extent of the subarea crops only each accumulated cost surface.

### 5.4.1 Pedestrian Walk and Driving

The first two theoretical models are terrain depending models. The movements of pedestrian (TM1) and the use of wheeled vehicles (TM2) with a critical slope value of 8% are the most common applications in archaeological studies [183].

For both cost components, the slope of a DEM is the base of operation. A DEM represents a real-world topography, whereby elevation values are stored in a set of raster cells [517]. Naturally, the DEM resolution influences the optimised path calculation (chap.: 3.2). Although the following examples refer to the Least Cost Path calculation, an accumulated cost calculation expects comparable results. Kantner [215] states that DEMs with resolutions of over 30 m are too unprecise to adequately model humans movement over a landscape. Additionally, a generated cost surface bears little resemblance to the landscape [517]. Herzog and Posluschny [180] compared Least Cost Path calculations with 25 m and 100 m resolution DEMs, resulting in two different

<sup>12</sup> <https://gitlab.com/FFaupel/analyse>



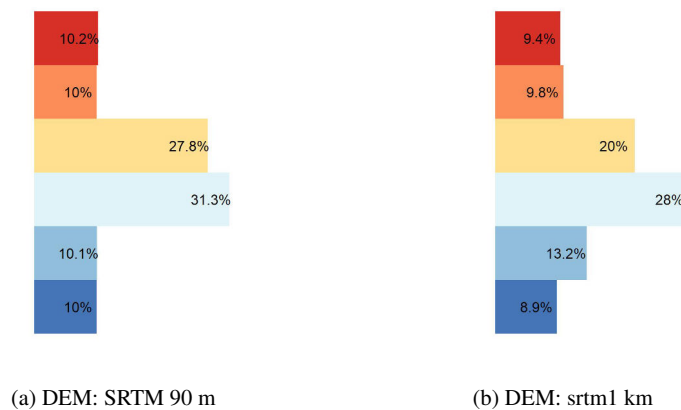


Fig. 5.6: Statistic of landform classification (method: DEV).

paths: 25 m following ridges, the other follows valleys. In contrast, little differences between paths calculated on 10 and 90 m resolution are documented by Surface-Evans [480]. Herzog and Posluschny [180] criticise that only a few authors address DEM related issues, like smoothing DEM with a possible decrease in the proportion of steep slope cells [454]. Comparing landform classes based on TPI calculations (chap.: 5.4.3) of SRTM90 and smoothed DEM to 1 km resolution illustrates changes (fig.: 5.6). Whereby ridges, upper slopes and valleys are reclassified consistently, middle and lower slopes and flat areas show the most variations and represent most of the data. The changes, especially regarding the reclassification of the upper slope, appear moderate; however, the DEM with 90 m resolution is used, ensuring an appropriate computational time [285]; [412], while reducing - more importantly, modern disturbances.

Defined by Li *et al.* [281], the slope is the first derivative of altitude on a terrain surface. It measures the rate of change in elevation over distance [183]. As stated by Lock and Pouncett [292], or Wheatley and Gillings [517] several methods to calculate slope are available and influence the results of Least Cost Path calculations. Besides degree, per cent or rise over run [454] express slope. For the slope calculation to construct cost surfaces, the rise over run is applied and transmitted to the cost function estimating costs. The cost function simulating energy expenditure while walking from Minetti *et al.* [316] and modified by Herzog [183] is applied to calculate costs for pedestrian movements.

The cost function presented by LLobera and Sluckin [290] and modified by Herzog [183] simulates the use of wheeled vehicles with a critical slope value of 8%. TM2 results in a raster where accumulated costs smoothed the relief, as only those areas with steep slopes are assigned with considerably high costs. Those areas occur on the edge of Swabian Alb and the Black Forest.

### 5.4.2 Visibility

Visibility, a cultural cost component as Herzog [183] states, derives from topography. The same constraints apply for creating slope-based cost surfaces (chap.: 5.4.1). Two contradicting models are created based on viewsheds. TM 3 models the avoidance of well visible areas, while preferred by TM 4. Viewshed analysis explores the indivisibility of two points (observer and target points) within a given landscape by assessing whether there is an uninterrupted straight line of sight [275]. This individual depiction of visibility, often with binary output, does not reflect reality's complexities [56]. Cumulative viewshed summarises individual binary viewsheds and results in a number indicating how often a cell was observable [516]; [517]. Wheatley and Gillings [517] point out that cumulative viewsheds are sensitive to edge effects.

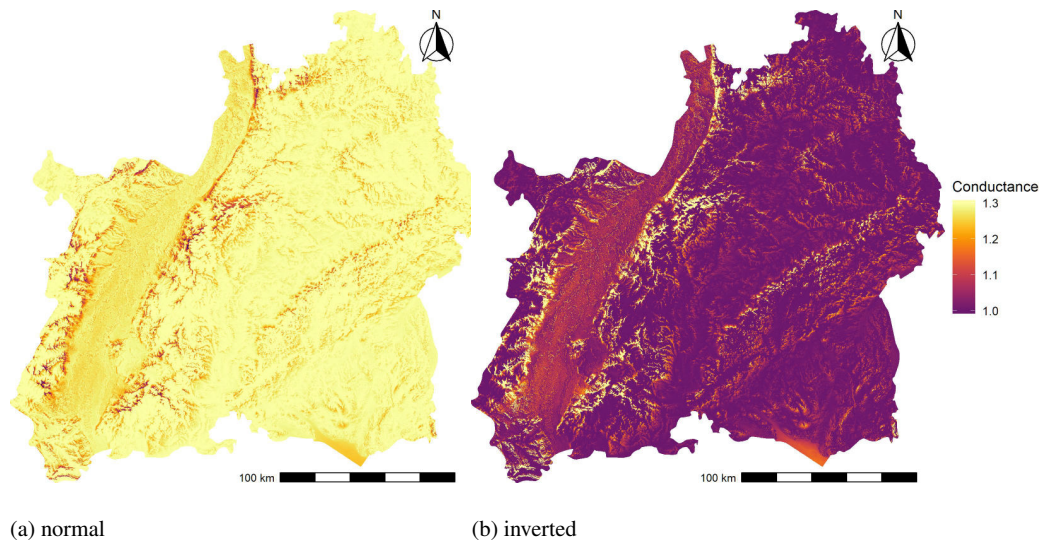


Fig. 5.7: Cumulative viewshed (method: `r.viewshed` (Haverkort [172]),  $r=3$  km , DEM: SRTM 90 m).

Fisher and colleagues [123] criticise the missing statistical testing of applied viewshed analysis. For example, Iron Age roads' visibility from hillforts is not tested against randomly distributed points to evaluate whether roads are generally well-visible. Here, cumulative viewshed to construct cost surfaces use regularly spaced sample points to create visibility values that depict global visibility. Testing using randomly spaced locations is not necessary.

A R script (`viewshed.R`<sup>13</sup>) documents the described workflow [388]. It uses the GRASS GIS implementation of the viewshed function `r.viewshed` [172]. Besides elevation values stored in a DEM, this function needs view-points and an output raster. Regularly spaced sample points with a distance of 3 km to each other are transmitted to GRASS as viewpoint locations. 8,832 separate viewsheds are calculated and cumulated to a cumulative view in R.

Besides inverting the cumulative viewshed, TM 3 and 4 altitudes of costs are increased by exponentiation with 2. Fig.: 5.7 illustrates the conductance values for avoiding visibility (TM 3). Those raster cells depicted in yellow have the highest conductance values, therefore the lowest costs. In Contrast to the model preferring visibility, an inversed cumulative viewshed serves as an input for TM 4. Costs from the pedestrian movements in TM 3 are rescaled with 10, and in TM4 with 10,000.

### 5.4.3 Lowlands and Mountain Ridges

Besides slope and visibility, TM 5 and TM 6 are two additional cost components based on terrain. Again, the models are designed to depict contradicting conditions. TM 5 prefers movement along low altitudes (fig.:5.8). Higher altitudes refer to high costs; in such a way, costs are exponentially lower alongside lowland movements. Elevation values from a DEM on a 90 m resolution are inverted, and the inverted elevation is exponentiated to increase costs moving from one altitude to another.

The construction of the cost component of TM 6 uses a topographic position index. Topographic Position Index (TPI) is a commonly used algorithm measuring topographic slope position and automate landform classi-

<sup>13</sup> <https://gitlab.com/FFaupel/analyse>

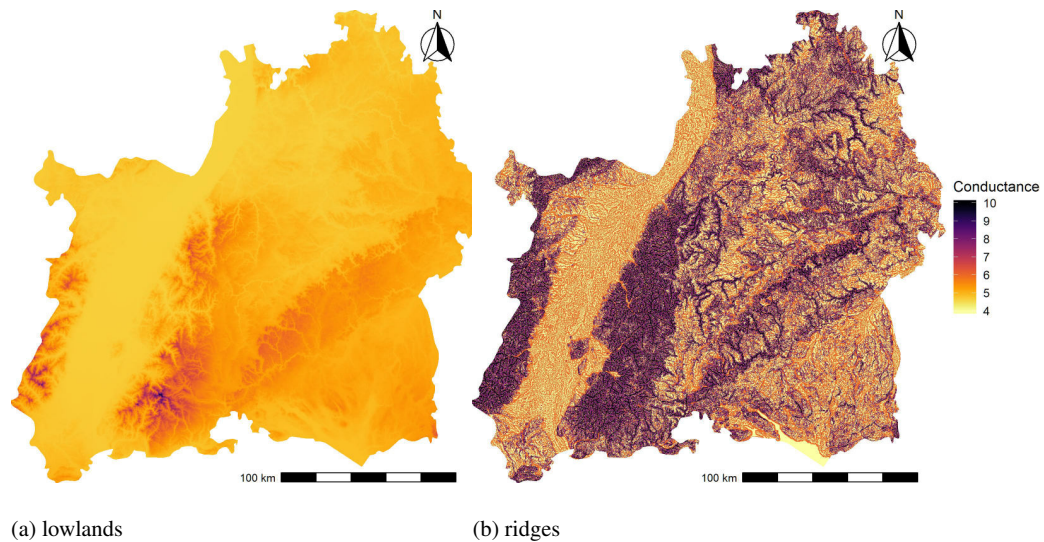


Fig. 5.8: Costs for movements along ridges and lowlands (method: DEV, data: SRTM 90 m, neighbourhood size 1 km radius).

fication [512]. It measures a central point's relative topographic position as the differences between the elevation and the mean elevation within a pre-determined neighbourhood. The range of TPI values depends on deviation differences and the neighbourhood size. Large neighbourhood sizes reveal major landscape units, and smaller ones highlight small features, such as minor valleys or ridges [152]. In a second step, the TPI can be used to classify into slope position classes<sup>14</sup> [512].

As TPI was developed and tested for mountainous and homogenous landscapes, it operates with sufficient accuracy in these areas. TPI is strongly influenced by surface roughness. An area of subtle relief with elevation differences of a few meters, TPI cannot estimate the landform correctly, as De Reu and colleagues [405] pointed out. For example, applying TPI would have led to the wrong classification of Bronze Age barrow location (mainly on middle slopes and flat area). They were located on higher ridges in subtle topography, affecting the archaeological interpretation [405]. De Reu and colleagues criticise that since TPI was integrated into widely used tools (like ESRI products), it was uncritically applied by users without solid geomorphological background [404]. Therefore, they propose to use the Deviation from Mean Elevation (DEV), [525] in heterogeneous landscapes with both low and high reliefs to improve landform classification as it allows to identify prominent locations also in flat areas [404]. The DEV method uses TPI for measuring the topographic position and the standard deviation of the elevation. DEV values range between +1 and -1<sup>15</sup>. Like TPI, positive values indicate a higher position than the given neighbourhood, while negative values indicate a lower position. Depending on the analysis, scale and heterogeneity of landscape, either landform classes by Weiss [512] or more complex landform classes by De Reu [404] classify DEV values. Besides choosing the appropriate algorithm, the size of the neighbourhood influences the landform classification. Most robust landforms are ridges and valleys, and most variable classes are upper slopes, which increase while middle slopes decrease [404].

A R script (GeoData.R<sup>16</sup>) documents the applied landform classification [388]; [404]; [512]; [159]; [39]; [417]; [12]; [413]. Rescaling of cost for preferring lowlands in TM 5 was necessary with a factor 100,000, while the same factor was necessary to rescale pedestrian movements in TM 6.

<sup>14</sup> Weiss defined six landform classes: ridge, upper slope, middle slope, flat area, lower slope and valley [512].

<sup>15</sup> Higher values might indicate anomalies within the DEM [404].

<sup>16</sup> <https://gitlab.com/FFaupel/analyse>

### 5.4.4 Archaeological Models

Finally, two models using archaeological data to simulate cultural costs. TM 7 uses the location of settlements to model attraction and TM 8 production sites. As not necropolis or barrows interact but the nearby living population, a gravity approach simulates settlement attraction. The designed model tests whether the location of settlements influences the path system. A buffer of lower costs surrounds settlements dating to the Early Iron Age to create TM 7. The choice of an appropriate buffer is crucial for the construction of this model. Large buffer zones like 5 km result in large interlinked zones with reduces costs. For coherent zones, the attraction of sites is not measurable. Too small buffers do not influence enough raster cells to facilitate a measurable effect.

Furthermore, a settlement can only attract attention if it is perceptible. A direct line of sight is not necessary; other peopling indicators are agriculture, frequently used paths or smoke overcome more considerable distances. However, these distances depend on local relief, seasons and population density. Therefore, an empirical value, the mean of the nearest neighbourhood distance (1,270 m), defines the buffer's size. Subsetting each buffer's values might lead to unwanted steps and ridges in the cost relief (see. fig.: 5.9). Steps can operate as barriers hindering wanted attraction during the idealized path construction.

The zone of attraction for iron production sites is defined similarly, resulting in a radius of 3,574 m. Those sites identified by Gassmann [143] are spatially restricted to the Swabian Alb. Therefore, this model only applies in this subarea; as for others, the data is missing.

After defining an appropriate size of zones for attraction, a function provided in the least-cost path library by Lewis [280] creates a feature cost surface representing attraction or repulsion of features in the given landscape based on theoretical background by Llobera [287]. The defined radius is divided by the DEM resolution to obtain the number of rings around each feature (15 rings). Afterwards, decreasing attraction values are assigned to each ring. The first mode, "a", uses only the feature cost surface and models the attraction by settlements disregarding topography. Modes "b" and "c" include the topography using the pedestrian cost surface created in TM1. The difference between b and c is the reduction to 70% and 30%.

Naturally, densely settled areas had a greater attraction force than only sporadically distributed sites. Source-critical effects, however, bias an influence of the total number of sites. As stated earlier (chap.: 4.1.1), the Neckar Valley and those covered by extensive research projects unbalance the data collection. Incorporating settlement density is highly sensitive towards counting errors. Additionally, not interaction intensity is modelled here; a path system might be equally attracted to one single settlement as it is attracted to a dense zone of settlements.

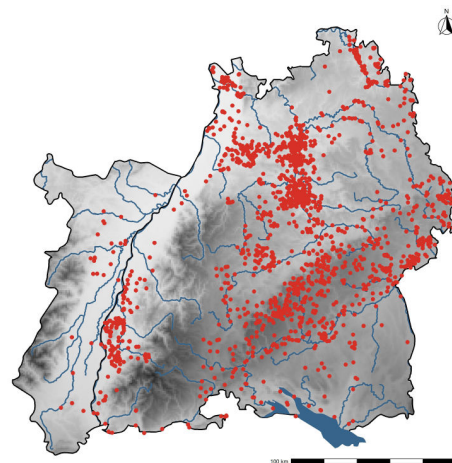


Fig. 5.9: Gravity zones around Early Iron Age settlements (data: SHKR20,  $r = 1,270$  km, DEM: SRTM 90 m).

## 5.5 Model Patterns of Interaction

In contrast to the basic work by Nakoinz [345], the present study does not aim at structuring the cultural area but at a better understanding of the infrastructure and interaction relationships of the Early Iron Age. In order to make a well-founded reconstruction of the cultural spaces, Nakoinz has to apply a complicated two-fold

cluster analysis in order to be able to identify recurring spatial structures. As Nakoinz states, the method is based exclusively on the question; therefore, type spectra are calculated at regularly distributed sample points analogous to Nakoinz for creating distance diagrams. The selection of three artefacts (vessels, ring jewellery and garb) is used together with the entire archaeological inventory to assess the spatial interaction structure. The cultural dissimilarity, preserved in the material culture, is measured by the cultural distance (chap. : ref sec: 3Inter). Some of the distance diagrams developed by Nakoinz *et al.* [347]; [336]; [337] appear in the same form or slightly modified. The strong reference to river systems in question has also led to developing a new distance diagram and considering so-called princely seats in their cultural and historical environment.

### 5.5.1 Type Spectra

Type spectra are a form of representing the distribution of types. The history of research often influences the classification of an archaeological type. Types can be classified as phenotypes of a composite object [303] or based on the combination of individual elements. The limits of a traditional archaeological classification are considered more precisely above (chap.: 5.1.1) and also in the chapter on archaeological artefacts (chap.: 4.3). The present numerical classification, however, allows decomposing artefacts into individual degrees of specialization. The same classifying features and attributes of artefacts are related to one another based on simultaneous models, previous predecessors, mutual influencing of producers, further development or modification [442].

The degree of specialization expresses a measure of information deriving from an artefact [345]. For example, the classification of a decorated artefact contains more data than an undecorated artefact. Alternatively, a sherd of the wall of a conical neck vessel provides only few information. On the other hand, a completely preserved artefact can provide a wealth of data relating to shape, technique, and decor. Therefore, the analysis should include the depth of the information on the degree of specialization. This weighting is easy to generate based on the SHKR classification<sup>17</sup>. The hierarchical order is projected into an unstructured classification so that a highly specialized data set counts each level of specialization. If there is only a low degree of specialization, this artefact counts less often into calculating the type spectra.

Interaction is a countable event. The counting of a foreign feature needs a transformation to become an interaction proxy (chap. : 2.2). This problem can easily be illustrated using the example of import finds. The proportion of identified imported goods depends mostly on excavation, publication and archaeological processing. The relation of imported goods to local material helps to reduce this disadvantage.

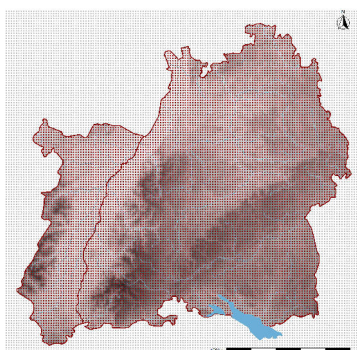


Fig. 5.10: Sample points for type spectra (DEM: SRTM 90 m).

The distribution of the sites and the natural features, conservation and rediscovery, is also influenced by research, leading to distribution priorities. In particular, conservation artificially distorts the composition of the artefacts. The special preservation conditions of the so-called *Keltenblock* [253]; [254]; [255] clearly illustrate the numerous missing items and features. Even if not all objects are transferable to other grave assemblages, such artefacts belong to material culture in a certain regional area. Graves represent an individual arrangement that is nevertheless not detached from the cultural environment, even emphasising remote contacts. Together with the finds from nearby settlements, this results in a regional representative compilation. Artefacts advertised as luxury goods, such as gold objects or imports from the Mediterranean region, are put into the right relation in their influence on the composition by local and everyday products.

The definition of which individual sites belong together and where to locate the boundary between a regional compilation is necessary. Because

<sup>17</sup> In this context, Nakoinz points out that methods that reduce correlation, such as a principal component analysis or *Mahalanobis* distance are not permitted [345].

of the already frequently mentioned cultural heterogeneity of the Early Iron Age and the spatial boundaries of cultural groups that cannot be identified, such a classification is inadmissible. No clear boundaries existed, so one cannot identify any features that would allow a subdivision. The risk of circular reasoning is also high.

Density mapping based on the KDE method (see above for a description of KDE 5.3) avoids the disadvantages described above. Regularly spaced sample points over the entire work area avoid an uneven distribution of the archaeological sites (chap.:5.10). Depending on the question, these sample points can be located, for example, at settlements. From each density map, extracting the density at each sample point results in a density value spectrum. The resulting range of types, therefore, relates to the corresponding sample point. The scope and detail of the type spectra depend on the selected artefact types and degrees of specialization. The type spectrum at a sample point are compiled by a vector of the individual's density values of find types. Normalization of the density values compensates for artificial distortions between areas with less and more fundamentals [345].

Considering all variables and not selecting assumed significant leading forms distinguishes the calculation of the cultural distance based on type spectra from traditional concepts of the cultural type fossil. Nakoinz illustrates this relationship very graphically using the geographic distance setting of sites only based on the coordinates' northing. Even if the locations differ based on their north values, a geographical distance without taking the easting value into account is wrong [345].

Since cultural areas are not focussed, it is permissible to select specific artefacts that are assumed in advance to show a social segment [345]. For example, wagons, swords, daggers and gold objects are symbols of a social elite. Whether it is the insignia of power, rank, or gifts is not of primary importance when considering the interactions between the individuals equipped in this way. Larger or overarching patterns might obscure latent variations in the interaction pattern. They disappear in the background noise. In some cases, e.g. to illustrate patterns of interaction of specific social segments, only a part of the classification should be used, or segments of decoration to retrace specially defined symbols [337].

Based on the results of the interaction analysis by Nakoinz [347] regarding the theoretical and methodological foundations, types of garb, ring jewellery, and ceramics were selected to be able to examine individual areas of interaction specifically. The preliminary results of Nakoinz indicate a connection with traffic routes for garb. Ring jewellery, ceramics and prestige goods seem to reflect extensive contacts.

The R script CalTS2km.R<sup>18</sup>) documents the described workflow. It provides all necessary functions of the used R libraries (magrittr [10], moin [232], R [388], raster [413], readr [522], rgdal [417], sf [376], shkrdata [339], sp [39], spatstat [12], tidyr [159]) to reproduce results.

Based on the working area's geographical boundaries, the sample points are generated at a distance of 2 km from one another and given an ID. The next step involves selecting the artefacts. Type spectra of the classification's facets are calculated (material, shape, technology and decoration). The steps for calculating the density values and extracting the type spectra do not differ between the facets. After the facet has been selected, the region's limitations (Baden-Württemberg, Bas-Rhin and Haut-Rhin) and the sites dating filter the entire data collection. Artefacts that consist of several components can include the materials glass and bronze. In these cases, the material entry is decomposed so that one entry for glass and one for bronze can be included in the evaluation. In addition to these composite artefacts, incorrect duplications of the facet designations from the database are filtered and corrected. like "AA221".

A density map loops through each type. For example, all occurrences that have A2 as the Chiffre refer to metal objects. Bronze objects are mapped, as well as iron objects. The mapping of a different degree of specialisation then only selects A221 as bronze objects, achieving the degree of specialisation's desired weighting. The method used to calculate the density is the KDE with a Gaussian membership function and 15 km bandwidth. The density mapping is transferred to a grid object within the loop so that the density values at the sample points can be extracted. The density values are then normalised. The resulting table contains the ID, the coordinates of the sample points and the density value of all types (by Chiffre code) ready for the distance calculation in a further step.

<sup>18</sup> <https://gitlab.com/FFaupel/analyse>)

### 5.5.2 Distance Diagrams

Nakoinz [345] emphasizes the importance of cultural metrics concerning the mathematical principles and the cultural-historic meaning. Naturally, the distance-determining metric is of importance for the creation of distance diagrams. The metric must meet four conditions:

- Elements have 0 distance from themselves.
- Points with 0 distance are similar.
- The distance is independent of direction.
- The distance between element 1 and 2 is less or equal the sum of distances between element 1 to 3 and element 2 to 3.

Curvatures in space are excluded. The Euclidean distance allows for such a metric, using the vector's length between the elements as the distance. A cultural metric exists when the distance between two type spectra is calculated as the vector's length between them using the Euclidean distance [345].

The present work pursues a spatial aspect when considering interaction. The cultural distance is plotted against the geographical distance in order to be able to provide an interpretation of the structure of interactions by comparing it with theoretical curves. The method is also applicable to other types of distance, such as examining the social aspect [347]; [464]. Nakoinz and colleagues [336] define nine types of distance diagrams. All possible combinations in the selection of viewpoints and foci: fixed, selected and all. Fixed points enable us to map the results in spatial relations, which allows for identifying the influence of different topographic features or different organisational structures. In contrast, all points allow us to interpret the effect of absolute distance on interaction like a threshold [347].

Distance diagram types of dd1, dd2, dd3 and dd5 are primarily used to examine the interaction patterns (fig.: 5.11). The reference point is fixed for diagrams of the type dd1, and a profile is selected, starting at the viewpoint. The cultural distance from the reference point to each point along the profile is plotted against each other's geographical distance. This diagram makes it easy to identify and interpret spatial references in the distance curve alongside the profile.

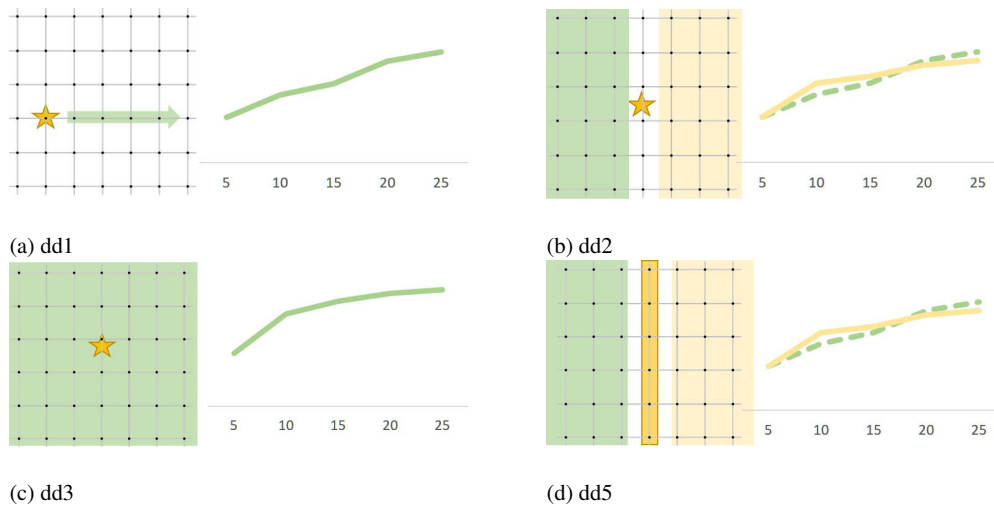


Fig. 5.11: Types of distance diagram.

One reference point is also selected for diagram type dd2 (fig.: 5.11). Based on the example with the princely seat, cultural distance is calculated to a segment of sample points. The cultural distance is again plotted against the geographical distance. For example, as selected sample points, all sample points below a nearby river or a cardinal direction are suitable. Such a representation allows the interaction pattern to be assessed for a selected area.

The diagram type dd3 selects a reference point, e.g. the princely seat, calculates the cultural distance to all other sample points and plots it against the geographical distance (fig.: 5.11). From this, the effect of absolute distances can be determined regarding a specific location.

The diagram type dd5 selects specific reference points, for example, a profile along a river (fig.: 5.11). Sample points that fall within a specific area are used to calculate the cultural distances. Sample points could be selected along both river banks up to a certain distance. The cultural distance is then averaged against the geographical distance.

The diagram type dd9 selects all sample points as reference points. During the first iteration, the cultural and geographical distance to every other sample point is calculated — the iteration proceeds throughout every sample point. The cultural distance is then averaged against the geographical distance.

For each princely seat, the code for creating the distance diagrams is stored separately. The use of the diagram type is explicitly pointed out in the relevant scripts.

### 5.5.3 Profile Diagrams

As already shown in the introduction (chap.: 1), Nakoinz has identified three communication corridors: along the valleys of the Rhine, Neckar and Danube [345]. Profile diagrams of the corridors are created to give a better assessment of the interaction patterns. This diagram type is a further development of the distance diagrams from Nakoinz and colleagues [336]; [337]. Based on dd1 diagrams, the curve's course does not run along with the profiles but along the corridor's central axis.

For calculating the cultural distance of orthogonal profiles, reference points are selected at a distance of 2 km on the corridor's central axis. Since both corridors considered refer to the rivers Rhine and Danube in the present case, the course of the river is the central axis.

The reference point is the corresponding sample point of type spectra (chap.: 5.5.1) on the central axis. The distance between the reference point and a target point of each profile is based on the type spectra's regular spaced sample points of the complete area. The profiles indicate the cultural dissimilarity to the respective reference point, enabling us to record similarities at different geographical distances.

Five different geographical distance classes are selected, representing local to regional references, namely direct surroundings (up to 10 km), local area (between 10 and 30 km), regional hinterland (between 30 and 50 km) and supra-regional setting (over 50 km). A reference map shows the geographical reference areas and helps to interpret the course of the curve. The cultural distance of a profile is averaged within the distance class and shown in the figures. When interpreting the curves, it is essential to note that the distance values refer to the central axis's reference point. Since the corridors under consideration are rivers, a corresponding curve displays each river bank. In addition to the representation of cultural distances as curves related to geographical distance classes, the cultural distances are summarised in the diagram type dd4 [336]; [337] (see above).

The Rhine flows mainly from south to north, which is why the profiles are oriented east-west. Figure fig. 5.12 shows the selected reference points of the central axis (green,  $n = 76$ ) and the sample points of the type spectra (orange,  $n = 6,878$ ). In contrast, the Danube flows mainly from east to west, so the profiles are oriented north-south. The figure (see (b) fig.: 5.12) shows the reference points of the central axis (green,  $n = 72$ ) and the sample points of the type spectra (orange,  $n = 6,477$ ). In both figures, it becomes clear that the length of the profile is not symmetrical. The boundaries of the working area occur east of the Rhine and south of the Danube. This restriction must be taken into account when regarding the curves in the profile diagrams.



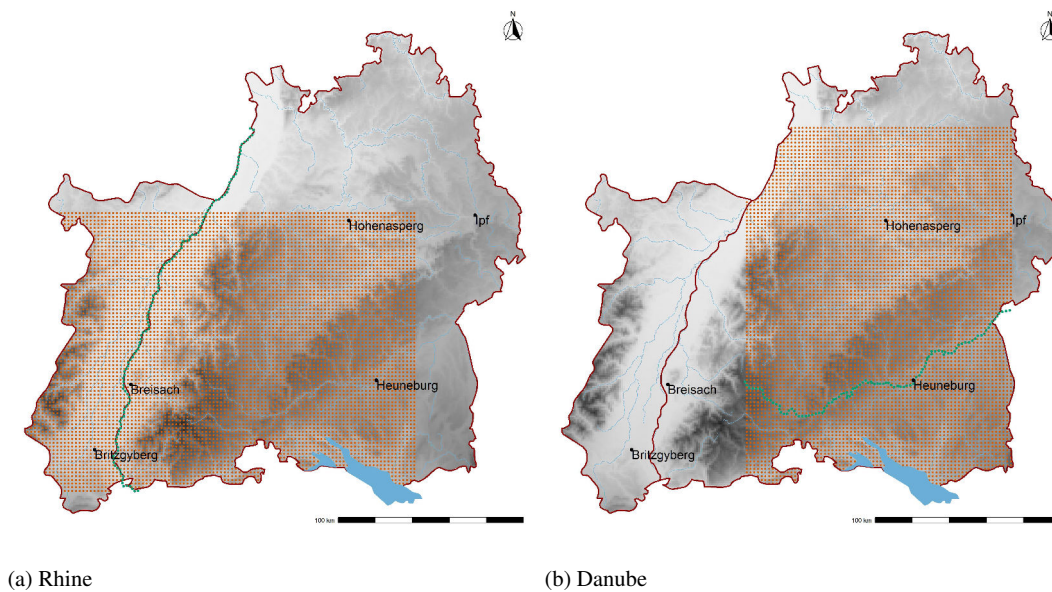


Fig. 5.12: Selected viewpoints and sample points for profile diagrams (green: viewpoints, orange: sample points, DEM: SRTM 90 m).

The profile curves are particularly suitable for recognising deviating interaction along the central axis. Since averaged cultural distances are shown as data points for each distance range, changes in the curve through these points show different interaction relationships. Low values reflect an intensive interaction since the type spectra show a small cultural distance. In contrast, high distance values along the axis are caused by different type spectra. The profile curve course does not provide any information about how the cultural distance has developed from a central axis point. Whether intensive interaction relationships occur in a distance area can be read from the absolute distance values.

If the maxima and minima are symmetrical in both directions from the central axis, the same interaction patterns are present for the corresponding distance range. A sizeable cultural dissimilarity of the central axis in the direct surroundings and the local area is due to the central axis's different type spectrum compared to the closer environment. The type spectrum includes both types and relations that are unusual for this area. There is an interaction boundary, or through interactions with more distant regions, a foreign spectrum occurs. Such a local interaction boundary should repeat in different type categories, similar to the defined archaeological culture. For the Early Iron Age, however, a diffuse boundary is more likely. Such a diffuse border can shift within a specific range, as far as there is an overlap of the individual groups. If there is an interaction boundary, it is expected that cultural proximity to the corresponding region of the group will arise. The spatial size of an interaction area is, of course, crucial for identification. Small areas might be unrecognisable due to the KDE bandwidth.

The desired interaction with more distant areas will also lead to a local, foreign spectrum of types since interaction always leave traces, and the corresponding distance range leads to lower distance values. However, since only regarding relation to the central axis orthogonally, an interaction partner lying apart from the orthogonal axis cannot be recognised in the curve progression.

Asymmetrical structures occurred when different interaction structures existed or the central axis lies in a peripheral zone. On the side with the lower values, the type spectrum is similar, i.e. culturally closer, whereas the central axis looks dissimilar in the other direction. Parallel structures are unintuitive in their interpretation. It does not conceal the same interaction pattern on both sides but somewhat opposing. Cultural proximity, on

the one hand, means cultural dissimilarity on the other. Asymmetrical interaction structures are hidden behind parallel curves.

Edge effects will influence if the sample points are close to the boundary of the working area. The fewer sample points there are in a distinct area, the greater the possible edge effects. While the density values for centrally located type spectra are robust due to data from the surroundings, this robustness lacks peripheral locations. A sharp artificial boundary also cuts off the inclusion of density values from the area behind.

An R script (AlongRhine.R<sup>19</sup>) documents the described workflow<sup>20</sup>. Furthermore, it provides all necessary functions of the used R libraries (R [388], sp [39], shkrdata [339], tidyr [159], sf [376], magrittr [10], readr [522], FNN [30]) to reproduce results.

After selecting those coordinates of the Rhine inside the investigation area, the closest type spectrum was selected as the reference point. Since the sample points of the type spectra have a regular distance of 2 km, the reference points are also distributed accordingly. The northing of the Rhine coordinate assigns the profiles. The calculation of the cultural distance from a profile's reference point to all other points along the profile takes place in a double loop. Selecting the profiles and sample points occurs in the outer loop, while the distances are calculated in the inner loop. In addition to the cultural distance, calculating the geographical distance is required later for the images. Whether a point is to the west or east of the reference point is assigned via the easting of the points.

In the profile diagrams, eastern profiles occur to the left of the central axis, so the cultural values are negated when illustrating. However, this has no further significance for the interpretation. One point cannot be more similar than the same to the other. The negative values are only due to the illustration. The cultural distances of the individual distance classes are averaged to create the profile diagrams. For this purpose, a table with profile numbers in rows and the individual distance classes east and west of the Rhine in columns stores all values. In addition to the cultural distances, the profile diagrams should also contain a smooth curve to follow the general trend in the data better. For the diagram type dd4, the entire sample points' cultural distances are averaged in 5 km steps of the geographical distance.

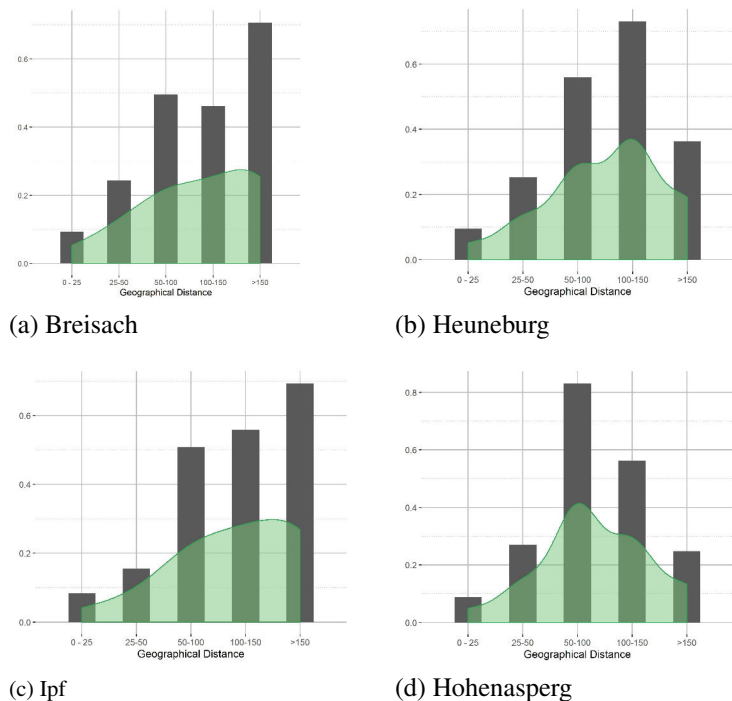


Fig. 5.13: Histogram of geographical distance classes.

<sup>19</sup> <https://gitlab.com/FFaupel/analyse>

<sup>20</sup> A similar workflow for the Danube only with a deviating orientation of central axis and profiles is documented in an R script (AlongDanube.R<sup>21</sup>).

### 5.5.4 Histogram of Cultural Distance

In contrast to the previous diagrams, which contrasts geographical distance to cultural distance, histograms represent cultural distance differently. The geographical distances are divided into symmetrical distance classes of 50 km (1 = greater than 150 km, 2 = 100 - 150, 3 = 50 - 100 km, 4 = 25 - 50, and 5 = 0 - 25 km). Only the smallest distance class is subdivided again to differentiate the local area's direct surroundings.

For a histogram, all observations in a category are counted and usually displayed in a bar graph. For displaying continuous scales in a histogram, the limits must be defined. The decile values of the cultural distance are the chosen method for determining the limits. Decile 1 includes the lower 10% of the total values. With deciles, it is not necessary to redefine the borders for each diagram to subdivide the classes.

The asymmetrical division of geographical distance classes in the immediate surroundings requires setting the cultural distances in proportion to the occurring sample points (fig.: 5.13). The proportion also compensates for the asymmetry of the reference points' position within the work area. Since the number of sample points increases with the radius around the reference point, the absolute counts of cultural distances also increase. For a reference point located at the edge, the proportion of regional sample points does not correspond to the expected increase. In order to be able to recognize deviations from the distance-dependent increase, the frequencies must represent the occurrence proportion.

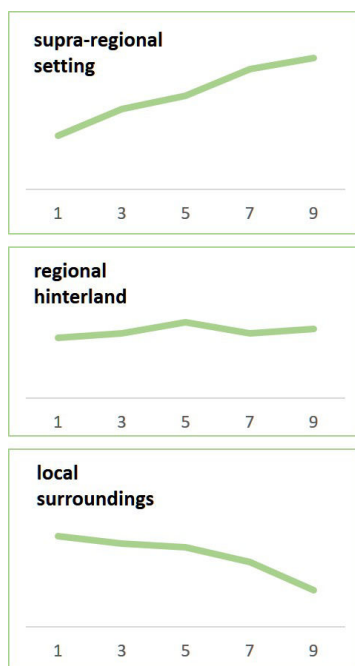


Fig. 5.14: Proportion of decile counts per distance class of distance-dependent cultural dissimilarity.

A high number of low distance values in the immediate surroundings and a continuous decrease with increasing distance class is expected (fig.: 5.14). Deviations from this distance-dependent interaction friction allow us to identify avoided and sought interaction partners. The low cultural similarity lies behind the deciles 1 to 3, 4 to 6 represent average dissimilarity, and the deciles 7 to 9 are dissimilar. Therefore, a high value of decile 1 for the direct surroundings expresses a high cultural similarity to the sample points up to 25 km away (e.g. fig.:6.21).

The histogram allows different perspectives onto the data — first, the course of the frequencies within a distance range, and second, deciles throughout distance classes. For example, in the immediate surroundings, a decrease of frequencies of higher deciles is expected. A low frequency of lower deciles and increasing frequencies for higher deciles, i.e. a reversed curve shape, is expected for the distant regions. In more considerable geographical distances, the higher cultural distances should predominate, assuming distance-dependent interaction friction. A flat course occurs for the middle distance range. Such ideal curves are unrealistic with empirical data, which shows deviating interaction relationships.

The other perspective follows the frequency of a decile over different distance ranges. For the first decile example, a decreasing proportion is expected here as the distance range increases. If there is a renewed increase in the short cultural distance in a higher distance range, this distance is probably an intensely targeted interaction area.

The histograms show whether there was an above-average number of interaction partners in a distance range. If this is the case, the expected distance-dependent frequency distribution reverses. The number of culturally low distance values increases and decreases accordingly elsewhere. If there is a significant reversal of the frequency distributions in adjacent distance ranges, this may indicate an interaction threshold.

## Chapter 6

### Results

The results of the before described methods (chap.: 5) are presented sub-sequentially, beginning with the entire area in question followed by the subareas Haguenau, Breisach Münsterberg and Swabian Alb. Additionally, two other princely seats — Ipf and Hohenasperg — reveal interesting further details on infrastructure and interaction patterns. For each spatial area, the results of infrastructure analysis and interaction pattern are composedly presented. Hence, after presenting the general and over-viewing trends, follow the regional evaluations.

#### 6.1 Baden-Württemberg and the Alsace

The 2,727 evaluated sites (see 4.1) cast into 1,291 burial sites, 1,201 settlements, 190 single finds and others. The distribution of barrows and settlements deviate (chap.: 4.1.1), similar to the distribution patterns of metal and ceramic artefacts. A possible source-critical bias has to be considered interpreting the results.

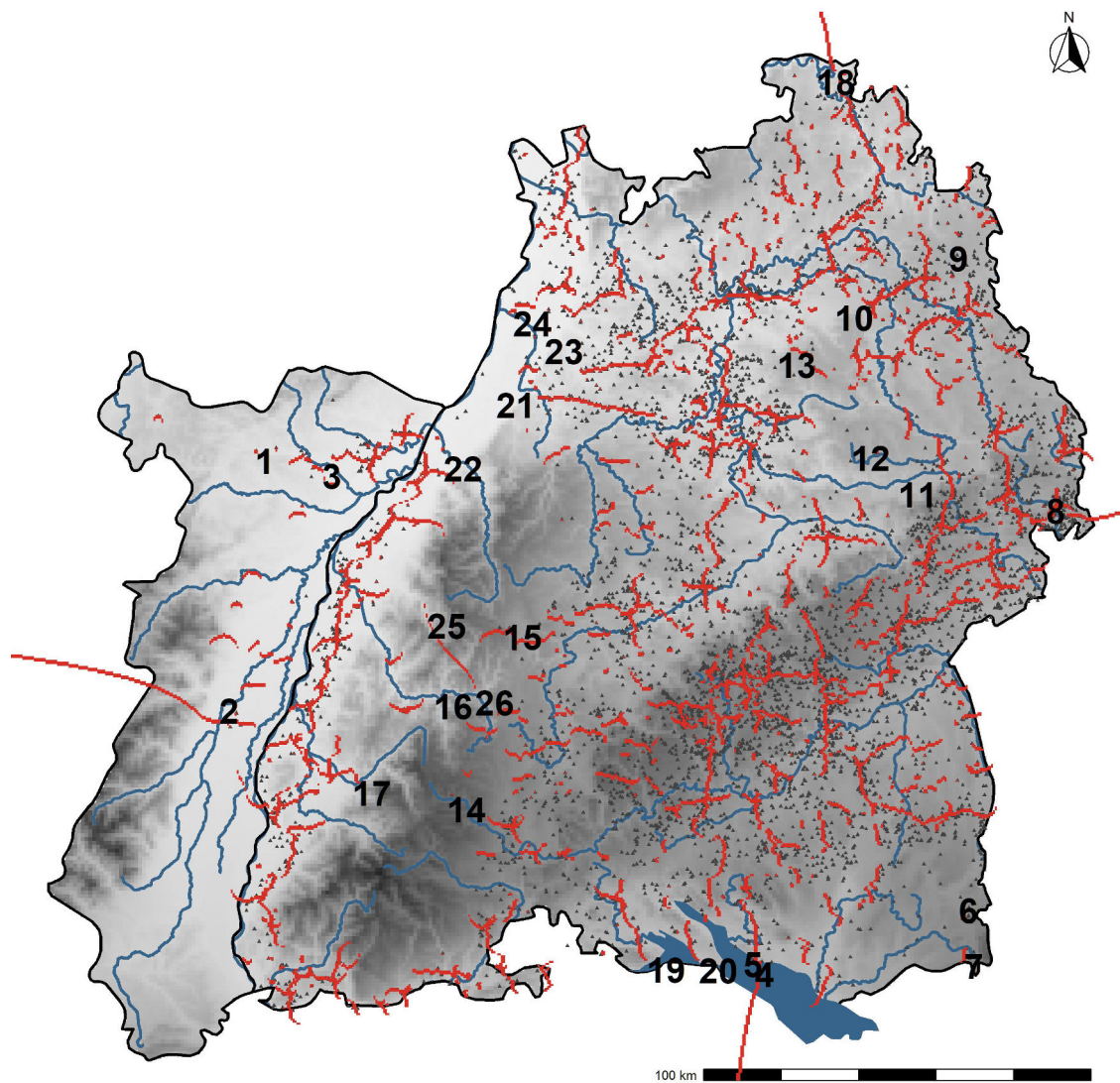
The 49,936 artefacts dating to the Early Iron Age are composing the following functional categories: 28,966 vessels (B1, chap.:4.3.1), 5,247 rings (B2, chap.:4.3.2), 2,860 parts of costume (B3, chap.:4.3.3), 809 weaponry (B4, chap.:4.3.4), 535 means of transportation (B5, chap.:4.3.5), 1,281 tools (B6, chap.:4.3.6), 6,128 art and jewellery (B7, chap.:4.3.7), 667 building materials (B8) and 3,443 unspecified or unknown artefacts (B9). These are 60% ceramic, 23% metal, 13% stone artefacts and 4% artefacts made of organic material. 71% of metal artefacts are bronze artefacts and 18% Iron. Silver occurs only sporadically (n= 7), while Gold (n=377, 3% of all metal artefacts) is much more common. Organic stones, like amber, gagate or lignite (n= 3,713, 7% of all artefacts) are numerous. However, if a different counting method would be applied (like weighting), the proportion of artefact material would change. Nonetheless, this assessment describes those materials stored in the SHKR20 and evaluated in the following sections.

##### 6.1.1 *Reconstructing Infrastructure*

Precise locations on individual barrows are not available across the entire study area. The locations of the necropolis suffice for a regional scope of the path system. Therefore, the coordinates of the necropolis stored in the SHKR database serve as monument location. In fig 6.1 besides geographical background and monument location of all necropolis dating before the end of the Early Iron Age (grey triangular), the reconstructed path system (red) overviews the complete area in question <sup>1</sup>. For the reconstruction of the entire path system, a raster

---

<sup>1</sup> A detailed documentation for reconstructing the path system is recorded in Repath.R <https://gitlab.com/FFaupel/analyse>.



1: Obermodern, 2: Sélestat, 3: Haguenau, 4: Hagnau am Bodensee, 5: Meersburg, 6: Leutkirch im Allgäu, 7: Isny im Allgäu, 8: Neresheim, 9: Schrozberg, 10: Neuenstein, 11: Schwäbisch Gmünd, 12: Welzheim, 13: Löwenstein, 14: Furtwangen, 15: Freudenstadt, 16: Haslach, 17: Freiburger Bucht, 18: Wertheim, 19: Hemmenhofen, 20: Konstanz, 21: Karlsruhe, 22: Rastatt, 23: Bruchsal, 24: Germersheim, 25: Oppenau

Fig. 6.1: Early Iron Age reconstructed path system (red: path system, triangular: necropolis, data: SHKR20, DEM: SRTM 90 m).

resolution of 500 m is chosen, respecting the missing detailed coordinates of individual barrows and the planned reconstruction of a supra-regional path system.

At the borders of the study area, calculation residuals can be recognized as unbranched straight connections. These occur near Sélestat (no 2), Hagnau am Bodensee (no 4, Lake Constance), Neresheim (at the border to Bavaria, no 8) and Wertheim (no 18). For an interpretation of the path system, these residuals are disregarded. However, manipulating results is not admissible in reproducible research.

Areas with less dense monuments occur as empty spaces observable near Leutkirch im Allgäu (no 6), Neuenstein (no 10), Schwäbisch Gmünd (no 11), Welzheim (no 12) and Löwenstein (no 13). Near Schrozberg (no 9), the method could not reconstruct paths although monuments are recorded, which might be caused by unintended edge effects near the border or, more likely, the locally defined bandwidth of the KDE was not sufficient. A local re-evaluation, with more precise coordinates of the monuments, might reveal here a path system. -Also, the limitations of the study area cause a missing northern path (between Karlsruhe (no 21) and Rastatt (no 22)).

Also, the Black Forest occurs as a large empty area. Path transects indicate a southern path around the Black Forest following the Rhine. Although paths crossing the Black Forest are not denied, those reconstructed at Haslach (no 16) and between Oppenau (no 25) and Schirach (no 26) are assumed to be calculation residuals. Some monuments support the path directing towards the Black Forest from Freudenstadt (no 15), therefore from this point onwards, a path might have crossed the Black Forest. However, without monuments in between, the Repath method reaches its limitations; it is not designed to predict a path system.

Accordingly, areas with lower monument density result in transected path reconstruction. The evaluation of cultural distances can highlight how and if these separated parts connect a larger segment of the path system. Naturally, redoing the reconstruction with better resolution of data and further data collection on a local scale will improve the results. The overall path system consists of several long transects branching into more complex structures. Areas with better data coverage show more detailed structures, and therefore, more complex branched path systems. An utterly connected path system occurs only locally, like at the Swabian Alb. The path system adapts in some cases to river systems (fig.: 6.3). A general trend being close to waters is not observable.

The path directing towards Lake Constance (Hagnau am Bodensee (no 5), Konstanz (no 20) and Hemmenhofen (no 19)) reconstructs more or less the only possible connection of these microchores. However, as neither relief nor location of waters is included in the method, no edge effect occurred, but realistic path systems show Lake Constance's connection to the Swabian Alb.

The Rhine occurs as a dominant northern corridor, caused by the study area's shape; however, the eastern and western hinterland is connected to this main path. The Freiburg-

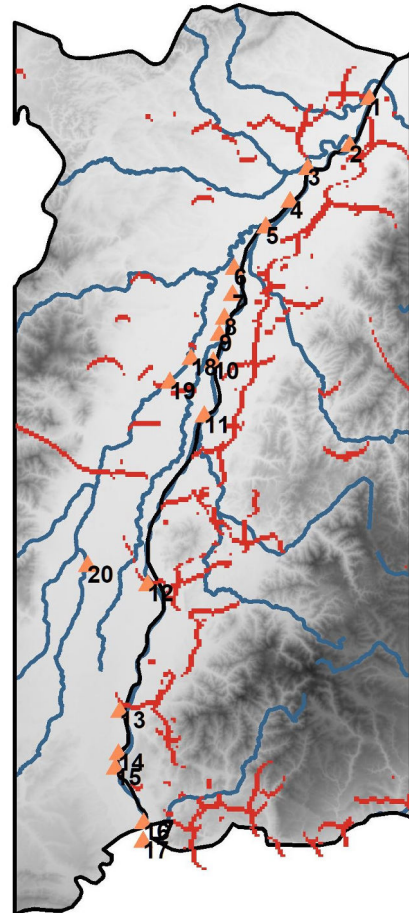


Fig. 6.2: Path system (Rhine) (red: path system, DEM: SRTM 90 m, 1: Seltz - Rastatt, 2: Auenheim - Hügelsheim, 3: Drusenheim - Greffen, 4: Ofendorf - Freistett, 5: La Wantzenau - Diersheim, 6: Straßbourg - Auenheim Kehl, 7: Ostwald 8: Schaffhardt, 9: Plobsheim - Altenheim, 10: Ottenheim, 11: Rhinau - Kappeln, 12: Vogelgrun - Breisach, 13: Ottmarsheim, 14: Niffer - Rheinweiler, 15: Kembs - Huttingen, 16: Huningue - Kleinhuningen, 17: Basel - Kleinbasel, 18: Erstein, 19: Ehl, 20: Sundhofen).

ger Bucht (no 17) is one of these junctions connecting the hinterland of the Rhine valley with the communication axis (chap.: 6.3). As mentioned before (chap.: 4.2.1 and 5.1), unbalanced data collection and data resolution between the former SHKR area Baden-Württemberg (necropolis:  $n=7,779$ ) and the Alsace (necropolis:  $n=237$ ) is especially pronounced in Haut-Rhine (fig.: 4.5). This difference is also visible in the path system's reconstruction (fig.: 6.1). The dense path system in Baden-Württemberg reduces only a few connections on the other side of the Rhine. Better coverage of data is again visible in the vicinity of Haguenau (see no 3 in fig.: 6.1). The results from Haguenau indicate the existence of a western path bundle (chap.: 6.2).

Logel [294] identifies possible passages across the Rhine based on the location of hoards and other Bronze Age artefacts. Due to the strong depositional tradition during the Bronze Age, the Bronze Age river deposits can indicate river passages. Besides a reclassification of sites, for better identification of river depositions [293]; Logel [294] identified depositions occurring symmetrically on both river banks. He identified up to 17 passages across the Rhine (see no 1-17 in fig.: 6.2), three pointing to potential passages across Ill (see no 18-20 in fig.: 6.2) [294]. The Repath method identified 9 of the Bronze Age passages (no 1, 3, 6, 10, 11, 12, 13, 15? and 19 in fig.: 6.2). As Repath does not use the location of Bronze Age artefacts, and Logel does not use Bronze Age barrows to detect passages, the here identified passages are probably used for a long period.

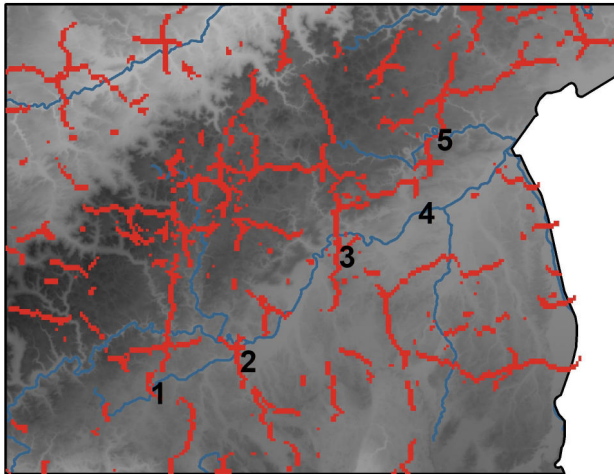
As mentioned before (chap.: 4.2), Schmid-Merkl [436] contradicts Logel's assumptions, that single finds indicate river crossings. She correctly points out that without excluding other circumstances leading to accumulated artefacts, the conclusion is biased. Natural effects would result in the accumulation of artefacts throughout all epochs. Changing depositional habits are also visible in artefact assemblages of the Rhine [436]. Missing Early Iron Age artefacts, hence, indicate a deposition of objects before and after. Their current location might deviate. Nonetheless, the Repath approach does not use artefact locations but the location of monuments. Those crossings identified by two independent methods seem robust and trustworthy.

In contrast to the communication axis reconstructed alongside the Rhine, the Danube communication axis is less pronounced. More junctions and branches are connecting to the hinterland. Near Meßkirch, Megen, between Riedlingen and Minderkingen and near Ehning, the path system crosses the Danube (see no 1 to 4 in fig.: 6.3 a). Cross validating these passages using similar data as Logel [294], might support these locations. However, near Blaubeuren (no 5 in fig.: 6.3 a), the path system moved northward from the Danube. Here, an edge effect might cause the occurring distance to the Danube. Dense path systems occur near Trochtelfingen until Ebingen and Burladingen and Oberwaldstetten.

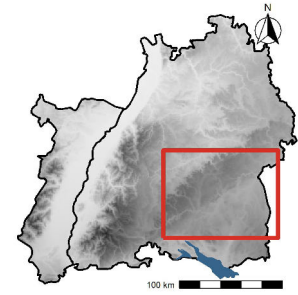
The path system in the Neckar valley follows the river from Freudenstadt (no 1 in fig.: 6.3 c) towards Horb am Neckar (no 2 in fig.: 6.3 c). Near Reutlingen (no 3 in fig.: 6.3 c) another crossing with a path transect leading to Herrenberg (no 5 in fig.: 6.3 c) not following the Neckar Valley. From Stuttgart northwards, the path system is more complex and seems to follow the Neckar again.

The valleys from Jagst, Tauber and Kocher are located in the northern periphery of the area in question. Here, a northern route arrives from Tauberbischofsheim (no 1 in fig. 6.3 e) reaching Bad Mergentheim and Assamstadt (no 2 and 3 in fig.: 6.3 e). Near Westerhausen (no 4 in fig.: 6.3 e), the path systems cross the Jagst directing to Forchtenberg (no 5 in fig.: 6.3 e) where it crosses the Kocher. The path system then follows the Kocher valley until reaching the Neckar. Both hinterlands of Kocher and Jagst are also connected.

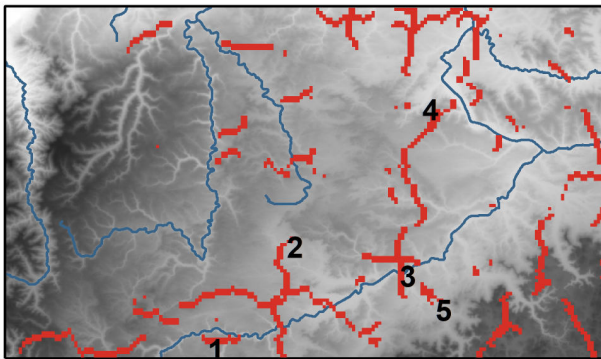
The reconstructed path system reveals long connected path transects connecting via branched paths the hinterlands. In areas with low data coverage, the Repath method does not reconstruct paths; however, some calculation residuals occur. Separate transects covering only a few raster cells appear as isolated fragments which do not mean they have been isolated during prehistory, but missing data restricts the reconstruction of the connections. Some reconstructed paths seem to follow modern roads. An intense archaeological investigation following these roads does not cause the reconstructed paths as the method does not connect barrows. It seems more likely that the paths persist until today.



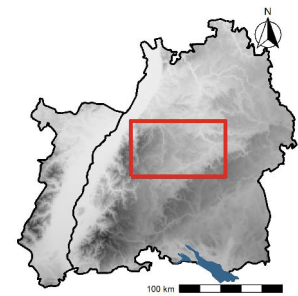
(a) Danube Valley



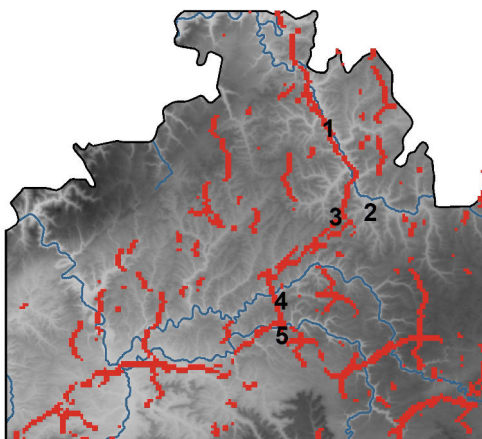
(b) location of subarea



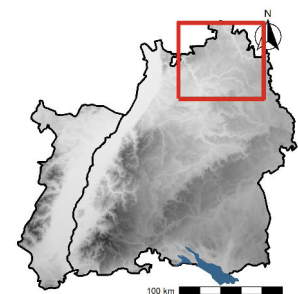
(c) Neckar Valley



(d) location of subarea



(e) Tauber, Kocher and Jagst Valley



(f) location of subarea

Fig. 6.3: Early Iron Age reconstructed path system (red: path system, DEM: SRTM 90 m)



### 6.1.2 Identification of Infrastructural Important Parameters

Fig. 6.4 compares the distances of each theoretical model and mode to path associated features (necropolis,  $n = 7,369$ ) illustrating the best model fit (chap.: 5.4, for modelling accumulated cost surfaces see TheoPathCorridor.R<sup>2</sup>, and for the evaluation see EvalPath.R<sup>3</sup>).

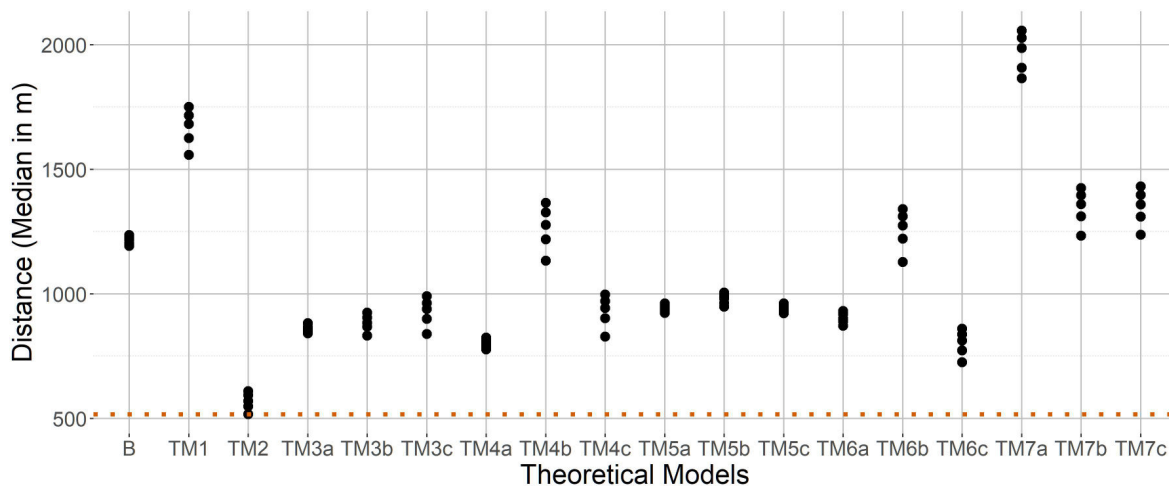


Fig. 6.4: Distances of TM 1 to TM 7 to monument locations (incl. modes a to c, red: best model fit, method: median of nearest neighbourhood in m).

Reference model B, which models connections as the crow flies, serves as a benchmark. A realistic model should result in shorter distances to monuments as reference model B (1,192 to 1,236 m). Those four models with greater distances are rejected as unrealistic. Two models result in similar distances, and 11 models seem to fit better to the prehistoric reality. Accordingly, the archaeological model TM7 (TM 7a: 1,864 to 2,057 m, TM 7b: 1,233 to 1,425 m, TM 7c: 1,238 to 1,430 m) which displays the attraction of settlements and model TM 1 (distance: 1,558 to 1,750 m) are rejected. As the accumulated cost surface of mode, TM 7a illustrates the unbalanced distribution of settlements (fig.: 6.5 o). The accumulated cost surface is unrealistically undetailed. Large areas with the lowest costs will provide most of the 10% best cells. It is not surprising, as the applied gravity model to simulate attraction is designed to be combined with a slope dependent cost surface.

Model TM 1 is also rejected based on these criteria. However, a pedestrian movement is still assumed to be the regular mean of transportation. Many low values might cause a bad global fit in the Rhine and Danube valley (fig.: 6.5 a). As only the 10% best values are used for the evaluation, TM 1 might fit better locally. The combination of reduced costs around settlements with pedestrian movement in modes TM 7b and TM 7c results in shorter distances to monuments as TM 1 indicates that the settlements attract the path construction. However, the correlation is not very strong.

The modes TM 4b (1,133 to 1,365 m) and TM 6b (1,127 to 1,340 m), both with equally weighted parameters, are also disregarded. The distances of the five nearest neighbours spread beyond the distance of reference model B. The accumulated cost surfaces of models with high ranging distances from closest neighbour to the fifth closest neighbour (TM 1, TM 7 a-c, TM 4b, TM 6b, fig.: 6.5) have in common large coherent areas of lowest costs. TM 1, TM 4b and TM 6b - these areas located dominantly in the northern part of the Rhine Valley and

<sup>2</sup> <https://gitlab.com/FFaupel/analyse>

<sup>3</sup> <https://gitlab.com/FFaupel/analyse>

the eastern part of the Danube valley are influenced by topography. As those areas are close to the border, fewer monuments serve as a comparison as in the central area.

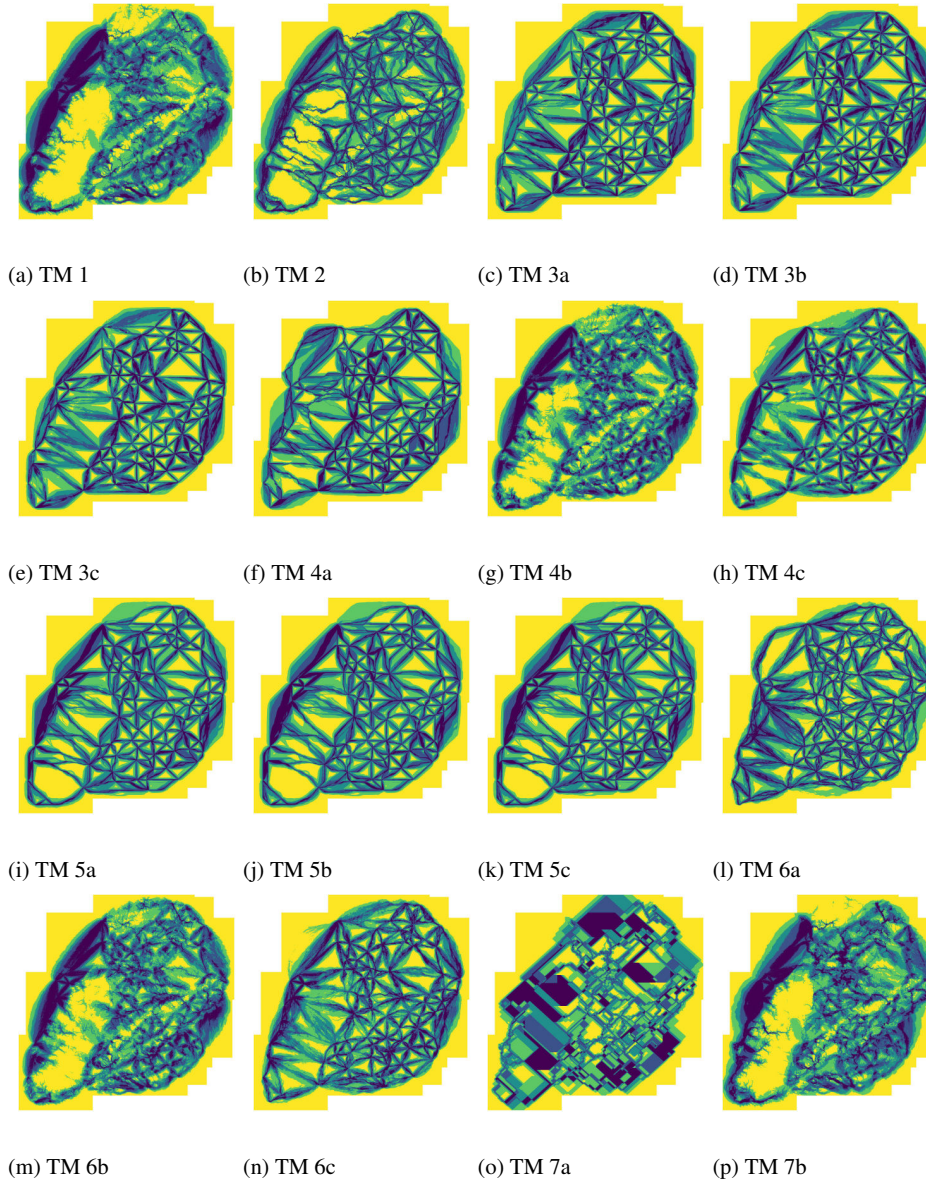


Fig. 6.5: Accumulated cost surfaces of theoretical models and modes.

The models preferring lowlands TM 5 (TM 5b: 948 to 1,005 m, TM 5a: 922 to 961 m and TM 5c: 921 to 962 m) have a better fit to the archaeological record than the reference model and have only slight variations in the distances to the five nearest neighbours. Furthermore, the accumulated cost surfaces depict only slight changes (fig.: 6.5 i-k). Model TM 3 (TM 3a: 841 to 882 m, TM 3c: 839-990 m and TM 3b: 832-924 m), which simulates avoiding visibility results in better but comparable results as TM 5. The range in distances to the next

five nearest neighbours increases from mode a to c. Similar to TM 5, the accumulated cost surfaces of TM 3 show only slight deviations (fig.: 6.5 c-e). The model TM 4, which prefers visibility, has distances ranging from 776 to 824 m in mode a and 828 to 997 m in mode c. Mode b has much higher distances, as already mentioned before. The accumulated cost surfaces show the differences between the modes (fig.: 6.5 f-h). TM 4b appears similar to TM 1. Movements along mountain ridges result in diverging distances for the three calculated modes. In comparison, mode b badly fits (see above), mode "a" has distances between 872 to 931 m. It is closer than the contrasting model TM 5. Mode c has the shortest distances with 725 to 859 m. However, the model TM 2 has the shortest distances to monuments ranging from 516 to 610 m. Therefore, this model shows the best global fit to the archaeological monuments.

The archaeological model TM 7 is rejected because reference model B adapted better to the prehistoric reality. The evaluation for TM 1, 4, or 6 might differ in a local re-evaluation. A disadvantage of using decile values for selecting the best alternative path results in dominance in low values selected from the Upper Rhine valley. This disadvantage illustrates the importance of a local re-evaluation of parameters, as those depend immensely on local variations. As a global trend, models preferring lowlands (TM 5 and 3) are not well adapted to the archaeological reality. Being visible and being able to see was more important than hiding. Therefore, models preferring highlands (TM 6 and TM 4) fit better. Ridges seem more relevant than river valleys. The best-fitting model is TM 2, modelling cost surfaces for wheeled vehicles. The fitting does not imply only wheeled transport, but avoiding steep slopes seemed relevant on a supra-regional scale.

### ***6.1.3 Interaction alongside Corridors of Communication***

Interaction patterns preserved in the type spectra of the entire material culture are compared in different ways. First, starting from a communication corridor (Rhine or Danube), the cultural dissimilarity is considered depending on the absolute geographical distance (distance diagram type dd5). Second, different segments of the material culture represent deviating cultural relationships. As indicated earlier by Nakoinz [347], vessels, ring jewellery and traditional costumes may serve as indicators for deviating contacts in the sense of geographical distance. After this summarising assessment of the interaction pattern, profile diagrams identify deviating interaction references along the central axes.

#### **Rhine**

The distance diagram of the type dd5 (chap.: 5.5.2), which considers the entire material culture, i.e. the entire Early Iron Age type inventory, shows different curves for both banks of the Rhine. Figure fig.: 6.6 shows that the mean cultural distance against the geographical distance from the corridor's central axis. The working area's asymmetry shortens the course of the western curve. Also, at a distance of around 50 km, reference points are only available in Alsace's northern part. The averaged distance values show a strong fluctuation, which makes adapting the curve challenging. After the initial stage described by Nakoinz [347], a high value causes a steep rise at a distance of 20 km and an equally drastic drop around 30 km. Two further maxima occur in the course of the curve. Between 30 and 50 km, the high distance values refer to the foothills of the Vosges. The apparent drop at the end of the curve, still below that of the initial stage, shows the cultural distance to the Haguenuau hinterland.

The curve's course on the opposite side of the Rhine (fig.: 6.6) shows a less significant spread of the cultural distances. However, some outliers can be identified. The curve's course begins with a slight increase in cultural distances between 25 km and around 100 km apart from a slight drop. The slight increase shows the expected continuous and distance-dependent increase in the interaction friction. In the area between 110 and 140 km, this continuous increase is replaced by fluctuations in the curve. Interestingly, the cultural distance values drop significantly at 150 km and correspond almost to the initial values. Comparing the curve with topographic landscape features, it is initially astonishing that the Black Forest does not appear as a barrier to interaction friction. The local area and regional hinterland include the hills of the Black Forest. The Neckar valley follows this,

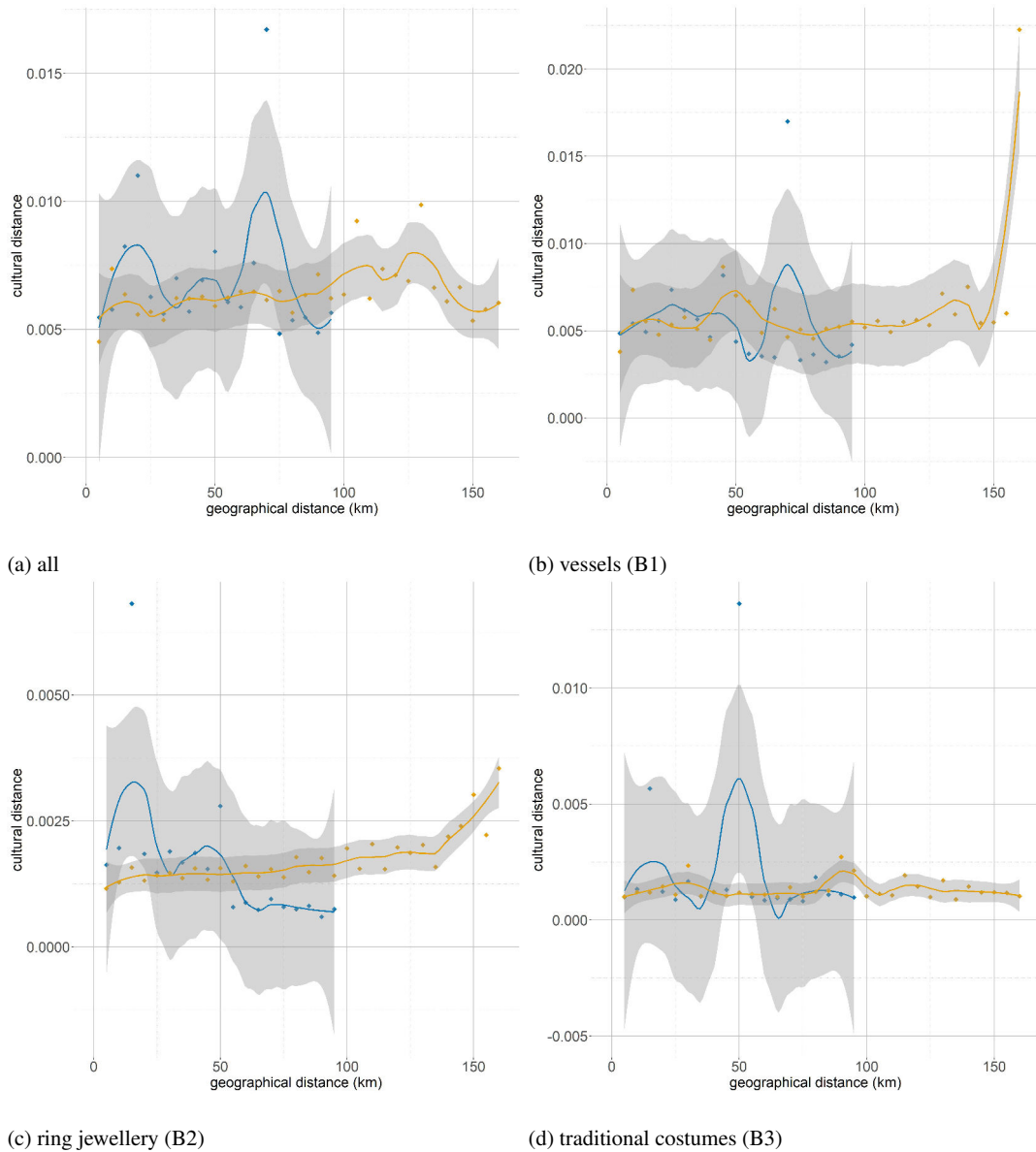


Fig. 6.6: Distance diagram type dd5 of the Rhine (blue: western river banks, orange: eastern river banks, data: SHKR20).

and at around 80 km, the Swabian Alb. The princely seats of Hohenasperg and Heuneburg are possibly hidden behind the depressions at a distance of 110 to 140 km. The profile diagrams offer a detailed representation.

For vessels, the comparison with the entire archaeological material shows different curves for both sides of the Rhine (fig. 6.6). The western curve is characterised by a few strongly fluctuating distance values, although maximum values occur at a distance of around 20 km and 70 km. After the initial stage, the vessels' curve slightly rises at 30 km disregarding the high value at 20 km. The falling curve can be explained by the cultural proximity of the underlying Haguenau hinterland. A slight increase is visible shortly before reaching the limits of the working area. The course of the eastern curves also differ. A slight increase after the initial step and subsequent depression in the regional hinterland is present in both curves. However, there is a maximum of

the distance values at 50 km. The distance curve then drops to around 80 km. From there, a slight continual increase up to about 130 km depicts the distance-dependent interaction friction. More interestingly, similar to the entire material, a slight depression occurs at about 150 km. Concerning vessels, however, the curve then rises dramatically.

For ring jewellery (fig. : 6.6), similarities to the entire material curve can be determined for the western profiles of about 50 km from the Rhine. Although the maximum values differ, the curves rise at 20 km and 50 km. The area over 50 km, which relates to the Haguenau hinterland, shows low distance values, similar to the vessels. However, the course of the eastern profiles is different. After the initial stage, the curve rises continuously up to about 130 km with an apparent rise afterwards.

The third comparison is the costume (fig. : 6.6). The western profiles curve again shows two maximum values at 20 and 50 km, comparable with the entire archaeological material. Nevertheless, the increase between 30 and 50 km is not pronounced. If disregarding the two maximum values, the result would be a relatively monotonic course without a clear, continuous gradient. The course of the eastern curve also differs significantly from the entire archaeological material. The comparatively flat curve progression is disturbed by higher values at around 30 km and more clearly at 80 km. After the high value at a distance of 80 km, the distance values briefly drop to the initial level. At 110 km, the level before the disturbance is reached again, and the curve continues its course.

A distance curve represents the interaction pattern in the direct surroundings for the type spectra of the entire archaeological material, vessels, ring jewellery and costume. The sample points location (fig. : 6.7) illustrates the spatial relationship. Profile no. 20 is concealed approximately at the height of the Britzgyberg. The Breisach Münsterberg locates near profile 37, and Kappel am Rhein near profile 45. The city of Haguenau (Bas-Rhin) lies close to profile 87.

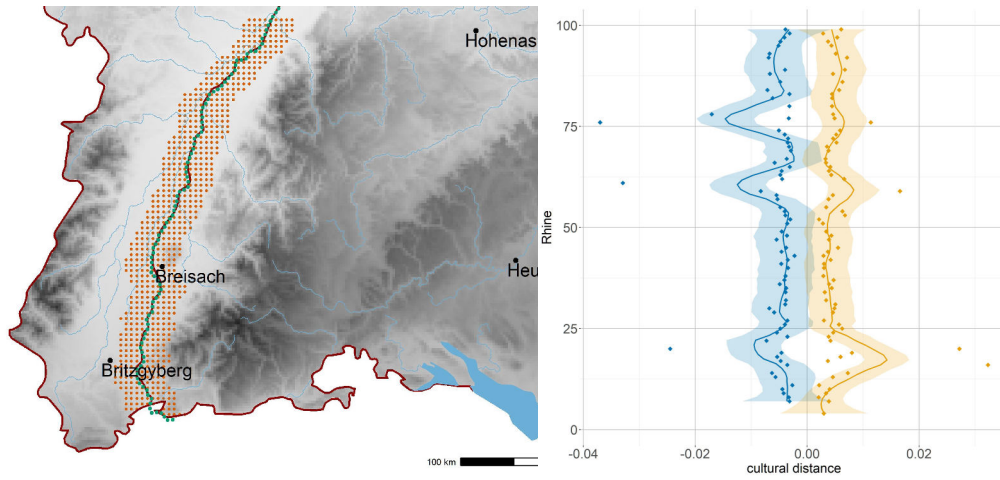
In both curves for the entire archaeological material (fig. : 6.7) occur symmetrical increased distance values, namely at the level of profiles 20, 60, 76 and 77. At the northern end of the central axis, there are comparatively small distance values. The eastern curve course shows high distance values symmetrically to the western course, but to a different extent. Profile 18 and 20 have higher values than the east. This relationship reverses in profiles 60 and 76. Compared to the eastern course, a local minimum of distance values occur at the level of profile 52.

The vessels' distance curve takes a different course (fig. : 6.7). On the one hand, the maximum values distinctively separate; on the other hand, there is no symmetry between the two banks. The curve's western course is uneven up to the level of profile 37, which is also reflected on the other side of the river, but not so clearly. Relatively constant distance value characterise the area between profiles 37 and 60. The variance is again smaller on the eastern side than on the western side. At the height of profile 65, the western curve's maximum value does not reflect the eastern side.

In contrast, higher values appear on the eastern side in the area of profile 80. The curve shape of ring jewellery is on the western side, due to high fluctuations in the distance values', remarkable and shows very high maximum values in the Haguenau Forest region. The eastern course differs significantly since the density values' variance is lower, and fewer extreme values occur. Nevertheless, symmetrical bottlenecks can be identified in three places (profile 12, 37 and 74). The costume and jewellery curves are primarily symmetrical but not congruent with the entire material culture's curves. Bottlenecks occur at the level of profiles 25, 37, 50 and 75. Maximum values are at the level of profiles 32, 57 and 83.

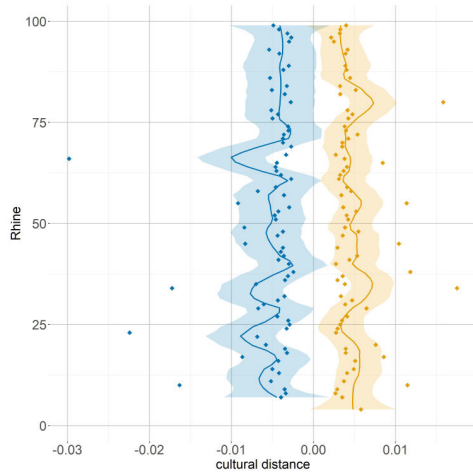
The symmetrical course of the curves indicates a similar interaction behaviour on both sides of the river with the immediate surroundings. Asymmetrical courses, as for ring jewellery and vessels, show different preferred interaction relationships between the two banks. In the vicinity of the Breisach Münsterberg, small distance values for vessels, ring jewellery and all archaeological artefacts are typical, from which the curves of the traditional objects deviate. At the height of the Britzgyberg high distance values are repeatedly determined. Considering the next distance class will shed more light on the influence of this reference point.

For representing the local interaction pattern, distance curves depict the four type combinations between 10 and 30 km (fig. : 6.8). The curves of the entire archaeological artefacts are symmetrical. The maximum values of the two banks are also comparable, albeit higher to the east. Maximum values are at the level of profiles 22, 63 and, less pronounced, 76. Again, the Britzgyberg seems to have a higher cultural difference to the Rhine

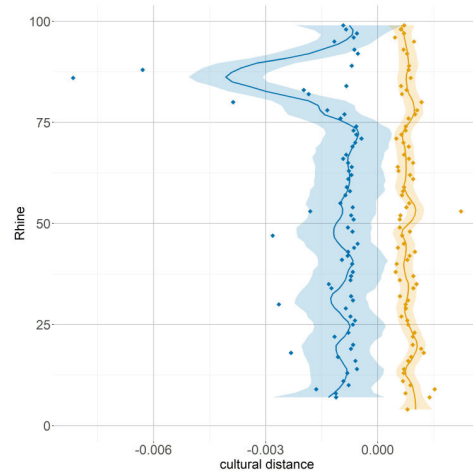


(a) spatial reference

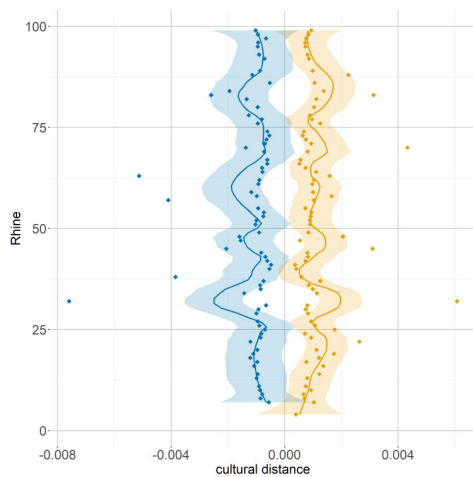
(b) all



(c) vessels (B1)



(d) ring jewellery (B2)



(e) traditional costumes (B3)

Fig. 6.7: Profile diagram of the Rhine for the direct surroundings (under 10 km) (blue: eastern river banks, orange: western river banks, data: SHKR20).

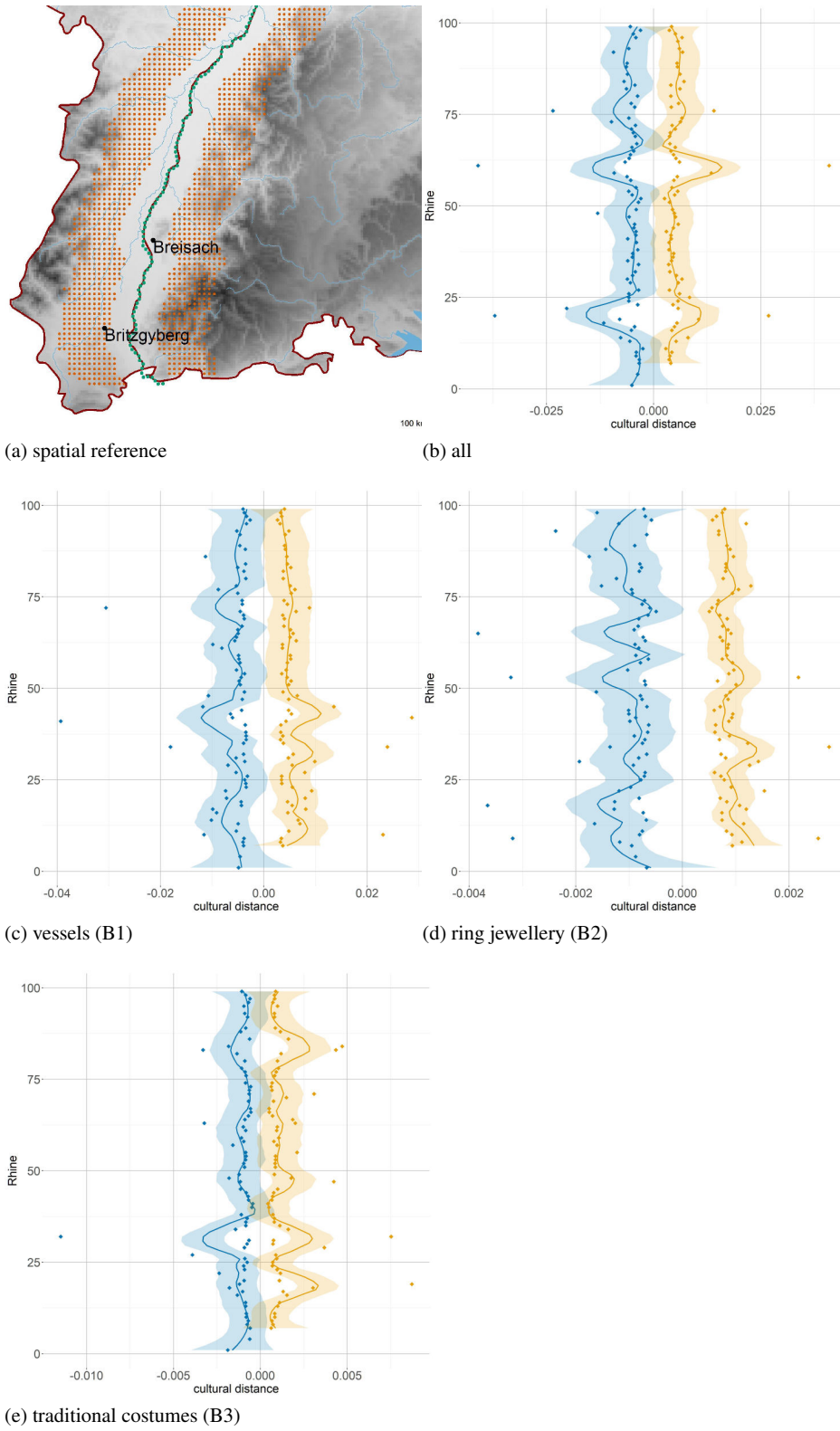
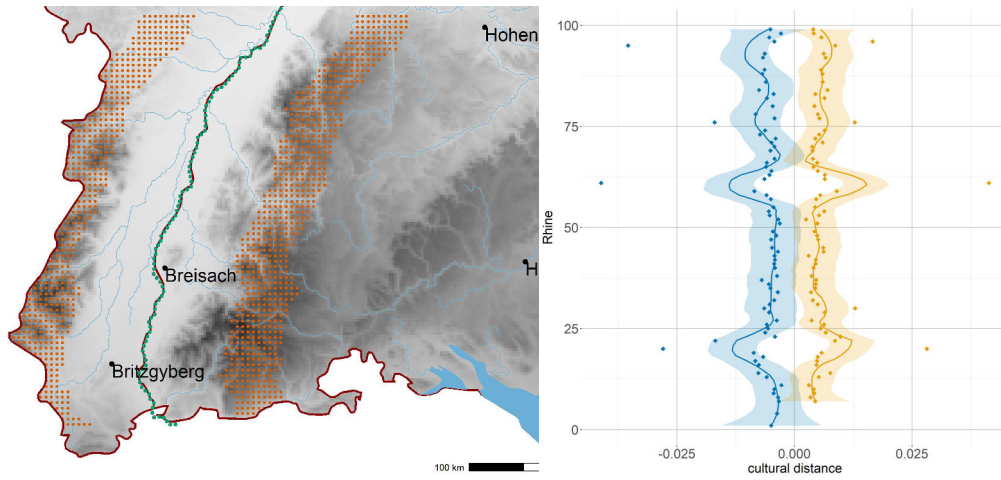
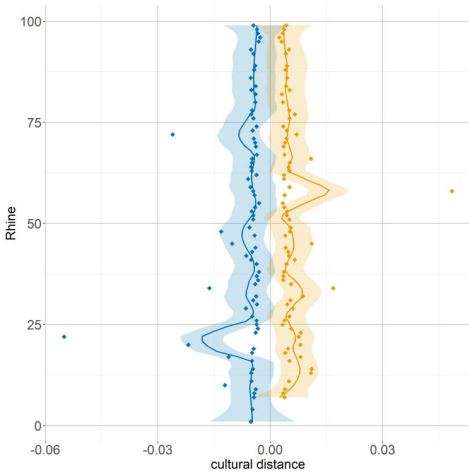


Fig. 6.8: Profile digram of the Rhine for the local area (10 to 30 km) (blue: eastern river banks, orange: western river banks, data: SHKR20).

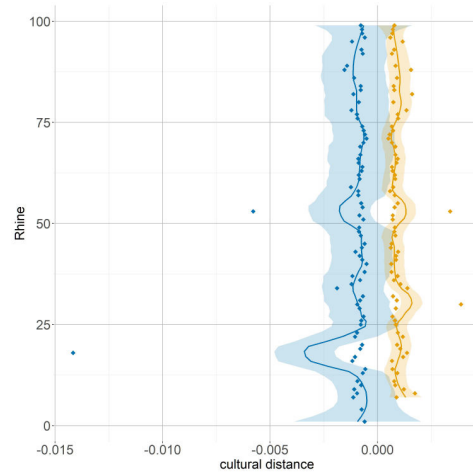


(a) spatial reference

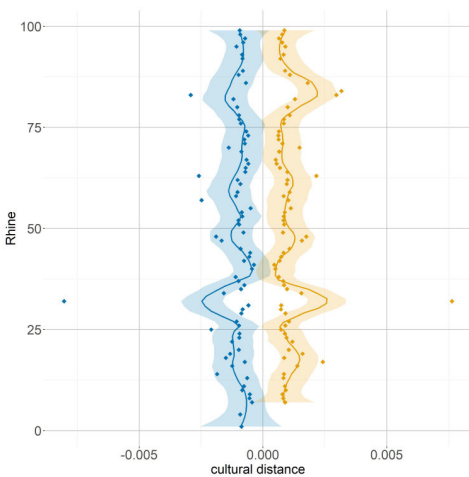
(b) all



(c) vessels (B1)



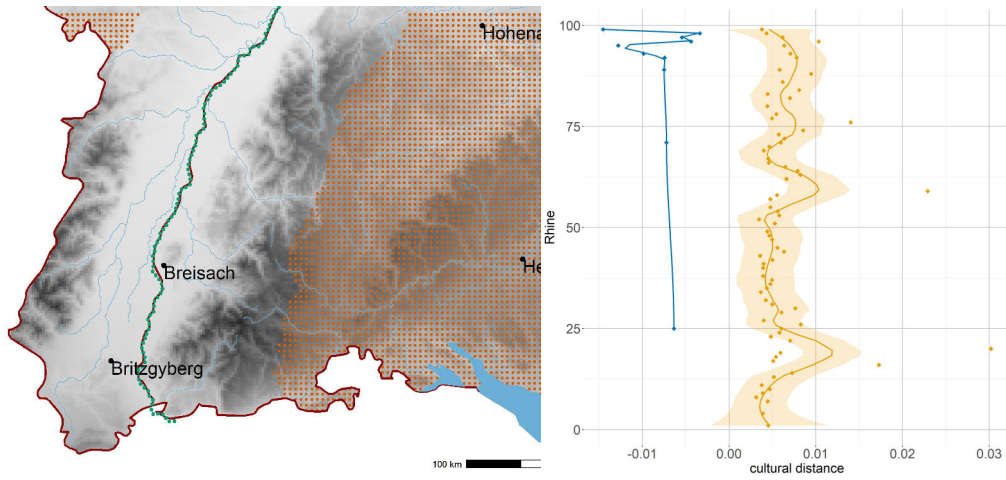
(d) ring jewellery (B2)



(e) traditional costumes (B3)

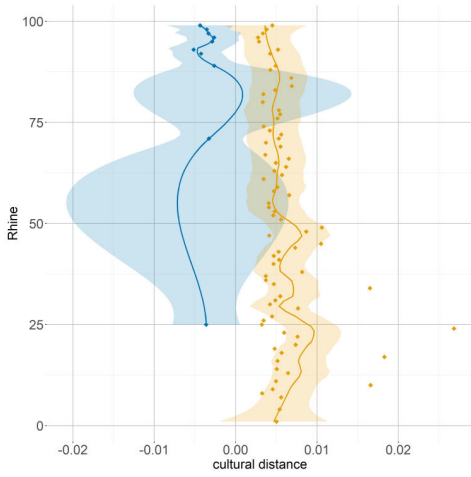
Fig. 6.9: Profile diagram of the Rhine for the regional hinterland (30 to 50 km) (blue: eastern river banks, orange: western river banks, data: SHKR20).



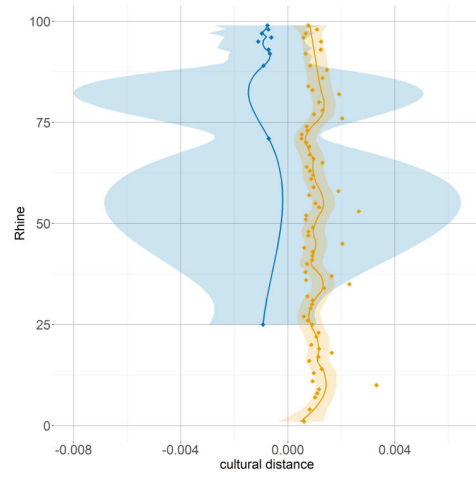


(a) spatial reference

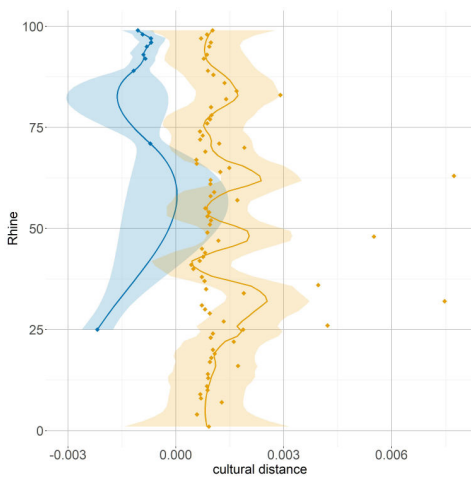
(b) all



(c) vessels (B1)



(d) ring jewellery (B2)



(e) traditional costumes (B3)

Fig. 6.10: Profile diagram of the Rhine for supra-regional setting (over 50 km) (blue: eastern river banks, orange: western river banks, data: SHKR20).

reference point, as does profile 60 (a little south of Strasbourg). The apparent similarity between the curves with a spatial reference under 10 km and the local area show a constant cultural dissimilarity for profile 20 and 60.

The comparison of the curves, based on vessels of the two distance classes, shows differences. The local curves' apparent asymmetry is slightly reduced compared to the immediate surroundings, with high and low values of the two curves occurring offset at the level of profile 20 (fig. : 6.8). At the height of profile 73, there are high distance values on the Rhine's western side, i.e. one-sided. Common bottlenecks exist at profile 35, between the profiles 50 to 60 and from profile 77 onwards.

The curves differ even more concerning the ring jewellery. Apart from the extremely high value in the immediate northern area, both bank areas' values vary in a similar area. However, the distribution of the bottlenecks and high values occurs across other profiles. Compared to the entire set of artefacts of the local area of the ring jewellery are higher, and the curve is asymmetrical. In contrast, it is noticeable in the curves of traditional costumes comparing different distance classes that the curves at greater distances from the Rhine rarely have high distance values, and the course is relatively flat. The bottlenecks are at profile 12, 25, 45, 50, 75 and thus at a comparable point to the local curve (fig. : ref fig: ProfilRhine0).

The symmetry of the curves on both sides for the local area is more pronounced than in the immediate area. There is a tremendous cultural distance along the Rhine between the two settlements Britzgyberg and Breisach Münsterberg, and in the areas close to Strasbourg and Haguenau. The settlements themselves, like Kappel am Rhein, are characterised by a low cultural distance. Kappel am Rhein and Breisach show a low cultural dissimilarity for the vessels. At least for Breisach, this is repeated in the type spectrum of traditional costumes.

For representing the regional interaction pattern, distance curves are calculated for the type combinations between 30 and 50 km (fig. : 6.9). The Vosges rise via the west and the Black Forest to the east. The Magdalenenberg levels with profile 40. When comparing the local and regional curves, deviating bottlenecks and high distance values become apparent. Symmetrical bottlenecks are at the height of profiles 25, 37, 45, 75 and 90, instead of in the range between 25-50 or 80 (fig. : 6.8). In contrast, the maximum values are at profiles 32, 53 and 80. The Magdalenenberg is in an area characterised by low cultural distances.

The course of the curves for vessels shows punctual corrections in the lateral environment. A slight increase of the eastern curve at the height of profile 30 is present in both distance ranges, and the increase in the western curve at the height of profile 80. Two significant increases occur in the area between 30 and 50 km, namely for the eastern curve at profile 57 and for the western one at profile 28. While the local area's ring jewellery curves were still clearly asymmetrical, the regional hinterland curves are mostly symmetrical. There are bottlenecks in profiles 12, 25, 37-45, 62-70. There is an apparent asymmetry at profile 18. Very high values are available here for the western bank. The course of the costume is comparable for local and regional areas. Bottlenecks and high distance values occur in the same profiles — the apparent asymmetry in the southern course of the curve vanishes in the regional hinterland area.

The symmetrical curve of the entire Early Iron Age type spectrum does not continue in the curves of the vessels. Nevertheless, the eastern curve's high values north of Kappel am Rhein (profile 55) reoccur and the high values of the western curve north of the Britzgyberg (profile 23). To the north of Kappel am Rhein, there are also slightly increased values for ring jewellery now on the western side. The costumes curve's symmetrical course has no equivalent in the general curve—the type spectra of the costume show different interaction structures.

The distance curves for supra-regional settings are calculated for the type spectra for 50 km and more (fig. : 6.10). Heuneburg occurs at the height of profile 39, and the Hohenasperg approximately at the height of profile 95. Only a tiny part of the eastern bank still contains sampling points. The curves created for the western bank of the Rhine are therefore not very meaningful. Statements about symmetry and asymmetry of the interaction structure are no longer valid for this geographical distance range.

The curve of the eastern bank of the Rhine (fig. : 6.10) corresponds to that of the regional hinterland (fig. : 6.9). A more considerable fluctuation of the values is observable in the northern part of the curve. The distance values for the curve concerning vessels are higher than for the regional reference area. Also, there are maximum values at profile 48 and 24. The generally higher distance values of the sample points at a greater geographical distance correspond to the expectation of a distance-dependent interaction.

The distance values are relatively lower than the closer regional sample points but scattering more distinctively regarding the ring jewellery. The course of the curve is comparatively uneven. Compared to the curve of the entire material, there are few similarities. Profiles 26 and 70 have low distance values. The costumes curves' values fluctuate in a close range for both distance classes, but the curve's values oscillate more strongly with sample points at a greater distance. Some very high distance values are on profiles 30, 48, 63 and 80. Except for the value of profile 60, there are other high values in the adjacent profiles, suggesting a cultural dissimilarity. On the other hand, the values for profile 45 are low, i.e. at Kappel am Rhein and between profile 70 and 75.

For the entire material, the ring jewellery and the costume, low distance values to the Rhine occur on this profile of the Heuneburg (profile 39). The curve of the vessels deviates significantly from this. In profile 95 (Hohenasperg), interestingly, there are low distances to the Rhine in all curves. Slightly higher values are recognizable for the ring jewellery and the costume. Although reaching the edge of the profiles under consideration, edge effects are relatively unlikely because the sample points are not in an edge position concerning the entire working area (fig. : 5.10).

### **Danube**

The distance diagram of the type dd5, considering the entire material culture, i.e. the entire Early Iron Age type inventory, shows similar curves for the two banks of the Danube. Figure (fig. : 6.11) shows that the mean cultural distance against the geographical distance from the corridor's central axis. The asymmetry of the working area interrupts the course of the southern curve. Although the averaged distance values fluctuate, the increase at the beginning of the curve is apparent. Interestingly, there is a dip in the distance curve and a renewed increase. The curve of the northern bank of the Danube shows the most significant fluctuation in distance values parallel to the southern curve in the range between 30 and 60 km. The fluctuation indicates that insufficient data coverage cannot exclusively explain the spread of the southern curve. If ignoring the two high values, the northern curve increases up to a distance of about 75 km. At a distance of about 120 km, the distance values drop almost to the initial value, followed by another moderate increase. It becomes evident that the Neckar Valley occurs at 50 km, and the so-called princely seat of Hohenasperg is about 100 km away, comparing the course of the curve with the location of the sample points.

The curves for the type combinations of the vessels show different courses for both banks than the entire material culture (fig. : 6.11). Sample points' uneven coverage can explain similar strong fluctuations in the southern bank's distance values in the range of 30 to 50 km. Nonetheless, an evident rise in the curve occurs with a maximum at around 50 km, followed by falling values. The course of the northern curve differs significantly in the lower spread of the values and the unexpected course. However, high distance values in the range of 30 to 50 km cannot be explained by uneven coverage of sample points. After a slight increase in the local area, the curve has a falling tendency. The distance values only increase from around 120 km.

The extreme values in the ring jewellery's southern curve make the description difficult (fig. : 6.11). The slight rise in the curve at about 50 km follows a slight depression and then sharply rising values. The course of the northern curve appears flat in contrast to the fluctuation of the southern curve. The distance values increase until just before 50 km. The lowest point of the depression occurs at around 55 km, after which a new maximum occurs at around 60 km. From then, the curve drops slightly to a distance of 110 km, where it again takes on a slight gradient. Like the vessels' distance curve, the local type spectra appear more foreign than those in the Neckar valley.

The courses of the two curves for the costume components, in turn, differ from those of the entire material culture, vessels and ring jewellery (fig. : 6.11). The southern distance values show an increase up to about 25 km away. The subsequent depression has its minimum at about 45 km. If ignoring the extreme value at 75 km, the curve progresses only slightly. The northern curve describes a slight increase at about 25 km, depression at about 45 km, high distance values at 50 km and 125 km. In between, there is no noticeable slope of the curve. From 125 km, the distance values for traditional costume components vary significantly. In contrast to vessels and ceramics, a local dissimilarity is not very pronounced, nor is there any similarity with the Neckar valley type spectrum.

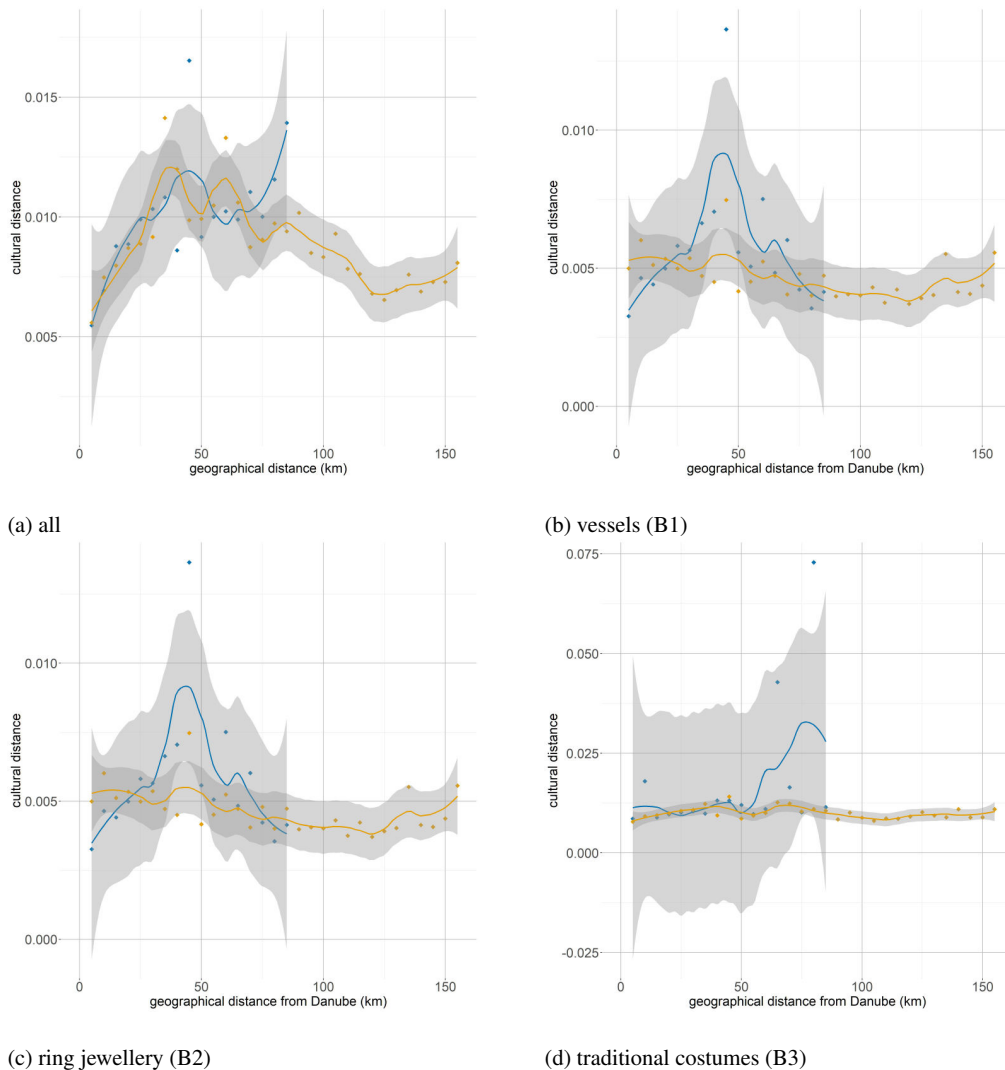
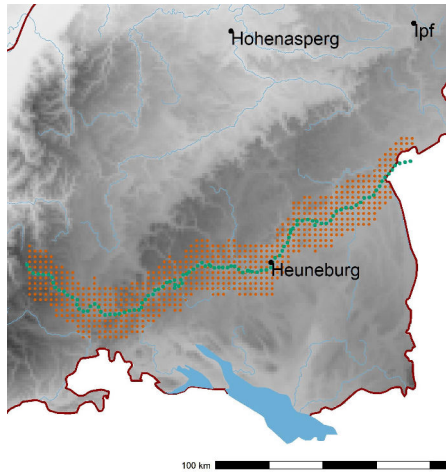


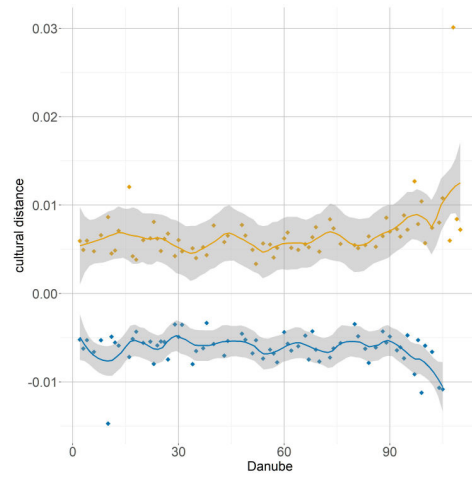
Fig. 6.11: Distance diagram type dd5 of the Danube (blue: southern river banks, orange: northern river banks).

For displaying the interaction pattern in the immediate surroundings, distance curves depict the type combinations up to 10 km (fig. : 6.12). Contrasting, the profiles for the Danube are on the ordinate, while the cultural distances are on the abscissa. According to their cardinal direction, the southern profiles' results are negated to appear in the graphic for visualising the two bank sides. The Heuneburg occurs at the height of profile 68. The curves of the entire archaeological material in the immediate surroundings are primarily asymmetrical on both banks. The higher values of the eastern profiles can be related to an edge effect at the working area's limits. The southern curve shows a smaller range of variation. Local minima occur on profiles 16, 30, 60 and 80. The northern course of the curve is characterised by a higher spread of the density values. Here, local minima occur in profiles 1, 35, 53 and 80.

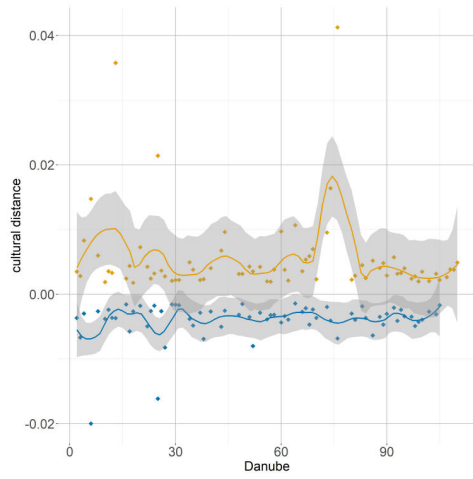
The curves for vessels (fig. : 6.12) are not symmetrical. While the southern curve shows a relatively even course, high distance values occur in the northern profile, especially at the height of profile 75. The spread of



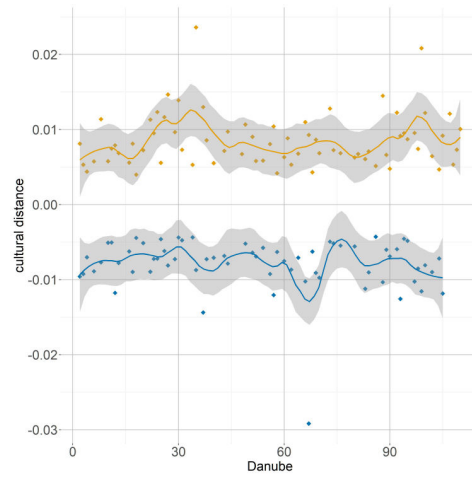
(a) spatial reference



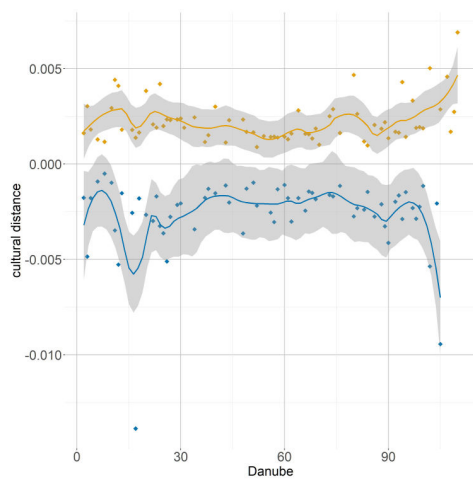
(b) all



(c) vessels (B1)

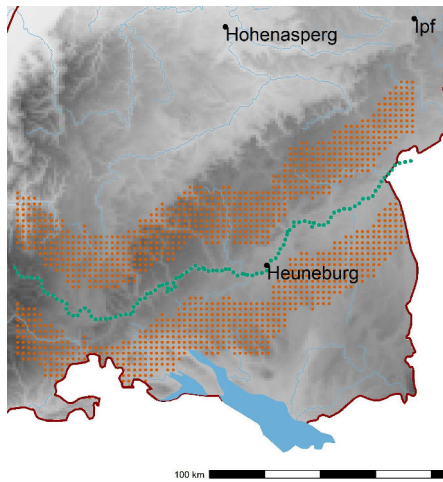


(d) ring jewellery (B2)

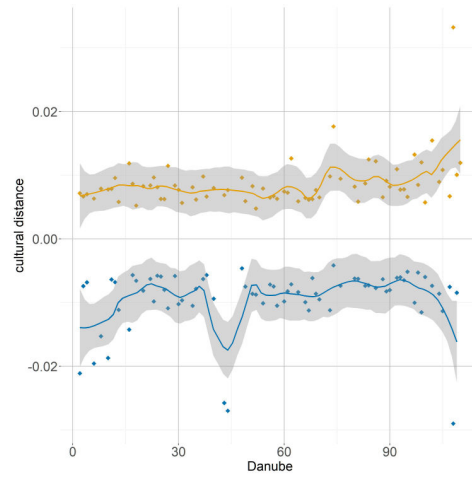


(e) traditional costumes (B3)

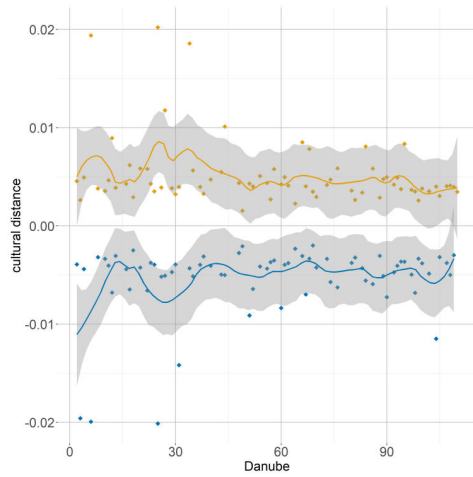
Fig. 6.12: Profile diagram of the Danube for the direct surroundings (under 10 km) (blue: eastern river banks, orange: western river banks).



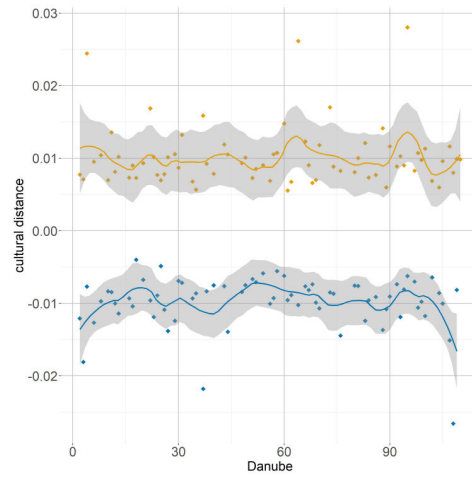
(a) spatial reference



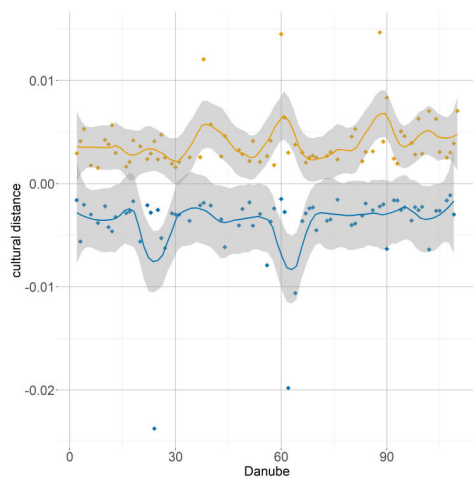
(b) all



(c) vessels (B1)

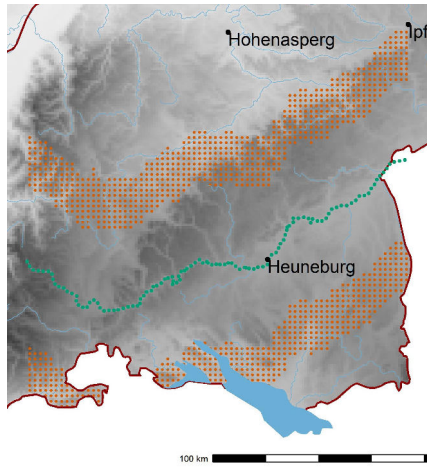


(d) ring jewellery (B2)

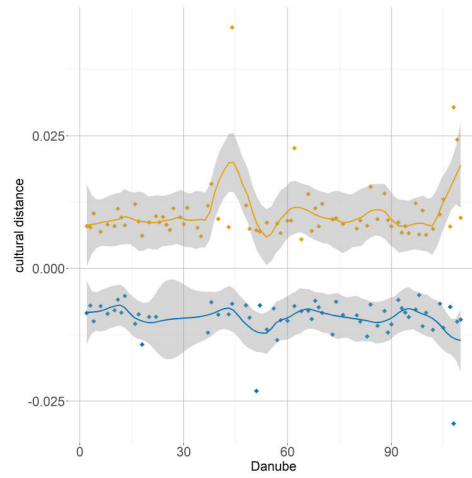


(e) traditional costumes (B3)

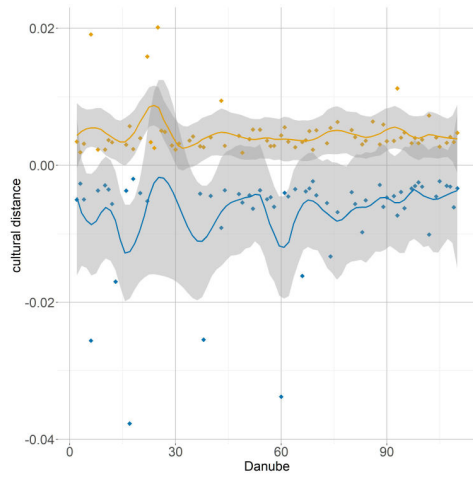
Fig. 6.13: Profile diagram of the Danube for the local area (10 to 30 km) (blue: eastern river banks, orange: western river banks).



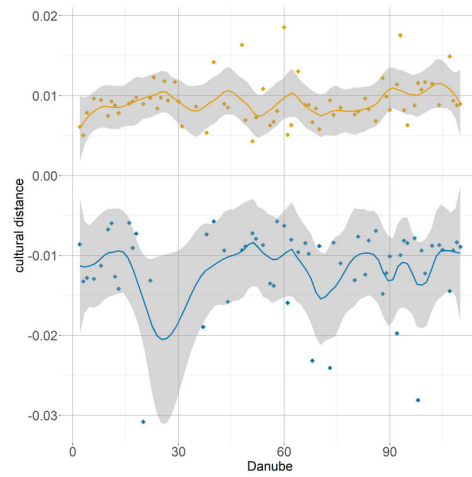
(a) spatial reference



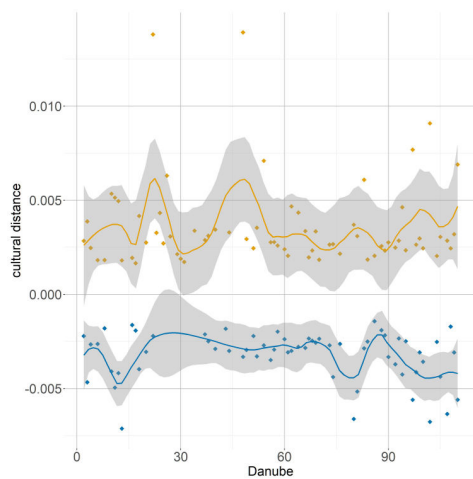
(b) all



(c) vessels (B1)

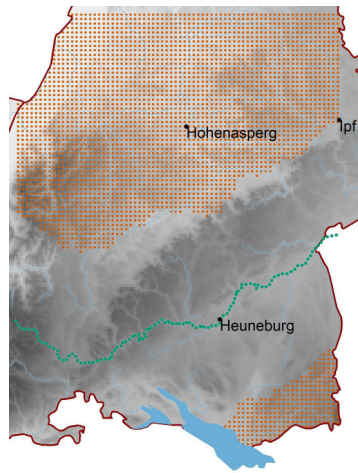


(d) ring jewellery (B2)

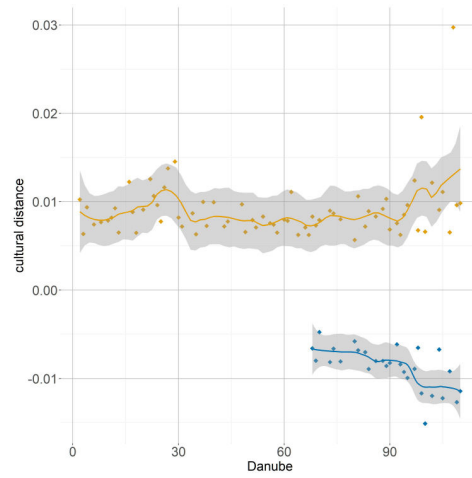


(e) traditional costumes (B3)

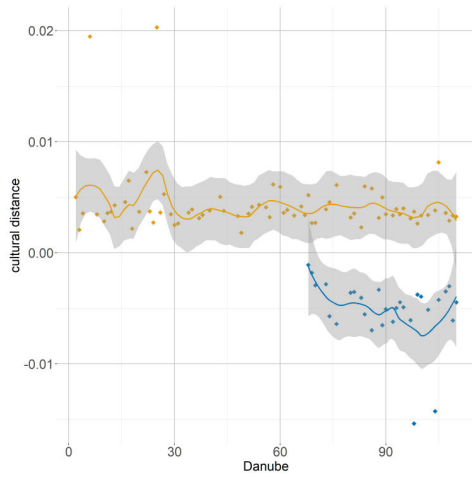
Fig. 6.14: Profile diagram of the Danube for the regional hinterland (30 to 50 km) (blue: eastern river banks, orange: western river banks, data: SHKR20).



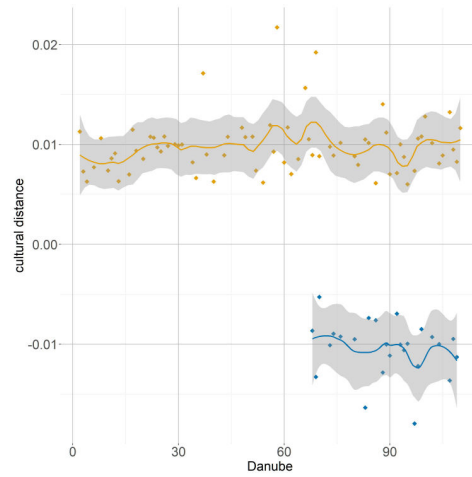
(a) spatial reference



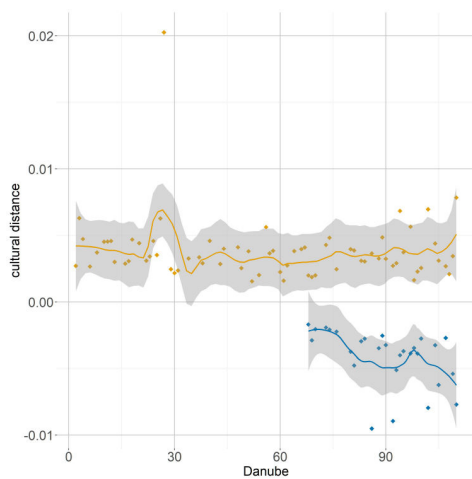
(b) all



(c) vessels (B1)



(d) ring jewellery (B2)



(e) traditional costumes (B3)

Fig. 6.15: Profile diagram of the Danube for supra-regional setting (over 50 km) (blue: eastern river banks, orange: western river banks).



the values along the northern curve is reduced from this point to the east. There are higher fluctuations at the beginning of the southern curve until profile 30 towards the east.

The curves of the ring jewellery are also clearly asymmetrical. The southern curve begins in the west with average values that reach a minimum at profile 30. Comparably low values are only reached again with profile 75. Profile 65 has the highest values. The course of the northern curve also begins in the west at low distance values. A maximum is reached at profile 30. Between the profiles 45 to 75, the values spread over a medium distance range. Another maximum occurs at profile 100.

Nevertheless, another curve shape displays the costume combinations. Interestingly, the values are inverted. Low values are shown in the southern curve compared to the high distance values on the northern curve. With certain deviations, the curves run parallel, which means for the interpretation, however, that the interaction structures are opposite. The southern curve has high values at profile 15 (Magdalenenberg), 90 and the curve's end. The northern curve rises to the east from profile 90.

The local area is represented in the cultural distance of the Danube to sample points 10 to 30 km (fig. : 6.13). The regional rehearsal points run in the south along the Wutach to Lake Constance and are on the Donau-Ablach Platte. In the north, the Swabian Alb is mainly followed. While the course of the southern curve shows apparent differences to the course of the immediate surroundings (fig. : 6.12), the northern curves' courses are similar. The southern curve begins in the west with strongly oscillating distance values, which decrease from profile 15 to a minimum value. A maximum occurs at profile 45. The distance values drop again to the curve's minimum value and only rise again at profile 90. The northern curve course has a flat course from the east up to profile 55. After the local minimum and a local maximum at profile 60, the curve rises at profile 75, forming another level with higher values than in the east.

When comparing the vessels' curves, the direct surrounding's distance areas differ significantly from the local area (fig. : 6.13). The curves of the two river banks are mostly symmetrical. In profiles 2 and 30 occur common maximum values. The position of the low values is usually not symmetrical but shifted by a few profiles. There are symmetrical bottlenecks in profiles 15 and 65.

The profile diagram for ring jewellery in the local area is just as asymmetrical as that of the immediate vicinity, but the courses differ. The southern curve no longer has any maximum values for profile 45. The high values have shifted slightly to the east towards profile 38. The increase in the curve from profile 90 towards the west remains similar. The northern curve has a flatter course but also a significantly higher spread of the distance values. Local maxima are in profiles 63 and 93. At profile 110 occur the lowest distances. Interestingly, the values of the southern curve rise at this point.

The curves for traditional costumes in the local area differ from the immediate surroundings, mainly because the two banks are now symmetrical. Both areas have high distance values in common at profile 20 in the southern curve. In the local area, symmetrical bottlenecks occur on profiles 15, 30, 58, 65 and 95. Common maximum values occur in profile 60. Interestingly, the symmetry of the interaction structure relates more to cultural closeness than distance. The northern curve shows a higher fluctuation.

The regional reference points of 30 to 50 km reach the edge of the Swabian Alb and partly the Neckar valley in the north (fig. : 6.14). The Ipf occurs within the most easterly profiles. Reaching the working area's limits in the south means no sample points, especially in the central-western area. There are entirely different curves for the regional and local area (fig. : 6.13) - the curves for the entire archaeological material run partially parallel. Low values of the southern curve correlate with the northern curve's high values at profiles 45 and 63. Conversely, low values in the north for profile 50 correlate with high values in the south. From profile 63, however, the curves run more symmetrically with a local maximum at profile 87 and the maximum in the east.

The vessels' profile diagrams (fig. : 6.14) show the same trend in the region as in the local area. The distance values decrease from east to west. However, this trend cannot be determined with certainty for the southern curve since sample points are missing. The northern curve has high distance values in the area of profile 25.

There are also differences in the curves of the local and regional areas for ring jewellery apparent. The southern curve has slightly higher values in the eastern than the northern part. The values also spread more widely in the south. A significantly higher range of cultural distances occurs for profile 65 in the south. Although

the two curves differ significantly, the values vary widely between profiles 35 to 65. In the area of profile 63, there are high distance values.

There is also little correspondence between the curves of the local and regional areas in terms of costume. The curve's southern course rises significantly and reaches a maximum at profile 12, probably influenced by insufficient coverage with sample points. The mean course of the curve, between profiles 35 and 60, differs significantly. In comparison, the values between profiles 60 and 75 scatter less. The minimum values are for profiles 63 and 87. The curve's northern course is characterised by more fluctuating values, leading to a restless curve. Minimum values occur for profiles 15, 30, 60, 70 and 83. Symmetrical structures are available for profiles 80 and 87.

Several supra-regional sampling points lay outside the working area (fig. : 6.15). The northern profiles cover the Neckar valley and reach the Hohenasperg and the Ipf at the edge. For all of the archaeological artefacts, a certain symmetry occurs of the curve courses from profile 70. The southern curve rises here comparatively up to profile 95. A steeper increase in values occurs in the northern curve. The remainder of the northern curve has a slope beginning in the west up to profile 29. With profile 31 a low level is reached, continuing until the renewed rise in profile 95.

The cultural distances concerning vessels in the supra-regional area (fig. : 6.15) fluctuate in the curve's southern course. Nevertheless, the increasing values from profile 75 to profile 90 are clear. Then the values fall again. The northern course of the curve shows high distance values and a higher spread in the western area. In the further course, local minima are weakly pronounced in profiles 32, 50, 70 and 105.

The courses of the curves of ring jewellery in the supra-regional representation are parallel. The curve's northern course begins with low-distance values that rise from profile 15 and reach a level that continues up to profile 50. The values between profiles 50 and 75 fluctuate significantly. A local minimum occurs with profile 95.

Constantly increasing distance values describe the course of the southern curve of the traditional costume from profile 75. In the northern curve of the traditional costume objects, the high values in profile 28 are still present. From the following minimum, the values continuously increase slightly to the east.

## 6.2 Haguenau

In the Haguenau Forest, antiquarian excavations began in 1862 by Maximilian de Ring at the necropolis of Schirrheimerweg, followed by Xavier Nessel [509]; [508]. Nessel excavated between 1862 and 1899 nearly 400 barrows in Haguenau Forest. His excavation techniques were excellent at that time. He, for example, sieved the earth, retrieved perishable artefacts (belt) and sometimes he noted position and depth of artefacts<sup>4</sup>. Nessel did not published the results himself; however, Schaeffer used the excellent documentation by Nessel for his publication in 1926 and 1930 [427], [428].

More recently, Wassong used Schaeffer's published maps to retrace all necropolis and document the current state for spatial analysis of the organisation of necropolis [509]; [508]. Wassong recorded 639 barrows<sup>5</sup> and identified 300 of the barrows excavated by Nessel. Usually, barrows form linear axes with regular spacing between 1 and 2 km. Therefore Wassong suggests, that isolated barrows might indeed only appear isolated. He remarks the ostentatious character of some exceptionally large barrows comparable to the Glauberg and Hochdorf barrows. Their superior topographic position close to waters and communication axes compares Wassong with the saga of Beowulf [509]. There, barrows should be ostentatious and on prominent location, well visible from waters for seeing and saluting. This natural location on the Rhine terraces rises to 10 m above the valley. Barrows tend to be larger, close to the Rhine and have a more extended chronology; both interpreted by Wassong

<sup>4</sup> More on research history in Haguenau Forest see [508].

<sup>5</sup> Only 190 barrows are dated, ranging from Bronze Age to La Tène B with dominance in Middle and late Bronze Age (64%) to Ha D (25%) [508].

as an indicator of their importance. The following section reconstructs a local path system based on individual barrow location and evaluates possible infrastructure parameters.

### 6.2.1 Reconstructing Infrastructure

GPS locations of individual barrows represent the best data quality available for the reconstruction of path systems. For the subareas of the Haguenau Forest, Wassong recently recorded 796 monuments [508]; [509]. 638<sup>6</sup> of these recorded barrows have GPS coordinates and allows us to reconstruct a detailed regional path system (for computational details, see *RepathHag.R*<sup>7</sup>). In contrast to the reconstruction of the entire path system, a resolution of 90 m depicts better local path systems.

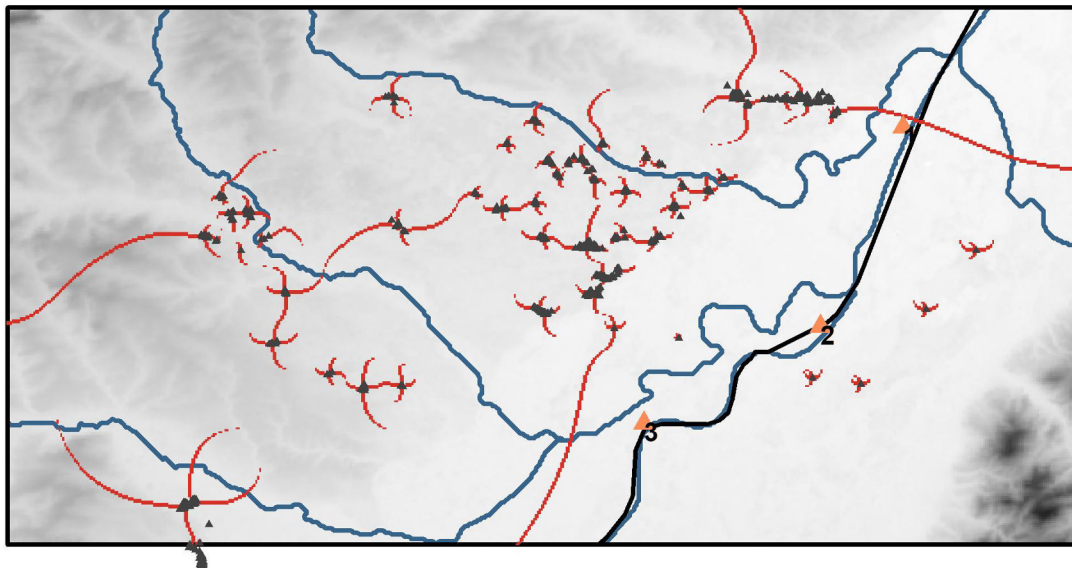


Fig. 6.16: Early Iron Age reconstructed path system in Haguenau (red: path system, DEM: SRTM 90 m).

As already mentioned, edge effects resulting in calculation residuals occur similarly (see above); however, they are less straight lines. The main paths seem to direct towards the Rhine, being well interconnected. Although barrows form a linear structure along the Rhine terrace, this occurs not as a consistent path by *Repath*. One passage across the Rhine identified by Logel [294] is correctly reconstructed (no 1 in fig 6.16). Wassong also states that groups of barrows near these passages indicate long-existing communication axes and paths [509]. The other two (no 2 and 3 in fig 6.16) probably caused due to edge effects. A southern route beginning near the river Le Moder directs in a south-eastern direction towards the Rhine. The path system crosses at least three times the river Le Moder and connects the southern path with the northern necropolis. A dense central path system is reconstructed with the best data coverage, resulting in one path along the edge of the Rhine terraces

<sup>6</sup> The remaining 158 barrows are those named by Schaeffer, which Wassong could not identify correctly [508].

<sup>7</sup> <https://gitlab.com/FFaupel/analyse>

and several branches into the hinterland. Two main routes leading from the Western hinterland to the Rhine and the main north-south terrace route describe the path system's main structure in the centre of the Haguenuau Forest. One very pronounced northern route directs from the West to the Rhine and the Bronze Age crossing (no 1 in fig. 6.16).

With an intuitive approach, Wassong [508] reconstructed five main routes from East to West, one following the river system. The Repath function reconstructed more interconnecting branches as Wassongs intuitive approach, while the other routes are reconstructed at least in transects. Those necropoleis' closer to the Rhine are in use for a more extended period than those more western located. During the 7th century BC, large barrows are erected near the Rhine, intensifying the north-south axis along the Rhine.

### 6.2.2 Identification of Infrastructural Important Parameters

Fig. 6.17 compares the distances of each theoretical model and mode to path associated features (barrows,  $n = 638$ ) illustrating the best model fit (chap.: 5.4, for modelling accumulated cost surfaces see TheoPathCorrdior.R<sup>8</sup>, and for the evaluation see EvalPathHag.R<sup>9</sup>) for the subarea Haguenuau.

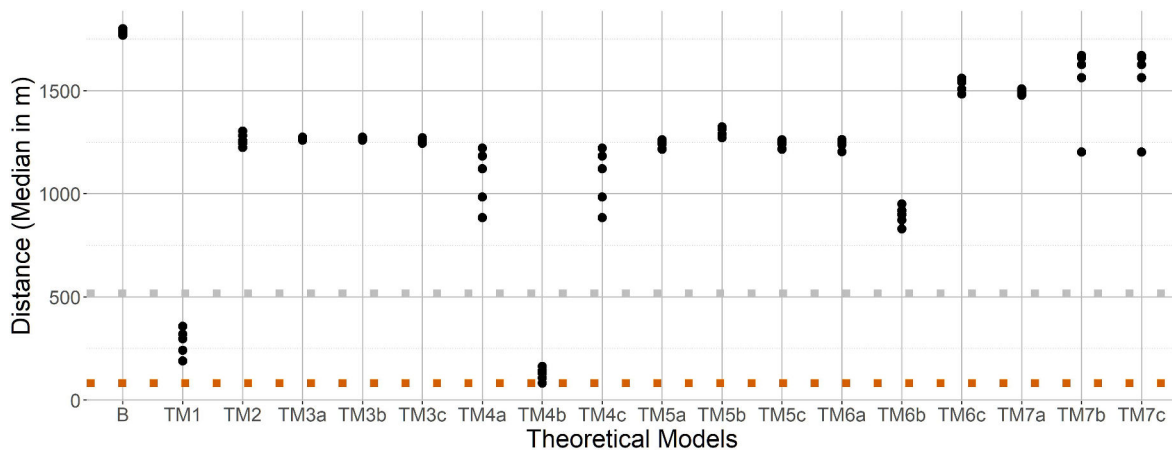


Fig. 6.17: Distances of TM 1 to TM 7 to monument locations for the subarea of Haguenuau Forest (incl. modes a to c, red: best model fit, grey: globally best fitting model, method: median of nearest neighbourhood in m).

All models and modes have shorter distances than the basic reference model B (1,769 to 1,801 m). This benchmark does not reject models in the subarea Haguenuau. Attraction to settlements TM 7 has the highest distances (TM 7a distance: 1,478 to 1,509 m, Tm 7b: 1,202 to 1,671 m, and TM 7c: 1,202 to 1,671 m) and especially mode b and c range drastically regarding the neighbours. The modes from TM 6 differ drastically in distances. TM 6 c has distances between 1,484 and 1,561 m being the worst fit of this model. TM 6a is distanced from 1,203 to 1,263 m, and TM 6b from 830 to 951 m. These values show that those modes, including pedestrian movements, are a better model fit than modes pronouncing movements alongside ridges. An opposite trend is observable for TM 5. Here, those modes, including pedestrian movements, have higher distances (TM 5b 1,271 to 1,325 m) than these pronouncing the parameter of preferred movements in lowlands (TM 5a and c 1,216 to 1,261 m). Similar distances result for TM 3 (TM 3a 1260 to 1,275 m, TM 3b distance: 1,260 to 1,275 m

<sup>8</sup> <https://gitlab.com/FFaupel/analyse>

<sup>9</sup> <https://gitlab.com/FFaupel/analyse>

and TM 3c 1,246 to 1,272 m). However, modes of avoiding visibility have equal distances resulting in a similar model fit. The use of wheeled vehicles results in distances from 1,224 to 1,303 m, higher than the global trend with only 516 m. Preferring visibility TM 4 has large differences between those modes pronouncing visibility (TM 4 a and c 885 to 1,221 m) and the mode equally regarding pedestrian movements (TM 4b 81 to 162 m). Compared with TM 1 (189 to 357 m), the combination of both parameters in TM 4b — visibility and pedestrian movements — results in the best model fit.

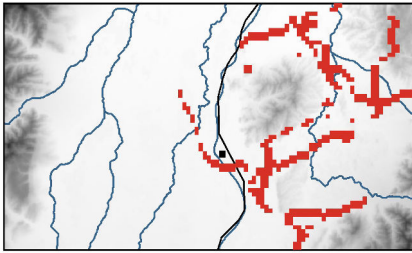


Fig. 6.18: Early Iron Age reconstructed path system in Breisach Münsterberg (red: path system, DEM: SRTM 90 m).

In the subarea Hagenau, no steep slopes occur. Flat areas and middle slopes dominate the area (fig.: 3.5). Cost functions modelling high costs for steep slopes will result in a moderate cost surface. Moving along mountain ridges (TM 6) and preferring lowlands (TM 5) results likewise in moderate cost surfaces as ridges occur only in the subarea's border zones and valleys are only represented with 7%. Simulating pedestrian movements results in low costs along the river valley as here only flat slopes occur. The model disregards the moving river bed of the Rhine or the river as a barrier. The combination of preferring visibility and pedestrian movements, however, is the best fitting model strengthening Wassongs point that barrows are erected in visible areas to be seen by travellers [509].

### 6.3 Breisach Münsterberg

The Breisach Münsterberg lies prominently above the Rhine and is therefore conveniently located in a presumed communication corridor [345]. Apart from the topographical location, the finds on the Breisach Münsterberg also indicate wide-ranging interaction (chap.: 1.1). This chapter takes a closer look at the infrastructure in the immediate surroundings of the Münsterberg, followed by the evaluation of the probably relevant path parameters. The patterns of interactions are examined using different distance diagrams that focus on different perspectives and geographical distances. The Breisach Münsterberg is related to other so-called princely seats and relevant exchange zones (fig.: 1.1).

#### 6.3.1 Infrastructure

For the subarea around the Breisach Münsterberg, the Repath method reconstructed a path system leading around the massive structure of the Kaiserstuhl (fig.: 6.18). The so-called princely seat Breisach Münsterberg is located next to the path system near a passage across the Rhine connecting the Freiburger Bucht. This passage (no 12 in fig.: 6.2) has also been identified by Logel [294]. Due to missing data on the Rhine's western river banks, no path system is reconstructed here; however, as the passage indicates, a path system surely existed.

Fig. 6.19 compares the distances of each theoretical model and mode to path associated features (necropolis,  $n = 97$ ) illustrating the best model fit (chap.: 5.4, for modelling accumulated cost surfaces see `TheoPathCorridor.R`<sup>10</sup>, and for the evaluation see `EvalPathBrei.R`<sup>11</sup>) for the subarea around the Breisach Münsterberg.

The reference model as benchmark rejects the mode b of model TM 6 as it has higher distances (B: 1,146 to 1,227 m and TM 6b: 1,441 to 1,495 m). Similar high distances result for mode c of TM 6 (1,008 to 1,078 m),

<sup>10</sup> <https://gitlab.com/FFaupel/analyse>

<sup>11</sup> <https://gitlab.com/FFaupel/analyse>

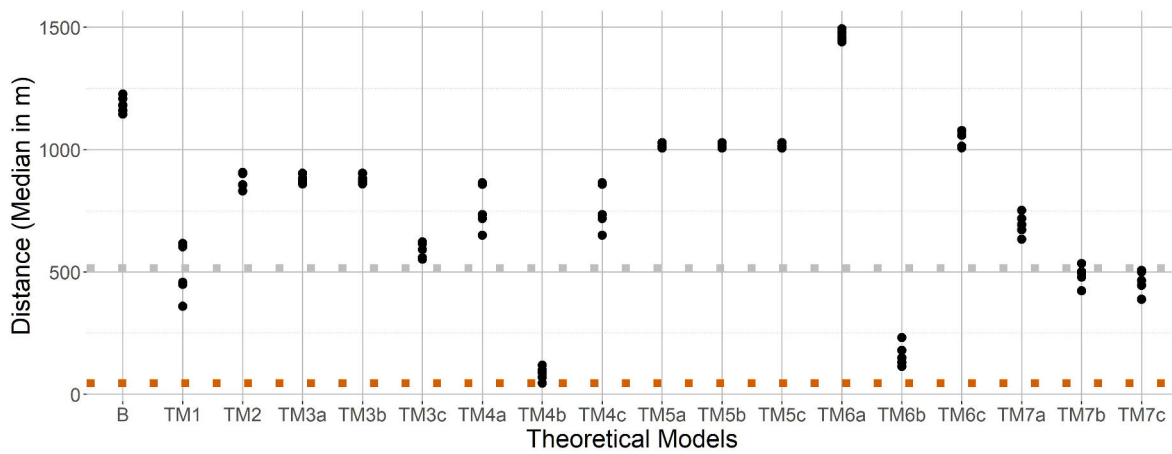


Fig. 6.19: Distances of TM 1 to TM 7 to monument locations for the subarea of Breisach Münsterberg (incl. modes a to c, red: best model fit, grey: globally best fitting model, method: median of nearest neighbourhood in m).

while the mode equally weighting pedestrian movements has low distances ranging from 114 to 232 m being the second-best fitting model.

All the model modes preferring lowlands (TM 5) have very similar distances ranging from 116 to 1,029 m. Shorter distances result for the visibility avoiding model TM 3. While mode a and b have medium-large distances (859 to 903 m), mode b with pronounced avoided visibility has shorter distances from 552 to 623 m. The model for wheeled transport (TM 2) has higher distances (832 to 907 m) compared to the global trend (516 m). The archaeological model simulating attraction of settlements (TM 7) has shorter distances for those modes respecting pedestrian movements (TM 7a: 634 to 752 m, TM 7b: 423 to 534 m, TM 7c: 388 to 506 m). The pedestrian movements without additional parameter (TM 1) has values ranging from 360 to 617 m resulting in the third-best fit. Preferring visibility equally weighting pedestrian movements has the shortest distances to path associated monuments ranging from 45 to 119 m. However, only preferring visibility TM 4a results in distances between 650 and 865 m similar to mode c.

A contrasting terrain characterises the subarea of Breisach. High mountainous areas at the western borders of the Kaiserstuhl and Tuniberg oppose the Upper Rhine Valley's sizeable flat area (fig.: 3.6). The cost surface for modelling movements along ridges results in high costs only in those bordering areas. In contrast, preferring lowlands has limited influence on the cost surface, as lowlands cover more extensive parts of the area and no manipulation of costs occurs. The three best-fitting models regard pedestrian movements, while significantly reducing distances occurs when including highland preferring models, especially visibility.

### 6.3.2 Interaction

To better understand the archaeological site Breisach Münsterberg concerning the interaction pattern, three different distance diagrams are created. The distance diagram type dd3 represents an overview of the relationships

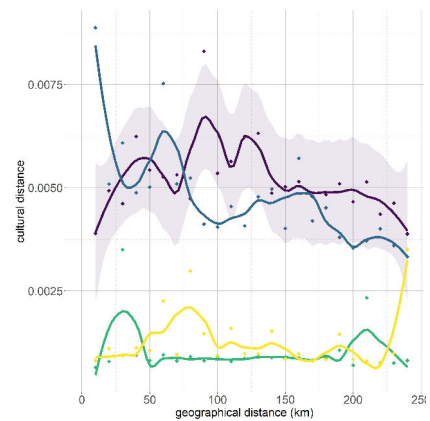


Fig. 6.20: Distance diagram dd3 of the Breisach Münsterberg (purple = all; blue = vessels, green = ring jewellery, yellow = costume).

depending on the geographical distance (chap.: 5.5.2). Although it is difficult to compare the distance values of the individual type combinations directly with one another, the common representation helps to recognize the deviations in the course <sup>12</sup>. Considering the frequency of distance values in distance ranges allows a better assessment of the interaction patterns at the Breisach Münsterberg. Because of the averaged distance values, interaction relationships with individual sites, e.g. the Heuneburg, cannot be differentiated from the global trend. Therefore, distance diagrams of the type dd2 focus on the individual cardinal points. Besides, there is a comparison of four different combinations: the entire material, the vessels (B1), the ring jewellery (B2) and traditional items (B3) (chap.: 5.5.1).

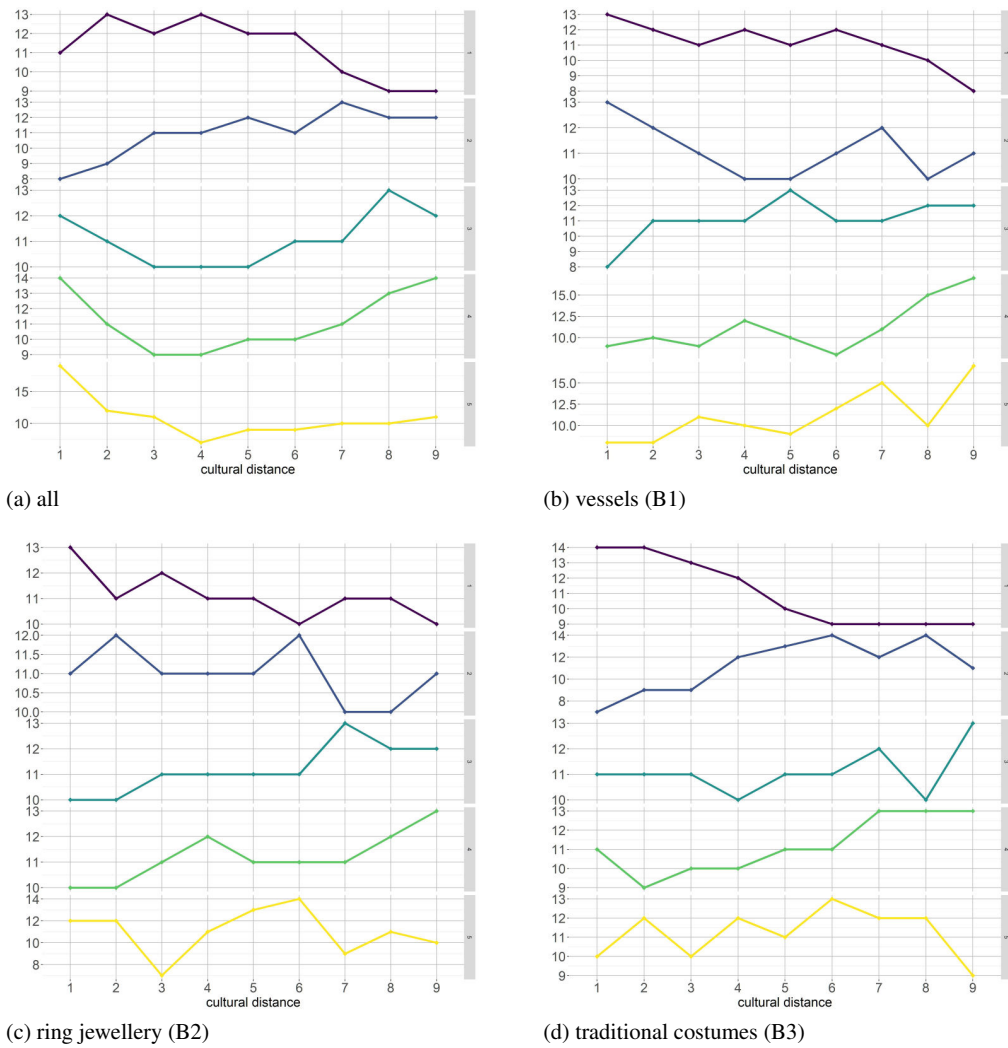


Fig. 6.21: Histogram of cultural distances of the Breisach Münsterberg.

<sup>12</sup> The individual dd3 diagrams of the type combinations are stored (...)

The entire material culture curve increases significantly up to about 50 km (fig. : 6.20). The values drop slightly at a distance of 60 km. After a further increase up to 90 km, the values drop again to those from 60 km. Astonishingly, the curve sinks slightly at a distance of 200 km. Increasing interaction friction with greater geographical distance is not strongly pronounced for the entire archaeological material with the Breisach Münsterberg as a reference point.

In contrast, this inverse curve progression is more pronounced in vessels (fig. : 6.20). If disregarding outliers, the curve results in a comparatively steady course up to about 40 km. High distance values occur at 60 km. The curve then sinks to a distance below the initial level. Up to 150 km, there is a slight increase in the curve depending on the distance. Between 150 km and 200 km distance, the values drop again and reach their lowest point at the curve's end.

The fluctuation of the distance values is significantly lower for ring jewellery and costume. The curve of the ring jewellery shows a slight increase up to 25 km away. The further course is restless due to increased values at 75 km, 90 km away and between 120 and 150 km. After 150 km, the values fluctuate slightly, which is mainly contrasted by the area with higher fluctuation in front of it. At 175 km, there is another climb. For the entire course of the curve, there is no apparent, distance-dependent increase in cultural distance.

The costumes curve shows an increase in values up to about 20 km after the initial stage. Then a plateau forms, which is still characterized by fluctuating values up to 50 km. The curve has low values at 60 km, 100 km, 150 km, 175 km and 200 km. The slightly increased values in the areas in between, however, are not very pronounced. The course of the curves results in a latent, distance-dependent increase in cultural distances. Cultural dissimilarity is more pronounced in the supra-regional hinterland (50 to 100 km) than in distant regions.

Because of the sometimes strong fluctuations in the previous representations, it seems logical to consider cultural distances' frequencies (chap. : 5.5.4). The number of sample points in the individual distance area is shown in fig. 5.13. For the Breisach Münsterberg, fewer sample points than expected occur in a wider regional area (100-150 km). The underrepresentation is due to the geographical proximity to the border of the departments of Bas-Rhin and Haut-Rhin. For describing the frequencies of cultural distances, the first viewing direction is chosen, considering the distribution of frequencies within a distance range.

About the entire material (fig. : 6.21), as expected, the frequency of cultural distance of the direct surroundings decreases. After reaching the lowest proportion at decile 4, the other middle and higher deciles are around 10%. A similar course occurs in the local area's distance range (25 to 50 km) and approximates the regional hinterland (50 to 100 km) for the lower 4 deciles. After that, the frequency increases significantly, so that deciles 1 and 9 occur almost equally often (about 15 %). The broader regional hinterland (100-150 km) shows the higher deciles' expected distance-dependent increase. In the supra-regional setting, the low deciles dominate again. Here the sought-after interaction above described for the Breisach can be seen at a further

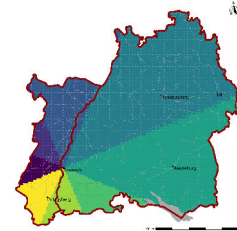


Fig. 6.22: Distribution of cardinal directions of the Breisach Münsterberg.

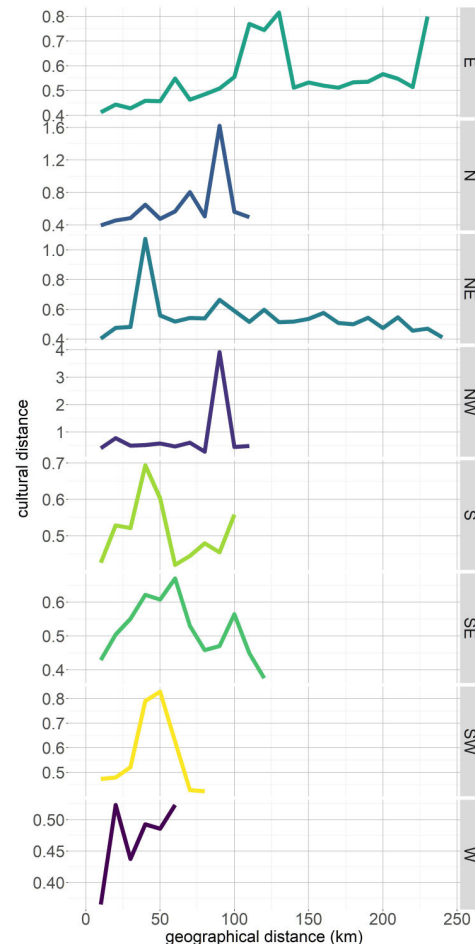


Fig. 6.23: Distribution of cardinal directions for diagram type dd2 of the Breisach Münsterberg.



distance. In this representation, the similarities in the interactions between the combinations considered are more apparent. Deviations occur for the ring jewellery in the immediate surroundings with dominating middle deciles. Garb shows a distance-dependent increase in proportions of frequency already in the regional hinterland. The trend is reversed in the broader regional hinterland (100-150 km) and corresponds to the other type combinations. Looking at the frequency of cultural distance for the vessels, it is clear that — contrary to the expected trend — there is almost a reversal of the distance-dependent interaction friction. They differ most in the entire material.

The observation of the histogram shows the interaction behaviour of the Breisach Münsterberg. Only the immediate surroundings (up to 25 km) are culturally much closer to the *Fürstensitz*; the princely seat already appears culturally distant in the local area. The expected distance-dependent interaction friction can be seen for the regional area (100-150 km), which changes when reaching the supra-regional area (over 150 km).

For the cardinal directions of the diagram type dd2, the eight directions were displayed one above the other (fig.: 6.23). Due to the known asymmetry of the working area, some curves are shorter. Figure 6.22 illustrates sample points of the reference points in all cardinal directions and other princely seats.

In an eastern direction from Breisach Münsterberg, the Black Forest occurs in 60 km, reflected in the curve with high values. It appears here as an obstacle to interaction. The higher values in the range between 100 and 130 km relate to the Swabian Alb sample points. The Heuneburg in 130 km distance is characterized by drastically decreasing values. High values again characterize the further course of the Swabian Alb from 230 km. In the area around the Heuneburg, the Breisach Münsterberg seems to have more intensively connected interaction patterns. The north-east and south-west profiles also clearly show the Black Forest as an obstacle to interaction. In the north-eastern profile, the often described increase in distance, followed by a decrease in values, is again visible. The cultural distances decrease approximately with reaching the princely seats of Hohenasperg (145 km) and Ipf (210 km). The Britzgyberg affects the southern and south-western profile. It is noticeable that there are high cultural distances at a distance of 45 km, i.e. when reaching the Britzgyberg. An exchange zone can explain this, as this region appeared in the profile diagrams (east-west oriented) to be culturally alien, also confirmed in a north-south direction. Edge effects are likely to occur at the end of the northern segment.

## 6.4 Swabian Alb and the Heuneburg

The so-called princely seat Heuneburg is one of the best-excavated sites of the Early Iron Age in Europe (fig.: 1.1). The hilltop settlement near the Danube is known for its imposing mud-brick wall and the graves in the immediate surroundings equipped with luxurious goods. The development of such an agglomeration has occupied archaeological research for decades (chap.:1.1). The location, near the Danube, is often described as a favourable traffic topography, and the Heuneburg supposedly controls the communication route along the Danube. The present work examines the infrastructure in the surroundings of the Heuneburg more closely, and the relevant parameters for the location of these paths are determined. The infrastructure analysis is followed by a detailed evaluation of the interaction structure starting from the Heuneburg to its immediate surroundings and supra-regional exchange partners.

### 6.4.1 Infrastructure

The before mentioned dense path system reconstructed on the Swabian Alb is also visible in the subarea around the princely seat Heuneburg. In fig. 6.24 the path system crosses at least three times the Danube: near Mengen, near the Heuneburg and Ehingen in the north. The Heuneburg is conveniently situated in the reconstructed

path system with connections along the Danube and into the Swabian Alb's hinterland. Additionally, long path transects connecting the Heuneburg to a north-south axis and several routes indicate paths into the Danube-Illler macrochore.

Fig. 6.25 compares the distances of each theoretical model and mode to path associated features (necropolis,  $n = 1,005$ ) illustrating the best model fit (chap.: 5.4) for the subarea of the Swabian Alb.

The high distances of the archaeological model TM 8 (TM 8a: 4,691 to 4,736 m, TM 8b: 4,570 to 4,687 m and TM 8c: 4,570 to 4,687 m) which simulates attraction to iron production sites, indicate that this model does not correspond to the archaeological record (fig.: 6.25). TM 1 modelling pedestrian movements also has high distances from 1,219 to 1,429 m). The second archaeological model TM 7 has high distances with also high variation in distances to the next five neighbours (TM 7a: 1,050 to 1,134 m, TM 7b: 1,106 to 1,302 m and TM 7c: 1,109 to 1,302 m). The benchmark from reference model B with distances between 1,090 to 1,123 m rejects the models mentioned above as unrealistic.

In fig. 6.26 model TM 8 is excluded, enabling visualising the distances of the other models better. The modes of the model preferring movement along ridges TM 6 spread across the fig. 6.26 with distances from mode b (1,191 to 1,458 m) higher than the benchmark of reference model B, to mode c (899 to 1,096 m) and mode a (832 to 896) being the third best-fitting model. Similar distances result for both lowland preferring models TM 3 (TM 3a and b: 859 to 900 m, TM 3c: 999 to 1,130 m) and TM 5 (TM 5a and c: 852 to 903 m, TM 5b: 946 to 1,026 m). The distances for wheeled transport TM 2 range between 618 and 720 m, slightly higher than the global trend (516 m). In the subarea of the Swabian Alb, TM 2 is the second best-fitting model. However, preferring visibility combined with pedestrian movements TM 4b results in distances between 461 to 645 m being the best fitting model. The modes a and c, which pronounce visibility, have significantly higher distances between 1,020 and 1,213 m).

The subarea of the Swabian Alb has referred to the landform classification (fig.: 3.7), comparable proportions of landform as the entire area (fig.: 3.4). Both archaeological models are reflected based on the benchmark of reference model B. While the data coverage for settlements in this subarea suffices due to intensive research activities around the princely seat Heuneburg, production sites' distribution results in 4 zones naturally depending on the raw material sources. Neither the attraction of settlements nor the location of production sites seems to influence this factor. A high amount of cells with the lowest costs in the accumulated cost surface of TM 1 occur in the Danube Valley at the border of this subarea, which might cause high distances and the lousy performance of TM 1. However, this does not explain the well-fitting model TM 4b, which regards pedestrian movements and visibility. The combination of both parameters is relevant to the location of the path system.

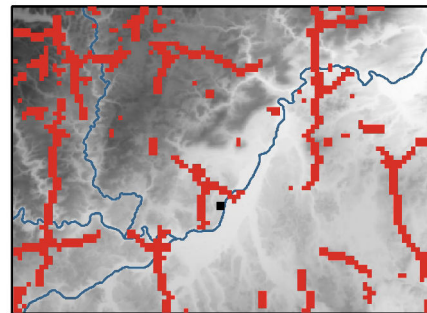


Fig. 6.24: Early Iron Age reconstructed path system on Swabian Alb (red: path system, DEM: SRTM 90 m).

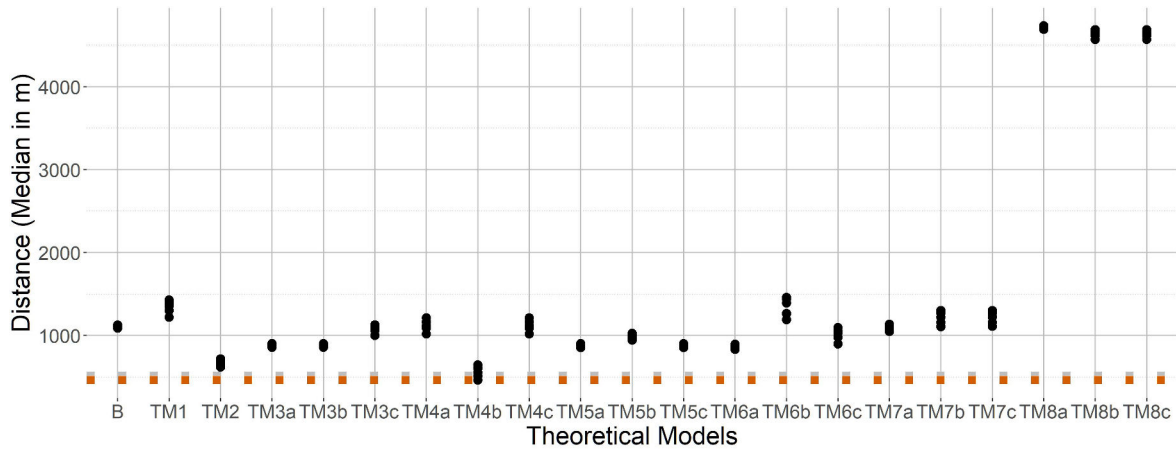


Fig. 6.25: Distances of TM 1 to TM 7 to monument locations for the subarea Swabian Alb (incl. modes a to c, red: best model fit, grey: globally best fitting model, method: median of nearest neighbourhood in m).

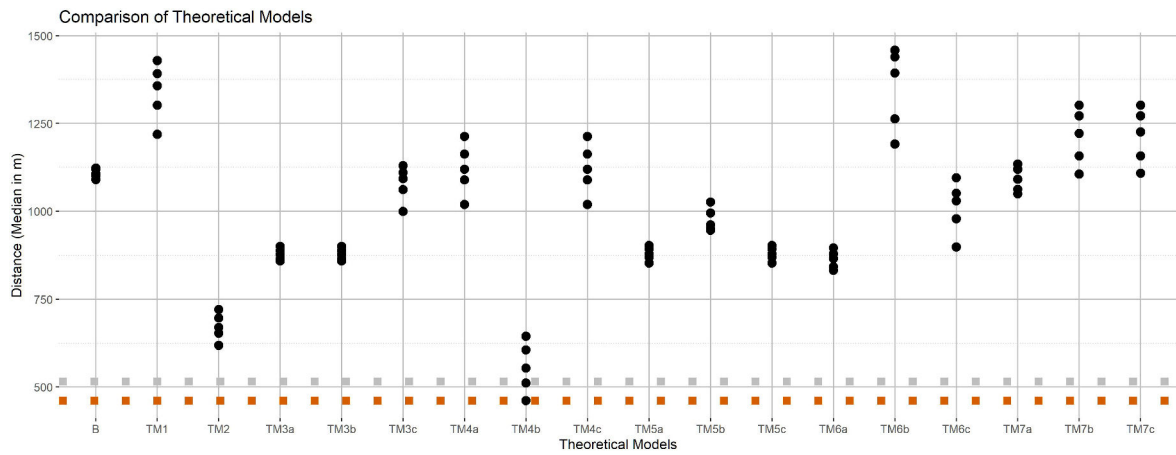


Fig. 6.26: Distances of TM 1 to TM 7 to monument locations for the subarea Swabian Alb (incl. modes a to c, excl. TM 8, red: best model fit, grey: globally best fitting model, method: median of nearest neighbourhood in m).

### 6.4.2 Interaction patterns of the Heuneburg

The representation of the interaction pattern of the Heuneburg follows the same scheme as already presented for the Breisach Münsterberg. After evaluating the global interaction pattern, with diagram type dd3, the cultural distance values' frequencies are considered. The dd2 diagrams of the individual directions allow the Heuneburg to be related to other princely seats. For a comprehensive representation of the interaction pattern, the entire material and type combinations of the vessels, the ring jewellery and the costume are opposed (chap.: 5.5.1).

The cultural distance increases significantly after the initial stage, concerning the entire material up to about 50 km (fig.: 6.27). In the further course, the cultural distance drops slightly on average. A first minimum occurs at a distance of 60 km. In 125 km, this is even more pronounced and continues as a plateau up to 200 km, only disturbed by higher values in the 140 and 160 km range.

The curve for vessels rises moderately up to 40 km. At 60 km, it reaches the values of the initial stage. Even lower values occur in 100 and 160 km, which indicates an initial stage too high. For the ring jewellery and costume, there is no noticeable increase after the initial stage. The cultural distance from ring jewellery increases up to 75 km, whereby at the same time, the values fluctuate more. The level reached at 75 km shows constant distance values besides a few deviations up to 125 km. After the increased values in 125 km, the values level again. Interaction friction that increases depending on the distance can only be determined in less than 100 km. Ring jewellery shows a cultural dissimilarity 130 km and 175 km away. For costume, the higher values shift slightly at 120 and 160 km.

The dd3 diagrams result in a comparable curve to that of the Breisach Münsterberg. Interaction relationships at a greater distance seem to occur more intensively than in a regional distance between 50 and 100 km.

For illustrating the interaction structure of the Heuneburg better, the distance histograms of the type combinations are compared (chap.: 5.5.4). Figure 5.13 shows the number of sample points in the individual distance classes. For the Heuneburg, the increasing number of sample points lacks in the broader regional area. Areas between 100 - 150 km and over 150 km are underrepresented because of the border with Baden-Württemberg in the south and east.

The small cultural distances dominate the entire material in the immediate vicinity (fig.: 6.28). This trend is already reversing in the local area, unlike in Breisach, where this only happens in the regional hinterland. The Heuneburg is vastly dissimilar to the sample points between 25 km to 100 km. There is another trend reversal in the broader regional environment and supra-regional setting, similar to the Breisach Münsterberg. The frequencies of ring jewellery differ from the entire material. The trend for the direct and local surroundings corresponds. However, in the closer and more distant regional areas, the low cultural distances are more frequent, indicating more shared elements.

In contrast to the trend for the entire material, this does not apply to the supra-regional setting. Astonishingly, the mean cultural distances for the costume dominate in the immediate surroundings. A distance-dependent trend occurs for the local area and closer regional hinterland. In the broader regional hinterland and supra-regional setting, the trend reverses. Another picture shows the type combinations of the vessels.

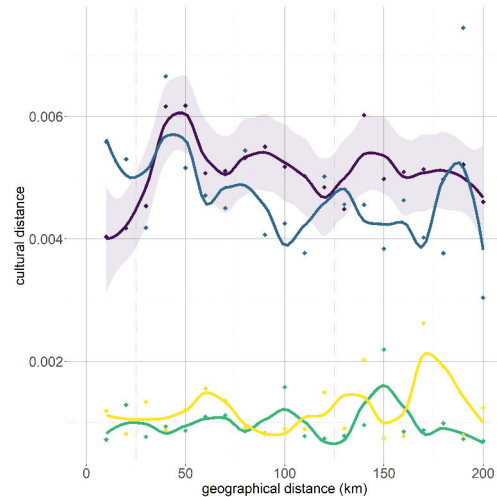


Fig. 6.27: Distance diagram type dd3 of the Heuneburg (purple = all; blue = vessels, green = ring jewellery, yellow = costume).

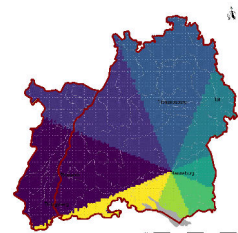


Fig. 6.29: Distribution of cardinal directions of the Heuneburg.

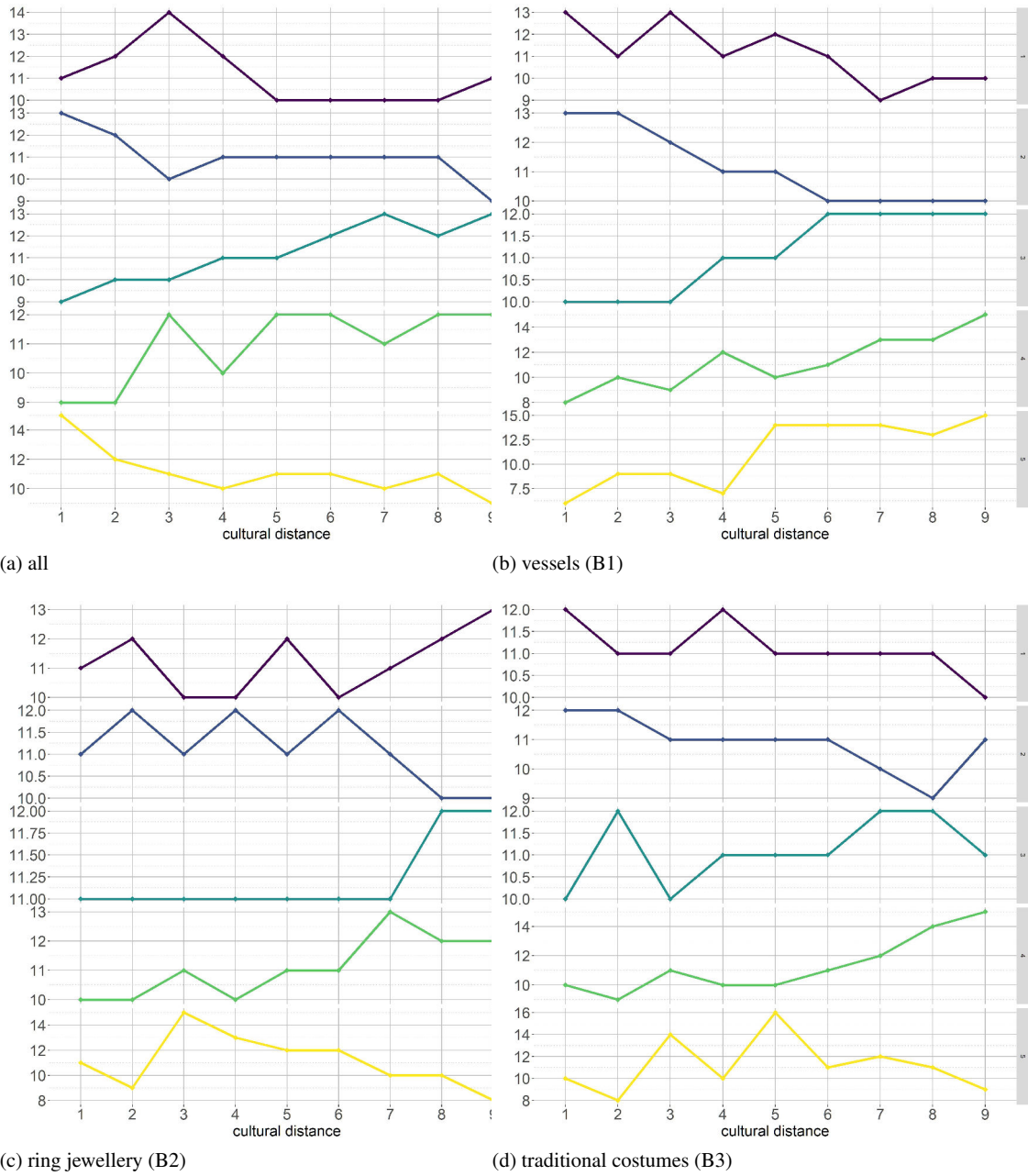


Fig. 6.28: Histogram of cultural distances of the Heuneburg (1 = over 150 km, 2 = 100-150 km, 3 = 50-100 km, 4 = 25-50 km, 5 = 10-25 km, 6 = 5-10 km, 7 = 1-5 km, 8 = 0-1 km, 9 = under 25 km).

Contrary to the distance-dependent interaction friction expectation, the higher cultural distances dominate in the direct, local and closer regional environment, reversing the broader regional environment and supra-regional setting. The Heuneburg seems to reach preferred interaction partners at a distance of 100 km, earlier than the Breisach.

For the cardinal directions of the diagram type dd2, the curves in figure 6.30 are plotted one above the other. Figure 6.29 illustrates which sample points belong to a cardinal direction and princely seats. Due to the working area's well-known asymmetry, the southern, south-eastern and eastern curves are shortened.

Starting from the Heuneburg to the west, the Breisach Münsterberg occurs in 135 km, and the Britzgyberg in 160 km. The edge of the Swabian Alb lies around 40 km away. This region appears as a disturbance because it drops to the previous level at a distance of 50 km. Another disorder can probably be associated with the Black Forest. The Breisach Münsterberg is indicated by small cultural distances in the curve, as indicated in the opposite direction (fig.: 6.23). The region around the Britzgyberg appears again culturally different. In a north-westerly direction, the Swabian Alb appears again as an obstacle to interaction; in 135 km of this direction, another obstacle corresponding to the location of the exchange zone south of Hagenau.

The Hagenau Forest, 150 km away, seems to have been a more intensive interaction partner of the Heuneburg, indicated by the high number of jet artefacts. In the northern direction, the Hohenasperg occurs in 90 km distance, after which the cultural distances decrease almost to the value of the initial level. Before that, the area of the Swabian Alb appears again as an obstacle to interaction. The Neckar, at a distance of about 75 km, indicates a low value in the curve. In the northern curve, the threshold described by Nakoinz, in diagram type dd9, appears near 200 km. For the north-eastern curve, a similar drop concerning the Ipf can be seen directly behind the princely seat, whereby the Ipf differs significantly from the Heuneburg in terms of its type composition. The recurring high values around 50 km cannot be related to a topographical obstacle or missing data. The Ablach occurs in a south and south-easterly direction, but the river is not understood as an obstacle. Instead, this indicates a border in the interaction area of the Heuneburg. Starting from the Heuneburg, significantly distant regions were targeted as intensive exchange partners confirming the interpretation of the Heuneburg as an exchange point.

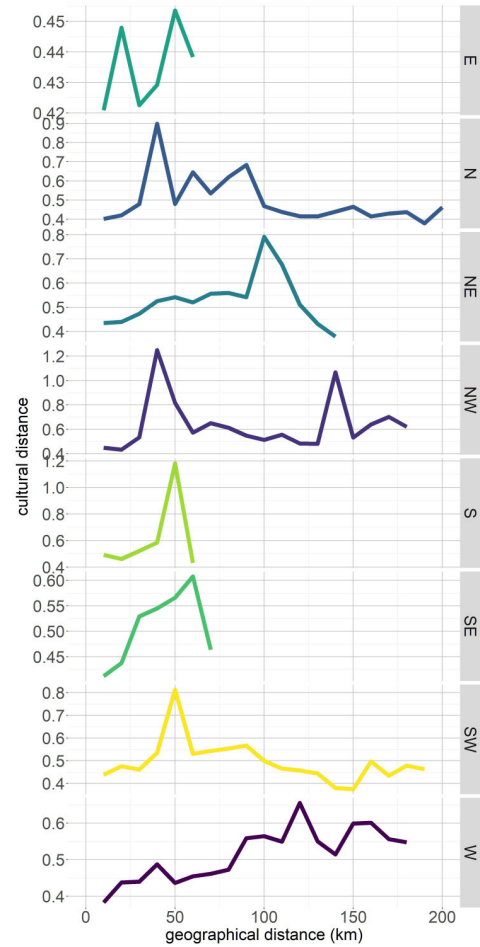


Fig. 6.30: Distribution of cardinal directions for diagram type dd2 of the Heuneburg.

## 6.5 Ipf and Hohenasperg

Ipf and Hohenasperg are two more so-called princely seats in the working area (chap.: 1.1). The Ipf is located directly north of Bopfingen and towers over the city by 200 meters. The distinctive conical shape of the mountain clearly distinguishes it from its surroundings. Topographical location and archaeological indicators indicate the Ipf as a meaningful exchange point of the early Iron Age (fig.: 1.1). The path system and evaluation of the parameters are examined more closely for this location. The far-reaching exchange relationships are examined

in detail with the help of various distance diagrams. However, the method's limits will also be reached here because the Ipf is relatively close to the work area's eastern border.

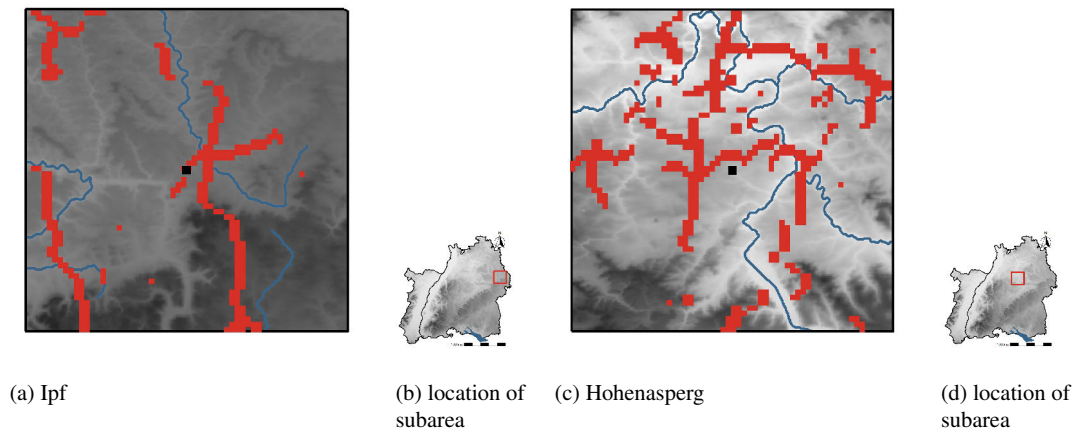


Fig. 6.31: Early Iron Age reconstructed path system (red: path system, DEM: SRTM 90 m)

The Hohenasperg is, mainly due to its exposed location and the so-called princely burial Kleinaspergle, assigned to the category of so-called princely seats (chap. : 1.1). Further research on the settlement is not possible due to the medieval and modern use of the site. Nevertheless, Nakoinz was able to determine a gateway position for the Hohenasperg [345]. The topographical location is examined more closely, and, as before, parameters are evaluated, and the interaction patterns.

### 6.5.1 Infrastructure

As the Ipf is located near Bavaria, the modern political border limits s limited by modern political borders( (fig.: 6.31 b). The occurring edge effects near Nesesheim already explained before do not influence the princely seat area's path reconstruction. Besides, the dense distribution of monuments documents good data coverage for the Repath method. In fig.: 6.1 a path directing from the Danube, passing Schwäbisch Gmünd (no 11) splits near Neresheim (no 8) and arrive at the Ipf. A northern transect is likely, but due to insufficient data not reconstructed. Fig.: 6.31 shows the embedment of the Ipf directly into the reconstructed path system.

The Hohenasperg is situated near the river Neckar, north of Herrenberg (no 4 in fig.: 6.3 c). Reutlingen's interrupted transect might continue on the eastern riverbank of the Neckar or follows a western route that directs to the location of the Hohenasperg. However, the branched transect passing by the princely seat is connected to paths crossing over the Neckar (fig.: 6.31).

Fig. 6.32 compares the distances of each theoretical model and mode to the path associated features (necropolis,  $n = 92$ ), illustrating the best model fit (for details of modelling parameter and calculating distances chap.: 5.4, for modelling accumulated cost surfaces see TheoPathCorrdior.R<sup>13</sup>, and for the evaluation see EvalPath-Ipf.R<sup>14</sup>) for the subarea around the Ipf.

The model which prefers visibility results in the highest distances for the subarea around the Ipf (TM 4a and c: 1,964 to 2,321 m, TM 4b: 688 to 904 m). Followed by the archaeological model simulating attraction of

<sup>13</sup> <https://gitlab.com/FFaupel/analyse>

<sup>14</sup> <https://gitlab.com/FFaupel/analyse>

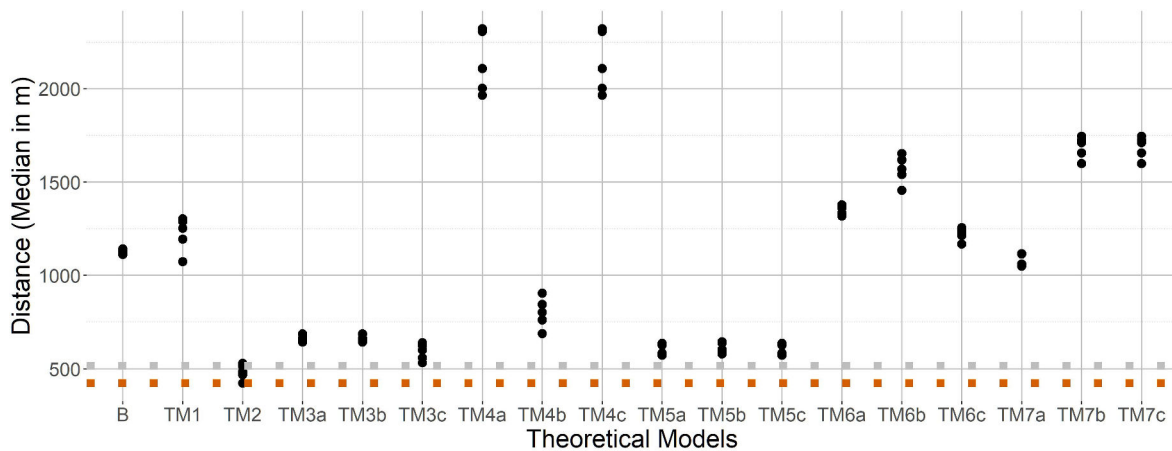


Fig. 6.32: Distances of TM 1 to TM 7 to monument locations for the subarea Ipf (incl. modes a to c, red: best model fit, grey: globally best fitting model, method: median of nearest neighbourhood in m).

settlements TM 7 (TM 7b and c: 1,599 to 1,745 m, TM 7a: 1,050 to 1,117 m). The other highland preferring model, TM 6 has also high distances (TM 6a: 1,318 to 1,378 m, TM 6b 1,456 to 1,652 m and TM 6c 1,169 to 1,255 m). Having greater distances as the reference model B (1,112 to 1,141 m), these three models are rejected. TM 4b and TM 7a have shorter distances as the benchmark; however, they are more distant from the monuments than others.

The distance to the nearest neighbour of TM 1 (1,073 to 1,303) has shorter distances as the reference model; however, it is rejected as the range exceeds the benchmark. The model avoiding visibility TM 3 has significantly shorter distances (TM 3 a and b distance: 643 to 686 m, and TM 3c: 532 to 639 m) as the reference model. Mode 3c is the second-best model fit. The other group of lowland preferring models, TM 5, results in distances ranging from 579 to 645 m for mode b and 573 to 636 m for modes a and c. Therefore, the modes pronouncing the parameter of preferred lowlands are the second-best fit to the archaeological data. Like the evaluation for the entire area, the wheeled vehicles' model is the best fit with distances ranging from 423 to 530 m.

For the area around the Ipf, pedestrian movements seem less relevant for paths such as avoiding steep slopes modelled in TM 2. Visibility and movements along ridges — highland preferring models — result in large distances rejected based on the benchmark of reference model B. In contrast, those models preferring lowlands TM 3 and 5 results in shorter distances.

Fig. 6.33 compares the distances of each theoretical model and mode to path associated features (necropolis,  $n = 172$ ) illustrating the best model fit (chap.: 5.4, for modelling accumulated cost surfaces see *TheoPathCorridor.R*<sup>15</sup>, and for the evaluation see *EvalPathHohen.R*<sup>16</sup>) for the subarea around the Hohenasperg.

The model is simulating pedestrian movements TM 1 (1,016 to 1,123 m) and movements along ridges, including pedestrian movements TM 6b (1,140 to 1,482 m) have more considerable distances to the archaeological monuments than the reference model B by modelling connections as the crow flies (890 to 946 m). The archaeological model simulating settlement attraction TM 7 (TM 7a: 736 to 807 m, TM 7b: 791 to 903 m and TM 7c: 785 to 903 m) has distances below the defined benchmark; however, more considerable distances as other better fitting models. Movements along ridges TM 6 results in very different distances for the three calculated modes. TM 6b has large distances (see above), while mode a ranges between 696 to 767 m and mode c ranges between 807 to 954 m. Both models of the lowland preferring group TM 3 (TM 3a and 3b: 599 to 654 m, TM

<sup>15</sup> <https://gitlab.com/FFaupel/analyse>

<sup>16</sup> <https://gitlab.com/FFaupel/analyse>



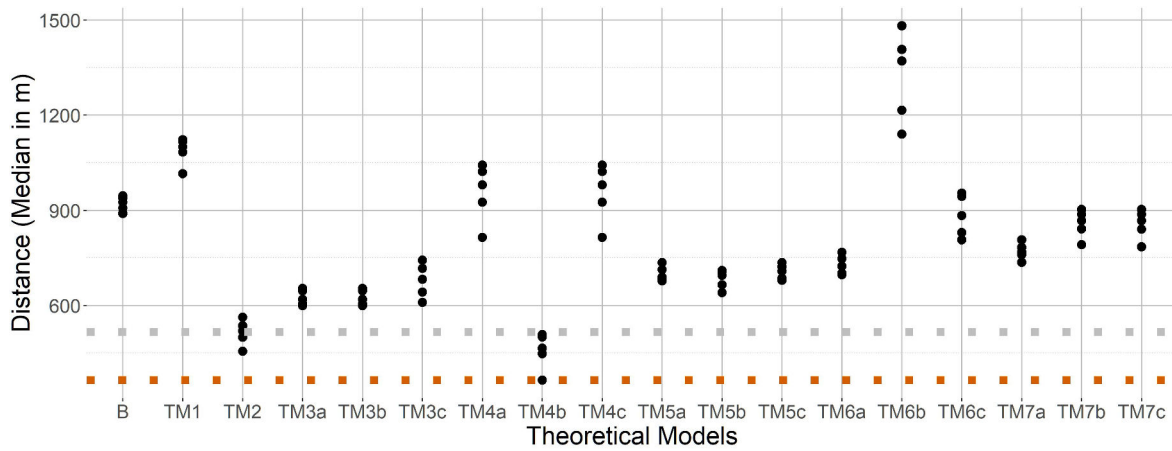


Fig. 6.33: Distances of TM 1 to TM 7 to monument locations for the subarea Hohenasperg (incl. modes a to c, red: best model fit, grey: globally best fitting model, method: median of nearest neighbourhood in m).

3c: 610 to 743 m) and TM 5 (TM 5a: 677 to 734 m, TM 5b: 640 to 710 m and TM 5c: 680 to 735 m) result in medium-large distances. TM 2 (456 to 562 m) and TM 4b (364 to 508 m) are the two best fitting models.

For the subarea around the Hohenasperg, visibility in combination with pedestrian movements and wheeled transportation models are the best fitting models. However, overlapping ranges complicate a decision regarding which model fits better.

### 6.5.2 Interaction patterns of the Ipf

Following the same pattern as before, the global interaction pattern of the Ipf leads to histograms, and dd2 representations of cardinal directions always described by using the four different type combinations.

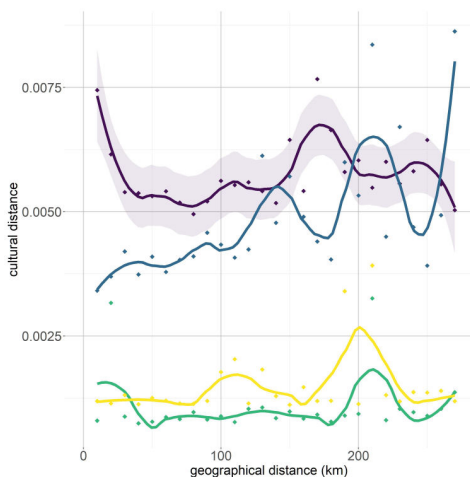


Fig. 6.34: Distance diagram type dd3 of the Ipf (purple = all; blue = vessels, green = ring jewellery, yellow = costume).

After the initial stage, the values for the entire material at the Ipf scatters until 50 km distance (fig. : 6.34). The values remain the same between 50 km and 100 km. A significant increase can only be seen again after 150 km. From here on, there is again a widespread of the values. After the initial step, the vessels' curve shows the distance-dependent slope up to a distance of 100 km. There are some very high values from a distance of 100 km, but most points continue to increase. The larger area of variance in the immediate surroundings also occurs in the curve of the ring jewellery. A distance-dependent increase in the values is hardly noticeable. Instead, the values do not vary widely in a distance range of 100 and 200 km. A slight, distance-dependent slope occurs in the entire course of the costume. After the initial step, which is not clearly defined, the deviating distance values occur at 100 km. The curves on the Ipf differ from those of the Heuneburg and the Breisach Münsterberg in that the interaction is not significantly more intensive at greater distances.

Because of the sometimes strong fluctuations in the distance values, it seems logical to consider cultural distances' frequen-

cies (chap .: 5.5.4). The frequencies of sample points in the individual distance areas are in figure 5.13. For the Ipf, a clear step between the local surroundings (up to 50 km) and a too shallow rise in the regional area is noticeable.

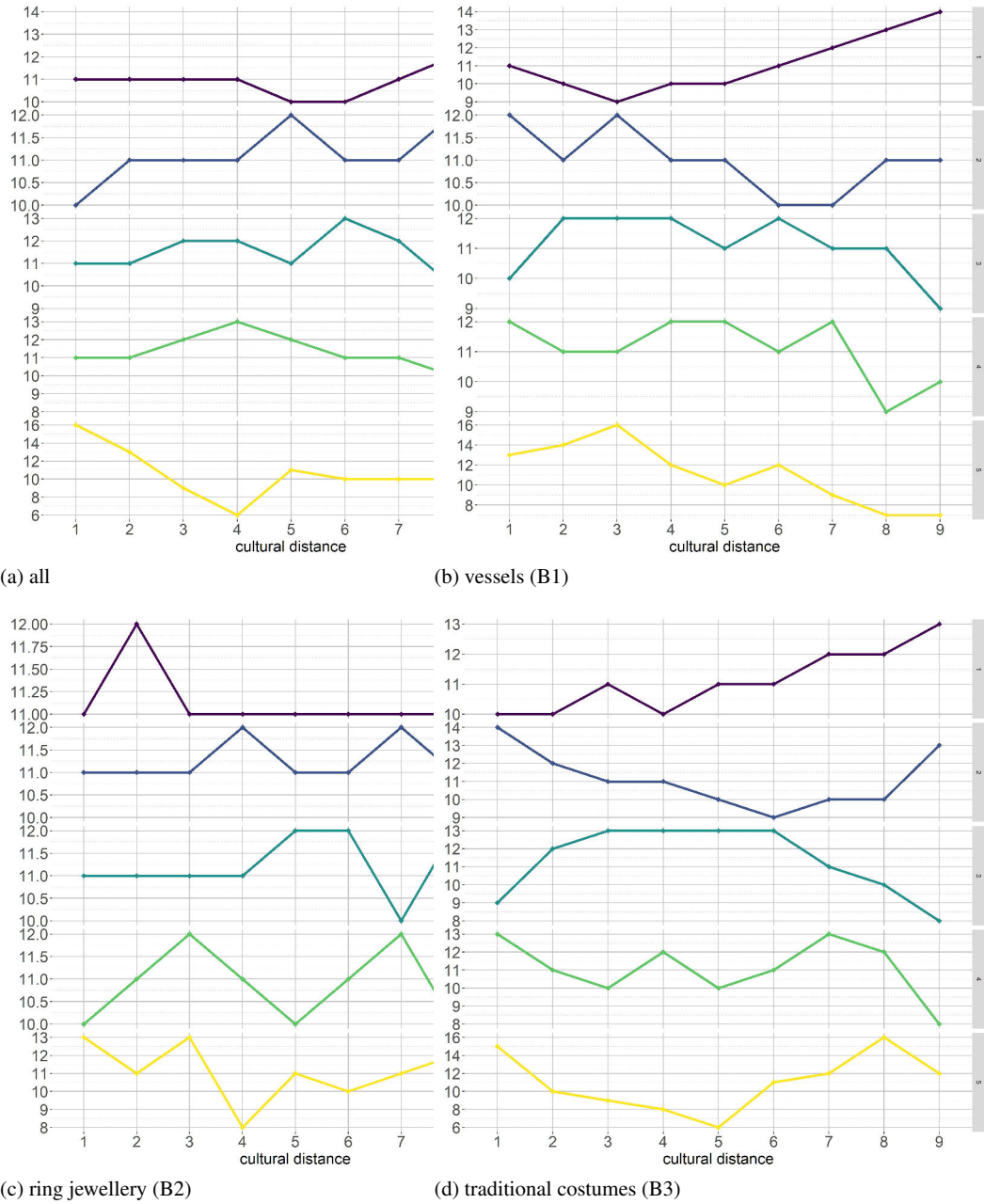


Fig. 6.35: Histogram of cultural distances of the Ipf (1 = over 150 km, 2 = 100-150 km, 3 = 50-100 km, 2 = 25-50 km, 1 = under 25 km).

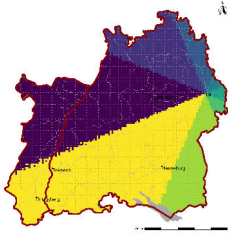


Fig. 6.36: Distribution of cardinal directions of the Ipf.

The distance histograms from the Ipf (fig. : 6.35) differs from the previously considered histograms (fig. : 6.28 and fig. : 6.21 ). The immediate surroundings' medium cultural distances are somewhat less frequent than low and high distances. A balanced relationship between the distances occurs for the local area. The small cultural distances dominate in the nearer and broader regional hinterland, probably reaching important interaction partners. The cultural distances in the supra-regional area show hardly any variation in frequencies. The type combinations of the ring jewellery create a largely identical picture. There is distance-dependent interaction friction in the direct local surroundings and the supra-regional setting for vessels. The distance-dependent interaction friction can also occur for costumes. The marginal position of the Ipf concerning the working area can have a strong effect on the diagrams shown. Above all, the lack of sample points in the local area and the influence of an edge effect can lead to an over-representation of the higher cultural distances with the comparatively low number. Therefore, it is fascinating to look at the cardinal points separately for this princely seat.

For the representation of the cardinal directions of the diagram type dd2 (fig. : 6.37), the edge position of the Ipf (fig. : 6.36) is very clear. The east, north-east and south-east are shortened so much that their courses' interpretation does not make much sense. Edge effects are also to be expected for the northern direction.

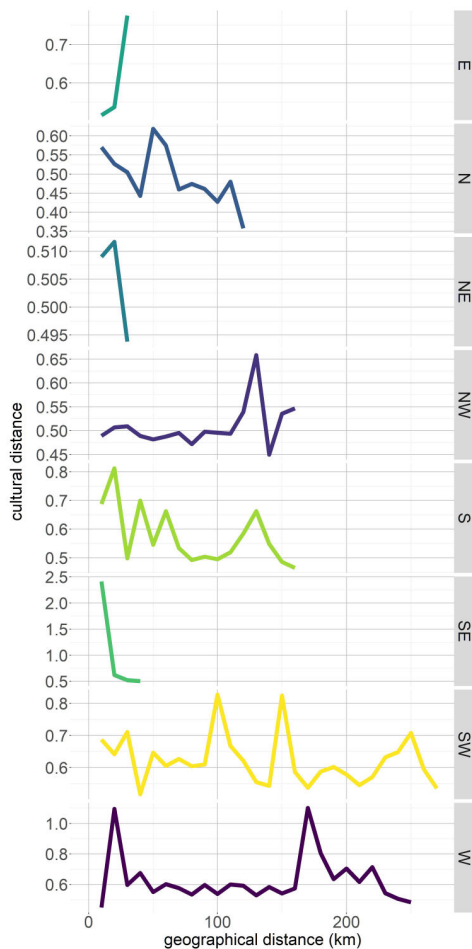


Fig. 6.37: Distribution of cardinal directions for diagram type dd2 of the Ipf.

In the northwest, the cultural distances are comparatively constant, up to 110 km away. In 125 km, an evident disturbance appears in the course of the interaction. In the western direction, the Hohenasperg occurs in about 60 km distance, where depression occurs. Apart from locally occurring fluctuations, the Black Forest's foothills appear as a further disturbance in the diagram in 160 km. The cultural distance sinks behind the Black Forest, but it does not reach the previously low level in the Nagold and Enz valley. The south-western direction is characterized by fluctuating values, making it challenging to identify areas with preferred interaction partners. The Heuneburg appears, as in the opposite direction, as a disturbance. The Black Forest can be associated with the disturbance 150 km away. Breisach occurs in 210 km, which is marked by a depression in the curve. Then the values rise again. The so-called princely seat Ipf appears different in its interaction pattern to the Heuneburg and Breisach Münsterberg. Intense interaction into the areas of other presumed princely seats is likely. The relation between Ipf and Hohenasperg needs further detailed evaluations. However, occurring edge effects might affect the interaction diagrams; better data coverage towards Bavaria will increase the local interaction pattern's knowledge.

### 6.5.3 Interaction patterns of the Hohenasperg

The four curves from Hohenasperg show different courses, but around 150 km high distance values are evident in all curves (fig. : 6.38). Significant fluctuations characterise the curve of the entire material. At a distance of 80 km from Hohenasperg, a low level with noticeably low scattering develops. After a distance of 100 km, another pronounced scattering is interrupted by low values in 150 km. After 200 km, the distance values fall again. The curve of the vessels shows increasing distance-dependent interaction friction after the initial stage. This continuous course is disturbed at distances of 50 km, 100 km and 175 km by slight depressions, and in 125, 160 and 200 km by deviating high values. After the initial stage, ring jewellery shows a slight distance-dependent slope. There is an increased spread of values from 160 km in contrast to the values in 150 km. A decrease in the variance of the distance after that is not discernible. The course of the costume can be described as monotonous. Throughout the course, some high values stand out from the range of variation. Perhaps these values conceal a region that differs from the Hohenasperg in its costume. Besides, the low dislocation values at 80 and 150 km may indicate more intensively maintained interaction relationships. The connection with other princely seats is elaborated more clearly in the following figures.

Because of the sometimes strong fluctuations in the previous representations, it makes sense to consider cultural distances' frequencies (chap. : 5.5.4). The regional area around the Hohenasperg is dominant, while the supra-regional sampling points are strongly underrepresented (fig.: 5.13).

The distance histograms of the four type combinations (fig. : 6.40) result in four different histograms. The direct surroundings show a slight predominance of the low deciles in the entire material, while the costume shows slight distance-inverse interaction friction. The distance-dependent frequency distribution is recognisable in the local area for the entire material and weakly for the ring jewellery. In the closer regional hinterland (50-100 km), a distance-dependent relationship between the vessels can be determined, while ring jewellery and the entire material show an even distribution of frequencies. The situation reverses in the broader regional hinterland (100-150 km). The expected distance-dependent frequency distribution occurs for this distance. For the supra-regional reference, only a weak frequency distribution that is inverse can be identified. The Hohenasperg histograms show a different interaction pattern than those of the Heuneburg (fig. : 6.28), Breisach Münsterberg (fig. : 6.21) and Ipf (fig. : 6.35). As expected, the Hohenasperg appears similar in its local area. In the nearer regional area, there seem to have been not an above-average number of interaction partners. These appear in the further regional hinterland (100 to 150 km).

The position of the Hohenasperg to the boundaries of the working area (fig. : 6.39) allow the evaluation of all curves of the cardinal directions of the diagram type dd2 (fig. : 6.41). Towards the north, south-east, south-west and north-east, the Hohenasperg appears more culturally foreign in the immediate surroundings than in a local distance range (25 to 50 km).

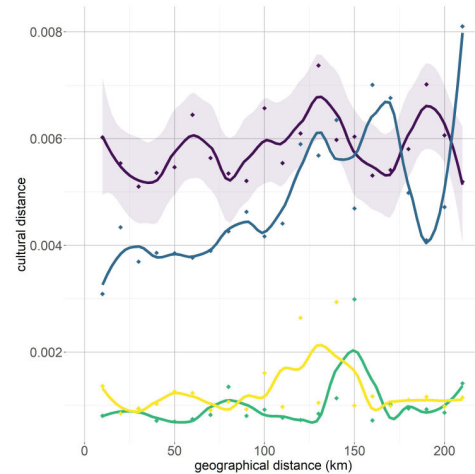


Fig. 6.38: Distance diagram type dd3 of the Hohenasperg (purple = all; blue = vessels, green = ring jewellery, yellow = costume).

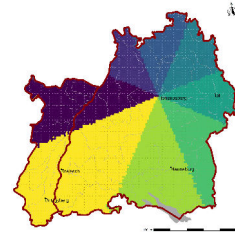


Fig. 6.39: Distribution of cardinal directions of the Hohenasperg.

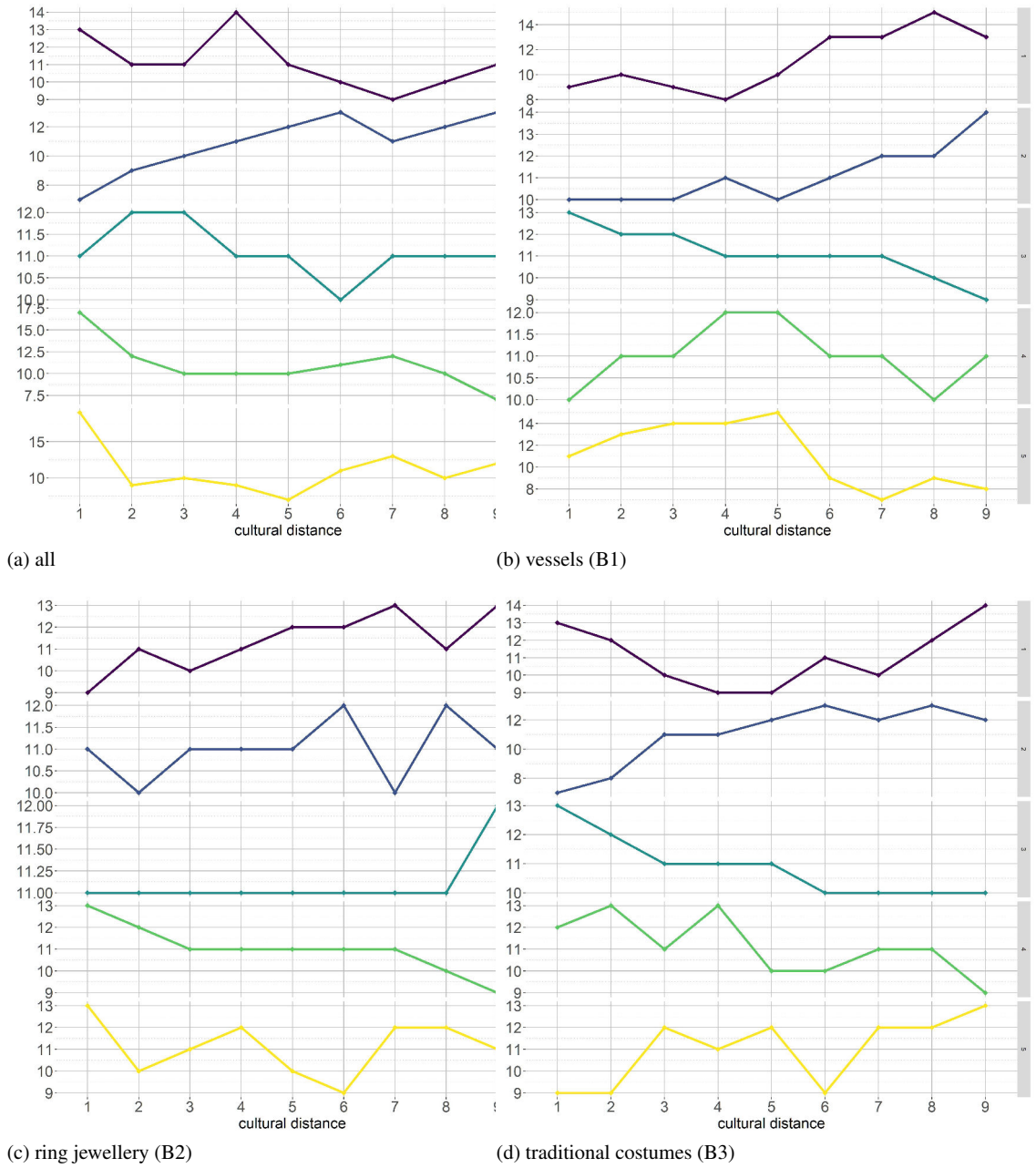


Fig. 6.40: Histogram of cultural distances of the Hohenasperg (1 = over 150 km, 2 = 100-150 km, 3 = 50-100 km, 2 = 25-50 km, 1 = under 25 km).

The Swabian Alb appears as an obstacle in the curve and the Heuneburg as depression to the south. Another disturbance is present 140 km away. Here the previously conspicuous border at the level of the Ablach could be shown. The disturbance in the Ablach area repeats in the southeast. In a south-western direction, disturbances in the curve shape occur at distances of 60 km, 110 km and 180 km. The depression in the curve starting from Breisach are not to be found in the curve starting from Hohenasperg. Here, more intensive interaction relationships emerge in 40 km, 110 km and 160 km. Similar to the Ipf, it seems to have existed more intensive interaction relationships along the Neckar valley. The Black Forest will produce some of the high values between 120 and 160 km. Possibly the local depression at 135 km is explainable with the intensive interaction with the Breisach Münsterberg. The western direction reflects an intensive interaction relationship along the valleys of the Nagold and Enz. The fault at 100 km seems to be due to the Black Forest's foothills, but an influence of edge effects is not entirely out of the question. After this disruption, a more intensive exchange with the Haguenau Forest becomes clear already indicated in the Rhine's profile diagrams. Like the Heuneburg, the Hohenasperg occurs on the edge of an interaction area, indicated by the high values in the immediate vicinity. The relationship to the Ipf region is difficult to interpret. Heuneburg and Breisach, like the Haguenau Forest, appear to be a preferred space for interaction.

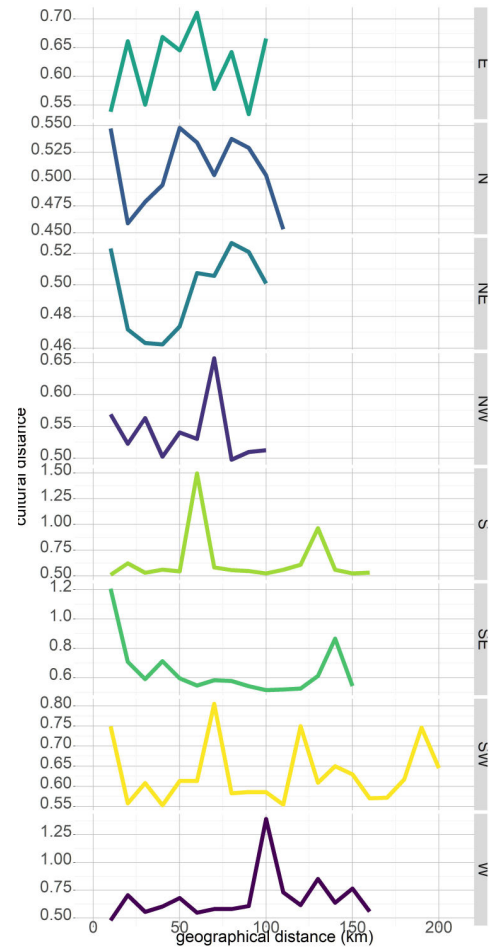


Fig. 6.41: Distribution of cardinal directions for diagram type dd2 of the Hohenasperg.



## Chapter 7

# Synthesis

This chapter focuses on the interplay of interaction and infrastructure holistically. First of all, the reconstruction of the path system and relevant parameters is discussed. The regional evaluation of the individual princely seats' infrastructure helps understand their location within the interaction network. The passages across the Rhine are particularly focused because rivers represent both a border and a connection. The present study attempts to approach this tension in two different ways. On the one hand, an attempt is made to identify possible passages through the Rhine; on the other hand, with the help of interaction analyses, an attempt is made to identify nodes that show an increased exchange rate. Salač [421] advocates a separate consideration of the interaction network and the path system. With the separate analysis of the infrastructure and evaluation of the interaction structure, the independent results are comparable. These elements highlight possible bottleneck situations of the princely seats to understand better the phenomenon of their emergence and, comparatively, of their short-term survival.

### 7.1 Infrastructure

Infrastructure surrounds us. Roads, highways, train routes and airports shape our understanding of mobility today. Covering long distances, relocating to another region or travelling to other continents has become standard.

Well-developed highways and a resilient infrastructure have a significant impact on the economic upturn in regions today. The long-term effects of the Roman transport network, for example, are demonstrated by Dalggaard et al. [68]. In prehistory, however, long-distance traffic was not happening daily. Apart from the economic routes within a settlement, the dominant function of infrastructure would have been the contact between settlements to cover everyday social and economic needs. Numerous indications point to this again and again. For example, Deneke [81] points out that efforts to secure paved access roads in local areas were carried out more intensively than for long-distance routes, or the remote location of long-distance traffic and the low impact of the use of wheeled vehicles on the path locations. Particularly in connection with the so-called princely seats, the location of long-distance traffic routes is often the focus because the wealth condensed at these sites shows a connection for exchange. Often long-distance trade throughout Europe is implied [463]; [375] without first considering the local path and exchange system. Hauser [171] points out that during the early Iron Age, it cannot be assumed that an institution operated and maintained paths, especially long-distance traffic. Therefore, long-distance traffic occurs via an exchange network based on local and regional paths. The importance of the large-scale exchange should not be questioned; rather, its volume should be reconsidered. The great importance that we assign to long-distance traffic today influenced by the modern volume of long-distance traffic and the impressive imports from the Early Iron Age. The analysis of an infrastructure system must begin with a regional evaluation. Here, the local and individual solutions are visibly determining the transport system.



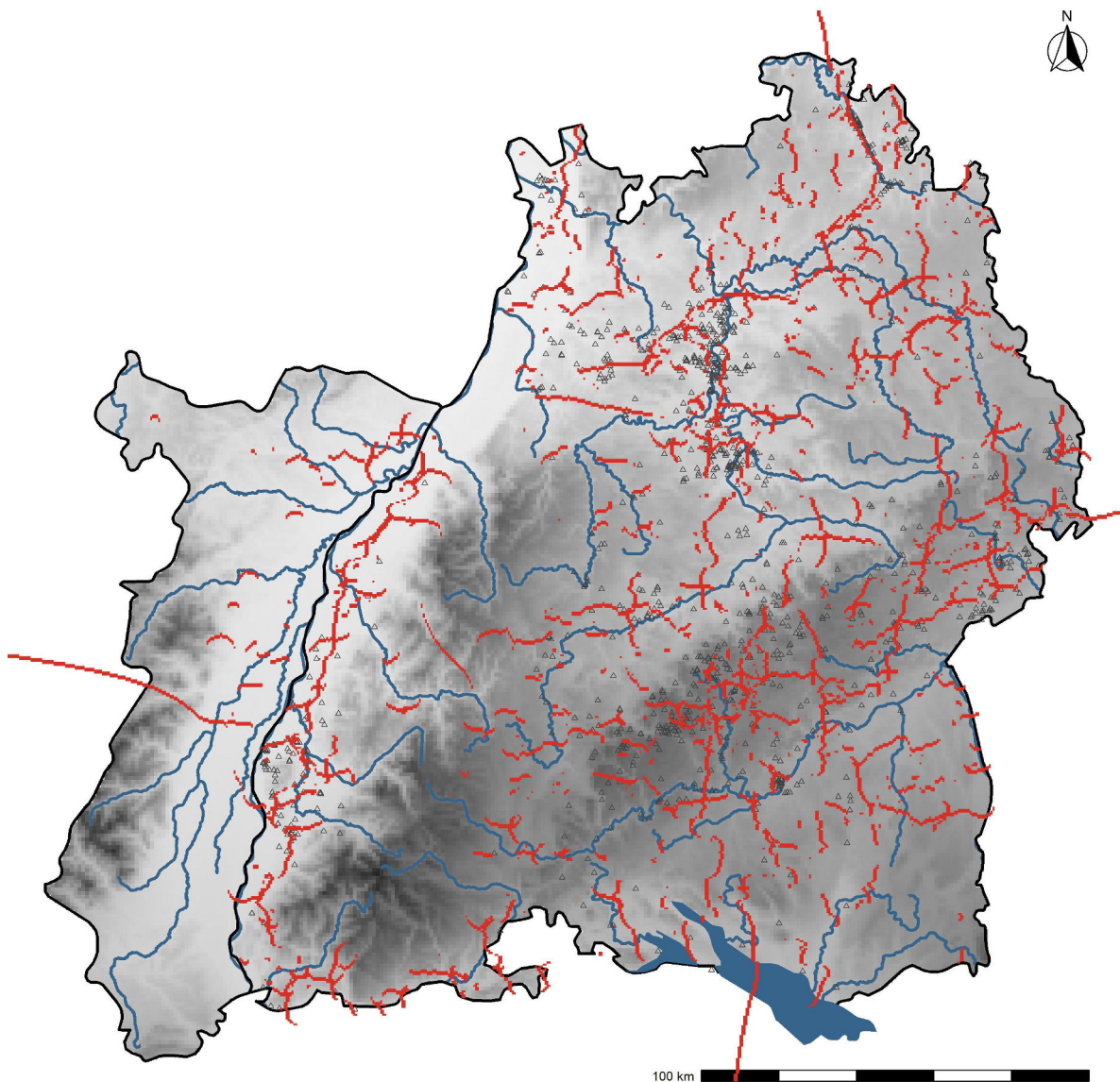


Fig. 7.1: Early Iron Age reconstructed path system (red: path system, triangular: settlements, DEM: SRTM 90 m).

The entire working area's local path system is reconstructed from barrows' location (chap.: 6.1.1). Because of their communicative character and their relation to paths, barrows have the function of path associated features (chap.: 2.3.2.4). Using the Repath method, the robustness of which enables us to reconstruct the path down to a reduction of the monuments to 20 % [111], and disadvantages of graph-based and intuitive path reconstruction are overcome (chap.: 5.3). Without intending to circumvent a careful criticism of the sources, it shows that valid results can be achieved despite the poor data situation in some cases. In figure 7.1 it becomes clear, for example, that a denser path system could be reconstructed on the eastern side of the Rhine than on the opposite bank. There was undoubtedly a comparable network of trails on the Rhine's western side, indicated in some areas, and especially evident in the Hagenau Forest with better data. With a better mapping of the western barrows,

it would be possible to reconstruct the missing path systems. Due to the locally adapted bandwidth of the KDE, there will only be marginal changes on the eastern side of the Rhine.

Terrain and rivers or lakes are only indirectly included in the path systems' reconstruction, as no barrows were built or preserved in these locations. It is only logical that the method takes into account the environmental conditions to a certain extent. The beforementioned heterogeneous landscape of the working area (chap.: 3) makes it challenging to estimate global parameters (chap.: 6.1.2). Due to the local calculation of monument densities and the reconstruction of the paths alongside density ridges, a small-scale adaptation to the location parameters occurs. In this way, a path system for a large area with a heterogeneous landscape can be considered, automatically taken into account the small-scale conditions. For example, no paths cross Lake Constance, apart from the calculation residual near Hagnau am Bodensee.

Already existing paths influence movements of humans [177]; [289]. The reconstruction of a path system should include the location of a current path that attracts pedestrians. It is unrealistic to assume that newly created connections would disregard an existing path. Although the existing paths are not directly included in the empirical model and no iterative method is applied, barrows, dating to the Bronze Age, including the pre-existing path's location into the Repath model.

By comparing the reconstructed path system with the settlements' location, a path often runs between settlements and connects them without lying directly on the path network (fig.: 7.1). Based on the observations on the relocating settlement centres [109]; [267]; [125], settlements seem to be connected to the regional road network by short branch paths.

### 7.1.1 Parameters of Infrastructure

After the description of the path system, the evaluation of the parameters should be considered in summary. In addition to the evaluation for the entire area (fig.: 6.4), the parameters in all sub-areas have also been evaluated (fig.: 6.17, 6.19, 6.25, 6.32) in order to be able to consider local occurrences.

The Least Cost Path method's applicability depends on the path's function (chap.: 2.3.2.2). Some path or journeys do not allow or require optimisation. In these cases, the use of a method that seeks an optimised path is inadmissible. The present study considers paths of daily demand and exchange. An optimisation will have taken place. In addition to relief-dependent costs, numerous other social factors are conceivable. Theoretically, it would be possible to predict the real Least Cost Path if all relevant factors are known and their cost modelling is correct. However, such a model would be extremely complex. Therefore, two factors are always combined with different weightings (tab.: 5.3)). Furthermore, measuring which model corresponds best to the empirical data. The Least Cost Path method's deterministic character reduces using an accumulated cost surface, mapping alternative routes besides the computational Least Cost Path.

Table 7.1 shows the three best theoretical models of the individual regions<sup>1</sup>. The excellent adaptation to the cost model for wheeled transport (TM2) in the entire working area is initially surprising since the influence of the wheeled vehicles on roads' location is only assumed from the Middle Ages [81]. If one looks at the accumulated cost surface for this model, it becomes clear that the low values are distributed more evenly over the working area than, for example, the accumulated cost surface of the pedestrian movements (fig.: 6.5). However, even when evaluating the individual regions, the TM 2 model is the best equivalent for the Ipf and at least the second-best adaptation to the empirical data for the Swabian Alb and Hohenasperg. Even if not deducing from this that there was a lot of wagon traffic for the early Iron Age, steep inclines were avoided.

The parameters with the best fit near the Ipf deviate from the overall trend. In addition to the excellent fit for TM 2, models that prefer the lowlands and have poor visibility are close to the empirical data. This deviation cannot only be explained based on the different topographic situation. The Swabian Alb's paths,

<sup>1</sup> Besides diagrams in chap. 6, the GitLab repository (<https://gitlab.com/FFaupel/analyse>) provides tables of distances to all five nearest neighbourhoods.

whose accumulated cost surfaces are similar, show an excellent adaptation to TM 4b and only secondarily to TM 2. The model, which takes pedestrian movements into account and good visibility, is the best model for Haguenu, Breisach Münsterberg, Swabian Alb and the Hohenasperg. Apart from an easily walkable route, good visibility is essential for the location of the paths. Models that weigh the altitude-seeking factors more heavily (TM 4 a, c and TM 6 a, c) often show a significantly lower fit.

Area	1st	2nd	3rd
Baden-Württemberg & Alsace	TM 2 (516 m)	TM 6c (724 m)	TM 4a (776 m)
Haguenu	TM 4b (81 m)	TM 1 (189 m)	TM 6b (830 m)
Breisach Münsterberg	TM 4b (45 m)	TM 6b (114 m)	TM 1 (360 m)
Swabian Alb	TM 4b(461 m)	TM 2 (652 m)	TM 6a (831 m)
Ipf	TM 2 (422 m)	TM 3c (532 m)	TM 5c (573 m)
Hohenasperg	TM 4b (364 m)	TM 2 (455 m)	TM 3a (599 m)

Table 7.1: Overview of the three best adapted theoretical models to empirical data.

The TM 4 and 6 models are similar in that they both include altitude-seeking parameters. For the region of Haguenu occurs the most remarkable differences in the adjustments between these models. TM 4b shows the best correlation in the empirical data. The excellent adaptation of TM 4b to the topography of the region can only be partially explained. In addition to low costs for a pedestrian, visibility was another essential factor. The comparatively low variance of the individual modes of TM 5 in the regions of Breisach, Hohenasperg and Ipf is possibly due to a non-ideal scaling of the combined cost surfaces.

The topographical conditions can only partly explain the deviations of the parameters in the individual regions. Good visibility and easily walkable routes often seem to have been substantial. Sometimes, ridges are used. Valleys and poor visibility are rarely significant. The region around the Ipf is particularly striking here. Amazingly, the location of the settlements is not a dominant factor in any region. The location parameters of settlements and paths seem to differ very clearly. Two aspects can explain the well-visible location of the paths. On the one hand, good visibility increases travellers' safety, as one can overlook a large area and easily see approaching people early on. On the other hand, being well- visible from afar communicates the approach.

### 7.1.2 Infrastructure alongside the Rhine

Rivers represent a dividing and connecting element in equal measure. This tension is just as crucial for answering questions about infrastructure as it is for interaction relationships. Two aspects have to be considered to evaluate the Rhine as an element of the infrastructure. On the one hand, there is the possibility to cross the river, and on the other hand, it can be used as a waterway. A detailed description of the reconstructed Iron Age paths in the Rhine Valley (chap. : 6.1.1) shows some passages that may have been used for a more extended period. A comparison with the Roman road network can reveal further continuity. Deneke rightly refers to often incorrect backdating of paths [81]. By comparing the reconstructed Iron Age paths with Roman roads, two independent data sources are compared.

The Roman roads in the Rhine Valley were presented by Gutmann [156] and recently by Blöck [40], whereby Blöck investigates the embedding of the settlements in the Roman road network (fig. : 7.2). A Roman road leads from Strasbourg to Neuf-Brisach across from Breisach along the western bank of the Rhine. Shortly behind Strasbourg, the Roman roads splits into two directions, one leading to Neuf-Brisach, the other eastwards to Mutzig. It follows a slightly curved route until reaching Ehl (near Benfeld), where it turns eastwards, reaching

a passage across river Ill, which has three not too deep river arms (Ill, Mühlbach and Pulvergraben). Gutmann notes that relicts of wooden constructions and several Roman coins prove a bridge at this position. A passage across the Rhine occurs nearby at Gerstheim to Ottenheim. The Roman road continues from Ehl in a southern direction passing Hilsenheim, Hessenheim until another junction occurs near Grussenheim. Here, a second passage across the Rhine at Artzenheim (and Jechtingen) connects to the eastern riverbank [156]. Blöck [40] further describes roman roads southern of Artzenheim.

The castrum Brisiacum is connected via a cul-de-sac with a northern passage to the western river banks. Additionally, Blöck maps on the eastern river banks potential Roman roads supported by locally restricted excavations. These roads connect Breisach to Freiburg and the Black Forest, around the Kaiserstuhl in northern direction and a southern direction passing the Tuniberg. While these roads follow more or less flat terrain, one route from Breisach to Freiburg crosses the Tuniberg directly. Two southern roads combine into one southern of the Tuniberg near Bad Krozingen. From Neuenburg am Rhein onwards, it follows the Rhine in the southern direction until the Rhine's knee at Basel, where both Rhine and roads turn in the eastern direction.

On the western bank south of Haguenu, the database is unfortunately too small to reconstruct the Iron Age paths, which is why the comparison mainly refers to the Rhine passages' location. The northernmost Roman passage across the Rhine is on the Gutmann map near Ottenheim. In the reconstruction of the Iron Age paths, a clear crossing area is mapped here (fig. : 6.2). The reconstruction also documents the Rhine crossing at Artzenheim / Jechtingen already described by Gutmann and the section at Riegel. At Riegel, there is a crossing area in the Iron Age path system. Blöck also maps a short course of a Roman road near Emmerdingen, which also coincides with the reconstructed route system. Deviating from the Roman routes by Blöck, the Iron Age paths show a more direct route from Breisach to Emmerdingen and up the Elz Valley. At Emmerdingen, there is a crossing point that continues the route to Riegel in the north. Since the deviation occurs in an area in which Blöck intuitively reconstructed the route's course, it remains questionable whether there is a discontinuity. The southern Rhine passages at *Cambete* (Cambes), *Basilia* (Basel) and *Castrum Rauracense* (Whylen) in the mapping of Blöck coincide with Cambes and Whylen from the reconstruction of the Iron Age paths.

Schmid-Merkl deals in more detail with the question of how the Rhine could be crossed during the Iron Age [436]. Because of its width and currents, it is unlikely that the Rhine was crossed by swimming. Passages, ferries and bridges are safer. In winter, the Rhine was often frozen until the 1910s and then more or less easily passable.

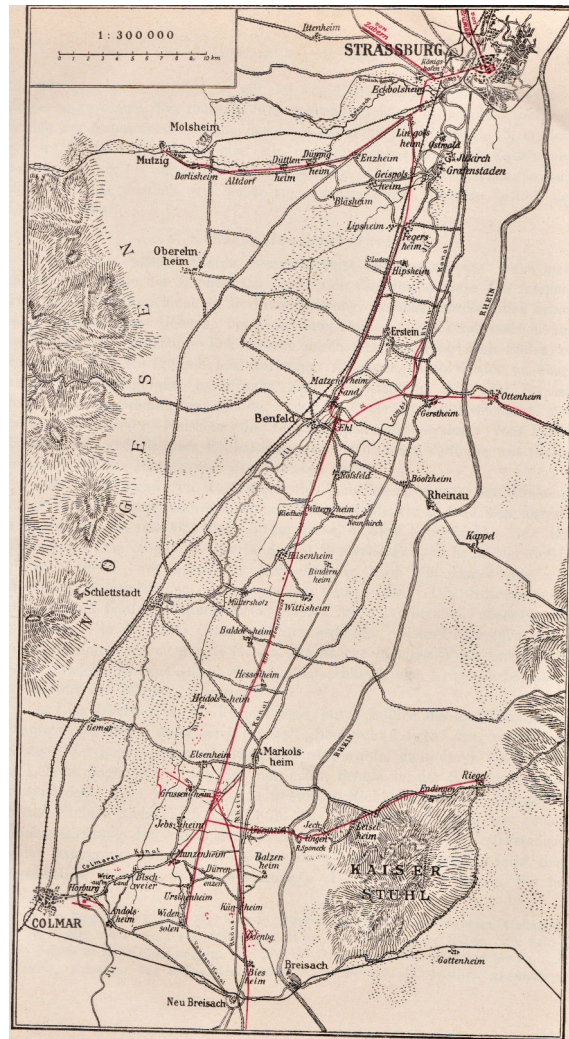


Fig. 7.2: Roman road network from Strasbourg to Breisach [156].

Numerous finds document an Iron Age bridge at Corneau-les-Sauges (Switzerland)<sup>2</sup>. Other examples also prove Iron Age bridges, like in Krichhain-Niederwald (Hessen) over the Wohra [309]. Passages were systematically and extensively investigated for the first time for the Saône [89], whereby structural interventions could be proven. According to Schmid-Merkl [436], this is no longer expected for the Rhine due to the river's great changes. Ancient sources rarely mention passages on the Upper Rhine, and when they do, they were only passable under certain conditions, such as at low water [216]. A crossing is conceivable at various points in the branched zone, but because of the strong currents, it is more dangerous than in the meander zone with a partly flat river bed [436]. Schmid-Merkl believes it is unlikely that crossings were used for centuries, as the river bed dynamics cause the passages to change continuously. Therefore, she assumes transitions that are used more briefly, such as at Istein (Unter dem Klotzen), Burkheim, Illkich or Geffern [436]. If one compares these transitions with that of the reconstructed paths, intersections or transitions match in all places. Only in Burkheim is a path indicated as a relic. Continuity from the Iron Age to later epochs has already been established for some transitions [156]; [40]; [214]. Nine of the 20 Bronze Age Rhine crossings proposed by Logel [294] could be confirmed with the Repath method (fig. : 6.2).

In contrast, Egg [76] suggests a passage near Kappel am Rhein usable during the summer. However, no artefacts support this passage according to Schmid-Merkl [436], and the suggested passage is not supported by the reconstructed Iron Age path system either. The relocation of passages with the development of the river bed should not be contradicted, but apart from the small-scale relocation, there seems to be a certain continuity across several epochs.

Schmid-Merkl makes it clear that crossing the Rhine was dangerous [436]. Also, the floodplains, old sidearms and tributaries or swampy areas make it difficult to cross the Rhine plain. Heavy wagons can only be used under minimal conditions, such as gravel in the river bed. Therefore, Schmid-Merkl suspects the primary use of rafts and boats [436]. In contrast to a simple crossing of the Rhine in winter or through low water, shipping traffic was idle for up to 1.5 months until the 19th century [418]. Before channelling the river, the route through meanders was lengthened, and the branched zone was challenging to navigate due to low gradients. Fog and shifting sand and gravel banks also have a down slowing effect on traffic [418]. Iron bars near Huttenheim [436] and descriptions by Caesar confirm that the Rhine was already being shipped in pre-Roman times [418].

Despite the river bed's dynamic, numerous passages can be identified using different proxies along the Rhine, showing continuity. Because of the limited number of hydrologically possible transitions, it is hardly surprising that continuities are emerging. This continuous use of the paths only makes sense if there were settlements along the paths connected through the epochs. The numerous passages that result from the reconstruction of the Iron Age data, which Logel also determined for the Bronze Age, or proven by relics of Roman roads, clearly show that the Rhine was crossed at different points, although this was associated with numerous dangers. The probability that boats or rafts were used is high, although the archaeological evidence is missing. The local population was undoubtedly involved in the traffic. They would know the local conditions best and would have been able to provide necessary infrastructures, such as means of transportation, landing areas, rest areas and transfer stations. The rich grave equipment in the Haguenu Forest and Kappel am Rhein, or the sites of Breisach Münsterberg and Britzgyberg possibly reflect this source as wealth (chap. : 7.4). The analysis of the interaction references along the Rhine yields interesting exchange points and zones (chap. : 7.3).

During the comparison with the Roman roads, for example, near Schwörstadt, the Iron Age route's astonishing consistency up to the present day was noticed. The Iron Age paths are congruent with the connecting roads (K6353) of Dossenbach, Niederdossenbach and Schwörstadt. In the forest area on the opposite side of the Rhine, roads intersect with the Dossenbacherstrasse. A suitable passage seems to be emerging here, which has been in use for a long time. Demanding terrain or rivers reduces the possible choice of a route (chap. : 2.3), which is why a certain continuity in these routes' position is certainly due to these given conditions. Other factors can more easily lead to a shift in the route [279]; [190]. However, whether the paths are used intensively depends

<sup>2</sup> The context in which the finds and human skeletons are interpreted differently, ranging from a catastrophe to an offering [447]; [139].

on the interaction network. While the Iron Age route today corresponds to a district road, a few kilometres east occurs a federal road (B518) that follows the more densely populated Wehratal.

## 7.2 Patterns of Interaction

In addition to examining the communication corridors (chap. : 7.3), the interactions between the so-called princely seats were examined in different ways. First, distance-dependent interaction thresholds were investigated using dd3 diagrams. The frequency of the cultural proximity of sample points in geographical distance areas depending on their occurrence enables us to assess the distance area in which culturally close or distant sample points predominate. In particular cardinal directions, the cultural distance allows for assessing interaction relationships in different regions. These diagrams' curves make it possible to recognise topographical obstacles and distinguish them from other interaction thresholds. In chapter 6, the interaction analysis results are divided into the individual regions and shown in detail. Similarities and deviations in the interaction relationships of the reference points are now summarised as an overview.

The scatter of the distance values in the dd3 diagrams can be traced back to strongly deviating interaction references. While most of the sample points show a more or less similar degree of cultural distance or a continuous increase is apparent, some sample points differ significantly from this. In comparison with the cardinal diagrams, these different references are visible. The sites considered (fig. : 6.20, fig. : 6.27, fig. : 6.34, fig. : 6.38) show a clear initial increase in cultural distance up to 50 km away, followed by a more or less clear decrease in cultural distance with increasing geographical distance. This inverse course of the distance-dependent interaction friction shows more intensive contacts at a greater distance. The gateway positions of the princely seats, as described by Nakoinz, seem to be reflected here. However, cultural distances represent not independent confirmation of this position in the interaction space. The same data and, in some cases, the same methods are used. The fact that this position reappears, although no attempt was made to define cultural spaces, indicates the robustness of Nakoinz's results.

The representation of the deciles' proportions divided into geographical distance ranges (up to 25 km, 25-50 km, 50-100 km, 100-150 km and over 150 km) allows the frequency of the cultural proximity of sample points to the reference point to be considered. From the comparison of the princely seats, it becomes clear that the Ipf has less intensive interaction relationships more than 150 km away, such as Breisach, Heuneburg or Hohenasperg. Noteworthy is the marginal position of the Ipf regarding the study area and, therefore, data coverage, restricting the assumption only to the extent of the study area.

While the Heuneburg shows more intensive interaction relationships at a distance of over 100 km, Breisach and Hohenasperg are only more apparent at over 150 km. On the Hohenasperg, on the other hand, there seems to be a more important interaction area 50 to 100 km away, which cannot be determined for Breisach, Heuneburg or Ipf. Within the local area (25-50 km), the culturally closer sample points dominate for the Hohenasperg and Ipf, which is the opposite for the Heuneburg. More culturally close sample points in the immediate vicinity (up to 25 km) can be seen in this form of representation for Heuneburg, Breisach and Hohenasperg. At the Heuneburg and the Breisach Münsterberg, similar distance-related interaction behaviour can be seen. The Ipf deviates more clearly than the Hohenasperg, although the values in the immediate surroundings of the Ipf are not reliable due to the marginal location of the site.

The different curves in the diagrams of the cardinal directions (fig. : 6.23, 6.30, 6.37, 6.41) show besides the different interactions, the cultural heterogeneity of the Early Iron Age. The Heuneburg has roughly similar interaction areas in all cardinal directions, except in the east and northeast direction. More intensive interaction partners occur at a distance of over 50 km. Therefore, the Heuneburg can be rated as an exchange point, which could not be deduced from the profile diagrams (chap. : 6.1.3). The Breisach Münsterberg appears culturally foreign to the south, south-east, south-west and west. The interaction area of the Breisach Münsterberg is oriented

towards the north, north-east, north-west and east in the local area corresponding to a gateway position<sup>3</sup>. An intensive interaction relationship between Ipf and Heuneburg is not directly recognizable. Cultural proximity to the Heuneburg can only be seen shortly after the Ipf. Foreign interaction areas at the Ipf may influence this discrepancy. However, edge effects due to the edge location in the working area must first be excluded from such an interpretation.

Regarding interaction thresholds, few areas could be identified. The Black Forest repeatedly appears as an obstacle in the interaction curve. Since the Black Forest is only sparsely populated and is generally a somewhat hostile environment, this connection is not surprising. Still, there are numerous records of interaction relationships across the Black Forest. While investigating the Rhine as a communication corridor (chap. : 7.3), two exchange routes are suggested, bypassing the Black Forest to the south and following the Kinzig valley and cross the Black Forest in the middle.

Two recurring interaction thresholds become apparent when comparing the regions. The Swabian Alb and 30 km south of the Danube present themselves as obstacles to interaction. The altitude of the Swabian Alb and more unsatisfactory climatic conditions [299] certainly influences the region's settlement, but this does not explain the princely seats' cultural dissimilarity. The dominant grave assemblages in the Swabian Alb, in contrast to the settlement assemblages in the Neckar Valley, might create such a threshold. The princely seats are settlements themselves, but the nearby barrows offset the source genus's effect.

The threshold near the Ablach in 30 km south of the Danube, is similar. Rivers cannot be generally accepted as the boundaries of interaction areas. Natural occurrences cannot explain these interaction thresholds. For what reason do the interactions between the princely seats differ in these regions? Are these regions skipped in the exchange network? Both interaction thresholds are on the edge of the communication corridors identified by Nakoinz. Is it possible that these marginal locations are not integrated into the supra-regional exchange network of the early Iron Age? Are they too far from the exchange routes, or are political and social differences significant here? A detailed consideration of the interaction references of these marginal zones of the supra-regional interaction area requires a separate interaction analysis and cannot be answered in this work.

The extensive interaction of ring jewellery highlighted by Nakoinz is confirmed along the Rhine and also for the Breisach Münsterberg (fig. : 6.20), Heuneburg (fig. : 6.27) and Ipf (fig. : 6.34), but not for the Hohenasperg (fig. : 6.38). While the other princely seats between 100 and 150 km have more intensive contacts, at the Hohenasperg, there is a significant increase in the cultural distance at this distance.

Ceramics, as another type of small finds, helps to identify exchange. Brosseder [45] describes, albeit not explicitly, a complex system with overlapping group symbols. Some decoration aspects allow for far-reaching interaction relationships to be shown, while other groups within a funeral community can be distinguished. This complicated network of regional and supra-regional references in the decoration describes the Early Iron Age's interaction relationships clearly. Depending on the social group, different relationships are emphasised. Brosseder describes that high-status burials, in particular, emphasise relationships with more distant regions. Interestingly, she explains the lack of regional styles through strong interaction. Intense contacts may hinder regional styles like at site Hallstatt (mainly on metal artefacts) [44]. Brosseder hypothesises, in areas with intense communication, like trade centres, the development of regional styles is much less pronounced than in more remote areas. This complex system between strong local reference and far-reaching relationships is also reflected in the ceramics' various distance curves. Regional references are clear to the Breisach Münsterberg and the Heuneburg, but not to the Hohenasperg and the Ipf. Consulting the KDE representations of the source filter's evaluation (fig. : 4.2), the poor local correspondence of the Heuneburg could be traced back to insufficient data regarding the ceramics.

---

<sup>3</sup> The partly unbalanced data basis between the Haut-Rhin and Baden-Württemberg can be excluded as a reason for this border location. Such effects would have to be repeated on the German-French border. Haguenu and Heuneburg connect, e.g. also short distances with each other.

Artefacts, archaeologically identified as imports, must be checked for foreign origin. The ceramics from the necropolis of the Hagenau Forest, defined archaeologically as foreign, are suitable for such a consideration <sup>4</sup> [110]. Although Bronze Age material was also taken into account, imported ceramic vessels cannot be differentiated. Hence, the archaeological markers suggesting exchange seem to relate to the exchange of information. Interestingly, there was a change in the production method between the Bronze Age and the Iron Age (fig. : 7.3). It is unlikely that the deposits will be exhausted in the Hagenau region, where ceramics are still made today. It was not the quality of the raw materials but other reasons that led to this change. Future detailed analysis of the interaction relationships from the individual burial communities in the Hagenau Forest through the Bronze Age into the Iron Age could reveal interesting local interaction relationships.

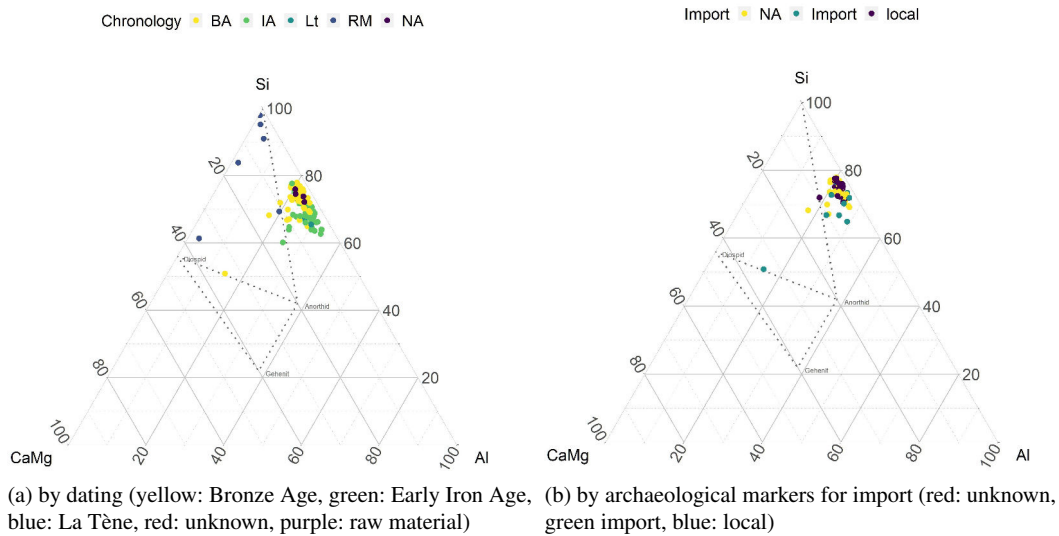


Fig. 7.3: Ternary diagram of major inorganic components of ceramic of the Hagenau necropolis (Bronze Age: n = 65, Iron Age: n = 49, unknown: n = 5).

<sup>4</sup> Analyses of vessels in museums or being completely preserved are often not possible with traditional methods. Even if sampling is not necessary, the artefacts often cannot be brought to the appropriate laboratory. The portable XRF method offers the possibility to carry out the analyses on site. Comparatively, fast analysis is also advantageous here. However, particular caution is required concerning contamination from storage and restoration and the method's inherent limits. The Bronze Age and Iron Age ceramics of the necropolis in the Hagenau Forest could be recorded almost completely using the pXRF method [110]. The 65 Bronze Age, 49 Iron Age vessels and 5 with unclear dating were measured repeatedly at different positions so that almost 500 measurements are available. The clay composition and the combustion atmosphere could also be examined through incident light microscopy on almost 50 artefacts. Using the major inorganic components of ceramic, Silicon, Aluminium, and Calcium combined with Magnesium, characterises the assemblage. Ternary diagrams illustrate the discrimination of calcareous and low calcareous ceramics. Likewise the temper, most objects from a dense group in the low calcareous part of the diagram. Some outliers towards the calcareous part are visible. Here, contamination due to conservation might be possible. A tendency to use kaolinite-rich clays in Iron Age is visible. The Bronze Age material displays discrimination of local and imported objects in fig. 7.3. The discrimination bases on archaeological markers like shape and decoration. Similar to Iron Age vessels, these supposed imported objects tend to contain more kaolinite-rich clay. Clear or significant discrimination is not visible in this chart and not in the representations using an Aluminium oxide, zirconium, and rubidium [110].



### 7.3 Communication Corridors

The eastern curve of the entire material culture, the vessels, the ring jewellery, and the costume show cultural proximity to the Rhine's reference points in the distance range of fewer than 50 km (fig. : 6.6). The cultural proximity is particularly evident in the range of ring jewellery and vessels. The rising eastern values, which can be traced back to a distance dependency of the interaction, is only interrupted by a few disturbances. For the entire material, higher values are conspicuous at a distance of 110 to 130 km, and significantly lower values after 150 km<sup>5</sup>. The vessels show a different course with maximum values at 50 km and 130 km. The apparent rise at the end of the curve could indicate significantly different ceramic traditions over 150 km away. Ring jewellery shows a strongly distance-dependent continuous curve progression up to 130 km. From then on, the cultural dissimilarity increases continuously and steeply. In contrast, the western curve's cultural distance for vessels and ring jewellery is lower after 50 km. Apart from a too high value, costume hardly shows any distance-dependent interaction to the west. The course of the curve may be too short to see a distance-dependent effect.

The curve of the dd5 diagrams of the Rhine (fig. : 6.6) roughly corresponds to the absolute geographical distances determined by Nakoinz [347]. After an initial stage, which expresses a measure of the type spectra's variability, Nakoinz determines a steadily increasing curve section for Baden-Württemberg, interrupted by falling values at around 150 km. The curve ends with sharply increasing distances. It is crucial to refer to the different diagram types to transfer the zones defined by Nakoinz. Nakoinz uses the type combination of costume and the diagram type dd9. Despite the different data situation, the diagrams on the Rhine (dd5) also show increasing distance values after an initial step and lower values 150 km away. For the entirety of the archaeological material, a preferred interaction can be determined 150 km east of the Rhine repeated for vessels, but not for ring jewellery and costume.

Enormously increasing distance values characterise the entire material of the Danube (fig. : 6.11) in the regional area up to 50 km. The northern curve then sinks to about 120 km to the initial level and moderately increases again. The low level in 120 km can also be found with the vessels and the ring jewellery. The costume has a similar course but reaches a low level at a distance of about 110 km. Apparently, in the Neckar Valley (about 110 to 120 km north of the Danube) occur important interaction partner.

The dominance of a combination of types (B1-B3) cannot be determined. The course of the curve of the entire data differs from that of the selected type combinations. This difference shows that the choice of only one artefact class is not suitable for describing the entire phenomenon, but only for a specific sub-area. The possible circular reasoning in reconstructing the archaeological cultures has been advised several times before. The selected type combination conceals a latent interaction structure in the overall data set can thus be clearly shown. It underlines once again the complex nature of cultural characteristics and contacts.

To interpret the interaction pattern of the communication corridor Rhine, starting from the south, the obvious symmetrical structures are examined more closely (fig. : 6.7, 6.8, 6.9, 6.10). Profile diagrams are particularly suitable for viewing deviating interaction references along the central axis of the corridor. The representation allows for seeing occurring north-south deviations in the spatial relationships of the Rhine's interaction curves. From the representations, it is difficult to identify intensive interaction relationships of a profile. This is mainly because the profiles only provide distance values on one axis concerning the profiles reference point. Other types of diagrams are more suitable for considering sites' individual spatial references (see above).

#### Rhine

The site Britzgyberg occurs at profile 20 and influences the edge in the immediate surroundings and local area. For all geographical areas, there are high deviations for the entire archaeological material. Concerning the entire material, profile 20 indicates a point of high exchange. Further, the local and broader environment does not match with the type spectra at this point. If one imagines increased interaction with distant regions, it is logical to stand out from its local surroundings in terms of cultural distance. Indeed, not all parts of society were

<sup>5</sup> Conclusions of this type of diagram on the cultural relation to individual sites, the princely seats, are not permitted. The cultural distance is averaged over the entire course of the central axis showing only a distance-dependent trend.

involved in the exchange, especially not all of the surrounding rural settlements, so that the foreign signature condenses at the node. Profile 20 will differ in its type spectrum from the sample point 100 km away due to the local characteristics. The consideration of other types of archaeological artefacts helps to filter out possible latent interaction structures. Various interaction relationships meet at the level of profile 20. A connection with the Britzgyberg is likely but must be further deciphered in more detailed studies.

The so-called princely seat Breisach Münsterberg is close to profile 35. Due to the small geographical distance to the Rhine, the artefacts of the Breisach Münsterberg will have a significant influence on the signature on the Rhine's profile point. The signature does not show any deviations in the interaction references for distance areas of the entire material. This phenomenon continues with only slight fluctuations as far as Kappel am Rhein (profile 45). Contrary to what was expected, the Breisach Münsterberg does not appear as an exchange node. However, it cannot be deduced from this that there were no intensive interaction relationships with distant areas. Compared to the other exchange nodes on the Rhine, the Breisach Münsterberg is a settlement that operated an intensive exchange with the surrounding population. Therefore, exchange relationships may only emerge as latent structures. This alignment may not have occurred in the exchange nodes, as the intensified interaction of an extensive settlement is missing.

There are also high deviations in the area around profile 60 for the direct surroundings, the local area and in the regional hinterland for the entire archaeological material. In the supra-regional context, these are not clear. Comparable to profile 20, profile 60 brings together different interaction relationships. An interaction area can be made out in the local area on the Rhine's eastern side regarding vessels. Contacts from the east may meet here via the Kinzig valley and the Rhine valley. The river Ill meets the Rhine a little further north of profile 60. The river valley of the Bruche arrives in the west. The river valleys are explicitly referred to here, not the rivers. Transport on the river may have taken place, but the evidence is lacking. Furthermore, the rivers Bruche and Kinzig flow north of profile 60 into the Rhine.

At the height of profile 75 occurs a more extensive plain between the rivers Bruche, Zorn and Moder. The range of types of profile 75 appears culturally foreign near the eastern bank's surroundings, continuing for both banks in the local area and the regional hinterland. For the supra-regional reference, this is also documented on the eastern side. Interestingly, the deviations north of profile 75 spread more widely. The higher values in the north in the Haguenau Forest area continue for the costume in all distance areas.

The Rhine profile curves show high deviations in the interaction relation with the north and south located type spectra of the central axis at three places (fig.: 7.4). Profiles 20, 60 and 75 differ in their type spectra from the immediate surroundings and the type spectra further away. Therefore, these points in the communication corridor are interpreted as points with a high exchange rate. The high exchange rate may seem surprising at first, as intensive interaction leads to shorter distances. If there is an exchange node at a sample point, elements of the connected regions occur here. This isolated foreign element occurrence will distinguish the type spectrum from the usual type spectrum of the direct and local surroundings. There will be little cultural

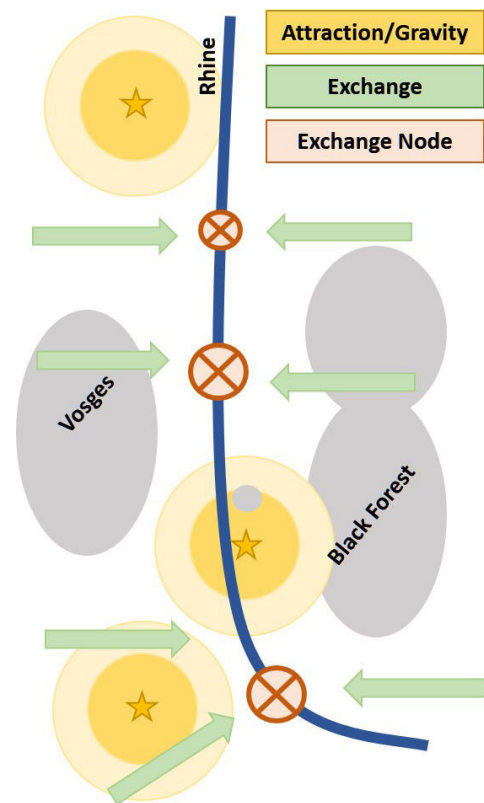


Fig. 7.4: Scheme of exchange system alongside the Rhine (star = larger settlements, green = exchange flow, red = node of exchange, yellow = gravity of settlements).

distance for other type combinations, which reflect an intensive exchange between the exchange node and its immediate surroundings.

Conversely, the local influence on the type spectrum of the exchange node will lead to a cultural dissimilarity with the type spectrum in contact zones. The consideration of the goods or elements affected by the exchange will produce a cultural similarity. The conclusion that a high deviation is a sign of an exchange node does not contradict the concept that this interaction leads to small cultural distances due to the inclusion of all material. Only in a second step are typical artefacts considered for the exchange (chap. : 6.1.3).

Symmetrical structures are also influenced by the symmetrical topographical obstacles on the Rhine. At the height of Britzgyberg, a connection to the Belfort Gap is conceivable and the Lake Constance region with which there is also a connection to the Danube (fig. : 7.4). The Kinzig valley offers a route through the Black Forest that connects the Rhine valley with the Neckar valley and the Danube. On the opposite side, the valley of the Bruche forms a path through the Vosges. Haguenau, which has been shifted slightly to the north, can be understood as a point of attraction. A particular part of the exchange seems to have condensed. Surprisingly, the area between Breisach and Kappel am Rhein is characterized by consistent interaction structures. The topographically favourable location of the Breisach Münsterberg suggests that an exchange centre has also been established, especially since the artefacts indicate the supra-regional importance of the site. The importance of the Breisach Münsterberg increases in Ha D's course, so it is possible - in addition to the material's alignment through the intensive contact as a significant settlement - that an exchange centre can only be recognized at this stage. In the mean of the profile diagrams, however, this is not clear. In contrast, the other places (profile 20, 60 and 75) seem to describe relationships over a more extended period. The Rhine passages confirmed by Logel and partly also by the route system's reconstruction are congruent with the junctions (fig.: 6.2). Tremblay-Cormier also points to Alsace's contacts to Lorraine via the Vosges [495].

There is an accumulation, especially at the height of profile 60. Even if the connection between the exchange node and the topography becomes clear, the interaction can only be channelled along routes. The population generates the impulses for the exchange, the needs to be met. Haguenau and Breisach Münsterberg are not directly at a junction, but the mainspring for the exchange must be sought in such areas.

On the one hand, the Rhine presents itself as a barrier, such as the inhumation burials in the Alsace and contemporary cremation habit on the other river bank with a delayed acculturation [298]. On the other hand, the possibilities for communication become clear again and again. This area of tension can be examined and understood in further regional studies.

### **Danube**

In contrast to the Rhine, symmetries rarely develop in the profile curves of the Danube banks (fig.: 6.12, 6.13, 6.14, 6.15). Asymmetrical interaction between the two sides of the river is predominant, in some cases also contradicting deviations. Accordingly, no symmetrical structures can assess the interaction patterns but rather deviations in the profile curves that recur through all areas. First of all, it is noticeable that the cultural distance values are the lowest along the entire communication route in the immediate surrounding. The fluctuation of the profile curve is present on both sides of the bank. The curves rise of both banks from profile 90<sup>6</sup>. The profile curves of the southern bank of the Danube are partly influenced by edge effects. Profiles 15 to 35, in particular, are affected by the local area.

In the local area and the regional hinterland, the distance values increase. Deviating interaction relationships can be seen in these profile curves. In the supra-regional setting, lower values appear in the regional hinterland. At the beginning of the west's profile curve, there are comparatively high distance values and clear oscillations both in the immediate surroundings and in the local area. For the regional hinterland (up to profile 15), lower values and a lower distribution of the profiles are noticeable. For the ring jewellery, there is an oppositely higher cultural dissimilarity that sinks towards the east. No edge effects up to profile 15 are to be expected in the local area. In this area, the central axis spectra are culturally dissimilar to those in the immediate surroundings. The northern bank shows no different interaction references. Unfortunately, there is a lack of data to understand

<sup>6</sup> The values from profile 100 are influenced by a possible edge effect and can be considered symmetrical.

better the Danube and Lake Constance region interaction. A higher exchange may occur in this area, which, unlike on the Rhine, is not so clearly reflected in specific points but instead forms a zone.

Deviations in the profile curves are for the northern curve in the immediate surroundings with profile 45, 75 and 83 increasing distance values. The Heuneburg appears culturally similar to the immediate surroundings. This cultural similarity also occurs in the local area, but the interaction references deviate directly to the east from the Heuneburg in profile 70, and a higher level of distance values develops to the east. Concerning the regional hinterland and supra-regional setting, no deviating curve occurs at the Heuneburg. Higher deviations are noticeable for the southern curve concerning the ring jewellery in the immediate vicinity and the regional hinterland. About the costume, too, profile 68 appears more dissimilar to the local area and regional hinterland than the neighbouring reference points to the Danube.

The interaction references on the Danube do not represent such concise structures as on the Rhine. Exchange nodes or zones do not establish themselves in the entire material's curves but rather as latent structures concerning vessels, ring jewellery or costume and often only related to one river bank. Such an exchange zone is recorded in the central axis's eastern area at the Danube's beginning. Profile 68, in the vicinity of the Heuneburg, latently indicates an exchange zone. There may be a third exchange zone in the eastern edge area. However, edge effects make the interpretation more difficult.

## 7.4 Bottleneck Situations of Princely Seats

This work aims not to explain the emergence of princely seats, a description of the Early Iron Age's social structure or political structure. The focus lies on the reconstruction of the path system, evaluating the parameters, and the interactions' investigation. The close location of the princely seats on the regional path network and the intensive interaction with regions over 50 km away improve the understanding of the Early Iron Age's exchange structures. The identification of the bottleneck situations shows other possible levels of interpretation of the data obtained.

Kimig's model of a nobility imitating Mediterranean living conditions [224] has been proven obsolete several times (chap.: 1.1). Other models to explain the phenomenon of princely seats like Härke's settlement hierarchy lack verifying evidence and is, at least partly, outdated [166]. Eggert [103] tries to provide a theoretical background and some terminological clarity for different approaches. His remarks on economic factors, as craftsmanship, have to be reconsidered. Furthermore, Eggert reduces indicators of the elite inhabiting princely seats like the consumption of pig. Centrality to model the phenomenon of princely seats failed upon verifying central places. The gateway model by Nakoinz [345] can be supported by the results of geographical studies by Posluchny [386]. Princely seats seem to be located 5 km to physio geographical borders or navigable rivers [386]. Hence, they are conveniently situated. These positions are as well convenient from a communicational point of view, as evidenced by Nakoinz's analysis.

Monumental constructions may indicate the control of staple [92]. However, in Iron Age Britain, hillforts indicate control over agricultural land with centralised storage, while no considerable wealth accumulates [189]. Posluchny calculated catchment areas for princely seats and rural settlements. An agricultural subsistence of princely seats is unlikely, as catchment areas of princely seats are distinctively smaller than of rural settlements [386]. The wealth of princely seats has to derive from other economic sources.

Control over trade results in the accumulation of prestigious objects and weapons, both are evident for so-called princely seats. The ownership of the means of transport creates control over trade. The location of princely seats on navigable rivers [386]; [105] can control traffic. If one does not want to accept river transport, a bottleneck situation can nevertheless arise here. If the river has to be crossed, boats, landing areas and rafts are necessary. These tasks were probably carried out by a local group, as they have the necessary knowledge of the immediate area.

The princely seats are also integrated into the local path system (fig. : 7.5). Their location, Heuneburg (fig. : 6.24), Breisach Münsterberg (fig. : 6.18), Ipf and Hohenasperg (fig. : 6.31) are located less than 1 km from the reconstructed path system and are located at crossroads. A passage through the Rhine for the Breisach Münsterberg has probably been in use since the Bronze Age. Artefacts are not used to reconstruct the path system, especially the mapping of imported goods [375] is unsuitable for reconstructing a route [421]; [171]. Biases due to existing sites' interpretation are reduced, as those sites are not included in the reconstruction. Although there have been intensive inspections and investigations in the vicinity of princely seats, the overall data situation for grave mounds in Baden-Württemberg can be assessed as good <sup>7</sup>.

The aspect of the visibility of paths indicates a different bottleneck situation. If a need for security is actually hidden here, the fortified hilltop sites offer a possibility of protection. The princely seats themselves do not necessarily have to overlook a wide area but instead offer a combination of good visibility, accessibility and fortification. Of course, a princely seat must be able to see and be well-visible from afar as a signal. If there is a lively exchange, a good location in the regional network of paths is essential. However, also in the local environment, the place must be easily accessible. The need for security and fortification of the settlement is contrary to this. A compromise between these factors may explain why the Heuneburg was not built on the Bussen. The foreign mud-brick wall of the Heuneburg will also have marked a market. Hillforts serve well as the point where a fee for safe passage could be extracted, like medieval castles of "robber barons" along the Danube served the same function to extract wealth from the trade in the post-Roman period [91].

The princely seat locations near exchange nodes and gateway positions reinforce the impression that wealth derives from exchange control. Possible development of markets and manufacturing at such locations would also have centralized flows. Although Schneider [442] investigates the time before the prince's seat bloom, he finds that they occur on previously existing exchange routes. Princely seats are being built in places with good infrastructure. Rural settlements are based on other parameters and are usually further away from the paths. In order to be able to carry out the exchange, the location was therefore not ideal for agriculture. Exchange nodes at rivers functioning as communication corridors, channels and bundle exchange from far-reaching contacts over 50 km away characterize the image of the Early Iron Age distribution system.

## 7.5 Perspectives

The present work has given rise to further problems and new questions. The results obtained with the Repath method illustrate the robustness of the method in different ways. Barrows are more likely to be destroyed in agriculture than in wooded areas. It would therefore be interesting to examine the effects of a non-random reduction of the monuments. In connection with the infrastructure analysis, a cost surface that considers the passages' location while the river is surrounded with higher costs would be [118]; [279], interesting. In this way, the theoretical models' adaptation can be better tested for the entire working area.

Using cultural distances to model social cost components in least-cost path analysis might overcome van Leusen's [499] statement on establishing social costs as subjective. Since cultural distance always refers to a fixed point as a reference, an averaged global cultural distance could be calculated for each cost cell. The cost surface would check whether the routes were oriented along interaction corridors. The global distance calculation, i.e. the averaged cultural distance to all other sample points, allow for small-scale interaction corridors to be identified. Another approach could be pursued by starting with a settlement and modelling the local interaction gradient as a cost surface. This approach shows possible individual preferred routes but is only applicable to one settlement.

---

<sup>7</sup> The mapping of aerial photography was included in the data acquisition. It is well known that there are significantly more barrows in the Swabian Alb than, for example, in the densely populated Neckar Valley (chap. : 4.2). This typical example of the influence of the source type (chap. : 4.1.1) on the reconstruction can be compensated to a certain extent by the robustness of the Repath method.

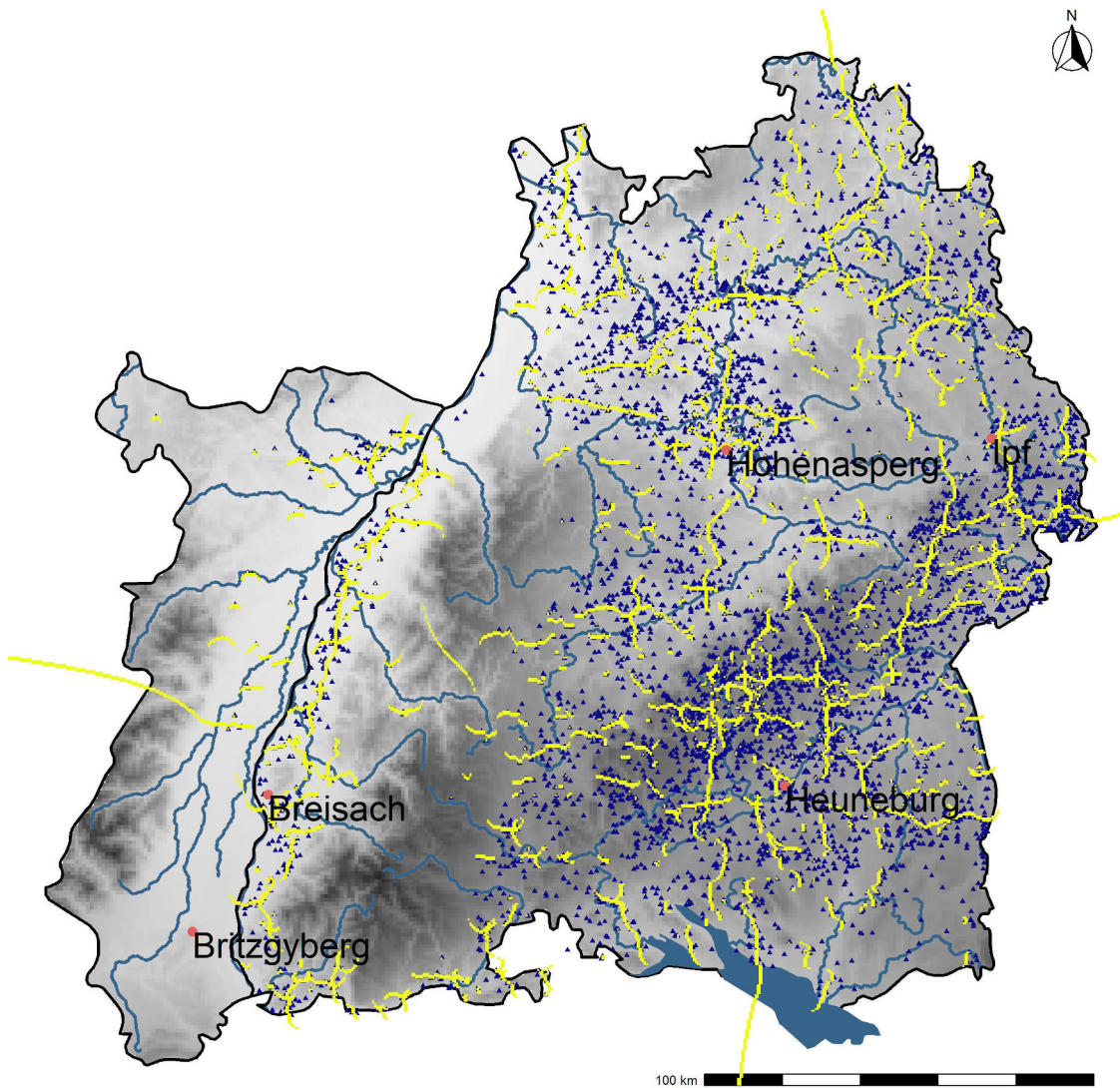


Fig. 7.5: Early Iron Age reconstructed path system (yellow: path system, triangular: necropolis, dots: princely seats, DEM: SRTM 90 m).

There will have been central and significant routes and routes less intensively used in a network of paths. While paved paths dominate today, it is mainly natural paths that predominate [81]. A hierarchical classification of path relics is not expedient if an extensive effort was made only for specific constriction points [445]. Only indirect parameters remain for the identification of central traffic arteries. The number of path associated features could be a possible proxy for the meaning, or, as Wassong suggests, the monumentality of the grave mounds [509]. Continuity is also a helpful indicator because if a route has existed for a long time, it must be assigned a particular meaning. Whereby there is less a cultural meaning than a natural space-dependent meaning. Other factors that would be suitable as indicators for a weighted path network would be using a Least Cost Path

analysis based on the identified location parameters, instead of the Euclidian distance, or the weighting based on key figures from the traffic geography.

The consideration of the interaction structure on the Rhine shows how the Britzgyberg [1] is integrated into its local environment, related to other princely seats and, above all, how the interaction relationships to the south towards Belfort Gab are presented. This question is not only relevant for the Britzgyberg but also the Breisach Münsterberg. The, as yet unexplained, interaction relationships in the Lake Constance area and into Switzerland would answer the open questions in the southern peripheral area. With the expansion of the working area to the east, the interaction space of the Ipf can be better assessed.

A stronger focus on the individual would be particularly interesting in the interaction analysis of individual necropolises. Such a micro-interaction analysis could improve the interpretation of the princely burials. This could provide further insight into how the burial community portrays its members in the grave and differences in the living world. Do members of the same necropolis show the same interaction relationships, or do individual burial communities differ? A comparison between settlement and grave interaction can reveal possible differences in which contacts and aspects of the community were essential to preserve in the grave or point it out during the burial.

## Chapter 8

### Summary

#### 8.1 Summary

Interaction relationships, infrastructure and distribution during the Early Iron Age are investigated with computer-based modelling and reconstructions in southwest Germany and Alsace. The well-known princely seats, Heunenburg, Breisach Münsterberg, Ipf and Hohenasperg, with their richly equipped barrows in the surrounding area and the hilltops extraordinary artefacts describe an epoch with radical processes of change in terms of settlement structures, political and social systems. The project focuses on interaction at different spatial scales and perspectives, reconstructing and modelling it with a broad interdisciplinary toolset. The theoretical background on interaction analysis and infrastructure allows for selecting appropriate methods and highlights the importance of material culture. Since material culture is central to interaction analyses in prehistory, describing sites and artefacts help to understand the Early Iron Age phenomenon. In addition, a source-critical examination avoids biases in the interpretation. After describing the archaeological data, it follows explaining the possible methods for reconstructing the path system and interpreting the infrastructure, the methodology for determining cultural distances and the possible graphical realisation of the results for the interpretation. The results are described according to geographical scaling so that after the whole region, individual case studies such as the Swabian Alb, the Haguenau Forest, Breisach Münsterberg, Ipf and Hohenasperg are described separately.

As opposed to local interaction relationships, global trends improve the understanding of the complicated system formed by the Early Iron Age's heterogeneous cultural area. By examining different type combinations (vessels, ring jewellery or costume components), range, thresholds and relationships are identified for different social segments. In contrast to the supra-regional perspective, regional case studies consider local dynamics and different geographical conditions. The spatial representation of interaction friction illustrates the integration of so-called princely seats into their hinterland in terms of interaction.

Also, river systems as interaction corridors and infrastructural elements are examined. To better understand the Rhine valley as a communication and distribution factor, the area encloses Baden-Württemberg and the Alsace (France); thus, the study area now connects the two most important European river systems - Rhine and Danube. The Rhine and the Danube serve as reference areas here, as they allow the study of communication corridors, different natural spaces and different primary orientations. The new perspective of analysing cultural distance leads to new distance diagrams: River profiles. The Rhine's profile curves show high deviations in the interaction references to the Rhine axis's neighbouring points at three points. These points have a high exchange rate, i.e. are exchange nodes. However, seasonal markets, crossings or harbour facilities assumingly existed in the vicinity of these nodes no longer preserved archaeologically. It is astonishing that these places preserve themselves in the find assemblages of the surroundings and become recognisable through interaction analysis methodology. The interaction references on the Danube do not show such concise structures as on the Rhine. Exchange nodes or zones do not establish themselves in the entire material's curves but as latent structures concerning vessels, ring jewellery or costume, often referring to only one riverbank. Cultural distance records



an exchange zone at the Danube's beginning in the central axis's eastern part. Another exchange zone is also latently recognisable near Heuneburg.

Although knowing the importance of transport for the Early Iron Age, reconstructions are lacking. So far, mainly theoretical models based on partial data (imported goods) and a focus on river systems outline possible connections, neglecting alternative routes, cultural effects, or the path's exact position. The local path system of the whole working area is reconstructed from the position of barrows. Due to their communicative character and their relation to paths, these function like path-associated features. With the RePath method, paths are reconstructed along density ridges of monuments, overcoming graph-based or intuitive path reconstruction disadvantages. Although pre-existing paths are not directly included in the empirical model; however, it includes Bronze Age burial mounds to consider pre-existing paths. Comparing the reconstructed path system with the settlements' location often shows a path in the area between settlements without directly crossing them. Settlements connected to the path system by short paths indicate shifting settlement centres within a settlement chamber. The reconstructed path system also makes it possible to assess princely seats within the infrastructure system, located near the reconstructed path system, clarifying the princely seats' relationship to exchange routes. Furthermore, relevant parameters influencing the localisation of a path are evaluated to understand the infrastructural system better. Local density maxima, i.e. crossing points, are extracted from the barrows' location and used for a Delaunay triangulation. Along the edges, accumulated cost surfaces of different theoretical path models are generated. These models include, for example, the movement of a pedestrian combined with low costs for good visibility of the surroundings. Calculating the average distance of those cells with the lowest accumulated costs to the nearest barrow provides a measure of the empirical data's fit to the theoretical model. The excellent fit to the cost model for wagon throughout the study area is initially surprising, as the influence of wagon transportation on the site parameters of the paths is only assumed from the Middle Ages onwards. Even if no dominance of the wagon is inferred from this, steep increases were avoided. Describing the study area as a homogeneous landscape is not possible as rather distinct topographical differences are present, the adaptation of the parameters in sub-regions show deviating parameters. However, the topographic conditions can only partially explain it. Good visibility and easily accessible routes often seem to have been significant. Two aspects can explain the preferred visibility of the routes.

On the one hand, good visibility increases travellers' safety, as one can overlook a large area and see approaching people early on. On the other hand, the individual is well visible and can communicate its approach. Explaining the princely seats' location, often not at the point of maximum visibility of the micro-region, visible to the reconstructed path. The astonishingly good integration of the princely seats into the empirical route system together with the relevant parameter of good visibility describes, on the one hand, the princely seats as centres of exchange, probably trying to profit from communication and contacts, and, on the other hand, the significant communicative character of the path system in the Early Iron Age. The princely seats' interaction relationships clearly show that distant places or groups of people appear particularly intensively as interaction partners, while in some cases, even the surrounding groups appear culturally alien. The more locally distributed artefacts partly offset this impression; for example, the pottery type combinations occasionally show a local connection of the princely seats. This preferential interaction with distant groups creates precisely this strangeness to the local spectrum and highlights the princely seats' unique find association. The often reoccurring cultural dissimilarity of the Swabian Alb to the princely seats is striking, which cannot only be explained by the source-critical effects, like an inevitable dominance of burial mounds on the Swabian Alb with lacking settlements.

In contrast, the grave ensembles near princely seats influence the compositions likewise. In addition, another astonishing interaction edge has repeatedly appeared south of the Danube along the course of the Ablach. These interaction patterns are yet not understood completely. The integration of additional material (Switzerland or Bavaria) will certainly help understand the southern Danube regions integration into the Early Iron Age's heterogeneous interaction pattern.

## 8.2 Zusammenfassung

Interaktionsbeziehungen, Infrastruktur und Distribution während der frühen Eisenzeit werden mithilfe von computergestützter Modellierung und Rekonstruktionen in Südwestdeutschland und dem Elsass untersucht. Die bekannten Fürstensitze, Heuneburg, Breisach Münsterberg, Ipf und Hohenasperg, mit ihren reich ausgestatteten Gräbern im Umfeld und dem außergewöhnlichen Funden in den Höhensiedlungen beschreiben eine Epoche mit umgreifenden Wandlungsprozessen bezogen auf Siedlungswesen, sozialen Strukturen und politischen Systemen. Das Projekt konzentriert sich auf Interaktion in verschiedenen räumlichen Skalen und Perspektiven, rekonstruiert und modelliert diese mit einem breit gefächerten interdisziplinären Toolset. Der theoretische Hintergrund zu Interaktionsanalysen und Infrastruktur ermöglichen zum einen geeignete Methoden auszuwählen und darüber hinaus wird die Bedeutung der materiellen Kultur verdeutlicht. Da die materielle Kultur zentral für Interaktionsanalysen in der Vorgeschichte ist, werden Fundorte sowie Artefakte der frühen Eisenzeit detailliert beschrieben. Vor allem der Beurteilung von möglichen Effekten der Quellgattung wird sich gesondert gewidmet. Nach der Darlegung der archäologischen Daten, werden die möglichen Methoden zur Rekonstruktion des Wegenetzes und Interpretation der Infrastruktur vorgestellt, gefolgt von der Methodik zur Ermittlung von kulturellen Distanzen und der möglichen graphischen Umsetzung für die Interpretation der Ergebnisse. Die Ergebnisse werden nach geographischer Skalierung beschrieben, sodass nach der gesamten Region, einzelne Fallstudien, wie die Schwäbische Alb, der Haguenaue Wald, Breisach Münsterberg, Ipf und Hohenasperg separat beschrieben werden.

Globale Trends im Gegensatz zu lokalen Interaktionsbeziehungen verbessern das Verständnis des komplizierten Systems, welches durch den heterogenen Kulturraum der frühen Eisenzeit geprägt ist. Durch die Untersuchung verschiedener Typenkombinationen (Gefäße, Ringschmuck oder Trachtbestandteile) werden Reichweite, Schwellenwerte und Beziehungen für verschiedene soziale Segmente identifiziert. Im Gegensatz zur überregionalen Perspektive berücksichtigen regionale Fallstudien die lokale Dynamik sowie unterschiedliche geographische Bedingungen. Die Integration sogenannter Fürstensitze in ihr Hinterland bezogen auf Interaktion wird anhand der räumlichen Darstellung der Interaktionsfriktion veranschaulicht.

Zusätzlich werden Flusssysteme als Interaktionskorridore und Infrastrukturelemente untersucht. Zum besseren Verständnis des Rheintals als Kommunikations- und Interaktionsfaktor umschließt das Gebiet Baden-Württemberg um den Elsass (Frankreich), so ist das zentrale Gebiet (Baden-Württemberg) mit den beiden wichtigsten europäischen Flusssystemen — Rhein und Donau — verbunden. Rhein und Donau dienen hier als Referenzgebiete, da sie die Untersuchung von Kommunikationskorridoren, unterschiedlichen Naturräumen und unterschiedlicher Primärorientierung ermöglichen. Die neue Perspektive der Analyse kultureller Distanz führt zu neuen Distanzdiagrammen: Flussprofile. Die Profilkurven des Rheins zeigen an drei Stellen hohe Abweichungen in den Interaktionsbezügen zu den benachbart gelegenen Punkten der Rheinachse. Diese Punkte im Kommunikationskorridor sind Punkte mit hoher Austauschrate, also exchange nodes. Im Umfeld dieser Knotenpunkte werden saisonale Märkte, Übergänge oder Hafenanlagen vermutet, die archäologisch nicht mehr erhalten sind. Erstaunlich ist, dass diese Orte sich in den Fundzusammenstellungen der Umgebung erhalten haben und mittels der Methodik der Interaktionsanalyse erkennbar werden. Die Interaktionsbezüge an der Donau zeigen keine so prägnanten Strukturen wie am Rhein auf. Austauschknäute oder -zonen etablieren sich nicht in den Kurven des gesamten Materials, sondern als latente Strukturen in Bezug auf Gefäße, Ringschmuck oder Tracht, die sich oft nur auf ein Flussufer beziehen. Eine solche Austauschzone wird zu Beginn der Donau im östlichen Bereich der Mittelachse erfasst. Auch in der Nähe der Heuneburg ist latent eine Austauschzone zu erkennen.

Obwohl die Bedeutung des Transports für die frühe Eisenzeit bekannt ist, fehlen Rekonstruktionen. Bisher skizzieren hauptsächlich theoretische Modelle, die auf Teildaten (Importgütern) und einem Schwerpunkt von Flusssystemen basieren, mögliche Zusammenhänge, wobei alternative Routen, kulturelle Effekte oder die genaue Position des Weges vernachlässigt werden. Das lokale Wegesystem des gesamten Arbeitsgebietes wird aus der Position der Grabhügel rekonstruiert. Aufgrund ihres kommunikativen Charakters und ihrer Beziehung zu Wegen haben diese die Funktion wegebegleitender Merkmale. Mit der RePath-Methode werden Wege entlang von dichtgraden der Monumente rekonstruiert und so Nachteile der Graphen basierten oder intuitiven

Wegerekonstruktion überwunden. Obwohl die bereits vorhandenen Wege nicht direkt im empirischen Modell enthalten sind, werden Grabhügel aus der Bronzezeit in das RePath-Modell miteinbezogen, sodass die Beeinflussung des Menschen durch bereits existierende Wege berücksichtigt wird. Der Vergleich des rekonstruierten Wegesystems mit der Lage von Siedlungen zeigt häufig einen Weg im Bereich zwischen den Siedlungen ohne sie direkt zu kreuzen. Offenbar wurden Siedlungen durch kurze Stichwege an das Wegenetz angebunden, was auf sich verlagernde Siedlungszentren innerhalb einer Siedlungskammer hindeutet. Das rekonstruierte Wegesystem ermöglicht es auch, die Position von Fürstensitzen innerhalb des Infrastruktursystems zu bewerten, welche in unmittelbarer Nähe zu dem rekonstruierten Wegenetz lagen. Dies verdeutlicht den Bezug der Fürstensitze zu Austauschrouten. Darüber hinaus werden relevante Parameter, die die Lokalisation des Wegesystems beeinflussen, zum besseren Verständnis des Infrastruktursystems evaluiert. Aus der Lage der Grabhügel werden lokale Dichtemaxima, Kreuzungspunkte, extrahiert und für eine Delaunay-Triangulation verwandt. Entlang der Kanten werden akkumulierte Kostenoberflächen von verschiedenen theoretischen Wegemodellen erstellt. Diese Modelle umfassen bspw. die Bewegung eines Fußgängers kombiniert mit geringen Kosten für gute Sichtbarkeit der Umgebung. In einem weiteren Schritt wird die gemittelte Distanz jener Zellen, mit den geringsten akkumulierten Kosten, zum nächstgelegenen Grabhügel berechnet. Daraus ergibt sich ein Maß der Anpassung der empirischen Daten an das theoretische Modell. Die hervorragende Anpassung an das Kostenmodell für den Wagenverkehr im gesamten Arbeitsgebiet ist zunächst überraschend, da der Einfluss des Wagentransports auf die Standortparameter der Wege erst ab dem Mittelalter angenommen wird. Auch wenn daraus keine Dominanz des Wagens abgeleitet wird, wurden steile Anstiege vermieden. Da die Region sich nicht als homogene Landschaft beschreiben lässt, sondern deutliche topographische Unterschiede vorhanden sind, wurde die Anpassung der Parameter in Teilregionen untersucht. Die topografischen Bedingungen können die Abweichungen der Parameter aber nur teilweise erklären. Gute Sicht und leicht begehbare Routen scheinen oft bedeutend gewesen zu sein. Täler und schlechte Sicht sind selten von Bedeutung. Zwei Aspekte können die gut sichtbare Position der Wege erklären. Einerseits erhöht eine gute Sicht die Sicherheit der Reisenden, da man einen großen Bereich überblicken und frühzeitig erkennen kann, wenn sich Menschen nähern. Andererseits ist man selbst gut sichtbar und kann sein Herannahen kommunizieren. Hiermit erklärt sich womöglich auch die Lage der Fürstensitze, die oft nicht an der Stelle mit der maximalen Sichtbarkeit der Kleinregion liegen, wohl aber gut sichtbar zum rekonstruierten Weg.

Die erstaunlich gute Einbindung der Fürstensitze in das empirische Wegenetz zusammen mit dem relevanten Parameter der guten Sichtbarkeit beschreiben zum einen die Fürstensitze als Austauschzentren, die wohl versuchen aus Kommunikation und Kontakten zu profitieren, und zum Anderen den bedeutenden kommunikativen Charakter der Wegeführung in der frühen Eisenzeit.

Die Interaktionsbezüge der Fürstensitze zeigen deutlich, dass entfernt liegende Orte oder Personengruppen besonders intensiv als Interaktionspartner auftreten, während teils sogar die umliegenden Gruppen kulturell fremd erscheinen. Dieser Eindruck wird zum Teil durch die eher lokal verbreiteten Artefakte ausgeglichen, so zeigt sich gelegentlich in den Typenkombinationen der Keramik eine lokale Anbindung der Fürstensitze. Diese bevorzugte Interaktion mit entfernten Gruppen erzeugt eben diese Fremdheit gegenüber dem lokalen Spektrum und hebt die besondere Fundvergesellschaftung der Fürstensitze hervor. Auffällig ist die oft wiederkehrende kulturelle Unähnlichkeit der Schwäbischen Alb gegenüber den Fürstensitzen. Hierbei können nicht nur Effekte der Quellengattung die Erklärung sein, denn trotz einer gewissen Dominanz an Grabhügeln, fließen auch auf der Alb Siedlungsfunde ein, und dagegen an den Fürstensitzen die Grabensembles der Umgebung. Außerdem ist eine weitere erstaunliche Interaktionskante südlich der Donau entlang dem Verlauf der Ablach wiederholt aufgetreten. Das Gräberfeld von Salem unterscheidet sich ebenfalls von den Fürstensitzen deutlich, weswegen hier zumindest eine fehlende „Elite“ nicht angeführt werden kann.

## References

- [1] A.-M. Adam, Genese und Entwicklung der befestigten Höhensiedlung auf dem Britzgyberg in Illfurth (Haut-Rhin, Frankreich). In: D. Krausse/D. Beilharz (ed.) "Fürstensitze" und Zentralorte der frühen Kelten. Abschlusskolloquium des DFG-Schwerpunktprogramms 1171 in Stuttgart, 12.-15. Oktober 2009. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 120 (Stuttgart 2010) 365–373.
- [2] A.-M. Adam/M. Lasserre, La butte du Hexenberg à Leutenheim (Bas-Rhin). Un habitat fortifié de la fin du Bronze final, fouilles 1994 à 1999. *Bulletin de la Société préhistorique française* **98**, 2001, 311–324.
- [3] A.-M. Adam/S. Deffressigne/M.-P. Koenig, La céramique d'habitat du Bronze final IIIb à La Tène B en Alsace et en Lorraine. Essai de typo-chronologie. *Revue d'Archéologie de l'Est* **29**, 2011.
- [4] A. Antoniadis/G. Oppenheim (eds.), *Wavelets and Statistics. Lecture Notes in Statistics*, 0930-0325 103 (New York, 1995).
- [5] B. Arnold, Reading the Body. Geschlechtsdifferenzierung im Totenritual der frühen Eisenzeit. In: C. Kümmel/B. Schweizer/U. Veit (eds.) *Körperinszenierung - Objektsammlung - Monumentalisierung. Totenritual und Grabkult in frühen Gesellschaften: archäologische Quellen in kulturwissenschaftlicher Perspektive. Tübinger Archäologische Taschenbücher Volume 6* (Münster 2008) 375–396.
- [6] B. Arnold, Memory maps. The mnemonics of Central European Iron Age burial mounds. In: K. T. Lillios/V. Tsamis (eds.) *Material mnemonics. Everyday memory in prehistoric Europe* (Oxford, Oakville, 2010).
- [7] H. Aubin, Maß und Bedeutung der römisch-germanischen Kulturzusammenhänge im Rheinland. *Berichte der Römisch-Germanischen Kommission* **13**, 1921, 46–68.
- [8] F. Audouze/O. Büchsenschütz, *Towns, villages and countryside of Celtic Europe* (London 1992).
- [9] J. Aufdermauer, Ein Grabhügelfeld der Hallstattzeit bei Mauenheim: Ldkrs. Donaueschingen. *Badische Fundberichte / Special Volume* 3, 1963.
- [10] S. M. Bache/H. Wickham, magritr. A Forward-Pipe Operator for R. R package version 1.5. (2014).
- [11] D. Bachmann-Medick, *Cultural turns. Neuorientierungen in den Kulturwissenschaften.* (Reinbek bei Hamburg 2006).
- [12] A. Baddeley/E. Rubak/R. Turner, *Spatial point patterns. Methodology and applications with R.* Chapman & Hall/CRC Interdisciplinary statistics series (Boca Raton, Florida 2016).
- [13] H. Baitinger, *Die Hallstattzeit im Nordosten Baden-Württembergs. Materialhefte zur Archäologie in Baden-Württemberg textbf46* (Stuttgart 1999).
- [14] I. Balzer, Hallstattzeitliche Keramik im Breisgau (Südbaden). In: B. Chaume (ed.) *La céramique hallstattienne. Approches typologique et chrono-culturelle; actes du colloque international de Dijon 21-22 novembre 2006. Art, archéologie & patrimoine* (Dijon 2009) 513–529.
- [15] I. Balzer, Technological Innovations in Pottery. Examples from Celtic "Princely" Sites (6th to 5th Century B. C.) in Continental Europe. In: W. Gauss/C. v. Rüden/G. Klebinder-Gauss (eds.) *The transmission of technical knowledge in the production of ancient Mediterranean pottery. Proceedings of the international conference at the Austrian Archaeological Institute at Athens, 23rd-25th November 2012* (Wien 2015) 139–163.
- [16] I. Balzer, Burial mounds and settlements. the funerary contribution to urbanism. In: S. Stoddart (ed.) *Delicate urbanism in context. Settlement nucleation in pre-Roman Germany* (Cambridge 2017) 63–84.
- [17] L. Baray, Les résidences princières comme "port of trade". In: P. Brun/B. Chaume (eds.) *Vix et les éphémères principautés celtiques* (Paris 1997) 251–260.
- [18] A. Baron, Provenance et circulation des objets en roches noires ("lignite") à l'âge du Fer en Europe celtique (VIIIème-Ier s.av. J.-C.). *BAR. International series textbf2453* (Oxford 2012).
- [19] A. Bauer, Langsam schleicht der Ochse, flotter geht das Pferd. Über Anspannung und Geschwindigkeit von Rindern und Equiden. In: C. Tappert/C. Later/J. Fries-Knoblach/ P. Ch. Rams/P. Trebsche/St. Wefers/J. Wiethold (eds.) *Wege und Transport. Beiträge zur Sitzung der AG Eisenzeit während der 80.*

- Verbandstagung des West- und Süddeutschen Verbandes für Altertumsforschung e. V. in Nürnberg 2010. Beiträge zur Ur- und Frühgeschichte Mitteleuropas 69 (Langenweissbach 2012) 5–13.
- [20] I. Bauer, Das Verzierungsprinzip der Alb-Salem Keramik. Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte textbf71, 1988, 107–121.
- [21] B. Becker/A. Billamboz/H. Egger/P. Gassmann/Ch. Orcel/U. Ruoff, Dendrochronologie in der Ur- und Frühgeschichte. Die absolute Datierung von Pfahlbausiedlungen nördlich der Alpen im Jahresringkalender Mitteleuropas. Antiqua textbf11, 1985.
- [22] B. Belina, Kultur? Macht und Profit! Zu Kultur, Ökonomie und Politik im öffentlichen Raum und in der Radical Geography. In: H. Gebhardt/G. Wolkersdorfer (eds.) Kulturgeographie. Aktuelle Ansätze und Entwicklungen. Spektrum Lehrbuch (Heidelberg 2003) 83–97.
- [23] H. Bender, Römische Strassen und Strassenstationen. Kleine Schriften zur Kenntnis der römischen Besetzungsgeschichte Südwestdeutschlands Volume 13 (Stuttgart 1975).
- [24] H. Bender, Römischer Reiseverkehr. Cursus publicus u. Privatreisen. Kleine Schriften zur Kenntnis der römischen Besetzungsgeschichte Südwestdeutschlands Volume 20 (Stuttgart 1978).
- [25] L. Bernard/G. Wieland, Sondagen an den vorgeschichtlichen Befestigungsanlagen auf dem Battert bei Baden-Baden. Archäologische Ausgrabungen in Baden-Württemberg 2009, 91–94.
- [26] L. Bernard, ArkeoGIS. NUMEAR textbf3, 2019.
- [27] L. Bernard/R. Wassong, Du Danemark au Fossé Rhéna. Un siècle d'analyse des voies de communication protohistoriques: évolution des méthodes et mise en commun des données. Archimède textbf3, 2016, 169–183.
- [28] C. Bernhardt, Die Rheinkorrektion. In: Landeszentrale für Politische Bildung Baden-Württemberg (ed.) Der Rhein. Bürger & Staat volume 50, (Filderstadt 2000) 76–81.
- [29] A. Bertrand, Archéologie celtique et gauloise <sup>2</sup> (1889).
- [30] A. Beygelzimer/S. Kakadet/J. Langford/S. Arya/D. Mount/Sh. Li, FNN: Fast Nearest Neighbor Search Algorithms and Applications (2010).
- [31] P. Bichet/J.-P. Millotte/H. Dartevelle, L'âge du fer dans le haut Jura. Les tumulus de la région de Pontarlier, Doubs. Documents d'archéologie française Volume 34 (Paris 1992).
- [32] J. Biel, Ein hallstattzeitlicher Grabhügel bei Schönaich, Kr. Böblingen. Archäologische Ausgrabungen 1975, 22–23.
- [33] J. Biel, Die Ausstattung des Toten. Reichtum im Grabe - Spiegel seiner Macht. In: J. Biel (ed.) Der Keltenfürst von Hochdorf. Methoden und Ergebnisse der Landesarchäologie in Baden-Württemberg: Katalog zur Ausstellung, Stuttgart, Kunstgebäude vom 14. August bis 13. Oktober 1985 (Stuttgart 1985) 78–105.
- [34] J. Biel, Vorgeschichtliche Höhensiedlungen in Südwürttemberg-Hohenzollern. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg Volume 24 (Stuttgart 1987).
- [35] J. Biel, Tracht und Bewaffnung. In: S. Rieckhoff/J. Biel/B.-U. Abels (eds.) Die Kelten in Deutschland (Stuttgart 2001) 138–159.
- [36] A. Billamboz, Dendrochronologie au-delà du temps. Approche paléodendrochronologique des constructions palafittiques de l'âge des Métaux dans le sud-ouest de l'Allemagne. In: H. Richard/M. Magny/C. Mordant (eds.) Environnements et cultures à l'âge du bronze en Europe occidentale. [Actes des Congrès Nationaux des Sociétés Historiques et Scientifiques, 129e, Besançon, 2004]. Documents préhistoriques textbf21 (Paris 2007) 57–69.
- [37] L. R. Binford, General Introduction. In: L. R. Binford (ed.) For theory building in archaeology. Essays on faunal remains, aquatic resources, spatial analysis and systematic modeling. Studies in archaeology (New York, 1977) 1–13.
- [38] K. Bittel/W. Kimmig/S. Schiek/R.-H. Behrends, Die Kelten in Baden-Württemberg (Stuttgart 1981).
- [39] R. Bivand/E. J. Pebesma/V. Gómez-Rubio, Applied spatial data analysis with R2. Use R! (New York, Heidelberg, Dordrecht, London 2013).
- [40] L. Blöck, Die Siedlungs- und Verkehrstopographie an Hoch- und Oberrhein am Übergang zu Spätantike. In: Brather (ed.) Antike im Mittelalter. Fortleben, Nachwirken, Wahrnehmung (2014) 249–285.

- [41] L. Bonnamour/A. Bailly (eds.), *Du silex à la poudre-. 4000 ans d'armement en val de Saône* (Montagnac 1990).
- [42] L. Bonnamour/S. Wirth, *Die Saône. Ein Glücksfall für die Flussarchäologie*. In: H.-P. Kuhnen/S. Bauer (eds.) *Abgetaucht, aufgetaucht. Flussfundstücke, aus der Geschichte, mit ihrer Geschichte*. Schriftenreihe des Rheinischen Landesmuseums Trier textbf21 (Trier 2001) 13–30.
- [43] R. Bradley, *The passage of arms. An archaeological analysis of prehistoric hoard and votive deposits* (Cambridge 1990).
- [44] U. Brosseder, *Studien zur Ornamentik hallstattzeitlicher Keramik zwischen Rhônetal und Karpatenbecken*. Universitätsforschungen zur prähistorischen Archäologie 106 (Bonn 2004).
- [45] U. Brosseder, *Ebenen sozialer Identitäten im Spiegel des Zeichensystems hallstattzeitlicher Keramik*. In: S. Burmeister (ed.) *Soziale Gruppen - kulturelle Grenzen. Die Interpretation sozialer Identitäten in der Prähistorischen Archäologie*. Tübinger Archäologische Taschenbücher 5 (Münster 2006) 119–138.
- [46] P. Brun/B. Chaume (eds.), *Vix et les éphémères principautés celtiques* (Paris 1997).
- [47] P. Brun, *Les « Résidences princières » comme centres territoriaux. éléments de vérification*. In: J. P. Mohen/A. Duval/C. Eluère (eds.) *Les Princes celtes et la Méditerranée. Rencontres de l'Ecole du Louvre* (Paris 1988) 128–143.
- [48] P. Brun, *Oppida and social « complexification » in France*. In: J. D. Hill/C. G. Cumberpatch (eds.) *Different Iron Ages. Studies on the Iron Age in Temperate Europe*. BAR international series 602 (Oxford 1995) 121–128.
- [49] P. Brun/C. Cathelinais/S. Chatillon/Y. Guichard/P. Le Guen/É. Nère, *L'âge du Bronze dans la vallée de l'Aisne*. In: Bourgeois J./Talon M (eds.) *L'âge du Bronze du nord-ouest de la France dans son contexte occidental. Nouvelles découvertes et propositions de périodisation. Actes de la table ronde du 125ème Congrès national des sociétés historiques et scientifiques, Lille 2000* (Paris 2005) 189–208.
- [50] O. Büchsenschütz/C. Gruel/T. Lejars, *L'âge d'or de l'aristocratie celtique, IVe et IIIe siècles avant J.-C.* *Annales, Histoire, Sciences Sociales* textbf67, 2012, 295–324.
- [51] O. Büchsenschütz, *Kulturgeographie und Archäologie*. In: D. Krause/O. Nakoinz (eds.) *Kulturräum und Territorialität. Archäologische Theorien, Methoden und Fallbeispiele; Kolloquium des DFG-SPP 1171, Esslingen 17.-18. Januar 2007*. Internationale Archäologie Arbeitsgemeinschaft, Symposium, Tagung, Kongress 13 (Rahden, Westf. 2009) 65–69.
- [52] S. Burmeister, *Geschlecht, Alter und Herrschaft in der Späthallstattzeit Württembergs*. Tübinger Schriften zur ur- und frühgeschichtlichen Archäologie 4 (Münster 2000).
- [53] H. Büttner, *textits.v. Alpenpässe*. In: J. Hoops (ed.) *Reallexikon der Germanischen Altertumskunde 1* (1973) 191–198.
- [54] E. Cassirer/J. Clemens/B. Recki, *Philosophie der symbolischen Formen; Teil 3. Phänomenologie der Erkenntnis. Gesammelte Werke Hamburger Ausgabe / Ernst Cassirer. ed. von Birgit Recki; Volume 13* (Darmstadt 2002).
- [55] J. M. Chambers, *Software for data analysis. Programming with R. Statistics and computing* (New York 2008).
- [56] H. Chapman, *Landscape archaeology and GIS* (Stroud 2006).
- [57] B. Chaume, *Vix et son territoire à l'âge du fer. Fouilles du Mont Lassois et environnement du site princier. Protohistoire européenne* textbf6 (Montagnac 2001).
- [58] B. Chaume/M. Feugère, *Les sépultures tumulaires aristocratiques du Hallstatt ancien de Poiseul-La-Ville (Côte-d'Or)*. *Revue archéologique de l'est et du centre-est, Special Volume 10* (Dijon 1990).
- [59] V. G. Childe, *The Bronze Age* (Cambridge 1930).
- [60] W. Christaller, *Die zentralen Orte in Süddeutschland* (Jena 1933).
- [61] J. G. D. Clark, *Prehistoric Europe. The economic basis* <sup>1</sup> (London 1952).
- [62] D. L. Clarke, *Analytical archaeology* (London 1968).
- [63] J. R. Collis, *Constructing chronologies. Lessons from the Iron Age*. In: A. Lehoëuff (ed.) *Construire le temps. Histoire et méthodes des chronologies et calendriers des derniers millénaires avant notre ère en*

- Europe occidentale: Actes du XXXe colloque international de Halma-Ipel UMR 8164 (CNRS, Lille 3, MCC), 7 - 9 décembre 2006, Lille. Collection Bibracte 16 (Glux-en-Glenne 2008) 85–104.
- [64] J. R. Collis, Why do we still dig Iron Age ramparts? In: S. Fichtl (ed.) *Murus celticus*. Architecture et fonctions des remparts de l'âge du Fer. Table ronde internationale organisée par L'Unité Mixte de Recherche 7044 de Strasbourg, Centre archéologique européen 11, 12 octobre 2006, Glux-en-Glenne. Collection Bibracte 19 (Glux-en-Glenne 2010) 27–35.
- [65] J. Conolly/M. Lake, *Geographical information systems in archaeology*. Cambridge manuals in archaeology (Cambridge 2006).
- [66] H. Corot, Notes pour servir à l'Étude de la Haute Antiquité en Bourgogne. Les epees du type de Hallstatt, les rasoirs, les perles et amulettes trouvés dans les tumulus de la Côte-d'Or. *Bulletin de la Société Scientifique, Histoire et Naturelles de Semur-en-Auxois* (1896).
- [67] F. Criado Boado/V. Vázquez-Villoch, La monumentalización del Paisaje: percepción actual y sentido original del megalitismo de la sierra de Barbanza (Galicia). *Trabajos de Prehistoria* textbf55, 1998, 63–80.
- [68] C.-J. Dalgaard/N. Kaarsen/Olsson, Ola, Selaya, Pablo, *Roman Roads to Prosperity*. Public good provision. *CEPR Discussion Papers* textbf12745, 2018.
- [69] H.-W. Dämmer, Zu späthallstattzeitlichen Zweischalennadeln und zur Datierung des Frauengrabes auf der Heuneburg. *Fundberichte in Baden-Württemberg* textbf1, 1974.
- [70] H.-W. Dämmer, Die bemalte Keramik der Heuneburg. Die Funde der Grabungen von 1950-1972. *Heuneburgstudien IV. Römisch-germanische Forschungen* textbf37, 1978.
- [71] A. Dauber, Zur Geschichte der archäologischen Denkmalpflege in Baden. *Denkmalpflege in Baden-Württemberg* textbf12, 1983, 47–51.
- [72] J. Déchelette, *Manuel d'Archéologie Préhistorique, Celtique et Gallo-Romaine*. II-2 Premier Âge du Fer en Époque Hallstatt (Paris 1913).
- [73] J. Déchelette, *Manuel d'Archéologie Préhistorique, Celtique et Gallo-Romaine*. Seconde Âge du Fer ou Époque de La Tène (Paris 1914).
- [74] J. Déchelette, *Manuel d'Archéologie Préhistorique, Celtique et Gallo-Romaine*. III-2 Premier Âge du Fer ou Époque du Hallstatt (1927).
- [75] S. Defressigne/M. Roth-Zehner/M.-P. Koenig, Quelques ensembles céramique d'Alsace et de Lorraine, du Hallstatt D1 à La Tène A. Première synthèse typo-chronologique. In: B. Chaume (ed.) *La céramique hallstattienne*. Approches typologique et chrono-culturelle; Actes du colloque international de Dijon 21-22 novembre 2006. *Art, archéologie & patrimoine* (Dijon 2009) 249–295.
- [76] R. Dehn/M. Egg/R. Lehnert, Das hallstattzeitliche Fürstengrab im Hügel 3 von Kappel am Rhein in Baden. In: *Römisch-germanisches Zentralmuseum* (ed.) *Monographien*, Volume 63 (Mainz, Bonn 2005).
- [77] R. Dehn, Die Bronzeschüssel aus dem Hohmichele, Grab VI, und ihre Verwandtenkreis. *Fundberichte Schwaben* textbf17, 1965, 126–134.
- [78] R. Dehn, Tarodunum und Kegelriß - Neues zur Spätlatènezeit im Breisgau. *Denkmalpflege Baden-Württemberg* textbf17, 1988, 94–97.
- [79] B. N. Delaunay, Sur la sphère vide. *Bulletin of Academy of Sciences of the USSR* 7/8, 1934, 793–800.
- [80] D. Denecke, Methoden und Ergebnisse der historisch-geographischen und archäologischen Untersuchung und Rekonstruktion mittelalterlicher Verkehrswege. In: H. Jankuhn/R. Wenskus (ed.) *Geschichtswissenschaft und Archäologie*. Untersuchungen zur Siedlungs-, Wirtschafts- und Kirchengeschichte. *Vorträge und Forschungen* 22 (Sigmaringen 1979) 433–483.
- [81] D. Denecke, *s.v.* Wege und Wegenetze. In: H. Jankuhn/J. Hoops (ed.) *Reallexikon der germanischen Altertumskunde* 22 (Berlin 2007) 626–648.
- [82] L. Dhennequin, Le processus de conception et d'évolution de l'épée longue hallstattienne en fer. In: P. Barral/A. Daubigny/A. Richard (ed.) *L'isthme européen Rhin-Saône-Rhône dans la protohistoire*. Approches nouvelles en hommage à Jacques-Pierre Millotte. Actes du colloque de Besançon, 16-18 octobre 2006 (2009) 129–139.
- [83] R. Diestel, *Graph theory*. Graduate texts in mathematics 173 (New York, Heidelberg 1997).

- [84] E. W. Dijkstra, A note on two problems in connexion with graphs. *Numerische Mathematik* **1**, 1959, 269–271.
- [85] D. L. Donoho/A. Maleki/I. U. Rahman/M. Shahram/V. Stodden, Reproducible Research in Computational Harmonic Analysis. *Computing in Science & Engineering* **11**, 2009, 8–18.
- [86] Drack, Zum bronzenen Ringschmuck der Hallstattzeit aus dem schweizerischen Mittelland und Jura. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* **55**, 1970, 23–87.
- [87] W. Drack, Anhängerschmuck der Hallstattzeit aus dem Schweizer Mittelland und Jura. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* **53**, 1966-1967, 29–61.
- [88] É. Dubreucq, Les mobiliers métalliques découverts sur les habitats du Ha à LTA. Approches qualitative et quantitative proposées pour quelques sites de l'Allemagne du Sud-Ouest à la France centrale. Lille thèses (Lille 2006).
- [89] A. Dumont, Les passages à gué de la Grande Saône. Approche archéologique et historique d'un espace fluvial (de Verdun-sur-le-Doubs à Lyon) (Dijon 2020).
- [90] C. Dunning, Le premier âge de fer sur le versant méridional du Jura. Chronologie, typologie et rites funéraires. Université de Genève, Thèse (2005).
- [91] T. K. Earle/J. Ling/C. Uhnér/Z. A. Stos-Gale/L. Melheim, The Political Economy and Metal Trade in Bronze Age Europe: Understanding Regional Variability in Terms of Comparative Advantages and Articulations. *European Journal of Archaeology* **18**, 4, 2015, 633–657.
- [92] T. Earle/M. Spriggs, Political Economy in Prehistory. *Current Anthropology* **56**, 4, 2015, 515–544.
- [93] T. K. Earle, *How chiefs come to power* (Stanford 1997).
- [94] N. Ebinger-Rist/D. Krausse, *Spektakuläre Funde – innovative Methoden* (2015).
- [95] H. Eckhardt, Pfeil und Bogen. Eine archäologisch-technologische Untersuchung zu urnenfelder- und hallstattzeitlichen Befunden. *Internationale Archäologie Volume 21* (Espelkamp 1996).
- [96] Markus Egg. M. Egg, Die hallsattzeitlichen Hügelgräber bei Helpfau-Uttendorf in Oberösterreich. *Jahrbuch Römisch-germanischen Zentralmuseum* **32**, 1985, 323–393.
- [97] M. Egg, Das Wagengrab von Ohnenheim im Elsaß. In: *Vierräderige Wagen der Hallstattzeit*. RGZM Monographien **12** (Mainz 1987) 77–102.
- [98] H. J. Eggers, Die vergleichende geographisch-kartographische Methode in der Urgeschichtsforschung. *Archaeologica Geographica* **1**, 1951, 1–3.
- [99] M. K. H. Eggert, Riesentumuli und Sozialorganisation. Vergleichende Betrachtungen zu den sogenannten „Fürstenhügeln“ der Späten Hallstattzeit. *Archäologisches Korrespondenzblatt* **18**, 1988, 263–274.
- [100] M. K. H. Eggert, Prestigegüter und Sozialstruktur in der Späthallstattzeit. Eine kulturanthropologische Perspektive. *Saeculum* **42**, 1991, 1–28.
- [101] M. K. H. Eggert, Le concept de « Fürstensitz » et autres problèmes d'interprétation: Annotations sur le « phénomène princier » du hallstatt final. In: P. Brun/B. Chaume (eds.) *Vix et les éphémères principautés celtiques* (Paris 1997) 287–294.
- [102] M. K. H. Eggert, *Prähistorische Archäologie* (2001).
- [103] M. K. H. Eggert, Wirtschaft und Gesellschaft im früheisenzeitlichen Mitteleuropa. Überlegungen zum "Fürstenphänomen". *Fundberichte in Baden-Württemberg* **29**, 2007, 255–302.
- [104] M. Eineder/J. Holzner, Interferometric DEMs in alpine terrain-limits and options for ERS and SRTM. In: *IGARSS 2000. IEEE 2000 International Geoscience and Remote Sensing Symposium. Taking the Pulse of the Planet: The Role of Remote Sensing in Managing the Environment* (2000) 3210–3212.
- [105] Ellmers, Die Archäologie der Binnenschifffahrt in Europa. In: H. Jankuhn (ed.) *Der Verkehr. Verkehrswegen, Verkehrsmittel, Organisation; Bericht über die Kolloquien der Kommission für die Altertumskunde Mittel- und Nordeuropas in den Jahren 1980 - 1983. Abhandlungen der Akademie der Wissenschaften in Göttingen 180* (Göttingen 1989) 291–350.
- [106] D. Ellmers, *Frühmittelalterliche Handelsschifffahrt in Mittel- und Nordeuropa* (Neumünster 1972).
- [107] D. Ellmers, s.v. Furt. In: J. Hoops (ed.) *Reallexikon der germanischen Altertumskunde. Volume 10* (1997) 285-267.



- [108] G. Elwert, Nationalismus, Ethnizität und Nativismus. Über Wir-Gruppenprozesse. In: P. Waldmann/G. Elwert (eds.) *Ethnizität im Wandel*. Spektrum 21 (Saarbrücken, Fort Lauderdale 1989) 21–60.
- [109] P. Ethelberg, *Det Sønderjyske landbrugs historie. Sten- og bronzealder*. Skrifter udgivet af Historisk samfund for Sønderjylland **81** (Haderslev 2000).
- [110] F. Faupel, Ceramic Analysis of the Haguenau Forest. Using pXRF to investigate Museum Collections (in prep.).
- [111] F. Faupel/O. Nakoinz, Rekonstruktion des Wegesystems und Identifikation von Wegparametern der Bronzezeit in Schleswig-Holstein. In: B. Nessel/D. Neumann/M. Bartelheim (eds.) *Bronzezeitlicher Transport 1. Akteure, Mittel und Wege 1. Ressourcenkulturen Volume 8* (Tübingen 2018) 249–268.
- [112] M. Fernández-Götz/D. Krause, Rethinking Early Iron Age urbanisation in central Europe. The Heuneburg site and its archaeological environment. *Antiquity* **87**, 2013, 473–487.
- [113] M. Fernández-Götz/D. Krause, Early centralisation processes North of the Alps. Fortification as Symbols of Power and Community Identity. In: P. Fontaine/S. Helas (eds.) *Le fortificazioni arcaiche del Latium vetus e dell’Etruria meridionale (IX-VI sec. a.C.). stratigrafia, cronologia e urbanizzazione*. atti delle Giornate di Studio, Roma, Academia Belgica, 19-20 settembre 2013 (Rom 2016) 267–286.
- [114] M. Fernández-Götz/I. Ralston, The Complexity and Fragility of Early Iron Age Urbanism in West-Central Temperate Europe. *J World Prehistory* **30**, 3, 2017, 259–279.
- [115] M. Fernández-Götz, Central Places and the Construction of Collective Identities in the Middle Rhine-Moselle Region. In: C. N. Popa/S. Stoddart (eds.) *Fingerprinting the Iron Age. Approaches to identity in the European Iron Age: Integrating South-Eastern Europe into the debate* (Oxford 2014) 175–186.
- [116] M. Fernández-Götz, Urbanization in Iron Age Europe. Trajectories, Patterns, and Social Dynamics. *Journal of Archaeological Research* **26**, 2, 2018, 117–162.
- [117] C. Filet, An Attempt to Estimate the Impact of the Spread of Economic Flows on Latenian Urbanization. *Frontiers in Digital Humanities* **3**, 2017, 205.
- [118] C. Filet/F. Faupel, Paths through Europe. Transportation time of goods in the La Tène period (in prep.).
- [119] G. Fingerlin, Flurbereinigung und Bodendenkmalpflege I. *Archäologisches Nachrichtenblatt Baden* **2**, 1969, 5–15.
- [120] G. Fingerlin, Flurbereinigung und Bodendenkmalpflege II. *Archäologisches Nachrichtenblatt Baden* **3**, 1969, 6–13.
- [121] G. Fingerlin, Flurbereinigung und Bodendenkmalpflege. Methoden, Erfahrungen, Ergebnisse. In: *Fachtagung 1979 der Flurbereinigungsverwaltung Baden-Württemberg*. In Eberbach a.N. ([Stuttgart] 1979) 7–15.
- [122] F. Fischer, Keimhaia. Bemerkungen zur kulturgeschichtlichen Interpretation des sogenannten Südimports in der späten Hallstatt- und frühen Latène-Kultur des westlichen Mitteleuropa. *Germania* **51**, 1973, 436–456.
- [123] P. Fisher/C. Farrelly/A. Maddocks/C. Ruggles, Spatial Analysis of Visible Areas from the Bronze Age Cairns of Mull. *Journal of Archaeological Science* **24**, 7, 1997, 581–592.
- [124] I. Fiz/H. A. Orenge, Simulating communication routes in Mediterranean alluvial plains. In: A. Posluschny/K. Lambers/I. Herzog (eds.) *Layers of perception: Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA)*; Berlin, Germany, April 2-6, 2007. *Kolloquien zur Vor- und Frühgeschichte* **10** (Bonn 2008) 316–321.
- [125] F. Fleischer/M. Landolt, Entzheim-Geispolsheim (Bas-Rhin, Frankreich). Zur Entwicklung einer Siedlungslandschaft in der frühen Eisenzeit. In: Tappert/C. Later/J. Fries-Knoblach/ P. Ch. Rams/P. Trebsche/St. Wefers/J. Wiethold (eds.) *Wege und Transport. Beiträge zur Sitzung der AG Eisenzeit während der 80. Verbandstagung des West- und Süddeutschen Verbandes für Altertumsforschung e. V. in Nürnberg 2010. Beiträge zur Ur- und Frühgeschichte Mitteleuropas* 69 (Langenweissbach 2012) 193–207.
- [126] É. Flouest, *Notes pour servir à l’histoire de la haute antiquité en Bourgogne* (Semur-en-Auxois 1872).
- [127] D. Fontijn, The significance of ‘invisible’ places. *World Archaeology* **39**, 1, 2007, 70–83.

- [128] R. Forrer, Un Char de Culte, à quatre roues et trone, découvert dans la tumulus gaulois à Ohnenheim (Alsace). *Cahiers Alsaciens Archéologie* **12**, 1921, 1195–1242.
- [129] F. Förster/R. Großmann/K. Iwe/H. Kinkel/A. Larsen/U. Lungershausen/Ch. Matarese/P. Meurer/O. Nelle/V. Robin/M. Teichmann, What is Landscape? Towards a Common Concept within an Interdisciplinary Research Environment. In: W. Bebermeier (ed.) *Landscape archaeology. Proceedings of the international conference held in Berlin, 6th - 8th June 2012*. ETopoi / Special Volume 3 (Berlin 2012) 169–179.
- [130] M. Foucault, *Les mots et les choses. Une archéologie des sciences humaines*. Bibliothèque des sciences humaines (Paris 1966).
- [131] M. Foucault, *L'archéologie du savoir*. Bibliothèque des sciences humaines (Paris 1969).
- [132] E. Fovet/K. Zakšek, Path Network Modelling and network of agglomerated settlements: a case study in Languedoc (South eastern France). In: S. Polla/P. Verhagen (eds.) *Computational Approaches to the Study of Movement in Archaeology. Theory, Practice and Interpretation of Factors and Effects of Long Term Landscape Formation and Transformation*. Topoi Berlin Studies of the Ancient World, Volume 23 (Berlin, Boston 2014) 43–72.
- [133] M. Freudenberger, Grabhügel und Kultanlage der Älteren Bronzezeit von Hüsby, Kreis Schleswig-Flensburg. *Archäologische Nachrichten aus Schleswig-Holstein* **14**, 2008, 30–32.
- [134] O.-H. Frey, Die Zeitstellung des Fürstengrabes von Hatten im Elsaß. *Germania* **35**, 1957, 229–2498.
- [135] M. Friedrich, Dendrochronologische Datierung der Toranlage der Periode Ia der Heuneburg. In: E. Gersbach/H. d. van Boom/M. Friedrich/S. Hopert(eds.) *Heuneburgstudien 10. Römisch-germanische Forschungen* **56** (Mainz am Rhein 1996) 169–180.
- [136] J. E. Fries/D. Heinrich, Die Hallstattzeit im Nördlinger Ries. *Materialhefte zur bayerischen Vorgeschichte* Volume 88 (Kallmünz, Opf. 2005).
- [137] J. E. Fries, Sag mir wo die Gräber sind. Kleine Brandgräber der Hallstattzeit und die soziale Pyramide. In: P. Trebsche (ed.) *Die unteren Zehntausend - auf der Suche nach den Unterschichten der Eisenzeit. Beiträge zur Sitzung der AG Eisenzeit während der Jahrestagung des West- und Süddeutschen Verbandes für Altertumsforschung e. V. in Xanten 2006*. Beiträge zur Ur- und Frühgeschichte Mitteleuropas **47** (Langenweißbach 2007).
- [138] A. Gallay, *L'archéologie demain*. Belfond.Sciences (Paris 1986).
- [139] J.-P. Garcia/C. Petite, Un événement hydrodynamique de haute énergie de type tsunami sur le lac de Neuchâtel pour expliquer le gisement du pont de Cornaux/Le sauges (et celui de la Tène). In: M. Honegger/D. Ramseyer/G. Kaenel/B. Arnod/M.-A. Kaeser (eds.) *Le site e la Tène. Bilan des connaissances - état de la question; Actes de la Table ronde internationale de Neuchâtel, 1-3 novembre 2007*. *Archéologie neuchâteloise* 43 (Neuchâtel 2009) 113–123.
- [140] G. Gassmann/A. Hauptmann/C. Hübner/Th. Ruthardt/Ü. Yalcin, Forschungen zur ketlischen Eisenverhüttung in Südwestdeutschland. *Forschungen und Berichte Vor- und Frühgeschichte in Baden-Württemberg* 92, 2005.
- [141] G. Gassmann/G. Wieland, Weitere Untersuchungen zur frühkeltischen Stahlproduktion im Montanrevier von Neuenbürg, Enzkreis. *Archäologische Ausgrabungen in Baden-Württemberg* 2008, 94–97.
- [142] G. Gassmann/G. Wieland/M. Rösch, Das Neuenbürger Erzrevier im Nordschwarzwald als Wirtschaftstraum während der Späthallstatt- und Frühlatènezeit. *Germania* 84, 2006, 273–306.
- [143] G. Gassmann/G. Wieland, Weitere Erkenntnisse zur frühkeltischen Eisenproduktion im Nordschwarzwald bei Neuenbürg-Waldrennach, Enzkreis. *Archäologische Ausgrabungen in Baden-Württemberg* 2005, 97–101.
- [144] H. Gebhardt (ed.), *Geographie Baden-Württembergs. Raum, Entwicklung, Regionen*. Schriften zur politischen Landeskunde Baden-Württembergs Volume 36 (Stuttgart 2008).
- [145] H. Gerdson, *Studien zu den Schwertgräbern der älteren Hallstattzeit* (Mainz 1986).
- [146] R. Gerlach, Wie dynamisch sind die geogenen Grundlagen einer archäologischen Prognose? Die Veränderungen von Relief, Boden und Wasser seit dem Neolithikum. In: J. Kunow/J. Müller (eds.)

- Symposium, Landschaftsarchäologie und Geographische Informationssysteme. Prognosekarten, Besiedlungsdynamik und prähistorische Raumordnungen; vom 15. bis 19. Oktober 2001 in Wünsdorf = The archaeology of landscapes and geographic information systems: predictive maps, settlement dynamics and space and territory in prehistory. *Forschungen zur Archäologie im Land Brandenburg Archäoprognose Brandenburg 1* (Wünsdorf 2003) 89–96.
- [147] E. Gersbach, Die Paukenfibeln und die Chronologie der Heuneburg bei Hundesingen/Donau. *Fundberichte in Baden-Württemberg* 6, 1981, 213–223.
- [148] R. Gietl/M. Doneau/M. Fera, Cost distance analysis in an Alpine environment: Comparison of different cost surface modules. In: A. Posluschny/K. Lambers/I. Herzog (eds.) *Layers of perception: Proceedings of the 35th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA)*; Berlin, Germany, April 2-6, 2007. *Kolloquien zur Vor- und Frühgeschichte 10* (Bonn 2008) 342–350.
- [149] A. Götze, *Ueber neolithischen Handel* (Berlin 1896).
- [150] G. Gozzadini, *Di un sepolcreto etrusco scoperto presso Bologna* (1854).
- [151] E. Gringmuth-Dallmer, Kulturlandschaftsmuster und Siedlungssysteme. *Siedlungsforschung. Archäologie - Geschichte - Geographie* 14, 1996, 7–31.
- [152] C. H. Grohmann/C. Riccomini, Comparison of moving-window and search-window techniques for characterising landscape morphometry. *Computers & Geosciences* 35, 10, 2009, 2164–2169.
- [153] M. Guggisberg, Keimelia. Altstücke in fürstlichen Gräbern diesseits und jenseits der Alpen. In: M. Guggisberg (ed.) *Die Hydria von Grächwil 1851-2001. Funktion und Rezeption mediterraner Importe in der Zone nördlich der Alpen* (2003) 175–192.
- [154] M. Guggisberg, Art on the northern edge of the Mediterranean world. In: P. S. Wells/K. Rebay-Salisbury/C. Haselgrove (eds.) *The Oxford handbook of the European Iron Age* (Oxford 2018).
- [155] A. Güimil-Fariña/C. Parceró-Oubiña, “Dotting the joins”. A non-reconstructive use of Least Cost Paths to approach ancient roads. The case of the Roman roads in the NW Iberian Peninsula. *Journal of Archaeological Science* 54, 2015, 31–44.
- [156] K. S. Gutmann, Bericht über Strassenforschung im Elsass im Jahre 1912. *Berichte der Römisch-germanischen Kommission* 7, 1912, 16–25.
- [157] W. U. Guyan, Zu hallstattzeitlichen Grabfunden aus Schaffhausen. *Zeitschrift für Schweizerische Archäologie und Kunstgeschichte* 31, 1974, 213.
- [158] Hadley Wickham, *ggplot2: Elegant Graphics for Data Analysis* (2016).
- [159] Hadley Wickham/Lionel Henry, *tidyr: Tidy Messy Data* (2020). <https://CRAN.R-project.org/package=tidyr>.
- [160] A. Haffner, Späthallstattzeitlich Funde aus dem Saarland. *Berichte der staatlichen Denkmalpflege im Saarland* 12, 1965, 7–34.
- [161] A. Haffner, Die westliche Hunsrück-Eifel-Kultur. *Römisch-germanische Forschungen* 36, 1976.
- [162] K. P. Hansen, Kultur und Kollektiv. Eine essayistische Heuristik. In: D. Krause/O. Nakoinz (eds.) *Kulturraum und Territorialität. Archäologische Theorien, Methoden und Fallbeispiele; Kolloquium des DFG-SPP 1171, Esslingen 17.-18. Januar 2007. Internationale Archäologie Arbeitsgemeinschaft, Symposium, Tagung, Kongress 13* (Rahden, Westf. 2009) 17–25.
- [163] K. P. Hansen, *Kultur und Kulturwissenschaft. Eine Einführung*<sup>4</sup>. UTB Kulturwissenschaft 1846 (Tübingen, Basel 2011).
- [164] S. Hansen, Aspekte des Gabentauschs und Handels während der Urnenfelderzeit in Mittel- und Nordeuropa im Lichte der Fundüberlieferung. In: B. Hänsel (ed.) *Handel, Tausch und Verkehr im bronze- und früheisenzeitlichen Südosteuropa* (München, Berlin 1995) 67–80.
- [165] S. Hansen, Großgrabhügel der älteren Eisenzeit zwischen West und Ost. Eine Annäherung. In: V. I. Molodin (ed.) *”Terra Scythica”. Materialien des Internationalen Symposiums ”Terra Scythica”*; (17. - 23. August 2011, Denisov-Höhle, Altai) (Novosibirsk 2011) 291–318.

- [166] H. G. H. Härke, Höhensiedlungen im Westhallstattkreis. Ein Diskussionsbeitrag. *Archäologisches Korrespondenzblatt* 13, 1983, 461–477.
- [167] H. G. H. Härke, Intentional und funktional Daten. Ein Beitrag zur Theorie und Methodik der Gräberarchäologie. *Archäologisches Korrespondenzblatt* 23, 1993, 141–146.
- [168] T. Harris, Moving GIS: exploring movement in prehistoric cultural landscapes using GIS. In: G. R. Lock (ed.) *Beyond the map. Archaeology and spatial technologies*; [proceedings of the NATO Advanced Research Workshop on Beyond the Map, Archaeology and Spatial Technologies, Ravello, Italy, 1-2 October, 1999]. NATO science series Series A, Life sciences 321 (Amsterdam 2000) 116–123.
- [169] J.-J. Hatt, Les fouilles de strasbourg et de Seltz en 1952 et 1953. *Comptes rendus de l'Académie des Inscriptoins et Belles-Lettres* 1953, 211–215.
- [170] P. Haupt, *Landschaftsarchäologie. Eine Einführung* (Darmstadt 2012).
- [171] F. Hauser, Anmerkungen zur Rekonstruktion des Verkehrsnetzes der Hallstattzeit. In: Tappert/C. Later/J. Fries-Knoblach/ P. Ch. Ramsl/P. Trebsche/St. Wefers/J. Wiethold (eds.) *Wege und Transport. Beiträge zur Sitzung der AG Eisenzeit während der 80. Verbandstagung des West- und Süddeutschen Verbandes für Altertumsforschung e. V. in Nürnberg 2010. Beiträge zur Ur- und Frühgeschichte Mitteleuropas* 69 (Langenweissbach 2012) 83–94.
- [172] H. Haverkort/L. Toma/Y. Zhuang, Computing Visibility on Terrains in External Memory. In: D. Applegate/G. S. Brodal (eds.) *2007 proceedings of the Ninth Workshop on Algorithm Engineering and Experiments (ALENEX)* (Philadelphia, Pennsylvania 2007).
- [173] T. E. Havernick, Hallstatt Glasringe und Haguenauer Perlen. *Trierer Zeitschrift* 38, 1975, 63–73.
- [174] H. Hayen, Bau und Funktion der hölzernen Moorwege. Einige Fakten und Folgerungen. In: H. Jankuhn (ed.) *Der Verkehr. Verkehrswege, Verkehrsmittel, Organisation; Bericht über die Kolloquien der Kommission für die Altertumskunde Mittel- und Nordeuropas in den Jahren 1980 - 1983. Abhandlungen der Akademie der Wissenschaften in Göttingen* 180 (Göttingen 1989) 11–82.
- [175] M. Hees, *Siedlungsarchäologie der Hallstatt- und Frühlatènezeit im Raum Heilbronn. Dissertation* (Tübingen: Dissertation. 2002).
- [176] M. Hein, Ein Scheidenendbeschlag vom Heiligenberg bei Heidelberg. Zur Typologie endbronzezeitlicher und ältereisenzeitlicher Ortbänder (Ha B2/ 3-Ha C). *Jahrbuch des römisch-germanischen Zentralmuseum* 36, 1989, 301–326.
- [177] D. Helbing/J. Keltsch/P. Monár, Modelling the evolution of human trail systems. *Nature* 388, 1997, 47–50.
- [178] H. Henning/C. Lucianu, Zipf, Christaller, Gräberfelder. Sind latente Besiedlungsstrukturen der Hallstattzeit aus der Verteilung der Nekropolen ersichtlich? *Archäologisches Korrespondenzblatt* 2000, 527–548.
- [179] F. Henry, *Les Tumulus du département de la Côte d'Or* (Paris 1933).
- [180] I. Herzog/A. Posluschny, Tilt-slope-dependent least-cost path calculations revisited. In: J. Erzsébet/R.Ferenc/S. Vajk (eds.) *On the road to reconstructing the past. Computer applications and quantitative methods in archaeology (CAA): proceedings of the 36th international conference: Budapest, April 2-6, 2008* (Budapest 2011) 212–218.
- [181] I. Herzog, Ehemalige Materialentnahmegruben erkennen - Auswertung von Höhendaten. *Archäologie und Informatik* 24, 2001, 39–43.
- [182] I. Herzog, Analyse von Siedlungsterritorien auf der Basis mathematischer Modelle. In: D. Krause/O. Nakoinz (eds.) *Kulturraum und Territorialität. Archäologische Theorien, Methoden und Fallbeispiele; Kolloquium des DFG-SPP 1171, Esslingen 17.-18. Januar 2007. Internationale Archäologie Arbeitsgemeinschaft, Symposium, Tagung, Kongress* 13 (Rahden, Westf. 2009) 71–86.
- [183] I. Herzog, The Potential and Limits of Optimal Path Analysis. In: A. Bevan/M. W. Lake (eds.) *Computational approaches to archaeological spaces* (Walnut Creek, Calif 2013) 179–211.
- [184] I. Herzog, Theory and Practise of Cost Functions. In: F. Contreras Cortés/M. Farjas/F. J. Melero (eds.) *Fusion of cultures. Proceedings of the 38th Annual Conference on Computer Applications and Quantitat-*

- ive Methods in Archaeology, Granada, Spain, April 2010. BAR international series 2494 (Oxford 2013) 375–382.
- [185] I. Herzog, A review of case studies in archaeological least-cost analysis. *Archeologia e Calcolatori* 25, 2014, 223–239.
- [186] I. Herzog, Least-cost Paths – Some Methodological Issues. *Internet Archaeology* 36, 2014.
- [187] R. Heynowski, Eisenzeitlicher Trachtschmuck der Mittelgebirgszone zwischen Rhein und Thüringer Becken (1992).
- [188] D. Heyse/F. Feuerhahn, Hotspot der Hallstattzeit. Griechische Importkeramik auf dem Marienberg in Würzburg. *Das Archäologische Jahr in Bayern* 2015, 2016.
- [189] J. D. Hill, How Should We Understand Iron Age Societies and Hillforts. A Contextual Study from Southern Britain. In: J. D. Hill/C. G. Cumberpatch (eds.) *Different Iron Ages. Studies on the Iron Age in Temperate Europe*. BAR international series (1995) 45–66.
- [190] B. P. Hindle, Medieval roads and tracks<sup>3</sup>. *Shire Archaeology* (Princes Risborough 1998).
- [191] F. R. Hodson, The La Tène Cemetery at Münsingen-Rain. *Catalogue and relative chronology*. *Acta Bernensia* 5, 1968.
- [192] K. P. Hofman, Gräber und Totenrituale. Zu aktuellen Theorien und Forschungsansätzen. In: M. K. H. Eggert/U. Veit (eds.) *Theorie in der Archäologie: zur jüngeren Diskussion in Deutschland*. Tübinger Archäologische Taschenbücher Volume 10 (Münster, New York, NY, München, Berlin 2013) 269–298.
- [193] G. Honeck, Fernhandelskontakte der Hallstattzeit als Medium des Kulturtransfers. In: R. Karl/J. Leskovar (eds.) *Interpretierte Eisenzeiten. Fallstudien, Methoden, Theorie: Tagungsbeiträge der 3. Linzer Gespräche zur interpretativen Eisenzeitarchäologie*. *Studien zur Kulturgeschichte von Oberösterreich Folge* 22 (Linz 2009) 345–360.
- [194] M. Hoppe, Die Grabfunde der Hallstattzeit in Mittelfranken. *Materialhefte zur bayerischen Vorgeschichte: Reihe A, Fundinventare und Ausgrabungsbefunde* Volume 55 (Kallmünz/Opf. 1986).
- [195] S. Hornung, Die südöstliche Hunsrück-Eifel-Kultur. *Studien zu Späthallstatt- und Frühlatènezeit in der deutschen Mittelgebirgsregion*. *Universitätsforschungen zur prähistorischen Archäologie* 153 (Bonn 2008).
- [196] M. C. Howey, Multiple pathways across past landscapes: circuit theory as a complementary geospatial method to least cost path for modeling past movement. *Journal of Archaeological Science* 38, 2011, 2523–2535.
- [197] D. L. Huber/R. L. Church, Transmission corridor location modelling. *Journal of Transportation Engineering* 111, 1985, 114–130.
- [198] E. J. Hudson, Walking and Watching. In: D. A. White/S. L. Surface-Evans (eds.) *Least cost analysis of social landscapes. Archaeological case studies* (Salt Lake City 2012) 97–108.
- [199] S. Hummel/D. Schmidt/B. Herrmann, Molekulargenetische Analysen zur Verwandtschaftsfeststellung an Skelettproben aus Gräbern frühkeltischer Fürstensitze. In: J. Biel/D. Krausse/G. Kaenel (eds.) *Frühkeltische Fürstensitze. Ätteste Städte und Herrschaftszentren nördlich der Alpen?: internationaler Workshop zur keltischen Archäologie in Eberdingen-Hochdorf, 12 und 13 September 2003*. *Schriften des Keltmuseums Hochdorf/Enz* 6 (Stuttgart 2005).
- [200] S. P. Huntington, The Clash of Civilisations. *Foreign Affairs* 72, 1993, 22–28.
- [201] J. S. Huxley, Evolution, Cultural and Biological. In: W. L. Thomas (ed.) *Current anthropology* (1956) 3–25.
- [202] D. C. Ince/L. Hatton/J. Graham-Cumming, The case for open computer programs. *Nature* 482, 7386, 2012, 485–488.
- [203] C. Jacob, Metallgefäße der Bronze- und Hallstattzeit in Nordwest-, West- und Süddeutschland. *Prähistorische Bronzefunde Abt. 2* Volume 9 (Stuttgart 1995).
- [204] K. H. Jacob-Friesen, Grundfragen der Urgeschichtsforschung. Stand und Kritik der Forschung über Rassen, Völker und Kulturen in urchenzeitlicher Zeit; [Festschrift zur Feier des 75jährigen Bestehens

- des Provinzial-Museums]. Veröffentlichungen der Urgeschichtlichen Abteilung des Provinzial-Museums zu Hannover 1 (Hannover 1928).
- [205] Jacob van Etten, R Package gdistance: Distances and Routes on Geographical Grids. *Journal of Statistical Software* 76, 13, 2017, 21.
- [206] B. Jenisch, „Grenze einst war ich den Galliern ...“. Spuren barocker Festungs- und Belagerungswerke bei Breisach am Rhein. Mit Beiträgen von G. Weber-Jenisch. *Fundberichte in Baden-Württemberg* 20, 1995, 845–884.
- [207] R. Jenkins, *Rethinking ethnicity. arguments and explorations* <sup>2</sup> (Los Angeles 2008).
- [208] H.-E. Joachim, Die Hunsrück-Eifel-Kultur am Mittelrhein. *Beihefte der Bonner Jahrbücher* 29, 1968.
- [209] A. Jockenhövel, Die Rasiermesser in Mitteleuropa. Süddeutschland, Tschechoslowakei, Österreich, Schweiz. *Prähistorische Bronzefunde Abt. 8 1* (München 1971).
- [210] A. Jockenhövel, Die Rasiermesser in Westeuropa. Westdeutschland, Niederlande, Belgien, Luxemburg, Frankreich, Großbritannien und Irland. *Prähistorische Bronzefunde* 8,3 (München 1980).
- [211] L. N. Joppa/G. McInerny/R. Harper/L. Salido/K. Takeda/K. O'Hara/D. Gavaghan/St. Emmott, Computational science. Troubling trends in scientific software use. *Science (New York, N.Y.)* 340, 2013, 814–815.
- [212] M. Jung, Nochmals zum Problem späthallstattzeitlicher Adelssitze. Eine kritische Wiederlektüre des Textes von Wolfgang Kimmig. In: R. Karl (ed.) *Interpretierte Eisenzeiten. Fallstudien, Methoden, Theorie; Tagungsbeiträge der 1. Linzer Gespräche zur interpretativen Eisenzeitarchäologie. Studien zur Kulturgeschichte von Oberösterreich* 18 (Linz 2005) 181–190.
- [213] M.-A. Kaeser, *Les lacustres. Archéologie et mythe national. Le savoir suisse: histoire* 14 (Lausanne, [Paris] 2004).
- [214] O. Kammerer, Le Haut-Rhin entre Bâle et Strasbourg a-t-il été une frontière médiévale? In: *Les Pays de l'entre-deux au moyen-âge. Questions d'histoire des territoires d'empire entre Meuse, Rhône et Rhin. Actes du 113e congrès national des sociétés savantes, Strasbourg, 1988. Actes du 113e congrès national des sociétés savantes. Strasbourg. 1988. Section d'histoire médiévale et de philologie* (Paris 1990) 171–193.
- [215] J. Kantner, Realism, Reality, and Routes: Evaluating Cost-Surface and Cost-Path Algorithms. In: D. A. White/S. L. Surface-Evans (eds.) *Least cost analysis of social landscapes. Archaeological case studies* (Salt Lake City 2012) 225–238.
- [216] I. Kappesser, Römische Flussfunde aus dem Rhein zwischen Mannheim und Bingen. *Fundumstände, Flusslaufrekonstruktion und Interpretation. Universitätsforschungen zur prähistorischen Archäologie* 209 (Bonn 2012, cop. 2012).
- [217] C. Keller, Die Rekonstruktion sozialer Gruppen der Hallstattzeit zwischen Enns und Donau. Eine statistische Analyse <sup>1</sup>. *Berliner archäologische Forschungen Volume 14* (Rahden/Westf 2015, 2015).
- [218] F. Keller, Beschreibung der helvetischen Heidengräber und Totenhügel, welche seit dem Jahr 1836 eröffnet worden. *Mitteilungen der Antiquarischen Gesellschaft Zürich* 3, 1845.
- [219] F. Keller, 5. Pfahlbaubericht. *Mitteilungen der Antiquarischen Gesellschaft Zürich* 14, 1863.
- [220] J. Keller, Die Alb-Hegau-Keramik der älteren Eisenzeit. *Tübinger Forschungen zur Archäologie und Kunstgeschichte* 18 (Reutlingen 1939).
- [221] K. Kersten, Zum Problem der ur- und frühgeschichtlichen Wege in Nordwestdeutschland. In: K. Kersten/G. Schwantes (eds.) *Festschrift für Gustav Schwantes zum 65. Geburtstag. Dargebracht von seinen Schülern und Freunden* (Neumünster 1951) 136–141.
- [222] I. Kilian-Dirlmeier, Die hallstattzeitlichen Gürtelbleche und Blechgürtel Mitteleuropas. *Prähistorische Bronzefunde Abt. 12 1* (München 1972).
- [223] W. Kimmig, Bronzesitulen aus dem Rheinischen Gebirge Hunsrück-Eifel-Westerwald. *Berichte der römisch-germanischen Kommission* 1962-1963, 1964, 31–106.
- [224] W. Kimmig, Zum Problem späthallstattischer Adelssitze. In: K.-H. Otto/J. Herrmann (eds.) *Siedlung, Burg und Stadt. Studien zu ihren Anfängen. Festschrift P. Grimm* (Berlin 1969) 95–113.

- [225] W. Kimmig, *s.v.* Bewaffnung Hallstattzeit. In: J. Hoops/H. Beck (eds.) *Reallexikon der germanischen Altertumskunde 22* Bake-Billigkeit (Berlin, New York 1976) 389–409.
- [226] W. Kimmig, Les tertres funéraires préhistorique dans la forêt de Haguenau. *Præhistorische Zeitschrift* 54, 1979, 47–176.
- [227] W. Kimmig, Die griechische Kolonisation im westlichen Mittelmeergebiet und ihre Wirkung auf die Landschaften des westlichen Mitteleuropa. [erste Theodor-Mommsen-Vorlesung 1982]. *Jahrbuch römisch-germanischen Zentralmuseum* 30, 1983, 5–78.
- [228] K. W. Kintigh/J. H. Altschul/M. C. Beaudry/R.D. Drennan/A. P. Kinzig/T. A. Kohler/F. Limp/H. D. G. Maschner/W. K. Michener, T. R. Pauketat/P. Peregrine/J. A. Sabloff/T. J. Wilkinson/H. T. Wright/M. A. Zeder, Grand challenges for archaeology. *Proceedings of the National Academy of Sciences of the United States of America* 111, 3, 2014, 879–880.
- [229] L. Klassen, Along the road. Aspects of causewayed enclosures in South Scandinavia and beyond. *East Jutland Museum publications* 2 (Aarhus 2014).
- [230] J. Klug-Treppe, *Hallstattzeitliche Höhensiedlungen im Breisgau* (2003).
- [231] C. Knappet/T. Evans/R. Rivers, Modelling maritime interaction in the Aegean Bronze Age. *Antiquity* 82, 2008, 1009–1024.
- [232] D. Knitter/M. Bilger/F. Faupel/C. Filet/Ch. Girotto/B. Grammer/W. Hamer/M. Hinz/O. Nakoinz/K. Radloff/H. Raese/R. Rivers/J. Roe/G. Roth/C. Tietze/J. Watson, CRC1266-A2/moin: Release after Moin Summer School (2018).
- [233] J. K. Koch, Der Wagen und das Pferdegeschirr aus dem späthallstattzeitlichen Fürstengrab von Eberdingen-Hochdorf (Kr. Ludwigsburg) (2006).
- [234] J. K. Koch/R. Scholz, Das Große Bürgle von March-Buchheim im Breisgau. Großgrabhügel nördlich der Alpen und eine Kommunikationsroute durch den Schwarzwald. In: R. Karl/J. Leskovar (eds.) *Interpretierte Eisenzeiten. Fallstudien, Methoden, Theorie. Tagungsbeiträge der 6. Linzer Gespräche zur interpretativen Eisenzeitarchäologie. Studien zur Kulturgeschichte von Oberösterreich* 42 (Linz 2016) 67–80.
- [235] M.-P. Koenig/G.-N. Lambert/J.-F. Piningre/S. Plouin, L'âge du Fer dans la forêt de Haguenau. In: A. Daubigney (ed.) *Fonctionnement social de l'Âge du Fer. opérateurs et hypothèses pour la France. table ronde internationale de Lons-le-Saunier (Jura), 24 - 26 octobre 1990 (Lons-le-Saunier 1993)* 177–196.
- [236] M.-P. Koenig, L'emploi du corail dans la parure hallstattienne d'Alsace. *Cahiers Alsaciens Archæologie* 30, 1987, 91–101.
- [237] H. O. Koepke, *Siedlungs- und Grabfunde der älteren Eisenzeit aus Rheinhessen und dem Gebiet der unteren Nahe.* (Weißbach 1998).
- [238] G. Kossack, *Studien zum Symbolgut der Urnenfelder- und Hallstattzeit Mitteleuropas. Römisch-germanische Forschungen* 20 (Berlin 1954).
- [239] G. Kossack, *Gräberfelder der Hallstattzeit an Main und fränkischer Saale. Materialhefte zur bayrischen Vorgeschichte* 24, 1970.
- [240] G. Kossack, The construction of the felloe in Iron Age spoked wheels. In: J. Boardman/M. A. Brown/T. G. E. Powell (eds.) *The European community in later prehistory. Studies in honour of Charles Francis Christopher Hawkes* (London 1971) 141–163.
- [241] G. Kossack, Gedanken zur Periodisierung der Hallstattzeit. In: *Die Hallstattkultur. Symposium: Papers* (1981) 35–46.
- [242] G. Kossack, Hallstatt und Laténeornamentik. In: H. Dannheimer/R. Gebhard (eds.) *Das keltische Jahrtausend. Ausstellungskataloge der Prähistorischen Staatssammlung München* 23 (Mainz am Rhein 1993) 138–152.
- [243] G. Kossinna, *Ursprung und Verbreitung der Germanen in vor- und frühgeschichtlicher Zeit. Irminsul* 1 (Berlin-Lichterfelde 1926).
- [244] G. Kraft, *Der Oberrhein als Keltenheimat. Oberrheinische Heimat* 27, 1940, 141ff.

- [245] R. Krause, Zum Stand der Forschungen auf dem Ip f und die Perspektiven aus dem Schwerpunktprogramm der DFG. In: R. Krause (ed.) *Neue Forschungen zum frühkeltischen Fürstensitz auf dem Ip f. Ip f-Forschungen 1* (Bonn 2014) 1–50.
- [246] R. Krause, Mediterrane Funde am frühkeltischen Fürstensitz auf dem Ip f im Nördlinger Ries. Räumliche Verteilung und historische Interpretation. In: S. Bonomi/M. Guggisberg (eds.) *Griechische Keramik nördlich von Etrurien. Mediterrane Importe und archäologischer Kontext; Internationale Tagung, Basel 14.-15. Oktober 2011* (Wiesbaden 2015) 193–202.
- [247] R. Krause/U. Brosseder, Großgrabhügel der älteren Eisenzeit am Ip f bei Osterholz. In: R. Krause (ed.) *Neue Forschungen zum frühkeltischen Fürstensitz auf dem Ip f. Ip f-Forschungen 1* (Bonn 2014) 145–175.
- [248] D. Krause, Hochdorf III. Das Trink- und Speisegeschirr aus dem späthallstattzeitlichen Fürstengrab von Eberding-Hochdorf (Kr. Ludwigsburg). *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 64, 1996.
- [249] D. Krause, La phiale. In: C. Rolley (ed.) *La tombe princière de Vix* (Paris 2003) 217–231.
- [250] D. Krause, Prunkgräber der nordwestalpinen Späthallstattkultur. Neue Fragestellungen und Untersuchungen zu ihrer sozialhistorischen Deutung. In: C. v. Carnap-Bornheim/D. Krause/A. Wesse (eds.) *Herrschaft, Tod, Bestattung. Zu den vor- und frühgeschichtlichen Prunkgräbern als archäologisch-historische Quelle; internationale Fachkonferenz Kiel 16. - 19. Oktober 2003. Universitätsforschungen zur prähistorischen Archäologie Volume 139* (Bonn 2006) 61–80.
- [251] D. Krause, Etappen der Zentralisierung nördlich der Alpen. Hypothesen, Modelle, Folgerungen. In: D. Krause (ed.) *Frühe Zentralisierungs- und Urbanisierungsprozesse. Zur Genese und Entwicklung frühkeltischer Fürstensitze und ihres territorialen Umlandes; Kolloquium des DFG-Schwerpunktprogramms 1171 in Blaubeuren, 9.-11. Oktober 2006. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg Volume 101* (Stuttgart 2008) 435–450.
- [252] D. Krause/M. Fernández-Götz/L. Hansen/I. Kretschmer, *The Heuneburg and the early Iron Age princely seats: first towns north of the Alps* (Budapest 2016).
- [253] D. Krause/N. Ebinger-Rist, Dem Keltenblock auf den Grund gegangen ... *Archäologische Ausgrabungen in Baden-Württemberg* 2012, 275–306.
- [254] D. Krause/N. Ebinger-Rist, Fremde Reiterin? Exotische Beigaben aus dem Fürstinnengrab bei der Heuneburg. *Archäologische Ausgrabungen in Baden-Württemberg* 2013, 115–119.
- [255] D. Krause/N. Ebinger-Rist, *Das Geheimnis der Keltenfürstin. Der Sensationsfund von der Heuneburg* (Darmstadt 2018).
- [256] D. Krauß-Steinberger, Pfeilspitzen aus einem reichen Lt-A-Grab von Hochscheid. *Archäologisches Korrespondenzblatt* 20, 1990, 87–100.
- [257] Kristiansen 1978 K. Kristiansen, The application of source criticism to archaeology. *Norwegian Archaeological Review* 11, 1978, 1–5.
- [258] K. Kristiansen, Towards a new paradigm. The third science revolution and its possible consequences in archaeology. *Current Swedish Archaeology* 22, 2014, 11–37.
- [259] A. L. Kroeber/C. Kluckhohn/W. Untereiner/A. G. Meyer, *Culture. A critical review of concepts and definitions. Papers of the Peabody Museum of American archaeology and ethnology* 47 (Cambridge, Mass. 1952).
- [260] W. Kubach, Einzel- und Mehrstückdeponierungen und ihre Fundplätze. *Archäologisches Korrespondenzblatt* 15, 1985, 179–185.
- [261] Kullen, Baden-Württemberg (1983).
- [262] S. Kurz, *Bestattungsbrauch in der westlichen Hallstattkultur. (Südwestdeutschland, Ostfrankreich, Nordwestschweiz). Tübinger Schriften zur ur- und frühgeschichtlichen Archäologie Volume 2* (Münster 1997).
- [263] S. Kurz, *Die Heuneburg-Aussensiedlung. Befunde und Funde. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg Volume 72* (Stuttgart 2000).
- [264] S. Kurz, *Neue Forschungen im Umfeld des Fürstensitzes Heuneburg an der oberen Donau. In: J. Biel/D. Krause/G. Kaenel (eds.) Frühkeltische Fürstensitze. Ätteste Städte und Herrschaftszentren nördlich*



- der Alpen?: internationaler Workshop zur keltischen Archäologie in Eberdingen-Hochdorf, 12 und 13 September 2003. *Schriften des Keltmuseums Hochdorf/Enz* 6 (Stuttgart 2005) 11–17.
- [265] S. Kurz, Relative und absolute Chronologie der Heuneburg. In: SPP1171 (ed.) *Frühe Zentralisierungs- und Urbanisierungsprozesse nördlich der Alpen*. Kolloquium Bad Dürkheim April 2005. Chronologische Eckdaten zu den Zentralisierungs- und Urbanisierungsprozessen während der Späthallstatt- und Frühlatènezeit (2005).
- [266] S. Kurz, Die Grabungen 2006 im Umland der Heuneburg auf der "Alten Burg" bei Langenenslingen, Kreis Bibrach. *Archäologische Ausgrabungen in Baden-Württemberg* 2006, 63–68.
- [267] S. Kurz, Neue Forschungen im Umfeld der Heuneburg. Zwischenbericht zum Stand des Projektes "Zentralort und Umland: Untersuchungen zur Struktur der Heuneburg-Außensiedlung und zum Verhältnis der Heuneburg zu umgebenden Höhengründungen". In: D. Krause (ed.) *Frühe Zentralisierungs- und Urbanisierungsprozesse. Zur Genese und Entwicklung frühkeltischer Fürstensitze und ihres territorialen Umlandes*; Kolloquium des DFG-Schwerpunktprogramms 1171 in Blaubeuren, 9.-11. Oktober 2006. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* Volume 101 (Stuttgart 2008) 163–184.
- [268] K. v. Kurzynski, "... und ihre Hosen nennen sie bracas". *Textilfunde und Textiltechnologie der Hallstatt- und Latènezeit und ihr Kontext*. *Internationale Archäologie* 22 (Espelkamp 1996).
- [269] K. L. Kvamme, There and back again. Revisiting archaeological location modeling. In: M. W. Mehrer/K. L. Wescott (eds.) *GIS and Archaeological Site Location Modeling* (Boca Raton 2006) 3–38.
- [270] K. E. Lageras, Visible Intentions. Viewshed analysis of Bronze Age burial Mounds in Western Scania, Sweden. In: C. Scarre (ed.) *Monuments and landscape in Atlantic Europe. Perception and society during the Neolithic and early Bronze Age*. *Archaeology* (London 2010) 179–191.
- [271] R. Lais, Das nördliche Kaiserstuhlvorland, seine Bodengestalt, Entstehungsgeschichte und frühe Besiedlung. *Schauinsland* 61, 1934, 9–20.
- [272] M. Landolt/M. Roth-Zehner/F. Fleischer, La Chronologie de la céramique de la fin du Hallstatt D3 à La Tène B2 dans le sud de la plaine du Rhin supérieur. L'apport des sites Alsaciens d'Enzheim (Dép. Bas-Rhin), de Geispoldisheim (Dép. Bas-Rhin) et de Colmar (Dép. Haut-Rhin). In: M. Schönfelder/S. Sievers (eds.) *L'Âge du fer entre la Champagne et la Vallée du Rhin*. 34e colloque international de l'Association française pour l'étude de l'âge du fer du 13 au 16 mai 2010 à Aschaffenburg. *RGZM-Tagungen* Volume 14 (Mainz 2012) 471–502.
- [273] M. Lasserre, Chrono-typologie de la céramique hallstattienne. *Avancées récentes*. SRA. *Bilan scientifique régional d'Alsace* 2007, 141–145.
- [274] M. Lasserre/T. Vigreux/F. Basoge/Th. Logel/O. Putelat/N. Schneider/M. Michler/F. Jodry/X. Boes, Le site de la fin du Bronze final du Hexenberg à Leutenheim (Bas-Rhin): études sur le paléoenvironnement rhénan et études archéologiques. Résultats préliminaires. *Bulletin de la Société préhistorique française* 108, 4, 2011, 731–754.
- [275] J. Lee/d. Stucky, On applying viewshed analysis for determining least-cost paths on digital elevation models. *International Journal of Geographical Information Science* 12, 1998, 891–905.
- [276] J.-P. Legendre, Organisation spatiale et pouvoir princier dans la région de Haguenau (Bas-Rhin) à la fin de l'époque Hallstattienne. *RAE* 40, 1989, 199–203.
- [277] K. Legler, Der archäologische Landschaftsbegriff aus wissenschaftsgeschichtlicher Perspektive. Ein Überblick. *Archäologische Informationen* 35, 2012, 39–52.
- [278] M. Lerenz-De Wille, Überlegungen zur Frauentracht der Späthallstattzeit an der oberen Donau. *Fundberichte in Baden-Württemberg* 1989, 251–272.
- [279] J. Lewis, The Suitability of Using Least Cost Path Analysis in the Prediction of Roman Roads in the Highland and Lowland Zones of Roman Britain. Master Thesis (Leicester: Master Thesis. 2017).
- [280] J. Lewis, leastcostpath: Modelling Pathways and Movement Potential Within a Landscape (Version 1.7.4) (2020). <https://CRAN.R-project.org/package=leastcostpath>.
- [281] Z. Li/Q. Zhu/C. Gold, *Digital terrain modeling. Principles and methodology* (Boca Raton 2005).

- [282] L. Linde, Höhenbefestigungen als Akteure polyhierarchischer Netzwerke (Dissertation in Vorbereitung) (2019).
- [283] L. Lindenschmit, Die vaterländischen Altertümer der fürstlich hohenzoller'schen Sammlungen zu Sigmaringen (Mainz 1860).
- [284] C. Lindner/C. R. Carbiener, Ökologie und Management. Auen am Oberrhein = Ecologie et gestion (Rastatt 1988).
- [285] P. Livingood, No Crows Made Mounds: Do Cost-Distance Calculations of Travel Time Improve Our Understanding of Southern Appalachian Polity Size? In: D. A. White/S. L. Surface-Evans (eds.) Least cost analysis of social landscapes. Archaeological case studies (Salt Lake City 2012) 174–187.
- [286] M. Llobera, Exploring the topography of mind: GIS, social space and archaeology. *Antiquity* 70, 1996, 612–622.
- [287] M. Llobera, Understanding movement: a pilot model towards the sociology of movement'. In: G. R. Lock (ed.) Beyond the map. Archaeology and spatial technologies; [proceedings of the NATO Advanced Research Workshop on Beyond the Map, Archaeology and Spatial Technologies, Ravello, Italy, 1-2 October, 1999]. NATO science series Series A, Life sciences 321 (Amsterdam 2000) 65–84.
- [288] M. Llobera, Working the Digital. Some thoughts from Landscape Archaeology. In: R. Chapman/A. Wylie (eds.) Material evidence. Learning from archaeological practice (London, New York 2015) 173–188.
- [289] M. Llobera, Memory at your feet. Modeling the agency of past trails. *Journal of Archaeological Science: Reports* 29, 2020, 102177.
- [290] T. J. Llobera, M./Sluckin, Zigzagging: theoretical insights on climbing strategies. *Journal of theoretical biology*, 249, 2007, 206–217.
- [291] G. R. Lock, Using computers in archaeology. Towards virtual pasts (London 2003).
- [292] G. Lock/J. Pouncett, Walking the Ridgeway Revisited: The Methodological and Theoretical Implications of Scale Dependency for the Derivation of Slope and the Calculation of Least-Cost Pathways. In: B. Frischer/J. W. Crawford/D. Koller (eds.) MAKING history interactive. Computer Applications and Quantitative Methods in Archaeology (CAA); proceedings of the 37th international conference, Williamsburg, Virginia, United States of America, March 22-26, 2009. BAR. International series 2079 (Oxford 2010) 191–202.
- [293] T. Logel, Les dépôts de métal en milieu humide et les gués sur le Rhin et l'Ille à l'Âge du Bronze. *Cahiers Alsaciens Archéologie* 50, 2007, 27–50.
- [294] T. Logel, Dépôts fluviaux, passages à gué et tertres funéraires dans la plaine alluviale du Rhin supérieur (Alsace/Bade). In: M. Schönfelder/S. Sievers (eds.) L'Âge du fer entre la Champagne et la Vallée du Rhin. 34e colloque international de l'Association française pour l'étude de l'âge du fer du 13 au 16 mai 2010 à Aschaffenburg. RGZM-Tagungen Volume 14 (Mainz 2012) 555–572.
- [295] W. Löhlein, Früheisenzeitliche Gräber von Andelfingen, Gde. Langenenslingen, Kreis Bibrach. *Fundberichte in Baden-Württemberg* 20, 1995, 449–545.
- [296] M. Løvschal, Lines of Landscape Organization: Skovbjerg Moraine (Denmark) in the First Millennium BC. *Oxford Journal of Archaeology* 34, 3, 2015, 259–278.
- [297] C. M. Lund, Guldvejen. Den ældre Eroncetids Handelsvej gennem Haderslev Amt (Haderslev 1940).
- [298] G. Lüscher, Die frühe Hallstattzeit (Ha C) am Oberrhein. In: S. Plouin (ed.) Trésors celtes et gaulois. Le Rhin supérieur entre 800 et 50 avant J.-C.; exposition présentée au Musée d'Unterlinden du 16 mars au 2 juin 1996; la majeure partie de l'exposition est reprise par Le Museum für Ur- und Frühgeschichte de Fribourg-en-Brigau du 13 juin au 7 octobre 1996 (Colmar 1996) 17–19.
- [299] C. Maise, Höhengiedlungen als Normalform hallstattzeitlicher Siedlungen? Beobachtungen aus dem Breisgau. *Archäologisches Korrespondenzblatt* 26, 1996, 65–73.
- [300] C. Maise, Zur Untergliederung der Stufe Ha C/D1 im Breisgau. *Fundberichte in Baden-Württemberg* 25, 2001, 389–461.
- [301] M. Mann, The sources of social power (London 1986).

- [302] G. Mansfeld, Späthallstattzeitliche Kleinfunde von Indelhausen. Zur Geschichte einiger Schmuckformen. *Fundberichte Schwaben Neue Folge* 19, 1971, 89–117.
- [303] G. Mansfeld, Die Fibeln der Heuneburg. 1950-1970; ein Beitrag zur Geschichte der Späthallstattfibeln. *Römisch-germanische Forschungen* 33 (Mainz am Rhein 1973).
- [304] K. H. Marschalleck, Vor- und frühgeschichtliche Straßenforschung. Beispiele aus dem Nordseeküstenraum. In: P. Grimm/W. Unverzagt (eds.) *Varia archaeologica*. Wilhelm Unverzagt zum 70. Geburtstag dargebracht. *Schriften der Sektion für Vor- und Frühgeschichte / Deutsche Akademie der Wissenschaften zu Berlin* 16 (Berlin 1964) 410–426.
- [305] B. Marwick, Computational Reproducibility in Archaeological Research. Basic Principles and a Case Study of Their Implementation. *Journal of Archaeology, Method and Theory* 24, 2, 2017, 424–450.
- [306] B. Marwick/C. Boettiger/L. Mullen, Packaging Data Analytical Work Reproducibly Using R (and Friends). *The American Statistician* 72, 1, 2018, 80–88.
- [307] K. Marx/F. Engels/J. C. Isaac, *Communist Manifesto*. Rethinking the Western Tradition (Cumberland 1900).
- [308] P. Mayer, 50 Jahre Rebflurneueordnung am Kaiserstuhl. *Schriftenreihe / Landesamt für Flurneueordnung und Landentwicklung* H. 8 (Kornwestheim 1997).
- [309] C. Meiborg, Die keltische Brücke von Kirchhain-Niederwald. Erste Ergebnisse der Ausgrabungen von 2009. In: Bayerische Gesellschaft für Unterwasserarchäologie e. V. (ed.) *Archäologie der Brücken*. Vorgeschichte, Antike, Mittelalter, Neuzeit (Regensburg 2012) 31–36.
- [310] G. v. Merhart, Studien über einige Gattungen von Bronzegefäßen (Mainz 1952).
- [311] C. Metzner-Nebelsick, Der "Thrako-Kimmerische" Formenkreis aus der Sicht der Urnenfelder- und Hallstattzeit im südöstlichen Pannonien. *Vorgeschichtliche Forschungen* 23 (Rahden/Westf. 2002).
- [312] T. Michael (ed.), *Diercke-Weltatlas* 1 (Braunschweig 2016).
- [313] P.-Y. Milcent, Le passage de l'âge du Bronze à l'âge du Fer en Gaule au miroir des élites sociales. Une crise au VIIIe siècle av. J.-C. ?. In: M.-J. Roulière-Lambert/A. Daubigny/P.-Y. Milcent (eds.) *De l'âge du Bronze à l'âge du Fer en France et en Europe occidentale*. (Xe - VIIe siècle av. J.-C.): (thème spécialisé). La moyenne vallée du Rhône aux âges du Fer, actualité de la recherche: (thème régional). actes du XXXe colloque international de l'A.F.E.A.F., thème spécialisé co-organisé avec l'A.P.R.A.B.: Saint-Romain-en-Gal, 26-28 mai 2006. *Revue archéologique de l'Est: Supplément* 27 (Dijon 2009) 453–476.
- [314] P.-Y. Milcent, Le premier âge du Fer en France centrale. *Mémoire de la Société Préhistorique Française* 34 (Paris 2004).
- [315] P.-Y. Milcent, Les importations italiques au nord-ouest du Midi gaulois (milieu du Xe-début du IVe s. av. J.-C.). inventaire et perspectives d'interprétation. In: S. Gori/M. C. Bettini (eds.) *Gli etruschi da Genova ad Ampurias*. *Atti del XXIV convegno di studi etruschi ed italici*, Marseille, Lattes, 26 settembre-1 ottobre 2002. *Atti di convegni / Istituto Nazionale di Studi Etruschi e Italici* 24 (Pisa 2006) 319–355.
- [316] A. E. Minetti/C. Moia/G. S. Roi/G. Ferretti, Energy cost of walking and running at extreme uphill and downhill slopes. *Journal of Applied Physiology* 93, 2002, 1039–1046.
- [317] A. Miron, Toilettebestecke mit Scharnierkonstruktion. *Archaeologia Mosellana* 1, 1989, 41–65.
- [318] D. Mischka, Methodische Aspekte zur Rekonstruktion prähistorischer Siedlungsmuster. Landschaftsgenese vom Ende des Neolithikums bis zur Eisenzeit im Gebiet des südlichen Oberrheins. *Freiburger archäologische Studien* Volume 5 (Rahden 2007).
- [319] D. Mitchell, *Cultural geography. A critical introduction* (Oxford 2000).
- [320] D. Modarressi-Tehrani, Untersuchungen zum früheisenzeitlichen Metallhandwerk im westlichen Hallstatt- und Frühlatènegebiet. *Bochumer Forschungen zur ur- und frühgeschichtlichen Archäologie* 2 (Rahden/Westf. 2009).
- [321] O. Montelius, Om tidsbestämning inom bronsåldern med särskildt afseende på Skandinavien. *Kongl. Vitterhets, Historie och Antiquitets Akademiens handlingar* Del 30 (Stockholm 1885).
- [322] O. Montelius, *Svenska fornminnesföreningens tidskrift* 11 (Stockholm 1902).
- [323] O. Montelius, Der Handel in der Vorzeit. *Præhistorische Zeitschrift* 2, 1910, 249–291.

- [324] C. Morel, CMOREL\_BDD\_Master\_v4 (20.09.2016).
- [325] A. Mouratidis/P. Briole/K. Katsambalos, SRTM 3 DEM (versions 1, 2, 3, 4) validation by means of extensive kinematic GPS measurements. A case study from North Greece. *International Journal of Remote Sensing* 31, 23, 2010, 6205–6222.
- [326] J. Müller, Zur sozialen Gliederung der Nachbestattungsgemeinschaft vom Magdalenenberg. *Prähistorische Zeitschrift* 1994, 75–221.
- [327] S. Müller, Vej og Bygd i Sten- og Bronzealderen (Aarboger 1904).
- [328] N. Müller-Scheeßel, Die Hallstattkultur und ihre räumliche Differenzierung. Der West- und Osthallstattkreis aus forschungsgeschichtlich-methodologischer Sicht. *Tübinger Texte Volume 3* (Rahden/Westf. 2000).
- [329] N. Müller-Scheeßel, Veränderungen im Umgang mit Grab und Leichnam während der Hallstattzeit. In: T. L. Kienlin (ed.) *Die Dinge als Zeichen. Kulturelles Wissen und materielle Kultur; internationale Fachtagung an der Johann-Wolfgang-Goethe-Universität Frankfurt am Main, 3.-5. April 2003. Universitätsforschungen zur prähistorischen Archäologie 127* (Bonn 2005) 339–354.
- [330] N. Müller-Scheeßel, Die "Fürstensitze" der jüngeren Hallstattzeit. Ergänzende Bemerkungen zu einem archäologischen Konstrukt. In: M. K. H. Eggert/H.-P. Wotzka/J. Bofinger (eds.) *Grundlegungen. Beiträge zur europäischen und afrikanischen Archäologie für Manfred K.H. Eggert* (Tübingen 2006) 101–108.
- [331] N. Müller-Scheeßel, Bestattungsplätze nur für die oberen Zehntausend? Berechnungen der hallstattzeitlichen Bevölkerung Süddeutschlands. In: P. Trebsche (ed.) *Die unteren Zehntausend - auf der Suche nach den Unterschichten der Eisenzeit. Beiträge zur Ur- und Frühgeschichte Mitteleuropa 47*, 2007, 1–10.
- [332] N. Müller-Scheeßel, Weitere Überlegungen zu den latenten Besiedlungsstrukturen der Hallstattzeit Süddeutschlands. *Tests auf Autokorrelation. Archäologisches Korrespondenzblatt 37*, 2007, 57–66.
- [333] N. Müller-Scheeßel, "Forschungsgeschichte" einmal anders. Soziale, politische und ökonomische Einflüsse auf Ausgrabungen in ältereisenzeitlichen Grabhügeln Süddeutschlands. *Ethnographisch-Archäologische Zeitschrift 52*, 2011, 59–82.
- [334] H. Musall, Die Veränderung des Oberrheinlaufs zwischen Seltz im Elsass und Oppenheim vom 16. Jh. bis zum Beginn der Tullaschen Korrektur. In: N. Hailer (ed.) *Natur und Landschaft am Oberrhein. Versuch einer Bilanz; Referate u. Aussprachen d. Arbeitstagung vom 27./28. Okt. 1977 in Speyer. Veröffentlichungen der Pfälzischen Gesellschaft zur Förderung der Wissenschaften 70* (Speyer 1982) 21–34.
- [335] G. Nagy, Ürschhausen-Horn. Keramik und Kleinfunde der spätbronzezeitlichen Siedlung. *Forschungen in Seebachtal 2*, 1999.
- [336] O. Nakoinz/D. Knitter, Modelling human behaviour in landscapes. Basic concepts and modelling elements. *Quantitative Archaeology and Archaeological Modelling* (2016).
- [337] O. Nakoinz/D. Knitter/F. Faupel/M. Nykamp, Modelling Interaction in Landscapes. In: P. Łuczkiwicz (ed.) *Landschaft und Siedlungen. Archäologische Studien zur vorrömischen Eisenzeit- und ältesten Kaiserzeit im Mittel- und Südost Europa* (Lublin 2020) 12–45.
- [338] O. Nakoinz/M. Hinz, 11 Modelle in der Archäologie. In: B. Thalheim/I. Nissen (eds.) *Wissenschaft und Kunst der Modellierung* (Berlin, München, Boston 2015).
- [339] O. Nakoinz, shkrdata. Retrieving and handling SHKR data with the package shkrdata
- [340] O. Nakoinz, Die Siedlungsgeschichte der südlichen Vulkaneifel. *Trierer Zeitschrift 64*, 2001, 9–48.
- [341] O. Nakoinz, Studien zur räumlichen Abgrenzung und Strukturierung der älteren Hunsrück-Eifel-Kultur. *Archäologische Informationen aus Baden-Württemberg 27* (2004).
- [342] O. Nakoinz, Die Methode zur quantitativen Untersuchung kultureller Ähnlichkeiten im Raum des Projektes "Siedlungshierarchien und kulturelle Räume". In: D. Krause/O. Nakoinz (eds.) *Kulturraum und Territorialität. Archäologische Theorien, Methoden und Fallbeispiele; Kolloquium des DFG-SPP 1171, Esslingen 17.-18. Januar 2007. Internationale Archäologie Arbeitsgemeinschaft, Symposium, Tagung, Kongress 13* (Rahden, Westf. 2009) 87–99.
- [343] O. Nakoinz, Ausgewählte Parameter der Lage von Wegen und Monumenten als Proxy für soziale Prozesse prähistorischer Gesellschaften. In: M. Hinz/J. Müller (eds.) *Siedlung, Grabenwerk, Großstein-*

- grab. Studien zu Gesellschaft, Wirtschaft und Umwelt der Trichterbechergruppen im nördlichen Mitteleuropa. Frühe Monumentalität und soziale Differenzierung 2 (Bonn 2012) 445–456.
- [344] O. Nakoinz, Verkehrswege der älteren Eisenzeit in Südwestdeutschland. In: C. Tappert/C. Later/J. Fries-Knoblach/ P. Ch. Rams/P. Trebsche/St. Wefers/J. Wiethold (eds.) Wege und Transport. Beiträge zur Sitzung der AG Eisenzeit während der 80. Verbandstagung des West- und Süddeutschen Verbandes für Altertumsforschung e. V. in Nürnberg 2010. Beiträge zur Ur- und Frühgeschichte Mitteleuropas 69 (Langenweissbach 2012) 73–82.
- [345] O. Nakoinz, Archäologische Kulturgeographie der ältereisenzeitlichen Zentralorte Südwestdeutschlands 224: Aus dem Institut für Ur- und Frühgeschichte der Universität Kiel (Bonn 2013).
- [346] O. Nakoinz, Fingerprinting Iron Age Communities in South-West Germany and an Integrative Theory of Culture. In: C. N. Popa/S. Stoddart (eds.) Fingerprinting the Iron Age. Approaches to identity in the European Iron Age: integrating South-Eastern Europe into the debate (Oxford 2014) 187–199.
- [347] O. Nakoinz, Räumliche Interaktionsmodelle. Prähistorische Zeitschrift 88, 1-2, 2014.
- [348] O. Nakoinz, Geographisch-archäologische Methoden und Konzepte der Identitätskonstruktion. In: S. Grunwald/K. P. Hofmann/D. A. Werning/F. Wiedemann (eds.) Mapping ancient identities. Methodisch-kritische Reflexionen zu Kartierungspraktiken. Berlin Studies of the Ancient World 55 (Berlin 2018) 245–262.
- [349] O. Nakoinz, Zentralität. Theorie, Methoden und Fallbeispiele zur Analyse zentraler Orte. Berlin Studies of the Ancient World 56 (Berlin 2019).
- [350] NASA JPL, NASA Shuttle Radar Topography Mission Global 3 arc second number. NASA EOSDIS Land Processes DAAC. Accessed 2020-03-04 from <https://doi.org/10.5067/MEaSURES/SRTM/SRTMGL3N.003>.
- [351] A. W. Naue, Die Denkmäler der vorrömischen Metallzeit im Elsass. Grabhügel und Grabhügelfunde, (Straßburg 1905).
- [352] H.-E. Nellissen, Hallstattzeitliche Funde aus Nordbaden. (Bonn 1975).
- [353] L. Olivier, Les bracelets rubanés de la Lorraine centrale et les relations entre la Sarre, la Lorraine et la Bourgogne au premier âge du Fer. In: J. M. Massing/J. Baudoux/J. Schaub (eds.) Études offertes à Jean Schaub. Blesa 1 (Metz 1993) 345–357.
- [354] L. Olivier, « Peuples », « cultures » et manifestations archéologiques de l'âge du Fer. Gustav Kossinna, Gordon Childe et nous. In: S. Plouin/P. Jud (eds.) Habitats, mobiliers et groupes régionaux à l'âge du actes du xxe colloque de l'A.F.E.A.F. Colmar-Mittelwihr, 16-19 Mai 1996. Revue Archéologique de l'Est vingtième supplément (Paris 2003) 231–239.
- [355] L. Olivier/Wirtz. B., Pareto chez les protos. trois petits essais "Archaeologie iconoclaste. In: A. Daubigney (ed.) Fonctionnement social de l'Âge du Fer. opérateurs et hypothèses pour la France. table ronde internationale de Lons-le-Saunier (Jura), 24 - 26 octobre 1990 (Lons-le-Saunier 1993) 131–176.
- [356] C. Orton, Mathematics in archaeology<sup>1</sup> (Cambridge 1982).
- [357] C. Osterwalder Maier, Die Unerreichbarkeit vollkommener Archäologie. Archäologie inherente Hindernisse. Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte 74, 1991, 229–231.
- [358] C. F. E. Pare, Ein zweites Fürstengrab von Apremenot "Les Motte aux Fees". Untersuchungen zur Späthallstattkultur im ostfranzösischen Raum. Jahrbuch römisch-germanischen Zentralmuseum 36, 2, 1989, 411–472.
- [359] C. F. E. Pare, Swords, Wagon-Burials and the beginning of Early Iron Age in Central Europe. Kleine Marburger Schriften 37, 1991.
- [360] C. F. E. Pare, Wagons and Wagon-Graves of the Early Iron Age in Central Europe. Oxford University Committee for Archaeology 35 (1992).
- [361] C. F. E. Pare, L'est de la France, l'Allemagne et la Méditerranée aux VIe et Ve siècles av. J.-C. In: A. Daubigney (ed.) Fonctionnement social de l'Âge du Fer. opérateurs et hypothèses pour la France. table ronde internationale de Lons-le-Saunier (Jura), 24 - 26 octobre 1990 (Lons-le-Saunier 1993) 97–104.

- [362] C. F. E. Pare, Beiträge zum Übergang von der Bronze- zur Eisenzeit in Mitteleuropa. Teil I: Grundzüge der Chronologie im östlichen Mitteleuropa. *Jahrbuch römisch-germanischen Zentralmuseum* 45, 1, 1998, 293–433.
- [363] C. F. E. Pare, Beiträge zum Übergang von der Bronze- zur Eisenzeit in Mitteleuropa. Teil II: *Jahrbuch römisch-germanischen Zentralmuseum* 46, 1, 1999, 175–315.
- [364] C. F. E. Pare, Tumulus burial and the question of the start of the Hallstatt Culture. In: J. Bourgeois/I. Bourgeois/B. Cheretteé (eds.) *Bronze Age and Iron Age communities in North-Western Europe; [handelingen van het Contactforum Exchange and Interaction. The Role of the Scheldt and Meuse during the Bronze Age and Iron Age (22 februari 2002)]* (Brussels 2003) 75–110.
- [365] C. F. E. Pare, s.v. Schwert. Hallstattzeit. In: J. Hoops/H. Beck (eds.) *Reallexikon der germanischen Altertumskunde* (Berlin 2004) 537–545.
- [366] O. Paret, Württemberg in vor- und frühgeschichtlicher Zeit. *Veröffentlichungen der Kommission für geschichtliche Landeskunde in Baden-Württemberg* 17, 1961.
- [367] H. Parzinger, Chronologie der Späthallstatt- und Frühlatenezeit. *Studien zu Fundgruppen zwischen Mosel und Save. Quellen und Forschungen zur prähistorischen und provinzialrömischen Archäologie* 4, 1988.
- [368] H. Parzinger, Zur regionalen Gliederung der Hallstattkultur aufgrund der Siedlungsverhältnisse. *Siedlungsforschung. Archäologie - Geschichte - Geographie* 9, 1991, 25–53.
- [369] H. Parzinger, Zwischen "Fürsten" und "Bauern". Bemerkungen zu Siedlungsform und Sozialstruktur unter besonderer Berücksichtigung der älteren Eisenzeit. *Mitteilungen der Berliner Gesellschaft für Anthropologie, Ethnologie und Urgeschichte* 13, 1992, 77–89.
- [370] H. Parzinger/J. Nekvasil/F. E. Barth/E. Fritz/T. E. Havernick, Die Býčí skála-Höhle. Ein hallstattzeitlicher Höhlenopferplatz in Mähren. *Römisch-germanische Forschungen* 54 (Mainz am Rhein 1995).
- [371] L. Pauli, Untersuchungen zur Späthallstattkultur in Nordwürttemberg. *Hamburger Beiträge zur Archäologie* 2, 1, 1972, 35–46.
- [372] L. Pauli, Die westliche Späthallstattkultur. Aufstieg und Niedergang einer Randkultur der antiken Welt. *Bayerische Vorgeschichtsblätter* 60, 1995, 133–142.
- [373] L. Pauli, Keltischer Volksglaube. *Münchener Beirträge zur Vor- und Frühgeschichte* 28, 1975.
- [374] L. Pauli, Der Dürrnberg bei Hallein III: Auswertung der Grabfunde. Zweiter Teilband. *Münchener Beiträge zur Vor- und Frühgeschichte Volume 18* (München 1978).
- [375] L. Pauli, La società celtica transalpina nel V secolo a.C. In: R. de Marinis (ed.) *Gli Etruschi a nord del Po* 22. *Zeta università* 9,2 (Udine 1988) 18–30.
- [376] E. Pebesma, Simple Features for R. *Standardized Support for Spatial Vector Data. The R Journal* 10, 1, 2018, 439.
- [377] R. D. Peng, Reproducible research in computational science. *Science* 334, 2011, 1226–1227.
- [378] T. Peucker/D. Douglas, Detection of surface specific points by local parallel processing of discrete terrain elevation data. *Computer Graphics and Image Processing* 4, 1975, 375–387.
- [379] S. M. Phillips/P. O. Leckman, Wandering the Desert: Least Cost Path. Modeling for Water Transport Trails in the Jordnada Mongollon Region, Fort Bliss, South-Central New Mexico. In: D. A. White/S. L. Surface-Evans (eds.) *Least cost analysis of social landscapes. Archaeological case studies* (Salt Lake City 2012) 46–66.
- [380] S. Piggott, *Approach to archaeology* (London 1960).
- [381] J.-F. Piningre, Nécropoles et société au premier âge du fer. Le tumulus de Courtesoult, Haute-Saône. *Documents d'archéologie française Archéologie préventive* 54 (Paris 1996).
- [382] J.-F. Piningre/V. Ganard, *Les nécropoles protohistoriques des Moidons et le site princier du Camp du Château à Salins (Jura)* (2004).
- [383] S. Plouin/M.-P. Koenig, Les bracelets hallstattiens à cannelures longitudinales. *Annuaire de la Société d'Histoire et d'Archéologie de Colmar* 37, 1990, 7–32.
- [384] S. Plouin, Quelques objets hallstattiens inédits de la région colmarienne. *Cahiers Alsaciens Archéologie* 48, 2004, 11–22.

- [385] A. Posluschny, Sehen und gesehen werde: Sichtbarkeitsanalysen als Werkzeug archäologischer Forschung. In: D. Krausse (ed.) *Frühe Zentralisierungs- und Urbanisierungsprozesse, Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 11, 367–380.
- [386] A. Posluschny, “Fürstensitze”, Zentralität und Hinterland. Erste Aspekte einer Synthese aus der Sicht des Projektes „Fürstensitz“ & Umland. In: D. Krausse/D. Beilharz (eds.) “Fürstensitze” und Zentralorte der frühen Kelten. Abschlusskolloquium des DFG-Schwerpunktprogramms 1171 in Stuttgart, 12.-15. Oktober 2009. *Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg* 120 (Stuttgart 2010) 359–374.
- [387] A. Posluschny, Early Iron Age Fürstensitze – some thoughts on a not-so-uniform phenomenon. In: S. Stoddart (ed.) *Delicate urbanism in context. Settlement nucleation in pre-Roman Germany* (2017) 9–26.
- [388] R Core Team, R: A Language and Environment for Statistical Computing. R version 3.6.0. “Planting of a Tree” (Vienna, Austria 2019-04-26). <https://www.R-project.org/>.
- [389] L. M. Raab/A. C. Goodyear, Middle-Range Theory in Archaeology. A Critical Review of Origins and Applications. *American Antiquity* 49, 1984, 255–268.
- [390] Rademaker K./D. A. Reid/G. Bromley, Connecting the Dots: Least Cost Analysis, Paleogeography, and the Search for Paleoindian Sites in Southern Highland Peru. In: D. A. White/S. L. Surface-Evans (eds.) *Least cost analysis of social landscapes. Archaeological case studies* (Salt Lake City 2012) 32–45.
- [391] B. Rahn, Cost Surface-Derived Least-Cost Paths. A Case Study from Iron Age Orkney. *IA* 19/2005.
- [392] J. Raushaus, *Das hallstattzeitliche Gräberfeld von Salem (Bodenseekreis)*. Masterarbeit (Tübingen 2016).
- [393] K. Rebay-Salisbury, *Human body in early iron age central europe* (2016).
- [394] K. Rebay-Salisbury, Rediscovering the body. Cremation and inhumation in early Iron Age Central Europe. In: J. I. Cerezo-Román/A. Wessman/H. Williams (eds.) *Cremation and the archaeology of death* (Oxford 2017) 52–71.
- [395] H. Reim, *Hallstattforschungen im Vorland der Schwäbischen Alb bei Balingen, Zollernalbkreis (Baden-Württemberg)*. *Kölner Jahrbuch Vor- und Frühgeschichte* 23, 1990, 721–735.
- [396] P. Reinecke/F. Wagner/K. Böhner, Mainzer Aufsätze zur Chronologie der Bronze- und Eisenzeit. *Altertümer unserer heidnischen Vorzeit, Festschrift des Römisch-germanischen Zentralmuseums* 5, 1902.
- [397] W. Reinhard, Die Saar-Pfalz-Gruppe der späten Hallstattzeit. *Saarpfalz* 2, 1995, 5–40.
- [398] W. Reinhard, *Studien zur Hallstatt- und Frühlatenezeit im südöstlichen Saarland*. *Blesa* 4 (Homburg-Saarpfalz 2003).
- [399] C. Renfrew, *Before civilization. The radiocarbon revolution and prehistoric Europe* (London 1973).
- [400] C. Renfrew, Trade as Action at a Distance. Questions of Integration and Communication. In: C. C. Lamberg-Karlovsky/J. A. Sabloff (eds.) *Ancient civilization and trade. School of American research advanced seminar series* (Albuquerque 1975) 3–59.
- [401] C. Renfrew, Alternative models for Exchange and Spatial Distribution. In: T. K. Earle/J. E. Ericson (eds.) *Exchange systems in prehistory. Studies in Archeology* (New York, NY 1977) 71–90.
- [402] C. Renfrew/J. Cann/J. Dixon, Obsidian in the Aegean. *Annual of the British School at Athens* 60, 1965, 225–247.
- [403] C. Renfrew/K. L. Cooke, *Transformations. Mathematical Approaches to Culture Change* (Saint Louis 2015).
- [404] J. de Reu/J. Bourgeois/M. Bats/A. Zwertvaegher/V. Gelorini/P. de Smedt/W. Chu/M. Antrop/Ph. de Maeyer/P. Finke/M. von Meirvenne/J. Verniers/P. Crombé, Application of the topographic position index to heterogeneous landscapes. *Geomorphology* 186, 2013, 39–49.
- [405] J. de Reu, *Land of the dead: a comprehensive study of the Bronze Age burial landscape in north-western Belgium*. PhD Thesis (Ghent 2012).
- [406] S. Rieckhoff/J. Biel/B.-U. Abels, *Die Kelten in Deutschland* (Stuttgart 2001).
- [407] S. Rieckhoff, Happy End oder Aufruhr? Zur Narratologie der “keltischen Kunst”. *Ethnographisch-Archäologische Zeitschrift* 51, 1/2, 2010, 215–238.

- [408] S. Rieckhoff, Raumqualität, Raumgestaltung und Raumwahrnehmung im 2./1. Jahrhundert v. Chr. In: P. Trebsche/N. Müller-Scheeßel/Reinhold (eds.) *Der gebaute Raum. Bausteine einer Architektursoziologie vormoderner Gesellschaften*. Tübinger Archäologische Taschenbücher 7 (Münster 2010) 275–306.
- [409] A. Rieth, *Die Eisentechnik der Hallstattzeit*. Mannus-Bücherei 70 (Leipzig 1942).
- [410] A. Rieth, *Werkzeuge der Holzbearbeitung. Sägen aus 4. Jahrtausenden*. Saalburg Jahrbuch 17, 1958.
- [411] T. Rihll/A. Wilson, Model based approaches to the analysis of regional settlement structures: the case of ancient Greece. In: P. Denley/D. Hopkin (eds.) *History and computing* (Manchester 1987) 10–20.
- [412] J. D. Risetto, Using Least Cost Path Analysis to Reinterpret Late Paleolithic Hunter-Gatherer Procurement Zones in Northern Spain. In: D. A. White/S. L. Surface-Evans (eds.) *Least cost analysis of social landscapes. Archaeological case studies* (Salt Lake City 2012) 11–31.
- [413] R. J. Hijmans, *raster: Geographic Data Analysis and Modeling* (2019). [;https://CRAN.R-project.org/package=raster](https://CRAN.R-project.org/package=raster).
- [414] O. Rochna, Halstattzeitlicher Lignit- und Gagatschmuck. *Fundberichte aus Schwaben, Neue Folge* 16, 1962, 44.
- [415] O. Rochna, Das Tonschiefer-, Sapropelit-, Gagat und Wachsmaterial der Heuneburg. In: S. Sievers (ed.) *Die Kleinfunde der Heuneburg. Die Funde aus den Grabungen von 1950 - 1979. Römisch-germanische Forschungen 42 Heuneburgstudien; 5* (Mainz a. Rh. 1984) 91–94.
- [416] E. Rodriguez/C. S. Morris/J. BelzE. Chapin/J. Martin/W. Daffer/S. Hensley, *An Assessment of the SRTM Topographic Products*. Technical Report JPL D-31639. Jet Propulsion Laboratory 2005.
- [417] R. Bivand/T. Keitt/B. Rowlingson, *rgdal: Bindings for the 'Geospatial' Data Abstraction Library* (2019). [;https://CRAN.R-project.org/package=rgdal](https://CRAN.R-project.org/package=rgdal).
- [418] P. Rothenhöfer, Rhenus Flumen. Bemerkungen zur Bedeutung des Rheins für die Wirtschaft im römischen Rheinland. In: M. Mirschenz/R. Gerlach/J. Bemmann (eds.) *Der Rhein als europäische Verkehrsachse. Bonner Beiträge zur vor- und frühgeschichtlichen Archäologie Volume 22* (Bonn 2019) 11–23.
- [419] U. Ruoff, *Zur Frage der Kontinuität zwischen Bronze- und Eisenzeit in der Schweiz* (Basel 1974).
- [420] M. Saerens/Y. Achbany/F. Fouss/L. Yen, Randomized Shortest-Path Problems: Two Related Models. *Neural Computation* 21, 2009, 2363–2404.
- [421] V. Salac, Kommunikationswege, Handel und das Ende der Oppidazivilisation. In: C. Dobiati/S. Sievers/T. Stöllner (eds.) *Dürrnberg und Manching. Wirtschaftsarchäologie im ostkeltischen Raum. Kollquien der Vor- und Frühgeschichte 7* (Tagung Hallein 1998) (Bonn 2002) 349–354.
- [422] E. Sangmeister, Die Grabtracht der Frauen im Nachbestattungsfriedhof des Magdalenenberg. *Archäologische Nachrichten aus Baden* 31, 1983, 21–27.
- [423] E. Sangmeister, Geschichte der Archäologischen Forschung in Baden. In: E. Sangmeister (ed.) *Zeitspuren. Archäologisches aus Baden. Archäologische Nachrichten aus Baden* 50 (Freiburg 1993) 8–20.
- [424] C. O. Sauer, The morphology of landscape. In: T. Oakes/P. L. Price (eds.) *The Cultural Geography Reader* (Hoboken 2008) 96–104.
- [425] M. Sauerbier/G. Schrotter/H. EisenbeissK. Lambers, Multi-Resolution Image-Based Visualization of Archaeological Landscapes in Palpa (Peru). In: S. Campana/M. Forte (eds.) *From space to place. 2. international Conference on remote sensing in archaeology = proceedings of the 2. International workshop, CNR: Rome, Italy, December 4-7, 2006. BAR. International series 1568* (Oxford 2006) 353–359.
- [426] F. d. Saussure, *Grundfragen der allgemeinen Sprachwissenschaft* <sup>2</sup> (Berlin 1967).
- [427] C. F.-A. Schaeffer, *Les tumulus de l'âge du Bronze* (Haguenau 1926).
- [428] C. F.-A. Schaeffer, *Les tumulus de l'âge du fer* (Haguenau 1930).
- [429] P. Schauer, *Die Schwerter in Süddeutschland, Österreich und der Schweiz I. Griffplatten-, Griffangel- und Griffzungenschwerter. Prähistorische Bronzefunde Abt. 4 2* (München 1971).
- [430] P. Schauer, *Der vierrädrige Wagen in Zeremonialgeschehen und Bestattungsbrauch der orientalischesch-ägäischen Hochkulturen und ihrer Randgebiete*. In: *Vierrädrige Wagen der Hallstattzeit. RGZM Monographien 12* (Mainz 1987) 1–23.



- [431] S. Schiek, Fürstengräber der jüngeren Hallstattkultur in Südwestdeutschland. Unpublizierte Dissertation an der Universität Tübingen (Tübingen 1956).
- [432] S. Schiek, Der ‚Heiligenbuck‘ bei Hügelsheim. Fundberichte in Baden-Württemberg 6, 1981, 273–308.
- [433] S. Schiek, Zur Geschichte der Archäologischen Denkmalpflege in Württemberg und Hohenzollern. Denkmalpflege in Baden-Württemberg 12, 1983, 52–58.
- [434] W. Schier, Die vorgeschichtliche Besiedlung im südlichen Maindreieck. Materialhefte zur Bayerischen Vorgeschichte. Reihe A. Fundinventare und Ausgrabungsbefunde 60 (Kallmünz/Opf. 1990).
- [435] M. B. Schiffer, Formation processes of the archaeological record (1987).
- [436] C. Schmid-Merkl, Der Oberrhein. Archäologie einer metallzeitlichen Flusslandschaft. Materialhefte zur Archäologie in Baden-Württemberg Heft 103 (Darmstadt 2016).
- [437] B. Schmid-Sikimić, Der Arm- und Beinschmuck der Hallstattzeit in der Schweiz. mit einem Anhang der Gürtelhaken und Gürtelgehänge der Hallstattzeit im Schweizerischen Mittelland, Jura and Wallis. Prähistorische Bronzefunde Abt. X 5 (1996).
- [438] S. C. Schmidt/B. Marwick, Tool-Driven Revolutions in Archaeological Science. *Journal of Computer Applications in Archaeology* 3, 1, 2020, 18–32.
- [439] M. Schmidt, Nadeln als Kopfschmuck in der Späthallstattzeit. *Universitätsforschungen zur prähistorischen Archäologie* 242 (Bonn 2013).
- [440] M. Schmitter, Betschdorf: Die elsässischen Steinzeutöpfer. *Rheinisches Jahrbuch für Volkskunde* 24, 1982, 37–64.
- [441] A. Schnapp, Archéologie et nations en Europe, aux sources du débat. In: *L’archéologie, instrument du politique? Archéologie, histoire des mentalités et construction européenne: actes du colloque de Luxembourg, 16-18 novembre 2005. Documents, actes et rapports pour l’éducation* (Dijon, Glux-en-Glenne 2006) 13–23.
- [442] R. B. Schneider, Kommunikation und Interaktion. Kontakt- und Einflussphären während der jüngeren Bronzezeit und älteren Eisenzeit Europas. Dissertation (Kiel 2012).
- [443] W. Schüle, Frühe Antennendolche in Westeuropa. *Germania* 38, 1960, 1–19.
- [444] A. Schumacher, Die Hallstattzeit im südlichen Hessen. *Bonner Hefte zur Vorgeschichte* 5 (Bonn 1972).
- [445] M. Schussmann, Holzbrücke und Steinstraße – Archäologische Befunde zum späthallstatt-/frühlatènezeitlichen Wegebau auf der Südlichen Frankenalb. In: Tappert/C. Later/J. Fries-Knoblach/ P. Ch. Ramsel/P. Trebsche/St. Wefers/J. Wiethold (eds.) *Wege und Transport. Beiträge zur Sitzung der AG Eisenzeit während der 80. Verbandstagung des West- und Süddeutschen Verbandes für Altertumsforschung e. V. in Nürnberg 2010. Beiträge zur Ur- und Frühgeschichte Mitteleuropas* 69 (Langenweissbach 2012) 41–47.
- [446] Schutkowski/Hermann, Geographical Variation of Subsistence Strategies in Early Medieval Populations of Southwestern Germany. *Journal of Archaeological Science* 23, 1996, 823–831.
- [447] H. Schwab, Archéologie de la 2e correction des eaux du jura. *Archéologie Fribourgeoise* 5 (Fribourg 1990).
- [448] M. Schwab/N. Karrenbach/J. Claerbout, Making scientific computations reproducible. *Computing in Science & Engineering* 2, 2000, 61–67.
- [449] A. Sehnert-Seibel, Hallstattzeit in der Pfalz. *Universitätsforschungen zur prähistorischen Archäologie* 10 (Bonn 1993).
- [450] S. Shennan, *Quantifying archaeology* <sup>2</sup> (Edinburgh 2001).
- [451] A. Siegfried-Weiss, Gesellschaft und Bevölkerung. Einführungskurs in die ur- und frühgeschichtliche Archäologie der Schweiz: 6. Kurs, Bern, 17.-18. November 1990 ([Bern] 1990).
- [452] S. Sievers, Die mitteleuropäischen Hallstattdolche. *Prähistorische Bronzefunde. Abteilung VI Volume 6* (München 1982).
- [453] S. Sievers (ed.), Die Kleinfunde der Heuneburg. Die Funde aus den Grabungen von 1950 - 1979. *Römisch-germanische Forschungen* 42 Heuneburgstudien; 5 (Mainz a. Rh. 1984).

- [454] M. J. de Smith/M. F. Goodchild/P. A. Longley, Geospatial analysis. A comprehensive guide to principles, techniques and software tools 6, 2018.
- [455] U. Sommer, Materielle Kultur und Ethnizität. Eine sinnlose Fragestellung? In: U. Veit/T. L. Kienlin/C. Kümmel/s. Schmidt (eds.) Spuren und Botschaften. Interpretationen materieller Kultur. Tübinger Archäologische Taschenbücher 4 (Münster 2003) 205–223.
- [456] Sormaz/T. Stöllner, Zwei hallstattzeitliche Grabkammern vom Dürrnberg bei Hallein. Neue dendrochronologische Ergebnisse zum Übergang von der Hallstatt- zur Frühlatènezeit. Archäologisches Korrespondenzblatt 35, 2005, 361–376.
- [457] K. Spindler/G. Gallay/R. Hauff, Magdalenenberg III (Villingen 1973).
- [458] K. Spindler, Magdalenenberg 4. Der hallstattzeitliche Fürstengrabbügel bei Villingen im Schwarzwald (Villingen 1976).
- [459] E. Sprockhoff, Die nordische Megalithkultur (1938).
- [460] A. Szymank, Neue Anforderungen im europäischen Naturschutz. Das Schutzgebietssystem Natura 2000 und die FFH-Richtlinie der EU. Natur und Landschaft 69, 1994, 395–406.
- [461] J. Stadler, Nahrung für die Toten? Speisebeigaben in hallstattzeitlichen Gräbern und ihre kulturhistorische Deutung. Universitätsforschungen zur prähistorischen Archäologie Aus dem Institut für Ur- und Frühgeschichte der Universität Heidelberg 186 (Bonn 2010).
- [462] C. Stahl, Mitteleuropäische Bernsteinfunde von der Frühbronze- bis zur Frühlatènezeit. Ihre Verbreitung, Formgebung, Zeitstellung und Herkunft. Würzburger Studien zur Sprache & Kultur Archäologie, Kunstgeschichte Volume 9 (Dettelbach 2006).
- [463] P. F. Stary, Der Mittelgebirgsraum als Transit- und Vermittlungszone hallstatt- und latènezeitlicher Kulturelemente aus Mitteleuropa ins westliche Ostseegebiet. Berichte der Römisch-germanischen Kommission 74, 1994, 537–564.
- [464] C. Steffen, Gesellschaftswandel während der älteren Eisenzeit. Materialhefte zur archäologie in Baden-Württemberg 93 (2012).
- [465] C. Steffen/M. Steffen, Siedlungssysteme der Späthallstattzeit in Baden-Württemberg. Modellierung des sozio-ökonomischen Potentials ältereisenzeitlicher Siedlungskammern auf Basis siedlungs- und sozialarchäologischer Kennzahlen. In: D. Krausse/D. Beilharz (eds.) "Fürstensitze" und Zentralorte der frühen Kelten. Abschlusskolloquium des DFG-Schwerpunktprogramms 1171 in Stuttgart, 12.-15. Oktober 2009. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg 120 (Stuttgart 2010) 333–357.
- [466] M. Steffen/W. Zirkel, Siedlungshierarchien und kulturelle Räume I. Die naturräumliche und wirtschaftliche Perspektive. In: R. Karl/J. Leskovar (eds.) Interpretierte Eisenzeiten. Fallstudien, Methoden, Theorie: Tagungsbeiträge der 3. Linzer Gespräche zur interpretativen Eisenzeitarchäologie. Studien zur Kulturgeschichte von Oberösterreich Folge 22 (Linz 2009) 177–190.
- [467] G. Stegmaier, Hallstattzeitliche Grabkeramik aus dem Neckartal. Zu charakteristischen Zierelementen der Region zwischen Schönbuch und Rammert. In: M. K. H. Eggert/H.-P. Wotzka/J. Bofinger (eds.) Grundlegungen. Beiträge zur europäischen und afrikanischen Archäologie für Manfred K.H. Eggert (Tübingen 2006) 527–540.
- [468] G. Stegmaier, La céramique décorée halstattienne en Bade-Wurtemberg. Chorologie et chronologie des phases Ha C et Ha D1. In: B. Chaume (ed.) La céramique hallstattienne. Approches typologique et chrono-culturelle; actes du colloque international de Dijon 21-22 novembre 2006. Art, archéologie & patrimoine (Dijon 2009) 541–558.
- [469] G. Stegmaier, Die Heuneburg. Zentrum der Keramikherstellung. In: D. Krausse/I. Kretschmer/L. Hansen/M. Fernández-Götz/B. Arnold (eds.) Die Heuneburg - keltischer Fürstensitz an der oberen Donau 11. Führer zu archäologischen Denkmälern in Baden-Württemberg 28 (Darmstadt 2015) 70–71.
- [470] G. Stegmaier, Keramik, Kunst und Identität. Regionale Verzierungsmuster der südwestdeutschen Alb-Hegau-Keramik als Elemente der Kommunikation und Gemeinschaftsbildung. In: R. Karl/J. Leskovar (eds.) Interpretierte Eisenzeiten. Fallstudien, Methoden, Theorie. Tagungsbeiträge der 6. Linzer Ge-

- sprache zur interpretativen Eisenzeitarchäologie. Studien zur Kulturgeschichte von Oberösterreich 42 (Linz 2016) 119–130.
- [471] Steuer, Der Handel der Wikingerzeit zwischen Nord- und Westeuropa auf Grund archäologischer Zeugnisse. In: H. Jankuhn/K. Düwel/H. Siems/D. Timpe (eds.) Der Handel der Karolinger- und Wikingerzeit. Bericht über die Kolloquien der Kommission für die Altertumskunde Mittel- und Nordeuropas in den Jahren 1980 bis 1983. Abhandlungen der Akademie der Wissenschaften in Göttingen. Philologisch-historische Klasse. Folge 3 Nr. 156 (Göttingen 1987) 113–197.
- [472] B. Stjernquist, Ciste a Cordoni. Rippenzisten; Produktion, Funktion, Diffusion. Acta archaeologica Lundensia. Series in quarto 6,2 (Bonn 1967).
- [473] A. Stobbe, Die Vegetationsgeschichte im südwestlichen Nördlinger Ries von der späten Bronzezeit bis zur Römerzeit. In: R. Krause (ed.) Neue Forschungen zum frühkeltischen Fürstensitz auf dem Ipf. Ipf-Forschungen 1 (Bonn 2014) 71–95.
- [474] P. Stockhammer, Keramik jenseits von Chronologie. Einführung. In: P. Stockhammer (ed.) Keramik jenseits von Chronologie. Beiträge der Arbeitsgemeinschaft "Theorie in der Archäologie" bei der Tagung des West- und Süddeutschen Verbandes für Altertumforschung e.V. in Xanten, 7. - 8. Juni 2006. Internationale Archäologie: [...], Arbeitsgemeinschaft, Symposium, Tagung, Kongress Volume 14 (Rahden, Westf. 2009).
- [475] S. Stoddart/C. N. Popa, Introduction. The Challenge of Iron Age Identity. In: C. N. Popa/S. Stoddart (eds.) Fingerprinting the Iron Age. Approaches to identity in the European Iron Age: integrating South-Eastern Europe into the debate (Oxford 2014) 3–10.
- [476] T. Stöllner, Die Hallstattzeit und der Beginn der Latènezeit im Inn-Salzach-Raum. Archäologie in Salzburg 3 (Salzburg, Salzburg 1996).
- [477] T. Stöllner, "Kulturwandel — Chronologie — Methode" - Ein Diskussionsbeitrag am Beispiel der Hallstatt- und Latènekultur. Prähistorische Zeitschrift 74, 2, 1999, 194–218.
- [478] T. Stöllner, The Rise of the Proto-Celts? The Transition from the Early to the Late Hallstatt-Period in Southern Germany. In: P. Anreiter (ed.) Archaeological, cultural and linguistic heritage. Festschrift for Erzsébet Jerem in honour of her 70th birthday. Archaeolingua Vol. 25 (Budapest 2012) 551–568.
- [479] S. L. Surface-Evans/D. A. White, An Introduction to Least Cost Analysis of Social Landscapes. In: D. A. White/S. L. Surface-Evans (eds.) Least cost analysis of social landscapes. Archaeological case studies (Salt Lake City 2012) 1–10.
- [480] S. L. Surface-Evans, Hunter-Gatherer Cultural Landscapes. A Case Study for a GIS-Based Reconstruction of the Shell Mound Archaic in the Falls of the Ohio Region of Indiana and Kentucky. Ph.D. (2009).
- [481] M. Tennekes, tmap. Thematic Maps in R. Journal of Statistical Software 84, 6, 2018.
- [482] B. Thalheim/I. Nissen (eds.), Wissenschaft und Kunst der Modellierung (Berlin, München, Boston 2015).
- [483] J. Thurnman, On the ancient British barrows, especially those of Wiltshire and the adjoining counties. Archaeologica 43, 1871, 285–544.
- [484] D. Timpe, Der keltische Handel nach histoischen Quellen. In: K. Düwel (ed.) Handel des frühen Mittelalters. Bericht über d. Kolloquien d. Komm. für d. Altertumskunde Mittel- u. Nordeuropas in d. Jahren 1980 - 1983. Abhandlungen der Akademie der Wissenschaften zu Göttingen, Philologisch-Historische Klasse Folge 3, Nr. 150 (Göttingen 1985) 258–284.
- [485] O. Tischler, Gliederung der vorrömischen Metallzeit. Correspondenzblatt der deutschen Gesellschaft für Anthropologie, Ethnologie und Urgesichte 7, 1881.
- [486] O. Tischler, Ueber die Formen der Gewandnadeln (Fibeln) nach ihrer historischen Bedeutung. Zeitschrift für Anthropologie und Urgeschichte Baierns's 4, 1881, 3–40.
- [487] W. Tobler, A computer movie simulating urban growth in the Detroit region. Economic Geography 46, 1970, 234–240.
- [488] W. Tobler, Non-isotropic geographic modeling. Technical Report 93, 1993.
- [489] K. Tomaschitz, Die Wanderungen der Kelten in der antiken literarischen Überlieferung. Mitteilungen der Prähistorischen Kommission 47 (Wien 2002).

- [490] W. Torbrügge, Vor- und frühgeschichtliche Flußfunde. Zur Ordnung und Bestimmung einer Denkmälkegruppe. *Berichte der Römisch-germanischen Kommission* 51-52, 1970-1971, 1–146.
- [491] W. Torbrügge, Die Hallstattzeit in der Oberpfalz I. Auswertung und Gesamtkatalog. *Materialhefte zur bayrischen Vorgeschichte* 39, A, 1979.
- [492] W. Torbrügge, Die frühe Hallstattzeit (HaC) in chronologischen Ansichten und notwendigen Randbemerkungen. Teil I: Bayern und der "westliche Hallstattkreis". *Jahrbuch römisch-germanischen Zentralmuseum* 38, 1991, 223–463.
- [493] W. Torbrügge, Die frühe Hallstattzeit (HaC) in chronologischen Ansichten und notwendigen Randbemerkungen. Teil II: Der sogenannte östliche Hallstattkreis. *Jahrbuch römisch-germanischen Zentralmuseum* 39, 2, 1992, 425–615.
- [494] M. Trachsel, Untersuchungen zur relativen und absoluten Chronologie der Hallstattzeit. *Universitätsforschungen zur prähistorischen Archäologie* (Bonn 2004).
- [495] L. Tremblay Cormier, *Identités culturelles et échanges entre Rhin et Rhône du Xe au Ve siècle avant notre ère* (2016).
- [496] L. Tremblay Cormier, French elite burials of the Early Iron Age. In: R. Schumann/S. van der Vaart (eds.) *Connecting elites and regions. Perspectives on contacts, relations and differentiation during the Early Iron Age Hallstatt C period in Northwest and Central Europe* (Leiden 2017) 287–303.
- [497] E. v. Tröltsch, *Fund-Statistik der vorrömischen Metallzeit im Rheingebiete* (Stuttgart 1884).
- [498] H. d. van Boom, *Grossgefäße und Töpfe der Heuneburg*. *Heuneburgstudien* 8 (Mainz am Rhein 1991).
- [499] M. van Leusen, *Pattern to process. Methodological investigations into the formation and interpretation of spatial patterns in archaeological landscapes*. (Groningen 2002).
- [500] P. Verhagen/K. Jeneson, Roman Puzzle: Trying to find the Via Belgica with GIS. In: A. Chrysanthi (ed.) *Thinking beyond the tool. Archaeological computing and the interpretive process*. BAR. International series 2344 (Oxford 2012) 123–130.
- [501] M. Vihinen, No more hidden solutions in bioinformatics. *Nature* 521, 7552, 2015, 261.
- [502] E. Wagner, Die Grabhügelgruppe bei Salem (A. Überlingen). *Veröffentlichungen der Grossherzoglichen Badischen Sammlung und Karlsruher Altertümer* 2, 1899, 55–74.
- [503] E. Wagner, *Fundstätten und Funde aus vorgeschichtlicher, römischer und alamannisch-fränkischer Zeit im Großherzogtum Baden: 2. - Das Badische Unterland* (1911).
- [504] H. Wagner, Un nouveau site princier du Hallstatt final dans le fossé rhénan supérieur? In: P. Barral/A. Daubigney/C. Dunning/G. Kaenel/M.-J. Roulère-Lambert (eds.) *L'âge du fer dans l'arc jurassien et ses marges. Actes du XXIXe colloque international de l'Association française pour l'étude de l'âge du fer* (Bienne (Suisse), 5-8 mai 2005). *Annales littéraires de l'Université de Franche-Comté* 826, 1 (Besançon 2007) 101–112.
- [505] J. Wahl, Die Kelten in Südwestdeutschland. In: D. Beilharz/R. Röber/K. Hald (eds.) *Die Welt der Kelten. Zentren der Macht - Kostbarkeiten der Kunst; [15. September 2012 bis 17. Februar 2013; Begleitband zur Großen Landesausstellung Baden-Württemberg 2012]* (Ostfildern 2012) 76–77.
- [506] G. Wamser, Zur Hallstattkultur in Ostfrankreich. Die Fundgruppen im Jura und Burgund. *Berichte der Römisch-germanischen Kommission* 56, 1975, 1.
- [507] T. F. Warneke, Hallstatt- und frühlatènezeitlicher Anhängerschmuck. *Studien zu Metallanhängern des 8. - 5. Jahrhunderts v. Chr. zwischen Main und Po*. *Internationale Archäologie* 50 (Rahden, Westf. 1999).
- [508] R. Wassong, *Organisation spatiale des nécropoles tumulaire des la Forêt de Haguenau*. *Magister* (2012).
- [509] R. Wassong, Tumulus et milieux humides. Rites, ostentation et lieux de passages. Les tertres de l'âge du Fer dans le fossé rhénan. In: F. Olmer/R. Roure (eds.) *Les gaulois au fil de l'eau. Actes du 37e colloque international de l'Association Française pour l'Étude de l'Âge du Fer*, Montpellier 2013. *Ausonius éditions. Mémoires* 39 (Bordeaux 2015) 11153–11162.
- [510] G. Wegner, s.v. Flussfund. In: J. Hoops/H. Beck (eds.) *Reallexikon der germanischen Altertumskunde* (Berlin 2004) 263–276.

- [511] K. Wehrberger, Das hallstattzeitliche Gräberfeld von Werbach, Main-Tauber-Kreis. Fundberichte in Baden-Württemberg 9, 1984, 81–221.
- [512] A. D. Weiss, Topographic position and landforms analysis. Poster Presentation. ESRI Users Conference (San Diego, CA. 2001).
- [513] R.-M. Weiss, Die Hallstattzeit in Europa. In: W. Menghin/I. Griesa/R.-M. Weiss (eds.) Hallstattzeit. Zaberns Bildbände zur Archäologie Sonderbände der Antiken Welt 2 (Mainz am Rhein 1999) 7–22.
- [514] L. Westenrieder, Geschichte der königlichen bayerischen Akademie der Wissenschaften (1807).
- [515] I. Westhausen, Ein Ring sie ewig zu binden... - Halsringe der späten Hallstatt- und frühen Latènezeit aus Baden-Württemberg, dem Elsass und dem Schweizer Mittelland. In: Interdisciplinarité et nouvelles approches dans les recherches sur l'âge du Fer. Interdisciplinarity and New Approaches in the Research of the Iron Age (2015) 161–165.
- [516] D. Wheatley, Cumulative Viewshed analysis. a GIS-based method for investigating intervisibility, and its archaeological application. In: G. Lock/Z. Stančič (eds.) Archaeology and geographical information systems. A European perspective (London 1995) 171–186.
- [517] D. Wheatley/M. Gillings, Spatial technology and archaeology. The archaeological applications of GIS ([Boca Raton] 2002).
- [518] H. V. White, Metahistory. The historical imagination in nineteenth-century Europe Hayden White (1973).
- [519] H. V. White, Tropics of discourse. Essays in cultural criticism (Baltimore 1978).
- [520] D. A. White/S. B. Barber, Geospatial modeling of pedestrian transportation networks: a case study from precolumbian Oaxaca, Mexico. Journal of Archaeological Science 39, 2012, 2684–2696.
- [521] H. Wickham, Advanced R, Second Edition <sup>2</sup> (Milton 2019).
- [522] H. Wickham/J. Hester/R. Francois, readr. Read Rectangular Text Data. R package version 1.3.1. (2018).
- [523] C. J. Wiktorowicz/B. Arnold/J. E. Wiktorowicz; Murray/A. Kurosky, Hemorrhagic fever virus, human blood, and tissues in Iron Age mortuary vessels. Journal of Archaeological Science 78, 2017, 29–39.
- [524] J. D. C. Wilhelmi, Beschreibung der vierzehn alten deutschen Todtenhügel, welche in den Jahren 1827 und 1818 bey Sinsheim in dem Neckarkreise Großherzogthumes Baden geöffnet wurden (Heidelberg 1830).
- [525] J. P. Wilson/Gallant John C. (eds.), Terrain analysis. Principles and applications (New York 2000).
- [526] C. Winkler/C. Gutmann, Leitfaden zur Erkennung der heimischen Altertümer erläutert durch 300 Zeichnungen. Bearbeitet für die Herren Geistlichen, Lehrer, Forst und Baubeamten, Bürgermeister, Landwirte und Altertumsfreunde (Colmar 1894).
- [527] P. E. Woodman, Beyond significant patterning towards past intentions. the location of Orcadian chambered tombs. In: C. E. Buck (ed.) Proceedings of the fourth meeting / U.K. Chapter of Computer Applications and Quantitative Methods in Archaeology. Cardiff University, 27 and 28 February 1999. BAR international series 844 (Oxford 2000) 91–105.
- [528] R. Wyss, Handel und Verkehr über die Alpenpässe. In: H. Jankuhn (ed.) Der Verkehr. Verkehrswege, Verkehrsmittel, Organisation; Bericht über die Kolloquien der Kommission für die Altertumskunde Mittel- und Nordeuropas in den Jahren 1980 - 1983. Abhandlungen der Akademie der Wissenschaften in Göttingen 180 (Göttingen 1989) 155–173.
- [529] G. K. Zipf, Human behavior and the principle of least effort. An introduction to human ecology (New York 1949).
- [530] H. Zürn, Die Hallstattzeit in Württemberg. unpublizierte Dissertation (Tübingen 1941).
- [531] H. Zürn, Zur Chronologie der späten Hallstattzeit. Germania 26, 1942, 116–142.
- [532] H. Zürn, Zum Übergang von Späthallstatt zu Latène A im südwestdeutschen Raum. Germania 30, 1952, 38–45.
- [533] H. Zürn, Hallstattzeitliche Grabfunde in Württemberg und Hohenzollern. Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg 25, 1987.

## **Appendix A**

### **Classification of Artefacts in SHKR Database**

- Tab. A.1 — SHKR levels
- Tab. A.2 — SHKR level B1: Vessels
- Tab. A.3 — SHKR level B2: Ring Jewellery
- Tab. A.4 — SHKR level B31: Fibula
- Tab. A.5 — SHKR level B31: Pins
- Tab. A.6 — SHKR level B31: Belts
- Tab. A.7 — SHKR level B4: Weaponry
- Tab. A.8 — SHKR level B5: Means of Transportation
- Tab. A.9 — SHKR level B6: Tools
- Tab. A.10 — SHKR level B7: Art and Jewellery

<b>Label</b>	<b>Category</b>	<b>Level</b>	<b>Classification</b>
<b>A</b>	<b>material</b>	<b>A1</b>	Ceramic
		<b>A2</b>	Metal
		<b>A3</b>	Rock
		<b>A4</b>	Organic Matter
		<b>A9</b>	Others
<b>B</b>	<b>artefact</b>	<b>B1</b>	Vessel
		<b>B2</b>	Ring Jewellery
		<b>B3</b>	Parts of Garb
		<b>B4</b>	Weaponry
		<b>B5</b>	Means of Transportation
		<b>B6</b>	Tools
		<b>B7</b>	Art and Jewellery
		<b>B8</b>	Construction and Production
		<b>B9</b>	Others
<b>C</b>	<b>technique of decoration</b>	<b>C1</b>	rills
		<b>C2</b>	relief
		<b>C3</b>	coloured
		<b>C4</b>	embossed
		<b>C5</b>	applied
		<b>C6</b>	perforation
		<b>C7</b>	torsion
		<b>C9</b>	others
		<b>D</b>	<b>decoration</b>
<b>D2</b>	decorated		
<b>E</b>	<b>types (named in Literature)</b>	<b>E1</b>	Vessel
		<b>E2</b>	Ring Jewellery
		<b>E3</b>	Parts of Garb
		<b>E4</b>	Weaponry
		<b>E5</b>	Means of Transportation
		<b>E6</b>	Tools
		<b>E7</b>	Art and Jewellery
<b>F</b>	<b>relative dating</b>	<b>F1</b>	Iron Age
		<b>F2</b>	Not Iron Age

Table A.1: SHKR levels

<b>B1</b>	<b>Artefact profile Vessel</b>	<b>rim</b>	<b>base</b>	<b>outlet</b>	<b>position of change in profile</b>	
<b>B 11</b>	<b>Open Shaped</b>	B 1 rounded	B 1 cylindric neck	B 1 regular base	B 1 narrow outlet	B 1 upper
<b>B 12</b>	<b>Closed Shaped</b>	B 2 shouldered neck	B 2 sloped rim	B 2 Standring	B 2 normal outlet	B 2 middle
		B 3 straight	B 3 concave	B 3 omphalos	B 3 wide outlet	B 3 lower
		B 4 carnation	B 4 steep	B 4 flat base		
		B 5 middle bend (Bauchknick)	B 5 straight	B 5 rounded base		
		B 6 metal vessel	B 6 convex	B 6 pointed base		
			B 7 bended			
		B 9 others	B 9 others	B 9 others		
<b>B 19</b>	<b>Others</b>	Special Type	funnel, sieve, spoon, lid etc.			

Table A.2: SHKR level B1: Vessels

<b>B2</b>	<b>Artefact: Ring Jewellery</b>	<b>ring body</b>	<b>cross section</b>
<b>B 21</b>	<b>neck ring</b>	B 1 solid	B 1 O (round)
<b>B 22</b>	<b>temple ring</b>	B 2 sheet	B 2 Q (squared)
<b>B 23</b>	<b>bracelet</b>	B 3 spirals	B 3 K (concave)
<b>B 24</b>	<b>anklet</b>		B 4 D (plano-convex)
<b>B 25</b>	<b>ear and finger ring</b>		B 5 C (c-form)
			B 6 I (sheet)
			B 7 T (barrel)
			B 7 P (polygonal)
<b>B 29</b>	<b>others</b>	B 9 others	B 9 S (others)

Table A.3: SHKR level B2: Ring Jewellery



<b>B 31</b>	<b>Fibula (Chronotype)</b>	<b>Phenotype</b>
<b>B 311</b>	<b>Hallstatt</b>	B 3111 <i>Schlangefibel</i> (serpentine fibulae) B 3112 <i>Bogenfibel</i> (arch fibulae) B 3113 <i>Kahnfibel</i> (Kahn fibulae) B 3114 <i>Paukenfibel</i> (Pauken fibulae) B 3115 <i>Doppelpaukenfibel</i> (double drum) B 3116 <i>Fußzierfibel</i> (foot fibulae) B 3117 <i>Doppelzierfibel</i> (doublezier fibulae)
<b>B 312</b>	<b>early laténe fibula</b>	B 3121 <i>Drahtfibel</i> (filaent fibula) B 3122 type Dux B 3123 type Münsingen B 3124 type <i>Kugelkopffibel</i> B 3125 type <i>Vasenkopffibel</i> B 3126 type Certossa
<b>B 313</b>	<b>figural fibula</b>	B 3131 type <i>Vogelkopffibel</i> B 3132 type <i>Tierkopffibel</i> B 3133 type <i>Maskenkopffibe</i>
<b>B 314</b>	<b>disk fibula</b>	B 3141 type <i>Scheibenfibel</i> B 3142 type <i>Weidacher Fibel</i> B 3143 type <i>Tutulusfibel</i> B 3144 <i>Vierpassfibel</i>
<b>B 315</b>	<b>middle laténe fibula</b>	
<b>B 319</b>	<b>others</b>	B 9 others

Table A.4: SHKR level B31: Fibula

<b>B32: Pin</b>	<b>shape of shaft</b>	<b>shape of head</b>
<b>B 321</b>	<b>straight</b>	B 32 1 circular <i>Kugelkopfnadel</i>
<b>B 322</b>	<b>swan-necked</b>	B 32 2 Spatenkopfnadel
<b>B 323</b>	<b>bow-necked</b>	B 32 3 disk <i>Scheibenkopfnadel</i>
<b>B 324</b>	<b>thickened</b>	B 32 4 <i>Kolbenkopfnadel</i>
<b>B 32...9</b>	<b>...</b>	<b>...</b>

Table A.5: SHKR level B32: Pins

<b>B33: Belt</b>	<b>Parts</b>	<b>Shape</b>
<b>B 331</b>	<b>belt hook</b>	<b>B 3312 triangular</b> <b>B 3313 rhombic</b> <b>B 3314 squared</b> <b>B 3319 others</b>
<b>B 332</b>	<b>belt plaque</b>	<b>B 3321 undecorated</b> <b>B 3322 embossed</b>
<b>B 333</b>	<i>Stangengliederkette</i>	
<b>B 334</b>	<i>Leibring</i>	
<b>B 335</b>	<i>Zweckenbesatzggürtel (belt ornament)</i>	
<b>B 336</b>	<b>belt shed</b>	

Table A.6: SHKR level B33: Belts

<b>B4: Weaponry</b>	<b>Weapon</b>	<b>Parts</b>	<b>Types</b>
<b>B 41</b>	<b>sword</b>	B 411 sword  B 412 sword chape  B 413 scabbard B 419 others	B 4111 Gündlingen B 4112 Mindelheim B 4113 La Tne Sword B 4114 Iron Hallstatt Sword B 4121 <i>beutel fömig</i> B 4122 with arrows B 4123 axes
<b>B 42</b>	<b>lance or arrow</b>	B 421 lance B 422 arrow	
<b>B 43</b>	<b>dagger</b>		
<b>B 44</b>	<b>sling shot</b>		
<b>B 45</b>	<b>axes</b>		
<b>B 46</b>	<b>Keule</b>		
<b>B 47</b>	<b>shield</b>		
<b>B 48</b>	<b>helmet</b>		

Table A.7: SHKR level B4: Weaponry

<b>B5: Trans- port</b>	<b>Means of Trans- port</b>	<b>Parts</b>	<b>Details</b>
<b>B 51 wagon</b>	<b>B 511 tire</b>	B 5111 wheels	B 51111 four-wheeled B 51112 two-wheeled
	<b>B 512 box and axle</b>	B 5211 Axle-cap B 5212 Axel nail B 5213 box fitting B 5214 terret B 5219 others	
	<b>B 513 yoke</b>	B 5131 yoke B 5132 yoke fitting B 5133 terret B 5134 yoke cap B 5139 others	
<b>B 52 har- ness</b>	<b>B 521 snaffle bit</b>		
	<b>B 522 phalera</b>		
	<b>B 529 others</b>		
<b>B 53 boat</b>			
<b>B 59 others</b>			

Table A.8: SHKR level B5: Means of Transportation

<b>B6: Tools</b>	<b>Category of tools</b>	<b>Shape</b>
<b>B 61 knives</b>	<b>B 611 <i>Hiebmesser</i></b>	
	<b>B 612 razor</b>	B 6121 A one-bladed B 6122 B two-bladed B 6123 C trapezoid B 6124 D half moon shaped
	<b>B 613 simples knives</b>	
	<b>B 619 others</b>	
<b>B 62 toiletry</b>	<b>B 621 tweezers utensils</b>	
	<b>B 622 tweezers</b>	
	<b>B 623 nail clip</b>	
	<b>B 624 scoop</b>	
	<b>B 625 needle etui</b>	B 6251 ring B 6252 wire
	<b>B 626 utensils with hinge construction</b>	B 6261 type Rebbio  B 6262 type Hochdorf B 6263 type Althofweiler B 6264 type Basel Gasfabrik B 6265 <i>moselländlicher</i> type B 6266 type Wederath B 6269 others
	<b>B 629 others</b>	
<b>B 63 barbeque</b>	<b>B 631 cooking grate</b>	
	<b>B 632 coal pan</b>	
	<b>B 633 skewer</b>	
	<b>B 634 fork</b>	
	<b>B 635 spoon</b>	
	<b>B 636 hook</b>	
	<b>B 639 others</b>	
<b>B 64 tools</b>	<b>B 641 anvil and hammer</b>	
	<b>B 642 pincers</b>	
	<b>B 643 axes</b>	
	<b>B 644 drill</b>	
	<b>B 645 saw</b>	
	<b>B 646 file and grindstone</b>	
	<b>B 647 chisel and graver</b>	
	<b>B 648 punch and mould</b>	
	<b>B 649 others</b>	
<b>B 65 textile production</b>	<b>B 651 loom weight</b>	
	<b>B 652 spindle whorl</b>	
	<b>B 653 sewing needle</b>	
	<b>B 659 others</b>	
<b>B 66 small tools</b>	<b>B 661 nail</b>	
	<b>B 662 rivet</b>	
	<b>B 663 hook</b>	
	<b>B 664 clip</b>	
	<b>B 669 others</b>	
<b>B 67 agriculture</b>	<b>B 671 millstone (lower part)</b>	
	<b>B 672 millstone (upper part)</b>	
	<b>B 673 sickle</b>	
	<b>B 674 plough</b>	
	<b>B 675 sickle</b>	
	<b>B 649 others</b>	
<b>B 69 others</b>		

Table A.9: SHKR level B6: Tools

<b>B7: Art and Jewellery</b>	<b>Artefact</b>	<b>Shape</b>	<b>Details</b>
	<b>B 71 large sculptures</b>		
	<b>B 72 small sculptures</b>		
<b>B 73 pendants and amulets</b>	<b>B 731 pendants</b>	B 7311 geometric shaped	
		B 7312 figural	
		B 7313 hollow	
		B 7314 basket	
		B 7315 Jingles	
		B 7319 others	
	<b>B 732 amulets</b>		
	<b>B 733 rings</b>		
<b>B 74 beads</b>	<b>B 741 round</b>		
	<b>B 741 round</b>		
	<b>B 742 oval</b>		
	<b>B 743 cylindrical</b>		
	<b>B 749 others</b>		
<b>B 75 fittings</b>			

Table A.10: SHKR level B7: Art and Jewellery

## Eidesstattliche Erklärung

Die Abhandlung ist - abgesehen von der Beratung durch Herrn PD Dr. Oliver Nakoinz - nach Inhalt und Form meine eigene Arbeit.

Sie wurde weder ganz oder zum Teil schon an einer anderen Stelle im Rahmen eines Prüfungsverfahrens vorgelegt, veröffentlicht oder zur Veröffentlichung eingereicht.

Die Arbeit ist unter Einhaltung der Regeln guter wissenschaftlicher Praxis der Deutschen Forschungsgemeinschaft entstanden ist.

Mir wurde kein akademischer Grad entzogen wurde

Franziska Faupel