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Digitising Patterns of Power (DPP): A Digital Approach towards Recording, Managing, Analysing and Presenting Archeological and Historical Information based on Case Studies from Eurasian Mountainous Regions

ABSTRACT

S. Eichert, B. Koschicek, M. St. Popović 2016. *Digitising Patterns of Power (DPP): A Digital Approach towards Recording, Managing, Analysing and Presenting Archeological and Historical Information based on Case Studies from Eurasian Mountainous Regions,* AAC 51: 257–283.

The aim of this paper is to present an international and multidisciplinary project entitled *Digitising Patterns of Power* (later referred to as DPP), which is funded by the programme *Digital Humanities: Langzeitprojekte zum kulturellen Erbe* of the Austrian Academy of Sciences. The project is hosted by the Institute for Medieval Research of the Austrian Academy of Sciences (its implementation period is 2015–2018). DPP is intended to compare four regions: the Carolingian Eastern Alps (8th–9th c.), the March / Morava–Thaya / Dyje Borderregion (7th–11th c.), the historical region of Macedonia (12th–14th c.), and historical Southern Armenia (5th–11th c.). The team concentrates on aspects such as: the depiction and analysis of space and location in medieval written sources, the interaction between developed and natural environment, the usage of space, and the emergence of new political, religious and economic structures of power. DPP is implemented within the framework of the programme *Digital Humanities: Langzeitprojekte zum kulturellen Erbe* of the Austrian Academy of Sciences. We are certain that the outcome of the project will render interesting results and insights, not only for the researchers focusing on the four aforesaid regions, but also for all those who seek new methods for investigating the past of our continent.

Key words: Early Middle Ages; Carpathian Basin; Balkan peninsula; Caucasus; Digital Humanities; History; Medieval History; Global History; Historical Geography; Archaeology; Spatial Analysis; Cartography; GIS; GIScience; WebGIS; Software Engineering

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INTRODUCTION

The project *Digitising Patterns of Power* (in the following DPP) is funded within the programme *Digital Humanities: Langzeitprojekte zum kulturellen Erbe* of the Austrian Academy of Sciences (Österreichische Akademie der Wissenschaften; ÖAW) for the duration of four years (1 January 2015-31 December 2018; Project Leader: Doz. Mag. Dr. M. St. Popović)[1]. It is hosted at the Institute for Medieval

[1] http://dpp.oeaw.ac.at/ (accessed 30 May 2016).

Research (Institut für Mittelalterforschung; IMAFO)[2] of the ÖAW and unites as a Cluster Project various experts from the fields of Medieval History, Byzantine Studies, Historical Geography, Archaeology, Geography, Cartography, Geographical Information Science (GISc) and Software Engineering.

DPP focuses on the depiction and analysis of space and place in medieval written sources, the interaction between built and natural environment, the appropriation of space and the emergence of new political, religious and economic structures of power. DPP compares four regions of the Medieval World (Fig. 1): the Carolingian Eastern Alps (8th–9th c.), the March / Morava–Thaya / Dyje Borderregion (7th–11th c.), the historical region of Macedonia (12th–14th c.) and historical Southern Armenia (5th–11th c.).

In order to achieve the aims of the project the Team from the Institute for Medieval Research (Austrian Academy of Sciences) is cooperating with an external project partner, namely the Team Department of Geography and Regional Research (University of Vienna)[3]. Moreover, DPP is drawing amongst others on the expertise of the renowned project *Tabula Imperii Byzantini* (*TIB*)[4] on the historical geography of the Byzantine Empire (Koder 1996; Popović 2010; 2014), which was included into the scheme of excellent Long-Term-Projects at the Austrian Academy of Sciences in 2015 and became a member of the Union Académique Internationale in Brussels in the same year[5], and on the former project *The Eastern Alps revisited — Continuity and Change from Late Antiquity to the Middle Age* (Austrian Science Fund, Project No. P24045; duration: 1 January 2012-31 December 2014)[6].

Thus, DPP is a cutting edge project within Digital Humanities and uses as well as develops digital tools for data-acquisition, data-management, processing as well as for analyses, visualisation, communication and publication. By following such an approach, DPP envisages at gaining new insights and innovative research-results, which could not be achieved based solely on traditional methods.

THE CASE STUDIES

Four case studies of the European (resp. Asian, depending on the definition) Middle Ages furnish insights in the development and sustainment of power in a spatial context. A focus is put on mountainous areas and the interaction of human development of power and natural environment. Research highlights of the four case studies in the year 2015 are as follows:

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[2] http://www.oeaw.ac.at/imafo/ (accessed 30 May 2016).

[3] *Cf.* on both teams of the project: http://dpp.oeaw.ac.at/index.php?seite=Team (accessed 30 May 2016).

[4] http://tib.oeaw.ac.at/ (accessed 30 May 2016).

[5] http://www.uai-iua.org/fr/projects/104/tabula-imperii-byzantini (accessed 30 May 2016).

[6] http://www.oeaw.ac.at/imafo/arbeitsgruppen/fruehmittelalter/projekte-historische-identitaets-forschung/einzelprojekte/ostalpenraum-revisited/ (accessed 30 May 2016).

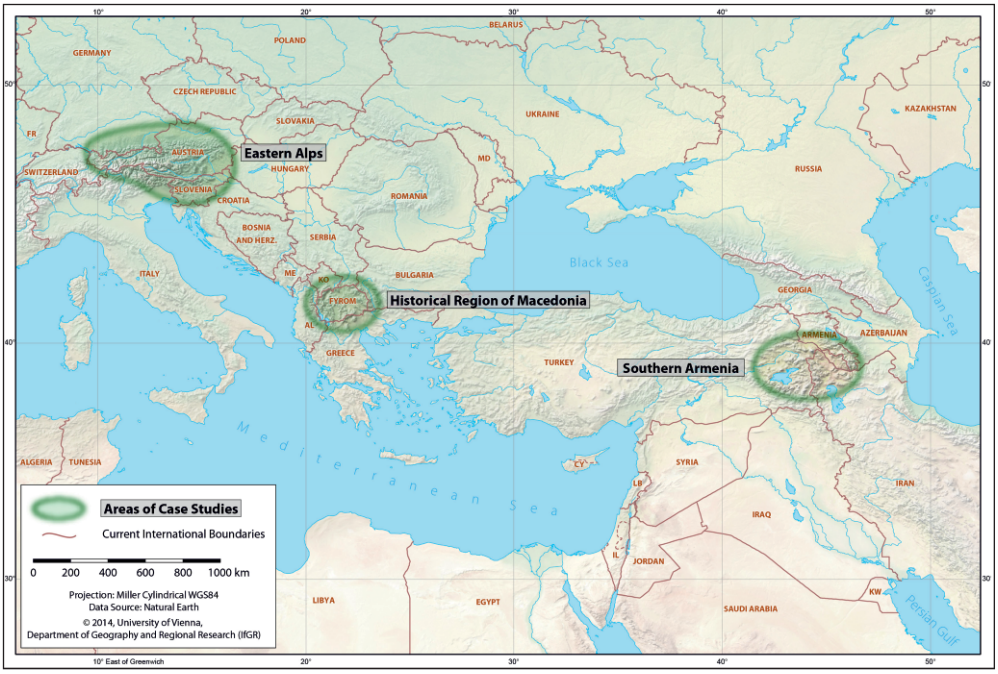

Fig. 1. Digitising Patterns of Power. Areas of Case Studies; prepared by the University of Vienna, Department of Geography and Regional Research.

Case Study No. 1.
The Carolingian Eastern Alps (8th–9th c.)

This case study[7] carves out the different structures that were established in respectively (a) the Late Roman Empire, (b) the Carolingian expansion (8th–9th c.) and (c) the medieval "Binnenkolonisation" (interior colonisation) of the Eastern Alps region starting from the 10th c. (Fig. 2). Furthermore, questionable historical concepts of land-seizure are investigated, thus creating a new explanatory framework for processes of expansion — decline — appropriation — transformation and organisation of space (De Jong 2001) in this area. The case study builds on the large data-pool already gathered by the IMAFO's Project *Eastern Alps Revisited* (see above) and expands it geographically and chronologically (Eichert 2012; Winckler 2012).

Digitalisation and/or extraction of the relevant information of selected charters of bishoprics and monasteries that were established in the region (Salzburg, Freising, Brixen, Gurk, Mondsee, Kremsmünster, Admont etc. and other institutions) as well as royal and ducal charters from the 8th–12th c. will be done. The extracted information comprises people in all their interconnections

[7] The scholar responsible for this part of the project: K. Winckler.

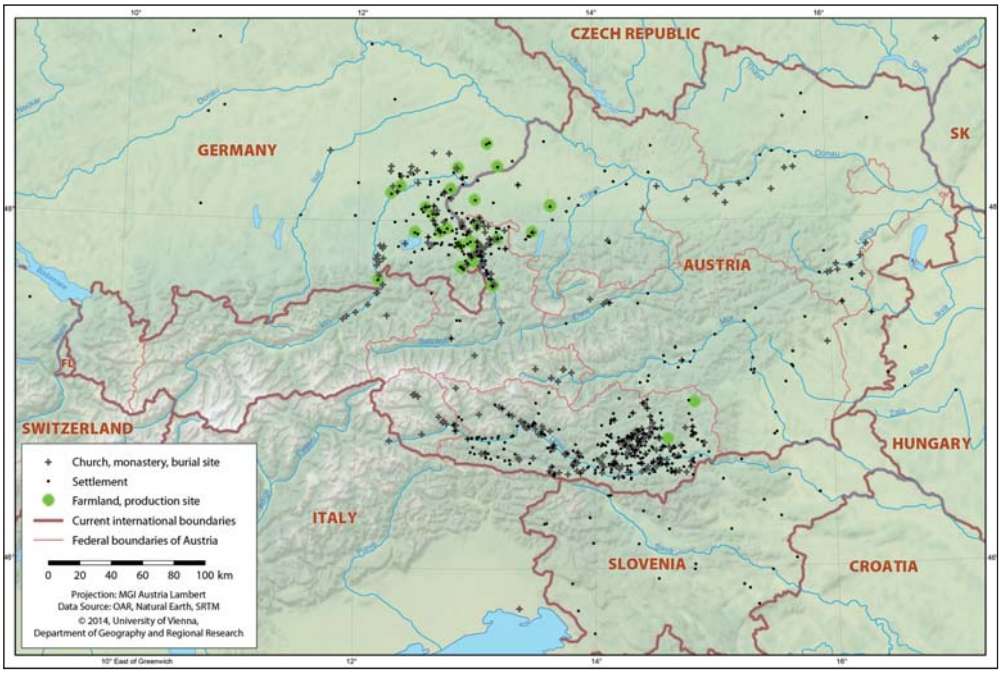

Fig. 2. Early Medieval Sites from Archaeological and Historical Sources collected in the OAR-Project Database; prepared by the University of Vienna, Department of Geography and Regional Research.

as well as places including economic and agricultural entities in order to find and analyse transformations of space.

In the year 2015 this case study was developed in several directions. Firstly, specific areas ("hotspots") were defined in order to create test-cases for the database, the geographic information system and the cross-project research questions. Thus, the case study will focus until mid-2016 on the test-case *Distant Property of the 8th and 9th cent. Bavarian Bishoprics containing Vineyards*. Vineyards are an excellent example for the display of power: vine was a prestigious good that required distant property and the produced goods needed an elaborate system of transportation and agricultural organization.

In 2015 matching areas were identified (Southern Tyrol, the area to the north of Regensburg, Wachau), corresponding sources collected and, partly, entered into the first version of the DPP OpenAtlas Database[8].

[8] Literature concerning the environmental history of these areas was collected and results will be presented at the International Medieval Congress (IMC) in Leeds (4–7 July 2016). Secondly, the general research questions regarding space and power in early medieval Bavaria were addressed in several works. Thirdly, contact was established with Ass.-Prof. Dr. Giuseppe Albertoni (Università degli Studi di Trento, Italy), who works on episcopal property in early medieval Trentino — Alto Adige, and was further enhanced.

Case Study No. 2.
The March / Morava–Thaya / Dyje Borderregion (7th–11th c.)

The project DPP, and especially Case Study No. 2[9], was extended by another case study concerning the Morava–Thaya border region and its development from the Early to the High Middle Ages. It is carried out by S. Eichert in cooperation within an international project of the University of Vienna (Institute of Prehistory and Historical Archaeology) and the Masaryk University Brno named *Frontier, Contact Zone or No Man's Land?*[10].

The cooperation is focusing especially on the "digital" part, and both projects (DPP and *Frontier, Contact Zone or No Man's Land?*) will benefit from the synergies. The collected data as well as the technological and methodological developments will be available for both teams. Only recently an additional cooperation with the Constantine the Philosopher University Nitra in Slovakia has been established. As a result, sites from the Slovakian part of the border region will also be included and available for further analysis within DPP.

The rivers Dyje / Thaya and Morava / March today define large parts of the border between Austria, the Czech Republic and Slovakia (Kelemen, Oberleitner [ed.] 1999). In the past this border region underwent serious transformations that culminated in the fall of the Iron Curtain. Fortunately, the frontier has again become permeable for interaction, exchange and communication. Also for the Early Middle Ages serious transformation processes can be observed and — depending on the context — the Morava-Thaya-region is seen as frontier, as contact zone or as no man's land (Měřínský, Zumpfe 2004; Daim 2007 [ed.]), where in different periods different systems meet:

For the 6th and 7th c. no real border can be seen. This changes in the 8th c., when a separation of different systems — subsumed under the terms Slavic and Avar — takes place. In the 9th c. there is the Carolingian Empire in the south-western and Great-Moravia in the north-eastern part. Due to the Hungarian raids and also because of ecological changes the region lives through regression in the 10th c. However, only a few decades later new settlements flourish aside from the old centres. Finally, in the 11th c. the region evolves to a border triangle between Přemyslid Moravia, Árpád Hungary and the Babenberg march.

These political and social entities have left certain Patterns of Power in the landscape. Due to the lack of historical sources in this case study the focus will be put on archaeological sources. Based on the data and results of an ongoing international research project the respective Patterns of Power will be reconstructed and visualised using a broad variety of analyses.

Though the area under study is not especially mountainous, this case study will serve as a comparison to the other areas of research in order to elaborate on terrain specific or terrain independent developments.

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[9] The scholar responsible for this part of the project: S. Eichert.

[10] http://homepage.univie.ac.at/stefan.eichert/gkn/ (accessed 30 May 2016).

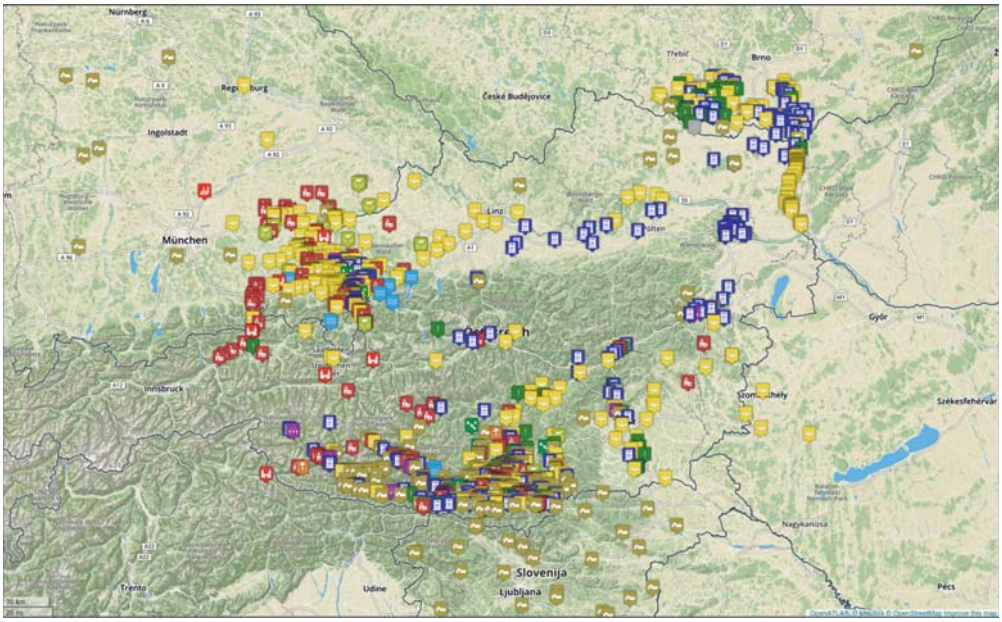

Fig. 3. Archaeological Sites from the Morava–Thaya Border Region; prepared by S. Eichert.

During the first year of the project DPP several dozens of hitherto known archaeological sites from the Morava–Thaya border region from the 7th to the 11th c. were collected and stored in the DPP OpenAtlas Database (Fig. 3). The collection contains information on the site itself, its features and the respective finds, as far as they are excavated and published, including figures and images, if they are available.

In order to categorise the various entities, a "thesaurus" for early medieval categories of sites, features, stratigraphical units and finds has been developed. It also includes common terms for chronological, typological, material etc. information.

A huge number of original finds made of copper-alloys was analysed in cooperation with the Vienna Institute for Archaeological Science (VIAS) through the scanning with an electron microscope (SEM). Digital 3D-models of these finds were made using photogrammetric methods by the specialists of *Crazy Eye*[11]. The methods and results will be published in the upcoming volume of *Archäologie Österreichs*.

In the wake of the archaeological part of the Eastern Alps case study the already existing data collection was completed by adding the Early Medieval sites from Styria, Lower and Upper Austria using the same framework as described above (Fig. 3).

[11] http://www.crazyeye.at/ (accessed 30 May 2016).

Case Study No. 3.
The Historical Region of Macedonia (12th–14th c.).
The Transformation of a Medieval Landscape

This case study[12] builds upon the manifold data provided by the author's volume *TIB* 16 *Macedonia, Northern Part*[13] and focuses on the territory of today's (FY)R Macedonia. The historical region of Macedonia, being at the crossroads of Orthodoxy, Roman Catholicism and Islam in the heart of the Balkan peninsula, is described in a huge variety of written sources of the past and is distinguished by a remarkable richness of monuments (that is Cultural Heritage), especially for the period from the 12th to the 14th c. (Koder 2000).

This case study within the project DPP concentrates on the transformation of the historical region of Macedonia from a Byzantine province into an area of military expansion and political acquisition by the Serbian medieval empire. This process had a direct impact on the settlement patterns in the region, the re-distribution of landed property, the monastic communities, the interplay between the resident population and nomads (especially the Vlachs) and the building of new infrastructure (that is monuments). Of special interest are the administrative centres and the venues of medieval state councils (as in-between category of temporary and durable places of settlement) of the Serbian rulers from the 12th to the 14th c. (Popović 2015a).

Following the idea of the aforesaid "hotspots", research is conducted by M. St. Popović and his scholarly co-workers, B. Koschicek and D. Schmid, on four target areas (Fig. 4), namely on the city of Skopje and its environs, on the monastery of Lesnovo and its landed property, on the city of Prilep and its surroundings and on the valley of the river Strumica. In the first year of the project DPP M. St. Popović and his student assistant D. Schmid have begun with research on two target areas, i.e. on Prilep and on Lesnovo.

Firstly, they evaluated three extensive medieval Slavonic charters of the Serbian king Stefan Uroš IV Dušan for the monastery of Treskavec near Prilep dated to the years 1334/35, 1343/44 and 1344/45 respectively. By comparing different scholarly editions of the charters and by extracting data from these written sources (e.g. on the settlement patterns in the respective regions, on nomadic groups, on the disempowerment of local magnates and the redistribution of landed property to new landlords etc.), which is of fundamental relevance for the research question of DPP, they prepared a core of source related material, which was then enriched by studies on the networks of transportation in the region in accordance with maps from the 19th and 20th c. and travel accounts from the 18th and 19th c.

On this very basis D. Schmid has started with the input of the respective data into the first version of the DPP OpenAtlas Database. A focus was put on

[12] The scholar responsible for this part of the project: M. St. Popović.
[13] http://tib.oeaw.ac.at/index.php?seite=status&submenu=tib16 (accessed 30 May 2016).

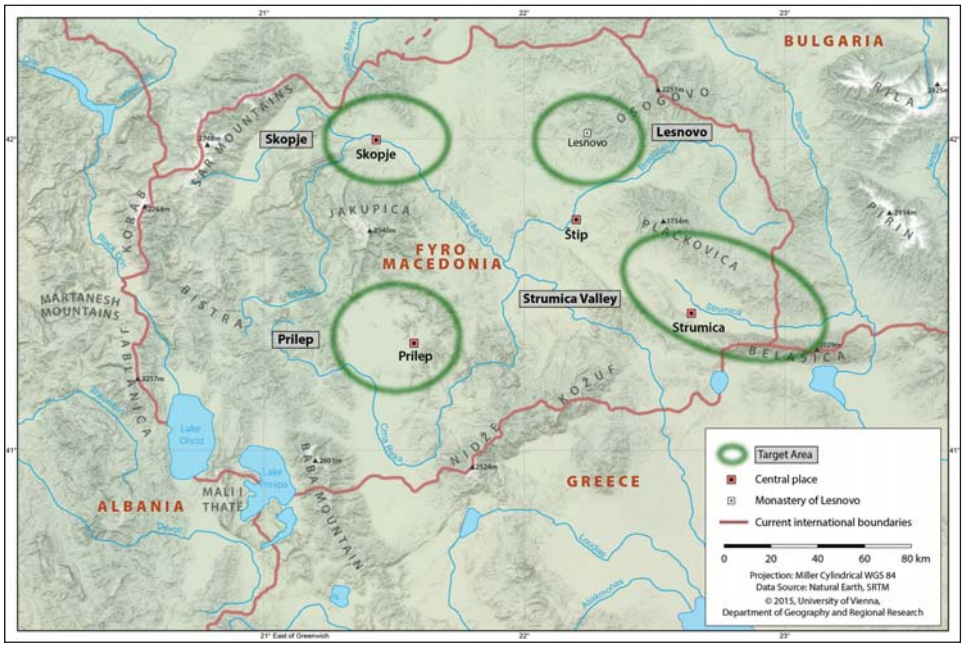

Fig. 4. The Four Target Areas of the Case Study No. 3; prepared by the University of Vienna, Department of Geography and Regional Research.

data referring to vineyards and (water)mills, which will be the common theme of the presentation of DPP at the International Medieval Congress (IMC) in Leeds (4–7 July 2016). This approach will help to shape substantially the joint research tasks of DPP in 2016.

Secondly, M. St. Popović has started with the collection and evaluation of medieval written sources on the monastery of Lesnovo. For the time being, he is focusing on the nomadic groups (i.e. Vlachs) in the region and the localisation of their seasonal dwellings. Relevant cartographic material, GPS waypoints, GIS-based data, shapefiles etc. were made available to the Team Department of Geography and Regional Research in order to facilitate the creation of a digital base map for DPP for the envisaged WebGIS.

Case Study No. 4.
Historical Southern Armenia: the "Rise and Fall" of Vaspurakan (5th–11th c.)

Based on the identification of central categories of analysis and data collection developed together with the other case studies (see above), a survey of the most important source corpora was undertaken, especially of the Armenian chronicle of T'ovma Arcruni and other written evidence as well as of the systematic catalogue of medieval sites and monuments (Thierry 1989)[14]. From the latter a digital

[14] The scholar responsible for this part of the project: J. Preiser-Kapeller.

data set of localities and geo-data was created in order to localise main areas for intensive research ("hotspots"), also for the geo-visualisation in cooperation with the Team Department of Geography and Regional Research. Further digital and analogue data sets for topographical conditions of the Lake Van area were collected as basis for additional layers to the geo-analysis. The textual sources were analysed with regard to specific human interventions into the landscape (buildings, agricultural and economic activities, movements) and their terminology in the ancient Armenian text to provide a basis for comparative considerations together with the other case studies. For a first in-depth local study, the region around the city of Van and its installations of artificial irrigation (stemming from the 9th c. BC) were selected, also as test case for a geo-visualisation. First results of these studies were presented at the University of Hamburg in 2015 and will be presented at the International Medieval Congress (IMC) in Leeds.

METHODOLOGICAL BACKGROUND

All of the aforementioned case studies have their respective research questions which are developed and investigated individually on a micro-level. However, there is common ground on a macro-level, which enables their comparison in order to make similarities or differences visible.

Central questions concern the correlation between space and power: How can we identify *Patterns of Power* in the landscape and how are they characterised? How can we interpret them concerning appropriation of power, its retention and transfer, its representation as well as the loss of it?

DPP combines written and archaeological evidence on physical entities (e.g. settlements, monuments, fortresses, up to entire landscapes etc.), events and involved actors and investigates the interconnections. One important goal of this approach is to shed light on the various levels of the observed *Patterns of Power* by investigating the assemblage of these elements in time and space. The perception, depiction and organisation of spaces and places in the Middle Ages encompass an interdisciplinary research field, which helps us to understand historical processes and relations. However, traditional representations of space like paper maps often fail to capture the complex and dynamic nature of spaces and places. Digital tools allow more dynamic and multi-scale representations of historical space and spatial phenomena and relations (Schobesberger, Cartwright 2013).

DPP brings together expertise from historical and archaeological research as well as Digital Humanities in the field of spatial representation and communication in order to explore medieval geographies. Via the aforementioned regional case studies, generalisable workflows and methodology, as well as digital communication and dissemination strategies are developed.

Central research topics are the perception, depiction and organisation of space in medieval texts, the interplay between built and natural environment (Howe, Wolfe 2002; Arnold 2013), the appropriation of land and the subsequent

installation of new power-structures (Sack 1986). In order to overcome old paradigms (Corradini 2006), new conceptions of appropriation, transformation and creation of space and places of power are evaluated: By digitising selected written sources as well as material evidence and by amalgamating them into a common spatially referenced database, further research-oriented analyses with digital tools become possible. Digital methods can identify the patterns of influence, untangle and re-trace complex processes and make networks of power visible. Phases of and reasons for the decline and increase of external control over regions as well as autonomous tendencies will thereby become clearly observable.

In the wake of the DPP-Workshop in September 2016 (see below) entitled *Digitising Patterns of Power: Theory and Practice in Historical Geography and Digital Humanities* the crucial research question shall be addressed and discussed, if and how *Patterns of Power* can be identified in all four case studies based on the written and archaeological sources. Furthermore, it will be debated, if common ground for all case studies can be achieved on this respective question, which shall lead ultimately to a dynamic type *Symbol of Power* or *Sign of Power* in the DPP OpenAtlas Database and which shall be visualised in the envisaged DPP Map Viewer (see below).

In Case Study No. 3 *Symbol of Power* or *Sign of Power* should be applied for a better and more profound understanding of the Serbian conquest of Byzantine Macedonia in the 14th c. The correlation of the dynamics of settlement patterns and of changing borders is evident. Several scholars have tried to reconstruct the course of the border between the Serbian kingdom / empire and the Byzantine Empire on a macro-level for the whole historical region of Macedonia. However, these approaches have so far neglected to use data on the development (e.g. from hamlet to village) or on the degradation (e.g. from village to deserted village) of settlements deriving from medieval Byzantine and Serbian Slavonic charters in order to comprehend the dynamics of the respective borders on a micro-level. Moreover, a very vivid proof for the change of elites in Byzantine Macedonia, i.e. the flight or the expropriation of the Byzantine nobility and the establishment of the Serbian nobility, which is described in medieval Byzantine and Serbian charters, is the term of *exaleimma* (in Greek ἐξάλειμμα). *Exaleimma* indicates "ruined properties", which reverted to the owner's lord (a private landlord or the state in its role as a landlord) as a result of the death or flight of its owner without leaving a proper heir.

So far, basing on M. St. Popović's research on locating and interpreting settlement patterns — and here specifically deserted villages and ruined properties as traces of destruction and of expropriation in the wake of the Serbian conquest of Byzantine Macedonia — nodes of change can be mapped (Fig. 5) and corridors of expansion identified (Fig. 6).

From the viewpoint of Case Study No. 3 such an approach would form a useful basis for a discussion with the aim to achieve a common ground for the dynamic type *Symbol of Power* or *Sign of Power* (Popović 2016a; 2016b).

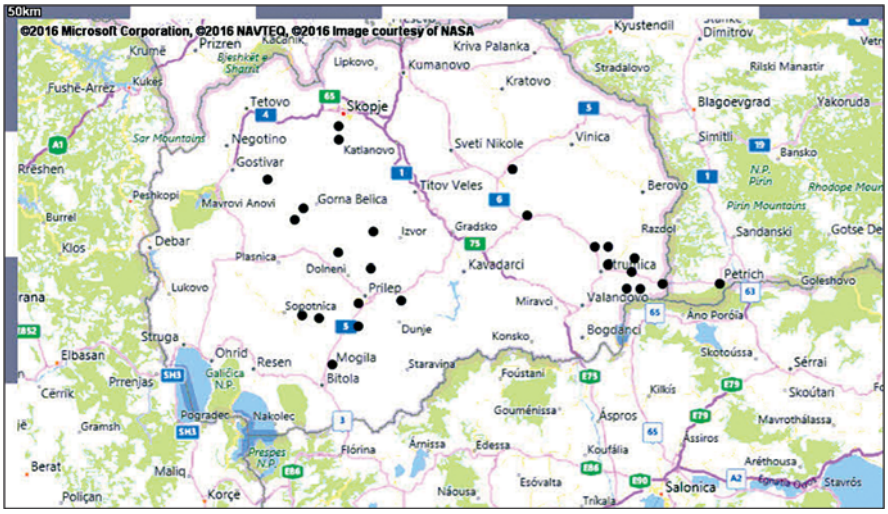

Fig. 5. The Serbian Conquest of Byzantine Macedonia — Nodes of Change; prepared by M. St. Popović.

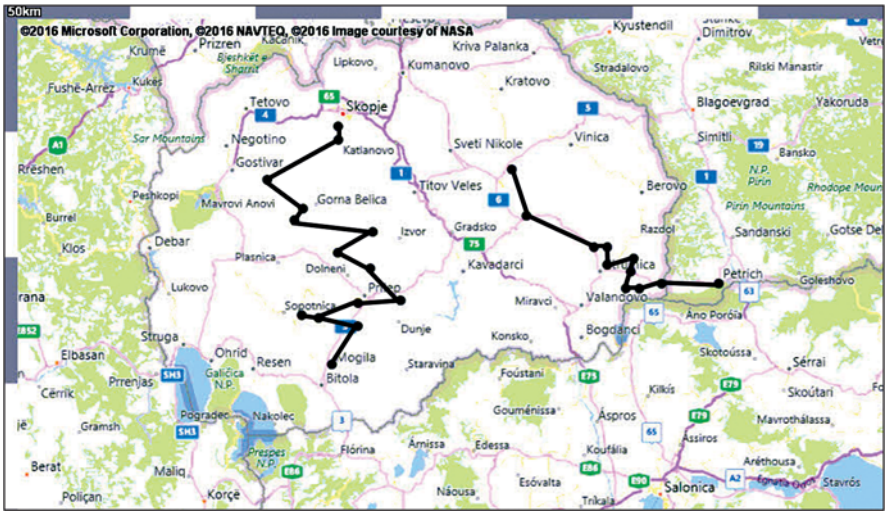

Fig. 6. The Serbian Conquest of Byzantine Macedonia — Corridors of Expansion; prepared by M. St. Popović.

THE DIGITAL ASPECT OF DPP

In the field of Digital Humanities there is an ongoing discussion on the definition of what Digital Humanities actually are. It is not surprising that there is not a single definition, but that there are manifold approaches to the topic (Gardiner, Musto 2015).

Digital Humanities in History and Archaeology is often understood as digital documentation of sources. This can be the scan of a medieval charter, the 3D model of an archaeological artefact or the virtual reconstruction of a monument and many more. Of course, this requires great technological expertise and it mostly belongs to the methodological part of our disciplines. Apart from digitising physical things, the acquisition of historical data and their interconnections within a suitable data model is important as well.

Closely connected to this aspect is also the presentation and visualisation of our sources and research results. Doing this digitally is considered to be a very important part of Digital Humanities. Interactive maps, virtual tours, 3D models of artefacts up to whole landscape visualisations and statistics on the web are very much appreciated by the scholarly community and the interested public.

DPP aims at fulfilling these tasks regarding Digital Humanities. Apart from the development of the OpenAtlas Software[15] and the digital data acquisition, which will be carried out with this tool, we focus on digital visualisation and publication with special focus on geocommunication of our data and results. In order to achieve these results, we use various classical methods as well as a broad variety of digital analyses.

THE OPEN-SOURCE DATABASE SYSTEM OPENATLAS

DPP uses information coming from a very heterogenous data pool and stores it in a combined database in order to analyse the data with various methods. One important aim is to investigate the various types of information not isolated, but in combination with each other. Therefore, DPP uses the OpenAtlas database system, which is also developed further within the project. OpenAtlas is an open source software for the work with data mainly of archaeological and historical evidence and it stores information on physical things, actors, temporal entities and their respective sources (Eichert 2014). It is based on classes and properties of the CIDOC-CRM[16], which is an international standard for Cultural Heritage documentation (Crofts *et al.* [eds.] 2011). This object-oriented reference model is used to record all necessary information and the interconnections between various entities.

In this data-model an archaeological site is for example represented by a network of nodes and links that are specified by the aforementioned CRM classes and properties. This network comprises physical things like artefacts, monuments, buildings, natural environment and spatial information like the dimension, shape and location of these objects that are linked to chronological information or to certain events like phases, the creation or destruction of a settlement and others that can again be linked to actors like persons, groups or legal bodies

[15] www.openatlas.eu (accessed 30 May 2016).

[16] www.cidoc-crm.org (accessed 30 May 2016).

that participate at or perform these events. All of these entities can also be linked to information objects like texts, images etc. Therefore, from a conceptual point of view, it is highly compatible and sustainable on an international level (Fig. 7). Regarding the technological framework the data is primarily stored in a PostgreSQL and PostGIS database and, thus, fulfils the state of the art of technical standards in this respective field.

Of course, such networks are at first sight very complex and might seem very confusing to scholars coming from Humanities. So the network does not have to be created by the user, but is made automatically by the software. The user simply enters information in a graphical user interface, draws polygons or points on a map and the nodes and links are inserted and updated automatically.

This network can be expanded and it is possible to dynamically enlarge it with more nodes and links that might be needed concerning the respective research questions. The open and established data standard allows to connect the data also to other projects or to provide them as linked open data. Overall classes like actors, physical things etc. and their interconnections are predefined by the CIDOC-CRM. Apart from this classification into basic classes, which is given by the software and allows a high compatibility to other projects on a general level, the user can customise and individually adapt the model to his or her requirements using user-defined types that can be linked to nearly all entities in the database.

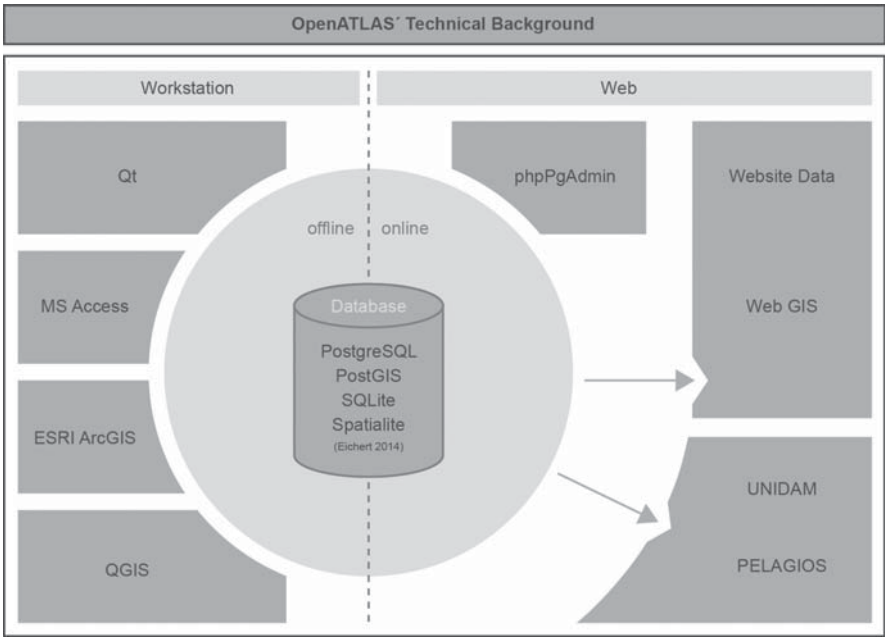

Fig. 7. The Technical Background of OpenAtlas; prepared by S. Eichert.

Thus, there is a basic ontology that can be customised and adapted individually by the users (Labrador 2012).

An archaeological artefact like a sword for example would be represented in the database as an entity of the CIDOC CRM class "Physical Object". This, however, does not tell us anything about the purpose and the type of the artefact. Users can therefore create their own categories that are organised hierarchically (with parent child relations between them) and link them to this entity (and of course others too). The physical object in this case could be linked to the "type" entity "spatha". "Spatha" can again be linked hierarchically (as a child) to "sword". "Sword" would be a child of "offensive weapon" and so on and so on. In this way it is possible to categorise the data on a very detailed level and still carry out comparisons on a general level. In the aforesaid case for example, "spatha" is a sub-category of "offensive weapon" and, therefore, a search for all "weapons" would also include the "spatha" and possible subcategories.

OpenAtlas is entirely designed as open source tool. The database backend is based on PostgreSQL with the PostGIS extension. Thus, it can be connected to all common GIS-applications and fullfils all requirements for further GIS-visualisations and analyses.

The interaction with the database happens via a graphical user interface, which is web based and can be accessed via any common browser. The main components are PHP, Javascript, HTML5, Zend Framework and Leaflet. The application runs on an Apache2 webserver. Since April 2016 the project is hosted on GitHub[17] and the documentation, bug-tracking, project planning, documentation and wiki are based on Redmine[18].

With OpenAtlas DPP aims at creating a tool to depict past realities in a database. It is intended to fit to the project's requirements and can be customised individually. It is also important for us to create an application that hopefully will be useful for others too and to develop it as free and open source software. By using the CIDOC-CRM a high compatibility on a general level is intended, while by using individual types a high level of customisation is possible at the same time.

SOFTWARE AND DATABASE ENGINEERING IN 2015

In the first year of DPP S. Eichert and the software engineer A. Watzinger have finished the first version of the DPP OpenAtlas Software, which enables a Database System for Object Oriented Modelling of the Past (Fig. 8).

A database backend was designed in PostgreSQL and PostGIS, using CIDOC-CRM for the data model. Additionally, a web interface for inserting and editing

[17] https://github.com/craws/OpenAtlas (accessed 30 May 2016).
[18] http://redmine.craws.net/projects/uni/wiki (accessed 30 May 2016).

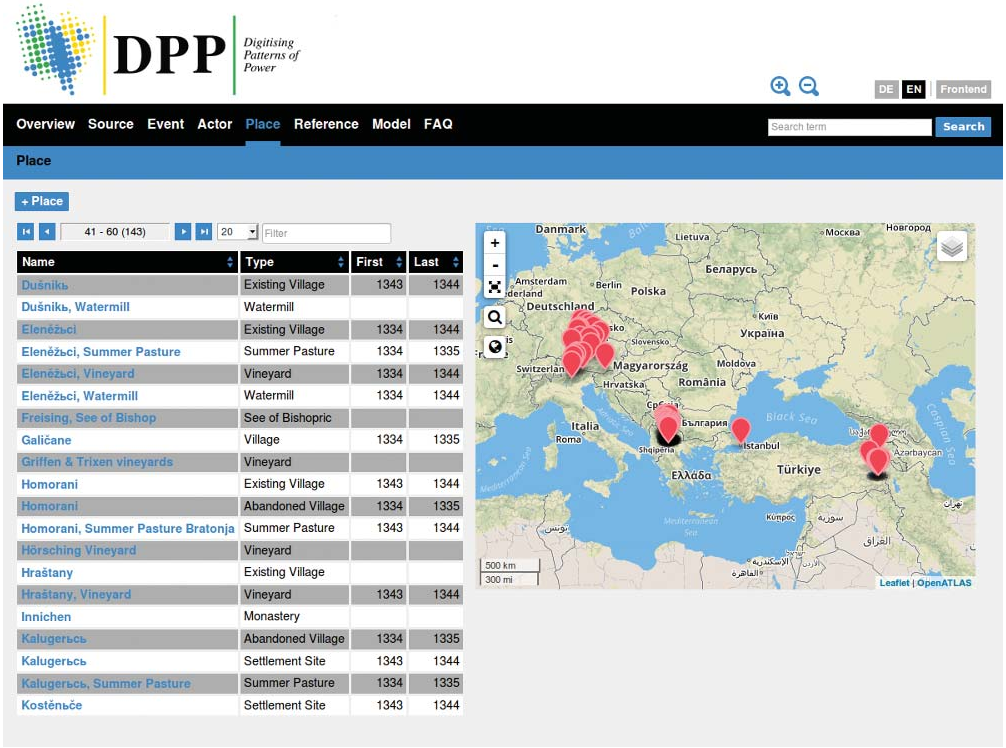

Fig. 8. The Web Interface of the DPP OpenAtlas Database;
prepared by S. Eichert, B. Koschicek, A. Watzinger, M. St. Popović.

data was created using standard technologies such as HTML5, PHP and JavaScript (Fig. 9).

At this stage the software offers the functionality to record information on actors, places, sources and events as well as their interdependencies. In order to enable users to work with spatial data, a map interface was implemented using the Leaflet library and OpenStreetMap data.

The next features to be developed in 2016 will be:

1) functionality to draw geometries directly in the browser for the localisation of places;
2) graphical visualisation of the entities' respective networks;
3) file upload and display of image data;
4) advanced queries as well as import and export of data[19].

[19] Since 1 November 2015 the Junior Scientist B. Koschicek has joined the DPP team at the IMAFO and acts, amongst others, as historian, server administrator, website developer and software engineer for the stand alone application.

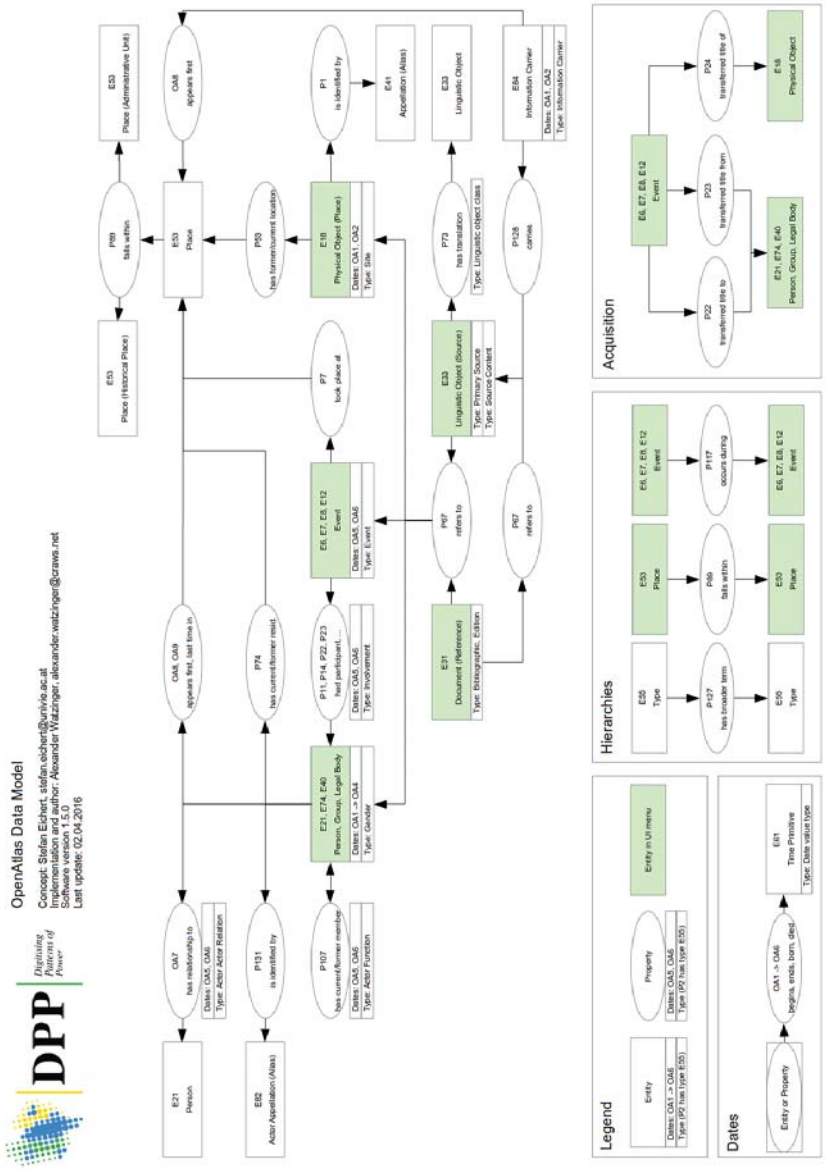

Fig. 9. The DPP OpenAtlas Data Model; prepared by S. Eichert, A. Watzinger.

REPRESENTATION OF SPACE AND SPATIAL FUZZINESS

As "space" and its relation to power are an essential part of our research, the spatial representation of the various entities, which are found in our sources, is a very important topic in DPP and closely related to the conceptual framework and data model.

Where possible, the precise location of physical things is recorded in the DPP OpenAtlas Database. Technically, this is achieved by using point, line and polygon geometries provided by PostgreSQL's GIS extension PostGIS. For the envisaged visualisation these vector data can be shown on various raster layers. From a technical point of view everything that modern GIS-software offers regarding geometries, is also possible within OpenAtlas — from one dimensional point coordinates to three dimensional meshes (Gregory, Ell 2007, 23).

In many cases though the medieval sources are not very accurate and often it is not possible to determine exactly the spatial position or extent respectively shape of the entity mentioned. The same can be said about archaeological finds. Especially, if they have been excavated a long time ago and not with modern methodology, we often lack substantial information on their original place of deposition.

Apart from the geographical (or spatial) fuzziness of one location also the general identification of an entity mentioned in the sources with a certain single place is not possible. Often there is more than one possible location for one entity. A charter, for example, may mention one settlement by its name, but today two villages in the vicinity may exist, which originate from the first, historical one.

This geographical fuzziness and general uncertainty (Kacprzyk, Petry, Yazici [ed.] 2010; Chiles, Delfiner 2012) is a remarkable challenge in Digital Humanities. It affects our work in DPP especially in two ways: On the one hand various qualities of spatial positioning are necessary to select sites for spatial analyses and filter others, whose position is not accurate enough. On the other hand it also plays an important role in the visualisation and public presentation of our data via a web-application with a cartographic interface respectively interactive online map.

Depending on the scale of the map, places in most cases can best be represented by dots. They have the same symbol-size, regardless the zoom level, and can be clustered, if there are too many of them in one specific area. Also if a place's location is stored in the database via a polygon, which marks its extent or the approximate area the place is located in, the center coordinate of this polygon can be shown as a dot. On small scales geometries like polygons would be invisible because their extent is so small compared to the area shown on the map. So, dots or symbols are used to show the locations of our sites on small scales.

Places, however, are not one dimensional, but have a certain extent or an area in which they are located. With OpenAtlas we also record these shapes. On large scales they are not displayed as dots anymore, but shown in the way in which they were drawn. We distinguish two cases here: On the one hand we might know the exact shape of the entity, e.g. the ground plot of a church drawn after an aerial photograph. On the other hand we might only know the approximate

area the place has been located in, which is drawn as a polygon, too. In the first case the place is shown as a dot at small scales and, beginning with a certain zoom level, as a polygon. The second case is similar, but at certain zoom levels, where the extent of the polygon is almost bigger than the map tile, the polygon vanishes and is replaced by textual feedback, which informs that somewhere inside the visible area the respective place is located at an unknown position.

To sum up, there are two big challenges regarding the spatial position of physical things:

Spatial fuzziness and uncertain identifications of places mentioned in the sources with real places. OpenAtlas and its database backend can of course not fill in missing information and deliver answers, which the scholars do not know themselves. However, in order to distinguish various spatial qualities DPP has developed a framework for the spatial position of physical things and their representation in the database:

In our sources there are mainly three classes of these entities:

1) physical things like buildings, settlements, regions, areas etc. that have or originally had a position in space and a certain extent;
2) roads / routes / rivers that have or originally had a position in space and a certain extent;
3) (find-)spots with no spatial extent that have only point coordinates.

Regarding the identification of a physical object with a spatial position / extent we distinguish various possibilities (Figs. 10–11).

Case 1 The extent is known and can be drawn as a polygon that represents the extent=shape of the respective physical thing.
E. g. the shape of a building or the area of excavation or the area of a settlement, that can be drawn for example from an aerial photograph or a map respectively, comes directly from on site measurement.

Case 2 The extent is not known, but can be located within a larger area with a known extent that can be drawn as a polygon.
E. g. a no longer existing settlement that is known to have been situated within a known area for example in a valley between two other known settlements.

Case 3 The extent is not known, but known to have been within a larger predefined area with known extent that is already in the database.
E. g. an archaeological findspot of unknown position that is known to have been situated inside the boundaries of a certain administrative unit.

Case 4 The extent is not known, but known to have been within a larger area with an unknown extent that cannot be drawn as a polygon.
E. g. a no longer existing settlement that is known to have been situated within an historical boundaries of a no longer existing county.

Case 5 There is no extent, but only a known centerpoint.
E. g. the coordinates, where an object has been found.

Case 6 Neither the extent nor a vague position within a reasonable larger area are known.

Fig. 10. Various Possibilities of Spatial Positioning; prepared by S. Eichert.

Within this framework we want to record the spatial position as accurate as possible. However, we also do not want to imply a certain accuracy that does not exist, e. g. by displaying places with uncertain position as dots. Also changes of the extent / shape can be documented and linked to temporal entities like phases (see below).

Depending on the spatial quality, we plan to carry out GIS analyses in a next step in order to gain new insights on the *Patterns of Power* that are represented by or in these places. This comprises site catchment, viewshed-analyses, predictive modelling, cost-surface and least-cost-path calculations, cluster and density analyses and many more (Wheatley, Gillings 2002; Conolly, Lake 2006; Gregory, Ell 2007).

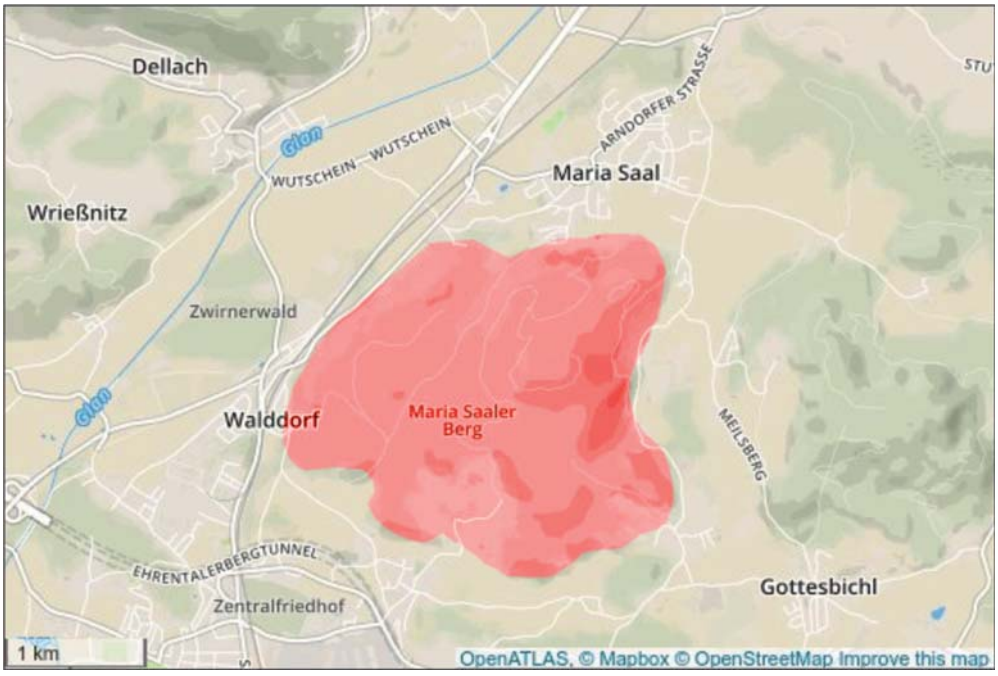

Fig. 11. Various Possibilities of Spatial Positioning; prepared by S. Eichert.

REPRESENTATION OF TIME AND CHRONOLOGICAL FUZZINESS

Apart from the entities' geographical location in space, also their chronological position in time is of special interest for DPP. As one might imagine, there are even more uncertainties regarding the chronological position of temporal entities in time (Virant 2000).

The data model used in DPP distinguishes between physical things (like places / settlements / buildings etc.) and temporal entities that may be connected to them. These entities can be one time events, phases, relationships and many more. The "life span" of a settlement could for example be such a temporal entity. This life span begins and probably also ends at certain points in time. The chronological information available though is rarely so precisely defined. Often we only know something like: "first half of the 10th c.", "not before 955" or "somewhen between 800 and 814" (Virant 2000, 125ff.).

In order to be able to use chronological information for analyses, they have to be stored in a numeric format and not as a descriptive text. The same is true for spatial positions, for which OpenAtlas cannot provide missing information and give answers to chronological questions, which the sources themselves do not answer. It tries to offer possibilities to record very precise information on

the one hand and also to store information on fuzzy chronological circumstances on the other hand.

OpenAtlas therefore distinguishes between the beginning and the end of temporal entities, which together define an event's timespan. If beginning and end happen at the same time (in case of a one time event), then the timespan would be zero. It may on the other hand also endure for centuries or longer in the case of certain phases. To make it even more complicated, the beginning and the end may again not be known precisely, but they might happen somewhen within a certain timespan. Therefore, the user may define not only a certain date, but one timespan for the beginning and one for the end of a temporal entity. Charlemagne's life span would be such a temporal entity. His birthday is assumed to be 2 April either in the years 742, 747 or 748, and we know that he died on 28 January 814 (McKitterick 2008, 72). In this case, his birth (=beginning of his life span) has not happened before 2 April 742 and not later than 2 April 748. His date of death is precisely known.

The user can now enter a timestamp (year, month and day — PostgreSQL timestamp format) as parameters for the birth date and for the date of death. If only the year is known, the software automatically creates the necessary time spans: a span lasting 365 days between 1 January and 31 December of the respective year. If only the month is known, a timespan of 30 respectively 31, 29 or 28 days is created.

The presented example of Charlemagne would appear in the DPP OpenAtlas Database as follows (see below, Table 1).

Table 1.

Sample Dataset on an Actor's Chronological Frame; prepared by S. Eichert

Charlemagne	
Alias	Charles the Great, Karl der Große
Gender	Male
Residence	Aachen
Appears last	Aachen
Birth	Between Apr 2, 742 and Apr 2, 748
Death	Jan 28, 814
Class	Person

With this system OpenAtlas and DPP can record precisely known chronological data, but also store fuzzy chronological information and still use it for calculations. The quality of the chronological date can automatically be derived from the beginning's respectively end's duration. The longer the timespan, the lower the accuracy and *vice versa*.

REPRESENTATION OF SPATIOTEMPORAL DEVELOPMENTS

The combination of temporal and spatial information in a database is a huge challenge, especially in Digital Humanities. Most of the theoretical as well as practical research on this is closely connected to GIScience. As Wheatley and Gillings state, there are various approaches to handle this four dimensional topic, but useful solutions for practical applications are limited so far (Wheatley, Gillings 2002, 215). Following G. Langran (1992, 29) we record time and space separately from each another in our DPP OpenAtlas Database. Our approach is an object oriented one (Renolen 1997, 8f.), where each entity is stored separately and possibly linked to multiple spatial and temporal entities. A physical entity like a village can be linked to a temporal entity like its first phase of settlement, which again can be linked to a spatial entity like polygons representing the shape or extent of this physical thing during this very phase of usage. This allows to record dynamically and investigate changes or conditions on multiple layers and levels. However, this causes also a complex network of relations that can become confusing. Technically, it is possible to record very complex geotemporal networks, but from a conceptual and practical point of view we recommend a certain degree of generalisation within the projects that use OpenAtlas to sustain the possibility for comparison.

GEOCOMMUNICATION

Patterns of Power exist in space and in time. Methods of geocommunication and GIScience will be used to visualise and explore spaces, places and spatial relations. GIScience, GIS and their respective tools of spatial analysis — e. g. spatial statistics, least-cost-path calculations and viewshed-analyses — are digital methods to gain insight into historical geographies. These digital methods are applied to the research questions of the historians and archaeologists of DPP, resulting in an interdisciplinary Digital Humanities approach.

To communicate the results of the spatial analyses as well as the historical and archaeological data and the spatial relations thereof, DPP aims to create an interactive and dynamic map-based online application. It will be an integral part of DPP and provide a framework for various aspects of the project. Querying the database and overlaying various thematic layers will allow the user to explore the data and retrieve spatial relations, yet undiscovered. Furthermore, Open Source technology, modular design, generalised workflow and compliance of data standards will guarantee sustainability, as the application modules can easily be adapted to other geographical and historical areas.

To provide an ideal cartographic background for the historical and archaeological data, background maps will be designed with the specific needs for this project in mind. These maps will be based on freely available data, which will be edited and refined by the project Team Department of Geography and Regional Research (see above).

A conceptual model to incorporate spatial uncertainty in the database has been developed in cooperation with team members from the Austrian Academy of Sciences, Institute for Medieval Research. Results of this conceptual model will be integrated into further project work.

Existing gazetteers have been evaluated regarding their use within DPP. However, the existing gazetteers are not comprehensive and can only be used as a basis upon which a gazetteer has to be built. A project with potential interlinks to DPP is for example The Getty Thesaurus of Geographic Names.[20]

In the course of the first year of DPP Geodata has been and is currently collected and enhanced for smaller scales. The primary focus in 2015 is on the acquisition of geodata on cities, borders and waterbodies. Furthermore, a natural colour background with terrain representation and ground cover is currently under development. First promising results have been obtained using a combination of shaded relief, Natural Earth raster data and the global forest data set of Hansen/UMD/Google/USGS/NASA.

The styling of large scale Open Street Map data to match basemap.at[21] is in progress. The investigation of a solution to easily and quickly generate updated maps from downloaded OSM datasets is the major aim of this work item. Mapyrus, a script based software to produce high quality maps from geodata, was considered to process OSM data. Preliminary tests conducted with small datasets derived from OSM data were largely successful. Nevertheless, other solutions to process OSM data will be investigated to further optimize the process as well as the results. Tests have been conducted with Mapbox Studio and CartoCSS.

The *Tabula Imperii Byzantini* (*TIB*) raster map for the volumes *TIB* 11[22] and *TIB* 16[23] has been georeferenced. Vector data derived from the raster map have been separated layer-wise and have been georeferenced. To use this geodata for geographical analyses, respective attributes have to be added. This will take place as one of the next working steps in 2016.

In order to view and evaluate geodata collected and edited for the project, a DPP Map Viewer has been developed. With this viewer, all geodata can be viewed, independent of its scale. It will also serve as a technical platform for the DPP application.

SCHOLARLY PAPERS, RESEARCH HIGHLIGHTS AND PUBLICATIONS IN 2015

First results of the project were promoted at various venues in Europe and the USA. In 2015 the DPP team has presented altogether 15 papers on manifold topics — i.e. historical, archaeological, geographical, technical and software-related — of the project. Some selected highlights shall be mentioned in the following:

[20] http://www.getty.edu/research/tools/vocabularies/tgn/ (accessed 30 May 2016).
[21] http://basemap.at/ (accessed 30 May 2016).
[22] http://tib.oeaw.ac.at/index.php?seite=status&submenu=tib11 (accessed 30 May 2016).
[23] http://tib.oeaw.ac.at/index.php?seite=status&submenu=tib16 (accessed 30 May 2016).

The kick-off was undertaken by M. St. Popović with a short presentation of the then newly approved project at the *Österreichische Tage der digitalen Geisteswissenschaften* (Austrian Academy of Sciences, Vienna, 1-3 December 2014).

At the International Medieval Congress (IMC) in Leeds 2015 K. Winckler presented a paper entitled *Mapping the Competition: Bavarian Bishoprics in Carolingian Times*. At the same congress S. Eichert introduced the audience to the technical and software-related aspects of DPP with the paper *OpenAtlas: An Open Source Tool for Mapping Historical Relations*, while J. Preiser-Kapeller spoke on *Topography, Ecology, and (Byzantine) Power in Early Medieval Eastern Anatolia and Armenia, 700-1050*.

In September 2015 S. Eichert was invited by the Czech Academy of Sciences in Prague to present a paper on *Digital Humanities in History and Archaeology*. D. Schmid and M. St. Popović took part in the workshop *Migrationes gentium* at the Austrian Academy of Sciences in September 2015 and gave an account on *Vlachen — umtriebige Nachbarn?: Zwei Fallstudien des Projektes Digitising Patterns of Power (DPP) zum byzantinischen Makedonien im 14. Jahrhundert*. J. Preiser-Kapeller was invited to the University of Hamburg in November 2015 to present a paper on *Well-Connected Domains: Armenian Mobility and Networks Before, Within and Beyond the Early Islamic Empire, 500–900 CE*.

At the 1st ICA (International Cartographic Association) European Symposium on Cartography in Vienna in November 2015 K. Kriz, A. Pucher and M. Breier spoke on behalf of the Team Department of Geography and Regional Research of the University of Vienna on *Digitising (Historical) Patterns of Power*.

Finally, M. St. Popović was invited by Princeton University (USA) to present DPP within the framework of the *PIIRS Climate and History Initiative* with a paper entitled *Digitising Patterns of Power in Macedonia (12th–14th c.): What do Nomads, Pasture, Camels and Hydrography Have in Common?*

In the first year of DPP two scholarly articles were published (Popović 2015b; 2015c) and two were submitted for publication in accordance with the research question of DPP[24]:

DISSEMINATION

In the first year of DPP M. St. Popović and B. Koschicek have established a digital DPP newsletter, which is distributed quarterly via e-mail. The goal of this newsletter is to inform in a succinct way on the content, the state and the evolution of DPP. Therefore, all previous issues of the DPP newsletter can be found online.[25]

[24] K. Winckler, *Konkurrierende Bischöfe und ihre Herrschaftsbereiche in den Ostalpen des 7. und 8. Jahrhunderts*, [in:] *Collection Haute Moyen Âge*, Brepols (in press); K. Winckler, *Tales of the Pagans: Bavarian Bishops in the 8th Century and the Creation of their Flock*, [in:] *Forschungen zur Geschichte des Mittelalters* (in press).

[25] http://dpp.oeaw.ac.at/index.php?seite=Newsletter (accessed 30 May 2016).

Moreover, B. Koschicek has established a homepage of the project DPP[26], which was requested 102,562 times in 2015 and which allows the users to subscribe or unsubscribe to the DPP newsletter.

OUTLOOK FOR THE YEAR 2016

As outlook for the year 2016 two highlights shall be mentioned. The first will be the International Medieval Congress (IMC) in Leeds (4–7 July 2016). Four out of four sessions of the DPP team have been accepted by the organisers. They are as follows:

session DPP I *Lordship, Landscape and Agriculture in Medieval Mountain Regions*[27];

session DPP II *Frontier, Contact Zone or No Man's Land? The Morava-Thaya Region from the Early to the High Middle Ages*;

session DPP III *Flocks, Farms and Frontiers*;

session DPP IV *Reconstructing Historical Landscapes: Conceptualization, Mapping and Geocommunication.*

Moreover, an International Workshop of DPP, entitled *Theory and Practice in Historical Geography and Digital Humanities*, will take place on 28–29 September 2016 at the IMAFO in Vienna[28].

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[27] This session will be chaired by the director of IMAFO, Prof. Dr. Walter Pohl.

[28] The first day of the workshop, 28 September, will be divided into two parts: The first part will be dedicated to *Power and Space*, the second part of this day will deal with *Realisation: Technical Aspects and Similar Projects*. On the second day, 29 September, our focus will be put on *Environmental Studies*. This workshop will be an ideal opportunity to present the project DPP, its case studies, database, software and its first results in greater detail to a wider audience, and we anticipate a joint and fruitful discussion on methodological issues; *cf.* the following link: http://dpp.oeaw.ac.at/workshop/ (accessed 1 October 2016).

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