

SESSIONS

Kulturportale – Virtual Cultural Heritage

Lost historic and cultural benchmarks are a loss of urban memory?

The urban planners' dilemma

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Abstract: The rehabilitation of the historic centre of Bucharest brought to light valuable fragments of medieval, modern and contemporary structures as they had been successively covered in time. Latest excavations in the city centre known as the University Square have been prompted by the city council's decision to create an underground parking garage. The findings revealed the scope of one of the most important religious and cultural centres of Bucharest. They provided valuable information on the whole ensemble of the early 19th century, as well as on other important layers dating back to the 16th and 17th centuries.

The recently launched international contest aims at adapting the space and image of the Square to the new functional and technical constraints, and creating a fully pedestrian area with adequate contemporary elements, while integrating the original statues in the newly created environment. The new prospective layout of the University Square is supposed to enhance the image of the University, eliminating current aggressions like car parking, lack of green areas, etc.

The paper aims at raising a number of questions and inviting reflection on:

- ▶ how to avoid irreversible actions in the future (demolition) where important landmarks of the cultural patrimony are concerned;
- ▶ how to increase the transparency of decisions, in order to balance private investment criteria, the preservation of the national built patrimony and the quality interests of the urban community at large.
- ▶ how to secure and preserve historic sites as initial points in the upgrading processes of the city.

Most important is to strengthen the *inter-professional collaboration* between archaeologists, architects, landscape specialists and engineers in analysing the potential of valorisation of cultural/historic patrimony in the contemporary urban structure.

Keywords: built patrimony, historic and cultural landmarks, urban structure.

Introduction

All big European cities developed as palimpsests, where beneath the contemporary fabric of the city there are many layers witnessing their transformation along the centuries. Contemporary developments boosted preventive archaeology as against classical archaeology. Development programs in Europe and around the world benefited from preventive archaeology in concert with the developers, as was the case for the TGV tracks, canals, highway building. As in other countries, preventive archaeology in Romania accounts for about 80% of all archaeological investigations. Preventive archaeology unearthed valuable objects and artefacts later scattered in various museums around the country. Recently they were assembled in the international exhibition The Lost World of Old Europe in the Danube Valley (first in New York then in Oxford

and Athens). The exhibition assembled over 250 archaeological objects of more than 6,000 old with the participation of 20 museums from Romania, Bulgaria and the Republic of Moldova. By the visibility thus gained they established the existence of a neo-eneolithic culture in the lower Danube area in the years 5,000–3,500 BC.

Our paper deals with recent developments in the central core of Bucharest namely the University Square, one of the emblematic quality public spaces of the city. Our aim is to raise a number of questions inviting to reflection on how to go on with the modernisation of our public spaces, how to strengthen *inter-professional collaboration* between archaeologists, architects, landscape specialists and engineers when adapting cultural/historic patrimony to the contemporary requirements of urban environment.

The context

The historic center of Bucharest bears witness of the successive layers of developments over the last centuries, not unlike in other cities like Strasbourg and Vienna. Extended to the North of the princely residence (*Palatul Voievodal*) the area had a predominantly commercial character, with one-two story building with shops at ground level.

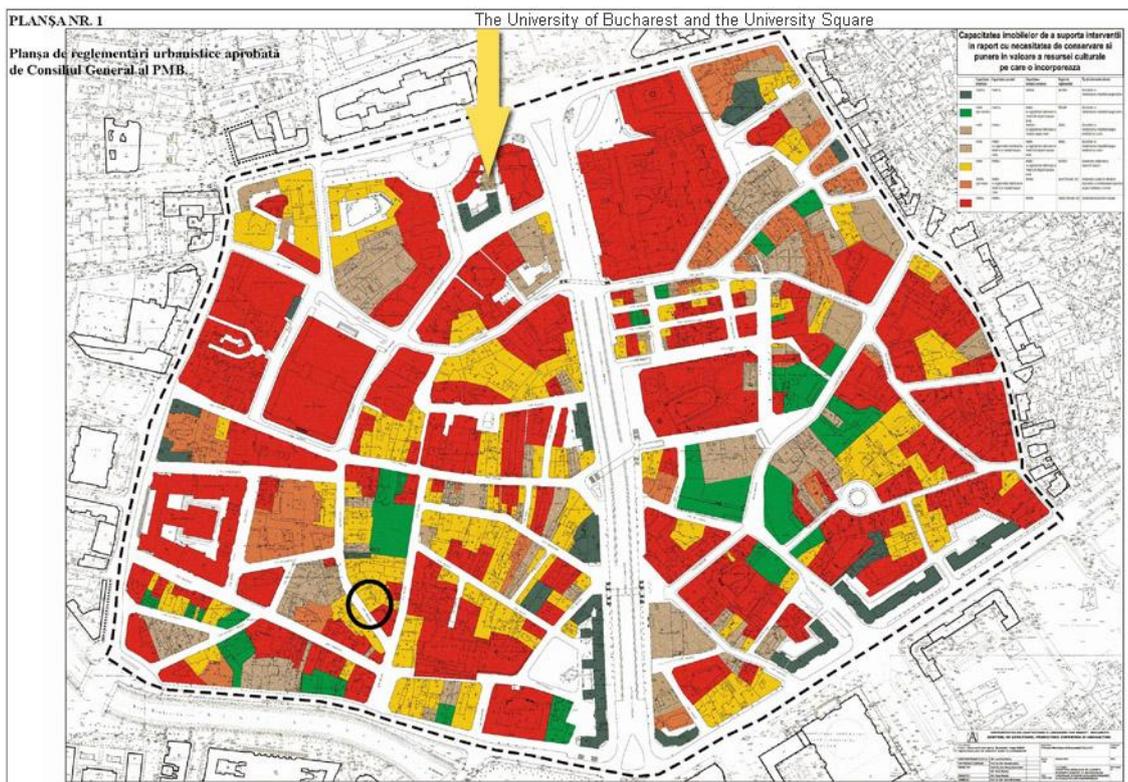


Fig. 1 – Current layout of the historic center of Bucharest (General Council of the Municipality of Bucharest).

The rehabilitation of the historic centre of the capital brought to light valuable fragments of medieval, modern and contemporary structures as they had been successively covered in time (Fig. 1). Excavations carried out at the University Square in the last couple of years by teams of archaeologists confirmed the existence and enabled the precise location of buildings from late 18th and early 19th centuries, which previously were known

The church of the Sfântul Sava Monastery would be demolished in 1870 to open up the area to a new urban environment. This was when the first modern East-West boulevard of the city was cut out from the medieval urban fabric with the aim to creating a representative urban square in front of the new Academy (MUCENIC 2004). All along the second half of the 19th century the building of the University numerous alterations/enlargements (Fig. 3, 4 and 5).

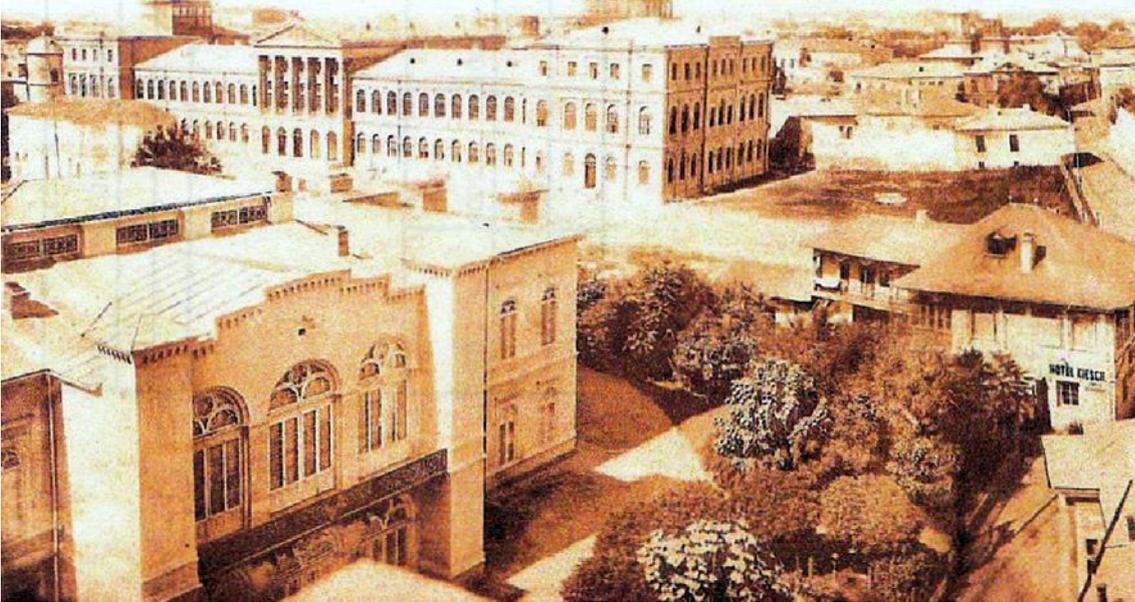


Fig. 3 – The University cca 1857 (OAR Lascu, N).

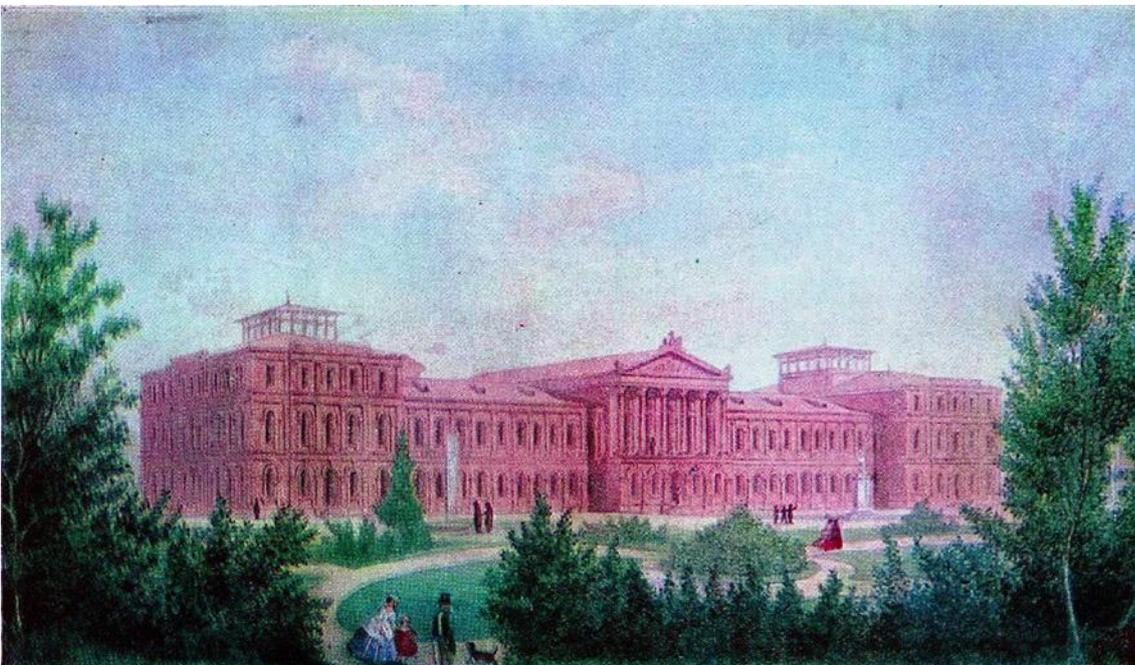


Fig. 4 – The University cca 1870 (OAR Lascu, N).



Fig. 5 – The University cca 1890 (OAR Lascu, N).

The newly created University Square proved to be an opportunity to create a quality public space first by locating a representative public monument (the equestrian statue of Mihai Viteazul), later to be completed with to other monumental statues of illustrious Romanian intellectuals (Fig. 6).



Fig. 6 – The University Square around 1930 (C. MUCENIC 2004: 89).

The final current shape of the University Square was approved in 1906, while in 1912 the landscaping project approved by the City Council gave the square the look it has today (Fig. 7).

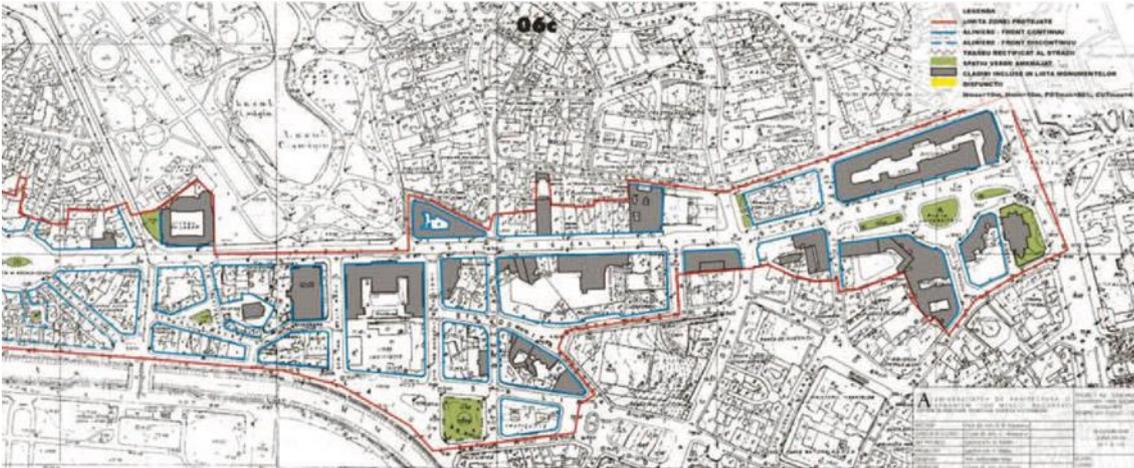


Fig. 7 – The University Square as part of a larger protected area (The General Council of the Municipality of Bucharest).

The University Square will further be undergoing changes with the extension of the University in the 1930s and the reconstruction that followed WWII and with the cutting of the North-South boulevard of the city. Currently at the Northern side of the square is the façade of the Bucharest University (Fig. 8) and the Southern side there are financial buildings built in the first half of the 20th century (Fig. 9).

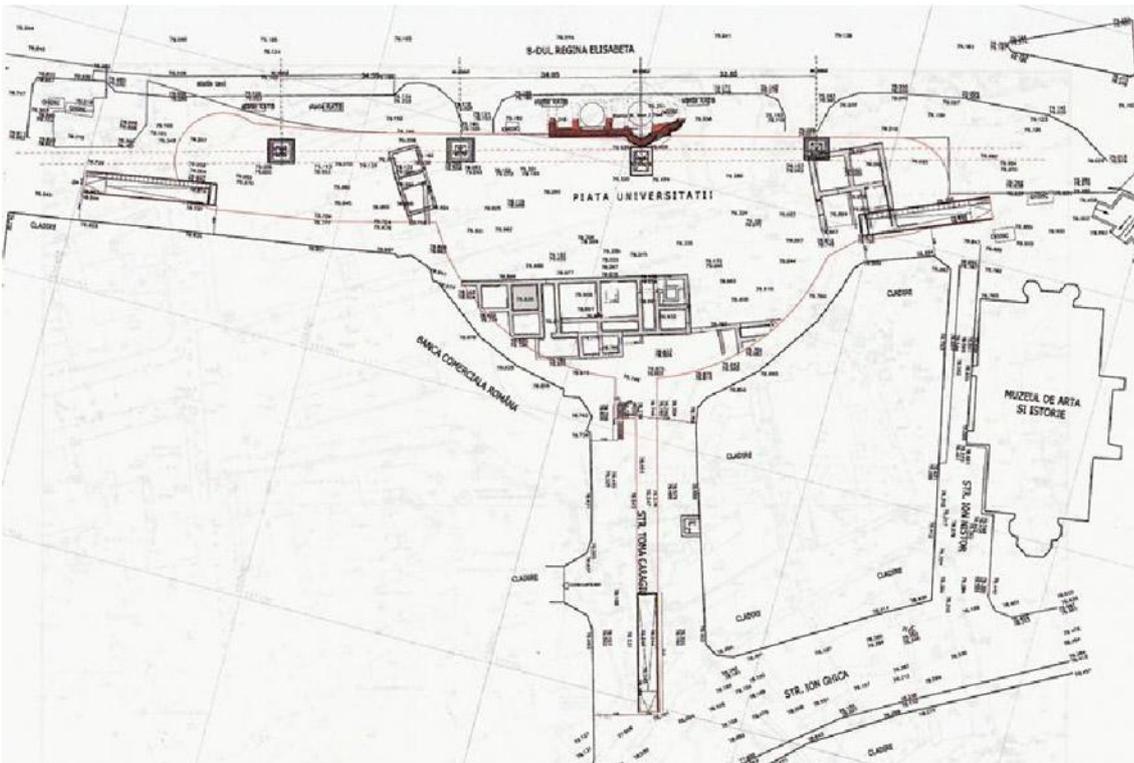


Fig. 8 – Layout plan of the proposed parking garage and of the excavations (red line) (Documents of the Competition).



Fig. 9 – Overall view of the excavations (photo R. Nemteanu).

All the above emphasized the importance of the area which was the location of the first institution of higher education around which the University Square would develop and grew into the landmark of the modern town. As shown in Fig. 10 the University Square is part of a larger central area including a great number of historic and cultural buildings (shaded in grey).

“... as a special presence in the urban environment ...” reflecting “... a unitary spatial approach in the respect of urban development plans completed with representative objects” (MUCENIC 2004).



Fig. 10 – Overall view of the excavations (photo R. Nemteanu).

A new stage in the modernization of the University Square

The decision of the town hall to further modernise the area and create an underground parking-garage prompted archaeological excavations between November 2010 and March 2011 (Fig. 11). The archaeological research provided valuable information as to the precise location of the components of the compound of the Sfantul Sava Monastery, revealed the scope of the cultural and religious center and provided valuable information on the whole ensemble of the early 19th century. The whole compound included the first university (a listed building by law), an important library, the first museum and also a botanical garden. The excavations shed light to the relative chronology of the findings and their relation to the existing documents.



Fig. 11 – Aerial vue from the University of the innerpartitions (photo R. Nemteanu).



Fig. 12 – Aerial vue from the University of the innerpartitions (photo R. Nemteanu).

The findings represent remnants of the church of the Sfântul Sava Monastery, remnants of the area surrounding it: the precise location of buildings, their inner division, structural elements, a necropolis etc., as well as other important layers dating back to the 16th and 17th centuries.

Were also brought to light elements of pavement, finishings, fragments of walls, water pipes and other fragments of the buildings of the monastery compound etc. The excavations also revealed the original layout of the streets' structure, before modernisation in the 20th century. *They are all part of the particular historic and cultural imprint of Bucharest among European cities.*

The new function of the University Square – a competition

The decision to create an underground parking garage beneath the University Square and the technical requirements of the project made it necessary to open up the archaeological site we discussed about above. Meanwhile this proved to be an opportunity to refurbish the existing space of the square so as to adapt it to the new function of the parking garage meanwhile creating a new urban environment.

The international competition launched aims at adapting the space and image of the Square to the new functional and technical constraints, and creating a fully pedestrian area with adequate contemporary elements while and integrating the original statues in the newly created environment. The new prospective layout of the University Square is supposed to enhance the image of the University, eliminating current aggressions like car parking, lack of green areas, etc.

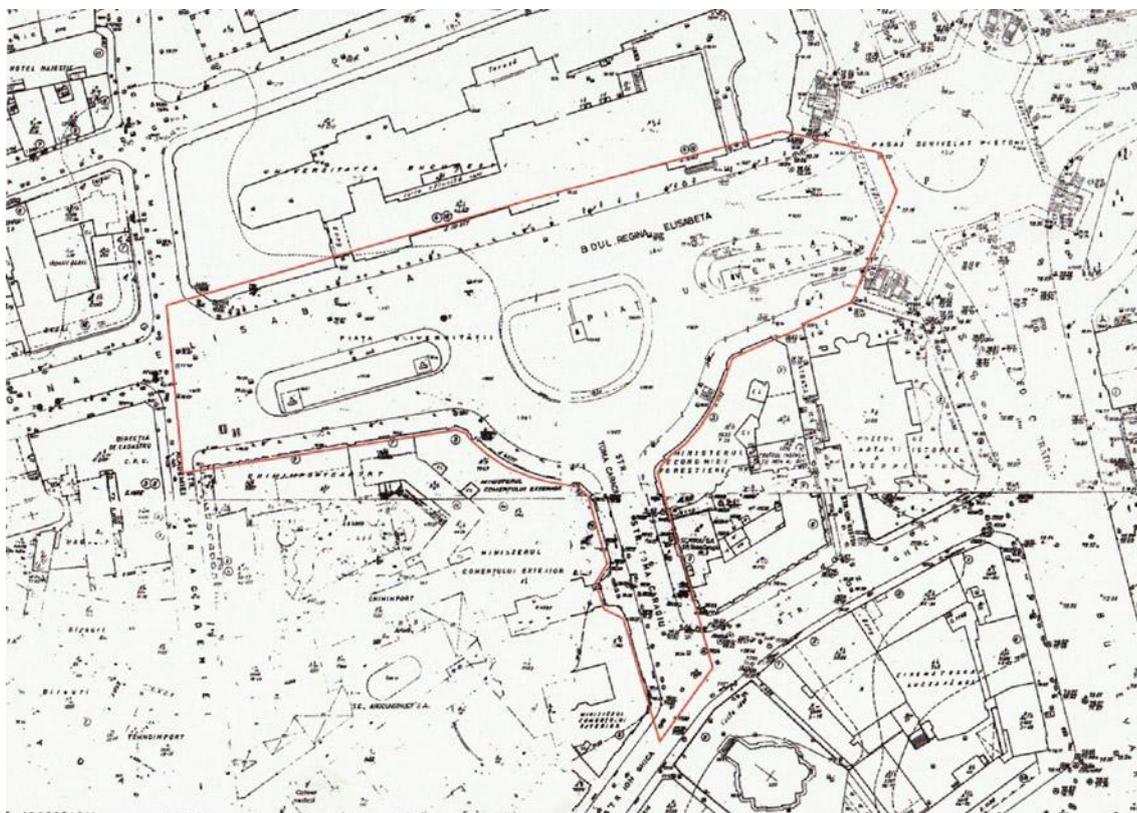


Fig. 13 – Layout plan of the competition area (OAR Concurs de solutii “Amenajarea spatiului supraterran Parcaj Universitate”, 2011).

Conclusions

Recent developments and projects at the University Square in Bucharest may be seen as an example of “*chain reaction*” where areas laden with centuries of history are dealt with. They invite to reflection as to how to reconcile the conflicting views of “*purists*” that would impede on modernization and progress while promoting development along the requirements of further modernization.

Further subject to reflection should be:

- ▶ how to avoid irreversible actions in the future (demolition) where important benchmarks of the cultural patrimony are concerned;
- ▶ therefore it is necessary to increase the transparency of decisions, in the respect of legality (in accordance with the official listing of monuments);
- ▶ how to balance private investment criteria, the preservation of the national built patrimony and the quality interests of the urban community at large;
- ▶ how to secure and preserve historic sites as initial points in the upgrading processes of the city.

Preventive archaeology is often being criticized for the speed it has to work due to the developers pressure. *It has to be carefully weighed who is to loose and who is to gain* where there is conflict between the interests of developers to speed up the procedures of preventive archaeology and the need to fully document and – if the case is – to preserve national values of patrimony.

Most important is to strengthen the inter-professional collaboration between archaeologists, architects, landscape specialists and engineers in analysing the potential of valorisation of cultural/historic patrimony in the contemporary urban structure. So as the winner be the urban community at large!

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Virtual reconstruction of monumental painting of the Church Spas-na-Nereditse in the city of Novgorod the Great

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Abstract: There are many architectural monuments and old relics, the restoration of which is an unrealizable task. This may be due to the difficulty and complexity of the work, lack of information about the object and other reasons. In such cases, the 3D reconstruction is an effective tool.

Saint-Petersburg State University developed a method of restoration of partially or completely lost monumental paintings. As an example and a practical application of new technology there a virtual reconstruction of fresco paintings of the Church Spas-na-Nereditse in the city of Novgorod the Great was completed.

The church was almost completely destroyed during the Second World War. According to the old drawings it appeared to be possible to reconstruct an architectural view of the church, but rare frescos of the XII century had been irretrievably lost. The extant parts of frescoes consist of 325,000 pieces and its manual restoration is still very far from completion.

In this case the method of computer-based reconstruction is much more efficient. The process of 3D reconstruction is always reversible, it provides several plausible variations and helps to find a compromise a decision on the issue of reconstruction or restoration of the object.

The method of computer-based reconstruction was used together with analog pictorial reconstruction. The first method provides plausibility, whereas the second method helps us to simulate the ancient process of painting, to convey the artist's style, to reproduce the form, direction and strength of the artist's touch and texture of the frescos. The basis for all works were archaeological materials, archival and contemporary historical, architectural and art papers, scientific research in this field.

Keywords: virtual, reconstruction, restoration, monumental, painting.

Reconstruction of Art and Cultural Monuments

Historical sites of the Russian monumental art, due to their centuries-long life, undergo inevitable changes in color and structure of frescoes, destruction or alteration of the original architecture. Numerous natural, climatic and anthropogenic factors cause considerable changes, partial or complete destruction of works of art. Despite the fact that it has been 65 years since the end of the Second World War, many ancient Russian art masterpieces still have not been restored to an acceptable display state. A considerable amount of materials is stored in museums waiting to be reinstalled in interiors of churches.

Nowadays wide experience in the exploration and restoration of monuments, as well as modern technologies allow to integrate the information in specific areas of knowledge, making it easily accessible to the public. In our case, we refer to architectural monuments of ancient Russia. Information about this objects is dispersed

across many sources: books, articles, drawings and sketches, located in different storage locations, and sometimes even in different countries. All available information can be presented in an integrated database. Single information source, based on results of reconstruction will help to understand the historical context and conditions under which the object was built, to reproduce the lost and missing data on each monument, and to update the existing traditional art databases. With enough data it becomes possible to present a monument at various stages of its construction and development, to analyze and demonstrate options for its reconstruction, to illustrate the features and history of its painting. The method of sequential computer reconstruction allows not just to review the virtual model of the monument, but also to get details, associated with the whole life of the object.

Creation and demonstration of historical reconstructions, as a progressive method of presentation of ancient exhibits, makes it possible to achieve a new level of preservation and transmission of cultural heritage.

About the Nereditsa Project

The “Nereditsa. Link of Times” research project currently takes place under development in the St. Petersburg State University.

Major museums and cultural institutions, such as: the State Russian Museum, the State Historical and Architectural Reserve-Museum of Novgorod the Great, the Institute of History of Material Culture of RAS, and Ilya Repin St. Petersburg State Academic Institute Of Fine Arts, Sculpture and Architecture take part in this research.

The project is dedicated to a unique monument of ancient architecture and art, the Church of the Transfiguration of Our Saviour on Nereditsa Hill. In 1992 the Church of the Transfiguration of Our Saviour on Nereditsa Hill was included into the UNESCO World Heritage List, along with several other monuments of Nov-gorod the Great and its surroundings (<http://whc.unesco.org/>).

The Church on Nereditsa Hill is one of the most famous monuments of ancient Russian culture. It was built by Prince Yaroslav Vladimirovich's order in 1198 and a year later, in 1199, its interior was decorated with fresco paintings. Exceptional art value, unusual unique iconography of the monument have earned it a worldwide fame.

Like the Saint Sophia Cathedral, representing the XI century, and the St. George Cathedral of the St. George's Monastery, representing the early XII century, the Church on Nereditsa Hill is considered to be a typological and stylistic architectural standard of the late XII century (KOMECH 1991).

During the Second World War, the temple was almost destroyed. Only half of masonry and 15% of frescoes were preserved. According to old drawings it was possible to restore an upper part of walls, arches and dome, but the rare frescos which had covered the entire church until the twentieth century, have been irretrievably lost (BULKIN 1994).

Archival material contains of:

- ▶ preserved fragments of frescoes;
- ▶ photos interior of the temple;
- ▶ detailed descriptions of the monument, made by experts from the State Historical and Architectural Reserve-Museum of Novgorod the Great and historians from Saint-Petersburg State University;

► copies of frescos, carefully preserved in the State Russian Museum.

In combination with modern technologies these materials provide a unique opportunity for a virtual revival of the lost masterpieces of ancient art – frescoes of the Nereditsa Church.

The Church of the Transfiguration of Our Saviour on Nereditsa Hill has been an object of scientific art research at St. Petersburg State University for many years. As a result, a lot of research materials about the history of the church, its architectural features and frescos has been collected. Scientific research of this monument has been provided at the St. Petersburg State University, Novgorod State Museum, State Russian Museum for several years.

The first expedition was organized by Saint-Petersburg University and Russian Archaeological Society in 1910. After the architectural restoration in 1903–1904, a number of scholars, including M. I. Artamonov (ARTAMONOV 1939), turned to studying its paintings. After being almost destroyed by the Nazis, the Church was restored in 1958, and researcher's attention was again focused mostly on the architecture (SHTENDER 1962).

Many thousands of fragments of frescos have been collected during restoration, architectural and archaeological work. At present, they are kept in museum collections. It does not seem possible to restore the fresco decoration in its original form (LUTSIY and JAWORSKI 2004). But using methods of virtual restoration, we can achieve significant results in solving this problem. Three-dimensional graphics technology, art modeling and virtual reality provide artistic reconstruction of the lost (partially or completely) cultural heritage with any specific scientific precision.

Virtual Reconstruction of the Church on Nereditsa Hill

In 2008 the materials describing the history of the Church, stored in various museums and archives, were collected and investigated under the "Nereditsa. Link of Times" project.

In 2009 the main publications on the history of the Church were collected and digitized, its frescos were analyzed and its restoration history was described.

In 2009 a three-dimensional model of the Nereditsa Church as well as artifacts and household objects associated with the history of the Church of Our Saviour on Nereditsa Hill were produced (Fig. 1).

At the present time the frescos are being restored. Restoration of this paintings is a serious problem. The extant parts of frescos are strengthened and preserved. Many thousands of fragments, which were collected in the course of restoration, architectural and archaeological works are kept in museum's collections.

The extant parts of painting consist of 325,000 fragments, and now they are being on restoration, which is still far not complete (Fig. 2).

According to enormous complexity and lack of effectiveness of the "manual" method of search and selection of fragments, it was decided to use a computer re-construction of the fresco. This method allows to avoid mistakes and find a com-promise decision on the issue of reconstruction or restoration of the object.

The choice of virtual reconstruction is appropriate according to practical needs of science and education.

One of the most important points of the whole research is the question of choosing the method of reconstruction - analogue or computer reconstruction.

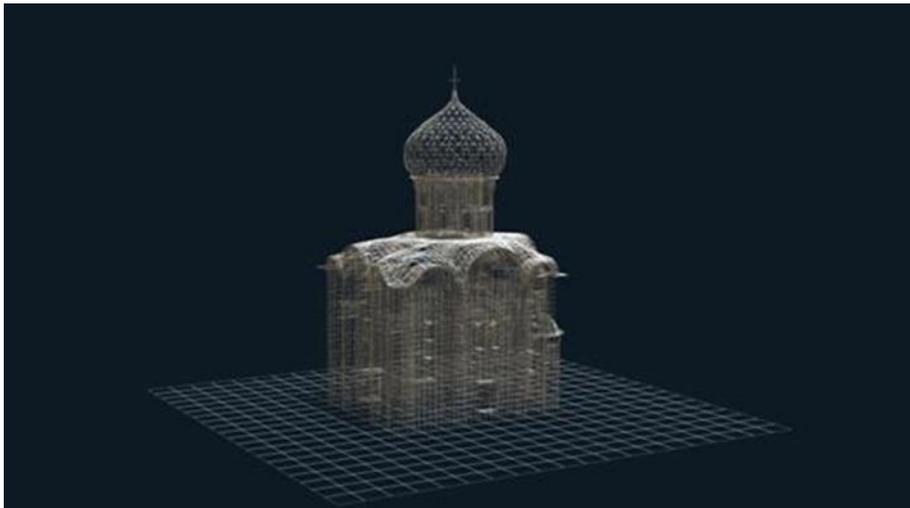


Fig. 1 – A three-dimensional model of the church Spas-na-Nereditse (virtual restoration, provided by department of information technologies in arts and humanitarian sciences SPbGU, completed by S. V. Shvemberger and E. V. Logdacheva in 2009).

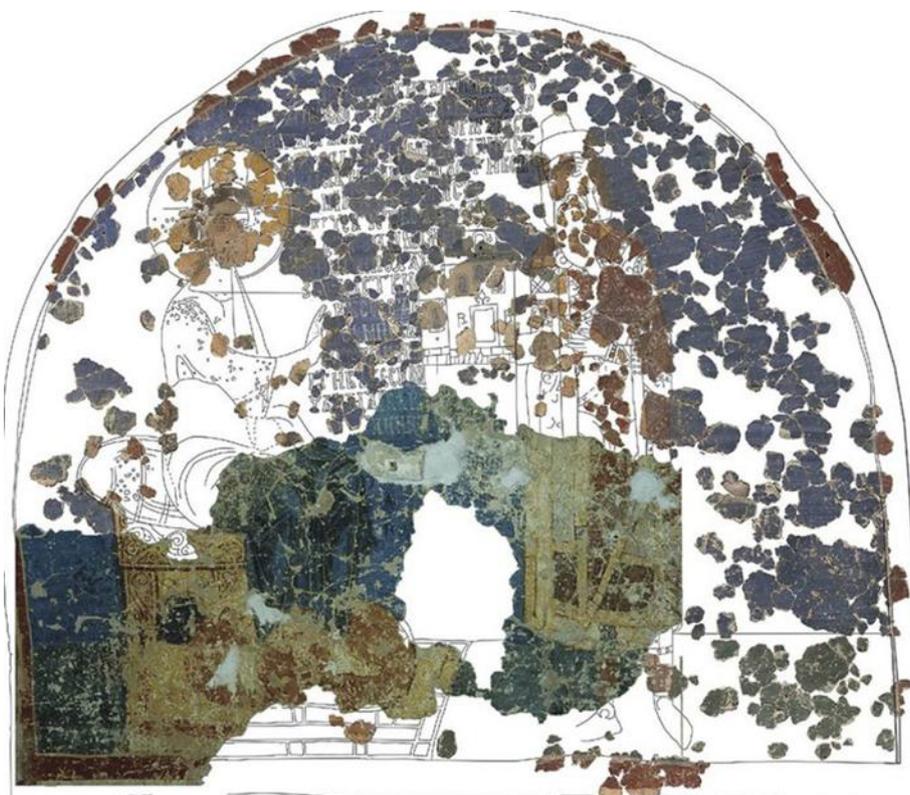


Fig. 2 – The process of fresco's restoration (result of scientific research, provided by Novgorod Museum, T. A. Romashkevich, T. A. Fedorenko, S. A. Lutsiy).

► 1-st method – a documentary historical reconstruction (virtual restoration).

In this case, reconstruction is the creation of a virtual object model, based only on extant fragments. This model can be completed with some objects (fragments of frescos, interior objects stored in museum's funds and collections), if they are mentioned in archival documents.

This method provides keeping historical accuracy, and it abandons reconstruction of the lost fragments by analogy.

► 2-nd method – analog reconstruction.

Extant ancient monuments, even preserved and restored, are often partially lost. Because of the lack of documentary evidence their recovery is a problem, that could be solved only through art and historical analysis. This ensures the authenticity of reconstruction. But in this case, the result can not pretend to be absolute reproduction of the original.

Moreover, it should be clear that, based on various documentary sources of information, we can reach several possible versions of the analog reconstruction, and all of them will be equally grounded on theory. Practical implementation of analog reconstruction requires involvement of experts in different fields of knowledge – not only specialists in computer graphics, but, first of all, artists, architects and archaeologists. In fact authentic virtual analogue of the object can not be created without deep understanding of its architecture and proportions.

This work requires high professional theoretical and practical knowledge of all project developers.

Starting working on restoration of the murals, we need to develop a methodology for recovery of losses, combining two methods – using of documentary materials and restoration of color and form, based on the study of analogues.

Specialists are attempting to determine the role of reconstruction in preservation and promotion of monuments. It is important to develop main principles of virtual reconstruction, such as:

- Applying the method of complex restoration, when the monument is taken as a system of architectural, painting, interior and exterior spaces.
- Development of main theoretical principles of admissibility and limits of application of modern technologies in recreating monuments of historical and cultural heritage in terms of ethical, legal and aesthetic aspects of reconstruction;
- Providing further reconstruction in accordance with these formulated principles on the basis of archival, historical, design, technical, literary, scientific, restoration, art, copied and other materials using computer technology;

These main principles are being tested on the example of reconstruction of the lost paintings of the Church of the Transfiguration on Nereditsa in Novgorod the Great.

Reconstruction Method for the Church on Nereditsa Hill

Collecting Supporting Information for the Project

First stage includes searching, analyzing, structuring of archival, historical, technical, literary, scientific, art and other documents which contain any information (photos, drawings, pictures, descriptions) about the frescos of the church.

Basic historical materials of the Nereditsa Church are kept at the State Russian Museum, the Novgorod State Museum, the Institute of History of Material Culture Sciences, methodological foundation of the State Academic Institute of Painting, Sculpture and Architecture named after I. E. Repin. The leading experts are: historians, art historians, restorers, muralists, keepers of these organizations have assisted authors of the project and helped to find, analyze and collect a lot of important information.

At the stage of collecting information about the object it is very important to find as much facts about the monument as possible, to make the fullest possible description. Qualitative archival photographic and illustrative material, knowledge of the exact coloring of paintings, permanent free access to all fragments of the frescos make the process of reconstruction more accurate, correct and fast.

Over a thousand archival photos of the church were investigated. Most of them are stored in the Novgorod State Museum. These photos capture all stages of restoration of the temple, which took place at the beginning of XX century.

Collections of unique architectural details and structural elements of the temple, such as plinfy, brick, stone, etc. were analyzed in the Novgorod State Museum. According to the curvilinear shape of the wall surface, these materials are needed for correct scaling of photos and liquidation of distortions. Also this in-formation is important to analyze the character of wall surface as a basis for painting.

Authors have carefully studied unique materials – fragments of frescoes, collected in the restoration workshops of the Novgorod Museum, which present the process of actual restoration of the frescos of the church.

Archival material stored at the Institute of History of Material Culture of the Russian Academy of Sciences were also studied by authors – this material consists of negatives and photographs taken in the church before the Second World War.

Watercolors that have been stored in collections of the Russian Museum appeared to be the main source of information about the coloring of Nereditsa paintings. These images are in fact the copies of frescoes, made before the war.

Copies of frescoes, created in various Russian churches, are stored in the methodological foundation of St. Petersburg State Academic Institute of Painting, Sculpture and Architecture. These materials are also necessary for recreation of color palette of fresco painting.

Measurements of the Existing Interior and Exterior

Before starting any restoration it is required to measure the object and to make various photographic images from different sides.

Complex building measure includes:

- ▶ front, side, back elevation measure;
- ▶ measurements of the inner space of the building;
- ▶ measurements of interior objects.

Available measure technologies:

- ▶ combination of methods of laser scanning and digital photogrammetry (for exterior and interior measure, architectural details measure and drawings);
- ▶ combination of methods of laser tacheometry and laser scanning (for measure drawings, section drawings, sweeps).

Exterior and interior of the Nereditsa Church were completely measured. In the result we presented drawings of the building and its interior (drawings were pre-pared in AutoCAD and have same system of axis, coordinates and heights).

Making Photographs of the Existing Interior

The whole interior of the church and extant fragments of frescos were photo-graphed. It was important to take all photos frontally, using the same scale, so that afterwards they can be easily inserted into single picture without distortions.

Making Photographs and Scanning of Extant Fragments of Fresco, Kept in Museum Collections

Elements of paintings, which were kept in museum's collections were also studied and photographed. In the process of analog fresco reconstruction photographs of existing fragments are used as main working material. Considering dependence of the fresco appearance and church lighting, we can't obtain objective impression of fresco colors. Thus all fragments should be photographed with the lighting, most similar to natural church lighting.

At the same time we use ordinary scanning as another method of copying of fragments. This method helps to avoid size and color distortion, typical for photography. Using color and densitometer scales, we can avoid color distortion, dimensional scale helps to avoid size distortion.

Technical and technological features of painting are especially important for restores. Materials, obtained by scanning, can be enlarged and studied in detail. This study helps to bring out special features of texture and materials, direction of brushstroke and stylistic manner, to analyze the morphological characteristics of the fragments. High resolution of modern monitors provide capability of multiple scaling, further reduction in graphics editing programs allows to detect almost in-visible elements, which could not be recognized by human eye.

Making a Single Tone Image Based on Archival Photographs

The next stage of the process is making a single image of the wall, based on archival documents.

Firstly we need to produce a monochrome image of the wall with extant frescos – it illustrates current state of the wall surface and it is a basis for the whole further reconstruction. This image consists of obtained photos of the church and it is adjusted according to drawings, produced on the stage of measurements (Fig. 3).



Fig. 3 – Monochrome image of the wall with extant fragments.

Then we start to complete this image with fragments, obtained from archival photographs. All of them are carefully adjusted to extant frescos.

Efficiency of this stage depends on the number of fragments remaining on the wall (reference points). In practice, it turned out that the majority of black-and-white photographs, completed before 1941, were not frontal, and they had distortions, so it made the work more difficult.

The monochrome image, completed with fragments from photographs is the documentary base for further reconstruction of color and pattern of lost parts (Fig. 4).



Fig. 4 – Monochrome image of the wall, completed with pictures from archival photographs.

Creation of scheme of estimated authors drawing

From this monochrome image we can get outlines of authors drawing. Outlines are put on monochrome sweep, and then basis is removed, thus we obtain outline image of estimated authors drawing (Fig. 5). This image provide us with exact data about width of strokes, pleats on clothes, boundaries of light and dark areas, boundaries of lost fragments.

Making sweeps of walls with extant fresco fragments, obtained from museum's collections

The next task was to put on estimated authors drawing extant parts of frescos, kept in museums collection. It is important to find exact place of each fragment on the wall, according to produced drawing.

Signs, which help to recognize exact location of the fragment:

- ▶ obvious morphological signs (proper for large fragments);
- ▶ color of composition;
- ▶ obvious coincidence of fragments outlines.

Obvious morphological signs are:

- ▶ coincidence of fragments of holy faces;
- ▶ coincidence of fragments of pleats;
- ▶ coincidence of specific ornaments and patterns;

- ▶ coincidence of architectural elements, fragments of landscape and greenery;
- ▶ coincidence of all graphical elements, which could be easily recognized.

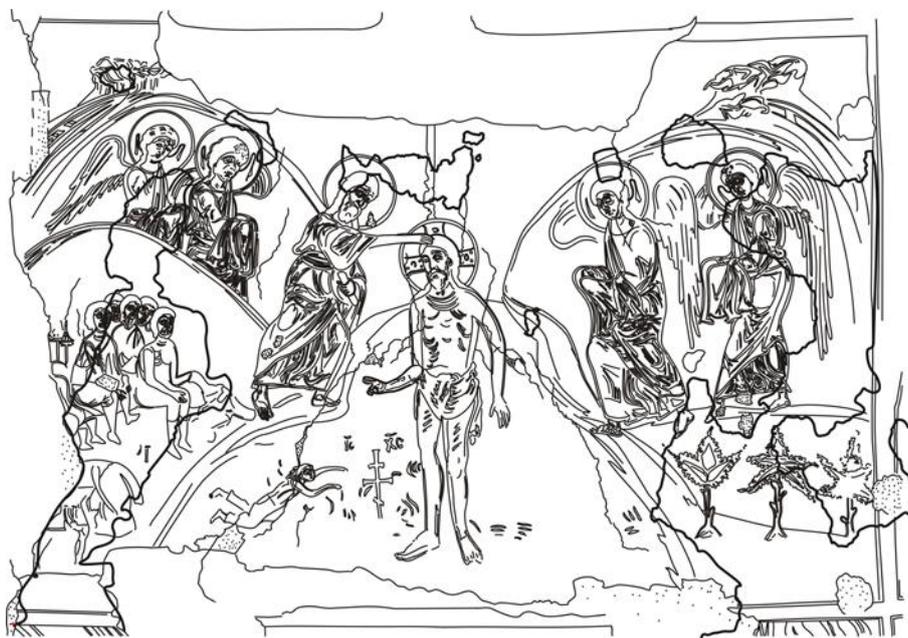


Fig. 5 – Estimated authors drawing.

Actually most of the fragments do not have obvious morphological signs. For example parts of background or self-colored clothes, parts, that had been already damaged when they were photographed. Location of such fragments can be de-fined according to direction and texture of brushstroke (this method is very efficient for parts of fresco background, where texture is well-defined).

Sometimes, but quite rarely, compilation of fragments can be provided according to contour of object, like parts of mosaic.

Previously prepared materials: high resolution photos and quality scanned images of fragments provide successful compilation of fragments. Reduction in graphical editing programs allows enlarging fragments and recognizing direction and intensity of strokes, tonal and color peculiarities. Sometimes smallest detail, which can seem to be inconsiderable, such as part of pleat or contour of figure, helps to define location of the fragment.

Deep study of background fragments helps to recognize even specific traces of bristle brush. Author's strokes differ in strength, amount of paint, direction. To de-fine location of fragments we can use these parameters as alternate. Thus the more parameters would match, the more accurate location of the fragment would be found.

Color variety of fresco fragments is another very important aspect of compilation. State of fragments can be different: they could have been stored in museums halls or in cellars and warehouses. Two fragment of the same fresco can vary in color because of different storage conditions. Moreover Nereditsa paintings have very complicated color and have lots of shades. Even inside one fragment of fresco color can variously change from warm to cold shades.

Background, earth, water and other one-colored objects of image can occupy quite large area of the whole painting. They can include considerable color transforming, for example, blue background, denoting sky, can vary in shade from warm to cold inside one composition.

Process of fragments compilation requires participation of experts, such as artists and restores, who have wide experience in working with the particular church. Free access to all materials provides efficiency of compilation process. Digital copies of fresco fragments make the whole work much easier and help to reduce time needed for searching for proper fragment.

In fact in graphical editing program all fragments are arranged on different transparent layers and its location is defined by moving them according to concerned authors drawing and searching for coincidence of all parameters.

It should be understood that if a fragment is installed into church wall improperly, in real life its dismantling would lead to further destruction of fragment. Whereas working with digital copy can't bring any harm to extant part of fresco. This method provides iterative approach, searching for the most suitable fragment and its substitution can take place at any stage of working.



Fig. 6 – Extant fragments of fresco from museum's collections, put on estimated author's drawing.

The result of this stage is image, on which extant fragments of frescos are put on estimated authors drawing (Fig. 6). For restores this image functions as a map of the whole fresco composition. Along with black-and-white sweep of the wall made from archival photos it becomes a basis for further artistic reconstruction. Created materials may help restorers to project the image on the wall and to draw the contour of the lost mural, so that it would be a base for collecting separated fragments of frescoes.

It is necessary to emphasize that at this stage there is no artistic interference. From this moment all activities can be called the analog reconstruction.

Producing of coloristic painting map

The next important stage is producing of technological coloristic map of murals.

Color reconstruction is one of the most complicated and one of the most interesting tasks. Variety of characters, their spirituality, unique relations between cold and warm shades, simplicity and at the same time impressive complexity, strength and monumentality of Nereditsa murals can't be transferred by copies or photographs.

Artistic character consists of many components: texture of the wall, stylistic manner of painting, order of application of paint, execution of details, but certainly color is the strongest means of expression.

We can obtain coloristic data from:

- ▶ Extant fragments of paintings from the walls of the church and from museum's collections;
- ▶ Historical descriptions of colors of frescos;
- ▶ Chemical research of pigments;
- ▶ Historical artistic copies of the church interior.

Also we can take information about color from iconographic canon. Tradition-ally symbolism of painting is transfused by canon signs. Conventional color is typical for monumental painting, and canonical color is typical for icons. Thus us-ing these prescriptions we can define color of clothes, background and separate elements with much authenticity.

Study of coloristic system of painting and creation of color palette – these are main tasks of this stage.

Color is very specific characteristic of painting. Even if a fresco was entirely preserved, over the years its color certainly must have changed. An example is monumental painting of Mirojskiy monastery. These frescos are deeply studied: iconography, stylistic manner, all elements and even smallest details – everything can be investigated. Certainly some fragments or top slice of painting can be damaged, but these changes do not influence so much on visual impression of the whole composition.

Discoloration is caused by chemical modification of paint. This process affects the whole picture. Color of ancient fresco can't be interpreted as original. This is the theme of individual scientific research in the field of monumental and easel painting. Modern technologies provide real opportunity to study this problem and find solution.

Color also changes because of different storage conditions. After Nereditsa destruction some fragments were left on the walls and undergone climate impact, others were left at earthen cellars of the church.

From documents about restoration of Nereditsa Church: “At winter and spring 1970/71 drying of fragments, gluing of fresh destructed fragments and boxing were completed... Paint was covered with thick dirty layer. Commission from the Novgorod Museum fixed 90% destruction of paint layer. Fragments of holy faces were not found”.

Reasons for discoloration:

- ▶ Actual destruction of bottom stucco layer – base for painting;
- ▶ Chemical modification of pigments;
- ▶ Lightning impact;
- ▶ Technical and physical impact (splits, scratches, graffiti, etc);
- ▶ Dust and micro particles from the air;
- ▶ Storage conditions: temperature and humidity variance; inappropriate monument ventilation;

- ▶ Latest restorations;
- ▶ Destruction or thinning of separate painting layers (top ceruse layers, thin glazing layers).

Graphical editing program allow changing hue and saturation of image and help to return estimated original colors.

A very important question is whether authors should restore estimated original color (as in 1199) or color before destruction (in 1941), or color as it could have looked if painting had not been destroyed. Finally it was decided to restore color as it could have looked today.

After finishing reconstruction, color of obtained images can be edited in graphical program. So it is possible to show gradual color modification from 1199 to nowadays. Thus virtual reconstruction gives an opportunity to show painting in definite time period as well as to show all changes of whole coloristic system of the fresco. This is a big advantage of virtual method, because we don't have to draw manually several versions of painting, related to different time periods.

Chemical analysis showed that ancient painters used quite many different pigments. Only natural ingredients were available and even in original version colors could be very different. Mixing of paint pigments could give even more various colors. It means that color variation was provided not only by visual effect of complex shades relations but also by using rich palette.

Authors have studied all characteristics of fresco color system and produced palette of painting, as it could have looked nowadays if the church had not been destroyed (Fig. 7). This palette became a basis for further artistic works.



Fig. 7 – Coloristic painting map of murals.

Producing of linear patterns at a scale 1:1 (performed only in artistic reconstruction, as the basis for paintings)

After this stage we begin an analog reconstruction of frescos, which is actually a process of painting of all lost fragments, based on archive materials and analogues. We create several templates with outlines, produced at a scale 1:1. These templates repeat the expected author's drawing, produced on the six stage of reconstruction.

Creation of artistic coloured cardboards the same size as real frescos or smaller (working models)

The task of this stage is to find appropriate technology of painting, artistic manner, drawing system. According to restoration documentation, there was no preparative drawing. It means that ancient painters worked in natural, free and unschooled manner. Images are very lively and inimitable. Every composition and all figures have its own artistic singularity.

Study of painting technology is an important task. The question is which particular paints should be used to archive most authentic result. Composition of modern polyvinyl-acetated and tempera differs very much from ancient paints, which were used for Nereditza frescos.

Usually pigments consisted of natural ingredients: minerals, clay produced in the region of construction. Very rarely some pigments (rare blue and green colors) were delivered from Byzantium.

In fact our research is not a factual reconstruction and our aim is to restore painting style, color system and general visual impression. Thus punctual copying, according to ancient technologies of XII century appears to be inexpedient.



Fig. 8 – Fragment of analog reconstruction.



Fig. 9 – Fragment of analog reconstruction.

Experience of such reconstruction is not wide. Most of such works are painting sketches, reduced against original. These images give only general information about composition, iconography and color of fresco. In such works color is very approximate.

Other examples are images, edited in graphical programs. Probably this method is theoretically possible, but usually in result digital copy loses artistic singularity and impression of original. It is impossible to imitate manual drawing automatically, without perception and deep understanding.

When painting is created manually, artist puts his feelings and mood into picture. All small complicated parts of painting are drawn very precisely. And at the same time all details are parts of whole composition, which leave strong impression, that can not be transmitted by digital copy.

When final versions of all artistic cardboards are ready (Fig. 8, 9), they can be put into single image.

Making sweeps of the walls

After the reconstruction of frescos it was made a sweep of the western wall of the church (Fig. 10). Lost elements of the interior were also reconstructed (Fig. 10, 11). The basis for the reconstruction was results of scientific research and archival material.



Fig. 10 – A sweep of the western wall of the church (analog reconstruction).



Fig. 11 – Western wall of the church (result of reconstruction).

Visualisation, producing of three-dimensional colour modeling

The final stage of work is three-dimensional color modeling (Fig. 11). In future static images, video, interactive models, which allow a user to choose the viewing angle of architecture and frescos are planned to be made up.

So, step by step, we have accurately recreate the frescos of the Church on Nereditsa Hill, which seemed to be lost forever.

Two main methods of reconstruction: a technology of computer graphics and analog pictorial reconstruction are used at the same time. Both of them have its advantages and disadvantages. The method of computer reconstruction provides maximum documentary accuracy – all manipulations with shapes and colors are made strictly in accordance with historical documents. In addition, each operation can be fixed at any stage of work. At the same time this method can't help us to convey the artist's style, to reproduce the form, direction and strength of the artist's touch and texture of the frescos.

So, especially when we deal with completely lost fragments of frescos, it is better to use the method of pictorial reconstruction. The main disadvantage of this method is its complexity. It is very difficult to provide exact documental accuracy and to find appropriate author's stylistic manner at the same time. Painting has become cyclic: some fragments were redrawn several times according to produced template until reaching expected result.

Virtual reconstruction may be used as the basis for making in future: for producing static images, videos, interactive models enabling users to choose a camera and viewing angles when browsing through architecture and artistic decorations.

In contrast to the widespread practice of relative approach to documentary materials, a specific feature of the project is maximum approximation of the model to the actual original appearance of the monument.

Documentary precision of the material provide usage of the results in practical work for the restoration of the object in future. Moreover, the method used in the project may open new possibilities to solve restoration problems of other fresco ensembles of the medieval Novgorod, also lost during the War.

The results of the project can be used for further practical work for the restoration of Nereditsa Church.

Virtual model of the church may be used in future as a basis for producing virtual exhibition. Using modern technologies, such as multi-projection systems, holograms, and augmented reality systems, information about the monument can be produced in interesting interactive form. Such information center can be organized in the Nereditsa Church, the Novgorod State Museum or any other complex.

The results of the work are presented at the educational portal of St. Petersburg State University

<http://sakai.spbu.ru/portal/site/169dd5df-93bd-4150-9a01-86f567045218> or <http://www.nereditsa.ru> in the form of educational resource Nereditsa.

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A tool in Cultural Heritage: the web application for the Museum of the sculpture in the Basilica of St. Silvestro at the Catacombs of Priscilla

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Abstract: The paper refers to a project in progress of a museum of sarcophages: the sculptures of the basilica of Saint Silvestro at the catacombs of Priscilla in Rome. The treatment of information and the usage of an interactive 3D web application represent in this context an innovative approach in Cultural Heritage and in particular in archaeology. The museum presents about 700 pieces of sarcophages dated between the beginning of the III century and the first half of the IV century. Recently, the sculptures were restored and in the inventory archived following the standard of the ICOM-CIDOC (International Committee for Documentation of the International Council of Museum). Our choice has been to maintain the pieces in their original context of the basilica and improve the accessibility: through an architectural project, using QR-code for warding to pages accessible from the local wireless network of the museum and a web-application based on a method called ISEE.

Keywords: interactive 3D, sarcophages, catacomb, web-application.

Overview

The development of tools in the Cultural Heritage has increased in the last years. The choice of which instrument one should use is not always easy due to the variety available in the market. Sometimes the projects invest many resources on the development of new softwares that not adapt to other projects. For instance the usage of G.I.S.s (Geographic Information Systems) for Spatial Analysis in archaeology has become a common instrument in the research to record 3D location (APOLLONIO et al. 2012; STANCO et al. 2012). The application of spatial technology in archaeology can be classified into three categories: visualization, data management, and spatial analysis. In particular the representative visualization, as the production of either a direct representation of archaeological evidence or the reconstructions of past places or objects (PAKKANEN 2008; ALAMOURI and PECCHIOLI 2010; KULITZ et al. 2006), can be an useful instrument for the common user to understand and involve him/her in the visit.

However reconstructions in three dimensional environment are not always manageable and the information connected cannot be visualized, but the research is improving in this discipline (VERDIANI et al. 2011).

The virtual world offers interactive or immersive representations of the reality with a whole host of new choices in terms of the viewer's perspective, the choice of what to present and the form in which to present it (WINTERBOTTOM and LONG 2006). We are likely on the verge of an era of better, more accessible and

more creative virtual reproductions as the Internet evolves toward Web 2.0 applications, resources and services. This technology is reaching avenues of representations that might otherwise have been limited to desktop applications.

The context

Our project is aimed at exposure archaeological material within the context of discovery. The context is therefore itself an archaeological object with critical access and specific need for enhancement. It is an archaeological context, partly used for liturgical celebrations and partly transformed into a place to preserve a collection of fragments of sarcophages, as well as being an area of transition and connection to the underground catacombs.

The Basilica of Saint Silvestro above the catacombs of Priscilla in Rome was built in 1907 over the foundations of two ancient constructions: one of the end of the III century and the other of the mid-fourth century (DE ROSSI 1890) (Fig. 1). The original building were incorporated in a funerary enclosure and surrounded by many mausoleums. The floor of both buildings has been tapped for the insertion of earthen tombs and along the walls were piles of arcosolia. In the fourth century, in the oldest one were transferred the bodies of two martyrs Felix and Philip and buried on the pope Silvestro (+ 335) (MARUCCHI 1906). In all of the funerary areas many sarcophages were placed and this artefacts were found in the excavations of the beginning of the XX century (TOLOTTI 1970). The marble fragments were hung on the walls of the reconstructed building, following the iconographic criteria (Fig. 2).



Fig. 1–2 – Roma. The St-Silvestro Basilica in the 1907 and in the 1970 (Photo Archive PCAS).

Activity

The first activity of the project involved the excavation of the archaeological structures located below the previous floor of the basilica to retrieve the context of the place. The findings led to the choice to build a glass floor to view the structures and leave at the same time act as a laying surface for the sculptures. The second step was the restoration of more than seven hundred fragments of sarcophages. The sculptural heritage was almost unknown and the restoration showed many very interesting news. In the past, the stone had been placed on the walls of the rooms of the basilica, according to an exhibition criterion based on the

iconographic subjects. This caused the dispersion of materials threatening the integrity of the works, which are now finally reassembling.

The third phase was the classification of marble fragments using ICOM-CIDOC standards. The ICOM-CIDOC is the International Guidelines for Museum Object Information. The aim of the project is to create a common language to share the information of the museum worldwide. Accurate and accessible documentation is an essential resource for collections management, research and public services and a museum documentation standards are necessary to enable information exchange and integration between heterogeneous sources of cultural heritage information.

The arrangement of sculptural materials was organized by the type of sarcophages in accordance with the iconographic subjects represented. The seven identified sections also allow you to follow the evolution of ancient funerary sculpture and the change of topics from first to fourth century. For each section a fragment was identified significantly more that will guide the understanding of variations. In the last section introduces the necessary criteria illustrations highlight recent additions to Christian art, while creating an introduction to the visit of the underground catacombs.

Microclimatic monitoring

The two buildings were positioned so as to incorporate two of the stairways leading to the underground catacomb, and this accessibility was thought to allow the pilgrims to visit the whole environment.



Fig. 3 – The current work in the Basilica of St. Silvestro (Photo Archive PCAS).

Today, the proximity between the external environment and the underground sites causes many problems to the microclimate of the basilica. The relative humidity values are consistently over 90% and the winter

temperature remains constant at around 12° C. The conditions described leads to a high chance of condensation.

These microclimatic factors have been carefully studied to find compatible solutions with the current project and the archaeological context (Fig. 3).

Our aim

The goal is to enhance the environment and the relative graves rebuilding its historical identity through a museum where the fragments of sarcophages can be highlighted. The museum has been thought and developed using the technology since the beginning. The accessibility of information and the data management contribute to our interdisciplinary collaboration.

In a previous phase a 3D model has been created from the laser scanner for several uses: it has been used by the different professional figures involved in the project, architectural and illumination planning (Fig. 4). With it one will be able to perform a virtual visit using a web application, giving access to more people. A purely virtual visit can improve the microclimatic situation, but an important application is to augment the real visit by allowing the visitor to find information that cannot be directly retrieved in the real environment.

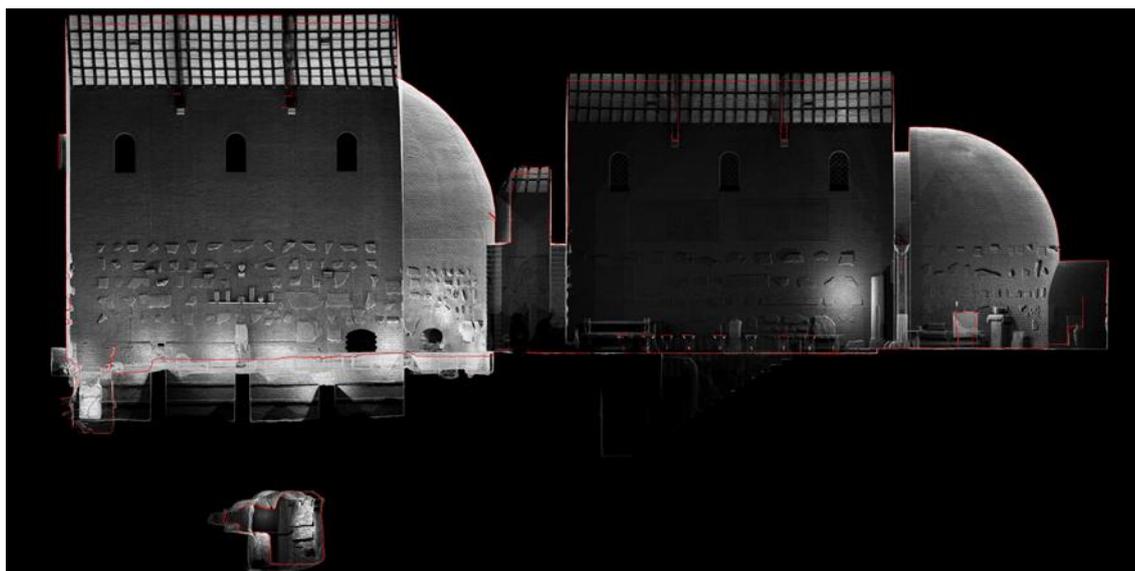


Fig. 4 – Section A: AREA 3D (Arch. A. Peruzzi and Arch. M. Pucci).

3D Web application

The approach has been to maintain the pieces in their original context of the basilica through a project and a web-application based on a method called *ISEE* (the name of the method that means “I see”). Its intuitive interface allows the user to navigate in the model and retrieve the information when he/she is looking. The basic idea of the *ISEE software* is to enable information retrieval by simply viewing inside a 3D environment, since moving and looking in the real world are basic modes which all viewers use. *ISEE software* ranks the relevant information by means of its position/orientation in 3D space as a viewer. The ranking algorithm that

we developed matches the intuitive expectation of users as verified by means of formal usability tests (PECCHIOLI et al. 2007).

The method ISEE is the attempt to connect different fields of research with modern technology through its intuitive approach and its versatility (Fig. 5).

We use the Unity 3D technology (<http://unity3d.com>) to visualize and interactively navigate 3D models. The Unity plug-in is available for all the major browsers (IE, Firefox, Safari) and platforms (Windows, OsX).

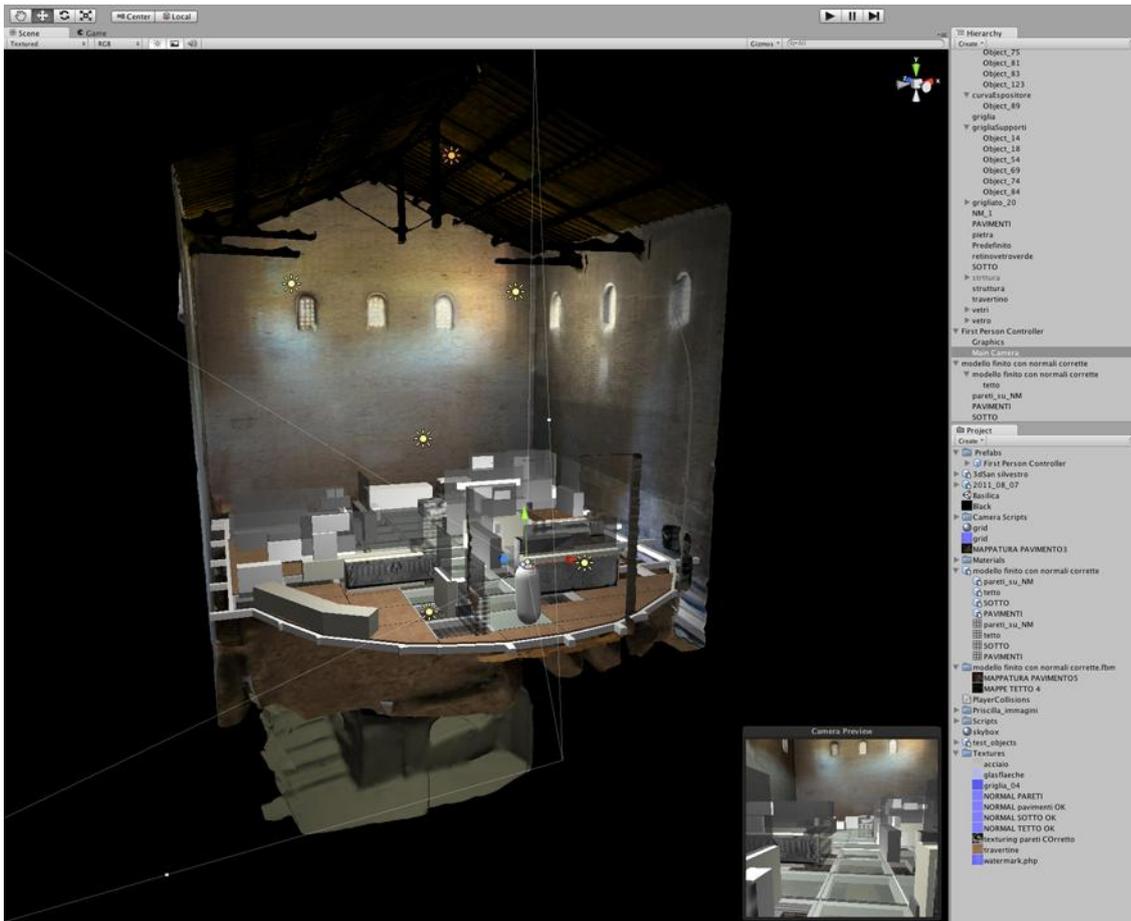


Fig. 5 – 3D Model imported in Unity3d.

Archaeology and 3D technology

In the virtual visit the user has two access levels: common user and researcher. The different interface will be structured using the intuitive and user-friendly interface of the system (Fig. 6). We are testing in these months the types of interface for the usability test.

The space of the museum does not allow to show all the information available, but only a synthetic description and a number of archive. To allow the user to view more information also a QR-code is printed. This connects the information available in the purely virtual visit to the real visit so that the user can read the information for each fragment in detail. The added information will be provided inside the basilica using a local network and the user will be able to read through his/her mobil device using QR-code. The platform is being developed and followed from an interdisciplinary team.

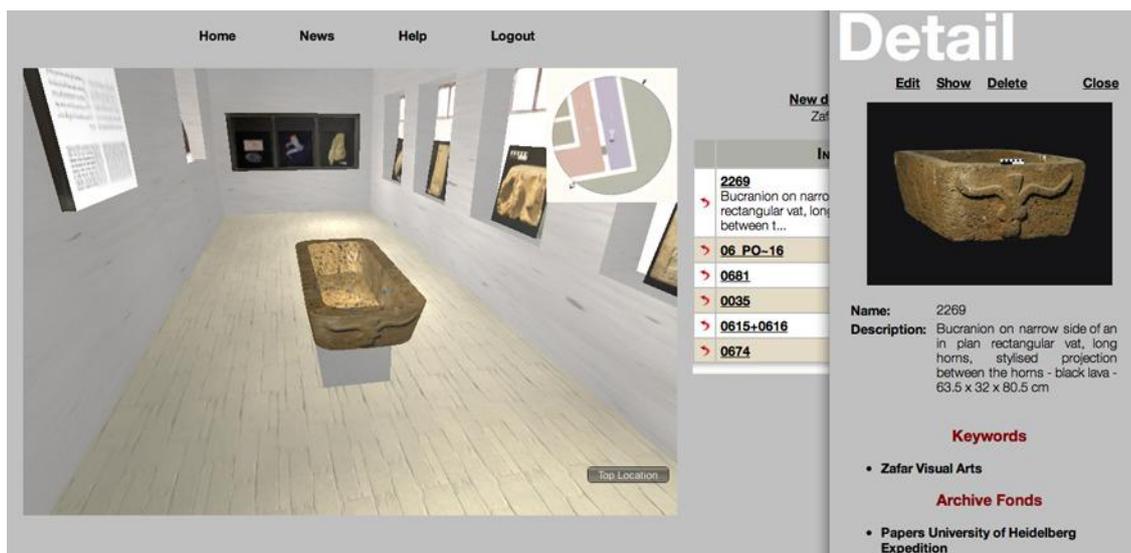


Fig. 6 – Example of ISEE interface: Zafar Virtual Museum, Yemen (in collaboration with Prof. Paul Yule, Heidelberg University, Germany).

ISEE and Arachne Database

Some of the sarcophages of the basilica of Saint Silvestro are already catalogued in a database called Arachne. Arachne represents a central object-database of the German Archaeological Institute (DAI). In the 2004 the DAI and the Research Archive for Ancient Sculpture at the University of Cologne (Germany) joined the effort to support Arachne as a tool for free internet-based research. Arachne is intended to provide archaeologists and Classicists with a free internet research tool for quickly searching hundreds of thousands of records on objects and their attributes.

In ISEE database the information is stored as normal files into folders and the so-called metainformation (created by, modified by, the name and a short first description) also in a relational database which allows the user to quickly query the data.

The information is archived in its original format (xml, jpeg, tiff, txt, mov, etc.). All data relative to the same piece of information is recorded in a folder, which contains also the meta-information recorded in the database in a special file in *xml* format.

The most users have familiarity with this type of structure: for its in the management of folders and files, the ease accessibility to data for controls and in particular backups. Often the data entered in the relational database are registered in a format that depends on its version, and need special tools to be copied, which can hinder future accessibility. Our approach tries to combine the advantages of database and filesystem storage.

ISEE contains a minimum set of information which may be extended: name of the file, path, a field of description, the reference date, inserted by, coordinates the location information and a view in the model. In this project for more in depth information ISEE database relies on Arachne and the ICOM-CIDOC archiving standard.

Developments

The team developer is realizing for the next May a new version, ISEE v. 3.0 with major changes which improve the usability (<http://isee.kitabi.eu>). The web application will take place in the site of the Pontificia Commissione di Archeologia Sacra to be accessible using the modern browsers (IE, Firefox, Safari) together the photographic archive and a history digital archive. The architectural project and the web application interact with each other.

Conclusions

Our interdisciplinary collaboration is a contribute to try an innovative solution for the accessing and managing the information in its context. The museum is inserted in a new tour of the catacombs of Priscilla which contributes to improve its cultural value. The different level of accessibility for the user through Internet, and that in situ using mobile devices, improve and integrate the data, giving to the visitor expanded range of choice and knowledge in a particular field of the archaeology.

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Virtual Museum of the Delta of the Neva River

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Abstract: The main objective of the virtual museum of the Neva delta is Russian city Saint-Petersburg, which is located on the banks of this river. The project focuses on the urban development of Saint-Petersburg, implement of modern architecture projects in the city and preservation of its cultural heritage. Nowadays in Saint-Petersburg there are several museums devoted to its historical and cultural development. Recently many virtual projects, such as online museums and virtual galleries, have been produced by different developers. But at the same time these sources often give incomplete information and occasionally seem to be avocational. Typical museum projects focus on certain aspects of city life and do not develop a theme of urban planning.

According to the dynamic growth and rapid development of Saint-Petersburg, problems of modern urban planning appear to be very important and even urgent.

Comprehensive approaches to construction of new architectural ensembles, modern architectural objects and reconstruction of old buildings in historic districts – these problems are very important not only for St. Petersburg, but also for other cities in Russia and all around the world.

St. Petersburg needs a new complex urban museum and cultural center, which would combine a classic exhibition with modern exposition halls, equipped with facilities for the most effective presentation of information: projection screens, interactive panels and equipment for presenting holographic images, based on three-dimensional architectural models, and other devices.

Such museum complex can be supplied with online museum, available for visiting by any Internet user.

Virtual Museum of the Neva delta, produced as a website can exist as an addition to a real museum complex, but also may be a single source of information.

Today the layout and content of the online museum are already completed, and the complex urban museum is at the concept and design stage.

Keywords: urban museum, virtual reconstruction, Saint-Petersburg.

Museum concept

Nowadays process of development of modern cities and reconstruction of its historical areas is very fast and sometimes insufficiently controlled. Thus problems of modern urban planning are extremely important.

Formation of new architectural ensembles, reconstruction of obsolete buildings, implementation of modern architectural objects into historical areas – these problems are very important not only for St. Petersburg, but also for other cities in Russia and all around the world.

The pace of our life demand modernization of transport infrastructure, old architectural objects obtain new functions and shape. Sometimes this transformations appear to be successful, but very often they seem to dissonant with historical urban environment.

In St.-Petersburg situation in this field is very complicated because architectural intervention into the existing urban environment is often spontaneous and not well-regulated by city-planning organizations.

There is no single concept of urban development of St. Petersburg, there are no strict building regulations, that would help to avoid urban planning mistakes (ROMANOV et al. 2010).

According to fast development of city's territories and specific character of this process, researches, connected with conservation of historical monuments and cultural heritage appear to be very important. We need to form a new modern image of Saint-Petersburg as a city with long rich history, to attract public attention to the problems of conservation of historical urban environment.

Currently, there are quite a lot various museum complexes, which focus on the history and culture of the city. Also, a lot of different virtual resources, sites and forums have appeared, where users discuss problems urban planning of St.-Petersburg and criticize new controversial architectural projects. This shows, that public interest in city-building process is very high today. At the same time these resources do not deeply investigate the problem.

St.-Petersburg needs a brand new museum and cultural center that would unite classic exhibition along with modern exposition halls, equipped with facilities for the most interactive presentation of information: projection screens, interactive panels, holographic images based on three-dimensional architectural models, and other devices. Use of new technologies helps to create absolutely new museum tours and virtual educational programs (LEBEDEV 2007: 35).

In addition to this museum complex a single virtual resource can be created. It is going to be a website published on the internet and accessible for any user from any part of the world. Virtual museum of the delta of the Neva, produced as a web site, can exist as a supplement to the real museum complex, but also may be a single information resource, which would focus on all aspects of development of Saint-Petersburg and river Neva. Today there are quite many different websites devoted to various aspects of city life, but there is no complete virtual museum of St. Petersburg, no global project, containing various information about history, development and current problems of the city.

Museums purpose

Main aim of creation virtual museum of the river Neva is attraction of attention of public society to the city and problems of its urban planning. We need to create new modern image of Saint-Petersburg as a city with long eventful history.

Another aim of the project is creation of structured data bank, which would contain various information about the Neva delta, and could be completed with new data at any time.

Study of Analogues

At the first stage of the project we need to produce a concept of the museum complex. At the same time we start to collect information about other similar project, already produced in other countries. One of the largest museum complexes of urban planning is Shanghai Urban Planning Exhibition Center.

It is a six-storey building, in which visitors can study all stages of urban development and future plans of Shanghai. Models of modern Shanghai and its urban planning are the largest and most interesting museum

exhibits. Each room is dedicated to specific issues of urban development: resettlement of old districts, installation of new communications, transport and other themes. Almost all rooms are equipped with workstations with interactive touch-screens, allowing visitors to get acquainted with the information in the form of virtual tours and computer games (Fig. 1).



Fig. 1 – Model of modern Shanghai and its urban planning at Shanghai Urban Planning Exhibition Center.

Beijing Urban Planning Exhibition Center focuses on similar subjects. Historical drawings and plans of old Beijing are stored here as well as general plan of Beijing of 2020 year. Some exhibits tell us about Olympic games 2008. The most interesting part of exhibition is model of modern Beijing, made in a scale 1:750.

Another interesting project is Singapore City Gallery, where a scaled model of the city is also performed. The museum exhibit shows the stages of development of Singapore, shows special features of the city which is at the same time a whole state. Exhibition Centre offers visitors a virtual interactive tours, panoramic video, game tours.

In many European cities there are special architectural exhibition centers, where temporary exhibitions are being organized. The aim of these projects is to present and discuss new trends in urban architecture. For example, such centers are in London (www.architecturecentre.co.uk), Copenhagen (Danish Architecture Center, english.dac.dk) and other cities and countries. Main theme of these projects is studying of modern urban architecture and discussion of innovative projects and future development plans.

Also there are some other museum projects, which focus mostly on historical development of different cities. For example, museums of Prague (<http://www.prague.net/prague-city-museum>), Copenhagen (<http://www.copenhagen.dk/>), Wroclaw (www.muzeum.miejskie.wroclaw.pl).

Museums in Prague and Copenhagen, along with the classic exhibits offer visitors to explore the medieval city model and reconstructed models of individual buildings and interiors. Museum of Wroclaw is also produced in the form of website (www.muzeum.miejskie.wroclaw.pl/vr/ratuszvr.html), where visitors can take a virtual walk through the halls and exhibits on-line (Fig. 2).

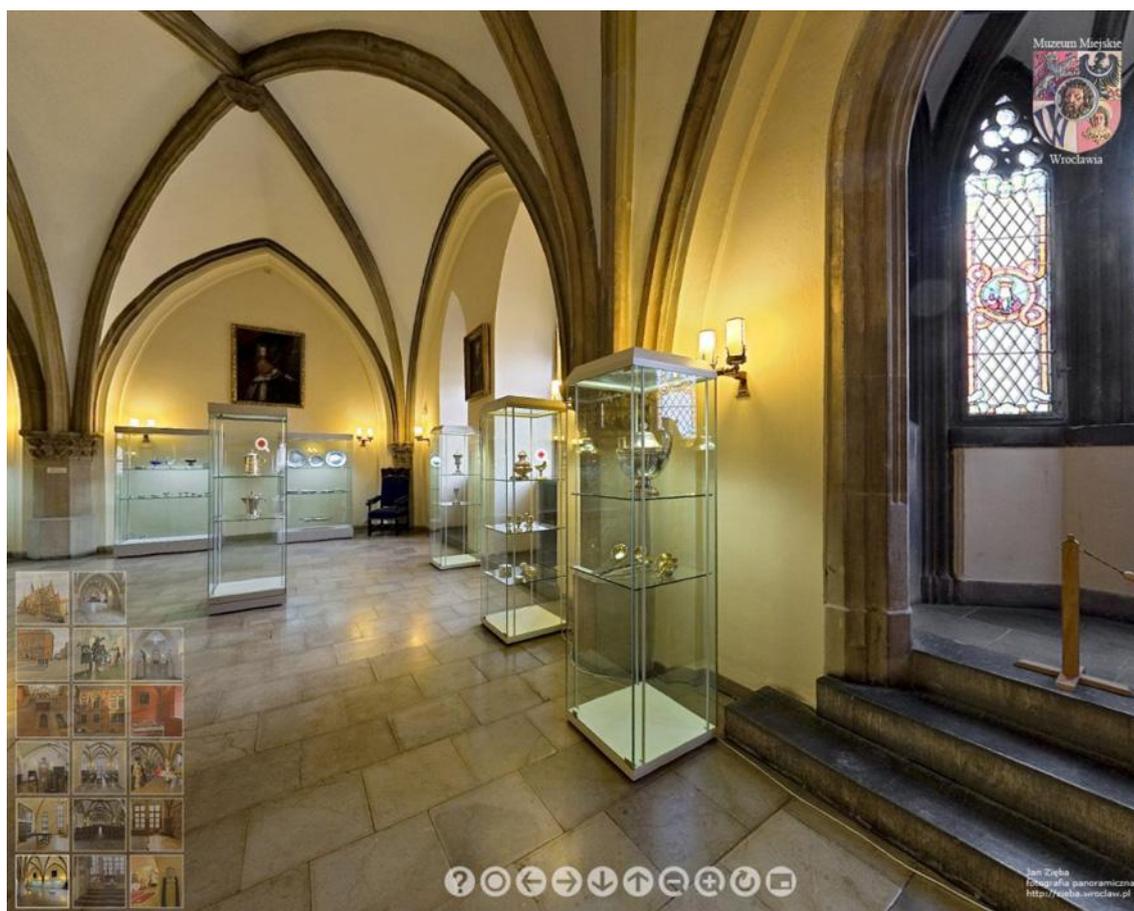


Fig. 2 – Virtual tour of Wroclaw museum web-site.

Many cities have their own websites. Most of them are produced in the form of on-line travel guide ((Vienna – www.wien.gv.at, Berlin – www.berlin.de, London – www.londontown.com, Prague – www.prague.net, Paris – www.paris.fr, etc.). But there are also more serious projects of urban virtual museums, which include virtual tours, interactive photo galleries, panoramas, maps, game tours and other techniques, which help to make operating with virtual museum much more convenient and effective. In such projects information content is also different, more attention is paid to historical, geographical and cultural aspects of urban development, these projects are complex, they to be a kind of encyclopedia of the city. Examples are on-line museums of London (www.museumoflondon.org.uk), Copenhagen (www.copenhagen.dk), Moscow (www.mosmuseum.ru). On-line museum of London includes virtual tours, some educational tours, realized in the form of small games and other virtual exhibits (Fig. 3).

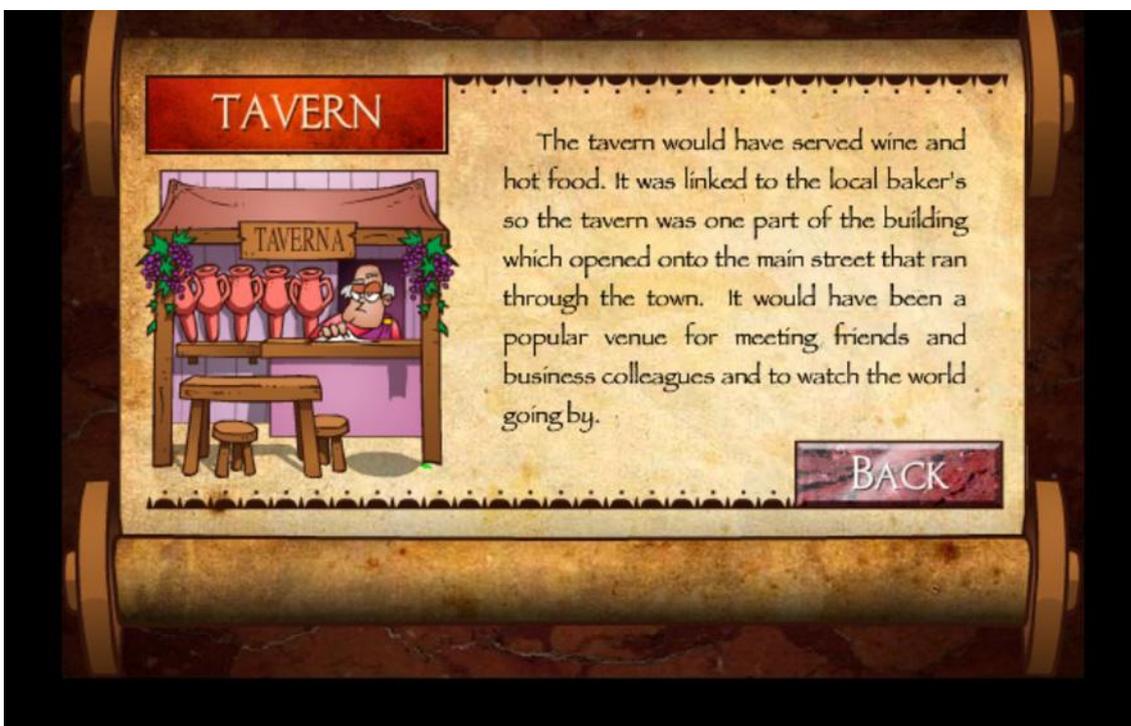


Fig. 3 – Educational games of London on-line museum.

As for the projects, dedicated to St. Petersburg, they are: the State Museum of history of St. Petersburg (www.spbmuseum.ru), website "virtual walk in the Russian Museum" (rmtour.ru), virtual tours of the Hermitage (www.hermitagemuseum.org).

Museum of history of Saint-Petersburg offers visitors permanent and temporary exhibitions, which illustrate historical development of the city. There are some special tours and educational programs for children. Museums website along with other information offers an interactive map and the panorama of the fortress. Project "virtual walk in the Russian Museum" as well as website of the State Hermitage Museum offer users interactive panoramas of museums halls.

Analyzing existing urban planning museums, we can formulate the following BASIC PRINCIPLES OF PRODUCING MODERN URBAN MUSEUM:

- ▶ Complex approach;
- ▶ Creation of complete information database;
- ▶ Study of new trends in urban planning, analysis of new architectural projects;
- ▶ Creation of social cultural center as an integral part of museum complex where conferences, seminars and symposiums about urban architectural projects and development plans can be organized and take place;
- ▶ Use of various methods of presenting information.

Modern urban museum should present not only historical past of the city, but actual problems of its further development. It should be an architectural center with temporary and permanent exhibitions, conference rooms and halls with all necessary equipment.

Creation of On-Line Version

On-line version of museum is also required. Producing of website can be a basis for real complex urban center. On-line version should cover all aspect of development of the city: its history, geography, culture, social life. This may be a kind of encyclopedia of the city, which would expand and develop simultaneously with the city. Website would attract new visitors and tourists, it can improve an image of the city. Not everyone has an opportunity to visit the museum in real life, and virtual version is accessible to anyone, who has access to the internet. Modern museum is a kind of social institution and it is important to make it accessible to a wide range of visitors.

Modern museum has also cultural and educational functions. Today it is very important to socialize problems of urban planning, especially among young people (NIKISHIN 1999: 75). Innovative approach in education, development of distant learning option, alternative methods of presentation may improve classical educational programs and attract public interest to urban architectural problems.

Now the on-line version of urban museum of Saint-Petersburg is being developed at Saint-Petersburg State University. The project is called "Virtual Museum of the delta of the Neva". During working under this project, a version of website was produced. The most important purpose was to work out museum structure and main themes of virtual exhibit.

Main themes of virtual museum should be selected in accordance with the interests of users. Virtual museum of the Neva delta is focused on everything that concerns to the past, present and future of the Neva and Saint-Petersburg, but modern development of the city and delta is the most important theme.

As for historical development of the city, it is very interesting to study previously unexplored facts and events. For example, unrealized architectural projects, lost or rebuilt monuments.

Also it is interesting to show how special geographical location has influenced development of Saint-Petersburg. Actually Neva is a young river and it appeared only 3000 years ago and the process of its formation can be shown using technology of virtual reconstruction.

An interesting feature of this project is a special role of water infrastructure of the city. Delta of river Neva is a whole system of canals and islands, and the special geographical location of Saint-Petersburg has certainly affected its urban development. Neva has been a transport way and has defended city for centuries. For

many years Saint-Petersburg developed in the context of Neva delta, that formed its structure, influenced life of citizens. In the project Neva and Saint-Petersburg are treated as a single system.

Another themes are:

- ▶ Ancient human settlement on the banks of the Neva river
- ▶ Flora and fauna of the Neva delta
- ▶ Archaeological research and finds in the area of the Neva river
- ▶ Ecology of the Neva delta and Saint-Petersburg
- ▶ Navigation on the river Neva
- ▶ Literature and references about the Neva river, myths and legends about St. Petersburg

Virtual museum has no limits, virtual exhibits do not need any space at museums halls. That why exhibition themes are not limited. Virtual museum of the delta of the Neva is a flexible system which can be completed with new information at any time.

Actually users can take part in creation of information content of the museum themselves, for example by means of forums or e-mail messages. Thus the main task is to develop a clear and logical structure of virtual museum, based on themes of virtual exhibition (Fig. 4).

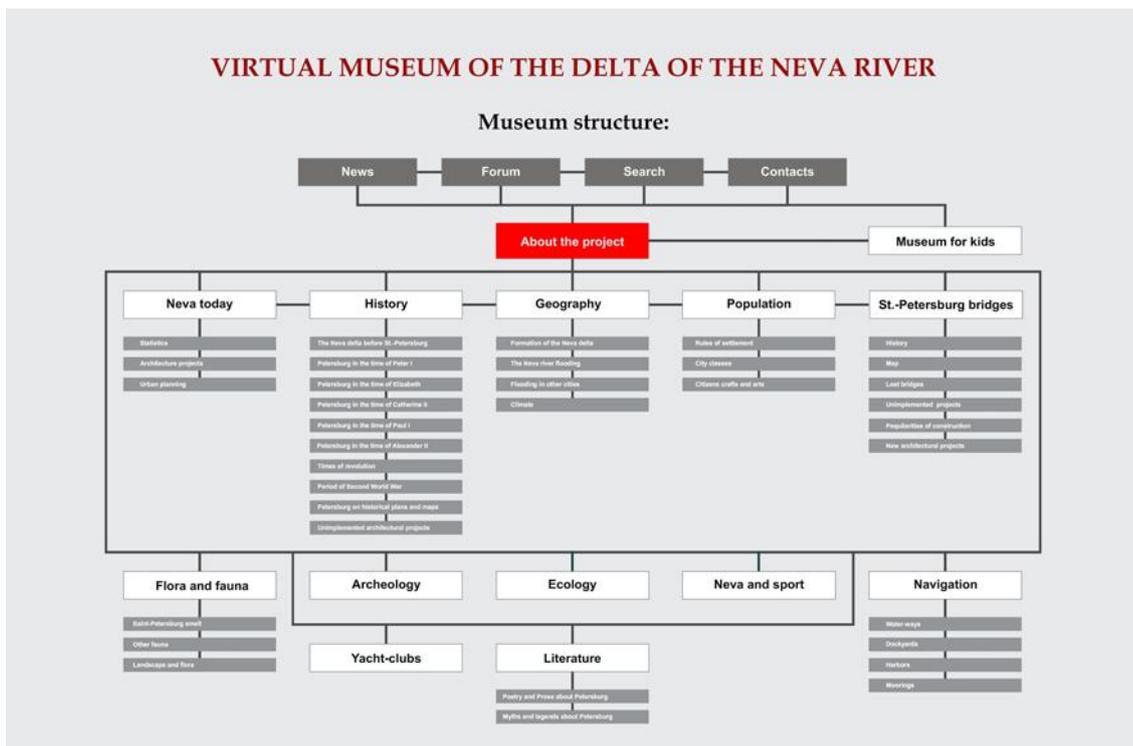


Fig. 4 – Structure of virtual museum of the delta of the Neva river.

As for informational content of virtual museum it is planned to develop:

- ▶ Virtual tours of the city in different historical periods
- ▶ Virtual excursions along the Neva river;
- ▶ Kid's virtual tours, games and educational programs, concerned to St. Petersburg, its history, geography, population and other themes;

- ▶ Three-dimensional models of architectural monuments and ensembles;
- ▶ Virtual models of unimplemented projects and lost monuments;
- ▶ Virtual models of modern architectural projects;
- ▶ Visualization of the Neva river flooding;
- ▶ Visualization of the formation of the Neva delta;
- ▶ Interactive historical and modern maps of the city;
- ▶ Videos, presentations, printed materials.

A part of museum content has been already created, but this work is far not complete and it continues. For example, an unimplemented Leblond's project was produced in the form of three-dimensional plan (Fig. 5).

The basis for this reconstruction was historical plan of 1716 year, made by Leblond when he was chief architect of Saint-Petersburg (SEMENTSOV et al. 2004: 57).

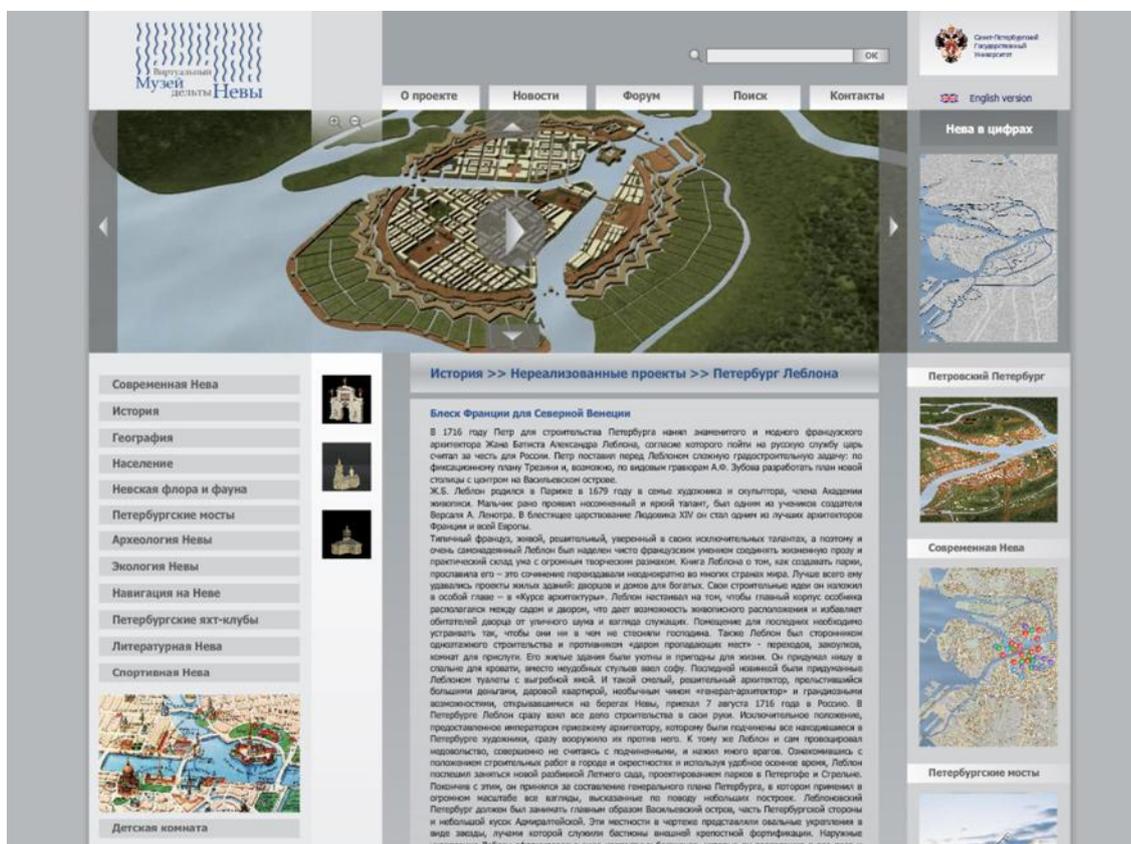


Fig. 5 – Section of virtual museum of the delta of the Neva river – Leblond's Petersburg.

Another interesting virtual exhibit is reconstructed three-dimensional plan of St.-Petersburg in the times of Peter-the-First. This reconstruction was also based on the historical documents – maps of Saint-Petersburg from 1714 to 1725 and more detailed map of 1738 (although second map refer to later period, it was also used as a basis because some objects mentioned in documents were absolutely indistinguishable on the first map) (Fig. 6).

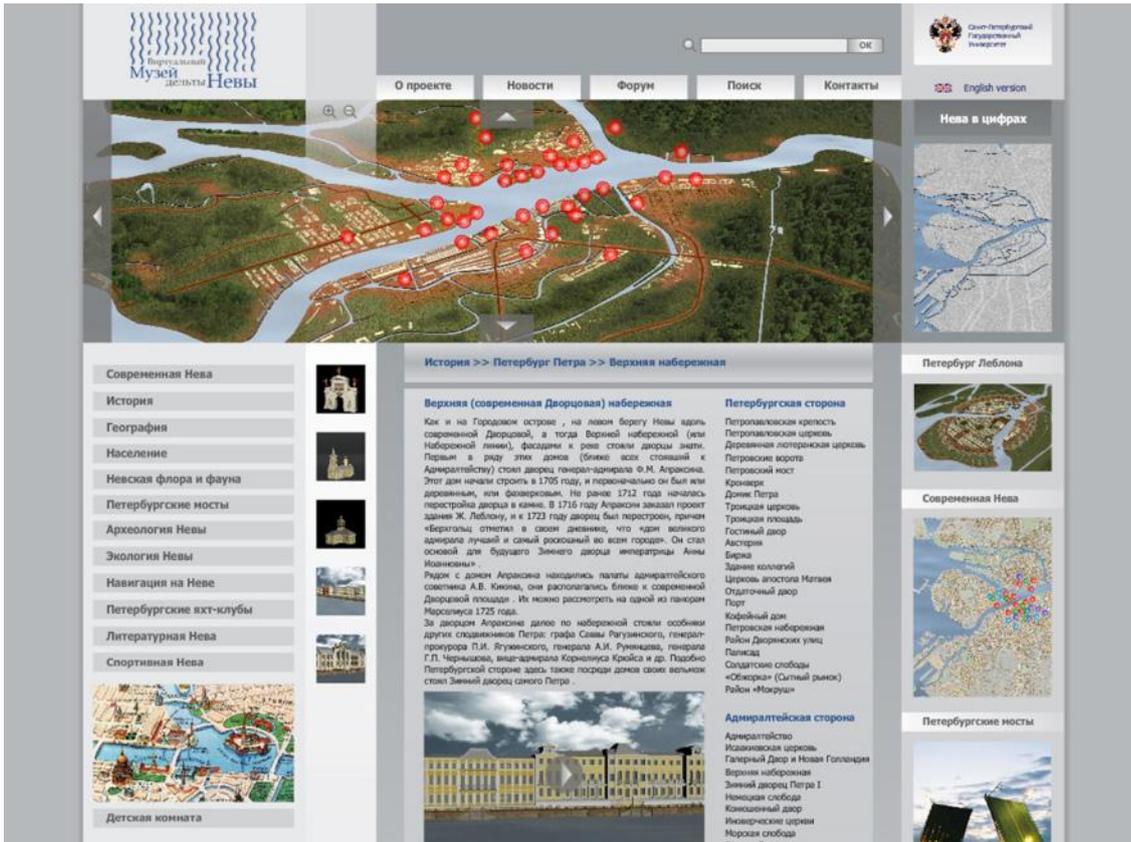


Fig. 6 – Section of virtual museum of the delta of the Neva river – Petersburg of Peter-the-First.

As well as the map, some buildings of this period were also virtually reconstructed. Sources for this reconstruction were publications and illustrative materials XVIII century, especially important were historical panoramic views of the XVIII century, made by Zubov A.F. and Marselius C. (ST. PETERSBURG IN WATERCOLORS, PRINTS AND LITHOGRAPHS XVIII - XIX CENTURIES. FROM THE STATE HERMITAGE 2009).

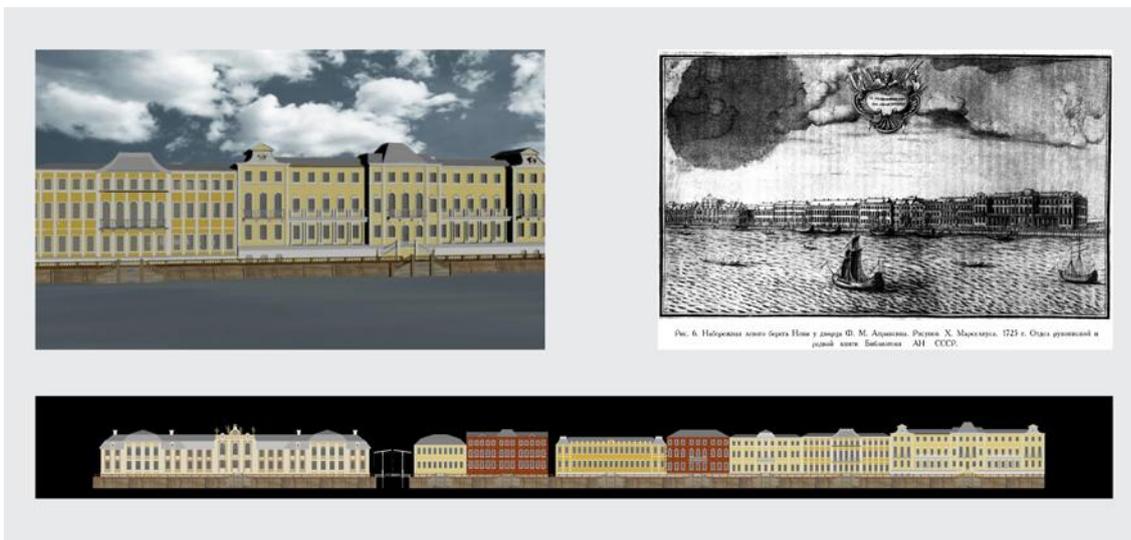


Fig. 7 – Example of reconstructed historical object - Palace Embankment in 1720s: reconstructed general view, basis – panoramic view, made by Zubov A. F. in 1725, reconstructed sweep.

Reconstructed objects are: shopping arcade, Peter’s gates, Palace Embankment, Winter Palace of Peter I, typical houses (Fig. 7). A section of the museum focuses on geography of the city and Neva river flooding. Actually these tragic events were really dangerous and only in 20 century the problem was solved by building dam (Fig. 8). Some other sections of the museum were also developed: three-dimensional models of modern delta (Fig. 9), historical maps and plans and some others. The project is being currently developed, and researchers continue working on it.



Fig. 8 – Virtual reconstruction of the flooding in 1724, the most wrecking in the history of St.-Petersburg.



Fig. 9 – Three-dimensional models of modern delta.

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SESSIONS

Streets, Roads and Squares – Development, Function and Conversion

From roman Dacia *principia* and *fora* to public market places in Transylvania

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Abstract: The paper analyses the roman Dacia open spaces architectural programmes, such as *principia* for the military camps and *fora* for the civilian settlements, and their transformations during the medieval and modern times periods in some important urban centers of the province. First of all, the the paper introduces the definitions of the roman open space architectural programm for *principia* and forum, closely connected one another as responding to a common functional purpose : both were public assembly places. The next step is to see how these architectural programmes were reconsidered (if they were) after the roman period. The paper presents next some case studies for the most important urban centers from Dacia, focusing on the central market place, and the way it was transformed or completely abandoned during the medieval and modern times. The analyse, the first one of this kind, is based on archaeological excavations results, several cartographic and litterary sources, ancient photos, etc. In order to have a complete image of the urban evolution phenomenon in Transylvania.

Keywords: *principia*, forum, Dacia, Transylvania.

Introduction

„*The art of laying out towns with due care for the health and comfort of inhabitants for industrial and commercial efficiency and for reasonable beauty of buildings is an art of intermittent activity.*” (Francis John Haverfield, *Ancient Town Planning*, Oxford, 1913)

When Francis John Haverfield published in 1913 his famous book from which we quote this paragraph, the world was already aware of the great importance of the urban classical tradition in the art of town planning. In fact, the major part of the European modern cities were built according to some basic classical urban principles, one of them being the permanence of the public open space right in the middle of it.

The medieval cities of Transylvania, one of the most important provinces of the east European area, knew this town planning principles right from the very beginning. But first of all it would be very interesting to find out what is Transylvania.

From Transylvania to Siebenburgen

When the ancient governor of Macedonia province in 75–73 BC, *Gaius Scribonius Curio*, tried to reach the region surrounded by the Carpathian mountains, known at that time under the name of Dacia, he was afraid of the deep forests he met there –“*Curio Dacia tenuis uenit, sed tenebras saltuum expauit*” (Florus, *Epitome of the Histories of Titus Livy*). At that time Transylvania was two thirds of the roman province of Dacia and it was almost reputed for its dreadful woods. In fact Transylvania or *Ultrasilvania* as it was known in the

medieval sources, meant exactly „the country beyond the forests”. Besides, the other name of this province according to the hungarian sources, *Erdély*, meant also „forest”, from hungarian „*erdő*”.



Fig. 1 – Transylvania today – 10 departments and the Banat Bihor Zarand and Maramures counties (ancient Partium).

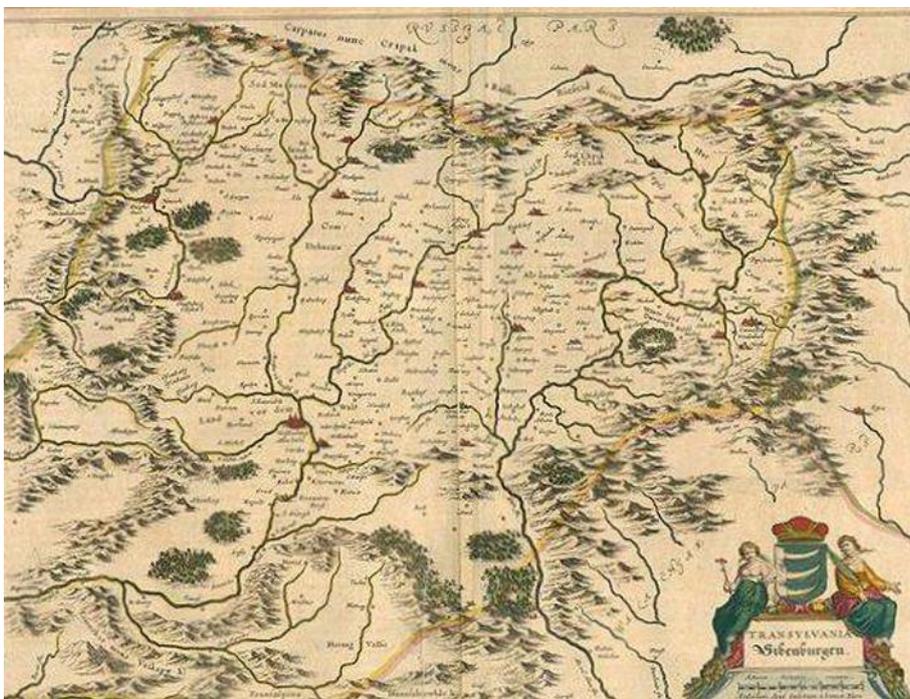


Fig. 2 – Transylvania-map from 1635.

Siebenbürgen was a medieval noun of Transylvania but there are still several theories explaining what it meant exactly. According to some XIII-th c. sources, Siebenbürgen has to be considered in close connection to seven village fortresses in Sibiu area, where the first saxonians colonists settled in 1247. The problem in

this case is that in Sibiu neighborhood more than ten village fortresses were attested at that time. Another theory, which seems to be more plausible, found support in a XV-th letter belonging to Aeneas Silvio Piccolomini, the Pope Pius II, mentioning seven medieval cities – Sibiu, Cluj, Sighișoara, Sebeș, Mediaș, Brașov and Bistrița – which were the most important of the whole province at that time.

Transylvania province today includes 10 departments – Alba, Bistrița, Brașov, Cluj, Covasna, Harghita, Hunedoara, Mureș, Sălaj, Sibiu – and a region which was called in the medieval documents as Partium – *partium regni Hungariae dominus* including actually Maramureș, Bihor, Zarand and Arad counties. The whole surface is actually of 100.293 km² and represents about 42% from the whole country of Romania (Figs. 1, 2).

Forum – principia and the medieval market place, symbol and meaning

There are close connections between open spaces meanings in civil or military roman settlements and those existing in the medieval cities which could be discussed here because they represents one of the most important aspects of the urbanism principles. First of all, it is interesting to point out that the *forum*, in the roman civil settlements or *principia*, in roman camps, had in fact a common functional purpose, i.e. they were both public assemblies open spaces situated right in the middle of the streets network. The forum was the roman city headquarters at the *cardo* and *decumanus maximus* crossroads and an important temple, dedicated to the capitoline triad, was built usually on the opposite entrance side. Several roman *municipii* or *coloniae* were founded exactly on this public open space consecrated to all kind of trades, justice, or general assemblies where crucial decisions for the public welfare were taken. The presence of the capitoline temple emphasized exactly the important meaning of this sacred public open space.

The *principia* was the roman camp headquarters situated at the *via principalis* and *via praetoria* crossroads and a legion chapel (*aedes legionis*) was built on the opposite entrance side (Figs. 3, 4).

This general central open space plan organised under a sacred authority, as the capitoline temple or the legion chapel, kept the same meaning during the medieval time when the cathedral replaced the roman monuments cited above. Furthermore, in some very few cases which will be discussed here, the public medieval market places have been developed on the ancient roman *forum-principia* locations or in their close neighborhood.

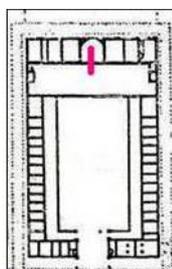
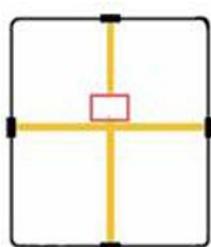


Fig. 3 (left) – The roman *forum/principia* at the crossroad of principal axes *cardo-decumanus maximus/via principalis/via praetoria*.

Fig. 4 (right) – *Principia* and *aedes legionis* (red) from V Legion Macedonica camp in Turda (Potaissa).

The first medieval cities of Transylvania and the occidental workshops

First of all we have to establish a proper term used to indicate the medieval settlements which will be discussed in this paper. According to the Cambridge English Language Dictionary *city* is supposed to be „*a large town and especially any town which has a cathedral*” so we are right to call by this term the major part of the medieval towns of Transylvania.

Urban life in medieval Transylvania was organized primarily around a few Roman abandoned settlements, whose walls were sometimes used as refuge citadels. One could cite about it some typical situations where the ancient walls of Roman times were used as refuge points for temporary communities settled outside the precincts.

Turda, the oldest medieval town in Transylvania, is attested for the first time in 1075 and it is located at the foot of a hill where was built the ancient Legion V Macedonian Roman camp. However, the Roman camp was not rebuilt or refurbished to a stable activity within the walls, as in Alba Iulia, whose first documentary attestation dates from 1097. Unlike Turda, the camp of the Legion XIII Gemina Alba Iulia was completely rebuilt in the X-th c. and its walls were used until the end of the XVII-th c, when the new Vauban fortification would replace and encompass the medieval fortress, built over the Roman foundations of the camp.

A third well attested medieval city is Oradea, but no Roman camp is known there. Its first documentary attestation dates from 1091, and it was at that time one of the most prestigious religious places from Transylvania, as the Romanesque cathedral built by King Ladislau (1077–1095) was supposed to house the royal necropolis of the prince family. Even if the ancient monument has been destroyed, new Gothic cathedral was built on the same spot, between 1342 and 1372. This is supposed to be the first „*hallenkirche*” (*hall type cathedral*) of Transylvania. As we know by the documentary sources, just in front of its west portal, in the main square, there were the bronze statues of Hungarian kings and saints Stefan, Emerich and Ladislau, made by George and Martin, whose works were highly appreciated throughout Transylvania and Hungary. Unfortunately, in the XV-th and especially during the XVI-th c. the cathedral has fallen into ruins and the remains were totally abandoned.

Some documents from 1113 mention another important center of medieval Transylvania under the name of „*Castrum Clus*”. This one also indicates the role played by the ancient Roman ruins of Cluj, the ancient city founded during emperor Hadrian reign known under the name of Napoca. The oldest monument of the medieval city, mentioned by the documentary sources, is a Benedictine church, built in 1222, completely destroyed in the XV-th century. On its foundations was originally built another church, entirely restored in the XIX-th c. which still retains a small trace of the earlier monument.

Another issue that deserves special attention is that of the urban typology developed in Transylvania.

We should discuss first the geographical and historical conditions of the location of the new medieval cities. In both situations the cases analyzed in Cluj and Alba Iulia, the medieval walls were built completely on the Roman *principia*, belonging to military camps, although for Cluj this problem is not yet definitely resolved. It is unclear, for example, what was really the army's role in the founding of the Roman settlement in Dacia. Besides, all other important medieval cities, most founded by the Saxons, arose on “virgin” land.

The development of medieval cities in Transylvania should be interpreted in the context of the massive Saxon colonisation which took place mainly between 1150 and 1220. This had an immediate effect because starting with the XI-th c. three major Catholic dioceses have been created: in Cenad, founded by bishop

Gerardus, in Oradea, founded by king Ladislau himself, and in Alba Iulia. Thus the religious transformations had an important impact on the cities development plans because the cathedrals belonging to these three dioceses concentrated around them the urban city life. We will see further which were the most important Transylvania medieval cities and how their plans have been changed during modern history.

Oradea

In 1091 *Oradea* became one of the most important medieval cities from Transylvania because of the great roman cathedral supposed to be the royal necropolis for the hungarian kings (Fig. 5). The original roman monument was completely destroyed and in 1342–1370 on its place was raised a huge *hallenkirche* (hall type cathedral) the biggest ever built in Transylvania. Destroyed during the XVI-th c. the vestiges of this important monument were integrated in the precincts which were raised at that time and restored later, in the XVIII-th c., in a Vauban style manner.



Fig. 5 – Oradea – Josephinian Landesaufnahme 1769,

wikipedia.org/wiki/File:GrandDuchyOfTransylvania_Josephinische_Landaufnahme.jpg.

Turda

Turda is the present day name of ancient Potaissa, an important roman military center where the Romans brought in 168–169 A.D the Vth Legion Macedonica. The legion camp was built outside the city, on a isolated hilltop which ensured a very good strategic position (Fig. 6). The camp was never affected by medieval or modern transformations and still preserves the major part of its vestiges. The medieval city has been developed at the foothill where the legion camp was built and its perimeter was temporarily used by the city inhabitants as a refuge spot during some very short periods of time. The first city medieval precincts were raised all around the foothill area during the second half of the XIIth c. but they were completely

destroyed in the XVth c. During the XV-th c. a new gothic cathedral was raised with a small public open area all around, both severely transformed during the XVIII-th c. In 1458–1504 a second gothic cathedral known as the Big Cathedral, became the city central area, with the city hall and the market place in its close neighbourhood, were still in place until the XVIII-th c. The place is no longer available today due to modern transformations of the area but the major part of the monuments are still functioning our days.

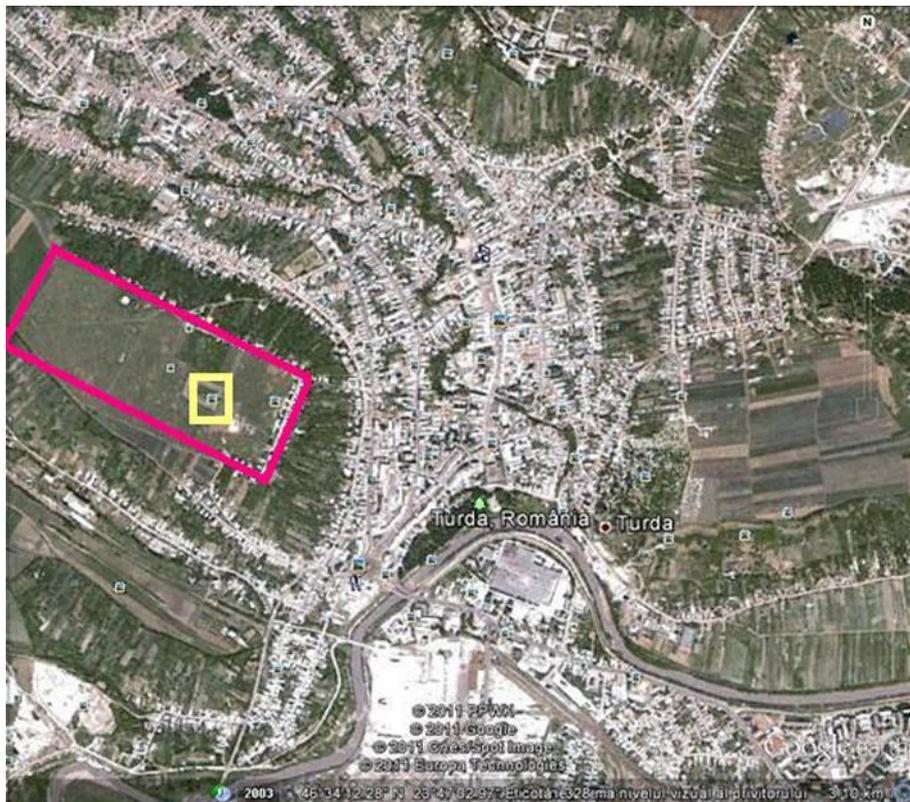


Fig. 6 – Turda today – Vth Legion Macedonica roman camp (red) and its *principia* (yellow).

Cluj

In *Cluj*, probably a military camp existed inside the modern city which became later the roman town known under the name of Napoca, as it was attested by a *milliarium* (mentioning the distance Potaissa Napoca). However, the forum supposed to be under the medieval and the modern city place, is not clearly determined (Fig. 7). As principal moments of the city history in 1173 the documents mentioned a *castrum Clus(i)*, whose precincts were built mainly on the roman city walls. In 1349–1450 was raised the gothic Cathedral St. Michael, one of the most important gothic monument from Transylvania. Its plan and the monumental decoration were inspired by a famous gothic workshop, coming probably from St. Elisabeth cathedral from Kosice, actually Slovakia, but several restorations during the XVIth and the XVIIIth c. altered the original image of the monument. The medieval city place was built during the XIVth c. and is still in place today.

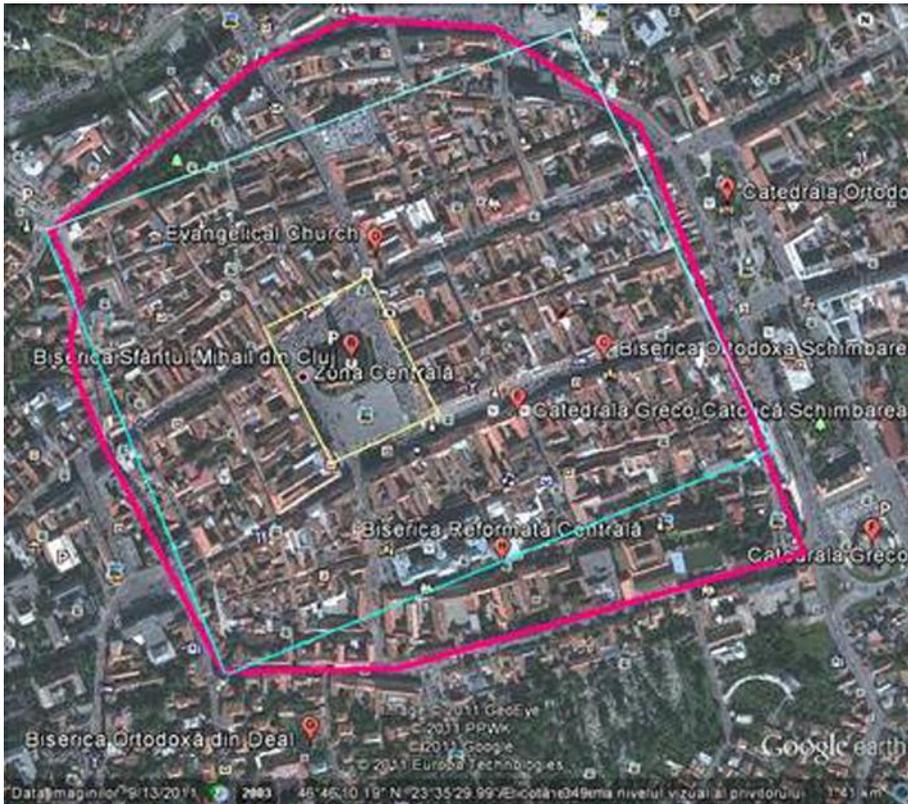


Fig. 7 – Cluj today – Medieval precincts (red) and the market place (yellow).



Fig. 8 – Braşov today – In the center the „Black Church” and the city market place.

Brasov

The city of *Brasov* knew an important development starting with the XIIIth c. when the first precincts with defensive towers were built mainly by different kind of the city guilds, as in Sibiu, Sebeș, Bistrița, as we shall see further. Starting with 1383 until the XVIIth c. was built, during several periods of time, the “Black Church”, the biggest gothic cathedral of Transylvania, probably as big as the one from Oradea, which has been destroyed (Fig. 8). The works began under the authority of a certain Thomas Szes, son of Mathew, an important merchant of the city, as it was mentioned on a document from 1377. The monumental decoration was made by a workshop coming from St. Elisabeth Cathedral from Kosice, which has been active also in Cluj. During the XIV c. was built the city hall and in its close neighborhood the market place. The ancient city center is still functional today.



Fig. 9 – Sebeș Josephinian Landesaufnahme 1769 – Medieval precincts and the city market place, wikipedia.org/wiki/File:GrandDuchyOfTransylvania_Josephinische_Landaufnahme.jpg.

Sebeș

Sebeș became an important medieval city starting with 1230–1235 when a roman cathedral, continued by gothic forms (Cistercian) specific for Cârța workshop was raised. Because of serious lack of funds and turks raids in the region the monument initial plan was abandoned and the chorus was transformed in the XIV-th c., according to the mature gothic influence, probably under the authority of a famous workshop of that time, lead by Peter Parler from Gmund. The gothic cathedral was raised in the same time with the city precincts,

i. e. during the XIV-th c., financed by different guilds as in Sibiu, Bistrita or Brasov (Fig. 9). At the beginning of the XV-th c. in front of the cathedral chorus was organised the city market place, which is still functioning today.

Bistrița

In 1361 is mentioned a so called “*civitas Bistriz*” (today *Bistrița*) and its first city precincts, financed by different guilds. Before that, during the second half of the XIII.th c. was built a franciscan cathedral, under the cistercian gothic influence, severely affected later on by utterly massive interventions (Fig. 10). The monument entirely transformed as it is today became an orthodox church. In the second half of the XIV-th c. a new gothic cathedral was raised in the middle of the city, several times affected by subsequent restorations. The most important interventions were those from 1560–1563, under the influence of a Renaissance workshop lead by Petrus Italus from Lugano (Petrus Italus da Lugano). A small market place was organised around the cathedral which is still functioning today.

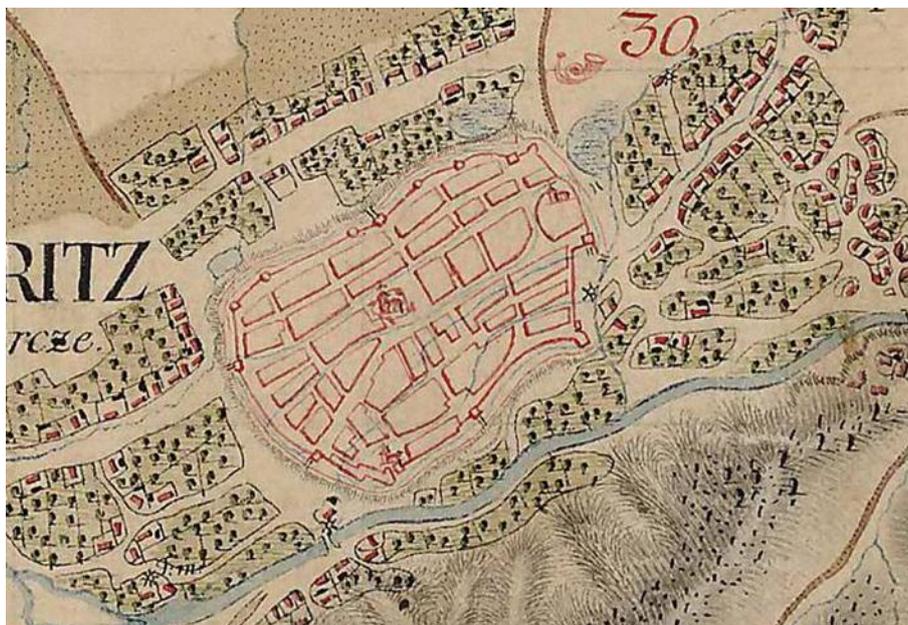


Fig. 10 – Bistrița – Josephinian Landesaufnahme 1769 – Medieval precincts and the city market place, wikipedia.org/wiki/File:GrandDuchyOfTransylvania_Josephinische_Landaufnahme.jpg.

Sibiu

In 1322 a document issued by the pope John the XXII, authorising the transfer of certain private lands under the bishop Olmutz authority, attests the existence of *Hermannstadt* (today *Sibiu*) (Fig. 11). The city gothic cathedral, one of the most important from Transylvania, knew three major phases. These were also closely connected with the market place evolution, enlarged in the same time as the cathedral was transformed. The first phase dates back from the XIV-th c. when the chorus, with its central apse, and the major part of the naves were built. In 1424 the cathedral has been enlarged with a new west side wing, known as *galilee* or *kirchevorraum*, and a tower. Finally, between 1470 and 1520 the monument became a „*hallenkirche*” (hall

type cathedral) as the north and the south naves were enlarged and mounted by tribunes. The market place, enlarged as the cathedral was transformed, has been fulfilled in the XVth c. and is still functioning today.



Fig. 11 – Sibiu – Map from XVIIIth c. In the center the city cathedral and the market place as it has been enlarged (yellow, red, green).

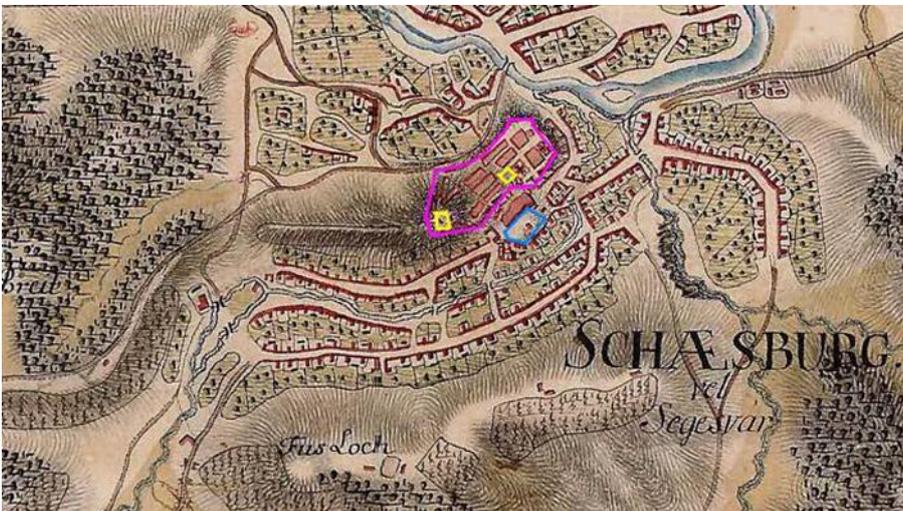


Fig. 12 – Sighișoara – Josephinian Landesaufnahme 1769. The „Hill Church”, the ancient market place (yellow) and the present market place (blue), wikipedia.org/wiki/File:GrandDuchyOfTransylvania_Josephinische_Landaufnahme.jpg.

Sighișoara

In *Sighișoara* the city precincts were raised during the middle of the XIVth c. around a hill with a very good strategical position. On the highest terrace of this hill were built the foundations of a cathedral, known under the name of “the hill church” (Fig. 12). Between 1450 and 1600 the monument became a “*hallenkirche*” and suffered several restaurations during the XVIIth c. The city market place could not find a good location

around the church because of space constraints and in the XVIth c. the first city market place was organised in the middle of the city area near the main entrance but inside the precincts. In the XVIIth c. a new market place raised outside the precincts, in front of the main entrance which still exists today.

Mediaș

The city of *Mediaș* is attested by a document from 1247 but the precincts were built later on, during the XIVth, when the St. Margaret cathedral has been raised in the center. The public market place was also organized in its close neighborhood and it is still functioning today (Fig. 13).

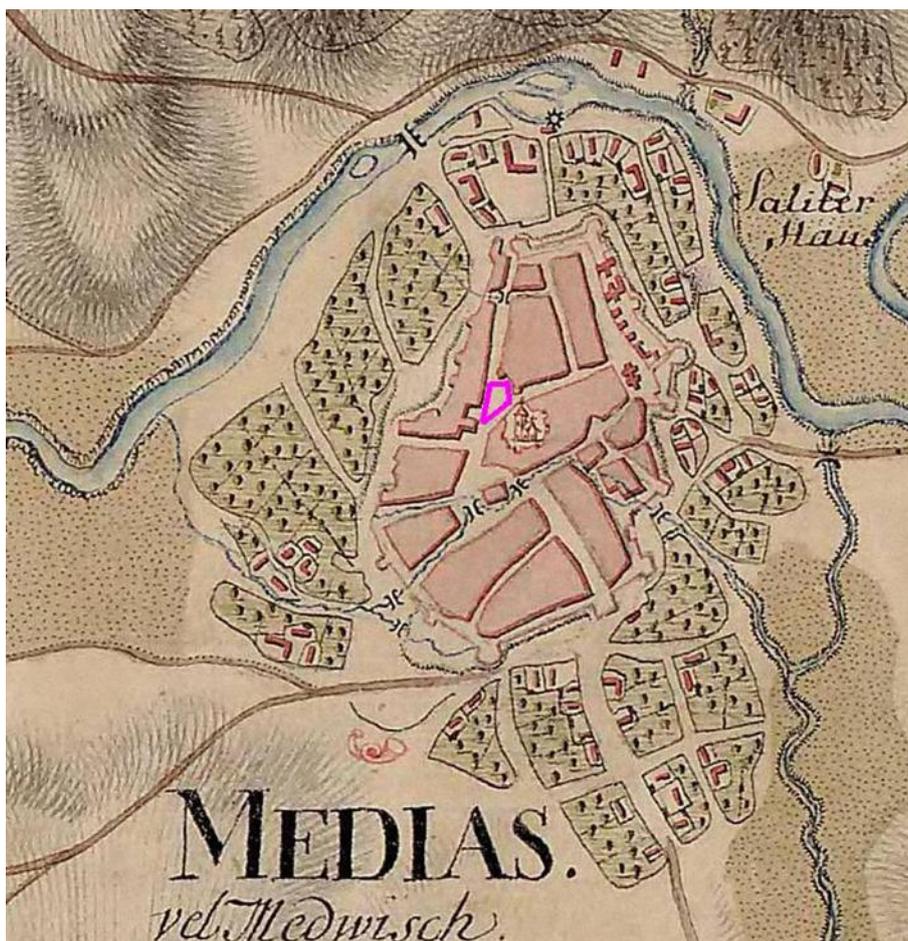


Fig. 13 – Mediaș – Josephinian Landesaufnahme e 1769. In the center the cathedral and the city market place, wikipedia.org/wiki/File:GrandDuchyOfTransylvania_Josephinische_Landaufnahme.jpg.

Alba Iulia

The evolution of the city of *Alba Iulia* is better known due to three plans made in 1687, 1711 and in 1769, the Josephinian Landesaufnahme which is one of the most valuable sources for this investigation. On the first plan, known under the name of "Pianta di Alba Iulia" we have a clear image of the medieval fortification which was raised right on the XIII Legion Gemina roman camp foundations (Fig. 14). Three axes are important to be stressed out because they still kept the principal roman camp ground structure. Thus, on the E-W direction we have the ancient *via praetoria* and *via decumana* and on the N-S *via quintana* and *via*

principalis obviously the main axes of any roman camp. On the second plan, made by the architect Giovanni Morando Visconti, the roman camp main axes were still evident but on the south side the ancient *via quintana* was partially erased because of a new building, the Catholic Bishopric Palace (Fig. 15). On the Josephinian Landaufnahme, from 1769, we can observe the same major streets trama structure. The roman camp axes were preserved, i. e. *via praetoria*, *via decumana* and *via principalis*, and some new medieval streets were built partially on the ancient *via quintana* direction (Fig. 16). Actually we still do not have sufficient arguments in order to establish exactly where the public market place would have been located on this final city plan. A large open space is still evident on the middle, where the roman camp *principia* used to be, but it is still difficult to say if this was the medieval city market place at that time.

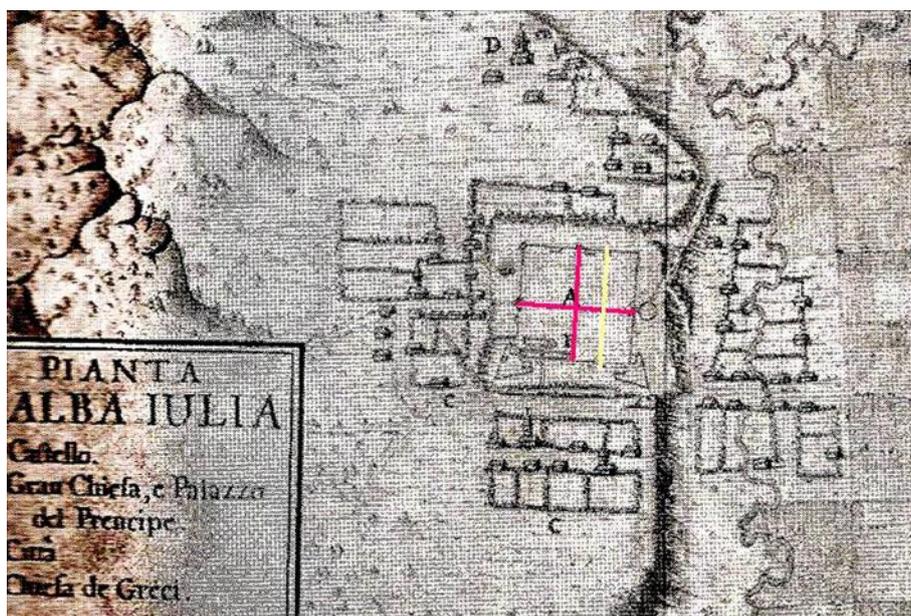


Fig. 14 – „Pianta di Alba Iulia”, 1687 – The XVIth c. precincts at the XIIIth Legion Gemina roman camp with its principal axes *via principalis* (yellow) *via praetoria/via decumana* (red).

Conclusions

At the end of this presentation some conclusions are self evident.

In three cases the medieval cities were implemented, more or less, on or near the roman military camps: Turda (Potaissa) the roman camp is located outside the medieval city precincts. On the other two cases we have roman camps which were superposed by the medieval precincts and the market places were organized right in the middle, on the *principia* location.

Cluj (Napoca) probably the medieval city market place was built on the roman *principia* military camp but this hypothesis has to be proved by more excavations all around the area.

In Alba Iulia a medieval public open space eventually a market place is still difficult to establish, but anyway it was organized on the roman legion headquarters (*principia*).

All the others medieval Transylvania cities were founded on „vergin” lands where no roman significant presence was attested. In these cases the church was the medieval city core. From a symbolic point of view

the medieval cathedral sacred the city public open place as in the roman camp, principia was sacred by the chapel legion (*aedes legionis*).

Finally, around the church were built defensive precincts or the church itself had some defensive elements (the chorus and the west towers mainly). However, these defensiv elements are much more evident to the medieval Transylvania villages.

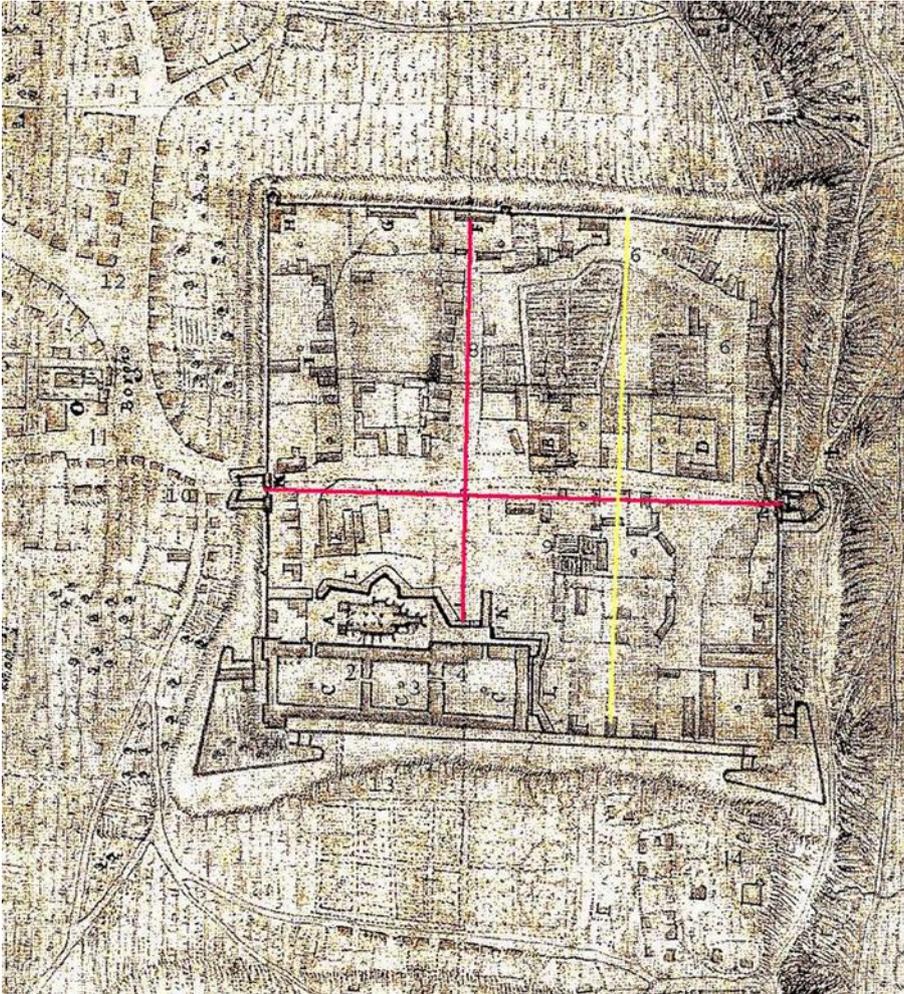


Fig. 15 – Alba Iulia, Plan made by Giovanni Morando Visconti in 1711 – Medieval precincts and the roman camp with its principal axes *via principalis* (yellow), *via praetoria/via decumana* (red).

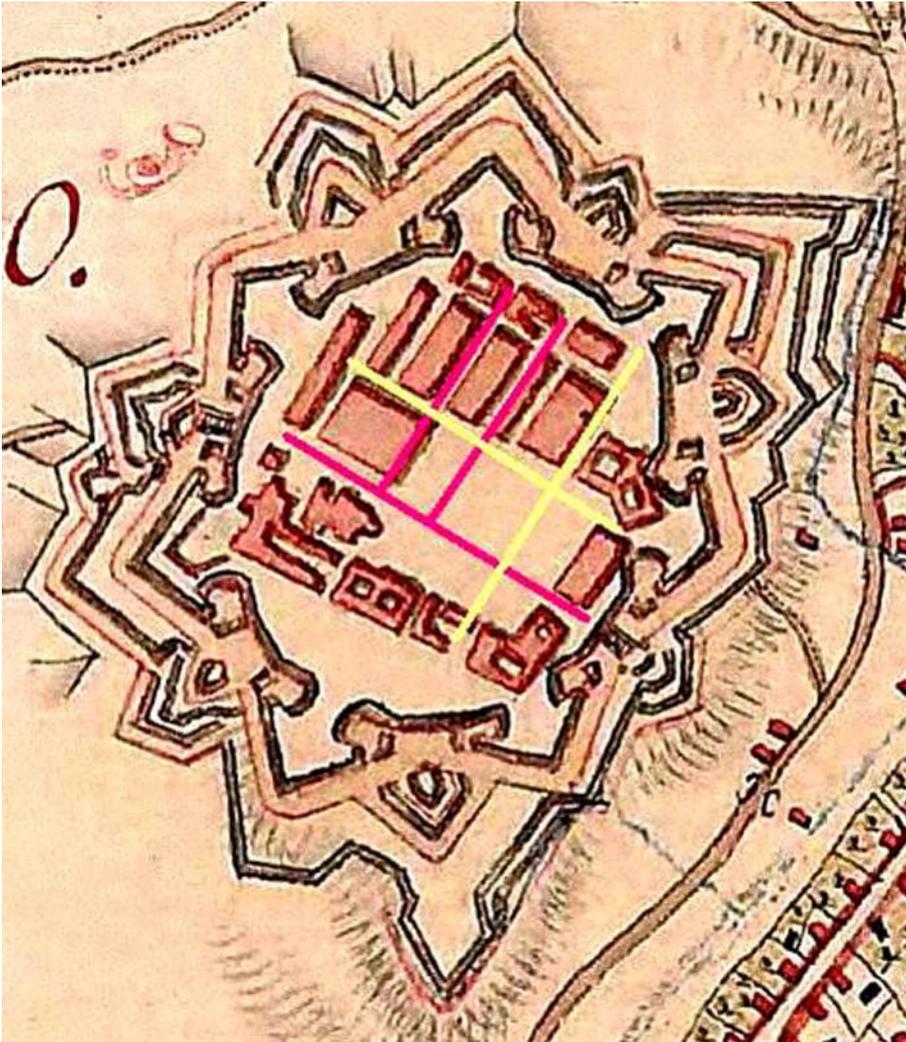


Fig. 16 – Alba Iulia – Josephinian Landesaufnahme 1769 – roman camp principal axes (yellow) and the medieval trama (red), wikipedia.org/wiki/File:GrandDuchyOfTransylvania_Josephinische_Landaufnahme.jpg.

The tripartite fora of the Augustan age in *Lusitania*

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Abstract: This paper undertakes a comparative analysis of the Roman cities of the ancient province of *Lusitania*. At the current state of studies, the archaeological excavations have brought to light monumental centres of the same type, which is the so called “tripartite forum” or “*basilica*-type forum”. The attention is focused on six towns: *Augusta Emerita*, *Ebora Liberalitas Iulia*, *Ammaia*, *Pax Iulia*, *Sellium* and Bobadela. Although the fragmentary and incomplete knowledge that still characterizes the monumental centres of *Lusitania* does not allow a global view of the topic, these fora are compared in order to understand their similarities and differences.

One of the case-studies analyzed is placed in the archaeological park of *Ammaia*, in the municipality of Marvão (Alto-Alentejo): this site has been chosen as research centre by the Marie-Curie IAPP project “Radio-Past”, whose team is currently applying a combination of “non-destructive” technologies. The integration of the results from the stratigraphic archaeological excavations, started in 1994, with the results from the topographic fieldwork and the geophysical prospections carried out in these years are providing interesting data about the forum area.

The aim of this comparison is to understand the original settings and later transformations of the monumental centres under investigation, but especially to delineate common developments in architectural project and chronological phasing. This paper concludes that the great amount of similarities among the Roman fora examined is probably due to the fact that all towns were founded in the Augustan age.

Keywords: forum, temple, Lusitania, Augustan age, town.

Introduction

The topic that will be discussed in this paper is part of an on-going research project, started in March 2010, concerning the Roman monumental centres of the Iberian Peninsula¹. I will focus this contribution on the fora

¹ This study has been performed under a biennial post-doc grant by Fundação para a Ciência e a Tecnologia (FCT) of Portugal, that I kindly thank for the great opportunity it gave me. I cannot forget to express appreciation also to the Centro Interdisciplinar de História, Culturas e Sociedades (CIDEHUS) of the University of Évora. This work is strictly connected with the researches carried out in the archaeological site of *Ammaia* by the Marie-Curie IAPP project, under the scientific direction of prof. Cristina Corsi (University of Cassino) and Frank Vermeulen (University of Ghent), in close collaboration with the University of Évora (which is the Coordinator Institution) and the Fundação Cidade de Ammaia. I thank prof. Cristina Corsi and Frank Vermeulen for kindly allowed me to publish some data acquired during the recent excavations at *Ammaia*. I owe my deepest gratitude to my supervisor Cristina Corsi, without which this work would not have been possible: she has supported me with her great knowledge, priceless advice and unending patience. It is an honor for me to thank prof. José Encarnação (University of Coimbra) for giving me crucial suggestions. I am indebted to many colleagues for providing a stimulating and fun environment in which to learn and grow: some of them are part of the team of the Radiopast Project, as drs. Dimitrij Mlekuz and Paul S. Johnson. I would like to show my gratitude to the collaborators from the University of Ghent: Lieven Verdonck for furnishing his processed GPR data and interpretations of the forum of *Ammaia* and Devi Taelman for his

of ancient *Lusitania*, the westernmost province of the Roman empire established by the 1st century BC and spread over large portions of modern Portugal and Spain² (Fig. 1).

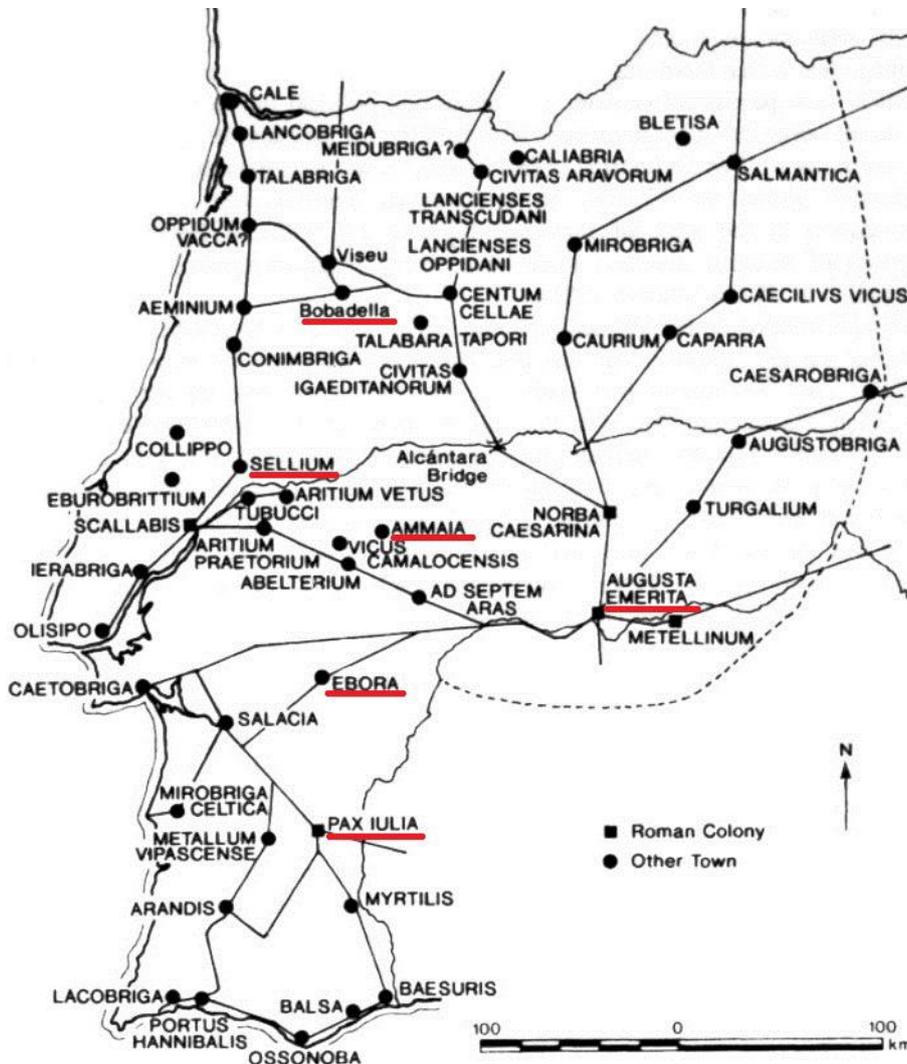


Fig. 1 – Map of *Lusitania*, with the names of the towns discussed in the text underlined in red (EDMONDSON 1990).

The type of monumental centre that I intend to analyze is the “tripartite forum” or “forum block” (WARD-PERKINS 1970: 1–19), which is also called “double”- or “compound-forum”. It is general knowledge that this kind of complex was characterized by the combination of three sectors with different functions: a temple or a *aedes*, often raised on a platform; a central courtyard; a *basilica* hall (GROS 1996: 212–213). This basic model, characterized by the temple facing the *basilica* from the opposite end of an elongated rectangular

valuable collaboration in the study of the just mentioned monumental centre. I am also grateful to Jeroen Verhegge for supplying the geophysical data acquired during his Master. I offer special thanks to Dr. Marianna Norcia, with whom I had the pleasure of supervising the students from the University of Cassino during the excavations 2010 in *Ammaia*. Finally, I have to sincerely thank my Portuguese colleagues drs. José Carlos Quaresma, Vitor Manuel da Silva Dias and Catarina Alves for offering their great cooperation with my investigations at *Ammaia*.

² See, among others, RICHARDSON 1996; OSLAND 2006.

forum enclosure, had a long period of elaboration, probably starting with the Augustan age, which led to a lot of different adaptations. It spread throughout the Roman Empire, including *Lusitania*. Unfortunately in this province the knowledge about the Roman monumental centres is still poor and fragmentary, especially as several ancient towns have remained in occupation, removing much of the old evidence or burying it under modern structures.

Although this analysis is strongly conditioned by vast gaps in our knowledge, also due to the fact that only some cities have been excavated and published, we think that the complexes which can be identified as tripartite fora (or *basilica*-type fora) in *Lusitania* are the following: *Ammaia*, *Augusta Emerita*, *Ebora Liberalitas Iulia*, *Pax Iulia*, *Sellium* and Bobadela. This does not mean that they are the unique cases of tripartite fora in *Lusitania*, but only that, among the centres till being investigated in that province, they have provided more archaeological data and so the reconstruction of their plans seems to be more reliable than others.

Ammaia

I will start from the case-study of the Roman town of *Ammaia*, because I took part to the excavations carried out in its forum in the last two years under the scientific direction of Proff. Cristina Corsi and Frank Vermeulen and thus the reconstruction of this monumental centre is playing an important role in my research project. *Ammaia* is located in the current municipality of Marvão, district of Portalegre, within the region of Alto Alentejo, on the western slope of the fertile valley of the Sever River. It may have been founded *ex nihilo* early in the first century AD, possibly during the reign of Augustus (VAN ROODE et al. 2011: 433). It was conferred the status of municipium by the time of Lucius Verus, as indicated by an inscription preserved in the nearby town of Portalegre (*CIL* II, 158 = IRCP, 616) (VAN ROODE et al. 2011: 433–434).

Thanks to the recent geophysical surveys carried out by the researcher P.S. Johnson in the framework of the Marie-Curie IAPP project “Radio-Past”, whose results will be presented in a forthcoming publication (CORSI et al. forthcoming), the regular urban planning of *Ammaia* has been reconstructed. It has been hypothesized that its small urban area extended over circa 22 hectares (VAN ROODE et al. 2011: 433) and it was composed of rectangular *insulae*: the forum likely occupied the area of about two of them, fitting well within the rectangular street pattern of the city³. In fact, the road running immediately outside the monumental centre, along its longitudinal eastern side, can be interpreted as the main north–south axis (the so-called *cardo maximus*), which was clearly connected with the excavated southern gate of the city (named Porta Sul) (VERMEULEN and TAELMAN 2010: 315) (Fig. 2).

³ See: VERMEULEN et al. 2005; VERDONCK et al. 2008; VERMEULEN AND THEMUDO BARATA 2009.

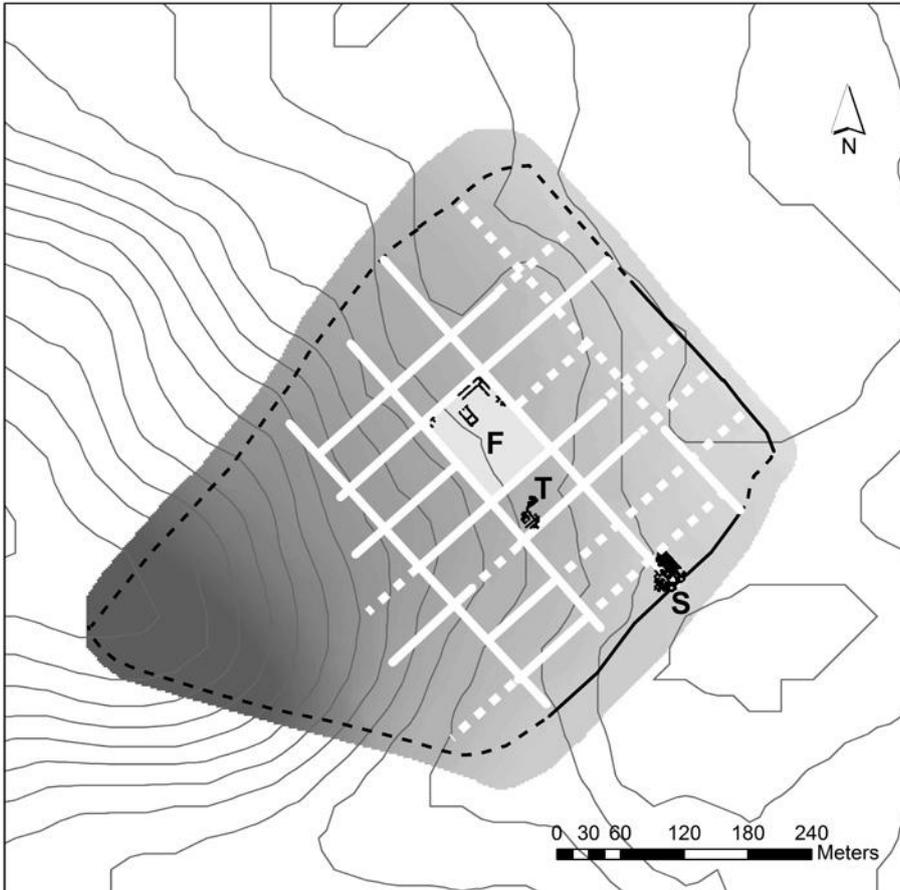


Fig. 2 – Archaeological map of the urban centre of *Ammaia* with the reconstruction of its orthogonal plan: F. Location of the forum; T. *Thermae*; S. Porta Sul (elaboration of Corsi C.).

The monumental *forum* measures about m 65 by 90: these are not usual dimensions for a Lusitanian city, but they correspond to the proportions 2:3 suggested by Vitruvius (*De Arch.*, 5, 1–2) (MANTAS 2010: 175) (Fig. 3).

The complex was originally located on a considerable slope with a predominant NE-SW orientation: this is the reason why it was partially built on an artificial terrace to overcome leveling problems. The sacred part of the forum was dominated by a probably *capitolium*-type temple, which was erected on a large podium with a monumental staircase on its short south-eastern side, directed towards the square. The podium of the temple, still standing above ground and preserved to a height of about 2.50 m, was about 9 by 17.30 m (Fig. 4).



Fig. 3 – Image of the GPR survey carried out in 2008 in the forum area of *Ammaia* and its nearby *thermae* (depth of ca. 70 cm below the surface): 1. Portico, 2. Temple, 3. *Tabernae*, 4. *Basilica*, 5. Forum square, 6. Temple platform, 7.-9. Streets, 10. Bathhouse, 11. Modern road, 12. Modern field boundary (VERDONCK et al. 2008).



Fig. 4 – View from the south on the preserved remains of the temple podium before the 2010 excavations (VERMEULEN et al. 2012).

It was built in *opus caementicium*, originally almost completely covered with lost granite blocks on three sides, while the frontal wall was maybe constructed in *opus incertum*. There are few remains on the upper part of the podium, which was divided into the *pronaos* and the *cella* by a still visible wall: the former was 7.50 m long, while the *cella* was 9.50 m long.

The fieldwork conducted in the temple area in summer 2010 and 2011 concentrated in the north-eastern part of the portico and especially south to the temple, where two small trenches were opened near the south-east and south-west corners of the podium, in order to investigate the topography and architectural setting of the temple area and the connection with the adjoining central forum square (VERMEULEN et al. 2012: 128–129). These investigations have revealed that the southern part of podium was flanked by two rectangular foreparts, attached to the two *pars antica* corners (so that they have a sort of thick “L” shaped plan). The area immediately in front (SE) of the *Ammaia* temple and directly south-east of it revealed several traces of more solid architectural intervention, such as a drainage floor made of river pebbles that surrounded the foundations of a monument (VERMEULEN et al. 2012: 131). The temple was plausibly surrounded by a floor of beaten earth⁴, as no traces of stone flooring were found in the limited excavation areas (VERMEULEN et al. 2012: 130) (Fig. 5).

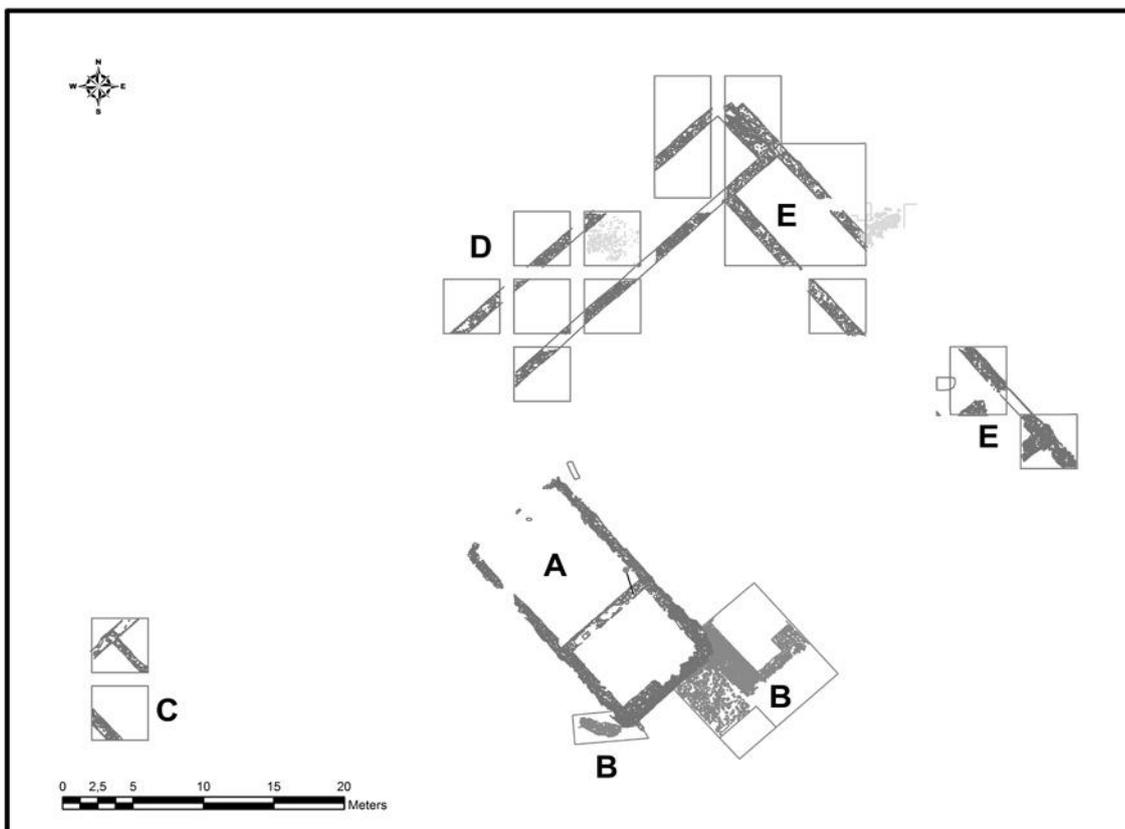


Fig. 5 – Excavated structures in the temple area of the forum: A. Temple; B. Forepart and staircase; C. Portico SW wing; D. Portico NW wing; E. Portico NE wing (VERMEULEN et al. 2012).

⁴ The use of only a beaten earth floor around the forum temple was also observed in other *fora* of Lusitania, such as in *Conimbriga* (ALARCÃO and ETIENNE 1977), although some of the best preserved and studied monumental fora in Roman *Lusitania*, such as those of capital *Augusta Emerita* (AYERBE VÉLEZ et al. 2009) and of *Aeminium* (ALARCÃO et al. 2009), display more sturdy floors.

All the data acquired seem to suggest that in the temple area there were two different building phases, but this topic is still under examination.

Another information acquired thanks to the excavations is that the temple seems not to be built on an artificial platform. Actually a possible long wall, in front of the staircase, appears south of the podium in the geophysical surveys, especially magnetometer and earth resistance readings, but it has not been discovered in the excavations performed till now. A likely explanation is that it is placed more to the south than earlier presumed and if so, the higher temple area may have been separated by the central forum square (VERMEULEN et al. 2012: 131).

The excavations performed in summer 2010 have supplied relevant information about parts of the portico and the *cryptoporticus* surrounding it (the northern part of the forum). The portico, which had an average internal width of 4.40 m, was used to create a more or less horizontal surface for the forum walking area. Its north-eastern side, in particular, served as a terrace wall for the whole complex, as this was the lower part of the slope. Around the temple area only the north-eastern wing of the portico was exploited as a *cryptoporticus* with two levels of use, while the other wings acted as simple porticoes with only one level of real use (Ibid.). The standing walls were made in *opus incertum* with a facing of roughly cut granite building blocks of unequal sizes.

With regard to the central square of the forum, the south-eastern part seems to have less free space, because it is m 32 wide, in comparison with the north-western sector around the temple, which is m 53,5 wide. The reason is that the central square was flanked by two rows of *tabernae*: they were 20 symmetrically positioned shops (VAN ROODE et al. 2011: 436) and both blocks of *tabernae* opened onto a corridor, which was likely colonnaded towards the square.

Furthermore, smaller monuments and several structures have been observed within the inner open area of the monumental centre: some could be related to water supply and drainage (aqueduct, sewers, cistern, fountains?), while others are bases for small public monuments or statues. The linear trace deviating from the town's orthogonal pattern has been identified as a drain or part of the aqueduct: it likely ran under the forum square's surface and it could be connected with the eastern basin supposed in the temple area (VERMEULEN et al. 2012: 131).

One of the most important points to stress is that the geophysical prospection definitively proved the presence of a monumental *basilica* on the south-eastern side of the forum: this building has not been excavated, but parts of the north-eastern wall can still be seen in the bank created by the construction of a modern road. The *basilica*, an elongated rectangular building measuring some 46 by 17 m, was characterized by a double row of internal roof-supporting columns (VERMEULEN et al. 2012: 129), spaced about every 4 m. The naves were perhaps unequal in width and the central aisle was about 7 m wide. On the short south-western side the building was flanked by three elongated rooms, whose function is still unknown, but it is believable that they were linked with the administrative functions of the building (Ibid.). One of them may have been an *aedes augusti*, or sanctuary for the emperor, as found elsewhere in Iberia and *Lusitania* (KEAY 1995: 308). The *basilica* probably had a few entrances: the main access was plausibly in the north-western longitudinal wall (VERMEULEN and TAELEMAN 2010: 315) and it was likely accessible from both the forum square and the street outside.

In conclusion, although the exact chronology of the forum of *Ammaia* is still unknown, a remarkable element comes from the preliminary study of the materials collected in the excavations 2010: the building chronology seems to start around the mid 1st century AD, probably under the reign of Claudius, while a phase of renovation of the complex can be possibly dated in Flavian times (last quarter of the 1st century AD) (VERMEULEN et al. 2012: 131). However, we expect further information from the study of the materials collected during the excavation 2011, which are still under investigations.

Augusta Emerita

It is generally known that the colony of *Augusta Emerita*, corresponding to the current Mérida, in Extremadura, was a foundation *ex nihilo* established by Augustus on the right bank of the river Guadiana probably between 25 and 19 BC (*Dio Cassius*, 53, 26, 1). It is clear that Rome planned *Augusta Emerita* this provincial capital as a mirror-image of Rome itself, because it was designed as a symbol of Roman power on the periphery of the Empire.

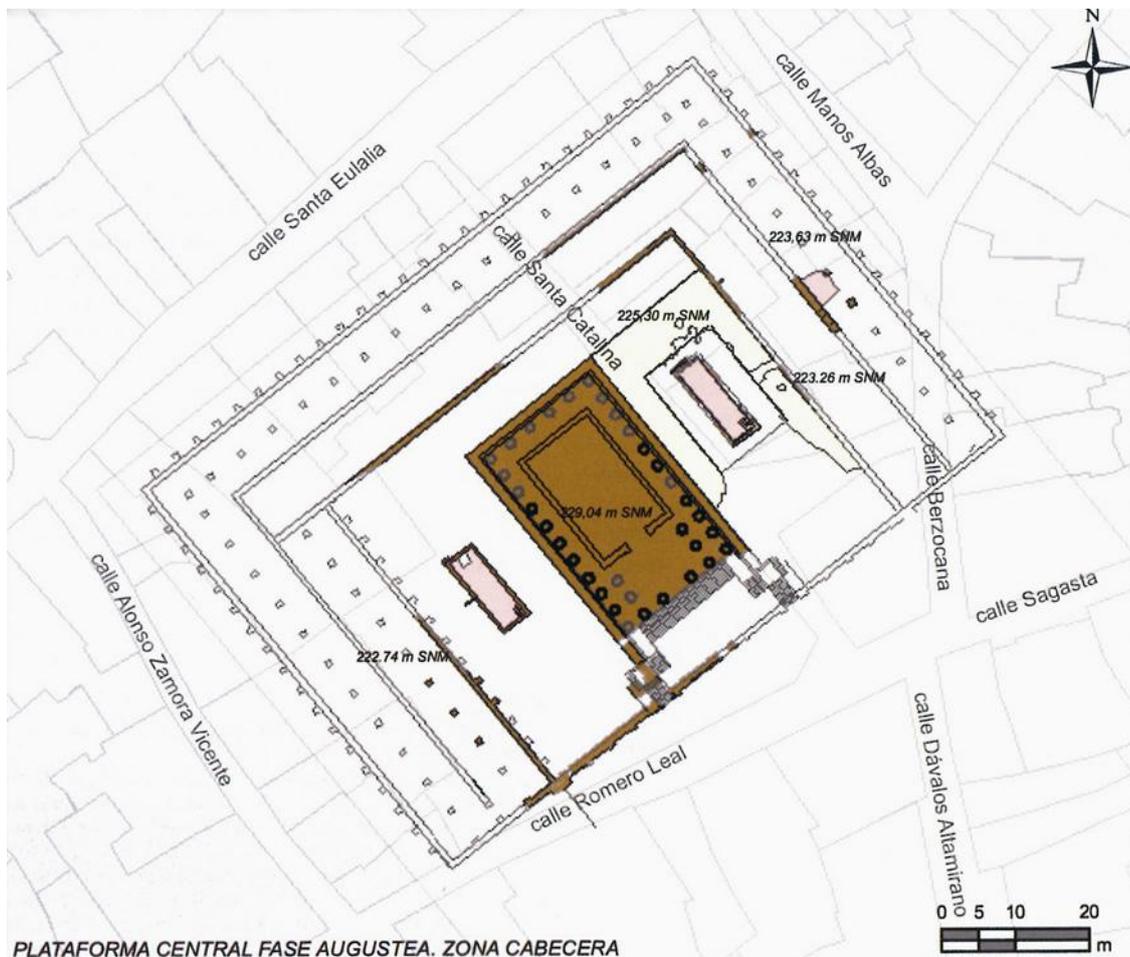


Fig. 6 – Colonial forum of *Augusta Emerita*: reconstructive plan of the central platform in the Augustan age (AYERBE VÉLEZ et al. 2009).

The town had an orthogonal plan from the beginning and it had a double monumental centre: a colonial forum and a municipal one⁵. The colonial forum, which was located in the eastern sector of the ancient city, had three different monumental precincts or *temenoi*, but in this paper we will focus only on the central platform, not only because it was the real core of the complex, but particularly because it had the typical plan of a tripartite forum. It is important to stress that, in the second half of the 1st century AD, the whole area of the colonial forum underwent a deep renovation and an enlargement of its precincts, especially on the eastern side. Thus, it had two different building phases: the first in the Augustan age and the second one in the Flavian age.

The central platform occupied the crossing between the two main urban axes: in fact, it was bounded on the north by the so-called *decumanus maximus* and on the west by the so-called *cardo maximus*, where there was an entrance with a monumental arch (AYERBE VÉLEZ et al. 2009: 807–809).

In this platform there is the so-called temple of Diana, but actually the deity to whom it was consecrated is still unknown⁶. It was an impressive building, oriented NE/SW: it was constructed on a platform 2 m above the surrounding area and it was raised on a podium 3.25 m high (Fig. 6).

Like most of the forum temples in *Lusitania*, it was built with local granite covered by stucco. This building was a peripteral and pycnostyle temple: the six columns of the short sides and the eleven columns of the long sides were topped with marble Corinthian capitals. The temple had the main entrance to the south, where there was a frontal staircase, flanked by two smaller side stairways, which encased a tribune or a platform (AYERBE VÉLEZ et al. 2009: 672–673). It has been hypothesized that this temple, with a tribune on the façade, belonged to the typology of the *templa rostrata*, such as that of *Venus Genetrix* in Rome (AYERBE VÉLEZ et al. 2009: 674–675). In the Flavian age, an *exedra* was added to the tribune: in this way, the frontage of the temple was completely closed towards the square.

The symmetrical position of the two large and equal *piscinae* placed along the two long sides of the temple is worthy of note: it is believed that they were built in the Augustan phase of the forum and their presence stressed the religious function of this area, as it has been hypothesized in the case of temple area of *Ammaia*. The temple was surrounded on all four sides by a *temenos* (m 59.06 by 49.20), bounded on three sides by closed walls, without porticoes. These walls delimited a double building: they were two adjacent structures, which ran parallel to each other; they were an inverted “U” shape and their function is still unknown.

The archaeological excavations have also revealed that under each of these buildings there was a “π”-shaped *cryptoporticus*: both of them had a rectangular plan and were divided into two naves by a line of pillars supporting a vaulted roof (Fig. 7). We still ignore the use of these structures, but we cannot exclude the possibility that they were exploited as public storage, such as has been observed in other similar edifications.

⁵ For the fora at *Augusta Emerita* see: MATEOS CRUZ and PALMA GARCÍA 2004; NOGALES BASARRATE and ÁLVAREZ MARTÍNEZ 2010.

⁶ With regard to this temple, see ÁLVAREZ MARTÍNEZ and NOGALES BASARRATE 2003.

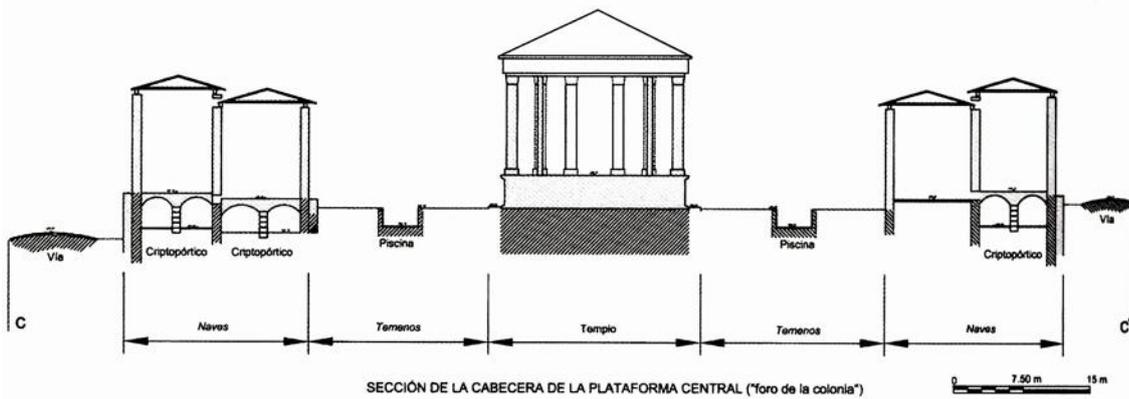


Fig. 7 – Section of the temple area of the central platform at *Augusta Emerita* (AYERBE VÉLEZ et al. 2009).

According to the traditional model of the tripartite forum, in *Augusta Emerita* the *basilica* was placed on the opposite side of the temple and the administrative area was separated by the sacred sector. Unfortunately, due to the lack of systematic excavations in this area, it is not possible to reconstruct the appearance of the *basilica* of the Augustan age. We only know that, during the Flavian remodelling of the forum, the sector of the big *basilica* was deeply monumentalized and new buildings were erected: in addition to the *basilica*, also the *curia* and a possible *aerarium* or *carcer* have been identified. The Flavian *basilica*, built in *opus incertum*, was divided into three naves by ten columns on the long sides and four columns on the short sides.

Ebora Liberalitas Iulia

The Roman town of *Ebora*, the current Evora, in the Alentejo region, received the *status* of *oppidum Latii antiqui / veteris Latii* from Octavian between the years 31 and 27 BC (PL., *Nat. Hist.*, 4, 117); then, it might have been promoted to *municipium* in 12 BC (FARIA 2001a: 352). Although it was not a *civitas ex novo*, it had a regular pattern and the forum was placed on the highest point of a hill, to the north of the crossroads of the two main urban axes.

The dating of the forum is still a matter for debate: it was completed or remodelled in the late first century AD, in the Flavian age, along with the forum of *Conimbriga*. But William Mierse (MIERSE 1999: 99, 102) has suggested an earlier date for the restoration of the temple in the reign of Claudius and Vasco Gil Mantas (MANTAS 2010: 174) has stated that the temple was reconstructed later, between the 1st and 2nd centuries AD, e.g. under the reign of Trajan.

The forum, which had a NS orientation, was built on a wide platform measuring 63.74 by about 120 m. Although most of it is today buried under some later buildings, a relevant part of the plan can be reconstructed (Fig. 8).

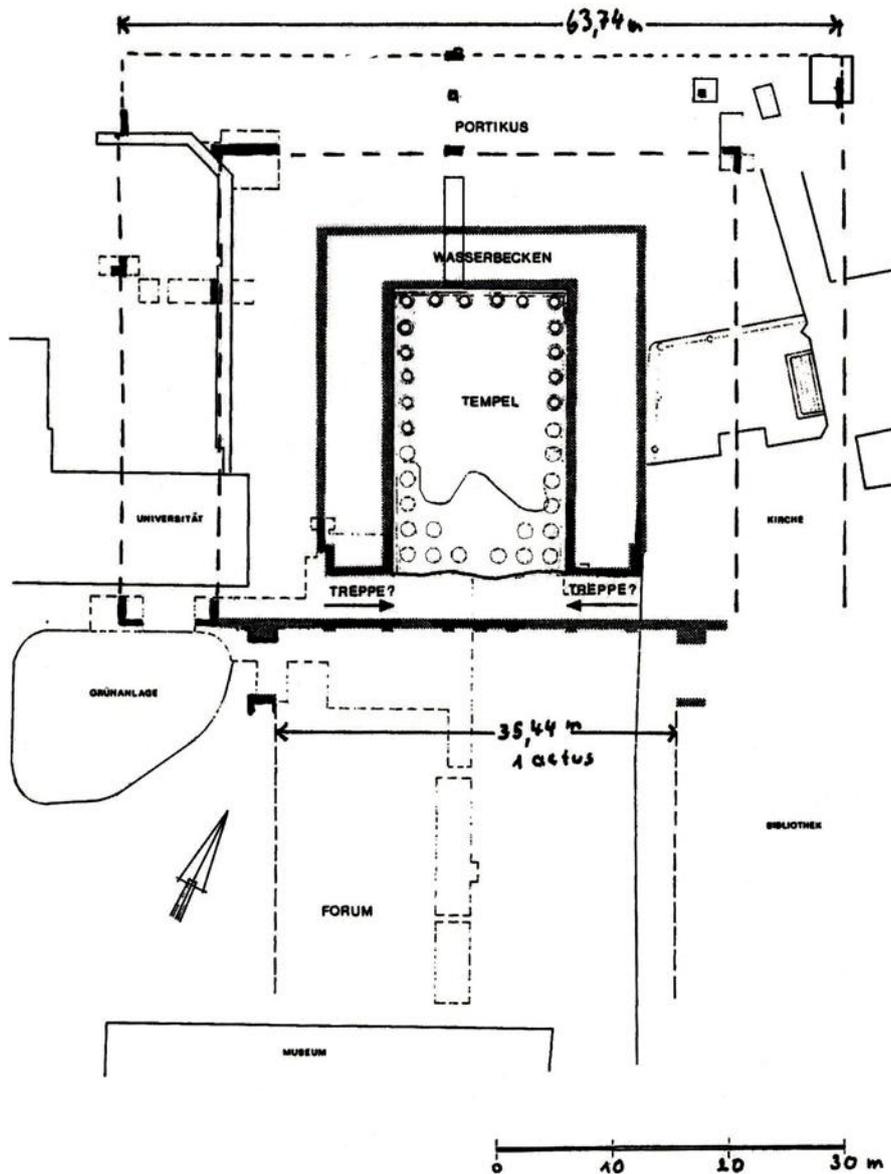


Fig. 8 – Plan of the forum at Eborac (HAUSCHILD 1994).

The temple, located on the northern side of the complex and surrounded on three sides by a “π”-shaped *cryptoporticus* that held up a portico, was perhaps devoted to the imperial cult (HAUSCHILD 2010: 28)⁷. The podium, constructed of large stone blocks encasing *opus incertum*, stands roughly 3.45 m above the level of its surroundings. The base of the structure and its cornice were constructed with large granite blocks, such as in *Ammaia* (HAUSCHILD 2002: 218). It was a peripteral hexastyle temple, quite large for *Lusitania*: it had six columns along the front and the rear, plus nine or, more probably, ten other columns along each side (Ibid.). Today, only fourteen are still in position: these columns, are topped with marble Corinthian capitals, which can be dated back to a period before the Flavian age, but the exact date is uncertain (HAUSCHILD 2010: 28) (Fig. 9).

⁷ About the temple see also: HAUSCHILD 1982; HAUSCHILD 1994.

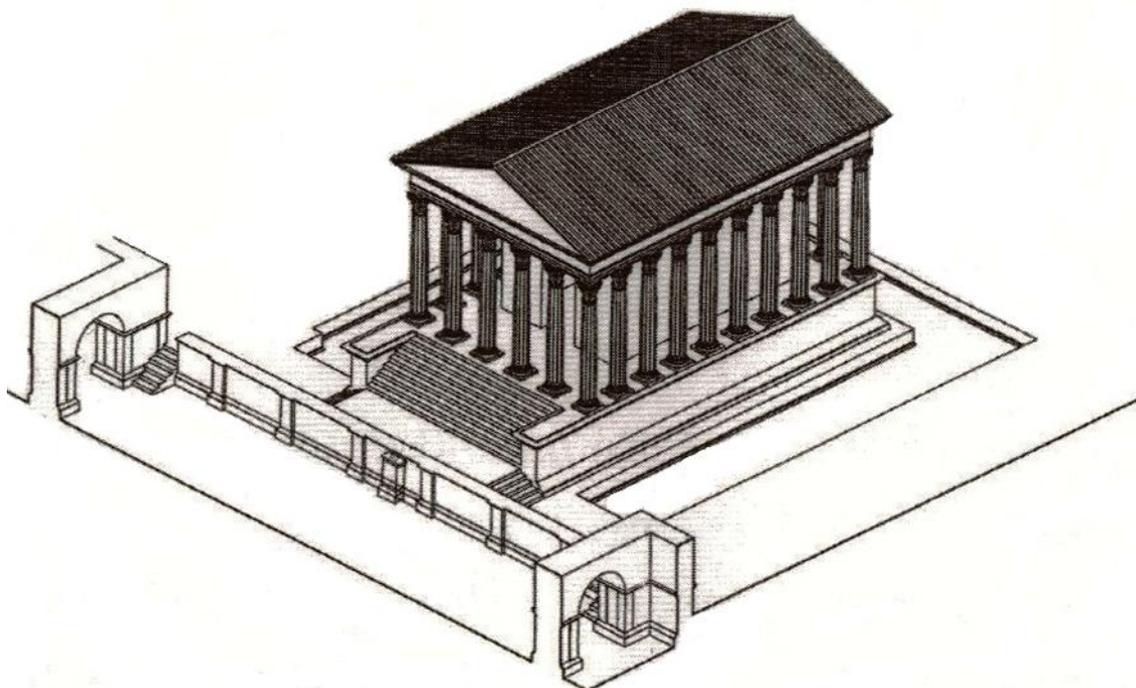


Fig. 9 – 3D Reconstruction of the forum temple at *Ebora* (HAUSCHILD 2010).

Some traces of plaster are still visible on portions of the temple walls and on the granite columns, indicating that the whole structure may have been plastered and painted in ancient times.

The temple was surrounded on the three sides (west, north and east), by a big water tank, about 5 m wide and 1 m deep: it probably belongs to a different building phase than the podium (Ibid.) and it was likely finished in the mid 1st century AD.

Originally, a front staircase provided access from the south of the temple, but later it was replaced by two lateral ascents, allowing the construction of a pilastered block wall, which cut across the façade of the sanctuary (HAUSCHILD 2010: 28–30). This transversal wall extended for 20 m and it had a thickness of 1.43 m. It could be coeval with the water tank because they were made with a mortar of the same quality (Ibid.). Its function was to separate and support the temple precinct (*temenos*) and the square located at a lower level. In this way, it served to raise the temple precinct above the rest of the forum, just like the front wall of the temple of Diana at *Augusta Emerita*.

On the western side, the presence of side porticoes and a series of buildings or halls, such as *curia*, *comitium* and *tabernae*, has been hypothesized: they probably departed from the western portico of the temple precinct and extended until the area today occupied by the museum of Evora.

The exact location of the *basilica* is still uncertain, but it is conceivable that it was on the southern side of the complex, according to the typical model of the tripartite forum. In fact, evidence relating to this building has been discovered in a room in the southern sector of the museum, where there is still a large Ionic capital, which was reused inside a medieval burial (HAUSCHILD 2010: 34).

Pax Iulia

One of the forums that show a similar architectural setting to that of *Ammaia* is *Pax Iulia*, a Roman town corresponding to the current Beja, in the Alentejo region (PLIN., *Nat. Hist.*, 4, 117): it was founded under Augustus between the years 31 and 27 BC (FARIA 2001a: 351–352) and was chosen as the capital of the Lusitanian *conventus* called *Pacensis*. The town, which was situated on a hill, underwent a significant urban improvement campaign in the early years of the first century AD. The forum probably had two different building phases: one in the Augustan age, when the city was founded, and another maybe in the last third of the 1st century AD (HAUSCHILD 2002: 49).

The monumental centre was placed within the confines of the modern Praça da República, at the highest point of the city. Since it is mostly unexcavated and the relationships between all the structures brought to light are not clear, it is impossible to reconstruct the general plan of the complex⁸. It was probably crossed by the so-called *cardo maximus*, which coincided with its short axis (ALARCÃO 1990: 49) and it has been suggested that the so-called *decumanus maximus* coincided with the eastern limit of the forum, but at present this is only an hypothesis (Fig. 10).

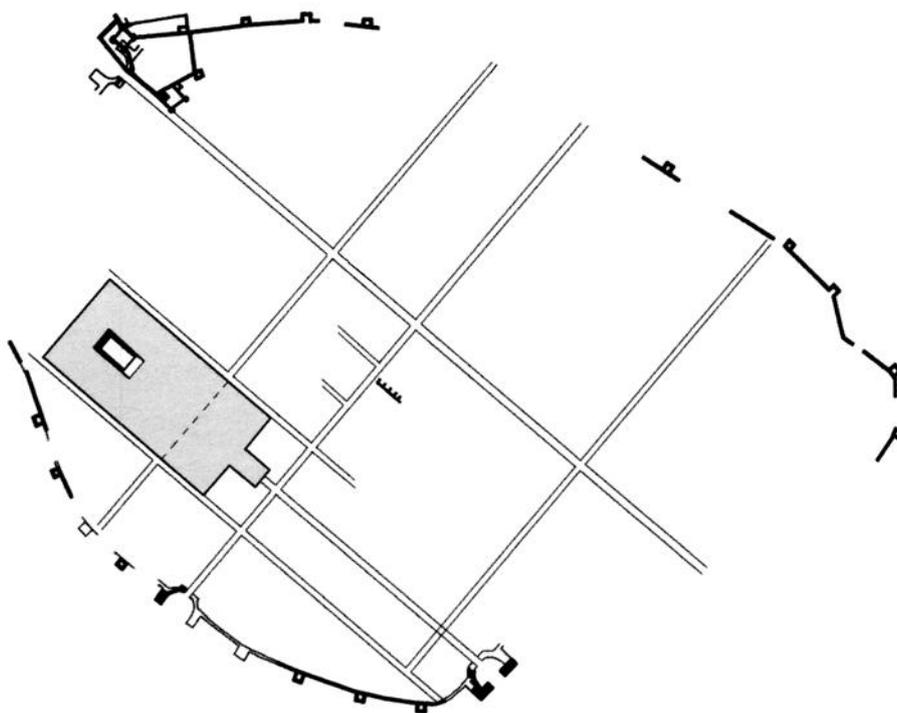


Fig. 10 – Reconstruction of part of the urban layout with the location of the forum at *Pax Iulia* (PONTE 2002).

The most prominent remain of this tripartite forum is the temple, which was unearthed in 1939 (VIANA 1942; VIANA 1947): the building, with a north–south orientation, was slightly larger than that of *Ebora*, measuring 29 by 16.50 m (ALARCÃO 1990: 48). Unfortunately, the podium and some Corinthian capitals were all that remained of the building at the time of its discovery. Hauschild has suggested to identify it as a hexastyle prostyle temple (HAUSCHILD 2002: 219), but not everybody agrees and Alarcão (ALARCÃO 1990: 49) has

⁸ See LOPES 2002.

suggested that it was a pseudo-peritperal building. As the forum temple at *Ammaia*, the sanctuary of *Pax Iulia* had a front staircase flanked by two side foreparts. Unfortunately, not much remains of the *cella*. The temple was surrounded on three sides by a floor made of a concrete, which has been wrongly qualified as *opus signinum*: the technical term used in Italian is “cocciopesto”⁹. The presence of this hydraulic mortar, 4.5 m wide, suggests the existence of a water tank, which was a strong structure (Ibid.). It was 7.20 m long, 2.40 m wide and it had an average thickness of 20 cm (LOPES 2010: 193–194) (Fig. 11).

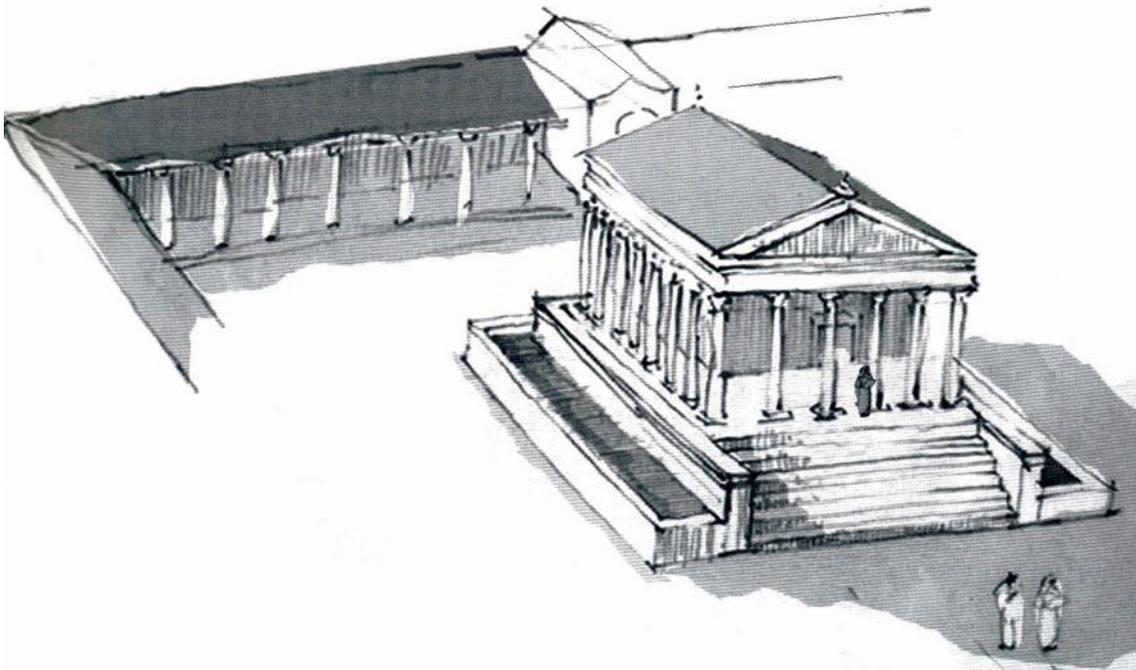


Fig. 11 – Hypothetical reconstruction of the temple area at *Pax Iulia* (LOPES 2010).

Alarcão (ALARCÃO 1990: 49) has hypothesized that the *basilica* was a big rectangular building, measuring 80 by 160 m (in the proportion of 1:2) and that the *curia* was a rectangular building (25 m long), adjacent to the outer long side of the *basilica*.

Recent excavations have brought to light two other buildings, whose function is still unknown (LOPES 2010: 194–197).

Sellium

The current city of Tomar, situated in the district of Santarém, in the Ribatejo region, was founded by Augustus on the left bank of the River Nabão. Although we still do not know the juridical-administrative *status* of the town under Augustus, Vasco Gil Mantas (MANTAS 1989: 33) has supposed that it was one of the 34

⁹ “Cocciopesto” is often confused with *opus signinum*, but they don’t have the same composition: the former is an hydraulic mortar composed of a compact mix of crushed terracotta and lime; it was applied as an impermeable layer in the structures exposed to water. By reading carefully the ancient sources, as Vitruvius and Pliny the Elder, it is possible to understand the difference between them (for a description of *opus signinum* see VITR., *De Arch.*, 8, 6, 14) and this distinction has been recently stressed by R. Ginouvès and R. Martin (GINOUVÈS and MARTIN 1985, I, s. v.); GIULIANI 1985: 171–174.

oppida stipendiaria established between the years 16 and 13 BC and that it received the *Ius Latii* probably during the Julio-Claudian age (under Tiberius or Claudius). It likely obtained the municipal status in the Flavian age and it became the capital of the *Conventus Scallabitanus* under Vespasian (PONTE et al. 1993: 511–514).

Although it has been estimated that the Roman town extended over an area of about 37 ha (PONTE 1989b: 27), only a small part of this wide surface has been unearthed and only the southern area of the forum has been excavated. Nevertheless, it is plausible that the sacred area was located in the northern portion of the complex, on the opposite side to the *basilica*.

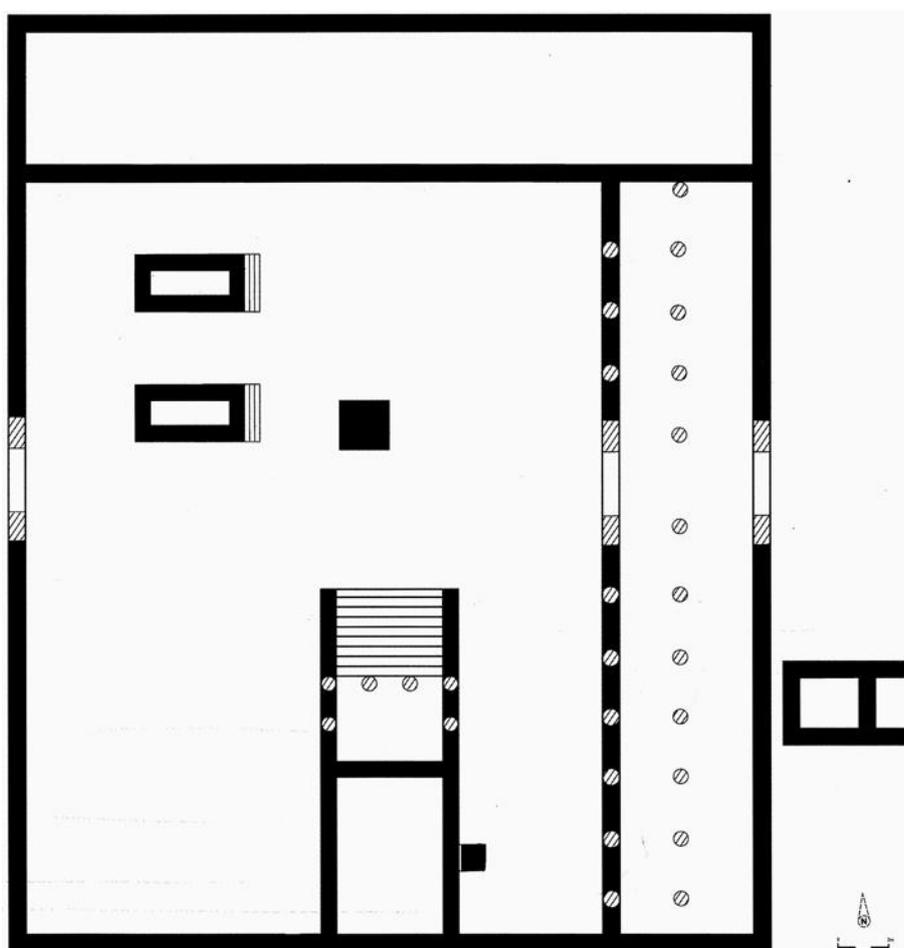


Fig. 12 – Plan of the forum at *Sellium* (PONTE 1989a).

As testified by the finding of a monumental head of Augustus (about 2.90 m high), datable to the 1st century AD, the construction of the complex was started by Augustus in the first half of the 1st century BC, probably between the years 16 and 13 BC (PONTE 2010: 325–326)¹⁰. However, some archaeological remains have suggested a Tiberian date for the completion. Unlike other cities, such as *Conimbriga*, in *Sellium* there is no evidence of a deep renovation of the forum in the Flavian age: if it were remodelled, it is more likely that it

¹⁰ The posthumous portrait confirms the existence of the imperial cult of Augustus at the time of Tiberius, probably in honor of the founder of the *civitas*.

happened later, maybe between the end of the 1st century AD and the beginning of the 2nd century AD (ALARCÃO 1990: 52). However, at present, there are no archaeological data documenting two building phases with certainty.

The monumental centre was fitted into the orthogonal urban plan carried out by Augustus and it was located in the north-east corner of the crossroads between the two most important city streets: the axis which is usually named *decumanus maximus* ran to the south of the *basilica* and the so-called *cardo maximus* ran along the western side of this building (PONTE 1989c: 100). It is conceivable that the access to the monumental centre was made through galleries or porticoes, which crossed the *basilica* and the square to the west and to the east. In fact, some evidence of the foundation walls of the *basilica* have made possible the reconstruction here of the entrance to the complex. On the western side there was probably a series of *tabernae* opening towards the forum precinct (PONTE 1989a: 12).

The *basilica* was a large rectangular hall of m 18,20 by 54.60, so that its long side was equal to the short side of the forum (PONTE 2010: 327) (Fig. 12).

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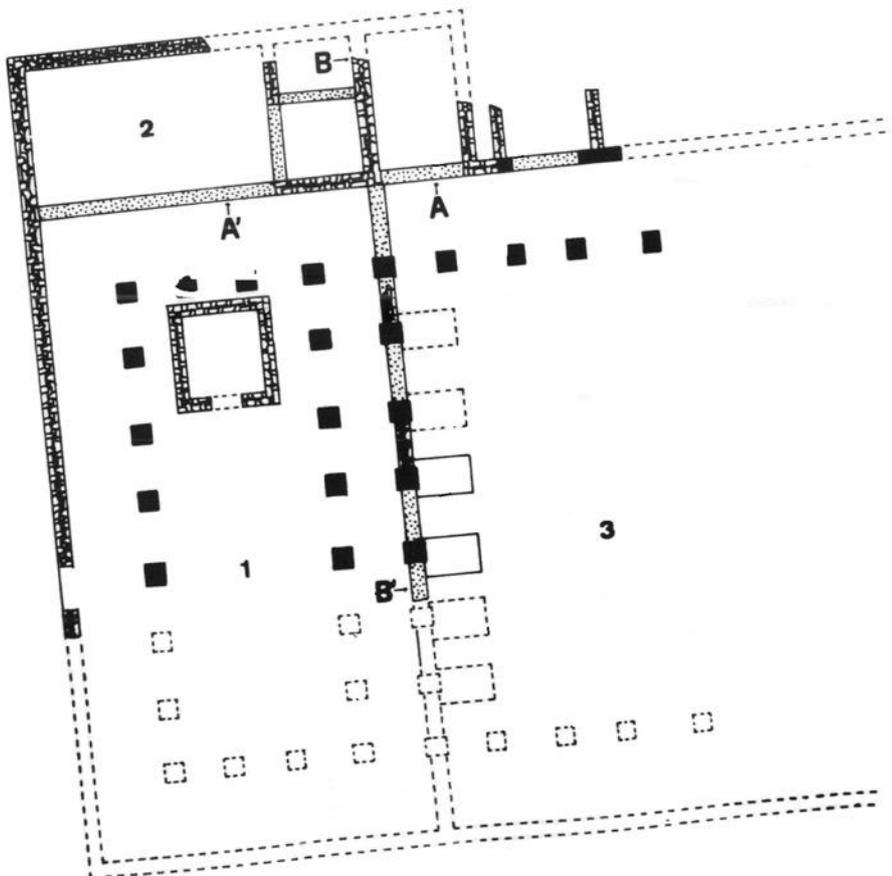


Fig. 13 – 3D Reconstruction of the known part of the forum at *Sellium* (PONTE 2010).

It had an inner portico with twenty columns, probably eight along the long sides and four along the short sides; thirteen of these columns are still preserved (ALARCÃO 1990: 50). The *tribunal* was placed on the

pedes) wide (in the proportion 1:2) (FRADE 2010: 50). This rectangular building, with a north–south orientation, had the frontage facing the north and the *pars postica* leaning against the southern wall of the monumental centre. A central staircase located in the northern frontage led to a platform: it corresponded to the *pronaos*, which was decorated with six Ionic columns. The *cella* was built on a high podium, which may have had a crypt below (Ibid.).

Thanks to the discovery of two inscriptions, we know that one of the other two smaller temples was dedicated to *Victoria* (CIL II, 5245) and the other one to the municipal *Genius* (CIL II, 401), but unfortunately only one of them has been brought to light.

The archaeological excavations have uncovered the remains of a portico located east of the temple: oriented in a north-south direction, it was 8 m wide (27 *pedes*) and it had a double colonnade: one located in the middle of the construction and another one resting on the western wall.

There are few remains of the *basilica*, placed on the opposite side of the main temple: even if there is no evidence of a colonnade inside, we can suppose that it existed.

Comparisons among the examined fora

As the excavations at *Pax Iulia*, Bobadela and *Sellium* were only partial and limited, our knowledge about their monumental centres is incomplete, but on the other fora we can make some assumptions. One of the first elements that these Roman towns have in common is the urban layout: although only three of them were foundations *ex nihilo* (*Augusta Emerita*, *Ammaia* and Bobadela), almost of all them had an orthogonal plan. It is not a coincidence that all these cities were founded in the Augustan age, because it is general knowledge that this typical urban layout reached its full development under Augustus and it spread rapidly in the urbanization of the West during the later part of the 1st century BC (MIERSE 1999: 92). In this perspective, the forum became the organizing device for the new foundations, as an imposed element, such as for the rebuilt older cities, where it was inserted into existing urban units (MIERSE 1999: 55).

Furthermore, all the cities examined in this paper testify that the forum had a strict connection with at least one of the two main urban axes, even when the complex was not centrally located (such as at *Ebora* and *Pax Iulia*).

Other features that the examined fora share are the following: (with the exception of *Ammaia*) the location on the highest areas of the towns; the construction of the temples on high *podia*, often with a central staircase; the frequent separation between the sacred area and the administrative and commercial sectors. In fact, with regard to *Augusta Emerita* (such as at *Barcino*), Mierse has suggested that the religious aspect was predominant over the administrative and commercial functions (MIERSE 1999: 98). This hypothesis may or may not be shared, but it is quite clear that in this monumental centre the architects placed emphasis on the temple as the primary structure of the complex (Ibid.). The validity of this theory could be confirmed by some changes carried out in the forum of *Conimbriga* in the Flavian age: in that period the *basilica* and the *tabernae* were destroyed and matching porticoes were erected over them (MIERSE 1999: 214). The aim of this modification was to remove the civic and administrative roles from the monumental centre and to focus attention on the temple at the northern end (Ibid.). In the central platform of *Augusta Emerita* the role of the temple was stressed through its elevation above the rest of the forum: the dividing line between the two

areas was first marked by a raised platform and later accentuated by adding to it an *exedra*. Something similar was made at *Ebora*, where the separating wall between the sacred sector and the lower square was transformed by covering it with a decoration of large marble slabs (HAUSCHILD 2010: 28). Unfortunately, the results from the recent excavations have not clarified whether the *Ammaia* forum had direct access to the temple area or not: actually, as stated above, the fact that "the ritual part of the complex was cut from the more profane part by a long wall" is only a mere hypothesis at the moment (VERMEULEN et al. 2012: 131). In conclusion, five of the six described temples (with the exception of *Sellium*, about which there is no evidence) were rectangular buildings, located in central positions and standing on high *podia*. With regard to the dimensions, the temple of *Augusta Emerita* was clearly the largest: it is worthwhile stressing that it was roughly the same size as the temple of *Barcino* (32.80 by 21.90 m) (MIERSE 1999: 99). The ones of *Ebora* and *Pax Iulia* were a bit smaller and they had similar dimensions, while the temple of *Ammaia* was most certainly the smallest. It is interesting to underline that three of these buildings, the largest, were all hexastyle temples, with columns decorated by Corinthian capitals: *Augusta Emerita*, *Ebora* and probably *Pax Iulia*. There is another relevant common element among the examined fora: if we exclude the two cities only partially excavated, *Pax Iulia* and *Sellium*, where this kind of structure has yet to be discovered, in all the other four towns the temple was enclosed by porticoes (like in *Conimbriga* and *Aeminium*). They sometimes hosted *tabernae*, like at *Ebora* and *Ammaia*, or they could have religious functions. In addition, at *Augusta Emerita*, *Ebora* and *Ammaia* there were *cryptoporticoes*: these underground constructions had different locations, dimensions and also functions in these three cities, but it is important to stress that in all these cases they caused elevation of the overlying structures and were sometimes used to compensate for differences in levels and inclinations. This solution links the Iberian architecture with the Roman models: maybe it is not a mere coincidence that the colony of *Norba Caesarina* was probably founded by italic contingents.

Another noteworthy element is the common presence of hydraulic systems: in *Lusitania* and the Iberian Peninsula there are several examples of hydraulic systems connected to the temple areas and perfectly integrated into the sacred complexes. Among the examined towns, we can mention the two *piscinae* of *Augusta Emerita*, the two pools of *Ebora*, the water tank of *Pax Iulia* and maybe the possible basin at *Ammaia*. This means that in all the cities where more extensive investigations have been carried out, the forum and the temple area in particular were characterized by structures in *cocciopesto*, used for water conservation. The presence of water was obviously connected with worship and probably with the religious ceremonies. It is interesting to stress that there are many other similar examples, not only in *Lusitania*, but also in the rest of the Iberian peninsula: *Civitas Igaeditanorum*, *Conimbriga* and *Colonia Augusta Firma* in *Lusitania*; *Ampurias*, *Astigi*, *Barcino*, *Baelo Claudia*, *Bilbilis*, *Clunia*, *Valeria*, *Termes* and *Carteia* in *Hispania*. The use of water tanks in the temple area is well documented also in Italy and it has been suggested that it is connected with the temples of Imperial cult, as testified by the forum temple of Ostia (PENSABENE 2004: 185).

Most of the described monumental centres share also the large dimensions of the *basilica* halls: at *Pax Iulia*, in particular, this building perfectly matched the Vitruvian model: as we have seen, it measured 80 by 160 m on average and it was separated by a quadrangular *curia*. Also the *basilica* of *Augusta Emerita* had an exact

proportion of 1:2, but it is different from the others due to its huge dimensions: about 2.000 m², which is a similar size to the buildings of *Tarragona* and *Clunia*.

Another common element is the use of the granite, a very solid material that abounds in the central and northern part of Portugal: in *Lusitania* it was often employed in the *opus quadratum* and in the *opus incertum* (which was often covered by plaster) (HAUSCHILD 2002: 215). The use of this local stone is certainly documented at *Augusta Emerita*, *Ebora*, *Pax Iulia* and probably *Ammaia*. In the monumental centre of these three towns, the excavations have documented a second building phase, which coincides with the introduction of marble in the decorative programme of the complex (NOGALES BASARRATE 2009: 140). The paving of the various areas of the forum represents a different matter, because “poor materials” like floor tiles were more often used than marble slabs.

Finally, it is quite certain that in all the described complexes there were two building phases: the later transformations often date back to the Flavian age and more rarely to the post-Flavian age. It is due to the fact that the changes of the juridical-administrative status of a town often corresponded to the renovation of the monumental centre. At *Augusta Emerita*, *Ebora* and *Pax Iulia* the excavations have documented that this second building phase coincides with the introduction of marble in the decorative programme of the monumental centre (NOGALES BASARRATE 2009: 140). With regard to *Ebora*, for example, Hauschild (HAUSCHILD 2010: 28) has stated that the wall that divided the temple area from the lower square was decorated with large marble slabs in a later construction phase (HAUSCHILD 2010: 28).

We can conclude that the great amount of similarities among the examined Roman fora is probably due to the fact that all towns were founded in the Augustan age: it cannot be a mere coincidence the fact that the *deductio* of all these towns and sometimes also the construction of their monumental centres dates back to the same period, between the years 31 and 13 BC. From the available evidence we can deduce that even the Roman fora erected in remote parts of the empire underwent a monumentalization, which in *Lusitania* coincided with the administrative reorganization carried out by Augustus.

At the current state of the studies, it is quite difficult to apply this hypothesis to other Roman centres of the Iberian Peninsula, particularly of the Augustan age, and especially for sites still to be excavated. With regard to *Lusitania*, *Ammaia* is the only case study where the reconstruction of the Roman town has been made possible via the integrated use of non-destructive technologies (geophysical prospection, LiDAR survey, geomorphological observations and low-altitude aerial photography). In the rest of the Iberian Peninsula the use of these kind of methods has been employed in a very few cases, especially located in the province of *Baetica*. *Munigua*, at a site today known as El Castillo de Mulva (about 60 Km northeast of Seville), is one of these centres, but its monumental centre does not belong to the typology of the tripartite forum and the chronology of the first phase of the complex is still uncertain. At *Italica*, which is north of the modern city of Santiponce (9 km northwest of Seville) and was the earliest Roman settlement founded in Spain (206 BC), the researchers have not discovered archaeological evidence of a forum erected in the Augustan age. At *Baelo Claudia*, located near the village of Bolonia (Cádiz), close to the Straits of Gibraltar in the western part of Andalusia, geophysical prospection have been performed in order to investigate the ancient earthquakes and the forum complex has been completely exposed and examined. It has two construction phases: the first one during the Claudian age (likely between 40 and 60 AD) and the second one in the Flavian period. It is a typical tripartite forum with some elements in common with the monumental centres of *Lusitania* (regular

urban layout, separation of the sacred area from the profane sector, presence of hydraulic elements, etc.). However, it must be said that in the few archaeological sites of the Iberian Peninsula where geophysical prospection have been employed, there are several uncertainties about the chronology of the visible structures. This means that data collected in the Roman towns where extensive and systematic archaeological excavations have been performed are absolutely necessary to understand the information acquired in other sites through the non-destructive technologies.

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Tracing Byzantine Routes

Medieval Road Networks in the Historical Region of Macedonia and Their Reconstruction by Least-Cost Paths

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Abstract: The reconstruction of medieval road networks in the southern Balkan peninsula has often been focused on the well documented *Via Egnatia* between Dyrrachium (Durrës) and Constantinople (Istanbul), which led to a marginalisation of adjacent routes. This can be explained by the fact that in comparison to the rich variety of written sources as well as of archaeological evidence concerning the *Via Egnatia* we simply lack useful data for other routes in the region.

This article shows that the existing gap can successfully be bridged by the application of two methods. One has been used on the macro-level of historical geography, the other on the micro-level. In the first part M. Popović analyses the development of routes as well as their importance (centrality) on the whole territory of the (Former Yugoslav) Republic of Macedonia with the means of network analysis. In the second part M. Breier is focusing on the micro-level of historical geography with a case study on a specific route between the towns of Štip, Strumica and Petrič by using GIS-based applications (least-cost paths) to predict a medieval road, which is in fact attested by the medieval written sources, but cannot be localised on the basis of archaeological findings.

Both methods (network analysis as well as least-cost paths) constitute the latest innovations in the field of computer applications and quantitative methods in archaeology. The achieved results show clearly that our lack of sources can be compensated to a certain extent by computer-based models, which have the potential to enhance the scientific work of archaeologists in the future and to familiarise the wider public with complex historical interrelations through visual representations/reconstructions.

Keywords: Byzantium; Historical Geography; Routes; Network Analysis; GIS.

The Historical Region of Macedonia and Network Analysis

In 1969 Francis W. Carter published an article entitled “An Analysis of the Medieval Serbian Oecumene: A Theoretical Approach”, in which he applied graph theory to urban places of the mediaeval Serbian state during the reign of Stefan Uroš IV. Dušan (1331–1355). He came to the conclusion that “Skoplje was not the ideal site, in terms of linkage, for Dušan to have had as his capital, Priština or Prizren would have been better” and “[...] that the capital should have been either Priština or Prizren, based on the most efficient use of route linkage and centrality in the state” (CARTER 1969: 53 f.).

On the basis of Carter’s approach I would like to contribute with my part of this article to the reconstruction of the transportation networks in the historical region of Macedonia, namely on the territory of today’s (Former Yugoslav) Republic of Macedonia for the time being, and to its evaluation with network analytical tools.

Firstly, I referred to the monograph written by the Serbian scholar Gavro Škrivanić, which is entitled “Putevi u srednjovekovnoj Srbiji” (“Routes in mediaeval Serbia”) and which was published in 1974 (ŠKRIVANIĆ 1974). Škrivanić reconstructed the transportation network in the above-mentioned area on the basis of written sources, archaeological data and surveys.

Secondly, I have recently found a historical map of the entire historical region of Macedonia in the “Woldan Collection” of the Austrian Academy of Sciences, which is entitled “Marsch-Karte von Mittel-Europa entworfen vom k.k. Generalquartiermeisterstabe” and dated to 1848, that is before industrialisation commenced in South-East Europe and railways substantially changed the pattern of transportation.

In a first step, I compared both in order to see if the mediaeval routes reconstructed by Škrivanić were still in use in 1848. Thus, I created a transportation network of the matching routes, which I visualised via Google Earth (see Fig. 1).



Fig. 1 – The Transportation Network in the Historical Region of Macedonia.

Thereafter, I proceeded by introducing the *König number* (*König's theorem*) as index of centrality. According to Wagstaff “The König number is derived from counting the number of edges in the shortest path between any given node and the node furthest away from it. [...] Low König numbers indicate greater centrality in the network” (WAGSTAFF 2006: 81). The achieved results – based on a pen and paper calculation – showed clearly that the node of Skopje is the most central one followed by the nodes of Štip and of Veles.

What has changed significantly since the pioneering work of Carter in 1969, are the technical innovations to compute and to illustrate results deriving from network analysis by using powerful hardware and complex software applications like *Pajek*, **Ora*, *Spatial Analysis on a Network (SANET)* by Okabe or to a certain extent *ArcGIS*.

My next aim was to recheck this stringent calculation based on the *König number* with one of the complex software applications mentioned above. Would my result on centrality be confirmed, if I transferred the described network into *Ora Version 2.2.9 (see Fig. 2)?

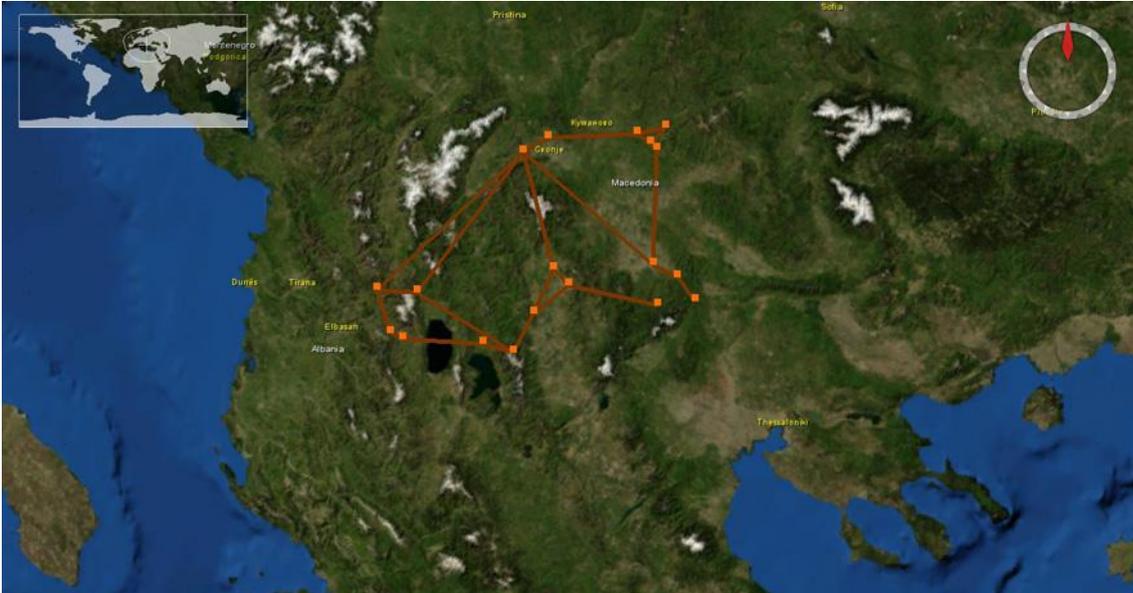


Fig. 2 – The Same Transportation Network in *Ora Version 2.2.9.

What can be seen in Fig. 3 are the results in the category *Closeness Centrality*. It shows the average closeness of a node to the other nodes in a network. Closeness is the inverse of the average distance in the network between the node and all other nodes. The city of Skopje has the highest value in this measure followed by Štip and Veles.

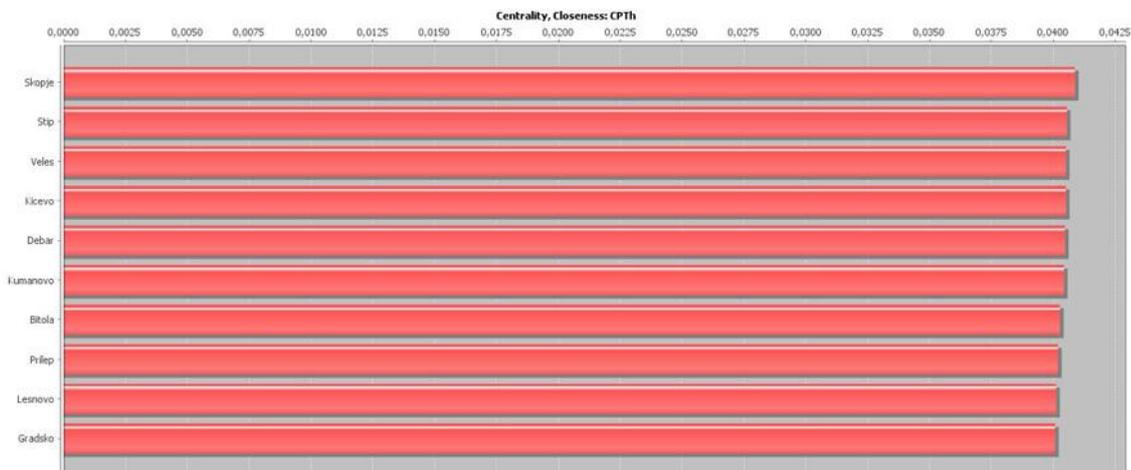


Fig. 3 – The Results in the Category Closeness Centrality (*Ora Version 2.2.9).

The introduction of the category *Betweenness Centrality* contributed to gaining an in depth and more sophisticated picture of vital nodes within the road network (see Fig. 4). The Betweenness Centrality means that a node v in a network is defined as follows: across all node pairs that have a shortest path containing v ,

the percentage that pass through v. Therein, the city of Skopje has the highest value followed by Štip and Veles.

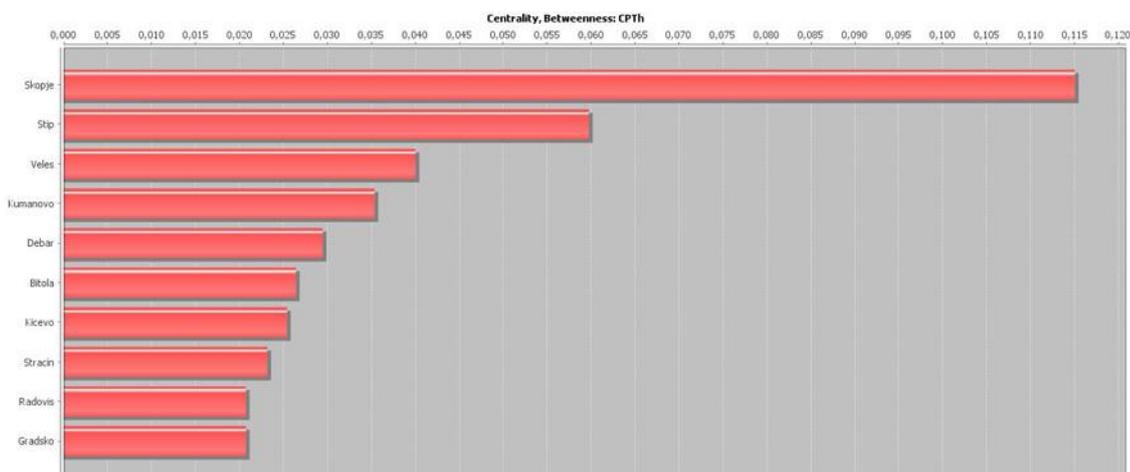


Fig. 4 – The Results in the Category Betweenness Centrality (*Ora Version 2.2.9).

If we take a look at the category *Total Degree Centrality*, we recognise that Skopje has the highest value (see Fig. 5). The Total Degree Centrality of a node is the normalised sum of its row and column degrees. Those nodes which are ranked high on this metrics have more connections to others in the same network.

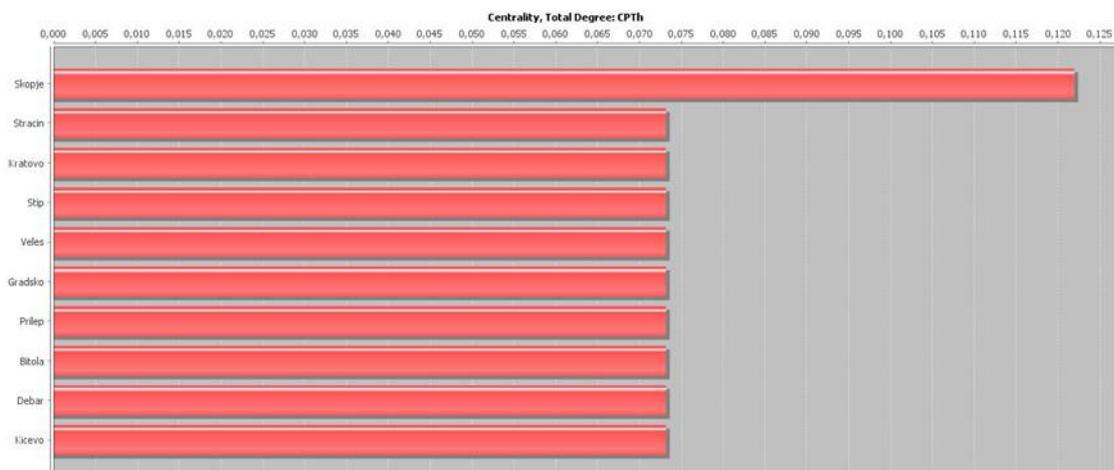


Fig. 5 – The Results in the Category Total Degree Centrality (*Ora Version 2.2.9).

It becomes clear that my results deriving from the application of the *König number* are confirmed. Skopje is the most central node in the whole network. Additionally, I was able to obtain further sophisticated data with the manifold applications offered by *Ora. Compare for example the Betweenness Centrality. In the near future I will enrich my scholarly results by incorporating mediaeval and preindustrial itineraries as well in order to analyse the shifting importance of routes.

At this point I would like to leave the macro-level of historical geography and draw the attention of the reader to the second part of this article written by M. Breier. It focuses on the micro-level of historical geography with a case study on a specific route between the towns of Štip, Strumica and Petrič by using GIS-based

applications (i.e. least-cost paths) to predict a medieval road, which I have found attested by the medieval written sources in the 13th and 14th centuries, but which cannot be localised on the basis of archaeological findings (POPOVIĆ 2010).

The Basilikos Dromos in the Strumica Valley – a reconstruction by least-cost paths

Within the transportation networks in the historical region of Macedonia the road between Štip, Strumica and Petrič is of special interest. It is mentioned in written sources from the 13th and 14th century and is described as basilikos dromos, which translates as “emperor’s road” (POPOVIĆ 2010). The road is situated in the eastern part of the present-day (Former Yugoslav) Republic of Macedonia and Western Bulgaria (see Fig. 6).

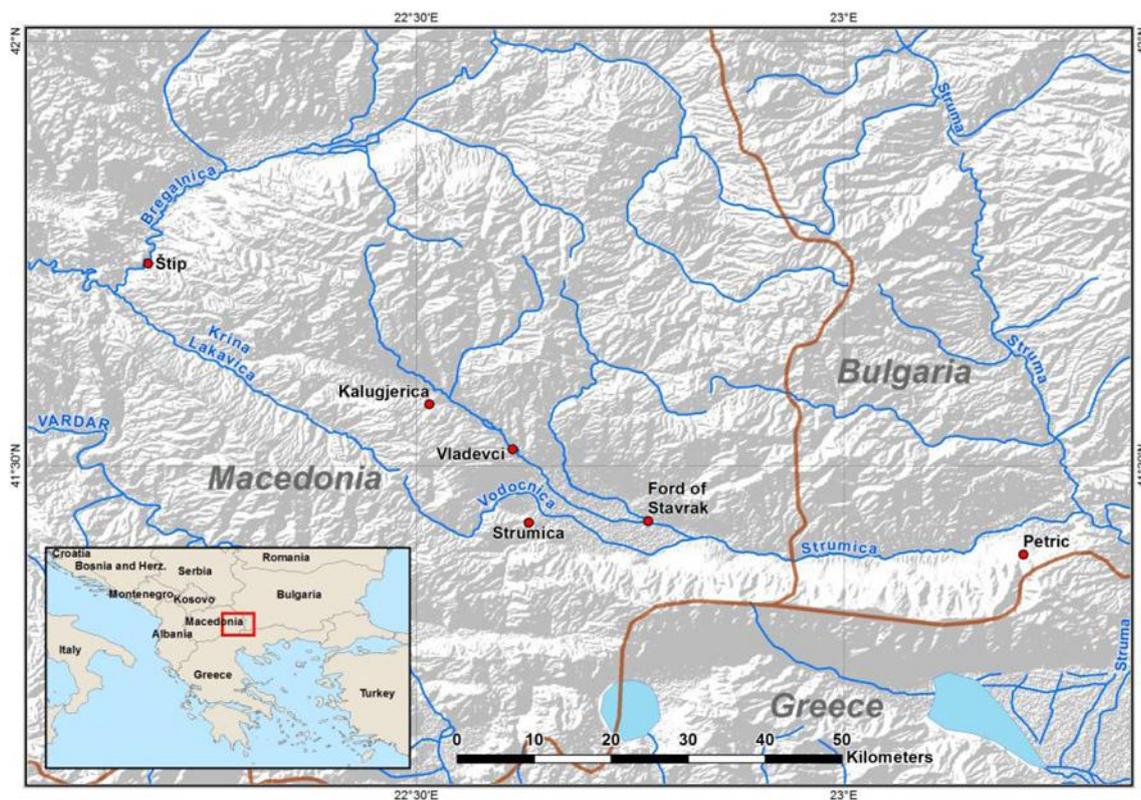


Fig. 6 – Overview of the area of interest.

Research questions

The name of the road and the fact that it is mentioned in more than one medieval document leads to the assumption that the road was not only relevant locally, but on a larger scale as well. It was most likely part of a connection between two important trade routes, the Via Egnatia and the Via Diagonalis. Therefore, it is desirable to include the road in the maps of the Tabula Imperii Byzantini (TIB). However, there are no archaeological remains of this road, or at least they have not been found yet. Therefore, least cost path calculations are a method for calculating a model of this road.

Least cost paths

Least cost paths are a method of finding the route over a surface from point A to B which has the least cost accumulated along the way. However, cost does not necessarily mean financial cost, but can also be some composite measure which is not constant across the area of interest. Therefore the term "friction" is often used instead of cost (DE SMITH et al. 2011: Chapter 4.4.2).

The basis for the computation of a least cost path is a cost of passage map or friction map, which is usually a raster representation of the area of interest. Each raster cell is assigned a value, which describes the cost of traversing that cell. The cost can depend on many factors defined by the attributes of that cell (e.g. slope, land cover) but also on the mode of movement (e.g. walking, driving) (CONOLLY and LAKE 2006: 215).

Data Situation

The data situation for this project is rather complicated. Since it is a research regarding the historical landscape, it would be ideal to have data representing this historical landscape rather than data just representing the contemporary landscape. However, digital historical geodata does not exist and even historical maps of the area are difficult to come by.

Although the river regulation of the Vodocnica and Strumica took place in the first half of the twentieth century, it was not possible to source any maps showing the situation before the regulation. The available map sketches drawn by Austrian officers in the 1830s only show parts of the landscape and do not line up properly with contemporary geodata. Furthermore, high quality large scale geodata from mapping agencies is still confidential in this area.

Budgetary restrictions further limit the available geodata. Therefore, primarily freely available geodata was used.

Cost factors

The cost factors for this project are derived from the relief and the rivers. From the relief, the effective slope was derived by the least cost algorithm of ArcGIS. The cost values are assigned to the slope values according to the energy expenditure during walking, based on the calculations of van Leusen, as shown in Fig. 7 (VAN LEUSEN 2002).

Further cost factors for the research are based on considerations by Dietrich Denecke. He states that medieval routes tended to follow the relief, staying roughly at the same height (DENECKE 1979). Therefore, the height above or below the riverbed is also included as cost factor.

For the rivers no exact hydrographical data beside the geometry is available; therefore rivers were assigned a unified cost, making them barriers in the landscape. Only the river section where the known ford is situated is assigned a lower cost. More detailed hydrographical data would be desirable, but, as aforementioned, historical hydrographical data is not available for the area of interest.

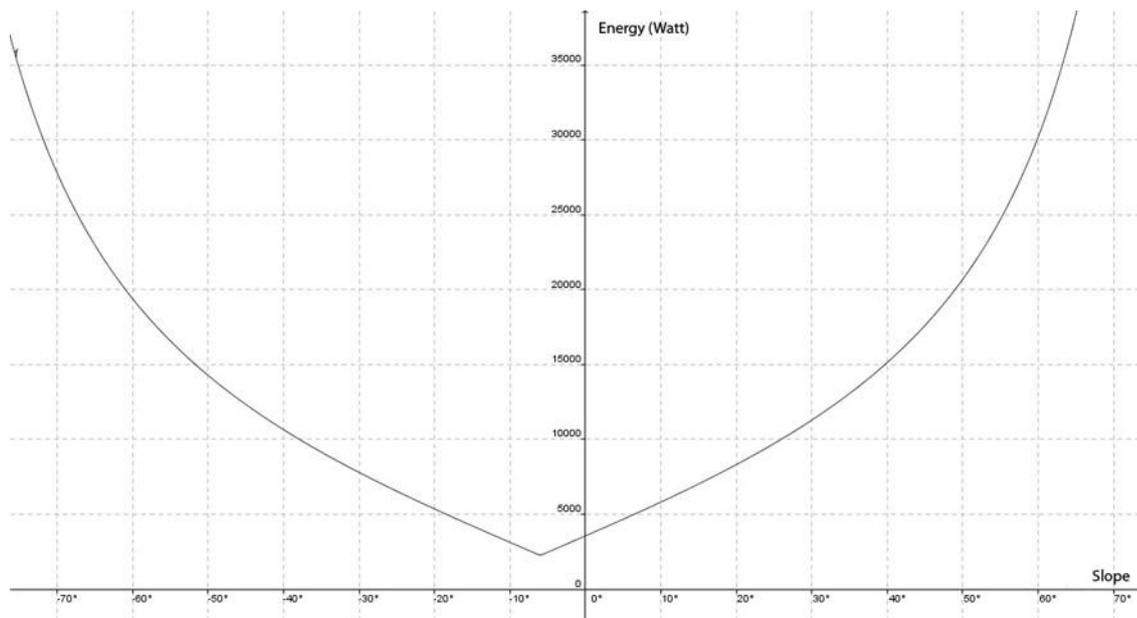


Fig. 7 – Energy expenditure during walking (based on VAN LEUSEN 2002).

Data acquisition and preparation

Two sets of digital elevation models (DEM) are used within this research. The SRTM (Shuttle Radar Topography Mission) data with a resolution of 90 meters and the newer ASTERDEM (Advanced Spaceborne Thermal Emission and Reflection Radiometer Digital Elevation Model) with a resolution of 30 meters are used to compare the effects of the resolution on the final results. Both datasets are available from their project sites.¹¹

For the hydrography, the watercourses from the Vector Map Level 0 (Vmap0, formerly known as Digital Chart of the World) are used. This dataset is compiled by the national mapping agency of the USA and is in the public domain¹². However, the geometry of the data is generalized for a scale of 1:1,000,000. Therefore the data has to be adjusted to the DEMs. These adjustments are done manually; using hill shaded renderings of the DEMs as well as scanned maps at the scale of 1:200,000.

Furthermore, additional point data of towns, fords and monasteries were recorded using a GPS receiver during a field trip in July 2010.

All datasets were projected into the UTM coordinate system and clipped to the same extent. They were adjusted to each other, in order to create a consistent database.

For the rivers, a buffer of 100m was created to prevent artifacts during the conversion into raster data. The least cost path algorithm would interpret these artifacts as places where the river could be traversed very easily (see Fig. 8). To model the rivers as effective barrier, the costs factor assigned to the rivers is 50.

¹¹ SRTM: <http://srtm.csi.cgiar.org>; ASTERDEM: <http://www.gdem.aster.ersdac.or.jp/index.jsp> (accessed: 16/01/2012).

¹² Downloaded from http://geoengine.nga.mil/ftpdir/archive/vpf_data/v0Eur.tar.gz (accessed: 16/01/2012).

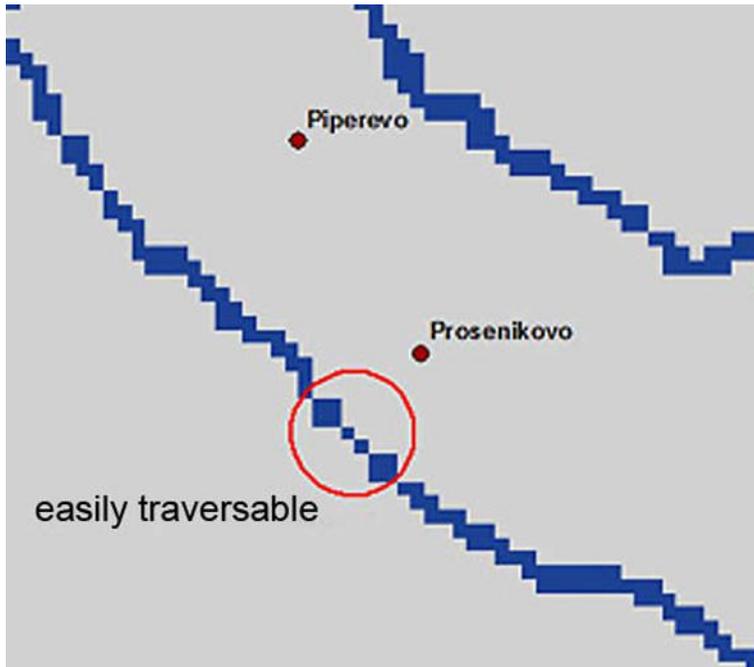


Fig. 8 – Artifacts of the conversion to raster data. In diagonal direction, rivers are no barrier at these points.

According to the aforementioned cost factors, the DEM has to be reclassified. Since Štip as well as Petrič are beneath 300m above sea level, higher areas are assigned a higher cost. Therefore, the cost duplicates for every 100m above 300m (Tab. 1).

| Height above sea level | Cost factor |
|------------------------|-------------|
| up to 300m | 1 |
| 301m–400m | 2 |
| 401m–500m | 4 |
| 501m–600m | 8 |
| more than 600m | 16 |

Tab. 1 – Costs according to height above sea level.

This cost factor ensures that the calculated path stays in the valleys. Without the inclusion of these costs, the path would leave the valley shortly after Štip and take a more direct course over the mountains. The results of the preliminary calculations including these factors seem to create a more likely path model than without these factors.

Calculations of the basilikos dromos

The isotropic (direction independent) cost factors are combined into a single cost of passage map using the map algebra functions of ArcGIS by multiplying the cost of the rivers with the cost according to the height above sea level.

The anisotropic (direction dependent) cost of the slope was calculated within the path distance function of ArcGIS. Input data for this calculation is the DEM (from which the slope is derived) and the function of the cost assignment to the slope. Here, the function for the energy expenditure during walking (see Fig. 7) is used.

All calculations are done with ESRI ArcGIS Desktop 10, using the modules *path distance* and *cost path*.

Preliminary calculation

The first calculations are conducted to tweak the cost factors and test the viability of the model. From the written sources, it is known that the basilikos dromos passes between the town of Kalugjerica and the Strumica as well as between Vladevci and the Strumica, before reaching the Ford of Stavrak (POPOVIĆ 2010).

For the testing of the cost factors, Štip was chosen as starting point and the Ford of Stavrak as end point. No points in between were included in the calculation. The preliminary calculation is based on the SRTM data. The result of these calculations is shown in Fig. 9. Although neither Kalugjerica nor Vladevci are included in the calculation, the calculated path passes near them. This is almost consistent with the written sources, although Vladevci is bypassed on the wrong side, but not far off. However, this result shows the viability of the cost factors and the model.

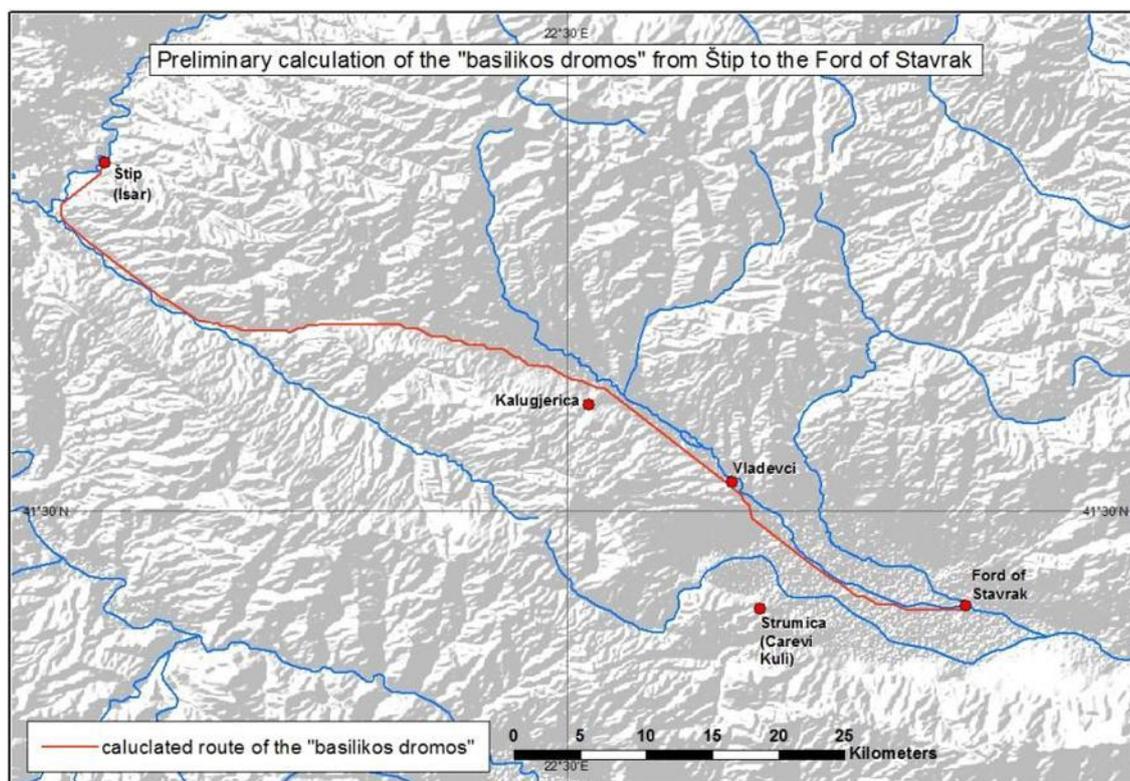


Fig. 9 – Preliminary calculation.

Final calculation

For the final calculation, more waypoints are included. From the written sources it is known that the basilikos dromos bypassed Petrič on the other side of the river, therefore, a point in this area is chosen as the end

point. Further waypoints are chosen between Kalugjerica and the Strumica and between Vladevci and the Strumica.

The calculation of the final model is done in four sections: Štip – Kalugjerica, Kalugjerica – Vladevci, Vladevci – Ford of Stavrak, Ford of Stavrak – Petrič. All four sections are calculated once with the SRTM data and once with the ASTERDEM data.

Results

The output of the cost path module is a raster dataset. For cartographic representation as well as comparison between the SRTM and ASTERDEM based results, vector based datasets are more suitable. Therefore, the results are converted into shapefiles. To further enhance the cartographic representation, generalized datasets were derived. These generalized results are shown in Fig. 10.

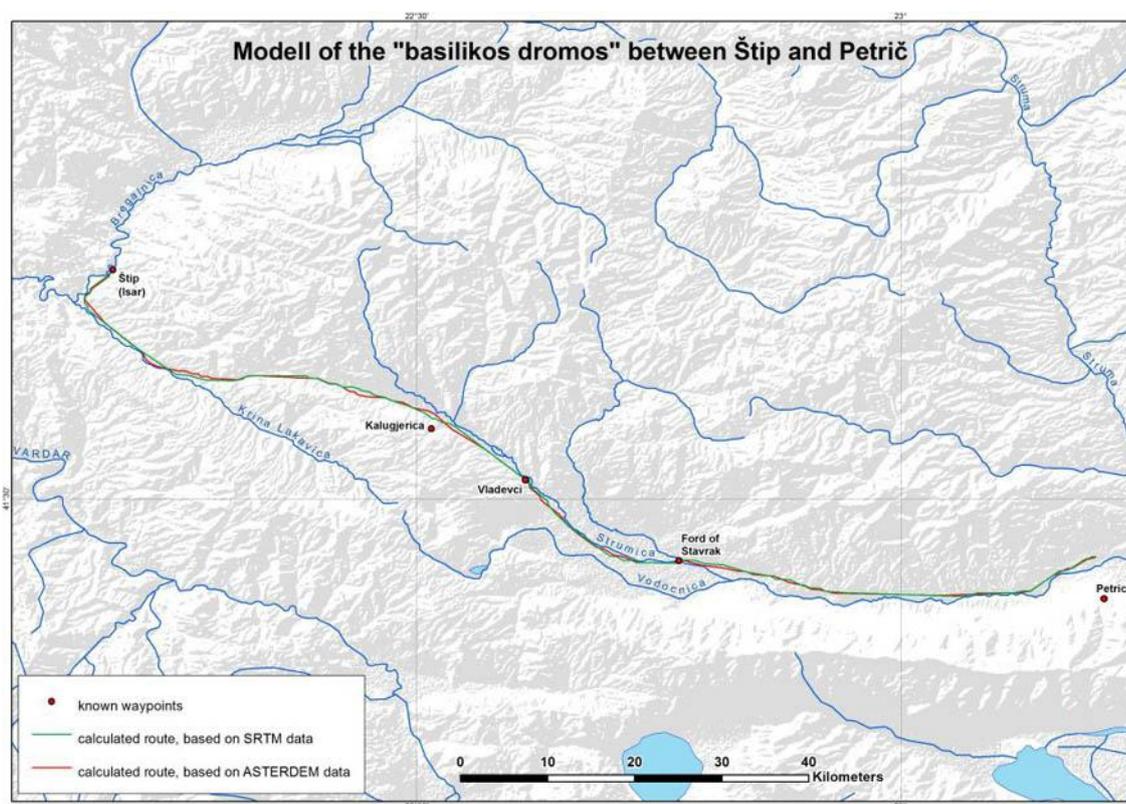


Fig. 10 – Final model of the basilikos romos.

Comparison SRTM and ASTERDEM

The calculation of the basilikos dromos is done twice. One route is based on the SRTM data, which has a resolution of 90m, the other one is based on the ASTERDEM data, which has a resolution of 30m. With both DEMs, the course of the basilikos dromos is roughly the same. The largest deviations are between Štip and Kalugjerica (Fig. 11). At point A, the deviation is about 500m, at point B it is about 470m, at point C about 570m and at point D about 480m. After Kalugjerica, the differences between the two courses are insignificant. For a better estimation an extensive evaluation of the whole model would be necessary.

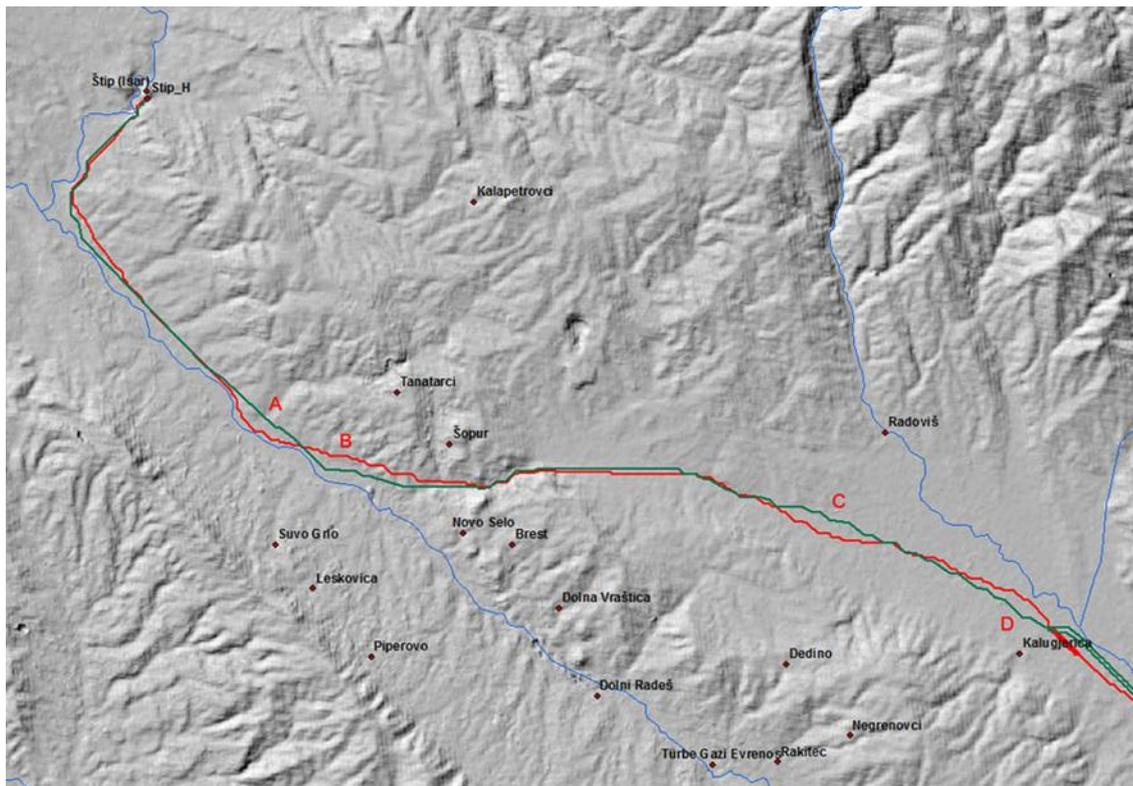


Fig. 11 – Comparison of calculations based on SRTM data (green) and ASTERDEM data (red).

Conclusion and Outlook

Least cost paths present a viable possibility to model medieval roads of which no known remains exist.

Although only physical cost factors are included in the analysis, the calculated road matches the estimated course of the road. The calculations are based upon freely available and very basic geodata.

Due to a tight schedule and budgetary restrictions, this research is more a feasibility study than an extensive research project.

Further evaluation of this model by calculating comparable, but known roads, would be necessary. This would also allow further refinement of the cost factors. Furthermore, the influence of the resolution of the input data could be tested more thoroughly.

It would be desirable to use more detailed geodata, like hydrographical data, as well as historical data.

Furthermore, the introduction of social geographic as well as political and military factors should be considered.

The road is calculated using the algorithm included in ArcGIS. Different algorithms, however, produce different results (GIETL et al. 2008). It would also be interesting to test various path finding algorithms with the basilikos dromos.

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Lost but found underground

Construction, development and maintenance of medieval streets and squares of Turku (Finland)

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Abstract: Due to the preservation and availability of the material, the studies of medieval town and urbanity in Finland are concentrated in Turku, which was one of the biggest towns of the Swedish realm and the most important town situated in the area of the present-day Finland. Until recently, the conceptions of the medieval streets and squares of Turku (Finland) have been based on unproven notions, on the oldest town chart from the 17th century and on few street names mentioned in preserved written sources. These conceptions have changed notably due to archaeological excavations conducted in the medieval town area in the past few years.

This study focuses on the constructing activities of the medieval squares and streets of Turku discussing the factors and consequences of this development. On the basis of the preserved material, it seems that the streets of Turku have been paved earlier and more systematically than previously stated and attention was also paid to the maintenance and sanitation of the streets and squares. All in all, the construction activities of streets and squares seem to relate closely to the growth of the town as well as its building activities indicating that they played an essential role in the development of the town structure. Since medieval streets, their maintenance and paving were on the responsibility of the owners of the plots adjacent to the street, they did not represent only town's public space and routes of transportation, but acted also as social forums for households and individuals.

Keywords: street, square, Middle Ages, Turku, Finland.

The starting point for the study

Turku was founded according to the present knowledge in the turn of the 13th and 14th century on the south-west coastline of the present-day Finland. It is the oldest town of Finland and during the Middle Ages it was one of the biggest and most important towns of the medieval Sweden forming an important gateway to the East (SEPPÄNEN 2009: 243). When the urban environment and construction activities of Turku are examined, we need to turn for the answers to archaeological evidence, since there are only a small number of written sources from the Middle Ages which have survived until now, and on the basis of those it is impossible to get a picture of the environment and physical structure of the town.

For example, the medieval sources reveal only seven street names, of which the oldest mention comes from 1426 (KOSTET 2011: 43). These documents do not reveal the location of the streets or any activities connected with their construction or maintenance. Nor do we have many visible signs of medieval streets in today's townscape either, since the last tracks of the medieval town were destroyed in a big fire in 1827 in which 75 % of the town completely demolished. The reconstruction of the city brought along substantial

changes in the layout of the medieval town area. Two squares, Market Square and School Square (later Old Great Square and Academy Square) remained composing a part of a larger open area of squares and parks in the vicinity of the cathedral. Medieval streets were deserted, and only a passage of Convent Street (Fin. Luostarin välikatu) leading originally from Market Square to Dominican Convent was spared partially maintaining the sense of the medieval atmosphere (Figs. 1 & 2).

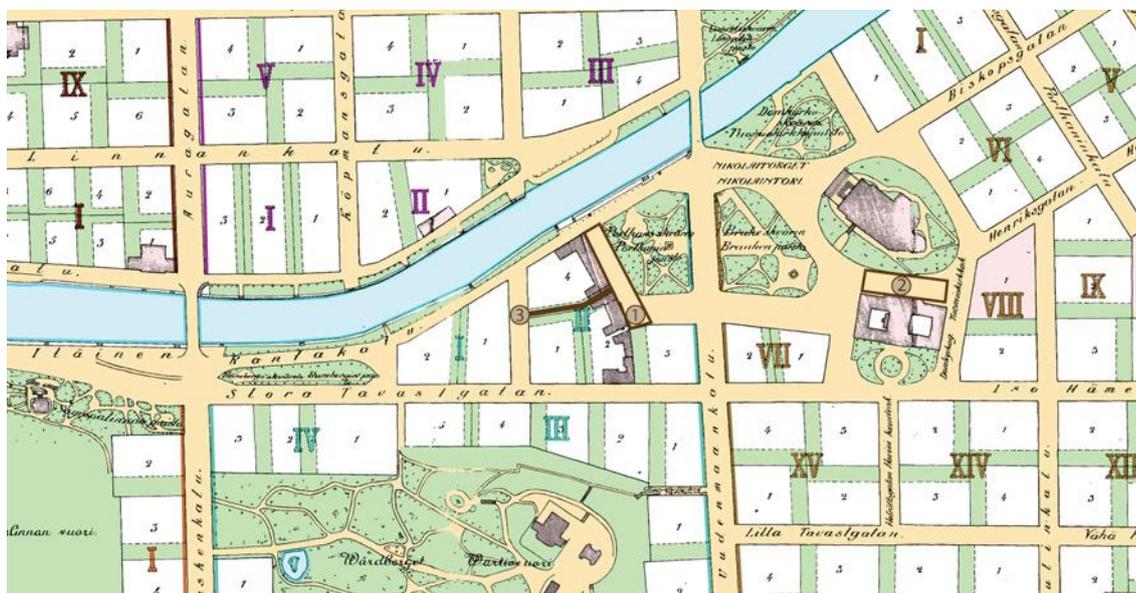


Fig. 2 – Excerpt from a map from 1897 presenting Turku with the new layout of the town after the fire 1827. By the order of the Governor General, the streets were to be wide and straight, the blocks divided into four lots with wide gardens separating the buildings. The Cathedral became a monument standing aloof on its hill, open from all directions surrounded by parks. The main idea of the new plan was to prevent the spread of fire, but also to distinguish the most esteemed buildings of the town. Additional markings circled on the map: 1) Old Great Square / medieval Market Square, 2) Academy Square / medieval School Square, 3) Convent Street (Copyright of the map: City of Turku, Environmental and City Planning Department).

This fire of 1827 was, however, not the only one that had consumed the medieval atmosphere. For example, during the 15th and 16th centuries the town was confronted with the fire possibly 16 times with major or minor destructions (KUUJO 1981:180; RUUTH 1909: 152–157). One of the most disastrous fires took place in 1546, which demolished the majority of ecclesiastical buildings and burgher houses in the central town area. The consequences of the fire have not been recorded nor saved in detail for posterity, but the fact that King Gustav Vasa urged administrators and decision-makers of the region to consider a completely new location for the town tells something about the scale of the fire (NIKULA 1987: 71–74; RUUTH 1916: 156). Anyhow, the town was rebuilt, but it remains for archaeological excavations to find out the changes this reconstruction work caused for the layout of the town.

The medieval layout of Turku has been a target of study mainly for historians since the early 20th century. The medieval streets have been localized on the basis of their names carrying topographical information and known from historical sources. The most illustrative source of information, however, has been the oldest map of the town made in 1634 (RUUTH 1909). Although the map has been drafted nearly nine decades after the fire of 1546, the layout it presents is probably quite the same as it was in the 16th century and possibly even earlier, since the reformations designed by the Governor General Per Brahe were conducted in the mid 17th

century and in this phase chiefly on the other side of the river inhabited mainly during the late 16th–early 17th century (PIHLMAN and KOSTET 1986: 27–29, 62). Despite the inaccuracies, the map offers a valuable tool for the inspection of the medieval layout of the town and a practicable baseline for archaeological discoveries concerning the streets (Fig. 3. About the precision of the map TUOVINEN 2010: 127–130).



Fig. 3 – Only a short passage of medieval Convent Street (Fin. Luostarin välikatu) has been preserved from destructions and reconstructions. The street lead from medieval Market Square to Dominican Convent leading today to Aboa Vetus & Ars Nova-museum (Copyright: Liisa Seppänen).

The contribution of archaeology for the study of medieval streets has been non-existent before the 1990s, and so far only one square has been a target of excavations reaching the layers from the Middle Ages (SALORANTA 2007). Although only some minor parts of few streets have been unearthed in excavations (Fig. 3), the findings seem to confirm the general idea based on observations in other towns that the most important streets have stayed unchanged in spite of destructions and reconstructions the town has encountered over the centuries. Consequently, the network of streets and squares has represented one of the most lasting elements of a town and the changes can be combined with the comprehensive and large-scale alterations of the town catalyzed most often by a fire or annihilation followed by complete reconstruction activities. In Turku, it seems that the main features of the street network constructed in the Middle Ages have remained the same until the 17th century and the most strategic streets remained unaltered until the big fire in 1827 when a completely new layout was created.



Fig. 4 – The oldest map of Turku from the 1630s with following additional markings by the author: 1) Cathedral, 2) The area of Dominican Convent, 3) Market Square, 4) School Square; a–f) parts of the streets found in recent excavations (Copyright of the map: The Museum Centre of Turku).

Structured development by design

The streets have played a salient role in the development of the town. This is manifested by the fact that the network of streets composed of the main street(s) and cross streets, has been valued as one of the criteria for the emergence of the town. Consequently, the question “what catalyzed the construction of the streets?” is in principle equal to the question “what catalyzed the construction of the town?” The process of formation of the streets has also been closely entwined with the structural development of the town, and accordingly, the construction of the streets, the changes in their course and alterations to the network are related to other building activities of the town.

It is quite apparent, that the topography of the area must be considered vitally important when we are tracing the factors, which guided the formation of streets and layout of the town. In Turku, this means that the first streets were adjusted to the course of the river Aura still running across the present-day town area and two narrow streams, which started from the lake nearby and ran through the area flowing eventually into the river. The oldest town area was also framed by a chain of hills, which formed a distinctive relief at the landscape in the Middle Ages. Since then the relief has lost its topographical distinction and the lake and its streams have vanished so that their course and location are unidentifiable in the townscape of today (About the different interpretations regarding the course of the streams GARDBERG 1969: 18–20; KOSTET 1989: 24; KUJJO 1981: 176; PIHLMAN and KOSTET 1986: 150–151, 153; VALONEN 1958: map by A. Kosonen

1941). Besides, the construction of the streets was affected by land ownership and different principles and goals set for the construction of the town, influenced by the other towns in the Baltic area. The geometrical symmetry and regularity, which traditionally have been considered as evidence for the planned and controlled construction of the street network, were not among these goals and principles during the Middle Ages (LILLEY 2002: 152–153, 158, 168).

Thus, the conceptions about the natural, evolutionary development of the medieval streets based on the irregularity and dissymmetry of the layout can be challenged for a good reason (About these conceptions see KOSTET 1989: 38; 2011: 45). The idea of planned layout and regularity of the streets of Turku was presented for the first time in 1969 by C. J. GARDBERG (1969: 36–37). His ideas were not, however, based on any evidence. Written and cartographical evidence about the systematic design of the medieval streets of Turku is non-existent and it was not before at the end of the 1990s and 2005–2006 when the first archaeological evidence of this matter came into daylight. The unearthed streets and remains of houses have proofed that the streets were constructed either simultaneously with the adjacent buildings or right after their erection (RATILAINEN 2010: 33; SEPPÄNEN 2012). After the inspection of the building remains and street surfaces, it seems to be very likely that there has been a plan of construction including both streets, squares and buildings, which had been created before any actual construction work was carried out. Thus, the streets and squares formed a central component in the construction of the medieval town indicating when the town was founded and how it grew and developed.

We can start tracing this plan by looking at the location of the major roads, which led in – or out from – the town. When we look at the oldest map of Turku, we can see that the main roads connecting the town to its surroundings met each other at Market Square, which would have formed the starting point for the network of streets. These roads – streets within the town area – were made when the town of Turku was established on the eastern bank of the river Aura (About the earliest phases of the town e.g. SEPPÄNEN 2009: 242–243; 2011). This situation is in a slight contradiction to the older hypothesis, according to which the roads leading to the east and south–east would have met each other originally on the other square, Horse Square, situating south-east of the cathedral. According to this hypothesis, the course of streets would have been altered after the sack caused by the troops from Novgorod when the new square, Market Square, would have been formed (GARDBERG 1971: 267–268). The earliest phases of these squares have not been solved yet, but the earliest construction phase of the Town Hall situating at the eastern end of Market Square has been dated to the early 14th century (UOTILA 2003: 123–126) when the town of Turku was taking shape. Besides, also Church Street (Fin. Kirkkokatu) running between Cathedral and Market Square has been dated to the first years of the 14th century (Fig. 4, F; RATILAINEN 2010: 33). Consequently, it is very likely, that Market Square would have existed already at this phase in the very same place where it still standing today.

I am inclined towards another hypothesis suggesting that originally these roads would have started from Market Square, which would have acted as a nucleus in the town plan and formed a starting point to other main streets of the town as well. The symmetry and radially of the main streets support this idea and they would have led to the most important buildings of the town built probably simultaneously with the streets. The streets from the main square would have led to the cathedral, the Dominican convent, the guildhall of St. Nicholas, and to a large building build probably by the Germans. The function of this building is uncertain,

but it could have been some sort of an assembly hall for German merchants, built according to dendrochronological datings in the early 14th century (VALONEN 1958: 74–89; ZETTERBERG 1990; Fig 4).

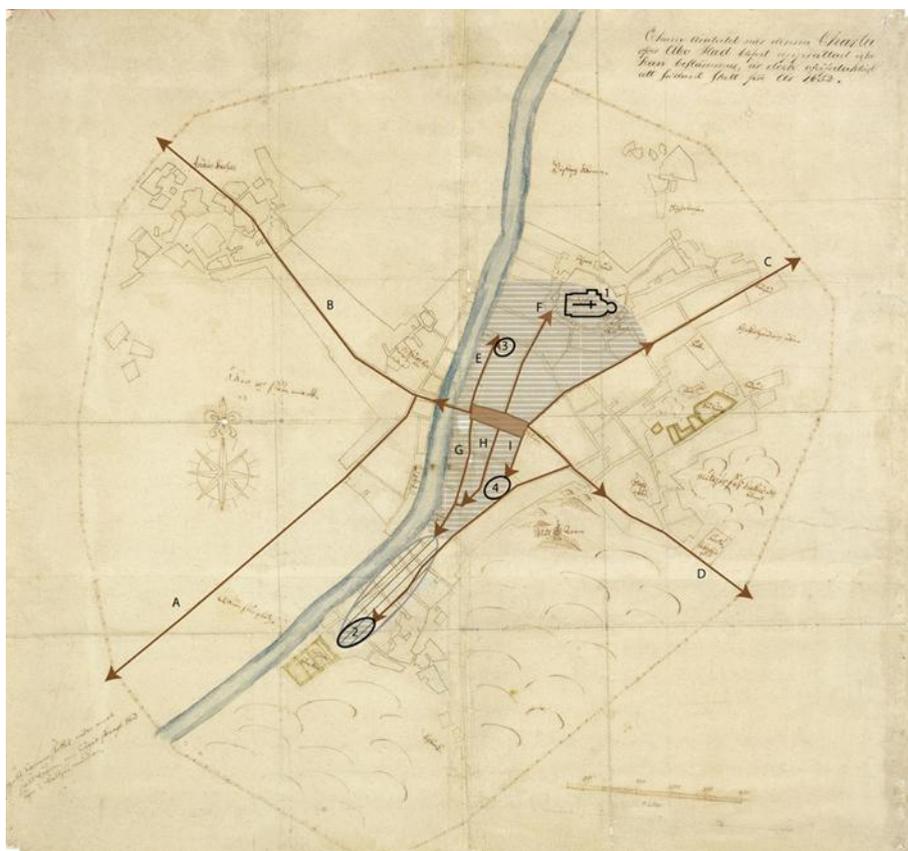


Fig. 5 – The symmetry of the main roads leading out from the town (A–D) supports the idea of a planned town with Market Square as a starting point. The main streets parallel to the river (E–I) led to the important buildings and places of the town: 1) Cathedral, 2) the area of Dominican Convent, 3) a large building from the beginning of the 14th century built probably by the Germans, 4) a possible Guildhall of St. Nicholas. The plausible inhabited area in the beginning of the 14th century is marked with vertical stripes. Diagonal stripes mark the area of uncertain inhabitation at this time (Copyright of the map: The Museum Centre of Turku).

This hypothesis is also supported by the fact that the names of the streets have changed seen from the borders of the square although the parallel course of the street would have enabled the use of the same name. However, there is an earlier suggestion that during the Middle Ages at least the streets next to the river would have been known by the same name only (River Street), and that the two branches of the street line would have been separated by different names not before the early modern period (PIHLMAN and KOSTET 1986: 60–61; RUUTH 1909, 72). The suggestion is leaning to the first preserved mentions of the street names since River Street (Fin. Jokikatu, Fig. 4, E) is known from the sources earlier than Convent Riverfront (Fin. Luostarin jokikatu, Fig. 4, G). It is very unlikely, however, that the name Convent Riverfront, which was leading from Market Square to the convent area of Dominicans would have been taken into use in the dawn of Reformation, and at the time when the convent had already lost its glory and practically torn into pieces and its materials were reused for the construction of castles (SEPPÄNEN 2012). On the basis of preserved documents, we are not able to conclude the construction time and order of naming the streets, since the written sources concerning the medieval Turku are small in numbers and defective in their

representativeness. For example, provided that we look at the preserved written sources only, the Town Hall would have appeared in the townscape in the early 15th century (REA 1996: 449) and Church Street in 1443. Archaeology has, however, proofed that the history of both can be traced to the first years of the 14th century. The manifested discrepancy between the information revealed by written sources and archaeological evidence on the other hand demonstrates only that there has been many eventful decades and construction phases in Turku in the times between.

If – as I am suggesting – the streets of Turku would have been constructed systematically according to a plan and simultaneously during the first years of the town, this means that also the inhabitation and buildings would have followed the same process at the beginning of the 14th century. According to this idea the first settlement of the town would have reached from the cathedral to the Dominican Convent of St. Olav and from the benches of river Aura to the main road (Hämeentie) leading to the north–east to Tavastland (Fin. Häme, Fig. 4). The archaeological evidence unearthed from the town area by now does not contradict with this idea, but it must be noted that the excavated areas within these limits are still quite small. Regarding the southern limit of inhabitation it would be essential to find out the earliest construction phases of the convent with new excavations. During the second main phase of the construction of the town in the late 1360s, the inhabited area extended beyond these limits to the north, east and west, and new side streets were added to the network of streets (SEPPÄNEN 2009).

Appearance and maintenance of streets and squares

Street surfaces

It was not only the amount of streets and geography in the town area, but also the way, how they were constructed and maintained which was related to the building activities of the town. According to the present knowledge, the oldest street of Turku is dated to the first years of the 14th century (RATILAINEN 2010: 33). All the evidence of the streets of this phase comes hitherto from Church Street (Fin. Kirkkokatu) which was running between Cathedral and Market Square (Fig. 4, F). Its location must have made it the most important street in the town area, which is good to remember when comparisons are made with other streets. The oldest surface of this street consisted of a layer of sand as a foundation laid on top of the natural clay and the actual topmost surface was made of chips of wood, waste from the woodworking, when new wooden houses had been built along the streets. This wooden refuse was also used on yards as a resist against dampness until the early 15th century. In the 1340s, the street was paved with gravel, but it was not until the end of the 14th or the beginning of the 15th century when Church Street got a surface made of logs (Fig. 5.; RATILAINEN 2007: 17; SALORANTA 2010: 64; SEPPÄNEN 2012).

Nevertheless, Church Street was not a pacesetter as far as paving was concerned. The first streets with log pavement have been found in those areas of the town that were inhabited at the end of the 1360s (See Fig. 3, d). The streets of these areas have been surfaced with logs already at this phase and soon after the first buildings of this area have been ready. So, these streets did not have any predecessors with a soil surface. On the basis of this, we get an impression that the habit of paving the streets with logs was first introduced into new areas of inhabitation and thereafter the paving activities of this kind would have been targeted at the older streets of the town, too. Interestingly, Church Street was not among the first streets that were paved

with stones either. The pioneers can be found in the same area that was leading the way for log paving too. This development took place after the big fire of 1429. After the fire, some streets were paved completely with stones using bigger stones in the side gutters and in the axis of the streets. From this period there is evidence at least of one street that was divided longitudinally in two so that the other half was paved with logs and the other half with stones. Consequently, the quality of the paving of the street has not always been the same for the whole length or width of the street.



Fig. 6 – Church Street (Fin. Kirkkokatu) which was running between Cathedral and Market Square was paved with logs for the first time in the end of the 14th or at the beginning of the 15th century. The width of the street was at least 3 m. The cut in the middle of the street visible in the lower part of the photo is a younger ditch. The pavement and the level of Cathedral Square of today can be seen on the top part of the picture (Copyright: Päivi Repo).

Stone pavements were not the only innovation introduced with the re-construction of the area, but it included also new kinds of houses like semi-detached houses and masonry houses, which were built along these stony streets. Unfortunately, the written sources reveal nothing about the social structure or professions of the people inhabiting this area in the Middle Ages. From the whole quarter, the sources mention only 15 people including both men of Church and laymen whose status and professions have not been revealed (KOSTET 1989: 16, 24–25). On the basis of the buildings and find material it seems that they have belonged at least to the middle class of the society. Before the fire, activities related to handicrafts, shoe making, dyeing and weaving are traceable in the material, but there is no clear evidence of any certain professional activities after the fire. The first written sources of the people in this area are dated to the 18th century when some of the most exalted craftsmen and burghers are mentioned among the inhabitants (SEPPÄNEN 2012). Anyhow, it seems that in the medieval Turku the streets have not been paved according to the importance of the street, but the new surface – whether it was made of wood or stones – was first presented on those

streets that had to be constructed or re-constructed because of the destruction or expansion of the town. Some of the streets that were paved with stones during the first phase had wooden predecessors but some of them were completely new constructions. The order of paving could have been related to the dampness of the area too, but probably, the most important factor for paving the streets were the people who lived along the street. Neither can we exclude the intensity of the traffic and the importance of the street for transportation when reasons for paving are considered (about the situation in Lübeck e.g. MÜHRENBURG 2001: 18). Studies in medieval towns in Sweden have, however, proved that even the most insignificant streets in this respect and the narrowest streets of the town have been paved at the same time or quite simultaneously with the broadest and most centrally situated streets. Consequently, it hasn't been only the importance of streets that has set the pace for paving activities (ANUND et al. 1992: 224–225; FERENIUS 2002: 67; JØRGENSEN 2008: 553; SÖDERLUND 2004: 483).

Although it seems that all streets in the central area of Turku have been paved at the latest at the beginning of the 16th century, it is quite probable, that not all the streets of the town were paved during the Middle Ages, but some of the streets in the marginal areas of the town remained unpaved until the early modern period. The paving with stones seems to become more general in the 16th and 17th century, but some new streets constructed in this phase, however, were made without wooden surfaces or stone pavements.

In many towns the paving of the streets with stones has been connected to the same period when wooden houses have been replaced with masonry buildings. On the basis of this observation, a conclusion has been made that paving activities would have been introduced at first to those streets lined with the first buildings of stone and brick. In Stockholm, however, the first paving phase has included some streets lined with wooden houses, too. In general, paving the streets can be connected to the time when the use of stone and brick as a building material increased in every respect, including the houses and their interiors and yards and outbuildings too (MOLAUG 2004: 507; SÖDERLUND 2004: 483; WESTHOLM 2004: 502). All in all, there have been many factors behind the paving activities of the streets, and not the least of these has been the fact that during the Middle Ages the maintenance of streets including paving has been controlled by the superiors and city officials (HOLMBÄCK and WESSÉN 1966: 89). Paving activities of the streets proof for the fact that the sanitation and tidiness of the environment has been attended in Turku during the Middle Ages like in many other towns as well.

Square surfaces

In Sweden, at least in Stockholm and in Visby, the pavement of squares has been closely connected to the pavement of streets (SÖDERLUND 2004: 483; YRVING 1986: 320). Therefore, this could presumably have been the state of affairs also in Turku, which was one of the most important towns of Sweden. The excavations conducted in the vicinity of Cathedral in 2005–2006 revealed several surfaces belonging to medieval School Square (Fig. 3, 4). On the basis of these excavations, the oldest square in this area dates to the mid 15th century. Its surface consisted of tightly packed soil, sand, chips and cuts of wood and pieces of leather waste and broken stave dishes, which had been used for drying the dampness of the soil.

At least the other margin of the square was lined at this phase with a passageway paved with stones and lined with longitudinal logs. The width of the passageway was c. 2.5 meters, which was the same as the

width of the narrowest medieval side streets of the town. When the buildings next to the passageway burned in a fire, the square was expanded to this area but the passageway remained where it was so that its location shifted towards the centre of the square (Fig. 6). In the third phase, in the latter part of the 15th century, this passageway was replaced with another pathway, which was only half as wide as its predecessor (1.2 meters). This passageway was also lined with logs, but the surface was made of bricks some of which were profilated and originated possibly from the Cathedral nearby. This passage replaced the old one probably after the fire 1464, which caused severe damage to Cathedral launching reconstruction activities in this area. For the first time, the whole square was paved with stones in the late 15th or early 16th century (SALORANTA 2007: 27, 29–30; SEPPÄNEN 2009) (Fig. 7).



Fig. 7 – In the mid 15th century, School Square had a soil surface with waste of wood and leather used as a resist against the dampness of the area. A passageway with a pavement of stone lined with logs on both sides led to Cathedral and Cathedral School (Copyright: Päivi Repo).

The earliest surfaces of the medieval Market Square of Turku are unfortunately still unknown. The first mentions about the stone pavement of the square date from 1737 (BRUSILA 1988: 142), but it would be very strange if Main Square of the town had been paved more than two hundred years later than School Square nearby Cathedral. Therefore, it would be reasonable to think that Market Square was paved in the late 15th or early 16th century at the latest, since this was the time when also the streets in the central town area leading to Market Square have been paved with stones. More information about the surfaces and construction of squares of Turku can be achieved with new archaeological excavations only.

Acts of maintenance – cleaning and repairs

There is clear evidence for the cleaning of the streets from the early 14th century onwards and the same concerns also the cleaning of the squares since the early days of their history. First of all, there have been no rubbish layers of nearly any kind on top of the surfaces when they have been unearthed in excavations. Furthermore, the stratified material generally represents a short period of time. Even if there would have been a thick rubbish layer with material extending for a longer time, this does not necessarily mean that the

rubbish would have been cumulated while the street was in active use. It would have been quite practical to level and fill the old surface with rubbish when the new layer was build on top of it. Anyhow, in Turku litter has not been systematically used in filling layers, but most often the foundations and filling layers consisted of clean sand or construction refuse (chips, cuts, mortar and bricks). Also the remains of broken broomsticks integrated into the soil surface of School Square proof for cleaning activities of the squares.



Fig. 8 – Probably after the fire in the 1460s, the passageway made of stones was replaced with another one made of bricks. School Square was completely paved with stones at the end of the 15th or in the early 16th century (Copyright: Päivi Repo).

The surfaces of streets and squares were renewed from time to time no matter they were paved or not. Even the soil surfaces were renewed with new layers of sand and gravel, chips and scraps of wood. The logs might have been changed and a new wooden surface has been constructed on the top of the old one. Stone streets have been quite long-lasting, which together with cleaning activities causes some difficulties, when we try to date their earliest phases. Anyhow, we should not restrict the examination of surfaces to preserved constructions only, because the same logs and stones might have been used more than once so that they have been removed before the new filling layer has been levelled and the usable material has been replaced on top of the new layer. For example, the pavement of School Square laid at the end of the 15th or early 16th century had been removed nearly completely before the new pavement was laid in the first half of the 17th century (AINASOJA et al. 2007; see also REISNERT 2004: 466; SÖDERLUND 2004: 483). Consequently, it is important to pay attention not only to surfaces but also to the filling layers underneath with possible differences in composition and stratification even though the differences may be very slight and undetectable.

Paving and cleaning activities of the streets and squares can be seen as expressions of the same idea and attitude that catalyzed the introduction of latrines and privies too. In Turku, these attitudes became more evident from the 14th century onward with general improvement in the environmental and sanitary conditions of the town. From other towns of the medieval Sweden, there is evidence of pavement activities already from the 13th and early 14th century onward (ANDRÉN 1986: 260–265; ANUND 2004: 441; REISNERT 2004: 465; SKOV 2004: 561; SÖDERLUND 2004: 482–483; WESTHOLM 2004: 498, 501).

From the mid 14th century onward, also the Swedish legislation was paying attention to the maintenance and surfaces of the streets. The town laws by King Magnus Eriksson ordered fines for the townspeople, who had not cleaned their streets (or parts of the streets) by certain dates. The fines were also given to those plot owners who had not paved their shares of the streets by the given dates (HOLMBÄCK and WESSÉN 1966: 89). All in all, archaeological evidence shows that the orders were generally followed. Even though the owner of the plot was mainly responsible for taking care of paving and cleaning activities, the work itself – at least the paving – could have been left, however, to professional pavers as has been reported for example in Stockholm and England. The salary of the craftsman has been collected from the plot owners with respect to the length of the plot (JØRGENSEN 2008: 556–557, 561, 564–567). There is no reason to think that this practise would not have been known in the medieval Turku although the earliest written information about “hiring the street makers” comes from the end of the 16th century (NIKULA 1987: 89–90).

Unlike previously thought, the streets did not represent only towns public or semi-public space, but they were closely related with individual plot owners, who were in charge for the construction, cleaning and maintenance of them although this responsibility was controlled, supervised and even promoted by town officials (GLÄSER 2004, *passim*; JØRGENSEN 2008; MÜHRENBURG 2001b: 18). This responsibility was taken obviously very conscientiously, thus the costs caused by these obligations were notified and counted in last wills and testaments too. This means that the streets could have acted as expressions of the plot owner’s authority, status and social value. The more so, whether the streets were privately owned and thus beyond the official supervision. Consequently, the streets acted in a very concrete way as forums for individuality and social relations and social ambition. They cannot thus be ignored when people’s social rank, value and importance are being estimated (ANUND 2004: 445; JØRGENSEN 2008: 547–551, 554–558; MACIAKOWSKA 2011: 258; MOLAUG 2004: 507; SÖDERLUND 2004: 482; WESTHOLM 2004, 498–499).

Summary

The excavations conducted in Turku during the past 15 years have changed the old ideas of the paving and maintenance of the medieval streets. According to the old conceptions, there would not have been such activities in the town before the 1640s (BRUSILA 1988: 142; NIKULA 1970: 44, 102–105; RANTA 1975a: 56–60). Although these activities have become general in the 17th century, it has been found out that also the first, soil surfaced streets of the town of the early 14th century have been cleaned, repaired and maintained. The first streets paved with logs appeared in the townscape of Turku at the end of the 1360s and 1370s, when the population of the town increased substantially and new areas were inhabited. According to the present knowledge, the first stone streets were built after the fire of 1429 when some parts of the town were reconstructed, and an opportunity was afforded to present the new techniques of construction and new

house types as well. These innovations were adopted in the areas that had been forerunners also then when the first wooden surfaces of the streets were constructed. This area, however, has not been considered as a central area of importance of the town, but rather as a marginal area of lower status and significance. According to the recent findings, the area has been inhabited by people belonging to the middle class of the society at the very least. Nevertheless, the reforms and innovations concerning the streets were not introduced first in the central areas generally considered as the most important parts of the town. The quality of the paving of the street has not always been the same for the whole length or width of the street, which is a concrete proof for the divided responsibility of the plot owners regarding the maintenance of the streets. Also the legislative orders in Sweden did pay attention to the condition of the streets from the mid 14th century onward, but seemingly the people had adopted this environmental attitude already before it was dictated by sovereignty. The paving of the streets in all parts of the town seems to become more general in the 16th and 17th century, but some of the streets made at the end of the Middle Ages and in the Early Modern Period might have had only a surface of soil in the first phase of their existence. The oldest square of Turku is probably Market Square existing and known today as Old Great Market Square. The earliest dating and development of the square are still unknown, but it seems to be very likely that the square had a central role when the plans for building the town and its network of streets were made. According to the theory presented in this article, the first streets of the town would have been constructed systematically and radially from Market Square leading to the most important places and main roads of the town. The evidence of the surfaces of the squares derives from the other square, School Square, from the vicinity of Cathedral. The square was paved with stones for the first time in the late 15th or early 16th century, when the paving of the streets had become more general. Earlier, the surface of square consisted of wooden chips and scraps with only a narrow passage offering a better walkway through the square. First this passage was covered with stones and later on with bricks most of which were in secondary use. The surfaces, paving and maintenance activities of the streets and squares of the medieval Turku constitute one evidence proofing for the fact that the medieval town of Turku on the fringes of the Hanseatic sphere was more controlled and environmentally conscious – both internally rising from the people and externally controlled by sovereignty – than previously considered. In this respect too, Turku seems to redeem its position as one of the most significant towns of the medieval Sweden.

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SESSIONS

Streets, Roads and Squares – Continuity versus Discontinuity

Retrogression, transformation and restart

Various aspects of streets and squares in Vienna's first district from the Roman period to modern times

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Abstract: Very similar to a town itself streets and squares can offer examples of discontinuity as well as for very different ways of continuity. Stating discontinuity might cut the discussion short, stating any way of continuity is just the starting point for proceeding on a very complex and multi-levelled/multilayer body of work.

In the case of explicit discontinuity the main task lies in describing the end of one continuous development and describing the beginning of a new and different process. Searching after the terminus and arguing about the reason/s for a hiatus in use and probably expansion or replacing is of the essence.

Continuity contains far more questions und needs more in depth explanation.

Continuous and unchanged use of an area might be one manifestation. Another option might be open space nearly undiminished in its expanse, but passing through different forms of utilization.

Vienna's 1st district offers various examples, ranging from perfect continuity in the strictest sense of the meaning as exemplified in the Herrengasse, to complete discontinuity on all scales displayed at the Michaelerplatz. In the first case a street simply remains a street while Roman remnants in the surrounding area are purposeful elected to be transformed into the foundation of a medieval town. Secondly – the Michaelerplatz – a square emerged as the result of various different processes, embodying the very essence of discontinuity.

Keywords: Structural changes, continuity/discontinuity, Roman period to Middle Ages.

Introduction

Vienna's densely build urban surface embodies various and sometimes even diverging examples of very different types of continuity and discontinuity. To give at least a few carefully chosen areas a closer and more differentiated look, it might be beneficial to commence with a few methodical considerations.

The Latin word *continuatio* mean "uninterrupted chain" as well as "sequel". This does not communicate quite the same content, but sufficiently defines the range of variations in understanding and interpreting the term adapted to archaeological questions.

Proving continuity or discontinuity of settlement is a comparatively simple task to accomplish. Archaeological evidence can be excavated, a hiatus can be established through archaeological research and appears, for example, in the shape of dark earth bare of artefacts. In this case the lack of archaeological items figures as the indispensable marker of an interruption of settlement activities (Fig. 1).



Fig. 1 – An example for “dark earth” from the “Judenplatz”, 1st district. Photo: Stadtarchäologie Wien.

Continuity or discontinuity of streets and squares is much harder to cope with and “de facto” nearly improvable. Only regular use of streets leaves traceable marks. Ongoing but irregular or low-frequent use remains practically invisible without taking samples for further analysis, especially when the street itself is degraded from a well preserved body of material provided, constructed and laboriously preserved for its very function, to a function bare of securely discernable maintenance work.

Squares defined as open places/spaces of considerably different and varying use, embedded in a pattern of changing structures are even harder to grasp.

This makes the one dimensional use of the terms continuity and discontinuity due to failure.

It might help to think in multiple layered terms such as: continuity of use, function and outlines.

The Tuchlauben – From Roman to medieval street

The modern Tuchlauben stretches from a square called “Hoher Markt” through the innermost core of Vienna, meeting the “Graben” just where the “Kohlmarkt” is about to begin (Fig. 2). Various segments of this street are referred to in written sources from the year 1278 onwards. Although bearing different names all these terms are closely connected to the cloth makers handcraft (PERGER 1991: 145–146).

The Tuchlauben clearly is not Roman so the pressing question is, if the clearly medieval outlines of the street we look at nowadays have or have not changed during the Middle Ages.

The research of the last decade gives clues, that besides the leap from Roman rectangularity to medieval point to point connection (Fig. 3), the street underwent another change as well, although slight and therefore difficult to prove.



Fig. 2 – The outlines of the Tuchlauben. Plan: Stadtarchäologie Wien.

While the street marking outlines of the buildings in the 13th to 14th century can be clearly discerned by observing the narrow sides of the houses Tuchlauben 17 und 19, we are generally ill-informed about the 11th and 12th centuries. The few archaeological features excavated at T17 (Fig. 4) dating before 1200 suggest that the street was probably more removed from its present location and therefore more closely attached to the former Roman structure. A Roman wall, for example, was reused in the 12th century by refurbishing the abandoned Roman structure with a mortar floor. There is no hint, that building structures reached the kerbside of the modern street as they did half a century later. In the 13th century the above-mentioned Roman wall was demolished and the mortar floor was neglected for the benefit of a restructuring process

comprising the whole parcel. At this time we have proof of stone buildings flanking at least this side of the street, freezing its course to that which still exists (GAISBAUER 2001: 220–222).

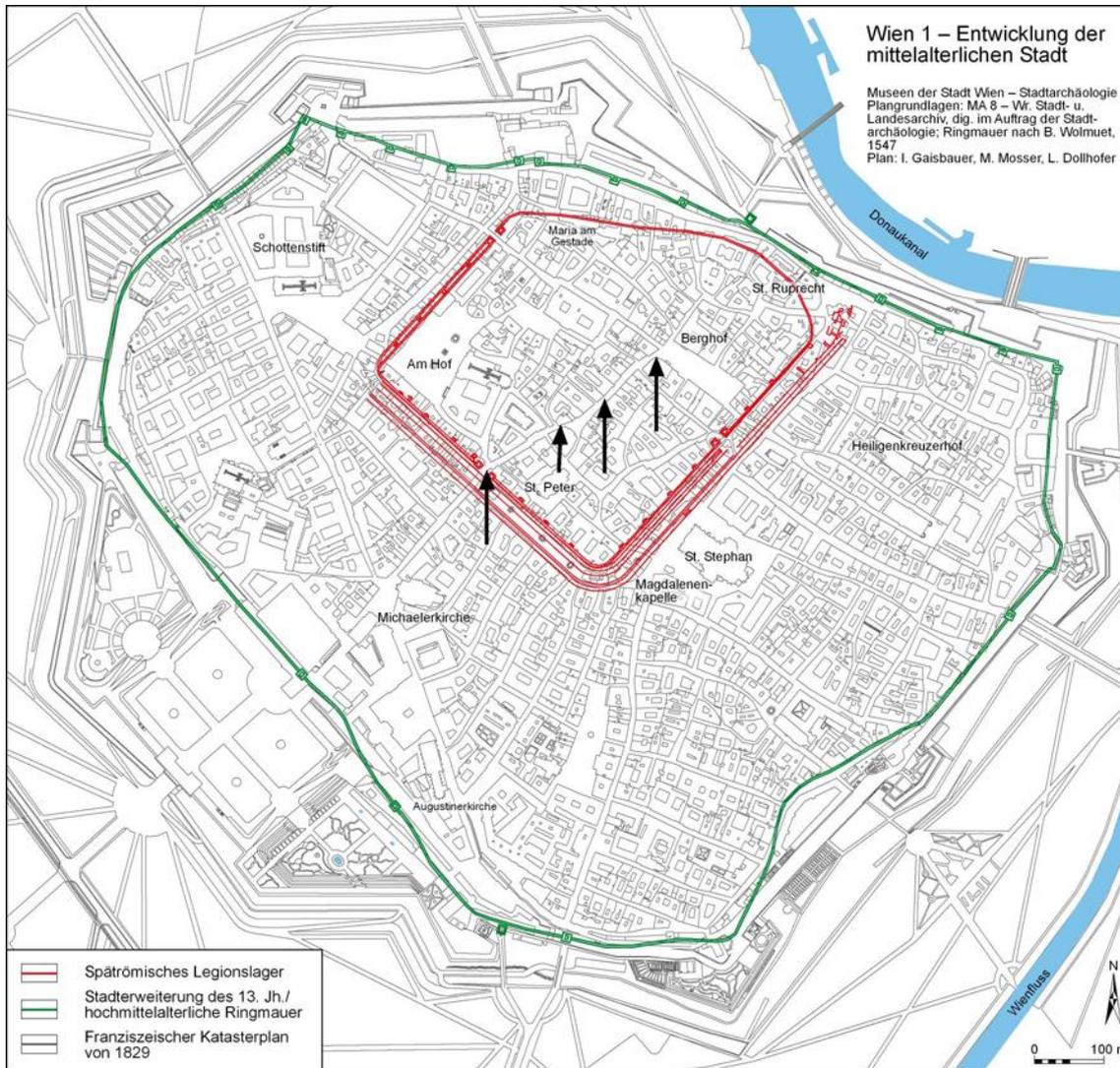


Fig. 3 – The Tuchlauben compared to the Roman street system. Plan: Stadtarchäologie Wien.

What still has to be researched is the question of whether this slightly differing orientation goes hand in hand with an overall change of settlement structures in Vienna – further research will indicate if we are observing a development that occurred in larger parts of the town at the turn of the 12th to the 13th century, resulting at least for one reason from a different handling and reuse of Roman remnants in the growing medieval town (GAISBAUER 2010: 149–153).

As long as we are focusing primarily on the usability of a street ignoring the totally different organizational background, we are observing some kind of continuity. Nonetheless it is doubtful whether this phenomenon resembles anything more than a mere reflex, a street or better to say a moving device, sticking out at random, for unfathomable reasons to a partly (this does affect the segment between the so called “Hoher Markt” and the area of Tuchlauben 8) similar route from Roman to modern times.

On the other hand a change in the precise outlines can be observed and, more importantly and inextricably from this mutation of outlines, the whole underlying scheme. A formerly military complex becomes a civilian settlement. The straight-lined Roman street becomes a primarily functional route through a settlement area. Its main purpose now lies as a convenient connection between a very important market place to one of the settlement's main gates.

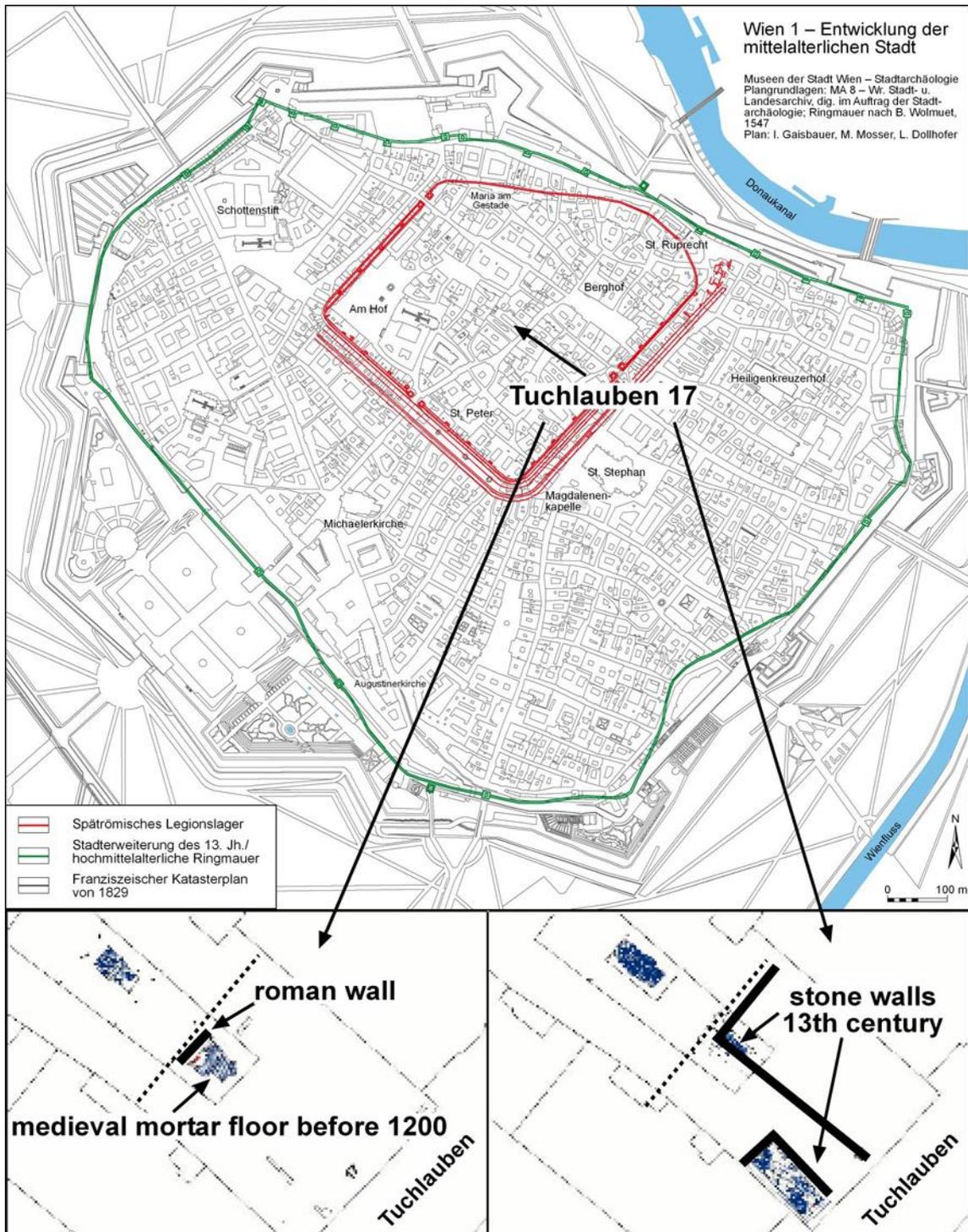


Fig. 4 – Roman remnant incorporated into a medieval building and the changes in settlement structures from the 12th to the 13th century. Plan: Stadtarchäologie Wien.

Spatial continuity with a late distinctive change of function

The “Graben”: from being part of two different fortifications to a late medieval/early modern street/square crossover

During the Roman period, the fortress was defended by extensive fortifications, consisting of a wall and a number of ditches differing in form from flank to flank as well as changing with time. In the late Roman period, the fortress relied on a deep and especially broad trench to the south-east and south and a system of three differing trenches to the south, being naturally protected by the Ottakringerstream and an arm of the Danube to the west and north (MOSSER 2004: 212–223). More recent research has only carried out on the southern side and here the work focused on the middle ditch (Fig. 5). Archaeological observations were as well forced into action as they were limited by the construction of the subway track und station area (GAISBAUER 2004: 230).



Fig. 5 – Location of the excavated part of the first medieval moat. Plan: Stadtarchäologie Wien.

The unearthed features represented nothing less than an apparently high medieval moat situated more within than above the Roman trench, close enough to the Roman creation to think of a term such as reusing and re-unearthing of this predecessor. This hypothesis is supported by a few written sources reporting the long lifespan of the Roman wall in medieval and even early modern Vienna – the most precious archaeological proof towards the reuse of Vindobonas fortification in Vienna. Decayed Roman strategies of border security, contorted by changed political and social structures, remained important probably because of the urgent need for safety (GAISBAUER 2004: 230–233).

This period of extensive fortification work based on Roman remnants must have taken place sometime between the very beginning of medieval settlement in the 10th century and the end of the 12th century. The moment of the next step in township development is treated as a certainty. Between the late 12th and the beginning of the 13th century a new, and in this case complete, medieval fortification incorporating large parts of nowadays first district was planned and implemented in stages (GAISBAUER 2004: 225–227) (Fig. 6).

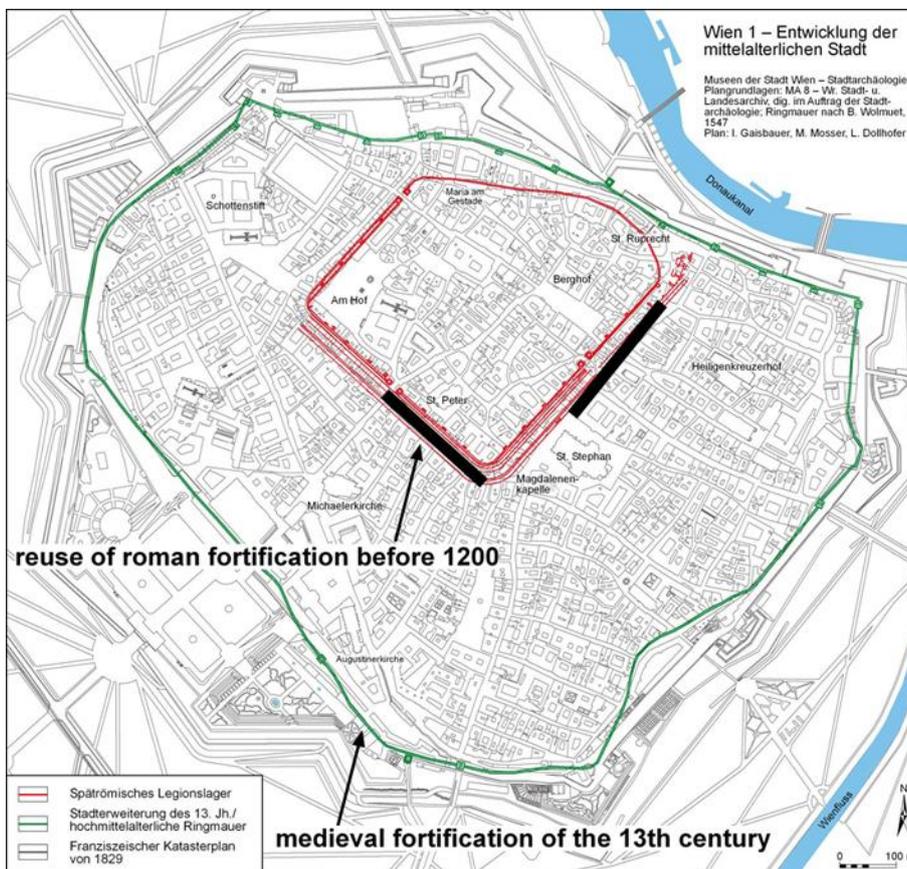


Fig. 6 – The marked areas display reuse of Roman structures. They also show the section of the Roman trench/medieval moat where the functional change from being part of the fortification to becoming a wastewater ditch can be observed. Plan: Stadtarchäologie Wien.

The old wall and moat, still displaying the Roman outlines, declined in significance and use. The wall seems to have become a stone pit, supporting the growing number of stone buildings. At least parts of the moat where used as a wastewater trench (GAISBAUER 2004: 228–229).

We do not know exactly, when the moat was filled in, changing its destination and function one more time. It was transformed from a wastewater trench into a distinctive if not prominent free space to an elongated square or shortened street, depending on the point of view (GAISBAUER 2004: 228–229) (Fig. 7).

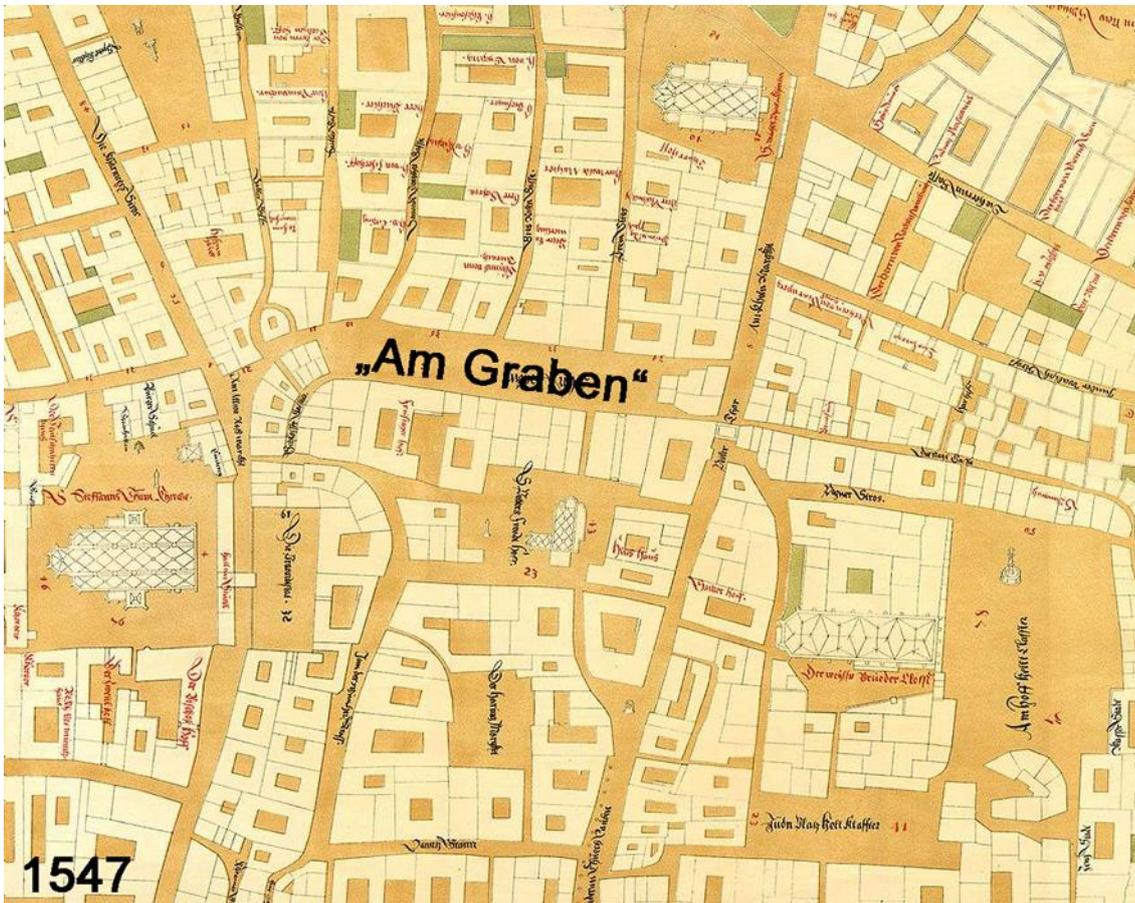


Fig. 7 – The end of the high medieval wastewater ditch was the birth hour of the place called “Am Graben”. Wien Museum Inv.-Nr. 31.021.

There are at least two elements of continuity in this process.

The first is less important but which should not to be forgotten is the continuity of free space. Duration of open space bare of any buildings can be seen as a somehow continuous state with its own quality especially if it lasts from Roman to modern times.

Much more important is the process of functional continuity we are confronted with in the light of partial reuse of Roman fortification elements in the very first effort to fortify medieval Vienna.

On the other hand the “Graben” is also an example for different ways of discontinuity.

It has to be emphasised that even maintaining parts of the Roman fortifications and reshaping this construction into the first town wall seems to be a perfect act of harking back on Roman perfection, but we are in fact looking at totally changed structures. Thus even the functional reuse of Roman remnants demonstrates social, political and economic discontinuity.

The change in medieval times is easier to categorize as multilayered discontinuity when the former moat becomes a wastewater trench and then, in a final transformation, a well used open square.

While archaeological research on the Tuchlauben as well as on the Graben was limited to very small portions of the whole structure, the Michaelerplatz was extensively explored and the results were published in full extent a few years ago. The outcome of these results will be summarized due to their significance to the main topic as the findings portray development through all periods due to superior research possibilities based on the large scale excavation.

The Michaelerplatz

The Michaelerplatz is situated in the centre of Vienna's first district, directly opposite to the town-side entrance of the Hofburg. The surrounding area has always been a "hot spot" being situated as it is in the centre of urban life. From 1990 to 1991 excavations took place at the Michaelerplatz prior a complete reshaping of the square. Included in the find results are the prominent remnants of several buildings dating from the Roman Period to the 19th century (DONAT et al. 2003 and 2005; GAISBAUER et al. 2007; KRAUSE et al. 2008) (Fig. 8).



Fig. 8 – Aerial image of today's Michaelerplatz, BEV 2011. Vervielfältigt mit Genehmigung des Bundesamtes für Eich- und Vermessungswesen in Wien T2011/72344.

The situation during Roman Times

Already in Roman times the area offered some specifics. To mention first, it was part of the *canabae legionis* situated only 250 meters from the *porta decumana*, the southern entrance of the legionary fortress of *Vindobona*. Secondly, there was a crossroad between two important long distance roads, the limes road (SAKL-OBERTHALER 1999), which connected the Roman castles situated along the southern bank of the

Danube and the route which exited the legionary fortress continuing the *via decumana-via praetoria* as a connection to the west (Fig. 9).

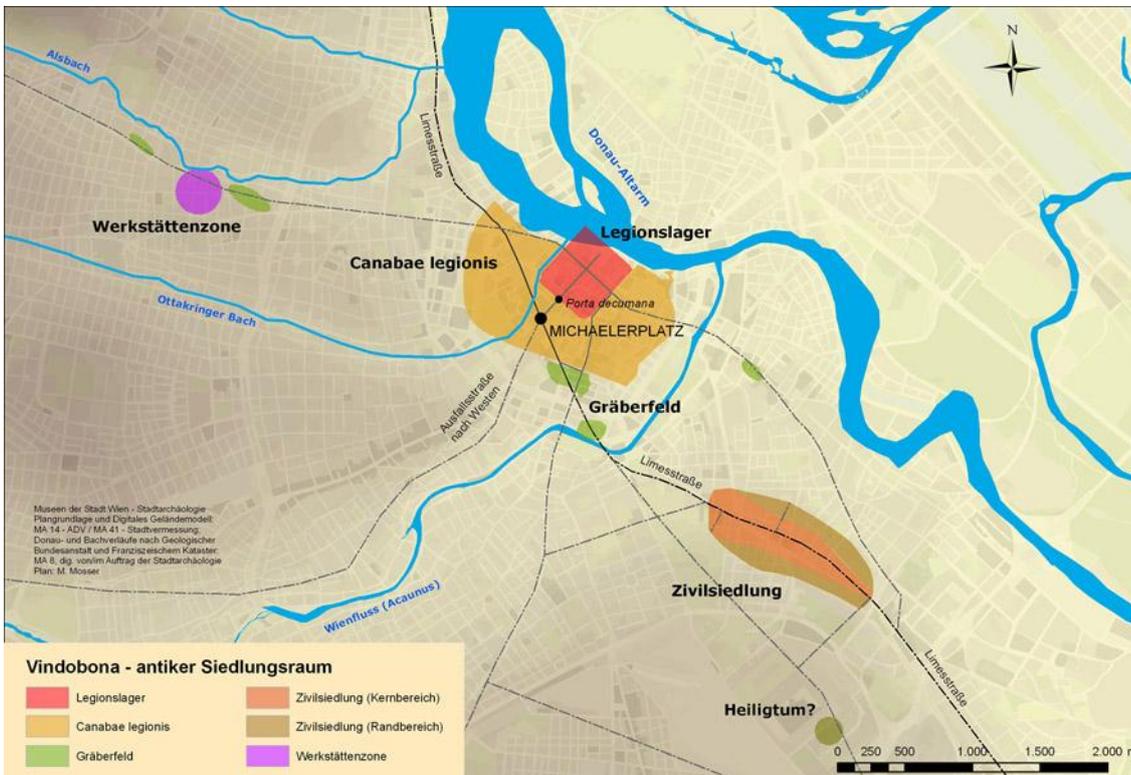


Fig. 9 – Topographical position of the Michaelerplatz within the Roman settlement of Vindobona. Plan: Stadtarchäologie Wien.

In 1990/1991 the basements of at least three Roman houses were excavated. One of these examples had evidently served as a blacksmith's workshop. This workshop was in use from the late first century up to the end of the fourth century A.D. This fact may be a hint to the importance of the place even during antiquity. The area was thus situated directly at the main axis of the *canabae legionis* in relation to all elements of the Roman settlement. Another interesting fact is, that, although the larger part of the *canabae legionis* was abandoned during the second half of the third century, being replaced by burial grounds (KRONBERGER 2005), this probably did not happen to some parts this domain. Whereas the houses seem to have vanished during late antiquity, the blacksmiths workshop continued in use (DONAT et al. 2003: 28–31) (Fig. 10).

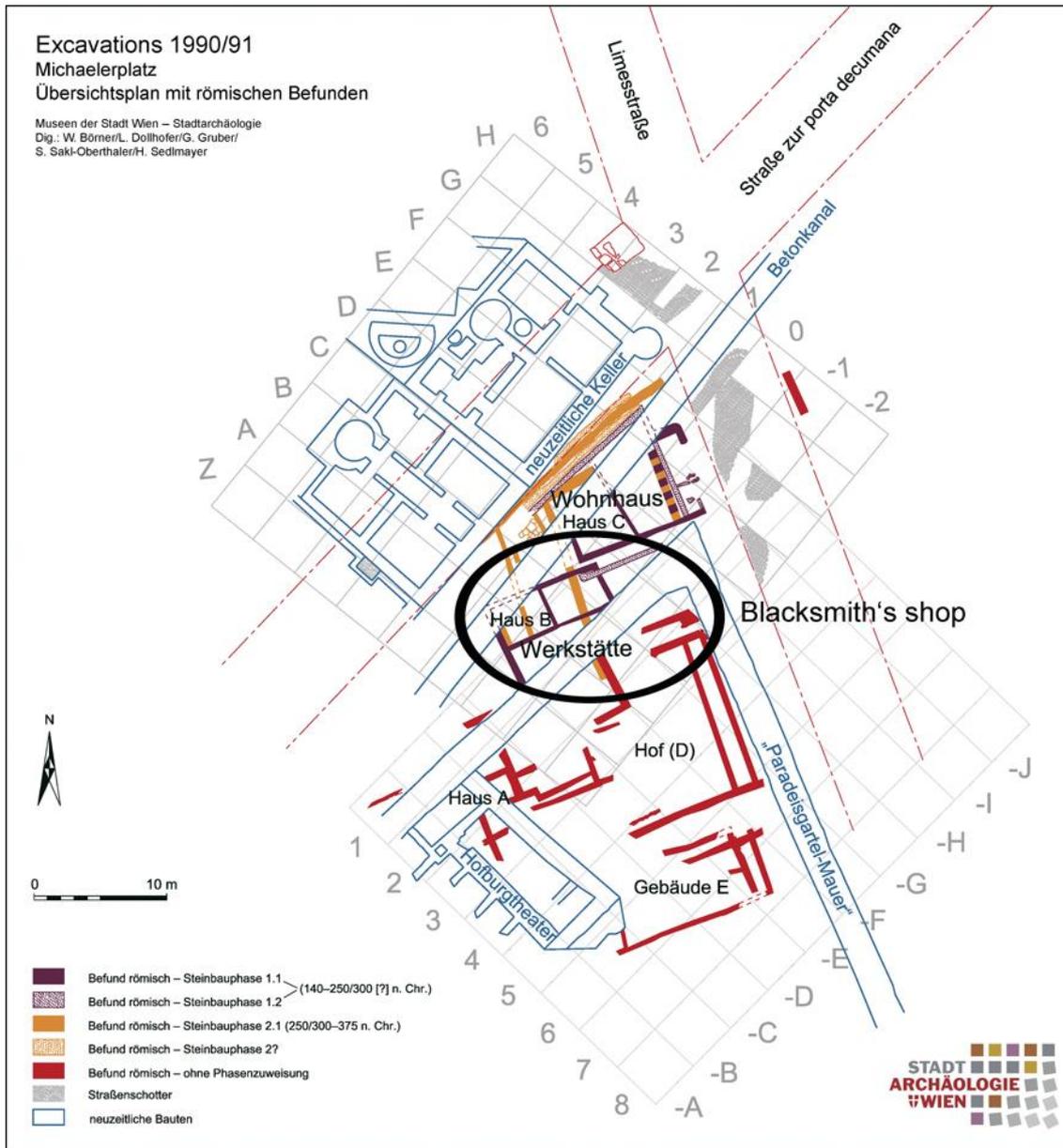


Fig. 10 – Construction phases of the Roman remnants excavated at the Michaelerplatz. Plan: Stadtarchäologie Wien.

Development during the Middle Ages (AUTORENTEAM MICHAELERPLATZ 2007) (Fig. 11)

As an archaeological documentary of the hiatus between antiquity and the Middle Ages (in case of the Michaelerplatz we are talking about a gap between the 5th and 11th century) there exist only two spots, where traces of post Roman soil development (dark earth) could be identified (GAISBAUER et al. 2007: 45–49). These features are amended by a few potsherds dating into the late 11th century (KALTENBERGER 2007: 72–78). Furthermore a few features were unearthed, documenting some activities in the Later Middle Ages: there are two pits (GAISBAUER et al. 2007: 49–53) filled with potsherds of the late 15th century (KALTENBERGER 2007: 82–94). Beyond that parts of the cellars below the buildings that stood in the northern part of the area are of medieval origin (GAISBAUER et al. 2007: 53–60).

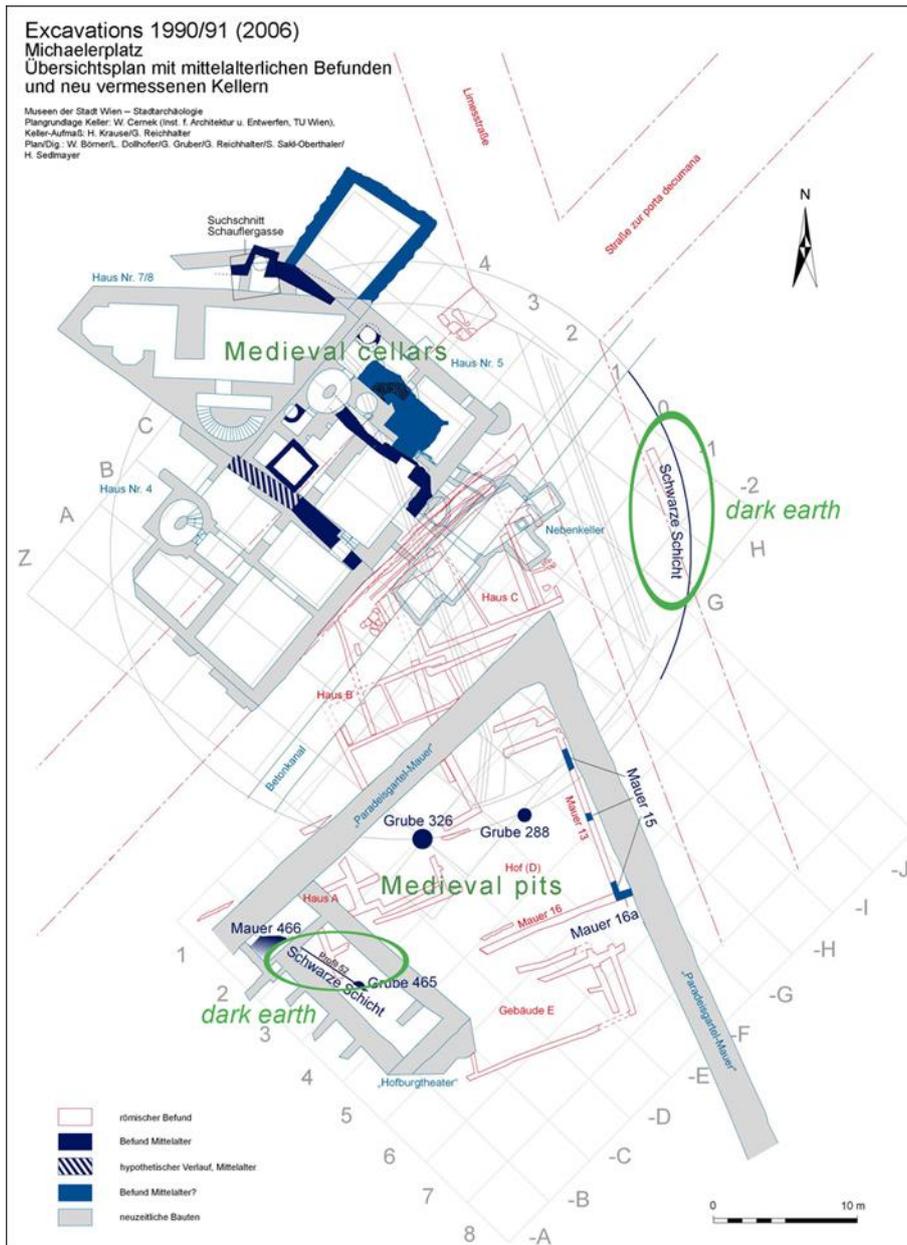


Fig. 11 – Medieval remnants excavated at the Michaelerplatz. Plan: Stadtarchäologie Wien.

In the early 13th century, during the expansion of the town carried out by the Dukes of Babenberg, a new surrounding wall was constructed. It seems to have replaced the rotten walls of the Roman legionary fortress which had, until then, served as the first medieval fortification (GAISBAUER 2004; OPLL 2010) (Fig. 12). In this period the area was definitely integrated into town (KRAUSE 2007). Abstracting the written sources dealing with the domain, two important topics are mentioned: in 1216 a street named *alta plataea* (Hochstraße/High street) is mentioned. Furthermore, written sources of the years 1255 and 1304 point out a *forum lignorum* which means a market where charcoal and wood were sold. This leads to the conclusion, that the present name Kohlmarkt dates back to this medieval “charcoal market” which can be translated into “Kohlenmarkt”.

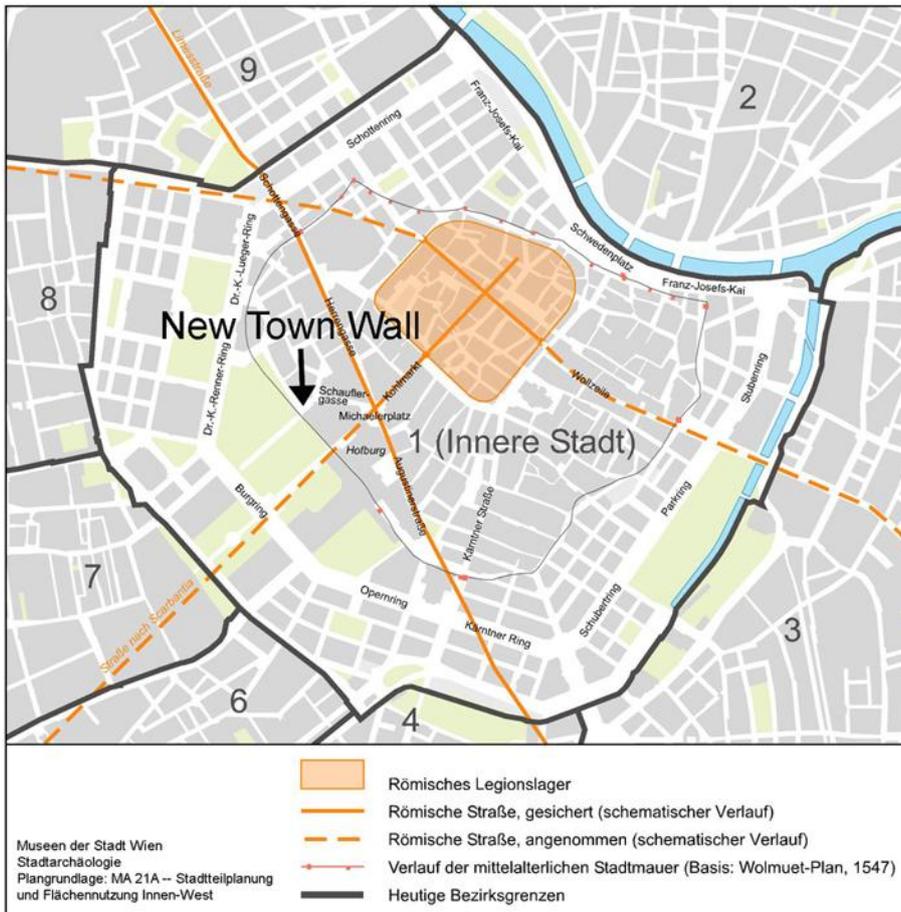


Fig. 12 – Topographical situation of the Michaelerplatz in reference to the Roman Legionary Fortress and to the medieval as well as to the present shape of the town. Plan: Stadarchäologie Wien.

The parish church of St. Michael also was built there in the first half of the 13th century as a consequence of the expansion of the town. Its graveyard is alluded to for the first time in 1310. There were also private houses standing in the surroundings of the church (KRAUSE 2007) (Fig. 13). However, the most important element was the Hofburg, as it was the residence of the sovereign. It was erected there as a medieval fort (Fig. 13) during the first half of the 13th century according to the latest results of construction research and it remained a fortress up to the 16th century (MITCHELL 2010). Its existence once more points out the outstanding topographical position of the area in medieval times. Again, the location was situated near two important centrelines of the urban road system: the former Limes road, in the Middle Ages called *alta plataea* (Hochstraße/High street), nowadays called Herrengasse/Augustinerstraße/Reitschulgasse and the former *via decumana*, medieval *forum lignorum*, now Kohlmarkt.

To summarize the topographical situation during medieval times one must realize that, concerning the *alta plataea* (Hochstraße/High street) there is continuity of form and function. In the case of the Kohlmarkt/*forum lignorum* (former continuation of the *via decumana*) the situation is a little bit more complicated: evidently there is perfect continuation of form, since the course and even the amplitude of the street have been preserved even to the present time. However there has to be noticed a change concerning function from a simple road into a street market. It has to be added, that there is nothing known about the condition of these roads during the early Middle Ages. It is most likely that topographical reasoning provides the impetus for the

“restart” in the 13th century. The Hofburg e. g. was constructed there in order to protect the town-side flank of the city (MITCHELL 2010: 35).

Development in post medieval times (KRAUSE 2007)

From the beginning of the post medieval times the dominating architectural element was the “Paradeisgarten” constructed (after 1480) in a raised position as a part of the imperial gardens (Fig. 13). Moreover it replaced some of the former private buildings. From this time onwards the expansion of the Hofburg as the imperial residence formed the shape of the domain.

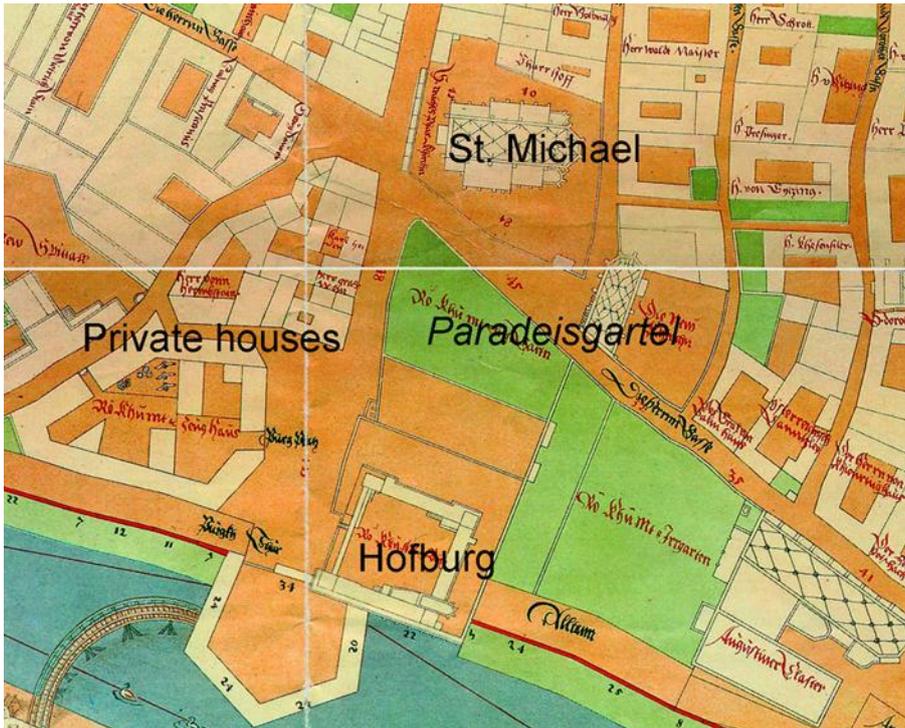


Fig. 13 – Detail of the plan of Bonifacius Wolmuet 1547, copy of A. Camesina. Wien Museum Inv.-Nr. 31.021.

Later absolutism became a stimulus for new representative buildings (BÖSEL and BENEDIK 1991). Under the reign of Emperor Karl VI (1711–1740) the Imperial Chancellery (1723–1730) and the Winterreitschule (1729–1734) which replaced the “Paradeisgarten” were constructed (Fig. 14). Charles VI also planned, and started to construct, a new noble entrance to the Hofburg following the baroque sense of representation. His daughter Maria Theresia (1740–1780) stopped the project in favour of building the Hofburgtheater instead (KRAUSE 2007: 26-27; KRAUSE et al. 2008: 94–104).

At that time a row of private houses was still standing directly vis-à-vis the entrance of the Hofburg (Fig. 15). Incidentally, the name “Michaeler-Pläzl” is mentioned for the first time in 1766.

Finally Emperor Franz Joseph I (1848–1916), more than 150 years later, gave the Michaelerplatz today’s shape, when he decided to build the Michaelertrakt (Fig. 16 and Fig. 8). After demolishing the Hofburgtheater and the “Stöckelhäuser” its shape was finalized in 1893, and with this last step the area transformed into a presentable urban square. So, in conclusion, one may say that the development of the Michaelerplatz from a crossroad into a square again is an example for discontinuity of shape. Moreover it is

an illustration of the manifold facts which are able to impact on areas of high importance in urban spaces (KRAUSE 2007: 36).

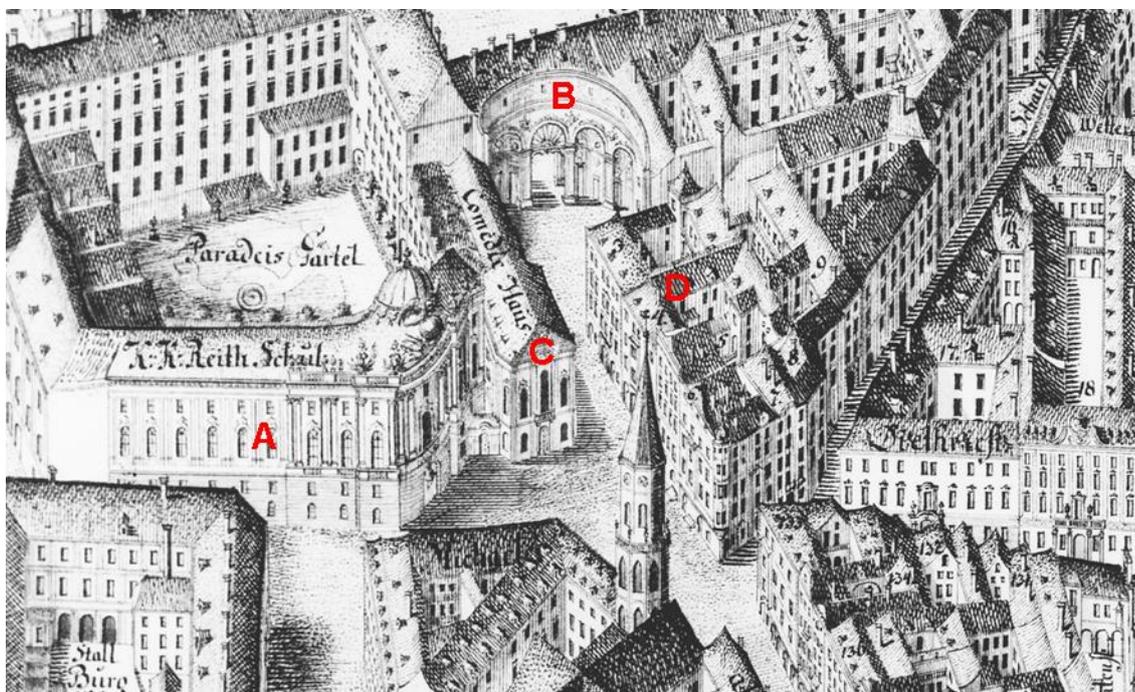


Fig. 14 – Detail of the “bird’s eye view” map of Joseph Daniel Huber (1769–1776). Wien Museum Inv.-Nr. HMW 196.846. A = Winterreitschule, B = Hofburgtheater, C = rotunda, part of the new entrance, planned by Charles VI, D = Stöckelhäuser.



Fig. 15 – View onto the Stöckelhäuser about 1989. Photo Wiha, Wien Museum Inv.-Nr. 40990/2.



Fig. 16 – View onto the Michaelertertor, in front of it the so called *Archäologiefeld*, where parts of the excavations of 1990/91 have been preserved. Photo: Gertrud Gruber.

Conclusion

Finally there is one definite conclusion to be drawn. Discussing questions of continuity and discontinuity must never become a process of trading one dangerously simplified concept against the other. As demonstrated none of the examples referred to embodied exclusively one or the other extreme. In all cases different ways of continuity and even discontinuity with varying background scenarios coexisted. The only way to deal with this mixture of aspects is to separate them from the beginning. Defining and analysing each of them with accuracy is of the essence before daring any kind of all embracing explanation.

As for Vienna's first district, a certain pattern of changing motivation for shaping settlement/building structures seems to emerge. In Roman times a stringent military concept supports building measures of the most practical, logical and thoroughly projected kind, especially inside the fortress. Things are quite different in high medieval times, except for one fact. The urge for creating functional structures remains, even without, or better to say because of the lack of the immense support and dense conjunction of Roman times. The Tuchlauben, becoming the shortest route from marketplace to one of the settlements main gates demonstrates this effort to fulfil basic needs. Lastly the Michaelerplatz shows a third aspect besides Roman planned functionality and high medieval necessarily functional thinking. At some stage of urban development the aspect of representation gained importance. In the 17th and 18th century the Michaelerplatz was designed as an open space mostly because of the wish to present the façade of the Hofburg, which was hidden behind houses. The shaping of a square in this case does not grow from the planning of a military

background or the civilian need for a marketplace. It has finally become a tool to visualise and represent power.

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From *Tergeste* to Trieste

Lines of urban development

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Abstract: The archaeological surveys taken over the last two decades in the heart of Trieste, especially in the neighborhood of "Cittavecchia" from Piazza Cavana along the ridge of via dei Capitelli, permit to reconstruct the various stages of development of the Roman city from the first century B.C. until late antiquity.

By creating an archaeological map implemented in a GIS, it was possible to understand the development guidelines that dictated the organization of the urban fabric of the ancient city, which occurred more markedly especially during the first century A.D.: in early stages of this expansion, the northern slopes of the hill of San Giusto, the higher area which hosted the first plant of the city, have been affected by a specific urban planning that had two clear guidelines; this system was in some way to affect subsequent stages of urbanization, so as to be visible in the city today.

Similarly, the approaches to the city and the roads inside the city respected this project and, even today, is possible to pick up their tracks in many modern roads.

Between the III and the IVth century A.D., the city suffered a substantial contraction, the construction of a new surrounding wall led to a new urban structure that partially influenced the city's development in later periods and of which, once again, is possible to find several traces in the articulation of the modern city.

The huge development of the city from 1700 onwards, with the construction of new neighborhoods outside the historical center of Cittavecchia and San Giusto hill, has allowed the preservation of the ancient village and in some cases has respected the ancient access to the city which remained in use even in the medieval period.

Keywords: GIS, ancient topography, Trieste, archaeology, ancient roads.

Introduction

Last year the project "Ancient Trieste: applications and information systems for the archaeological map" was ended as part of a PhD in Geomatics and Geographic Information System held at the University of Trieste and ended in 2011.

The project involved the systematic collection of topographic data useful for the reconstruction of the different stages of development of the Roman city from Ist BD till the VIth AD and the first centuries of the Middle Ages; through survey activities in the field during archaeological investigations that have concerned the city center, particularly the neighborhood of Cittavecchia and through the collection of archival data, an archaeological map on digital support has been done, geo-referenced to various cartographic systems using the structural and urban profiles of the modern city.

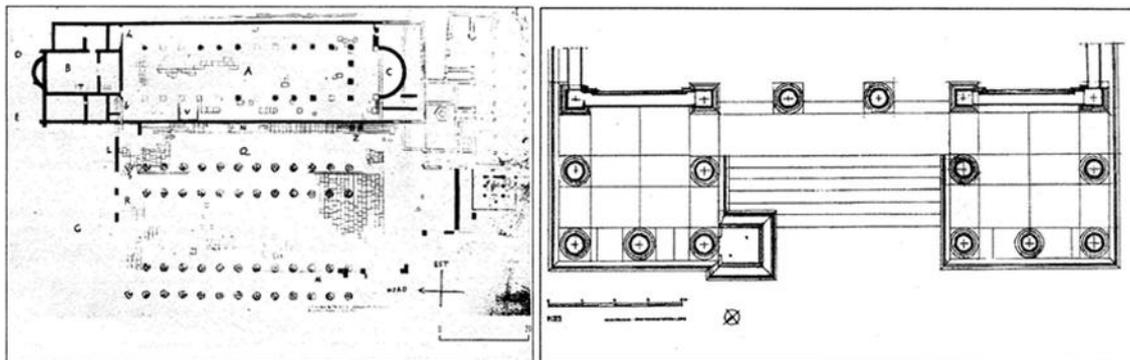


Fig. 1 – Final map of the *forum* and the *basilica* (STICOTTI 1934) and the *Propylaea* (PAVAN 2006).

A database has been connected to the cartography with all the data regarding historic, archaeological and topographic information collected from 18th century to our days, constituting in this way a large computer archival merged into a GIS, which system of analysis and research permitted to review the several phases that marked the urban development of the ancient city.

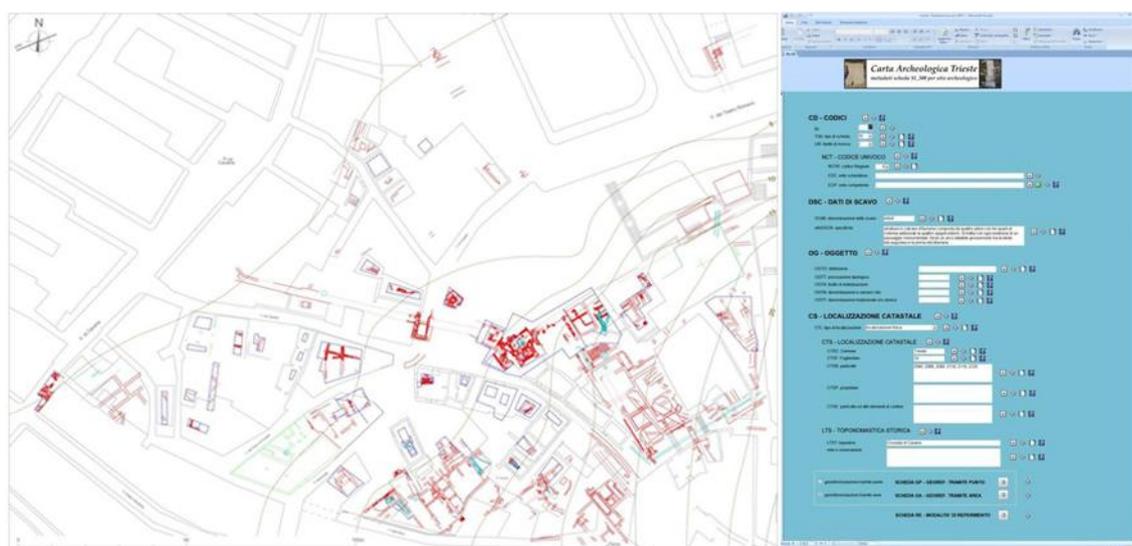


Fig. 2 – The archaeological map and the database.

From this project several researches and analysis have been elaborated: between them, the one dedicated to the reconstruction of the ancient road network and the urban developments in the roman period constitutes a significant part of the studies regarding history, archaeology and topography of Trieste.

Brief studies of urban development of the city

For a better understanding of its urban events, it's important to remember that Trieste, the roman *Tergeste*, is a high ground built-up area that overlooks the gulf at the north east end of the Adriatic sea; this geomorfological situation determined the adoption of a flexible model of urban planning, as is clearly visible in the archaeological map. The examination of this map shows that there isn't a single urban planning but many coexist, although it's possible to suppose a sequence of them.



Fig. 3 – Location of Trieste in Italy.

The first attempt to a general reconstruction of *Tergeste* was made by Pietro Kandler in 1856 (ZORZON 1989). Others works about the topography of Trieste are those of V. Scrinari in 1951 (SCRINARI 1951; SCRINARI et al. 1990), F. Maselli Scotti in 2001 (MASSELLI SCOTTI 2001), M. Verzar Bass in 1999 (VERZAR BASS 1999), P. Ventura in 1996 (VENTURA 1996) and G. Meng (MENG 1999). A recent publication is the ones from C. Morselli, reconstructing the entire sequence of the development of a sector of the city from I B.C. until the 20th century (MORSELLI 2007).



Fig. 4 – Urban development of the city.

Following the development of the urban center in the roman times it's possible to recognize three different moments covering the period between the Ist century BC to the VIth century AD: in a first stage, attributable to the first system of the urban fabric, the city developed on the top of the hill of San Giusto, probably

continuing a pre-roman settlement mentioned in ancient sources but for which no traces has yet been found. In a second phase in the early decades of the 1st AD, it expanded outside the original late republic city walls along the slopes of the same hill to the west and south west mainly, towards the sea.

In the third phase during the late antiquity, from the IVth AD, it's possible to see a narrowing of the urban area, whose areal extent affected again the top of the hill of San Giusto that, from this moment on, will be the core of the city until 1700. In this period, with the creation of new districts (Teresiano, Franceschino and Giuseppino) due to the economic growth of the city inside the Austro-Hungarian Empire, with the final destruction of the medieval city walls, the area of Cittavecchia, become simply one of the district of the new city, underwent a gradual deflection and degradation lasted to the 1900.



Fig. 5 – The four districts: Cittavecchia (yellow), Teresiano (blue), Franceschino (red) and Giuseppino (green).

Ancient roads

Through the analysis of survey data it's obvious that the first urban plan received a specific urban planning whose generative road axis were set to the cardinal points: this structure is still evident in the road system and in the buildings distribution that occupy the upper part of the slopes of the hill of San Giusto.

The current roads of via della Cattedrale, via del Castello and via dell'Ospitale, all oriented in the east west direction, with the perpendicular via delle Monache, are the re-proposition of the original roads that intersected the urban plan in the I BC, immediately west to the monument which occupied the top of the hill of San Giusto, consisting of the civil basilica, the area of the forum and the *Propylaea*.

This building was presumably the monumental entrance to a temple, whose traces have been completely erased from the construction of the castle that has definitely influenced the upper part of the hill, and whose construction dates back to the early XIVth century.

Today, the remains of the *Propylaea* are included inside the Basilica of San Giusto, a XIVth century building, result of previous articulated structural phases; as today via della Cattedrale is axial to the Basilica, in the same way in the Roman period the road of which via della Cattedrale proposes the modern re-proposition led to the front of the *Propylaea* themselves.



Fig. 6 – Guidelines set to the cardinal points.

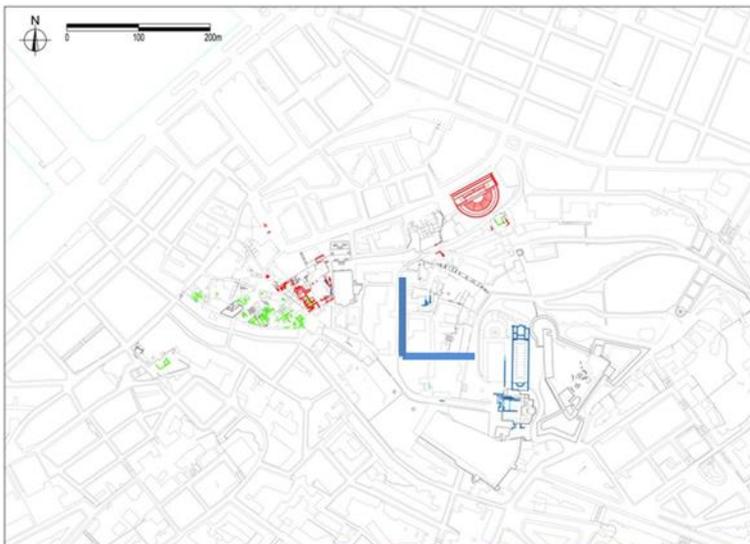


Fig. 7 – Road system and buildings distribution on the hill of San Giusto.



Fig. 8 – The remains of the *Propylaea*.

The astronomical orientation of this sector of the city is also confirmed by the structures highlighted during the several archaeological investigations carried out in this area, primarily the Roman Civil Basilica itself and, indeed, the *Propylaea*.

With the growth of the city during the Ist century AD, orography strongly influenced the urban plan, insomuch as downstream in the west part relative to the top of the hill, the lines of urban planning and development left the classic chessboard scheme and were set on a two generator axis generally oriented 59° east in the northern sector and 53° east in the southern; in the contact areas between these two sectors an overlap between these two system has been found, probably the result of subsequent urban re-orders and regularizations.

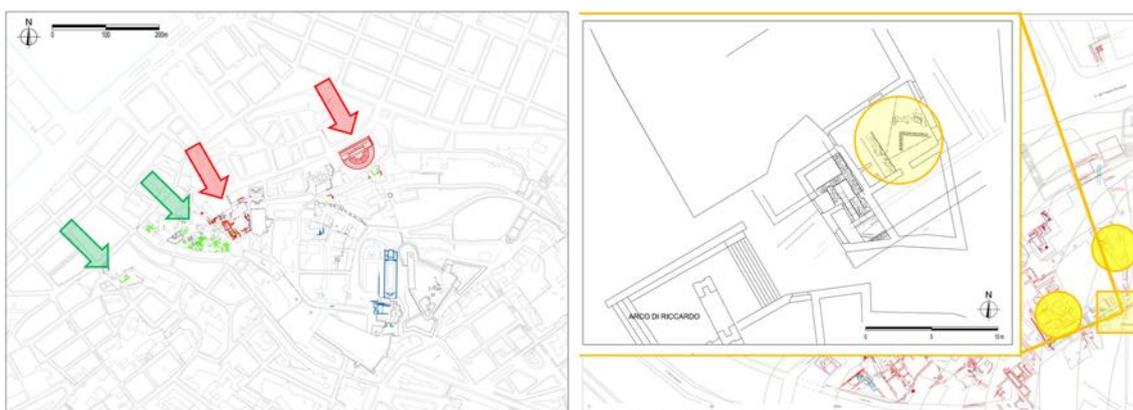


Fig. 9 – Distribution of guidelines and overlap between guidelines.

This overlap is evident near the Arco di Riccardo, a monumental transit during the I AD which replaced an original opening into the republican city walls.

The road that crosses this passage still remains in use as a road to the top area of the hill coming from east; this transit has also been used in recent centuries: as examples of that the several ancient prints depicting the Roman structure in the various historical moments.



Fig. 10 – The street under the Arco di Riccardo.

Just next to the Arco di Riccardo arrives another road axis whose route originated in a phase of expansion of the Roman city: the present via dei Capitelli, important east-west route linking the district of Cavana downstream with the central part of the district of Cittavecchia upstream, roughly follows a previous axis which traces have been highlighted both downstream, in correspondence with an important area excavated in 2003/2004, and upstream in front of the afore mentioned Arco di Riccardo.



Fig. 11 – Via dei Capitelli.

From the archaeological and topographical data acquired in recent years, it was possible to suppose the existence of a commercial forum near the coastal area, in axial position in respect to the route proposed now by via dei Capitelli and downstream this one; the shift from the downstream sector that had commercial nature to the upstream sector that had monumental and public nature, was emphasized by the presence of a four pillars monument, probably an arch dated to the 1st AD, under and alongside of which the first stretch of the road departs.



Fig. 12 – The commercial area.

This road was, during the late antiquity, around the end of the IVth AD, the basis of the route of the new city walls that delimited the city extension excluding in fact the southern districts.

The route of the city walls in this area was joined to the persistence of the ancient road, which from being an urban route became external to the new city walls and tangent to them; in the medieval period, with the construction of the new city walls further south west, along the present via delle Mura, the road that later became via dei Capitelli regained its original function as an urban link between the downstream urban area and the upstream hill of San Giusto, which acquired during the medieval period, respectively, the names of Cavana and Caboro.

Perpendicular to the current via dei Capitelli another important road develops, whose origins date back to the Ist century AD roman urbanization: it's via di Crosada and its westward prosecution called via del Pozzo di Crosada, for the presence of an important medieval point of water supply.

The name "Crosada" refers to the word "cross", that is crossroad: the toponym emphasize in fact the importance of the intersection between this road and via dei Capitelli.

The road layout of the roman period that is presented again by these streets today, was clearly identified westernmost in really recent excavations carried out following the building recovery in the district of Santi Martiri. In this area a log stretch of a road in excellent condition has been highlighted in different moments, following the advancement of the coast line, made in the first decades of the Ist century AD.

In the area in which this stretch of road has been brought to light, the XVIIIth century's urban organization has completely deleted its original route, following the achievement of Borgo Giuseppino, even if the original name "Santi Martiri" refers to the presence of a really important sepulchral area of the late imperial period which evolved just along the road: in recent excavations several and very important traces were found which, following the tradition, would be related to the grave of San Giusto, the city's patron saint martyred in the early IVth century AD.



Fig. 13 – Via di Crosada and Via del Pozzo di Crosada.

The persistence in the use of such a coastal route from the roman to the late ancient period and then also in the following periods, is testified by the presence, just in correspondence to the already mentioned crossroad between via di Crosada and via dei Capitelli, of one of the fortified gates of the IV AD city walls highlighted in the late 1990s; this structure shows on one hand the will of keeping the south-west north east coastal route even through the new cut done by the walls, and on the other the need to a fortified control in this important part of the city.

The projection to east of this road leads straight to the already mentioned via del Pozzo di Crosada and via Crosada and, continuing in nearly straight line further north east, reaches the area of the roman theater, whose *post scaenam* was built just on this road.

This road, in fact, was a kind of coastal ridge, oriented south west-north east, joined the two extremes of the city along the seaside and, heading north, went on to Aquileia crossing a bridge, whose structures were highlighted immediately northbound the roman theatre during the first years of the XX century.

The demolitions of this area of the historic center done during the 1920s following the urban redesign of this part of the city during the fascism completed partially but sufficiently to permanently change the structural

aspect, completely erased the medieval route of via di Riborgo which re-proposed roughly speaking the roman coast route; through the virtual reconstruction of the demolished structures and the suggestion of the road network that defined it, it was possible to verify the partial continuity between the probable roman route and the following medieval road arrangement.

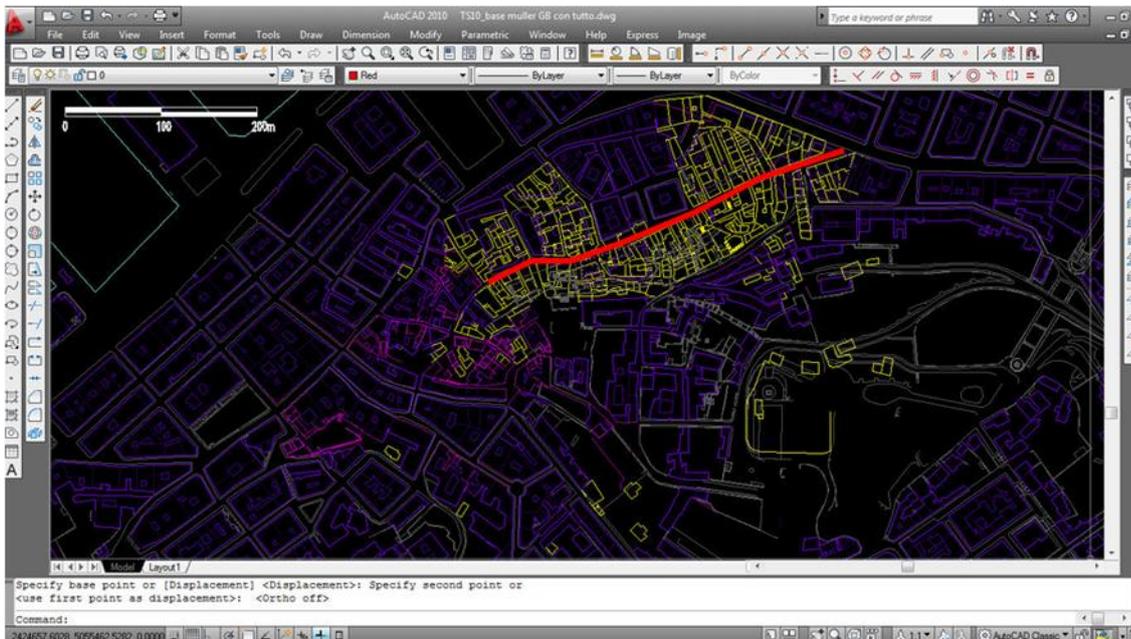


Fig. 14 – Via di Riborgo.

Today, the medieval via di Riborgo is covered by via del Teatro Romano along which there still are some of the buildings demolished in the '20s.

Returning to the east and going up the first slopes of San Giusto hill long this side, behind via del Teatro Romano, starts via di Donota which origin may be contemporary to the very first roman city plan, if not earlier. The current road, in its most downstream, goes from the back of the theater *cavea* to westward until it inserts, with a strong curve southward, to the already mentioned via delle Monache that we have just seen it's oriented according to the cardinals points.

Just at that curve, in conjunction with a part of the late republic city walls highlighted in this area, it has been partially identified an opening that opened in an oblique way referring to the road, following the construction typology typical of that period.

This road was the entrance from north to the top of san Giusto's hill. In the downstream of via Donota, next to his initial part, just behind the roman theater, a burial area has been excavated which during the IInd century AD took the place of a *domus* dated back to the Ist century AD: this situation testifies how in this period this part of the city was considered suburban.

The burial area was used until VIth century AD, the road instead continued to exist also in the following centuries; particularly in the medieval period was built the Donota gate which gave his name to the street and that was placed side by side to a tower, partially conserved, and proposed in several vintage prints.

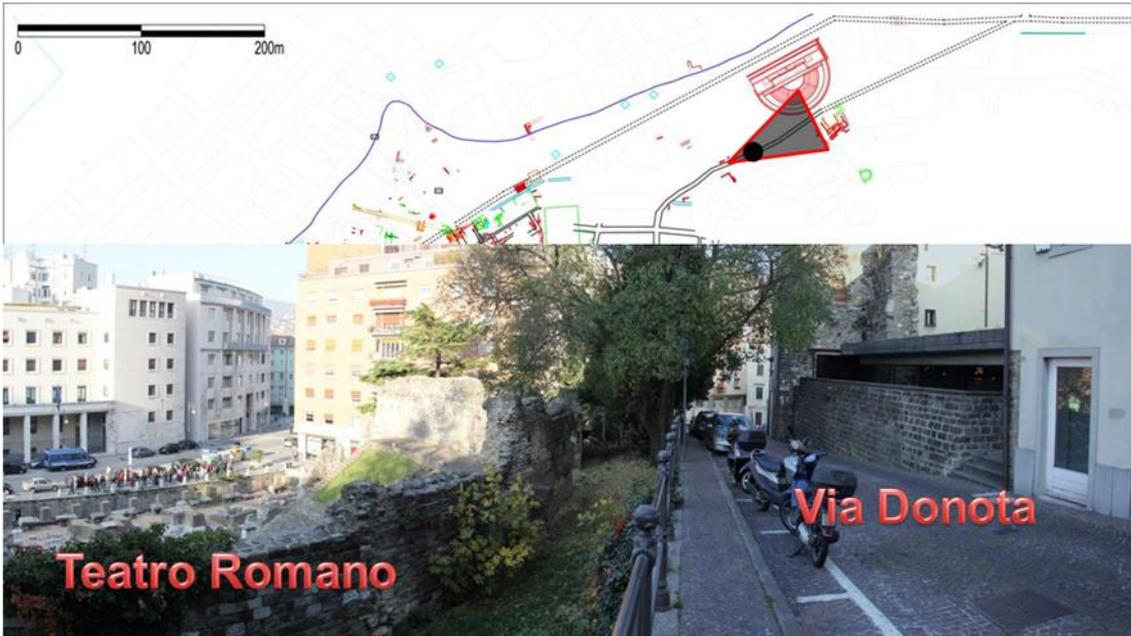


Fig. 15 – Via Donota as it's nowadays.

Suburban roads

In conclusion, a brief but necessary mention to the suburban roads that connected *Tergeste* to Aquileia, the eastern inland and Istria.

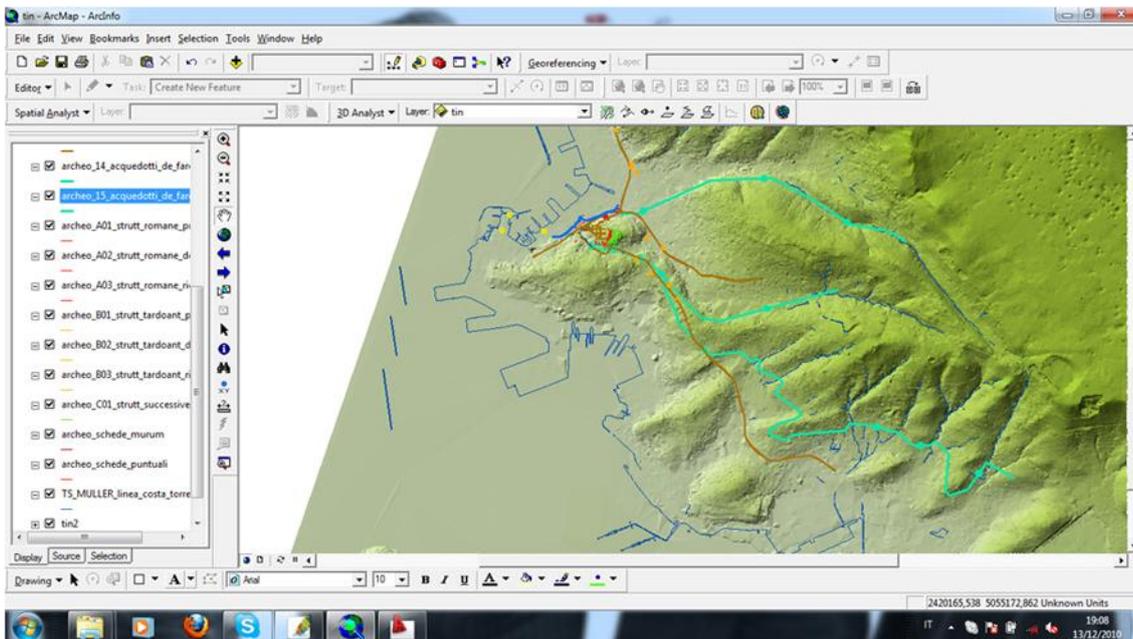


Fig. 16– Topographic analysis.

Already in 1800 important topographical and archaeological studies promoted, among others, by Pietro Kandler, proposed the layout of these roads especially on the basis of the discovery of burial areas near the town; recent topographic studies permitted with the use of spatial analysis to propose interesting hypotheses

about the extension of these routes farther than the ancient city and to verify the continuity of use in the following centuries, until their transformation in urban streets during the 1800th century.

This is the case of via Udine which, from the part of the city immediately north of the Borgo Teresiano which occupied in 1700th century the salt flat, continues north west to reach Strada del Friuli whose name refers precisely to the ultimate goal of this track; this is the road that, along the karst edge reached the river Timavo and then proceeded to Aquileia, joining the via Gemina that connected Aquileia to Emona, today's Ljubljana.

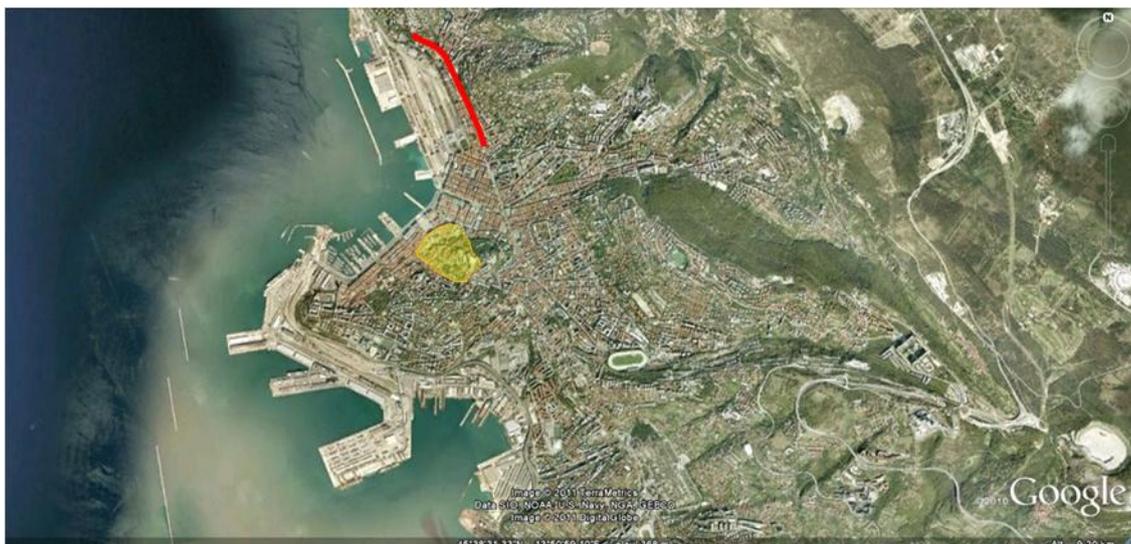


Fig. 17 – Via Udine.

The track that is now trade out by via Settefontane is probably the one that led to the eastern inland: this route passed over the hills immediately behind the city heading, east to the today's district of Cattinara and continuing until it found the via Gemina.

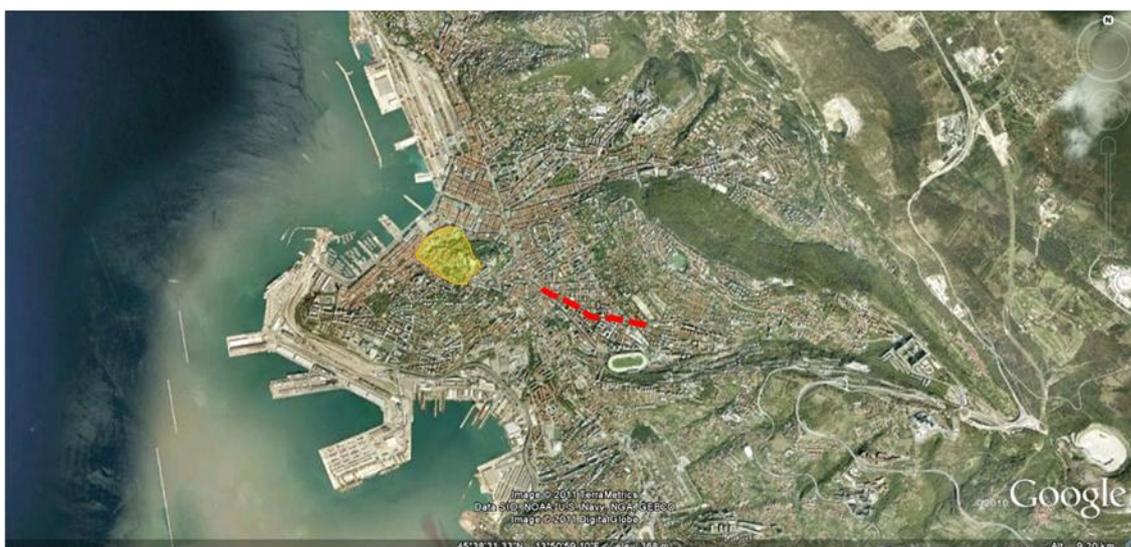


Fig. 18 – Via Settefontane.

Finally, just south east of the San Giusto hill, started the road that connected Tergeste to Istria: today's via Bramante, via San Giacomo in Monte and Strada Vecchia dell'Istria, from west to east, are the modern route which follows the ancient; this road was the part of via Flavia, built during the emperor Vespasiano between 78 and 79 AD nearest to the city.

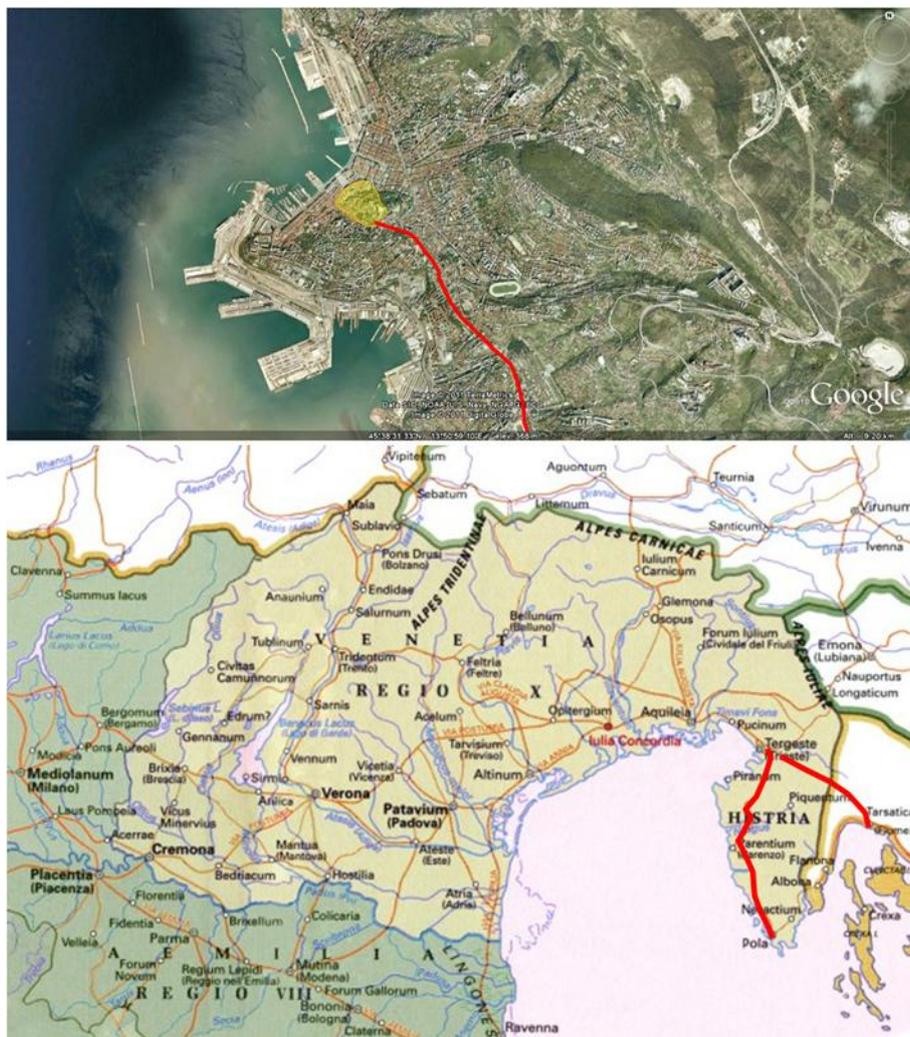


Fig. 19 – Via Bramante and the ancient via *Flavia*.

Today, the modern road that follows the route of the ancient, has the same name, via Flavia and, continuing towards Muggia and Istria, is still a very important link road to Trieste, as it was two thousand years ago for the ancient Tergeste.

Conclusions

In conclusion, the creation of the archaeological map on digital support and the implementation of the GIS not only allowed the collection of heterogeneous data favoring the study and the research, but are a great tool for the analysis of the ancient structure of the city. Allowing to overlap different kind of data, the GIS map

permit to better understand the several changes occurred during the entire life of the roman city and also the reasons why, during the growth of the town, the topography changed so significantly.

Furthermore, overlapping different types of cartography and creating thematic maps, it was possible to observe how often the modern streets follow the route of the ancient ones, thanks also to the placement of the several archaeological finds that were along the city and above all suburban roads.

Acknowledgments

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Late Medieval Archaeological Layers of Kyiv and Their Key Role in Studying City Structures (13th–15th cent.)

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Abstract: Period from second half of 13th to 15th cent. is very special in the history of Kyiv for all the aspects of city life, including its historical topography. The importance of its studying is actualized due to further reasons: almost total absence of written and cartography sources which highlights the role of archaeological data, and the fact of quite late including of those layers into the sphere of scientific interest (central city districts previously has been regarded as almost totally ruined by Mongol invasion of 1240).

Thus, studying the archaeological evidence opens the way to deeper investigation of Kyiv historical topography development. It includes the quantity of objects and materials found, the capacity of cultural layers, quality parameters of archaeological objects, the level of artifacts collections representativeness, and all the possible remains of districts' and streets' existence.

First full data summarizing of 13th–15th cent. materials has been published by Prof. G. Ivakin in 1996. Since that, lots of archaeological excavations have been conducted. They included finds of various housing, utility objects, cultural layers and district structures in all the main Kyiv districts: the Upper City, Podil and Pechersk.

Topographical concentration of the mentioned period objects is different for various parts of the city and concerns the streets structure investigation. Main archaeological data comes from the monastery areas which formed 'cores' of city patterns. One of the most interesting facts is development of Pechersk – formerly a peripheral district which, during Late Middle ages, started transforming into one of the important urbanization centers of Kyiv.

So, accumulation of archaeological data for Kyiv of the 13th–15th centuries is a key instrument for studying urban patterns, including streets system development.

Keywords: Kyiv, Late Middle ages, archaeological investigations, districts, streets.

During Middle Ages Kyiv was known as one of the largest cities in the world, inhabited by more than one hundred thousand people. In 1240 it has been seriously destroyed by Batu Khan (http://en.wikipedia.org/wiki/Batu_Khan) who led the Mongol invasion. After this, during Golden Horde (http://en.wikipedia.org/wiki/Golden_Horde) period, Kyiv was being administered not directly by Horde, but through the local noblemen. The city was laid under big tribute, and the period of decline started. Later, after Syniovodska Battle (http://en.wikipedia.org/wiki/Battle_of_Blue_Waters) in 1362, Mongol domination was stopped. Kyiv and surrounding areas were incorporated into the Grand Duchy of Lithuania (http://en.wikipedia.org/wiki/Grand_Duchy_of_Lithuania) by Algirdas (<http://en.wikipedia.org/wiki/Algirdas>), Grand Duke of Lithuania. Nevertheless, Kyiv still have been constantly ruined by tartar minor invasions. The hardest of those took place in 1482, when the Crimean Tartars sacked and burned much of city. Thus,

period from the 2nd half of 13th to 15th centuries (or "after-Mongolian" period) is one of the most interesting and least known stages of city evolution. The question of streets and squares continuity/discontinuity is one of many unclear areas of Kyiv history. The object of the paper is to find out its actual condition and interpret accessible archaeological data.

Historical evaluation of the period went through different stages. Until the mid 20th century, city life continuity in general has been doubted by a number of researchers. This situation was rooted in further reasons: 1) the heavy lack of written sources for 14th–16th centuries; 2) there existed theory of almost total ruination caused by the invasion, which prevailed in historical thought for a long time. The last one also included statements about population change and views on invasion as a source of total influence on history flow in general. Understanding of the period started changing since the second half of 20th cent., and the concept of total decline was disproved. Nevertheless, the ruinations by Mongols and Tatars has seriously damaged Kyiv and slowed its evolution, including social, economical and cultural processes. Those processes, as well, influenced city structures development. Metaphorically, mentioned times could be named as 'Dark Ages', especially when speaking about the second half of 13th up to first half of 14th centuries. But the city life was not interrupted.

Concerned period is still extremely poor for all types of historical sources, especially comparing to earlier and later periods. It complicates studying of streets and squares development. Written sources are basically represented with short mentions, which do not give us any information about city structures. Cartographical sources also don't lighten the situation. The earliest one is a plan of the city by Athanasii Kalnofoisky (Pechersk Monastery monk), created later, in 1638 (fig. 1). More precise plan was composed by Colonel Ivan Ushakov in 1695. Both were not based on scale and instrumental measurements. Still, they can be used retrospectively as an important source for reconstructing earlier periods. More accurate plan was created by architect Andrii Melenskyi in 1803. It is instrumentally precise and helps in studying city structures, which were principally changed later in 19th cent. (IVAKIN 1996).

Such situation with historical sources actualizes the role of archaeological data for Late Middle Ages Kyiv history. Its potential was put into attention quite recently, due to objective and subjective reasons.

Objectively, the cultural horizons are thin due to the lower intensity of life after Mongol invasion and Tatar ruinations. Reduced intensity and quality of life caused the weakness of archaeological layers. Secondly, the Late Middle Ages materials were getting diffused into highly developed layers of intensively developed periods: Kyiv Rus' below, and Modern times above. Finally, they were seriously damaged by building activities of later times, especially in 19–21st cent. Subjectively, as mentioned above, the results of Mongol invasion and Tatar ruinations were overestimated for a long time. Scientists remained inattentive to the 'Dark Ages'. Furthermore, chronological differentiators were hardly known; sometimes the materials could have been attributed in a wrong way, or attributed in too wide chronological scope. After the mid 20th century archaeological evidences were found more and more often within the city. During recent decades, archaeological investigations of Late Middle Ages have got transformed into an independent branch of Kyiv archaeology and key source of historical reconstructions. Archaeological evidence opens the way to deeper investigation of city historical topography development. It includes further aspects:

- ▶ the quantity of objects and materials found,
- ▶ the capacity of cultural layers,

- ▶ quality parameters of archaeological objects,
- ▶ the level of artifacts collections representativeness,
- ▶ all the possible remains of districts' and streets' existence.



Fig. 1 – Plan of Kyiv by A. Kalnofoisky. 1638 (Copyright: G. Ivakin, 1996).

First full summarizing of data on 13th–15th cent. archaeological materials has been published by Prof. Glib Ivakin in 1996. This work has proved wrong the theory of city total ruination and revealed the main aspects of Kyiv history. The author showed the picture of city's historical development and answered many disputable questions. The results of investigation proved that all main historical districts of the city survived and continued their development, although it was slowed down. Not less than a half of stone buildings have got through the invasion. Most of those conclusions were based on archaeological materials (IVAKIN 1996).

Since that, lots of archaeological excavations have been conducted and published. During the latest decade, they revealed various housing, utility objects, cultural layers and cemeteries in all the main Kyiv parts: the Upper City, Podil and Pechersk (fig. 2).

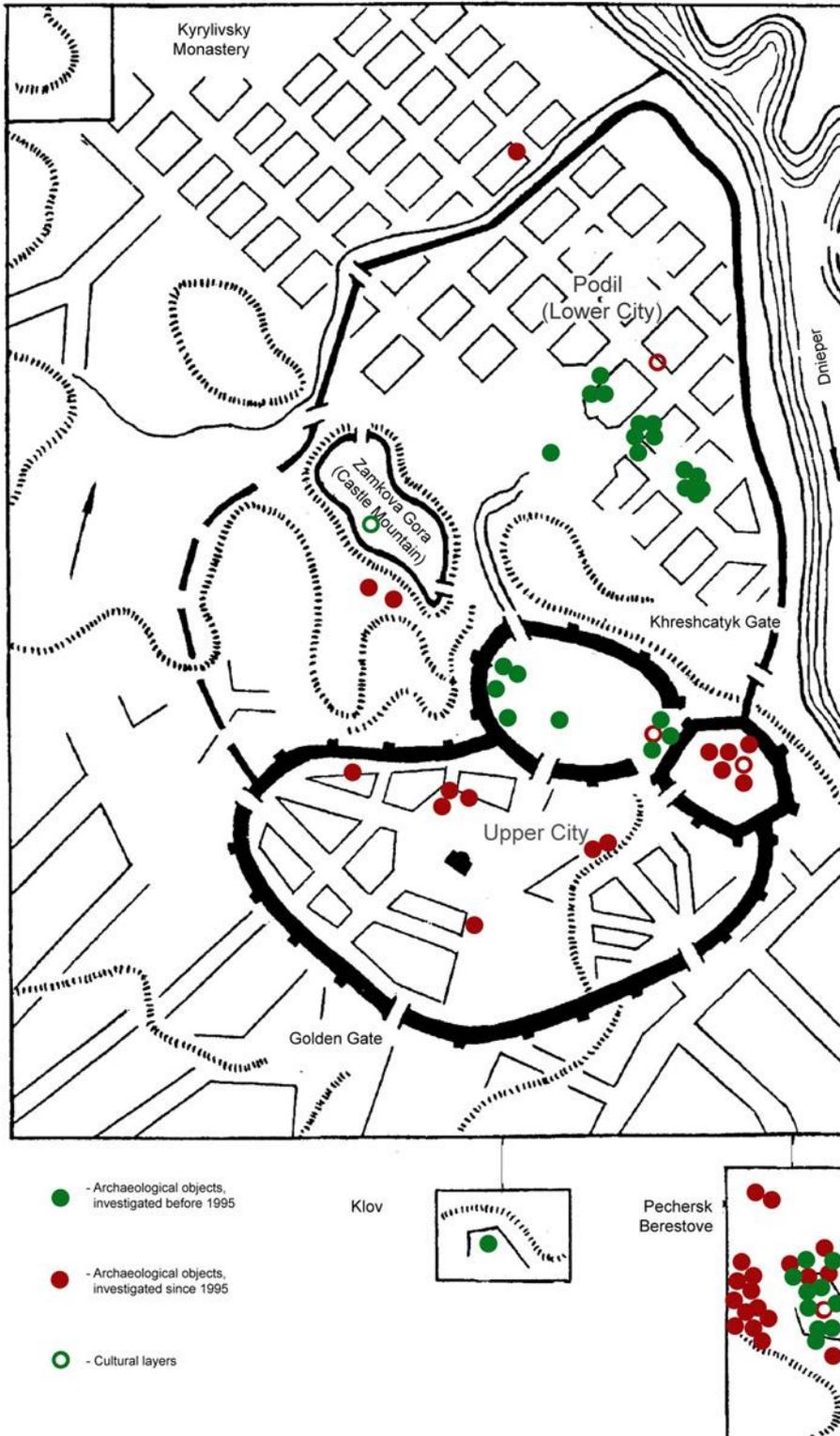


Fig. 2 – Topography of 13th–15th centuries archaeological objects (Copyright: O. Onogda).

Unfortunately, due to the mentioned above reasons, the archaeological layers are quite weak. The absolute majority of finds consists of household and utility complexes which are the most representative category of archaeological sites. Cultural layers are being found more seldom. Recently, 5 complexes of 13–15th cent. were found in the upper city. A range of objects was found on the territory of Mykhailivski Golden Dome Monastery in late 1990s. Those materials have been dated by the finds of numismatics from 14th and 16th cent. At least 2 objects were found in Podil (Lower City). Big concentration of Late Middle Ages objects is known for the territory of Pechersk. These ancient outskirts of Kyiv were named after Pechersk Monastery, founded here earlier. Later, it transformed into a powerful structure and one of the cores of city development. 4 complexes have been excavated on the territory of Kyiv Pechersk Lavra recently. Archaeological investigations nearby, on the territory of former Voznesensky Convent, revealed a complex of about 20 objects dated from 14th to 16th centuries. Some of those have been dated by the finds of 15th–early 16th cent. coins. Majority of the objects from Voznesensky Convent were represented with stratigraphically thick constructions deepened into solid ground (fig. 3). Such sickness is not typical for the cultural layers of Late Middle Ages (ONOGDA 2009).



Fig. 3 – XV – early XVI cent. object: fragment of stratigraphy. Excavations on the territory of former Voznesenskyi Convent (Pechersk district of Kyiv), 2005 (Copyright: A. Chekanovskiy).

So, in general, the archaeological sites of the second half 13th–15th centuries are inconsiderable in number, if compared to earlier and later periods. They are being fixed in the form of separate spots, located segmentary in the main historical and topographical components of Kyiv. Cultural layers are being hardly fixed. Unfortunately, the remains of streets are not traced alongside those objects, and we got no straight evidence of roads as well. Archaeological objects mostly are represented with the soil underground parts of

household and utility objects. Collections or archaeological materials from the objects filling consist mostly of pottery. It actualizes working out pottery classifications. Up to date the Late Middle Ages pottery is represented with several types of pots and other minor forms. They belong to several technological traditions which co-existed during the Dark Ages:

- ▶ pots of primitive forms and technology which remind of forms from 11th cent. Those are being associated with the economical decline of the period;
- ▶ pots which represent evolution of the local Kyiv Rus tradition; they give evidence of technological changes and beginning of use of a high-speed potter's wheel in 15th cent
- ▶ pots which are analogical to the types of pottery from neighboring regions and represent minor and temporary influences on the ceramics production (fig. 4).

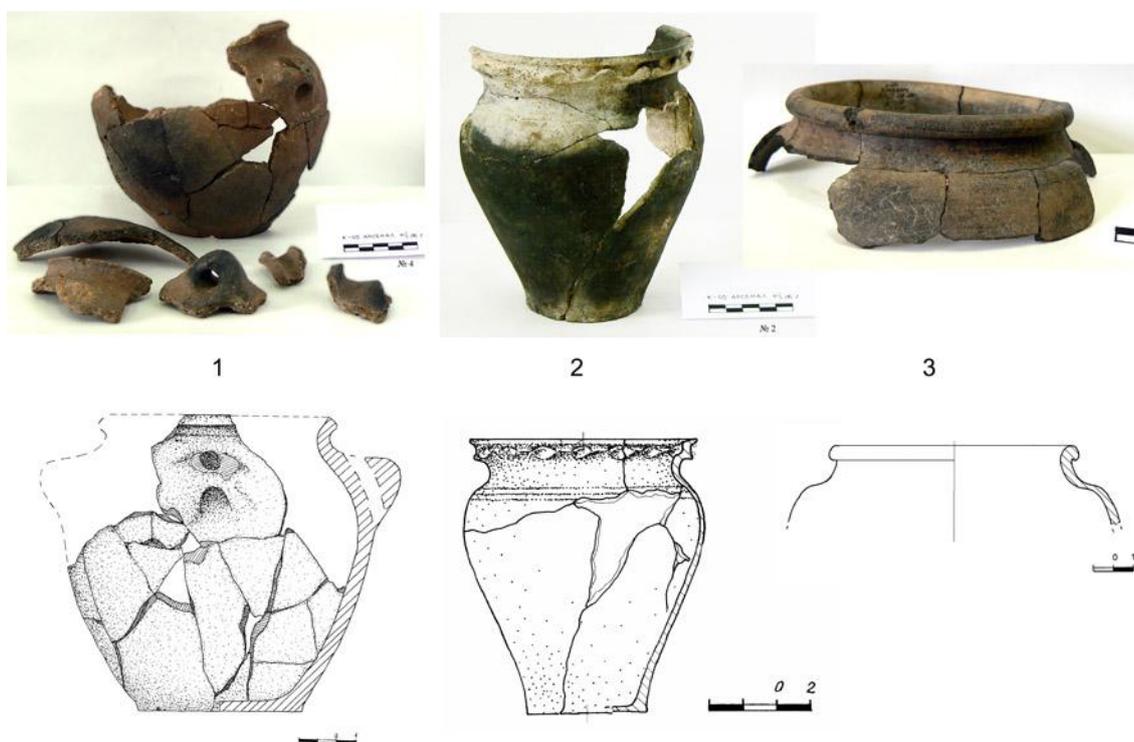


Fig. 4 – Main types of pots. Kyiv, XIV – XV cent. Voznesenskyi Convent, 2005 (Copyright: O. Onogda).

Reconstruction of city historical topography, thus, is available only by fixing the cores of life development in different areas. The general picture of city life, traced by excavations results, shows that archaeological sites are represented better and more completely on the monastery territories. Those include Pechersky, Vydubysky, Mykhailivsky Monasteries and former Voznesenskyi Convent, which were mentioned above. These territories have higher concentration of housing and utility objects, as well as much higher representativeness of archaeological collections. Pechersk suburban area later even transformed into one of 2 main centers of city agglomeration in 16th–17th cent (KLYMOVSKYI 2002). Opposite to secular parts of the city, monastery territories have got agglomerations of various objects. On the one hand, it could be explained by the fact of more purposeful and large-scale investigation of monastery territories. But on the other hand, we should take into consideration historical facts, not only such formal specifics of field investigation. It is

known that conquerors (at least Mongols for sure) were tolerate to religions of the won countries. They treated local church organizations in a tolerate way (IVAKIN 1991). It could have affected better preserving of monastery complexes during invasions and their further transformation into bases of social and economical revival.

So, the cores of city districts development are quite clear for the Late Middle Ages period, but the evidence of streets structure archaeologically remains unclear. In this situation we can look for the patterns from earlier periods. Data of archaeological investigations was summarized by S. Taranenko who has gathered known street remains of 11th–13th cent. They were correlated with the plan of Kyiv from 1803 (TARANENKO 2010). Such method gave important results. It has shown that majority of archaeologically known streets and roads coincide either fully, or in the direction, with the street structure of early 19th cent. It has also proven the fact of their localization continuity during a long period of time. This situation is quite typical for Eastern Slavic city centers.

Considering these facts, we can assume retrospectively, that while city planning structure has survived during such a long period within the lower city, the situation with other districts remained more or less the same. As we trace the city cores by the concentration of archaeological sites of 13th–15th centuries, they belong to well-known centers of city life. And there is almost no hesitation that through the period of economical decline in 13th–15th centuries, there were no reasons and resources for changing the streets system. The only example of a totally new city structure, which was built during the 'Dark Ages' period, is building of a new castle on a big separate residual mountain which rose above Lower city for about 70–80 m. It was constructed here probably during the times of count Volodymyr Olgerdovych (mid 14th cent.) and later gave name to the hill – Zamkova Hora (Castle Mountain). The castle included residency of the count, permanent garrison, military depots and houses of noblemen. The inner part of the castle was firmly built up (IVAKIN 1996). The defense wall was constructed of timber and has got towers. There were two big gates – Voievodska and Drabska, and small gate which led to Lower City. All of those must have been connected with roads to the city. The castle was built in earlier Kyiv Rus traditions – with maximum usage of relief, free planning organically combined with the form of the hill, and construction of timber-soil defense buildings (fig. 5). Later in 16th cent., with the development of fire engines and changes of military strategies, the topographical situation of the castle stopped being so advantageous. It started regressing. Archaeological investigations on the territory of former castle were sporadic. They have shown only some remains of defense constructions and some household objects from 14th–15th cent.

Summarizing, we'd like to state further: the period of 13th–15th centuries really lacks all types of historical sources for studying city development. The most important and informative are the archaeological materials, which were taken into scientific consideration very late. They, on the one hand, help reconstructing some aspects of Kyiv development and show that city was not totally ruined, but still was seriously damaged. On the other hand, they remain weak as for investigating such problems as development of streets and roads. Without doubts we can trace only the cores of city development which are being shown in objects concentrations in main historical districts. Investigations of other periods let us assume that street patterns development was conservative, and remained more or less the same form Kyiv Rus times up to early 19th century, including Late Middle Ages period. It gets more evident when we consider the social and economical processes, which show that there were no reasons to change the system during the period of

decline after Mongol invasion and later through the "Dark Ages". Of course, we really hope for any kind of streets remains to be found in future, which will provide archaeological evidence for our assumptions.

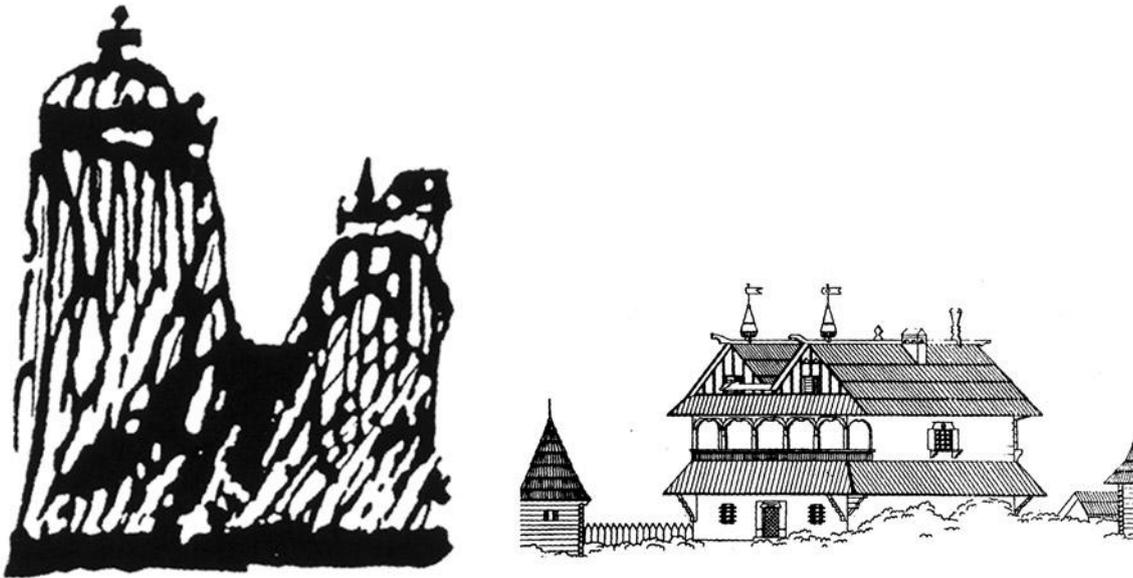


Fig. 5 – Old Kyiv Hill and Castle Hill pictured by M. Gruneveg in 1584 (left; copyright: G. Ivakin 1996), reconstruction of Voievoda Palace in Kyiv Castle, by P. Iurchenko (right; copyright P. Iurchenko).

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The street network of Kyiv Podil in X–XIII centuries by the archaeological records

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Abstract: Streets and roads are among the main components of the city structure. Because of the small amount of the historical records on street network of the Kyiv Podil in X–XIII century, the problem of street network in Kyiv could be solved with archaeological investigations.

The history of archaeological investigations of the Kyiv Podil has about 80 years. Over 160 excavation sites were organized during this time. 24 parts of streets and roads were excavated. The roads (12.5%) are the carriageways without the building and fences from both sides. Streets (78.5%) are the carriageways with the fences from both sides. Usually fences separated the roads and the households.

Two types of streets and roads are identified by the width: 2.6–3.7m (80%) and 4.5–6.0m (20%). Another two types of streets are identified by the morphology of pavement. These are the “unpaved roads” (83%) and the “bridge roads” (17%).

The modern map of Kyiv Podil and the map dated by 1803 that was created before the Podil redevelopment were compared. Four groups of streets and roads are identified. Streets and roads of the first group (38%) have the same location and direction. The objects of the second group (37%) have the same direction and parallel location. Streets and roads of the third group (4%) have the same location and some deviations in a direction. Streets and roads of the fourth group (21%) have different location and direction.

This analysis gives a possibility to outline that the street network of Kyiv Podil has not been changed before the fire in 1811. The results may finish the long discussion on this problem.

Key words: archaeological investigations, street, Kyiv Podil.

Podil is a very good place for the settlement location, and that was understood well by the ancient population of the Middle Dnieper region. The hills located south and south-west from Kyiv make this place, the first and the second terrace, and the terrace above the floodplain, defended enough. Podil lowland unites grasslands, rivers and lakes from the west. The so called Upper-City, administrative and religion center, was located at the hills Starokyivska, Zamkova and Dytinka (Fig. 1).

Some versions of the city origin were proposed, starting by the IX century and finishing by the official date – 482. We accept the first date for the origin of Kyiv Podil. The earliest date we know for this part of the city is a dendrochronological date 887 year, coming from the excavation-site at Zhytnij Rynok (SAGAIK 1991).

These excavations were provided in 1972–76. The cultural layer was lying 10–12 m below modern Kyiv (Fig. 2). The remains of ten homesteads and about fifty buildings were excavated at that time.

The dendrochronological date presents only the time of the earliest blockhouses building. Therefore the formation of the city street network we date by the X century. However, the “earliest settlement” also had to

have a planning order, and the first streets probably were the base of future street network system. Tatars and Mongols destroyed Kyiv in 1240. Therefore the middle XIII century is a latest date for Kyiv as the Kyiv Rus capital. It would be the chronological border of our investigation.



Fig. 1 – Fragment of the topographic map of Kiev, 2001.



Fig. 2 – The excavations on Kontraktova square in 1972 (Copyright: GUPALO and TOLOCHKO 1975).

The streets and roads are the main components of the city planning structure together with the fortification, markets, temples and palaces. We should define what the streets are and what the roads are correctly. Well known philologist I. I. Sreznevskij proposed the great variety of the “street” meanings: the “square”, the “passage between the houses”, the “passage”, the “gates” and the “row”. The definition of the term “road” is very simple. It means the “way” (SREZNEVSKIY 1903).

Ukrainian dictionary proposes the following meanings of the “street” and “road”. “Road – is a space for walking and riding, bounded by the two rows of houses, or two rows of houses with a passage between them”. “Road is a part of a land for walking and riding; or a part of a land with the traces of somebody’s or something moving; or a place for walking and riding” (1971).

The problem of the Kyiv street network was not developed well because of the absence of archeological information. That is why the scholars were very careful about it just before the latest quarter of XX century: “Of course, there were streets, because people had to ride and walk; there were squares also. But nobody knows how they were looking like” (IVANTSOV 2003). “The streets had so small wide that it was difficult to ride for the two wagons. It seems unlikely that the streets before the Mongols’ time had a bigger wide” (TIKHOMIROV 1956).

The papers that summarized the research of the city by 1970ies were dealing with the homesteads and streets also. Scholars were very careful with the parallels between the planning structure of the Late Medieval city and city’s modern planning structure. “The question of the preservation of Ancient Rus traditions of the Podil planning in XVII–XIX ct. is still open” (GUPALO 1982). Only the excavations could answer this question.

Archeological investigation of the Kyiv Podil was started by the All-Ukrainian Archaeological Committee surveys in 1925–1929. For the first time the cultural layer 8.3 m deep was analyzed in Kyiv (IVAKIN 2010). V. Bogusevich organized the first excavations in 1950 and discovered the components of the Posad mass-building dated by X–XIII century. Most of the information came from the large-scale excavation at the time of metro building. Because of the incorporation of Podil to preservation territory “Ancient Kyiv” in 1972 and the modern mass building, Podil Standing Expedition was organized in 1984.

Over 160 excavation-sites and surveys were organized in this part of the city between 1950 and 2008. We may point out 62 excavation-sites were the components of mass-building and city planning structure of X–first half of XIII century were found. The roads were found in 24 cases at 19 excavation-sites. Let us analyze some examples.

Three blockhouses, the X–XI century crossroads with wooden fences across the streets were excavated at Heroiv Trypillia in 1972. One of the roads, that were going parallel to the bank of Dnieper, was 6 m wide and another one, which was going from the hill to Pochaina, was 3 m wide. The dirt road had no tracks (GUPALO and TOLOCHKO 1975) (Fig. 3).

The part of the road, 14 m long, was excavated at 42, Nyzhnij Val in 1989. Four layers of the road are represented by humus layer with the remains of wood and charcoal. The road was uneven and had the wheels tracks. The entire road was covered by charred wood. Most probably there was a wooden platform there that did not “live” long. Drainage ditches 0.25–0.35 m wide and 0.3–0.4 m deep were found across from the both sides of the road. The road lies at the X–XIII centuries horizons. That means that the street network was standing during three centuries as a minimum (BOBROVSKIY et al. 1989) (Fig. 4).

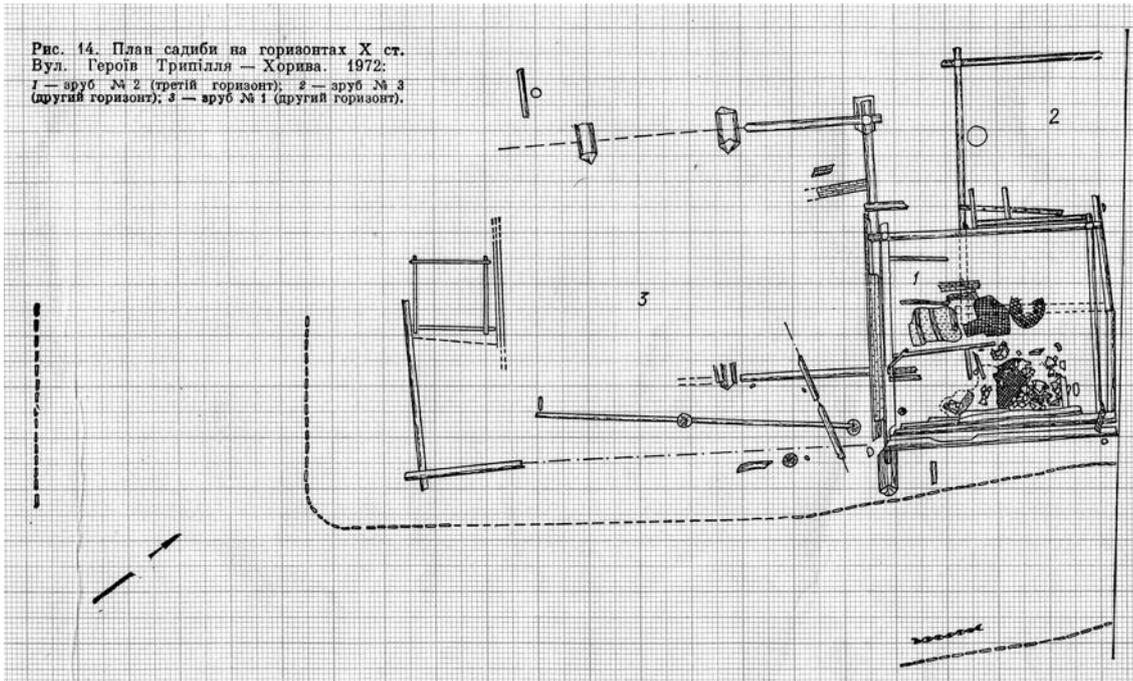


Fig. 3 – Plan of the X ct. homestead. Excavations at Horyva str. – Heroiv Trypillia str., 1972 (Copyright: GUPALO and TOLOCHKO 1975).

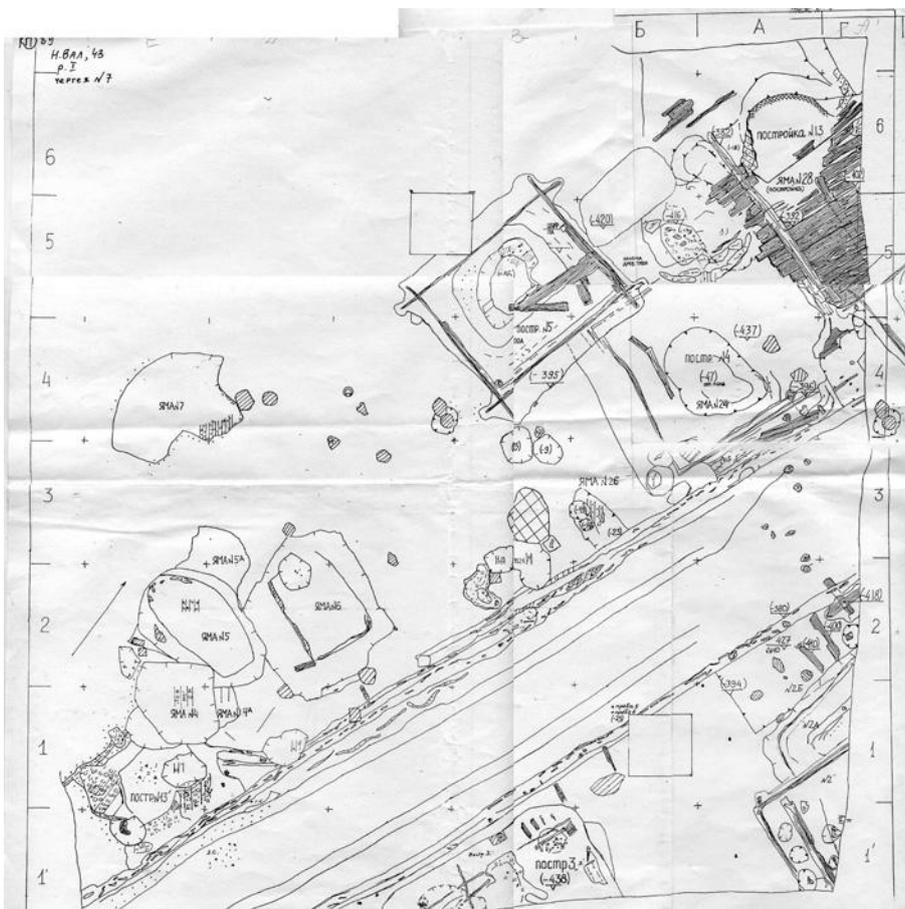


Fig. 4 – The excavation-site at 43, Nyzhniy Val, 1989; XI ct. Layer (Copyright I. I. Dopira).

The remains of the wooden church that was found in Kyiv for the first time, the cemetery and the part of the road dated by XII century excavated at 3/7, Mezhygirska. The carriageway was made from ground and had the wheels traces 0.02–0.05 m wide and 0.1 m deep. This part of the road was 9 m long and 3–3.3 m wide. The borders were marked by the fences (ZOTSENKO and TARANENKO) (Fig. 5).

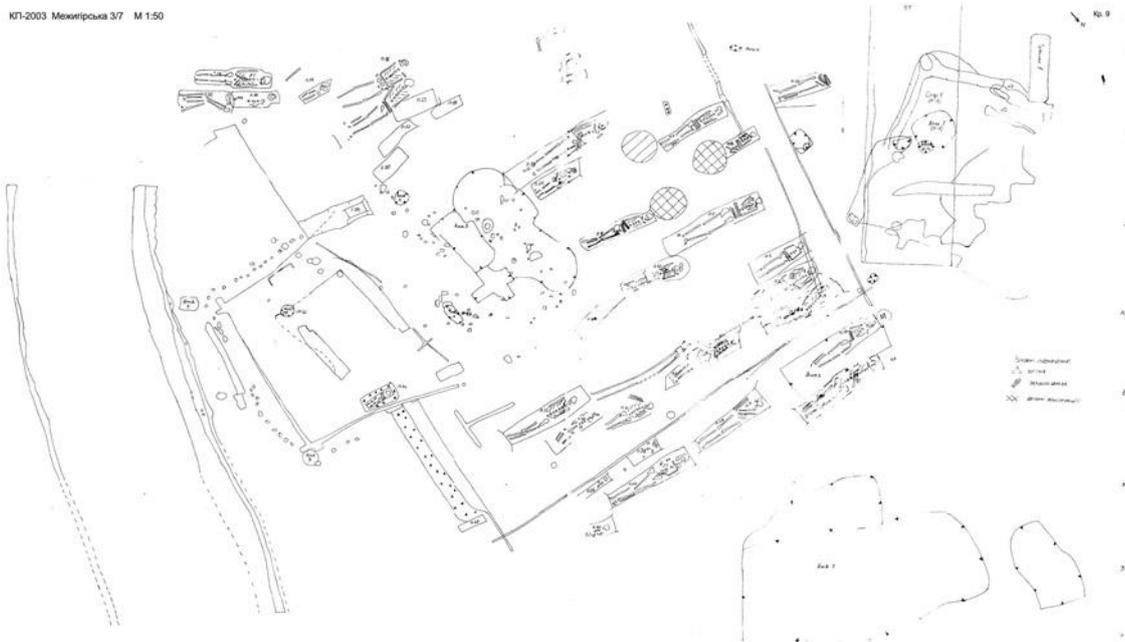


Fig. 5 – The excavation-site (2) at 3/7, Mezhygirska str., 2003. XII ct. layer (Copyright O. Yu. Zhuruhina).

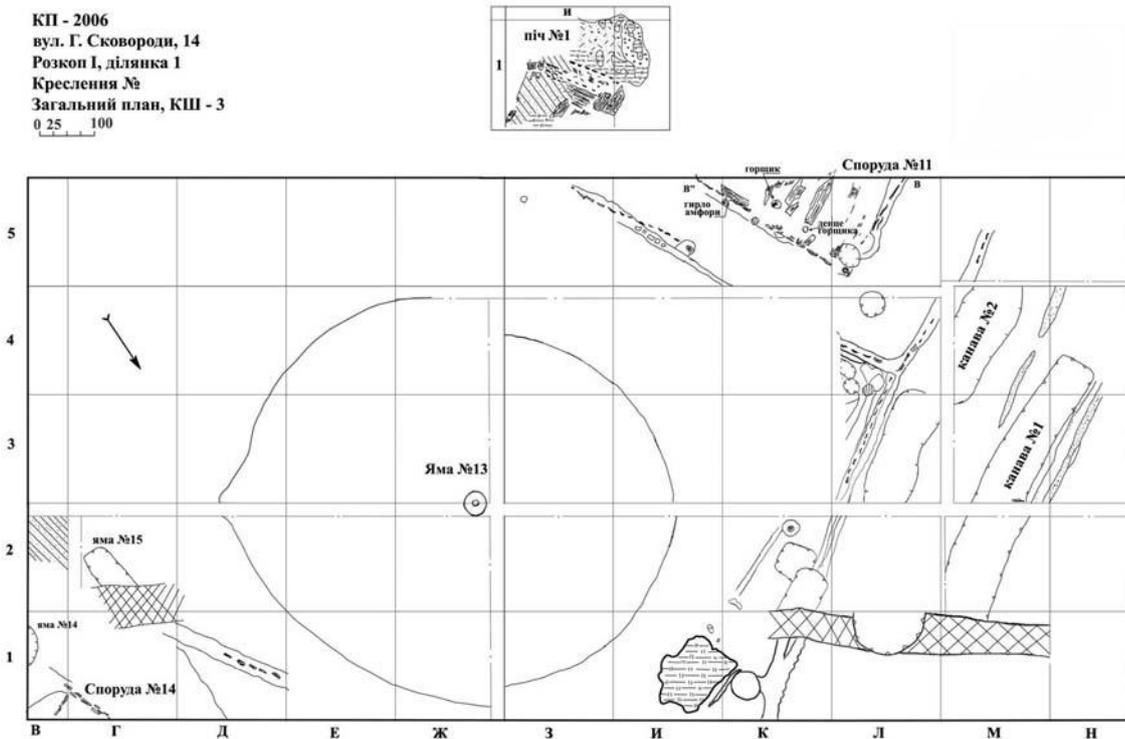


Fig. 6 – The excavation-site at 14, Skovorody, 2006. XI–XII ct. Layer (Copyright D. M. Peftits).

The remains of three homesteads dated by XI–XII century were found at 14–16, Skovorody in 2006. Their borders were marked with the fences. This part of the road, 10.25 m long, was 5.25 m wide in its largest part. The distance between the tracks was 2–2.10 m wide. The remains of the fence were found from the north. Two layers of the road and the drainage ditch were investigated. The direction of the street did not change. It just moved south for one meter (IVAKIN and PEFTITS 2009) (Fig. 6).

The fence with the drainage ditch and the track excavated at 14, Skovorody in 2006. Another drainage ditch and the track located south from them. The chronological difference between these roads is about 20–40 years (Fig. 7).

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вул. Г. Сковороди, 14
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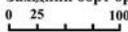
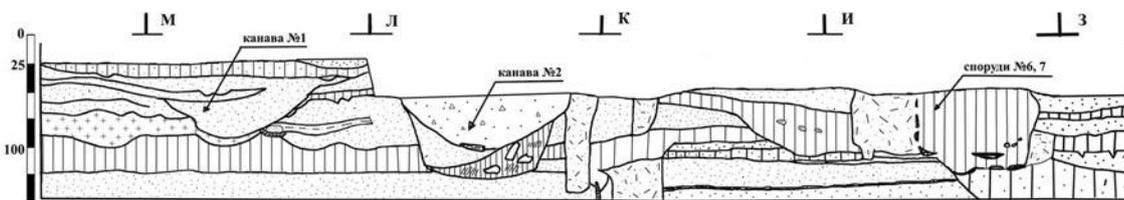



Fig. 7 – Stratigraphy of the part of the road. The excavation-site at 14, Skovorody, 2006 (Copyright D. M. Peftits).

Let us analyze the streets and roads. By the “roads” we mean the parts of carriageways without the houses and fences across them. Three roads were found at 68, Verkhnij Val; 30 Shchekavytska; and 12, Obolonska. By the “streets” we mean the carriageways with the fences and homestead across them (Fig. 8).

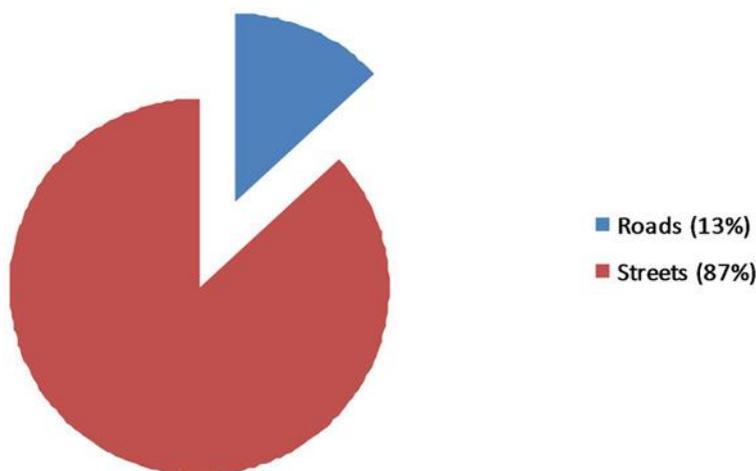


Fig. 8 – Correlation of the excavated streets and roads.

The wide was counted in fifteen cases. Two groups of streets may be separated. The first group includes the streets 2.6–3.7 m wide; the second group includes the streets 4.5–6 m wide. Therefore we may separate the main lines and the lanes (Fig. 9).

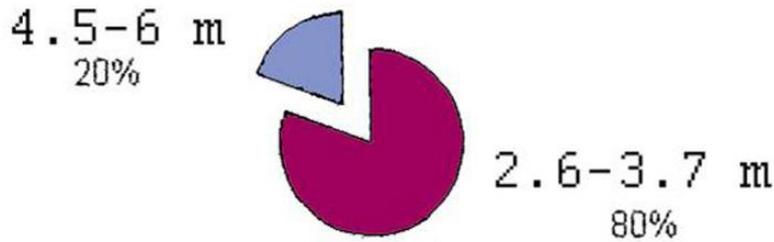


Fig. 9 – Correlation of the carriageways wide.

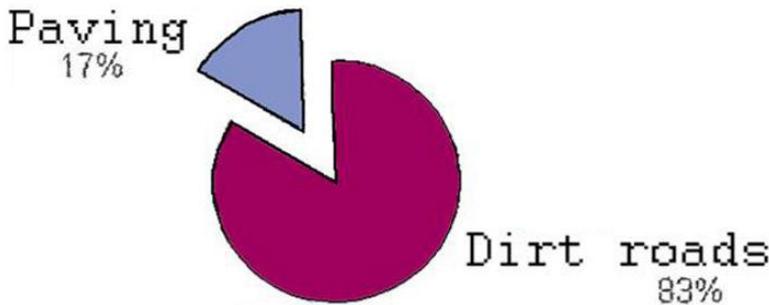


Fig. 10 – Correlation of the carriageways by their morphology.

According to their morphology another two groups of carriageways may be separated. They are the dirt roads and the paving. By the paving we mean the roads with the wooden constructions (Fig. 10).

The paving were built from two to four lags perpendicular to a carriageway. We know only one example of the paving made from six ones. They were joined with the wooden piles. The lags were 0.2–0.35 m wide. The drainage ditches were located across the carriageways and were 0.7–0.8 m wide and 0.4 m deep. There were fences across the streets. Most of wooden constructions were made from pine.

Archaeological data made possible the analysis of the street network of Ancient Rus Podil and its comparing to the medieval and contemporary street networks. V.O. Kharlamov and G.V. Alferova proposed to analyze Podil planning structure basing on the XVII century data, i.e. the plan made by colonel Ushakov in 1695 (ALFEROVA and KHARLAMOV 1982) (Fig. 11).

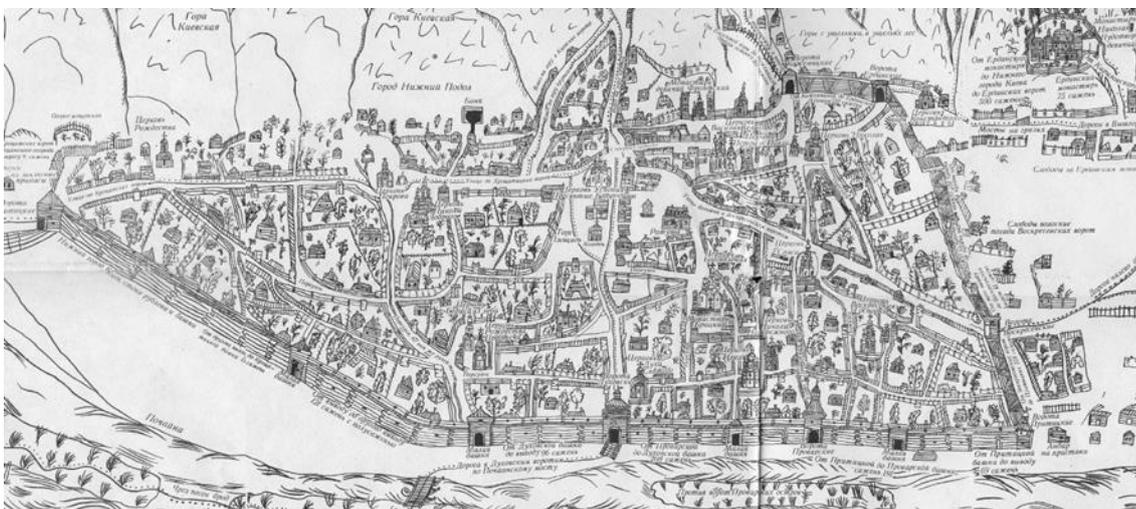


Fig. 11 – Plan of Podil made by colonel Ushakov in 1695 (Copyright ALFEROVA and KHARLAMOV 1982).

As we may see on a Fig. 11, the plan made in 1695 is a small-scale plan. It is rather a scheme of the city, than a map. However, it shows the general character of building, blocks configuration and the defense system. It should be noted that the problem of the city planning structure was open and the mentioned paper is just one of the first attempts of the analysis of Kyiv planning structure.

I used the experience of architect Paskevich and compared the recent topographic plan with the plan made in 1803. That was the last plan made before the re-building after the fire in 1811, which destroyed almost the whole Podil. Streets and roads found at the excavation-sites were pointed on this common plan (TARANENKO 2010) (Fig. 12).

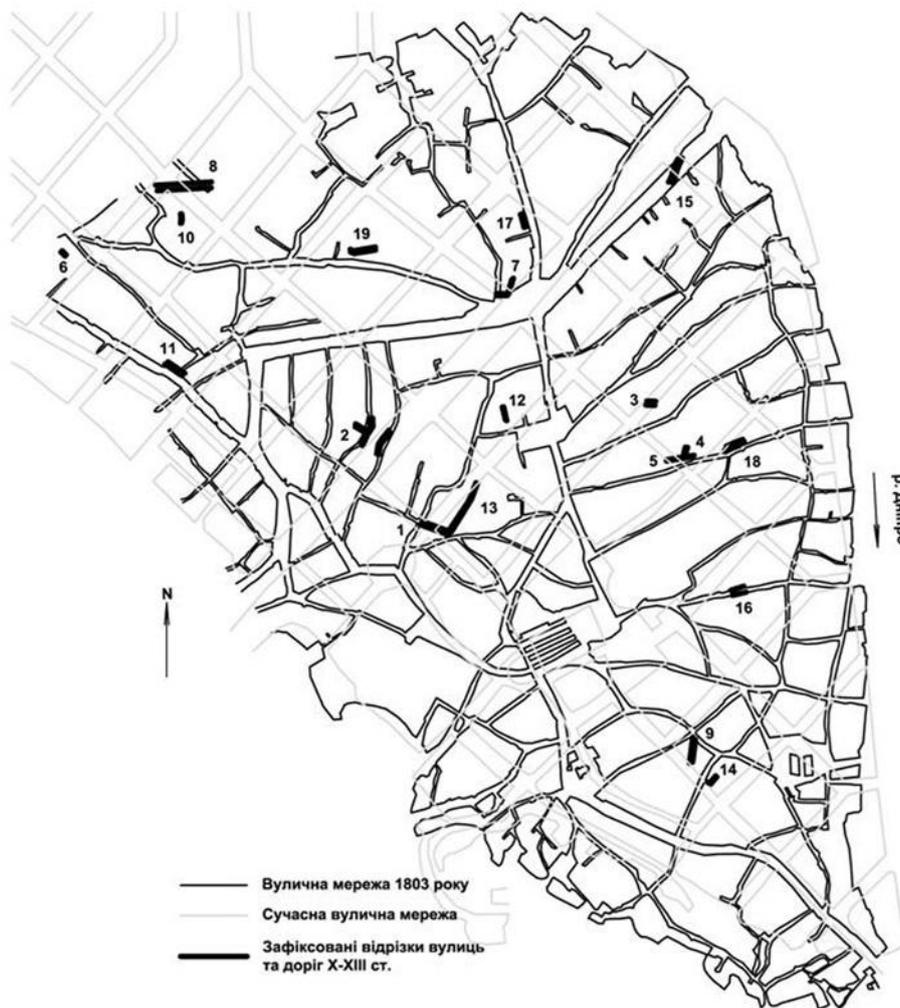


Fig. 12 – Plan of Kyiv Podil (contemporary plan and the street network in 1803) with the parts of streets and roads, X–XIII ct (Copyright Taranenko, 2010).

1. Heroiv Trypillia str. – Khoryva str., 1972–1973. 2. Verhniy Val and Nizhniy Val streets, 1974–1975. 3. Investigations at the heating main building at Heroiv Trypillia str., 1983. 4. 14–16, Voloska str., 1987. 5. 14–16, Voloska str., 1988. 6. Obolonska str., 1988. 7. 43, Nyzhniy Val str., 1989. 8. 43, Mezhygirska str., 1989. 9. 18, Sagaidachnogo str., 1991. 10. 12 (P-2), Obolonska str., 1993. 11. 7/10, Shchekavytska str., 1998. 12. 27, Khoryva str., 1999. 13. 3/7, Mezhygirska str., 2004. 14. 16–18, Sagaidachnogo str., 2004. 15. 68, Verhniy Val str., 2004. 16. 8, Illinska str. 17. 27/44, Pochaininska str., 2006. 18. 14–16, Skovorody str., 2006. 19. 30, Shchekavytska str.

Four groups of streets and roads may be separated. Streets and roads of the first group (38%) have the same location and direction. The objects of the second group (37%) have the same direction and parallel location. Streets and roads of the third group (4%) have the same location and some deviations in a direction. Streets and roads of the fourth group (21%) have different location and direction (Fig. 13).

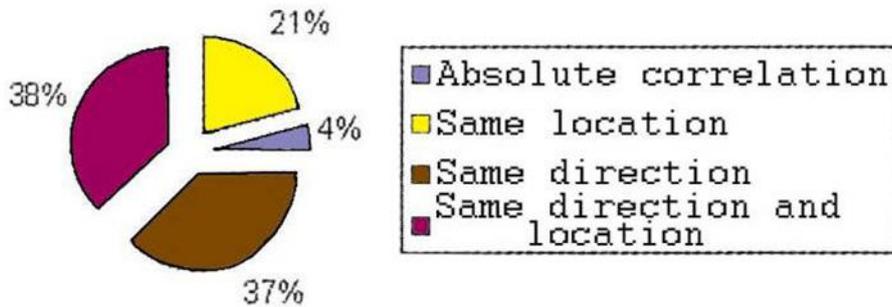


Fig. 13 – Correlation of the streets and roads dated by X–XIII ct. and 1803.

This analysis lets to outline that the street network of Kyiv Podil has not been changed before the fire in 1811. The results may finish the long discussion on this problem. The analogies are coming from the Ancient Novgorod where multi-layer paving were excavated, Ryazan, Suzdal, Vitebsk, Minsk and other Ancient Rus cities.



Fig. 14 – Digital map of Kyiv Podil mass-building on a contemporary topographic map (Copyright S. P. Taranenko).

The interactive digital map was created with this database. All the components of mass-building, buildings, fences, streets and roads, were pointed on a map. The digital map of Kyiv Podil mass-building was made on a contemporary topographic map. As of today, 62 excavation-sites with 547 components of the mass-building and planning structure of X – first half of XIII century are pointed: houses and buildings (348), fences (175), streets and roads (24). The objects that had an important place in the planning structure are pointed also: churches (5), cemeteries (10), hydro-technical buildings (3) and streams (4) (Fig. 14).

Figure 15 presents the fragment of the digital map with following excavation-sites.

1. Excavations at 2, Heroiw Tripillia-Horyva, 1972.
2. Excavations at Kontraktovaya Square metro station, 1976.
3. Excavations at 3/7, Mezhygirska (R-2 and R-3), 2003.
- 3.a. Excavations at 3/7, Mezhygirska (R-4), 2003.
4. Excavations at 13/11 Horyva, 2010.

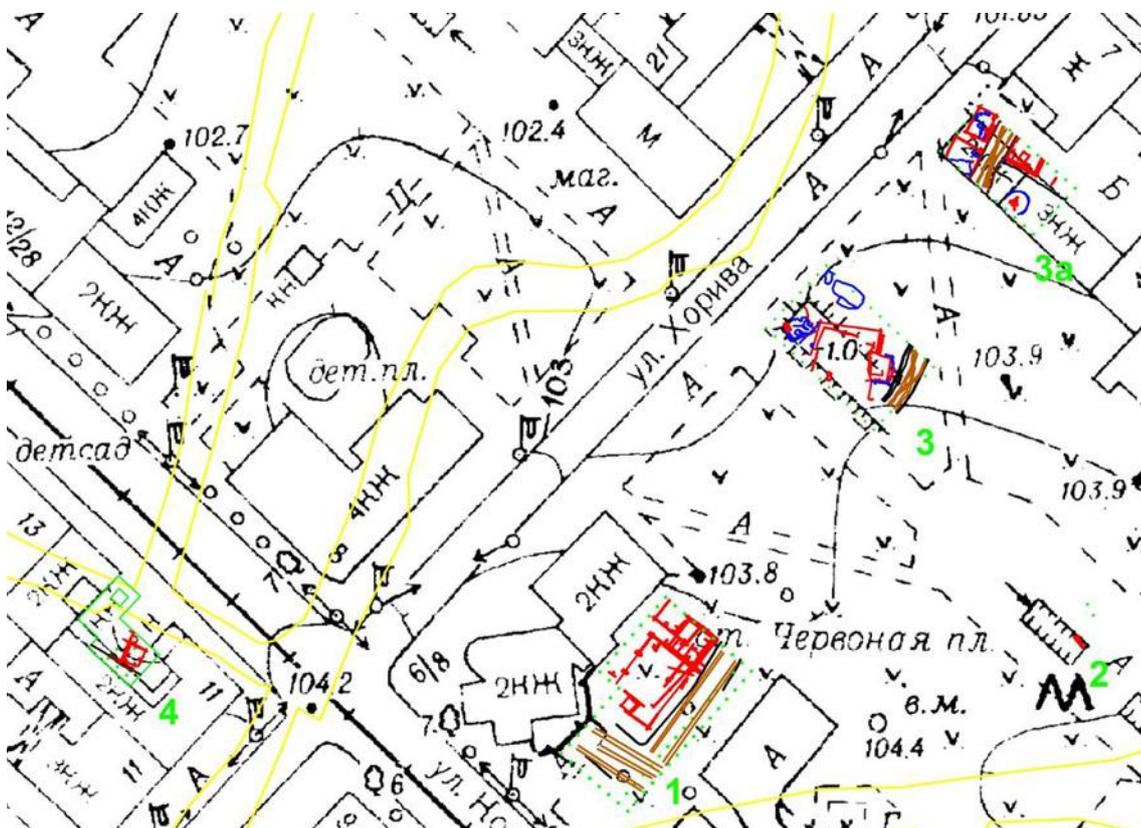


Fig. 15 – Fragment of digital map of the Kyiv Podil mass-building on a contemporary topographic map (Copyright S. P. Taranenko).

Green lines and dotted lines are the borders of the excavation-sites or the borders of the net of fixation. Red lines are the remains of wooden constructions. Brown lines mark the carriageway. Blue lines are the pits within the household complex of the homesteads. Black and brown lines are the fences. Sure, these colors may be changed. As one can see, the parts of the Ancient Rus street that were found at three excavation-sites are joined together. They are dating by X–second half of XII century.

Work with this map as with a new source provides lots of possibilities of the Podil investigation. Now we may analyze the Ancient Rus blocks starting from the homestead as a main building constant. This approach may

be useful for counting the number of homesteads in a different time (X, XI, XII, and XIII centuries) and the calculation of the approximate population number. In general, this map is the base of real scientific reconstruction of Kyiv Podil in X–XIII centuries.

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SESSIONS

Pre-Excavation Strategies

DATASCAPE

Survey and Data Integration in the Amstelland Atlas Project

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Abstract: Researchers of the Cultural Heritage Department of the Netherlands and Amsterdam City Archives are engaged in an interdisciplinary research project on the subject of Amstelland, the area south of the city of Amsterdam. In this project, the result of which will be a GIS-based atlas, an interdisciplinary approach to landscape is followed. The central theme of the Amstelland study is the interdependence of the city and its surroundings, the mutual influence of urban and rural landscapes over time. This article starts with a description of the main characteristics of the Amstelland territory. It is followed by some methodological remarks about the research project, which involves the integration of data from many different sources and historical periods and therefore can be characterized as a 'survey of surveys'. This multi-layered approach is demonstrated on the basis of analysis of both historic surveying and modern data about the archaeology and built heritage of the Ronde Hoep polder, one of the most remarkable landscape structures of the area.

The Amstelland Atlas Project aims to get a grip on landscape dynamics by constructing a multi-layered survey, in which the layers are interconnected. Therefore, it is necessary to evaluate historical knowledge by understanding that every layer of archaeological, archival or historical data, has gone through its own process of formation. Only by seeing through this process, a genuine understanding of this complex 'datascape' is possible.

Keywords: Amstelland, The Netherlands, urban and rural landscapes, peatland archaeology, Ronde Hoep polder.

In 2010, the Landscape Research Department of the Cultural Heritage Agency of the Netherlands was asked to conduct a research project of the Amstelland area, located to the south of Amsterdam. This request was the direct result of the publication of another landscape study by the department, which was aimed at the *Bretten* area, west of the centre of Amsterdam (ABRAHAMSE et al. 2010). This earlier study was carried out in close cooperation with Erik Schmitz, researcher at the Amsterdam City Archives, who also agreed to contribute to the Amstelland Atlas project. Both studies are conceived along the lines laid out in recent years by the development of the method of 'landscape biography'. The Amstelland Atlas project can take advantage of the experience of the Bretten area project, as well as the lessons learned from other recent research projects (see, for instance: NEEFJES et al. 2011). Landscape biography was developed to conduct interdisciplinary research of landscape, with the intention of integrating knowledge and putting research to the use of landscape management (for some more information about the method of landscape biography and its use in the Netherlands, see for instance: SPEK et al. 2006; ABRAHAMSE et al. 2008). The Amstelland Atlas is expected to be published in the autumn of 2012.

The Amstelland Area

Amstelland is not a clearly defined administrative region. Amstelland is the territory located to the south of the city of Amsterdam, in the municipalities of Amsterdam, Amstelveen, Uithoorn, Diemen, Ouder-Amstel, Abcoude and De Ronde Venen. It consists of a series of polders on both sides of the river Amstel, the basin of which lies in a rapidly urbanizing area (Fig. 1). Not only urbanization, but also the layout of new infrastructures, the changes in agriculture, such as the discontinuation and new use of farms, the increase in scale in agriculture and the development of new, man-made nature areas have caused radical changes in the landscape and will presumably keep on doing so in the future.



Fig. 1 – Recent aerial photograph of the Amstel area (copyright: Cultural Heritage Agency of the Netherlands).

Reclamation

Amstelland was first put to agricultural use during what is generally called 'The Great Reclamation' of the peat moors in the western part of the Netherlands, which took place in the Middle Ages, roughly during the 10th and 11th centuries. To make agriculture possible, the peat moors had to be drained by digging parallel ditches, usually at a more or less right angle to a river or other 'reclamation base' (Fig. 2). These ditches served for drainage and were property lines at the same time. The medieval landscape structure of elongated parcels is still visible in the parts of Amstelland that have an agricultural use and have not been built in.

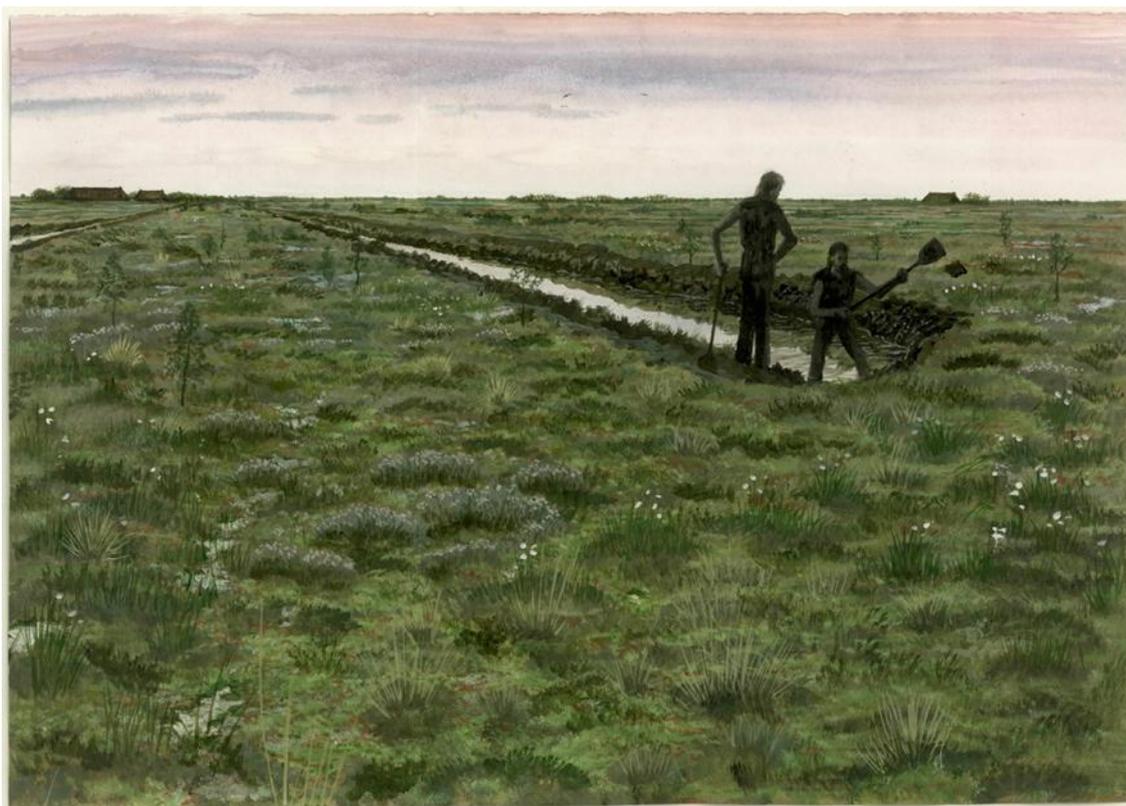


Fig. 2 – The grand-scale reclamation of the peat bogs in the western part of the Netherlands took place in the 10th and 11th centuries (copyright: Rob van Eerden).

From the moment these peat moors were drained, the soil started to sink, because of a process of oxydation and settling of the peaty underground. This process is constant and irreversible; as the soil sinks, deeper drainage is necessary for agriculture, which causes further settling and the need for ever deeper draining. This process resulted in the need for protection of the low-lying areas from flooding. As early as the 13th century, the Amstelland area had to be protected from flooding by building river and sea dikes around it. The dam in the river Amstel to which Amsterdam owes its name, was also built in this period as a part of the effort to preserve the costly agricultural land, which was the result of considerable investment over time, which also included the building of windmills. At first, individual farmers built their own small mills to be able to control the water levels on their lands. During the 16th and 17th centuries, this effort was taken over by waterboards and polder administrations, who built fewer but much larger windmills.

Urban Influence

Over time, the influence of the city over its periphery, and also over Amstelland, grew stronger. From the middle ages onwards, agricultural produce went to the city's markets. The rural economy was oriented on the demands of the ever growing city. Considerable tracts of agricultural land were owned by the citizens of Amsterdam or by urban institutions, such as convents, hospitals and orphanages. In the Dutch Golden Age, urban influence grew stronger over time. The city grew rapidly, from a small merchant town along the river Amstel in the late 16th century, to one of the largest cities in Europe, in the 1660s. Its built surface was multiplied by a factor of five during the 17th century (ABRAHAMSE 2011). Many rural estates were bought by Amsterdam residents (SCHMIDT 2011). Mansions along the rivers Amstel and others waterways were built and inhabited by Amsterdam merchants and regents. The building of mansions started during the first quarter of the 17th century, and took off after 1648, when the war against Spain came to an end. During the 18th century, even more mansions were built outside the city, in Amstelland as well as elsewhere. The river itself became a place of recreation. A yaught harbor was laid out before 1672 on the bank of the river, near the city's edge, and on summer days the Amstel must have been the place where many citizens went rowing and sailing.

Modern Urbanization

The urbanization that took place in Holland during the Golden Age, with Amsterdam as a culmination point, might have been stunning to both contemporaries as well as modern researchers, proved to be next to nothing when compared to 19th and 20th-century urban development. After a period of stagnation, Amsterdam started to grow rapidly from the 1870's onwards. Ever larger city extensions followed each other in rapid succession. The city's extensions of the 19th century were the result of private investment. From the early 20th century, the government played a prominent role in urban projects of an ever expanding scale. H.P. Berlage's Plan Zuid ("Plan South") was an urban design that in which monumental blocks and streets were the central elements. After the Second World War, modernist urbanism and road infrastructure took over. Amsterdam's General Extension Plan of 1935 (Fig. 3) led to the layout of huge, spacious districts, in which the traditional urban block was traded in for an open structure of freestanding buildings, surrounded by extensive public parks and gardens (JOLLES et al. 2003). Large sections of the farmlands in Amstelland were absorbed by the city of Amsterdam, with suburban communities, such as Amstelveen and Diemen, in its tracks.

Together and in close relation to the city's extension, the General Extension Plan provided for large green and recreation areas. Most of these were meticulously designed and planned and took the form of huge public parks. The Amstel river borders however, kept on being used as agricultural land. A few areas were designated for new nature areas, which have a profound impact on the open Amstelland landscape.

Over the past decades, Amstelland has become surrounded by huge urbanized areas. The overall surface area of the farmlands has decreased significantly. But besides this rapid urbanization at the borders, small-scale urbanization has had profound effects inside the area.

At the same time, the urban influence has become ever stronger. Farms and other agricultural complexes were transformed into or replaced by residential buildings, while most of the grounds kept being used for

agriculture. Only a small minority of the inhabitants of Amstelland is not dependent on work in the city. Amstelland as a whole has kept its rural character, but the areas along the main infrastructures, such as the river Amstel, have to a considerable extent changed into suburban housing areas and undergone a process of gentrification. The management of the farms that kept being in operation, has changed profoundly: in addition to the original agricultural activities, many farmers are engaged in recreational and educational activities. These creeping processes have been going on for decades now, and are no less influential than the city's extensions itself. When compared to the other green areas around the city, Amstelland over time has gotten some of the characteristics of space left over, of an unplanned peripheral zone. Because of the openness of the landscape, these small-scale changes tend to stand out.

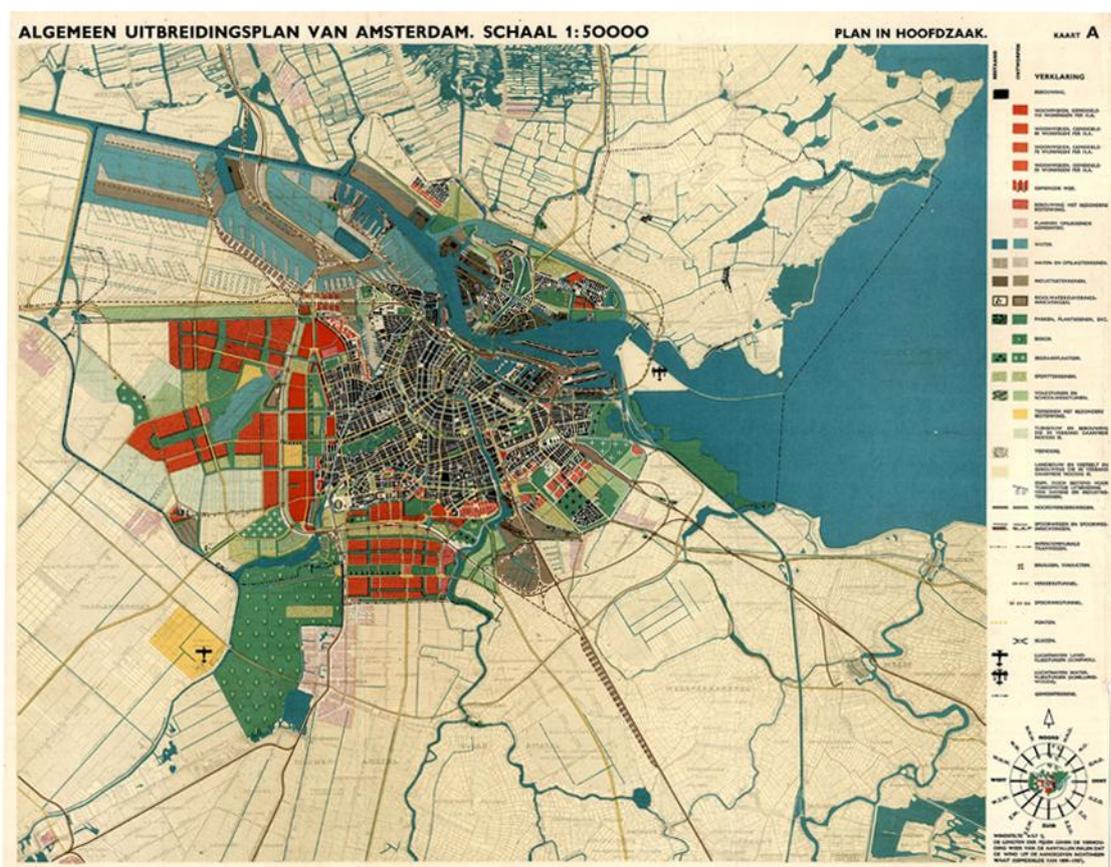


Fig. 3 – Cornelis van Eesteren's General Extension Plan of Amsterdam, 1935.

A Survey of Surveys

An atlas like the one that is being produced during the Amstelland project, is an attempt to describe and analyze the multi-layered and dynamic cultural landscape of the western part of the Netherlands, as it was formed and transformed constantly during the last millennium under the influence of man. Therefore, a chronological series of maps will be compiled on the basis of a GIS (geographical information system). These series of maps will be complemented with extensive explanatory notes and illustrations. The GIS system is made on the basis of landscape reconstructions from different periods, historical maps and landscape and urban history research. On the basis of this chronological series, another map is compiled

which contains an overview of the existing archaeological and built heritage and landscape structures. The combination of this heritage map with an overview of future plans for the area, gives insight in the potential future destruction and degradation of heritage and can contribute to landscape and urban planning (ABRAHAMSE et al. 2010).

Basically, a landscape study like the one of Amstelland that is in the making now, is an extensive survey of the area, based on recent literature and research of earlier archival documents. In a way, it is a survey of surveys, that reflects the making of the landscape by man and the archival records that have come down to us from various periods in history.



Fig. 4 – Manuscript map, drawn as a first topographical survey in the mid-19th century.

The Character of Survey

The character of these surveys has changed over time. From medieval times onwards, when the first settlers undertook to reclaim the wilderness in the west of the Netherlands, techniques were used to measure the uncultivated lands and divide them into regular parcels for agricultural use by the *locatores* of the landlords. Medieval cities were laid out according to plan, in the realisation of which surveyors were involved

(BOEREFIJN 2010). These early surveys have only scarcely come down to us in the form of archival material, but their results are visible on topographical maps from the 19th and 20th centuries and (partly) in the existing urban and rural landscapes (Fig. 4).

During early modern times, surveyors played an essential role in the great city extensions, such as the Amsterdam canal belt, but also in the lake drainage, polder and canal projects that were undertaken during the Dutch Golden Age.

But surveying was in no way limited to the planning and realization of urban and landscape projects. Before the emergence of the first modern cadastral registry maps, local public authorities and polder administrations had surveys made up for the purpose of property management and tax collection, while large landowners, especially religious and charitable urban institutions like convents, orphanages, hospitals and old men's homes, created extensive administrations as a means of managing their properties in and outside of the city. Often these include maps, that were in some cases assembled to make up atlases.

When regional planning and modern urbanism were introduced in the Amsterdam region in the early twentieth century, the concept of survey – the English word was also used in Dutch now – took on a new meaning. Modern planning was based on *tabula rasa*, empty space. The existing agricultural landscape and its regular, medieval structure disappeared under thick layers of sand. Before designing their world famous *General Extension Plan for Amsterdam* (1935), the urbanist Cornelis van Eesteren and his researcher Theodoor van Lohuizen carried out an extensive scientific research project, which generated all data judged necessary: population prognoses, land use data, and spatial demands for a range of urban functions. In this period, surveying was not only broadened, but it was also more integrated in the urban planning process.

Archaeological Surveys

Archaeological surveying of the area around Amsterdam has been conducted over the last decades. In the peatbog area of Waterland, north of the city, an overview of field surveys has been combined with historical research of field names in the late seventies and eighties, thus providing a multi-layered approach to settlement history (BOS 1988). In Amstelland, large-scale archaeological survey took place during the 1980s, as part of the Regional Archaeological Archiving Project, or RAAP (DATEMA 1987). An historical-geographical survey of Amstelland was conducted as a part of the restructuring of the agricultural area in the eighties (VERVLOET and MULDER 1983). Apart from this, the Diemen-North area, at the east of the city, was researched in the eighties and nineties by amateur archaeologists (WOLTERING 1988; BLOK et al. 2009). The Archaeological Service of the Municipality of Amsterdam carried out excavations in the hamlets of Oud-Diemen and Overdiemen (LAGERWEIJ and VEERKAMP 2009). To the west of the city, they excavated several sites in and around the mediaeval village of Sloten (BAART 1987; BAART 1989; BAART 1992). Apart from these surveys, many scattered archaeological observations were published. Since the signing of the Valletta Convention in 1992, archaeological research is linked to disturbances of *in situ* archaeological archives. This seems to have resulted in an approach that is guided by predictive cartography (which, by the way, is seldom up to date and often based on desktop research, and on observations that have not been related to geological and historical processes) and which is resulting in the collection of scattered and diverse data that hardly contribute to our understanding of formative processes of landscapes

and settlements. An extreme example of random data collection and subsequent misunderstanding and misinterpretation is to be found in the desktop research of the northern part of the Ronde Hoep (MULDER 2006; see also: DE BONT 2009: 562–565). Mulder comes to the conclusion that a large lake came into existence after the reclamation of the Ronde Hoep, only to be drained in the second half of the 18th century. This is in flagrant contradiction with any archival sources about the area.

After the decline of functionalist urban planning in the 1970s, the significance of historical data in our interaction with the cultural landscape has become stronger. In present-day planning, the concept of multi-layered cultural landscape has taken the place of *tabula rasa*. The concept of survey has become an even broader denotation. We might safely say that the type of research of Amstelland that is being conducted now, is an example of the next generation of survey, which aims at the integration of data about cultural landscapes, built heritage and archaeology, for both research as well as planning purposes.

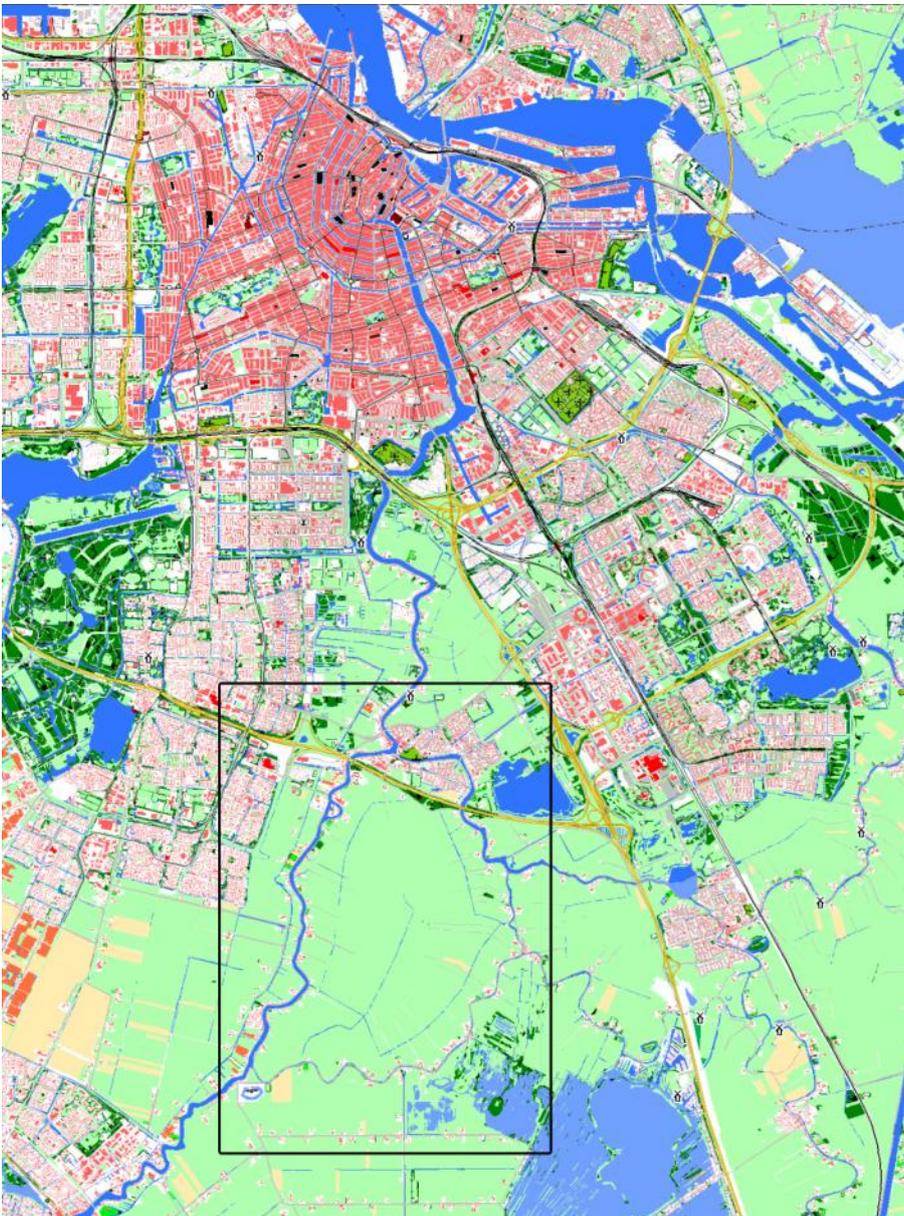


Fig. 5 – The Ronde Hoep Polder is located ca. 9 kilometers from the centre of Amsterdam.

The Archaeology of the Ronde Hoep Polder

A multi-layered approach can be demonstrated by the example of the Ronde Hoep Polder, a more or less egg-shaped grassland area, situated approximately nine kilometers from the centre of Amsterdam. Today, the Ronde Hoep is highly valued as an empty space: an open area in between urbanized areas (Fig. 5). Compared to Amstelland as a whole, its structure is largely untouched by modernisation or urbanization. Standing at the southern edge of the polder, one has panoramic views in all directions.

The Ronde Hoep, like the rest of Amstelland, was reclaimed during the tenth or early eleventh century. Its landscape structure is the result of more or less simultaneous reclamations from the east and the west sides, that were separated from each other by the 'meensloot' or 'common ditch' that basically cuts the polder in two even parts. The reclamation from the east, from the Waver river, is somewhat irregular compared to the western parts, which might point towards an earlier date of reclamation. The western part seems to have been a part of a larger reclamation that was carried out on both sides of the river Amstel.



Fig. 6 – The wedge-shaped part of the Ronde Hoep Polder opposite to the village of Ouderkerk (copyright: Paul Paris).

The noticeable wedge-shaped structure of the parcels on the northern side (Fig. 6) is no more a coincidence than the structure of the other parts. It is located opposite to the mediaeval settlement of Ouderkerk, the site of the oldest known church of the whole of the Amstelland area (VAN DER WAALS and VAN REGTEREN ALTENA 1961; NUMAN 2005: 41–42, 162–163) and also the residence of the Van Amstel family. The first Van Amstel, Wolfgerus, was mentioned as early as the year 1105. He was a *ministerialis* of the Bishop of Utrecht, and probably supervised reclamations of parts of the area, and also was the representative of the Bishop in the judicial sense.

From ca. 1500 onwards, the city of Amsterdam started to extend its influence over this region, first by reorganizing the drainage in 1525 and then by buying the seigniorial rights from the Count of Brederode in 1529 (SMITH 1939: 81–82).

One of the oldest maps showing the Ronde Hoep Polder dates from 1555 (Fig. 7). The area is marked by two cows – cattle farming was the main agricultural activity at the time. The map was drawn up to serve in a judicial case about the turnip and hemp tithes, which was the result of a conflict between the Kapittel van Sint Marie (St. Mary's Chapter) in Utrecht and the City of Amsterdam, as the legal successor of Reinout, Count of Brederode (BAKKER and SCHMITZ 2007: 83–84). In itself, this indicates a shift in the balance of power in the Amstelland region, where the city not only takes the place of the nobility, but right away gets into conflict with another powerful party from an already waning era.

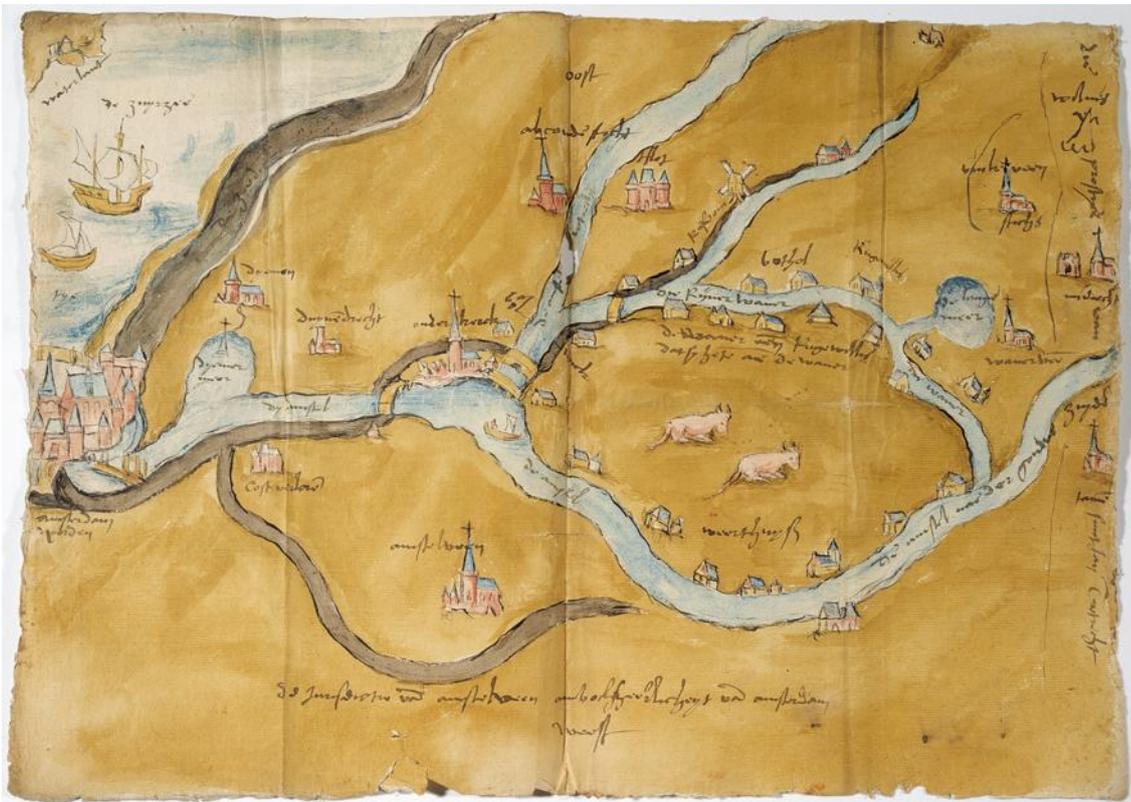


Fig. 7 – Map of Amstelland, 1555. The city of Amsterdam, in the north, is on the left edge (copyright: Stadsarchief Dordrecht/DiEP).

In 1637, it became necessary to reorganize the drainage system of the Ronde Hoep polder. At that time, every farmer had to rely on his own small windmill for drainage, numbering 36 in total. Three new big

windmills were built, large ditches were dug, and the dikes along the rivers were raised (BORDING 1983). This involved city-based knowledge and financing and the involvement of modern surveying techniques. The 1640 survey consisted of a map and an accompanying register by surveyors Lucas de Hoij and Steven Pauw. The map is kept at the archives of the Amstelland waterboard, whereas the register is at the archive of the Amsterdam Hospitals, at the City Archives. Better drainage aimed at raising the production of dairy farms, which produced milk, butter and cheese for the expanding city. During this time, Amsterdam institutions, like the Hospitals, built modern farms to add value to their property of agricultural lands. The 1640 survey provides a list of all landowners in de Ronde Hoep polder. We can use these data in two other ways: to look back and forward in time (Fig. 8).



Fig. 8 – Map of the Ronde Hoep Polder, 1640. The north is at the left. Land owned by Amsterdam citizens is marked in red, land owned by urban institutions in green, and by a citizen of Dordrecht in yellow (color indications were added for this article).

Looking backwards, land owned by the city of Amsterdam stems from the 1529 overtaking of the seigniorial possessions of Reinout van Brederode. As we have seen, this indicated a shift from noble to civil powers shaping the countryside. The land owned by the Amsterdam Hospitals was originally owned by monasteries and secularized in 1578, along with all other ecclesiastical properties. In some cases, linking Hospital property to convent property extends our historical scope to the beginning of the fifteenth century (Fig. 9). Looking forward in time, the 1640 survey can also be used to follow the changes in landownership up to the present time.

We can also link the 1640 survey to modern data. For instance, we can take a look at the list of protected monuments. The Ronde Hoep polder contains a number of listed buildings. Two 16th–17th century farms are

situated on land formerly owned by Amsterdam institutions (Fig. 10). One of them was supposedly built as a part of the 17th-century farm building scheme by the Amsterdam Hospitals (Fig. 11), one other might. Since these institutions took good care of their built property over time, it is not so surprising that these farms made it to the heritage lists. These modern heritage lists in themselves are a reflection of a historical process.



Fig. 9 – Charter from 1418. Jan Eggert, lord of Purmerend, grants the Amsterdam Old Nunnery Convent 9 ½ *morgen* land in *Jan Betten zate* ('the seat of Jan Betten') and the half part of a house and yard on this property. This land can be localized in the northern part of the Ronde Hoep, opposite the village of Ouderkerk, and was later owned by the Amsterdam Hospitals, indicated in green on Fig. 7 (copyright: Amsterdam City Archives).



Fig. 10 – Map showing city-based landownership in the Ronde Hoep Polder in 1640 (cf. Fig. 8) and protected monuments in 2011. Farms are indicated separately (copyright: Menne Kosian/Cultural Heritage Agency of the Netherlands).



Fig. 11 – 17th-century farm built by the Amsterdam Hospitals, today a listed monument (copyright: Erik Schmitz).

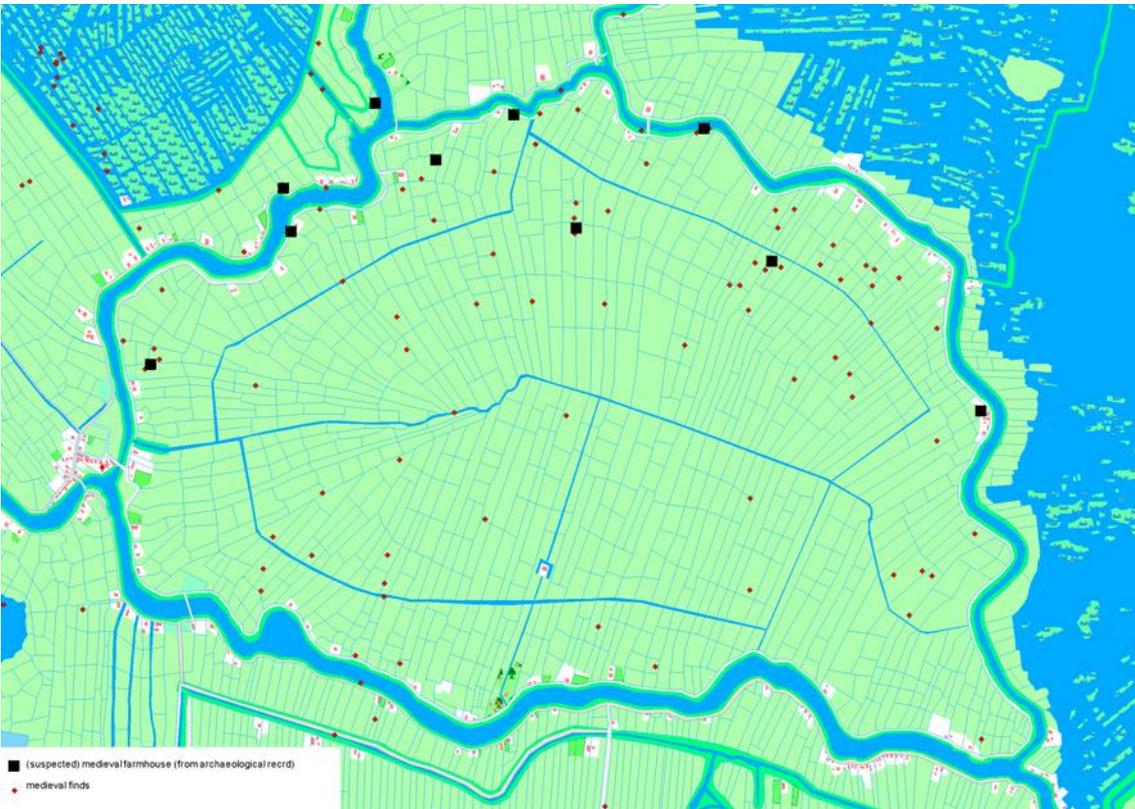


Fig. 12 – Archaeological finds in the Ronde Hoep Polder and surroundings (copyright: Menne Kosian/Cultural Heritage Agency of the Netherlands).

Another example of the layering of data involves modern archaeological surveying. In the 1980s the Amstelland area was archaeologically surveyed by the RAAP project. The overall conclusion was that Amstelland is a relatively empty area. Most of the evidence of mediaeval habitation lies hidden under farmsteads dating from a later age and also close to and under the river dikes. If we take a look at the archaeological data from the Ronde Hoep polder, we see in the eastern part more developed river banks, causing a pattern of shifting dikes and dike roads and more dispersed finds. In the west, the river banks are much smaller. There, traces of mediaeval occupation are likely to be hidden under the dikes and later farmsteads (Fig. 12). Two excavations show that this is the case. The first example is located on the opposite bank of the river Bullewijk, at the north-east of the Ronde Hoep polder. During the rebuilding of the front part of a farm called “De Leerspiegel” in 1986, mediaeval floor layers and a hearthplace were discovered. They were situated under the dwelling space of the farm, close to the river dike. Occupation seems to have started in the 12th century (DATEMA 1988). The farm was listed as a monument of national importance, and has curiously remained so even after demolition and reconstruction (Fig. 13).



Fig. 13 – The farm “De Leerspiegel”. Its situation right next to the river dike is an indication of the old age of this farmyard (copyright: Cultural Heritage Agency of the Netherlands).

The second example is an excavation by the Archaeological Service of the Municipality of Amsterdam in the hamlet of Overdiemen, along the river Diem, in 1992. At the site of a farmstead that was abandoned in the 18th century, traces of mediaeval habitations were came to light (Fig 14). The oldest farm at this site was

situated on the river bank. Only the rear part could be excavated; the remaining part was located under the river dike. Two pieces of construction wood from the building were dated to the year 1033 by dendrochronology (LAGERWEIJ and VEERKAMP 2009: 66). This is actually one of the oldest traces of reclamation activities in the Amsterdam area.



Fig. 14 – Excavation of an 11th–12th-century site close to the Diem river dike (copyright: BMA Amsterdam/Wiard Krook).

The results of the R.A.A.P. archaeological survey and the above-mentioned excavations were not taken into consideration prior to large-scale dike reinforcements in the Amstelland area. Relatively small, steep dikes were covered by much broader, gently sloping dikes. In this process, much of the archaeological records were either destroyed by the digging of new ditches along the land sides of the new dikes (Fig. 15), or covered by the new dikes themselves (Fig. 16). The replacement of farm buildings by villas or other new buildings proved another destructive force in the archaeology of Amstelland. Short time memory loss has caused long time memory loss. The Ronde Hoep is rapidly turned into an empty space, not only as a landscape to the unsuspecting visitor, but also in an archaeological sense. *Tabula rasa* was abandoned as a planning doctrine, but it remains an imminent threat because of the erosion of archaeological and historical data.

The Amstelland Atlas Project aims to get a grip on the landscape by constructing a multi-layered survey. It is necessary to evaluate historical knowledge by understanding that every layer of archaeological, archival or historical data, has gone through its own process of formation. Only by seeing through this process, a genuine understanding of this complex datascape of interconnected layers is possible.



Fig. 15 – Section of a mediaeval farmstead during dike reinforcement. At the top left we can see the destruction of mediaeval habitation layers by a newly dug dike ditch. The protruding wood in the center indicates the rear part of a farm and was dated to the year 1033 (copyright: BMA Amsterdam/Wiard Krook).



Fig. 16 – Dike works at the south side of the Ronde Hoep Polder, 1987 (copyright: Erik Schmitz).



Fig. 17 – The Ronde Hoep Polder seen from its southern edge (2011) (copyright: Erik Schmitz).

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Archaeological predictive model of an urban area. The study case of Pisa, Italy

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Abstract: The Department of Archaeological Science of the University of Pisa is undertaking a research project aimed at the creation of a predictive model for urban areas. The case study is the town of Pisa, but the aim is to realize a replicable model useful for similar urban areas. Through the use of spatial and geostatistical analysis, the cooperation with geologists to analyse the ancient surrounding environment and with mathematicians to elaborate a specific algorithm, we want to realize an Archaeological Information System able to define the specific nature of archaeological practice. Pisa's AIS was developed to manage heterogeneous data, which draw the urban archaeological complexity, and to develop effective predictive tools, working on an intermediate scale which allows to analyse how the geographic space has influenced the economic, political and logistic choices. This has led to the need to work with both topographical (geomorphologic, hydrographical, toponymic data, etc.) and urban data (archaeological stratifications, buildings, road network, hypotheses of historians and archaeologists, etc.), combining inter-site analysis and archaeological excavation GIS' resources. To combine multi-temporal and multi-scale data, it was necessary to provide for digital data conversion and georeferencing of archaeological excavation data acquired at different times and different scales and the integration and overlap of data obtained with different techniques and diverse topographical reliability and precision. The particular attention to the aspect of management of the archaeological raw data, that is all the excavation and fieldwork recording (planning of context, context recording sheet, photographs, findings quantification sheet), suggested the necessity to realize an open digital archive and to provide possible standardization of digital formats, metadata records and archaeological data recording, so as to allow the comparison between the data.

Keywords: Predictive archaeology, open digital archive, urban area, algorithm.

MAPPA project: Methodologies Applied to Archaeological Potential Predictivity

Introduction

Like many other Italian cities, Pisa (Italy) is a settlement that goes well back into history, so it's an excellent case study. Its subsurface conceals the remains of walls, floors, tombs and roads, as well as the fragments of tiles, vases, lamps and sculptures: briefly, the more or less solid traces of the lives of the people who have inhabited the city over its almost three thousand years of history. By studying the city's archaeological artefacts and its pollen, coal and human/animal bone remains and by analysing the area's geological and geomorphological features and its resources, it is possible to reconstruct the landscape, or better the landscapes, that have evolved over time and have influenced the city's economic and cultural development, and in turn have been influenced by them.

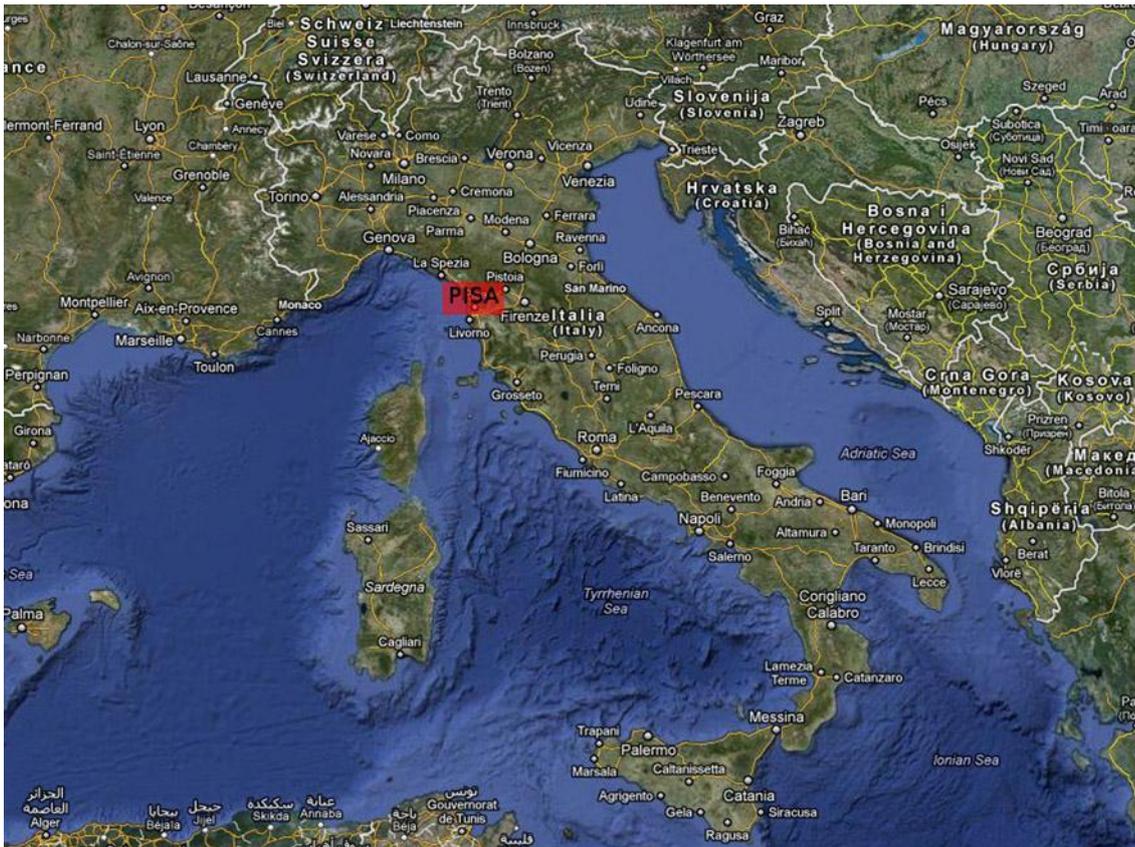


Fig. 1 – Pisa, Italy (copyright MappaProject – Università di Pisa from Google Maps).

The ground on which we walk, build and live today is an extraordinary palimpsest where uncountable traces that have been left by our predecessors evolve, merge and overlap. Yet since these traces lie under the ground, the vitally important needs of the city's life and development need to be taken into account: safeguarding archaeological heritage does not mean fighting development, on the contrary, sustainable management models should be proposed and solutions should be studied which do not simply safeguard but enhance archaeological heritage in terms of cultural enrichment and of further development of the supply of tourism services. They should also aim to recover technological experience and rediscover traditions and trades which could be extremely helpful to today's community. As a consequence of the entry into force of the Law on preventive archaeology (Italian Legislative Decree 195/2006), evaluating archaeological potential has finally become a key issue. It guides operational decisions during work on sites involving construction or environmental transformation: knowledge of the area's archaeological potential allows the authorities responsible for protecting the territory (Superintendencies) and for planning its development (Municipalities, Provinces and Regions) to provide more knowledgeable opinions and to immediately inform the interested persons on the chances of finding buried remains during excavations. This can all be done before opening the building site, without stopping the building works or definitely blocking any projects already under way. The Map of Archaeological Potential is an answer to the problem of finding appropriate tools for making archaeological research demands coexist with present day and future needs. The map stems from the common archaeological map and combines archaeological-historical information with data resulting from geological and geophysical surveying and prospecting, geomorphologic reconstructions, historical mapping

and registers, toponymic data, and analysis of urban construction elements. Further processing, carried out on the basis of coded interpretative models, will allow us to make assumptions on the greater or lower chance of archaeological remains in areas of which we have no existing information today. In other words, the map is a predictive map. Evaluation of the possibility that certain areas may conceal archaeological remains of which we have no news is achieved by projecting knowledge regarding neighbouring areas on them, with a degree of approximation that varies according to the quantity and quality of data available. It can be said, therefore, that the Map of Archaeological Potential is a new-generation tool that helps gain knowledge of the local area and whose advantages cover many scopes of application. A further aspect must not be underestimated: the creation of a Map of Archaeological Potential is not only a vital tool to learn and safeguard archaeological heritage and to fully enhance its resources; it is also the first step to raising new collective awareness of the importance of becoming familiar with this heritage, which is imperative to any kind of archaeological protection.

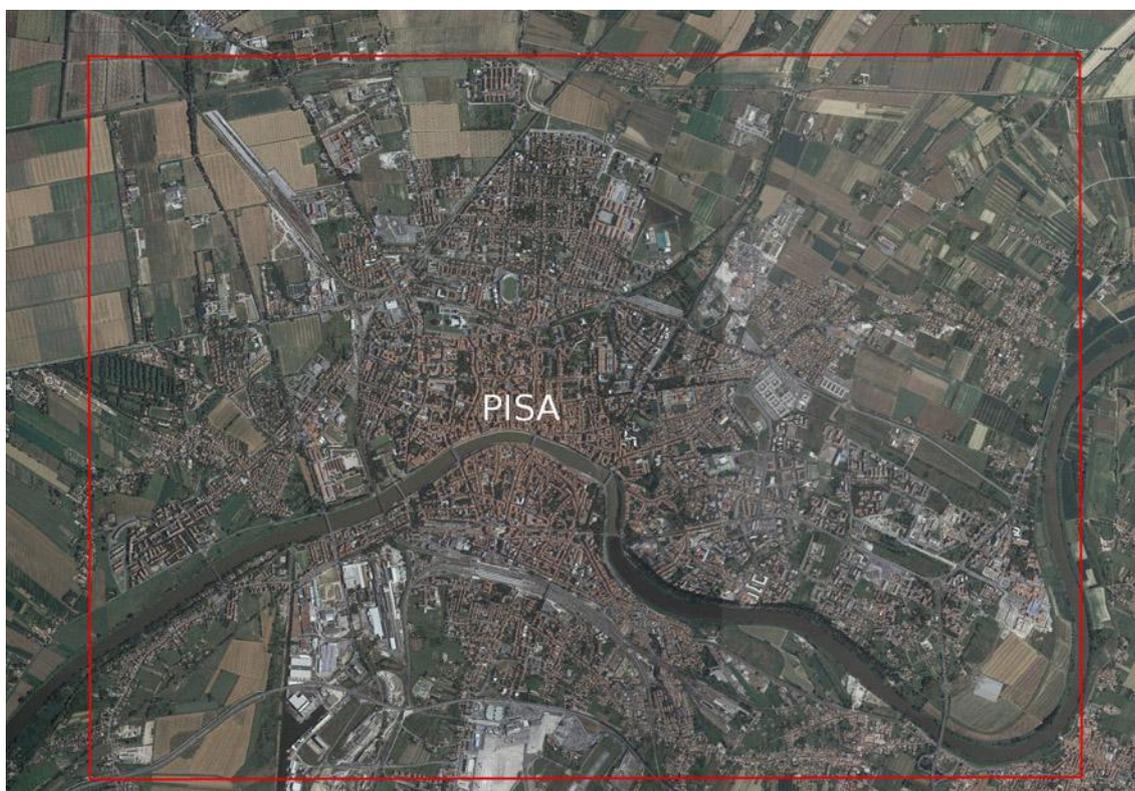


Fig. 2 – The red rectangle define a 32 square kilometers area around the urban center of Pisa, Italy (copyright MappaProject – Università di Pisa).

The project

The project started on July 2011 and will end on June 2013 and it's being carried out by the Dipartimento di Scienze Archeologiche (Department of Archaeological Sciences), the Dipartimento di Scienze della Terra (Department of Earth Sciences), the Dipartimento di Matematica (Department of Mathematics) with the external collaboration of the Direzione Regionale per i Beni Culturali e Paesaggistici della Toscana (Regional Directorate for Cultural and Landscape Heritage of Tuscany), of the Soprintendenza per i Beni Archeologici

della Toscana (Superintendency for Archaeological Heritage of Tuscany), of the Soprintendenza per i Beni Architettonici, Paesaggistici, Artistici ed Etnoantropologici per le Province di Pisa e Livorno (Superintendency for Architectural, Landscape and Ethno-anthropological Heritage for the Provinces of Pisa and Livorno), of the Comune di Pisa (Municipality of Pisa), of the Istituto Nazionale di Geofisica e Vulcanologia (National Institute of Geophysics and Vulcanology), of the Aerofototeca Nazionale (National Aerial Photograph Archive), of the Laboratorio di cultura Digitale – CISIAU Centro Interdipartimentale di Servizi Informatici per l'Area Umanistica (Digital Culture Laboratory – CISIAU Interdepartmental Centre of Information Services for the Humanities).

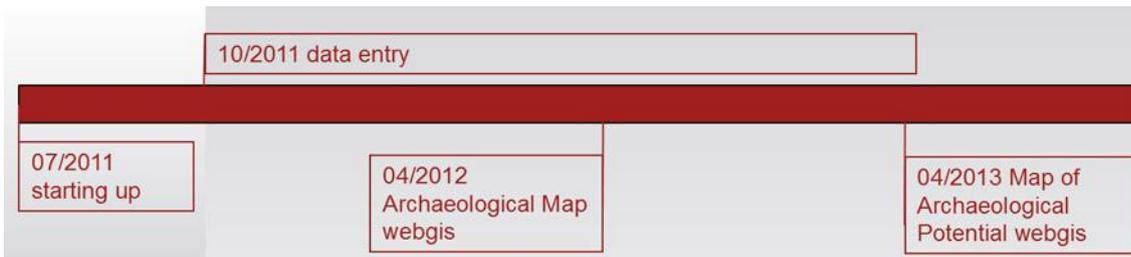


Fig. 3 – The Mappa project timeline: the project started on July 2011 and it will end on June 2013 (copyright MappaProject – Università di Pisa).

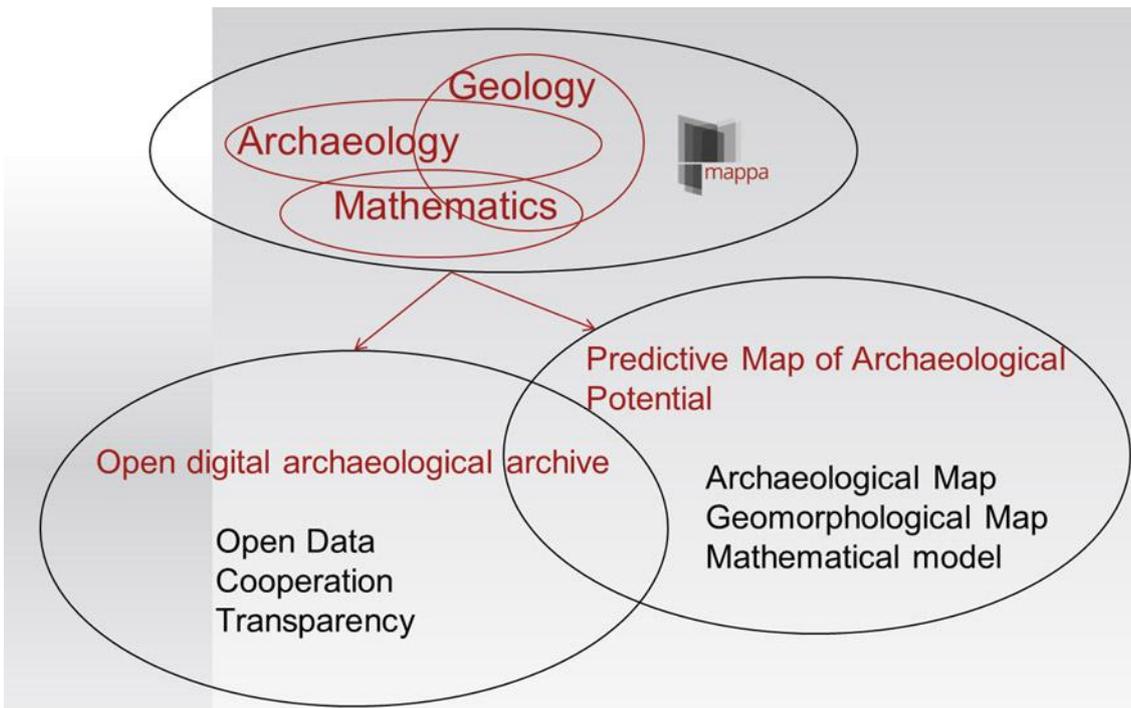


Fig. 4 – Archaeologists, geologists, mathematicians: a dynamic group of researchers who are convinced that a multi-disciplinary approach and free access to knowledge can propel innovation and research development (copyright MappaProject – Università di Pisa).

Unlike famous international examples, research dealing with these problems and their focal issues is highly disadvantaged in Italy. Although many projects have been funded over the past years regarding the introduction of highly advanced technologies, a common and systematic multi-disciplinary approach has not

yet been developed which aims at "managing" buried archaeological heritage in terms of planning and safeguarding. The project intends to achieve the following objectives:

- ▶ Enhancing the development and research of archaeology by fostering collaboration with experts from different research sectors (earth sciences and mathematics). By developing a common language and observing from different perspectives, the project will especially aim at achieving a methodological development of the issues tackled in the project and at increasing the progress and competitiveness of the individual disciplinary sectors. Within this context, we seek to develop and test predictive mathematical models applied to archaeology which will have a social impact in terms of archaeological heritage protection, territorial planning and historical knowledge.
- ▶ Creating a repeatable model that may be applied to all multi-layered urban centres in order to facilitate land use decisions regarding archaeological heritage management and protection issues. This will mitigate impact on heritage and promote the sustainability of territorial planning processes. We firmly believe that university research must be at the service of civil society and provide its results in the form of exploitable tools, with effects both on citizens and on cultural heritage.
- ▶ Providing a standardised protocol of Operational Guidelines, drawn up with measurable and repeatable criteria. A further objective consists in providing local governmental and protection institutions with an integrated "package" that will make urban planning easier during the planning phases and optimise both financial resources and implementation time. The system also represents a valid tool for supporting private development projects since it facilitates archaeological impact assessment procedures and safeguards cultural heritage.
- ▶ Creating a standardised, digital and user-friendly (i.e. open data) archaeological data archiving model, which may be applied to all Tuscan and Italian urban contexts after it has been tested on samples in Pisa. The implementation of a system such as this (the only one in the country to date) will promote the communication and diffusion of the research results and the direct transfer of technological innovation via web.
- ▶ Training and professionally qualifying new R&D experts with a multi-disciplinary approach in order to develop a competitive system model. We aim to create new experts with strong specific skills but at the same time capable of speaking a common inter-disciplinary language. We firmly believe that this is a qualifying element for the professions involved in the project and for the development of a knowledge-based society that is capable of integrating topics that differ by scientific approach and method, and of developing a highly competitive system model.
- ▶ Pisa has a very special environmental context, characterised by numerous watercourses and wetlands which have frequently changed over the centuries and significantly altered the territory. For this reason, we believe that a detailed geomorphological reconstruction is of vital importance, especially with regard to the diachronic migration of natural watercourses in the urban area and identification of the artificial canals connected to them. Furthermore, it will help us interpret the dynamics of urban settlement over various historical periods (ANICHINI et al. 2011a).

The data model

MAPPA Data Model is developed to manage heterogeneous data, which drawn the urban archaeological complexity, and to develop effective predictive tools. This has led to the need to work with both topographical (geomorphologic, hydrographical, toponymic data, etc.) and urban data (archaeological stratifications, buildings, road network, hypotheses of historians and archaeologists, etc.), combining inter-site analysis and archaeological excavation GIS resources.

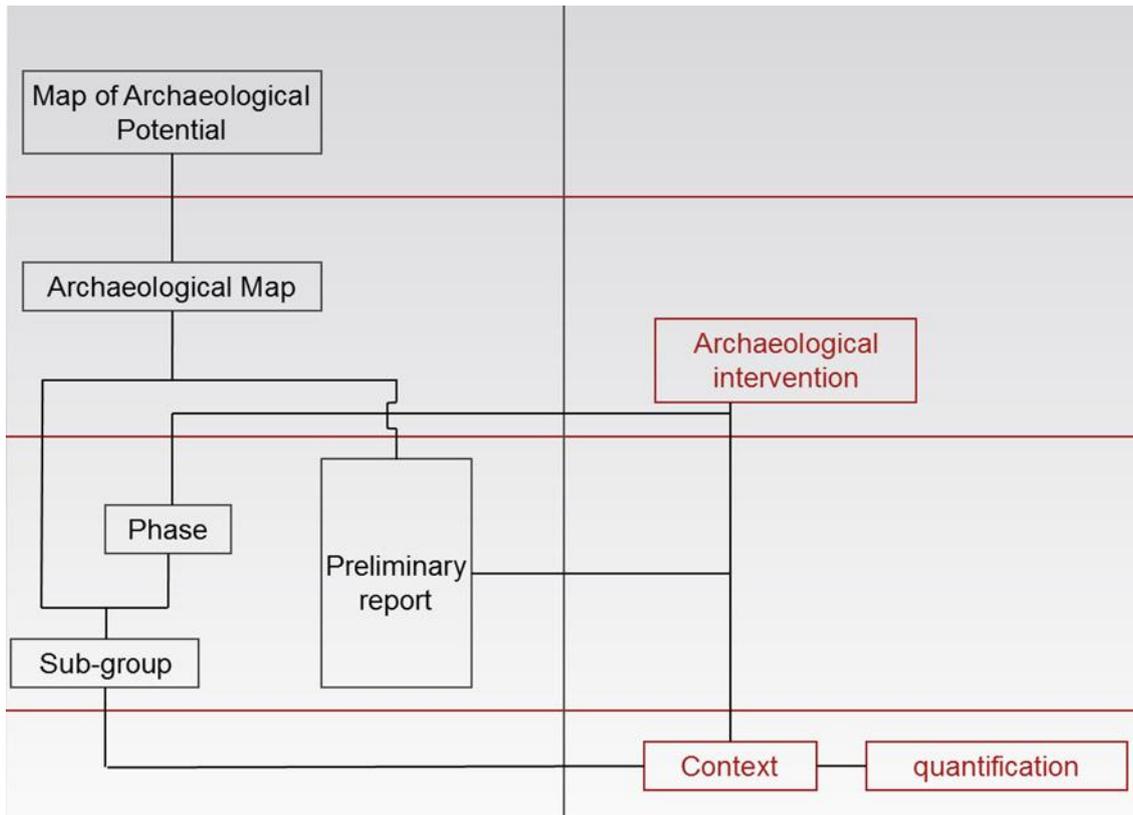


Fig. 5 – The 4 level archaeological data model (copyright MappaProject – Università di Pisa).

The archaeological data model is a 4 level model which combine raw data and interpreted data. The model goes from less synthetic data (i.e. the context level) to the more synthetic data. This model suits the Relational DataBase Management System and the GIS Geodatabase. The centre of the model is the archaeological intervention. To enable proper processing queries, it's necessary a comprehensive geographical and archaeological data entry, according to a consistent use of geometric primitives for reproducing vector objects. As a general principle it was decided to use polygons for georeferencing all data location. Archaeological excavation data entry was based to the principles of archaeological stratigraphy, archaeological plans coming from a complete archaeological dataset or from a partial archaeological dataset have been addressed through an identical graphical representation, but using different files. Deposits and cuts are drawn as polygon, symbols as line.

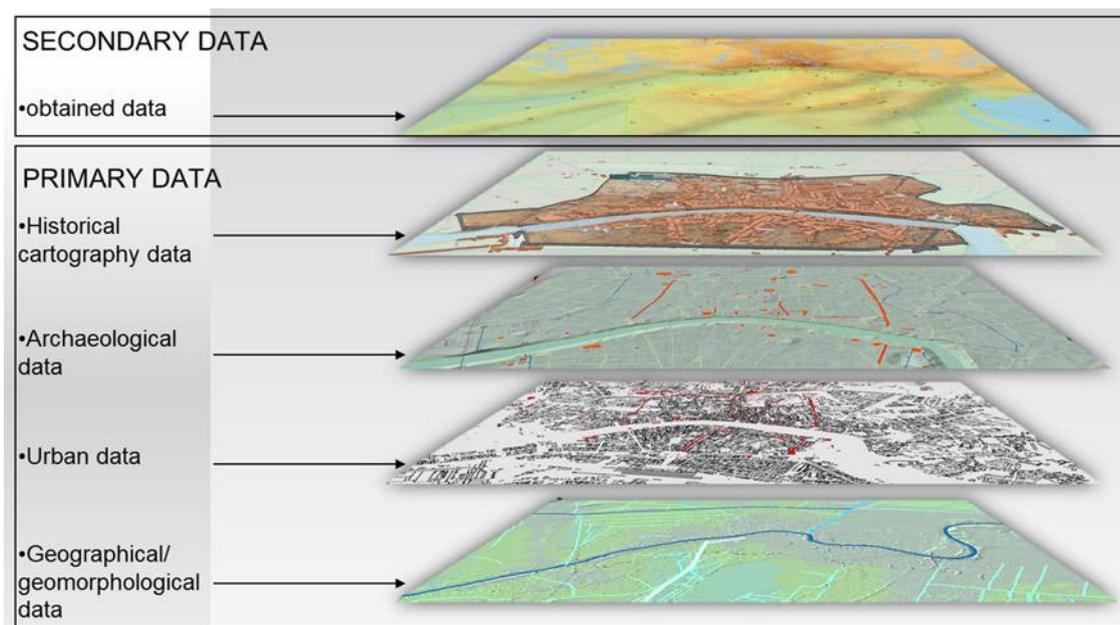


Fig. 6 – To summarize the model includes: geographical/geomorphological data; urban data; historical cartography data; all archaeological data from occasional findings to stratigraphical excavations; obtained or secondary data (copyright MappaProject – Università di Pisa).

The Data model also includes:

- ▶ filing of published data, of archive data and of data resulting from building archaeology, and data georeferencing and vectorisation in order to understand urban fabric development and the level of architectural heritage preservation;
- ▶ the collection of written, published documentary sources with the aim to locate no longer existing place names, production activities, infrastructures and topographic structures;
- ▶ the computerised acquisition of historical mapping to trace urban transformation throughout the modern and contemporary ages;
- ▶ finally, mapping of stratigraphic gaps by recording the thick network of underground environments including cellars, garages, cisterns, basement areas, underground services, as well as the portions already subject to archaeological excavations which have led to the removal of stratigraphic deposits.

Definition of Archaeological Potential

The archaeological potential of an area represents the possibilities that a more or less significant archaeological stratification is preserved. Archaeological potential is calculated by analysing and studying a series of historical-archaeological and paleo-environmental data retrieved from various sources, with a degree of approximation that may vary according to the quantity and quality of the data provided and their spatial and contextual relationships. The archaeological potential of an area is, in itself, a factor independent of any other following intervention that is carried out, which must be regarded as a contingent risk factor. The process for defining overall urban archaeological potential consists in drawing up a series of predictive maps relating to the city's historical periods. For this reason, the parameters required for the predictive definition of the city throughout its historical periods had to be defined to begin with, followed by the parameters needed

for calculating the archaeological potential. This phase of the process required the contribution of the different disciplines involved in the project. In terms of subsurface geology, the criteria for determining the parameters for the predictive definition of the city throughout its historical periods basically refers to the distinction between river channel areas and extra-channel areas. The latter include wetlands and (dry) floodplain areas, in a broad sense. Paleo-depositional reconstruction of the uppermost subsurface, through *facies* analysis of a series of stratigraphic sections, will consequently allow the areas crossed by channels (prevailing lithology: sand), marshes (prevailing lithology: organic lime and clay with low consistency, peat and sand) and dry floodplain areas (prevailing lithology: consistent lime and clay, interrupted locally by thin sand layers) to be distinguished. The different settlement potential that these areas and their relations represent throughout the various periods helps predict the probable presence of settlements. This general criterion is applicable to all the stratigraphic intervals that we will be able to reconstruct, and must naturally be integrated with both archaeological and geomorphological data: geological maps define stratigraphic units and sedimentary bodies, geomorphological maps show relief forms and define the geomorphic processes responsible for their genesis, in addition to recent modifications. In order to define the values of archaeological potential on the basis of geomorphological data, therefore, it is necessary to understand, together with the archaeologists, the settlement criteria for a certain area during the various cultural phases. Generally speaking, each morphological unit (or morphotype) can be more or less suitable for settlements. Indeed, certain 'cultures' prefer wetlands, others favour flat areas, while others have a preference for topographic summits. Geomorphological surveying, therefore, must be based on a detailed definition of the morphological units of the current landscape and on the identification of their spatial position. Particular attention must be given to their extension in order to outline their limits with relative accuracy. Subsequently, with the help of stratigraphic data regarding the uppermost subsurface, the diachronic evolution of the forms must be characterised. A distinction must be made particularly for cases presenting:

- ▶ continuity, over time, of geomorphic processes, yet spatial variation of forms (e.g. river processes continue to prevail yet the position of the riverbeds changes);
- ▶ geomorphic processes that follow on from the previous due to climatic modifications and/or crustal dynamics (e.g. marshes transformed into lagoons due to coseismic subsidence);
- ▶ geomorphic processes that commence or end by human intervention throughout the territory (e.g. deforestation, reclamation, etc.).

Determination of the criteria for a geomorphological-based predictive definition must also take into account the limits of paleo-topographic reconstruction connected to the compacting of sediments and to subsidence, which tend to reduce the differences in height between the morphological units. It must also be different for each historical period and strictly relate to the archaeological data.

In archaeological terms, the following parameters will be taken into consideration for the predictive definition of the city throughout its historical periods:

- ▶ typology of finds, inferred on the basis of the interpretation of the archaeological records appropriately standardised in categories;
- ▶ quality and quantity of the archaeological data;
- ▶ spatial relations between the finds, which allow identification in probabilistic terms of the presence of further finds in areas that have not been archaeologically investigated;

- ▶ typological relations between the finds, which allow identification in probabilistic terms of the presence of further finds in areas that have not been archaeologically investigated;
- ▶ expert judgment: the experience of experts will be a useful tool for determining the possible existence of archaeological remains since their statistic and mathematical evaluation will use knowledge which would otherwise be difficult to manage.
- ▶ land use: it is important to consider all anthropic traces – including traces that are not strictly connected to constructions or settlements, such as agricultural and/or farming practices – and to assign a different parametric value to them.
- ▶ historical data from written sources and maps, thanks to which it is possible to reconstruct the city environment, both in the presence and (especially) absence of archaeological records.

The final phase of analysis focused on defining the overall parameters that best determine urban archaeological potential and are based on a period predictive model. The following parameters were identified:

- ▶ type of settlement: the presence of settlement structures and their different typology directly contribute to determining the level of archaeological potential;
- ▶ density of settlement: the topographic concentration of the settlement directly contributes to determining the level of archaeological potential;
- ▶ multi-layering of deposits: the greater or lesser archaeological diachrony directly influences the level of archaeological potential;
- ▶ removable or non-removable nature of the archaeological deposit: the presence of a deposit that cannot be removed has a direct impact on the level of archaeological potential;
- ▶ degree of preservation of the deposit: calculated according to the presence of anthropic and natural removals and, therefore, to the presence of documented stratigraphic gaps, it directly influences the level of archaeological potential;
- ▶ depth of the deposit: this is a controversial parameter and its use alongside the other parameters mentioned above will be evaluated during the course of the project. We are quite aware that this is a highly risky issue because it appears to be strictly related to the contingency aspects of the project execution and could be confused with the calculation of archaeological risk. Instead, the parameter that will be measured is related to whether the deposit is superficial or not and to the higher or lower possibilities of it being intercepted. The depth at which we expect an archaeological deposit to be preserved could represent a valid parameter within a decision-making tool. Consequently, the depth of the deposits could inversely have an impact on the level of archaeological potential (ANICHINI et al. 2011b).

The Page Rank model

The few examples of existing Maps of Archaeological Potential are based on the statistical analysis of known data from which predictive data on archaeological potential are inferred non-empirically and non-systematically. Highly advanced mathematical theories, which are mature enough to significantly contribute in areas commonly considered as falling outside their scope of application, have never been used or have been unjustifiably used so far in many research sectors (especially in the field of historical-archaeological

studies). This is also due to the general difficulty of communication between experts belonging to different disciplinary areas and, consequently, to the scarce amount of inter-disciplinary research activities. One of the approaches used in literature (probably the simplest) to predict archaeological potential consists of a predictive model capable of generating a decision rule. The input needed to determine this rule may be, for instance, land configuration (plain/slope), the presence of nearby water sources or soil type. Variants to this approach may include assigning 'weights' to the different conditions, so that more importance is given to some conditions and less to others. At the same time, significance tests may be used to evaluate whether the proposed predictive model may be associated to the presence of archaeological sites within a certain confidence interval (CUMMING 1997; WHEATLEY and GILLINGS 2002). Models based on these rules are very easy to implement; however, they provide on/off results – for example, the presence or absence of an archaeological site – and do not go further than simply juxtaposing a number of easy rules. In other words, they do not exploit the power of a mathematical model or the computing capabilities of a computer. Literature also provides another approach for determining archaeological potential (WHEATLEY and GILLINGS 2002), based on the application of linear (or logistic) regression. This approach arises from the need to reply to questions that the above-described method cannot answer. For instance:

- ▶ How can a predictor influence the model?
- ▶ How can *continuous* quantities instead of discrete quantities be predicted?

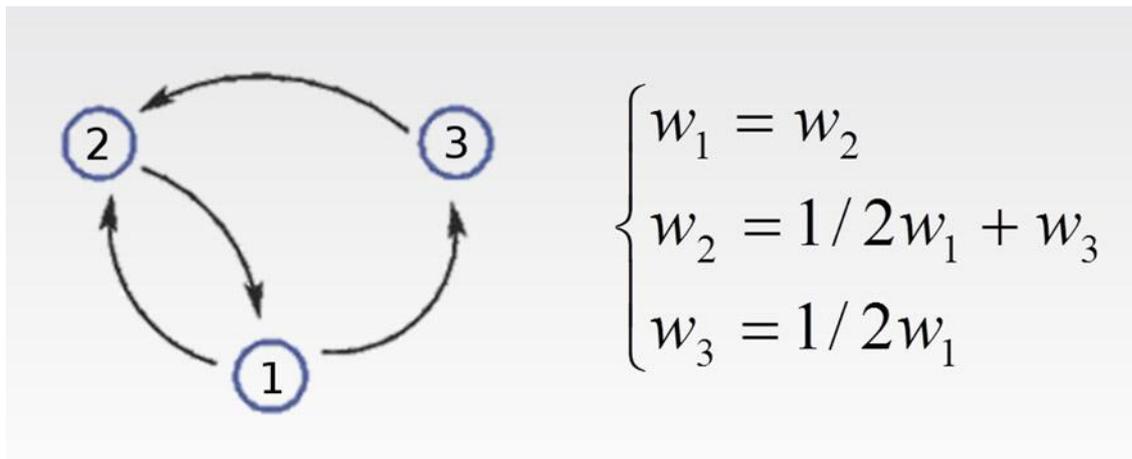


Fig. 7 – Page rank at work... (copyright MappaProject –Università di Pisa).

Linear regression can be used to answer these questions, and is an easy approach, both in terms of its implementation and from a mathematical viewpoint. Several variants may also be introduced in the regressive models (single or multiple regressions, non-linear regressions, statistical regressions, etc.) (SHENNAN 1997; WESCOTT and BRANDON 2000). Although the approaches based on linear regression have the benefit of using variables to predict further variables, the model they implement is too simple and does not take into account the great complexity that must be considered when determining archaeological potential.

Based on the discussions between the mathematical team and the archaeological and geological teams, an analogy arose between the criteria used for attributing archaeological potential and the criteria used for

assigning importance to web pages in search engine algorithms. When determining archaeological potential, geo-morphological and archaeological data are first integrated with an interpretation process in order to assign groups and then – through analytical work – to create the different maps of archaeological potential for historical period. Finally, the different historical periods are ‘overlapped’ to reach the final result. The interpretation process of the context consists in achieving a stratigraphic categorisation from a series of archaeological and geological data, based upon the spatial and functional relations among the various finds. This process becomes further evident when determining the groups, and also with the construction of the map of potential by archaeological period. The key issue of this analysis from an abstract viewpoint is the identification of the relations that exist among the various finds, both in spatial terms and in functional terms. In other words, the presence of a particular find near another that has already been discovered could *strengthen or weaken* the probability that they will form a more complex structure, and so strengthen or weaken the archaeological potential of the area itself. This is exactly the criteria upon which page ranking algorithms are based, whereby each web page attributes importance to the web pages it points to (via a link) and, in turn, receives importance from the web pages it receives a link from. A page that has a link to other pages, distributes its importance in equal parts to the other pages and therefore gives part of its importance to the pages it points to. Starting from this criterion, and applying it to every page, the importance of each page is assigned according to the weight attributed to it by the other pages; vice versa, it assigns importance to the pages it points to. Application of these operations results in a linear system comprising an extremely large number of equations (in the case of web pages, around 40 billion): the result of this system of equations, after it has been solved, is the importance of each single page. Indeed, if suitably modelled, the criteria used for attributing archaeological potential are particularly reminiscent of the criterion used to assign importance to web pages, since each archaeological find/ object gives importance to those nearby, from which, in turn, it receives importance. Consequently, the importance of a find and the archaeological potential of a point in the subsurface basically depend on the relevance of the finds and on the archaeological potential of nearby areas, and vice versa. In order to adapt a page rank model to the determination of archaeological potential, variants need to be created that take into account some of the problem’s characteristics. The subsurface will be modelled as a set of cells in a three-dimensional space; importance will be transferred from one cell to the others on the basis of a categorisation of finds. The strategy that will be implemented to adapt the page rank model is the following:

- ▶ a three-dimensional grid will model the subsurface of the urban area of Pisa. The single cell of the grid will act as the web page, and the importance of the cell, determined at the end of the procedure, will be the archaeological potential;
- ▶ the archaeological potential available for a cell will be used in a twofold manner: in a relative manner to build the elements of the matrix that controls the transfer of importance of the cells, and in an absolute manner, providing a value of importance to the specific cell where an archaeological find is present;
- ▶ the part regarding the construction of the matrix that controls the transfer of importance will be carried out on the basis of categories used for classifying the archaeological finds; in particular, each category will characterise the geometry of the distribution of importance;
- ▶ finally, the part regarding the specific importance of the single cells will determine the actual value of archaeological potential; in fact, the matrix controlling the transfer of importance will determine the

“archaeological potential” of one cell instead of others, however, in order to provide an absolute value, a “base value” must be assigned to certain cells, essential for calculating all the other values.

Geological information, regarding the presence of watercourses or specific land configuration, will be used in a binary manner, i.e. it will be used as a necessary condition for a value of archaeological potential greater than zero (BINI et al. 2011; BINI et al. 2012).

Dissemination: MAPPAgis and the open digital archaeological archive (MOD)

All data spatial data included in MAPPa Data Model will be published through a web GIS called MAPPAgis.

The first release is now (June 2012) online (http://mappaproject.arch.unipi.it/?page_id=452&lang=en).

Currently, it's possible to navigate the archaeological intervention layer and the aerial photography layer.

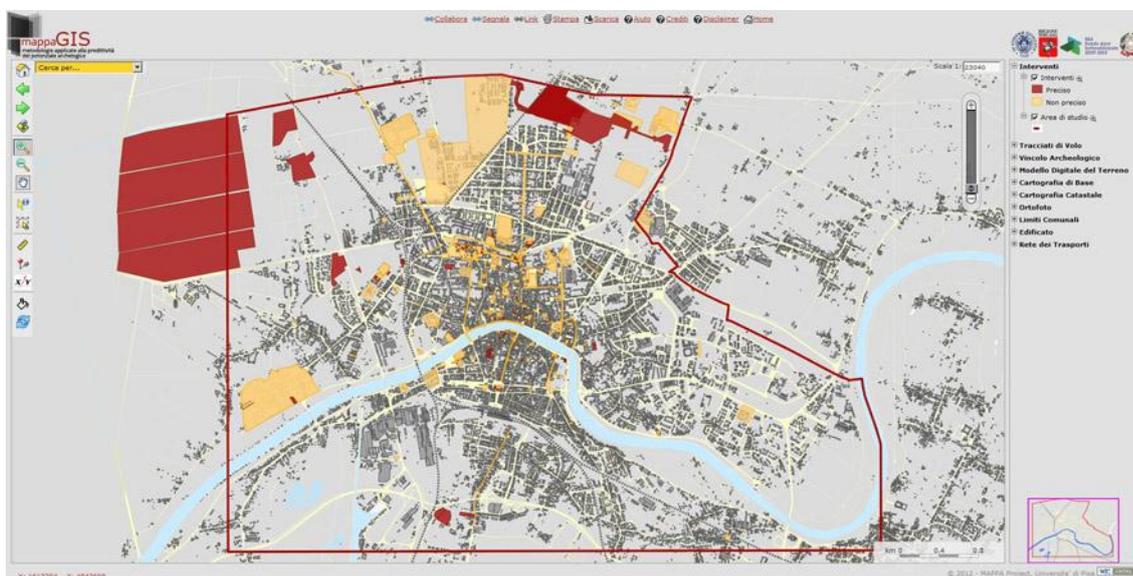


Fig. 8 – The MAPPa project web GIS (copyright MappaProject –Università di Pisa).

The archaeological data will be also disseminated as open data through Mappa Open Data (MOD) an archaeological open data archive that will be introduced on June 9, 2012 at the Opening the Past Conference (http://mappaproject.arch.unipi.it/?page_id=1258&lang=en). There are currently no existing open digital archives in Italy: the greatest problem lies in making the archaeological community accept such a revolutionary instrument, which is often more intent on protecting data for future publications. Furthermore, complete research on archaeological documentation is missing in Italy: although the methodological and procedural debates were definitely closed at the start of the 1990s, technical and IT progress, alongside the growth of professional archaeology, make them highly relevant. The increasingly varied archaeological community in Italy, which includes government agencies, research institutions and professional archaeologists, makes this issue an ever more urgent matter. Indeed, archaeographic data must be created by a plurality of subjects that must actively take part in the creation of good practices and standards for collecting archaeological data. Such standards represent the professional consent to common practices and are of use when checking the compliance of working and/or organisational processes within a professional community, at least on a national scale. Data sharing depends on standards (GATTIGLIA 2009). The open

digital archive intends delivering bottom-up initiatives that will involve the entire archaeological community, forcing it to change habits and to impose necessary standards. The open digital archive goes hand in hand with data publication and the protection of the individuals who have collected the data. Archaeography is a research activity, consequently sharing the raw data will be considered a scientific publication, through the use of specific copyright/copyleft licences (CC BY). Finally sharing means being able to analyse the data and generate new archaeological interpretations, allowing research to grow with a collaborative approach.

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The London Crossrail project, desk study, reconnaissance and evaluation. Data sources and outcomes

Liverpool Street – a case study

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Abstract: Crossrail is a brand new 118km urban railway being constructed across central London, UK. It comprises 56km of new and refurbished line, 37 station upgrades and six major new central London underground stations. The new underground railway passes through the heart of the West End of London and along the north edge of the Roman and Medieval city where deep excavation for the construction of several new central London stations has required the careful assessment and evaluation of the archaeological deposit sequence. The surviving archaeology is anticipated to extend to up to 6m in depth below the modern surface and provide an urban archaeological record from the 1st to 3rd centuries AD Roman city (Londinium) right through the post Roman and medieval periods to the recent past.

This paper looks at how a wide variety of desk study sources, reconnaissance exercises, ground deposit modeling and site testing evaluation methods has allowed the development of an informed project design to be developed for detailed excavation, recording and presentation of results at Liverpool Street, one of the main new station sites in central London. Interdisciplinary liaison with other professional teams has allowed archaeologists to build a comprehensive understanding of the actual research potential at this site.

Outcomes from site investigations are reviewed and a commentary provided on how effective or not each stage was, and what lessons may be applied to similar situations.

Keywords: Project Design; Multidisciplinary; Data Integration; Site evaluation.

Background

It's not just underground, it's under control

This phrase is famously quoted by a North American utility management company (Bloodhound Inc. <http://www.bhug.com/>). It's a confident statement in the ability of the technology tools they have available to identify, locate and manage the complex labyrinth of underground services, some of which have been forgotten and abandoned and entered, in effect, the archaeological record. As professional archaeologists we would want to be able to give our clients equally robust answers when they ask us what we expect to find, how long will it take to excavate, and what impact the finds will have on the design of the project, construction methods and the project programme. To address this challenge archaeologists need to develop multi-disciplinary methods for reconnaissance and site evaluation that not only tell us what new knowledge we shall gain from a research investigation, but how we can achieve it (methods), how quickly we can achieve it (programme), and how it will affect others in our multi-disciplinary teams (technical and financial).

As inevitably these objectives compete, robust predictive information gives the archaeologist an equal seat at the negotiating table. Developer clients, whether public or private need assurance. Archaeologists should use all the tools at their disposal to provide a professional project design that meets the research objectives and the programme, technical and financial concerns of teams that deliver infrastructure and building projects. Historic and more recent documentary sources are particularly relevant in the urban context. Combining these results with reconnaissance surveys (often undertaken by engineering teams, but utilised by archaeologists) enable archaeologists to plan meaningful site investigations to inform a fully detailed predictive deposit model that can be used as the essential framework of the project design. Going beyond the traditional desk based assessments, to envision below ground conditions, and their complex impacts in their entirety, provides that assurance. This paper focusses on the new Crossrail Station, Liverpool Street, as a case study of a major central London development in one of the city's busiest business districts. The investment in a thoroughly meticulous methodology, has allowed a fully collaborative project design for evaluation to be achieved, and the objectives of all parties to be realised in good time to mitigate the effects of unanticipated or unexpected finds.

Location and context

Crossrail is a major new 118km railway that connects the Thames Valley towns to the west of Greater London (including Heathrow Airport) in the existing western rail corridor, through central London in a new underground railway (Fig. 2, Fig. 3), with new stations at several new interchanges with mainline railway stations and the London Underground. It continues out to eastern counties of Kent and Essex north and south of the Thames estuary. See the Crossrail Project Website for further details.

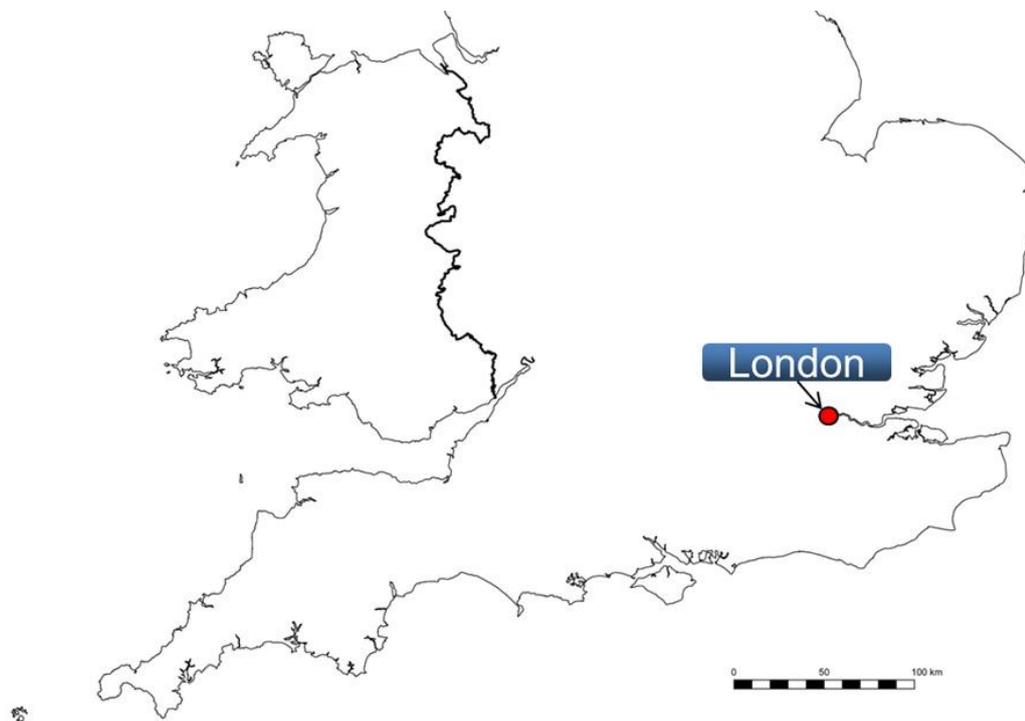


Fig. 2 – UK location plan (Reproduced from Ordnance Survey map data by permission of the Ordnance Survey © Crown copyright 2010).

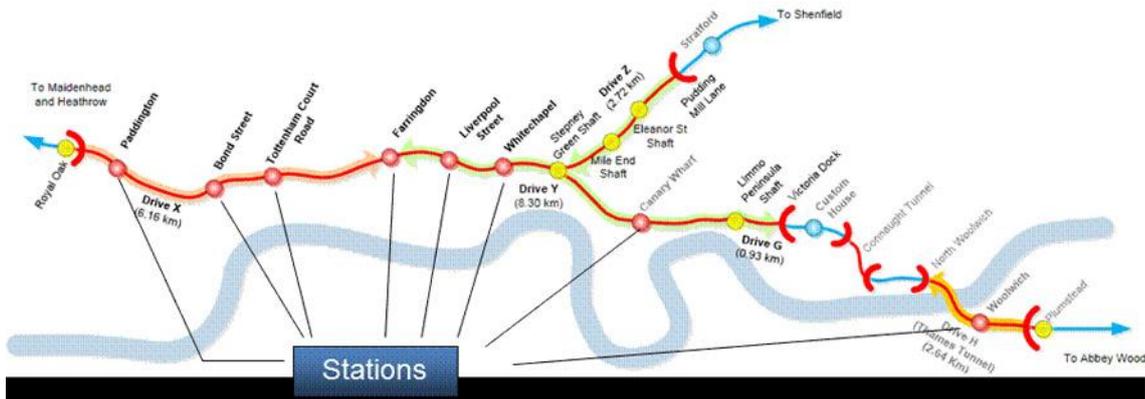


Fig. 3 – Central London Crossrail route map and location of Crossrail Stations (Copyright: Crossrail Ltd.).

The major areas of archaeological impact are at the new underground station sites in central London; at the portals where the surface railway enters the twin tunneled sections; and where access shafts are required to build and operate the new railway. Eight new stations are being built, five main access shafts and seven portals are being constructed. All of these locations present a risk of encountering significant archaeology and a major opportunity to develop new research knowledge. When the archaeology programme is complete around 40 separate excavations are expected to have been completed (CARVER 2010).

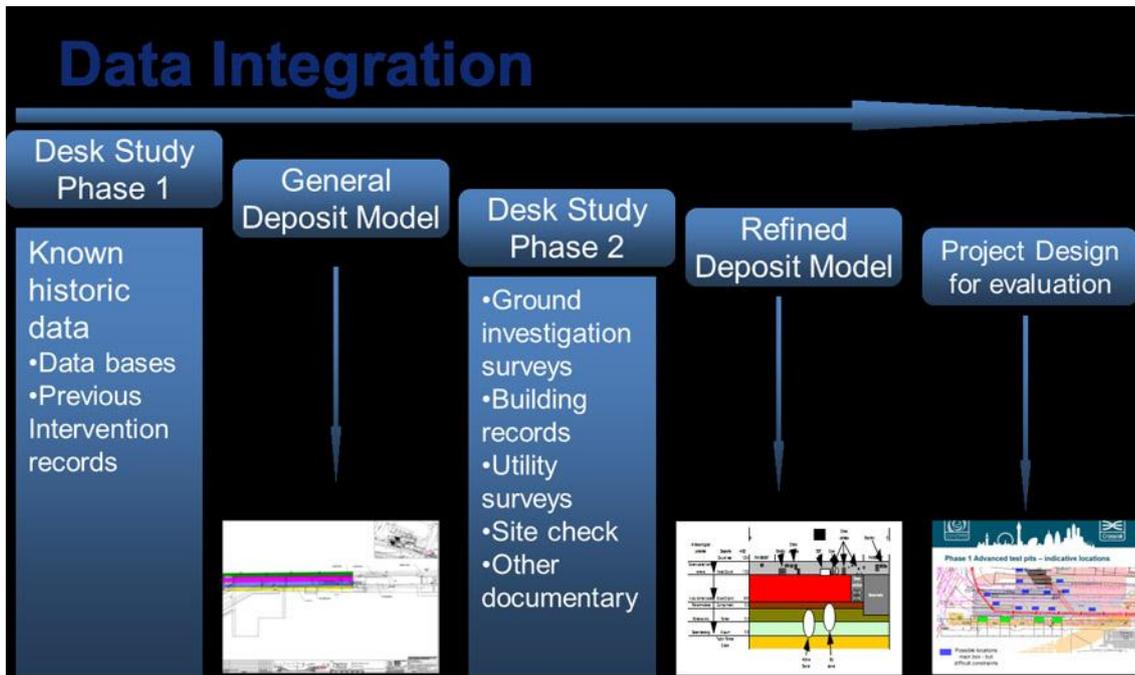


Fig. 4 – Phases of data integration (by J Carver: Copyright: Crossrail Ltd.).

This paper looks at the data sources available to develop the project design and research process through five distinct phases (Fig. 4). The preliminary assessment (Desk Study Phase 1) of the sites took place within the framework of the project environmental impact assessment (CROSSRAIL 2005a/b). A detailed desk based assessment was then carried out for specific locations during development of the final engineering design resulting in a general deposit model (COURT 2008). The Desk Study Phase 2 phase expanded the

specific understanding of the deposit model through monitoring and review of additional documentary sources and site specific reconnaissance surveys. This led to the refined deposit model and project design for archaeological evaluation (COURT 2010).

In common with other European historic capitals, London has a wealth of historical data for the medieval and post medieval periods and a documented understanding of the layout and urban density of the Roman (ROWSOME 2011) and medieval city (COURT 2008). Phase 1 was therefore able to draw on a well-developed urban archaeological deposit model for London and follow well established methods for archaeological research (NIXON et al. 2002; COL n. d).

Desk Study Phase 1 – The EIA stage sources

The preliminary assessment phase relied on the national heritage dataset provided by ENGLISH HERITAGE. Accessible online, this provides the definitive GIS data for nationally designated heritage assets including Listed Buildings, Scheduled Monuments, Registered Parks and Gardens, Registered Battlefields and Protected Wreck Sites. Further areas are designated and managed by local government authorities include Archaeological Priority Areas (or Zones) and Conservation Areas (<http://www.english-heritage.org.uk/caring/listing/local/conservation-areas/>). All the above spatial data was copied as point, polyline and polygon elements to the project GIS and formed the cultural heritage baseline for progressing the preliminary vertical and horizontal alignment for the railway.

The next phase of data integration comprised compiling a preliminary understanding of the archaeological character of around 100 locations required for construction purposes. Two key databases are available in the Greater London area to achieve this. The Greater London Historic Environment Record database (GLHER) (<http://www.english-heritage.org.uk/professional/advice/our-planning-role/greater-london-archaeology-advisory-service/sites-and-monuments-record/>) is the most complete computerised database of designated and non-designated sites of archaeological and historic importance within Greater London. The information includes historic and antiquarian findspots, identifies the location of key historic features derived from (non-comprehensive) historic mapping research and summarises of the results of all previous archaeological investigations in the city. A summary version of the database is accessible online through the national Heritage Gateway (<http://www.heritagegateway.org.uk/gateway/>) in common with many regionally based HER's throughout the UK.

An essential supplement to the GLHER is the London Archaeological Archive and Research Centre (known as LAARC), provided by the Museum of London. The LAARC online catalogue holds summary and archive information on several thousand archaeological investigations that have taken place in Greater London over the past 100 years (<http://www.museumoflondon.org.uk/laarc/catalogue/>). Datasets from both the above sources were retrieved and cleaned for inclusion in the project GIS. The potential for the many construction sites to encounter human remains from disused and now built over burial grounds was recognised early on by the archaeologist undertaking the EIA. GIS polygons for all previous burial grounds and cemeteries were therefore created from historic map evidence to enhance the baseline dataset (Fig. 5).

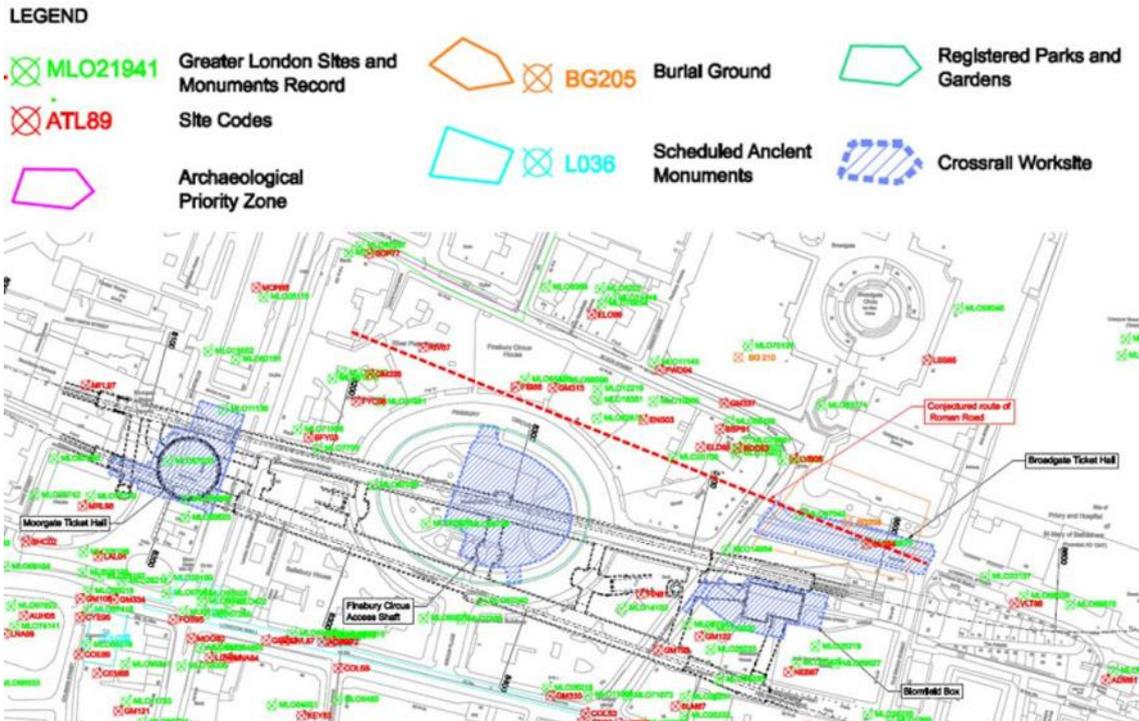


Fig. 5 – Phase 1 data sources GIS integration (Copyright: Crossrail Ltd.).

The General Deposit Model

The historical and archaeological baseline and inferred range of archaeological potential at any particular location was established by the data collated in Phase 1 as described in the previous section. The next step was to determine a general deposit model through the assimilation of further site specific datasets within a detailed desk-based assessment. This was not undertaken for every location. It was necessary only where the inferred significance and/or complexity of archaeology at a particular site location suggested that a better understanding of the site geometry was essential to determine an appropriate strategy for site evaluation and mitigation design. This was generally the case within the central zone of the City of London and its immediate hinterland where deeply stratified urban sequences were expected.

The detailed desk based assessment added a number of data layers to the site model requiring in depth assessment and analysis, including integration of: all historic map data (Fig. 5) for spatial and (where available) height data; geotechnical borehole logs (Fig. 6); datum levels extracted from Phase 1 data records (such as recorded from nearby previous archaeology investigations Fig. 7); research at the City of London Metropolitan Archives

(http://www.cityoflondon.gov.uk/Corporation/LGNL_Services/Leisure_and_culture/Records_and_archives/About_LMA/) to review further historical data concerning land use and detailed historical building plans and foundation design drawings; and Crossrail technical engineering reports and drawings that described the form and location of existing utility services and building foundations (COURT 2008).

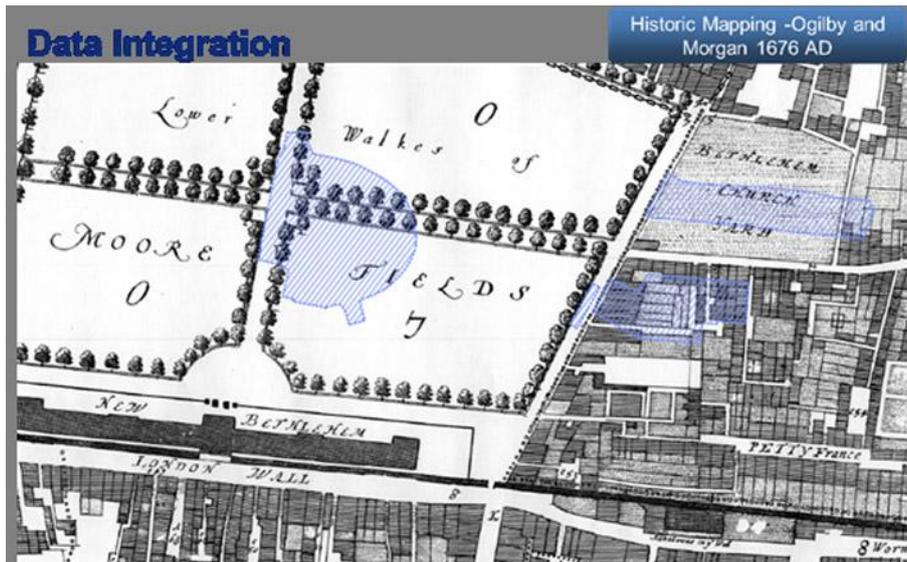


Fig. 6 – Historic Map evidence with site areas overlaid.

The datasets were added to the project GIS and allowed development of a general deposit model soil profile showing the expected depth, complexity and geometry of archaeological deposits at each site (Fig. 8). Although the generalisations presented in Figure 8, on the type and quality of expected archaeological deposits and expected depths of deposit sequences derived from these data, are a useful advance from the Phase 1 desk study data, in our case study, centered on a busy City of London highway, they provided insufficient detail to plan evaluation investigations in detail and integrate them with the project programme. To progress to a refined deposit model, actual site observations through reconnaissance surveys and additional documentary ground data that became available during development of the detailed engineering design were utilised (Desk study Phase 2). This put the team in a position to design site specific evaluation methods, moving from predictive archaeological potential informed by the general deposit model to the actual potential, opportunities and constraints present at specific sub sites.



Fig. 7 – Monitoring of geotechnical boreholes in Liverpool Street (Copyright Crossrail Ltd).



Fig. 8 – Detailed integration of previous excavation data in GIS (Copyright Crossrail Ltd.).

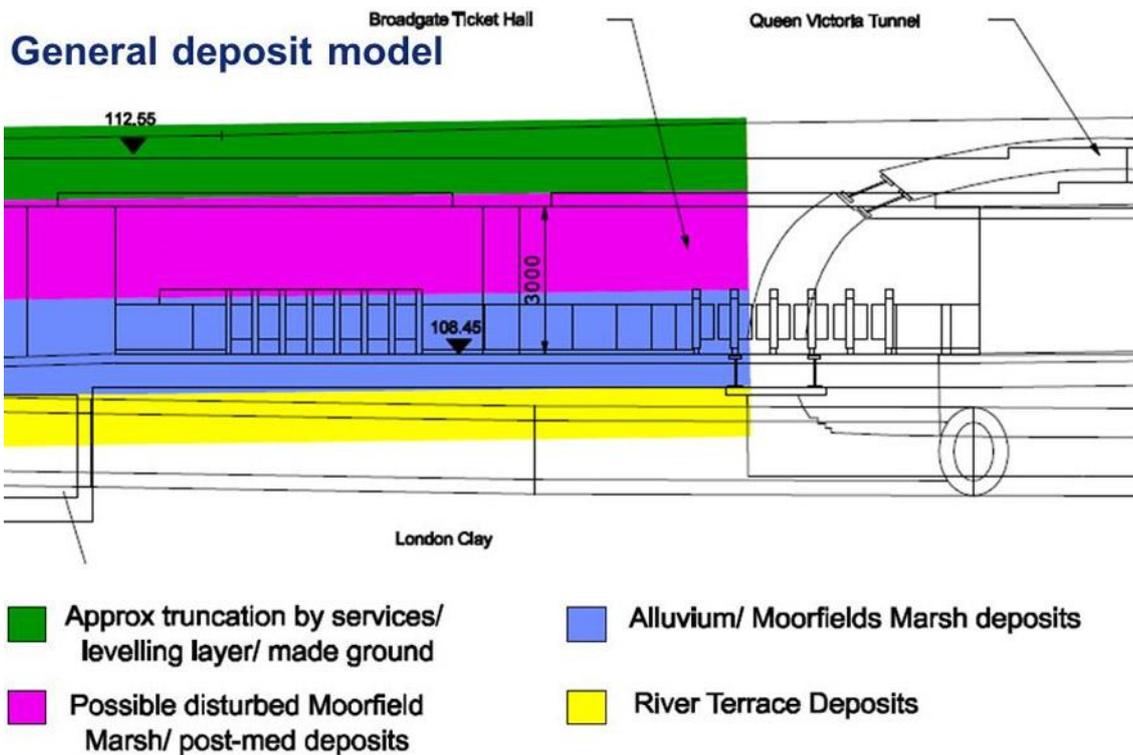


Fig. 9 – General deposit model for Liverpool Street Broadgate subsite (Drawn by M Court: Copyright: Crossrail Ltd.).

Site location and historic setting

Our specific case study is the new Crossrail station at Liverpool Street. The site is within the central city of London district, within the extra-mural zone of the Roman and Medieval city. Four separate sub sites are being investigated at Moorgate, Finsbury Circus, Blomfield Street and Liverpool Street itself (Fig. 9). The sites are located to the north of the Roman and Medieval City wall. Residual prehistoric finds from the Neolithic, Bronze Age and Iron Age have been common, although no major prehistoric site has been discovered in the immediate vicinity to date. Roman roads leading out of the city, Moorgate and Bishopsgate,

are associated with Roman cemeteries and sporadic burials. Extra mural settlement and many Roman finds, buildings, minor roads and quarrying evidence are all known from previous investigations, for example at Moor House adjacent to the Moorgate site (BUTLER 2006). A historic tributary of the Thames, the ‘Walbrook’, is anticipated to divide the site along Blomfield Street. The river has been placed in a below ground culvert for some centuries and John Stow, writing in AD1598, describes how the course had been buried below ground and vaulted over with brick (STOW 1598). From previous antiquarian siting’s and excavations in the 19th and 20th century the course of the tributary is fairly well understood, and it is expected to pass along the line of Blomfield St. To the west of the Walbrook, the area known as Moorfields was a marsh or boggy area that hypothetically developed outside the Roman town wall in the 3rd century AD as a result of the town wall disrupting the natural drainage from the higher ground to the north, creating an area that was regularly flooded. Certainly the area remained boggy for several centuries and buildings constructed on the area in the 18th century suffered documented foundation problems and subsidence.

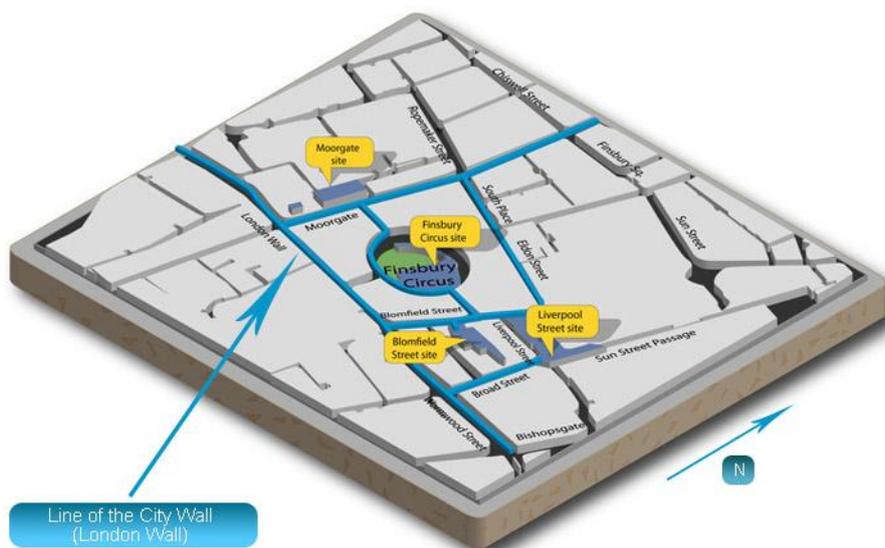


Fig. 10 – Case study location map (Copyright: Crossrail Ltd).

Desk study Phase 2 – Refining the deposit model

The Phase 1 desk study (Fig. 8), tells us much about the character and general archaeological potential of the area. The known historic, geotechnical and archaeological data shows that the Thames Terrace Gravel terrace, the Taplow Terrace, dating to approximately 280–128,000 years BP (Before Present) is present uniformly at around 6–7m below the existing ground level. Overlying this is a mixed undifferentiated alluvial sequence, interpreted as the Moorfields marsh deposits. The evidence also identifies a post medieval layer above this that coincides with the general levels at which the post medieval urban development occurred. Above this is the modern and 20th century made ground.

However the general deposit model raises several key questions that require a more intensive analysis of the actual character and geometry of archaeological survival to develop a refined deposit model for each sub site:

- ▶ What impact had existing and historic buildings and utility infrastructure had on the stratigraphic sequences?
- ▶ Could building records, architectural drawings and foundation designs be studied to confirm the levels of truncation across the site?
- ▶ Could study of utility records clarify the level of truncation within the key site at Liverpool Street?
- ▶ What reconnaissance surveys could be carried out to validate the refined deposit models and in particular differentiate and quantify the Roman, Medieval and post-medieval stratigraphy?

Building plans, architects drawings and site visit

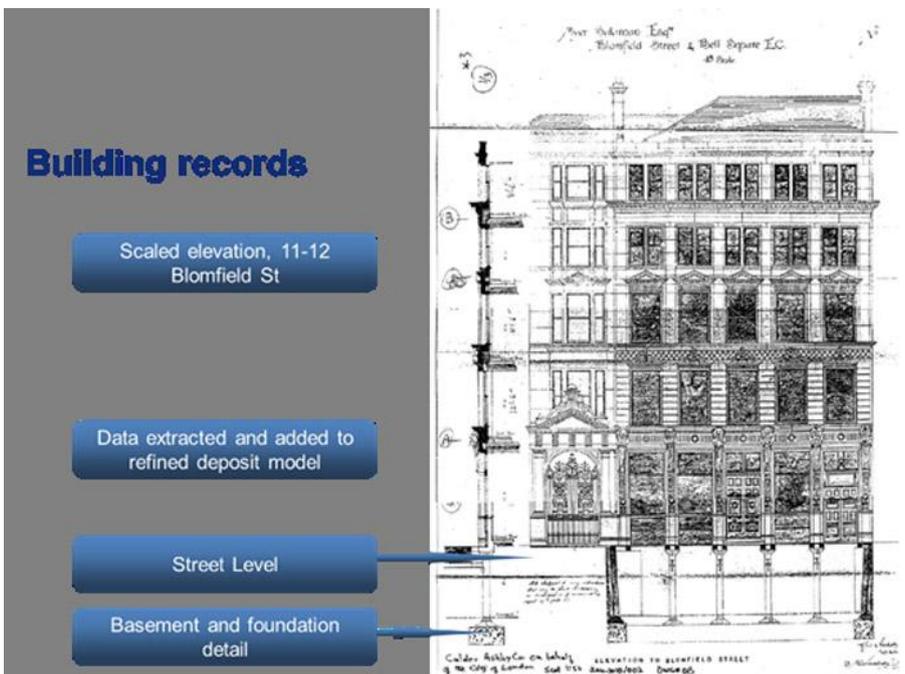


Fig. 11 – Use of historic building records to establish foundation and basement details (Copyright: Crossrail Ltd).

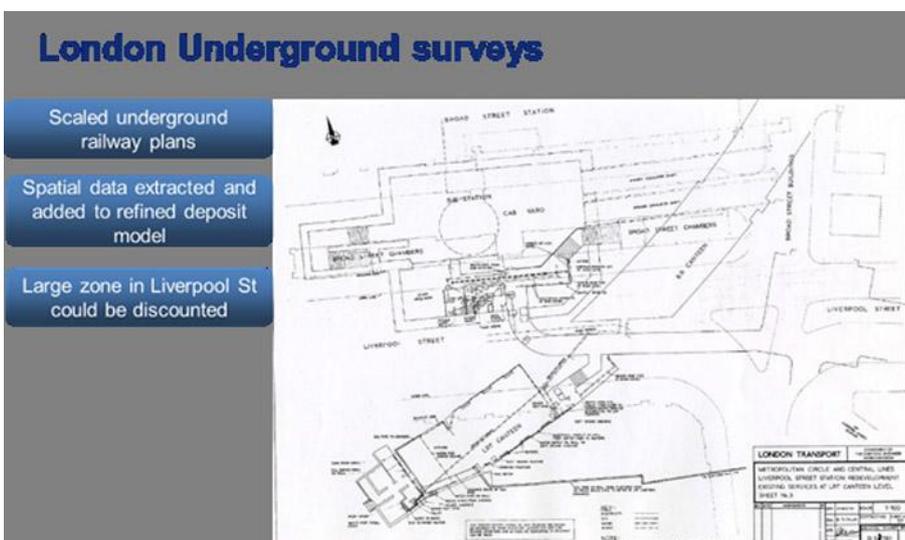


Fig. 12 – Use of historic building records to establish extent of underground structures (Copyright: Crossrail Ltd).

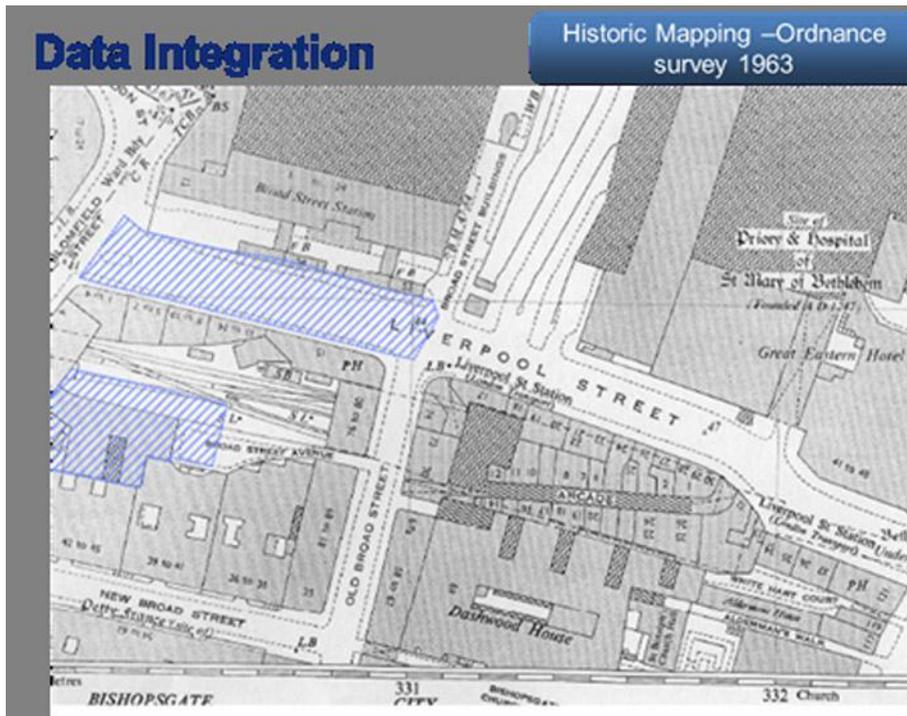


Fig. 13 – Use of 20th century historic maps to map recent building impacts (Copyright: Crossrail Ltd).

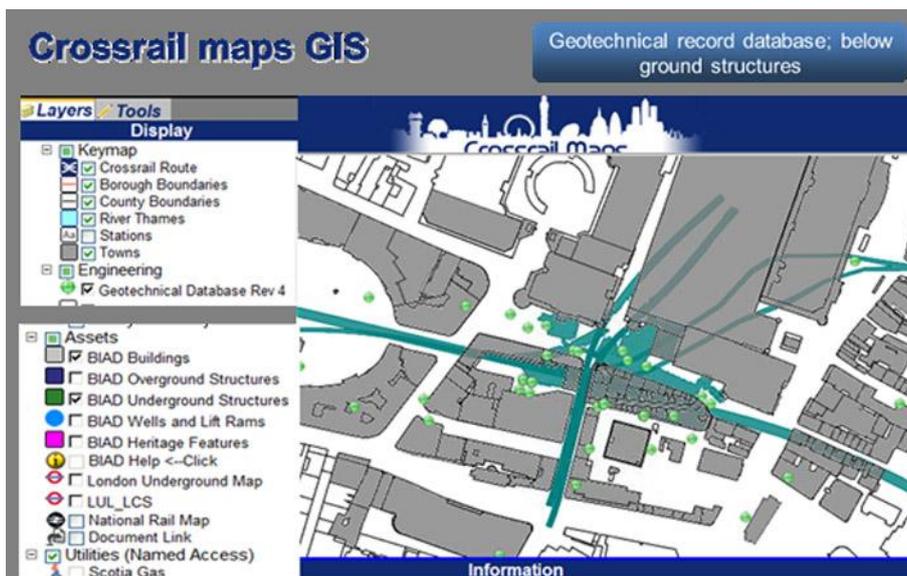


Fig. 14 – Integration of data on below ground obstructions and geotechnical records in ‘Crossrail Maps’ project GIS (Copyright: Crossrail).

Basement Levels were recorded during a Crossrail site survey and this data was compared to historic (i.e. of previously demolished) buildings plans and section profiles to inform the predictive model. Foundation design data was also sourced for existing buildings and structures (Fig. 11, Fig. 12, Fig. 13) on the sites and analysed to understand impact from previous piles, deep foundations and underground structures. This stage required persistence in research as the records relating to previous buildings had not been centrally archived and came from several sources. In particular the London Metropolitan Archives were extremely helpful in tracking down records of existing buildings. The results allowed locations to be categorized for

archaeological risk. *Low Risk*, where previous construction levels would have removed all of the archaeological deposit; *Medium Risk*, where a majority proportion of the archaeological deposit will have been removed, and *High Risk*, where minimal truncation of archaeological levels could be expected. All below ground data was processed and included in the Crossrail specific GIS 'Crossrail Maps' for easy desk top reference (Fig. 13).

Integration of utility records

The next phase of data integration required interdisciplinary liaison with other professional teams. Detailed surveys for existing obstructions and utility services within the highway were undertaken by our engineering colleagues to determine the scope of necessary diversion works. The survey data was processed to determine an accurate 3-d spatial record of the location and type of existing utility infrastructure within the site area (Fig. 14). This information was crucial in informing what opportunities and constraints existed for intrusive site investigations prior to the diversion of utility services that we knew overlaid and, had to some extent, truncated the latest post-medieval archaeological horizon.

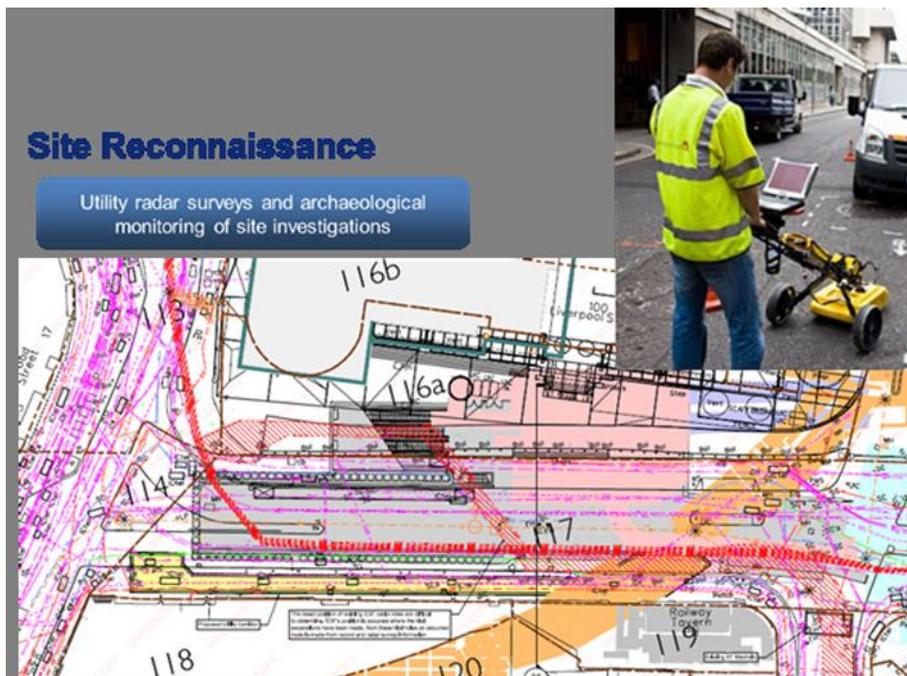


Fig. 15 – Analysis of ground penetrating radar surveys in GIS (Copyright: Crossrail Ltd).

As discussed earlier, boreholes for geotechnical surveys had been monitored by an archaeologist (Fig. 6) to inform the general deposit model. In the case of Liverpool Street that exercise had also confirmed that human remains were present in the soil sequence in two locations. The next phase, site validation of the radar data to determine the required utility diversions at the site, was also closely monitored by an archaeologist to investigate if the spatial distribution of human remains in secondary (disturbed) context was consistent across the site as was expected from the historic map evidence (Fig. 15).



Fig. 16 – Archaeological monitoring of utility investigations allowed spatial distribution of disturbed human remains to be recorded (Copyright: Crossrail Ltd).

Data integration and project design

All of the detailed desk based assessment and reconnaissance survey datasets were assimilated in the project GIS to allow presentation of the refined deposit model (Fig. 16). The refined deposit model allows a full quantitative and qualitative risk assessment and scope and specification for works to be prepared in advance of actually testing the full site sequence in an archaeological evaluation. In our case study, the sheer density of existing utilities in the street meant that the highly accurate radar survey data allowed the size and location of evaluation holes to be placed in the least constrained positions therefore saving the wasted time and resources in opening up and relocating the investigation to an alternative place when an obstruction was encountered. Also crucial was the ability of the deposit model to provide data to estimate accurate volumes of material of the different archaeological horizons, allowing reliable human resource, equipment, programme and cost forecasts to be set out prior to work starting. The substantial depth of the sequence (up to 6m below ground level) required an engineer to carry out temporary works designs to determine the safest method of earthworks support, access arrangements for people and soil removal, ground gas monitoring, and any predicted ground settlement effects on utilities and nearby structures (such as gas mains or adjacent buildings).

The refined deposit model allowed an informed strategy for site evaluation to be planned. The project design for the evaluation focused on three main research questions (Fig. 17) addressing the character and dating of the Roman period levels, what happened in the post Roman period and the suggested silting up of the area with marsh deposits caused by the early 3rd century city wall construction, and the condition and survival of the post-medieval cemetery and the character and type of inhumations present. A fourth key question addressed the quantification of the resource to determine (taking account of the three primary research questions) what sample sizes may be required in any further detailed excavation works and the time and

resources needed to fulfill a revised set of research aims. A careful record was therefore made during the actual investigations to record time and motion data for the excavation of each archaeological phase, and the effect of any difficulties encountered.

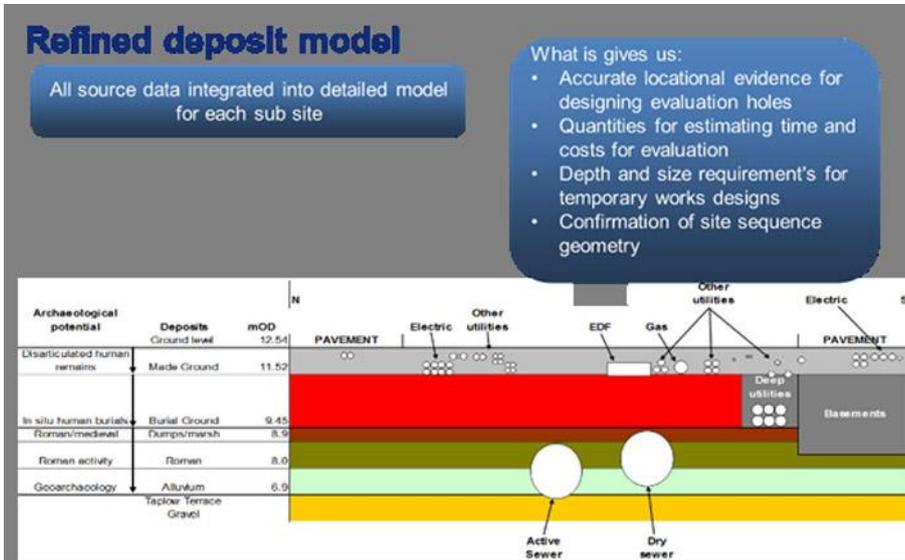


Fig. 17 – Extract from refined deposit model for Liverpool Street (Drawn by Jay Carver and Mike Court; Copyright: Crossrail Ltd).

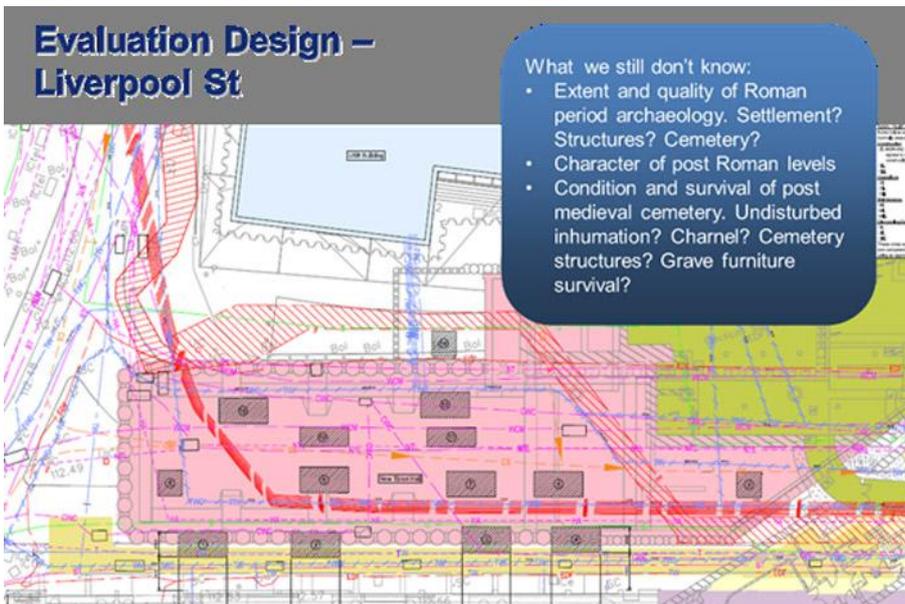


Fig. 18 – Liverpool Street archaeology site evaluation. The grey boxes show the proposed trial trench locations inserted into areas with least surface constraints (Copyright: Crossrail Ltd).

Nine trial investigations were completed in Liverpool Street in 2011 (Fig. 18). An essential undertaking was to ensure that, at least in a selection of locations, the full sequence to the natural pre-Roman levels was investigated to fulfill the research aims above and fully test the refined deposit model. This was completed in four of the holes and required excavation to c. 6m below ground level and the full recording of the later parts of the sequence. In the remaining holes investigation excavation was limited to either the upper surface of

the in-situ burials, or the upper surface of the post Roman, pre-cemetery deposits. This approach allowed us to strike a balance between a full evaluation of the resources and the need to avoid unnecessary excavation (at this stage) within the confines of the small investigation holes that were typically 4m in length by 2m wide.



Fig. 19 – Liverpool Street archaeology site evaluation in progress 2011. The works were done in two phases to allow traffic to continue to use one lane of the highway (Copyright: Crossrail Ltd).

Results

Outcomes from site evaluation were found to closely match the predictions set out in the refined deposit model. As anticipated, the protecting environment of Liverpool Street itself (a highway since remodeling of the area in the 18th century) had effected very good preservation of the archaeological sequence. Aside from truncation by utility infrastructure within the top 1.5m below ground level, and occasional deeper impacts from adjacent basements and an underground public WC, the archaeology is essentially intact with good bone preservation, less preservation of softer organics (wood etc.) and evidence for structures with the cemetery. Some 4000 inhumations are anticipated from extrapolation of the evaluation data to the final development area. The Roman and post-Roman sequence broadly suggests residential roadside settlement rather than industrial or cemetery use. The full results of the work shall be made available via the Crossrail website in due course.

Several critical factors have informed the level of data integration undertaken for this project. The presence of a potentially deep sequence and extensive cemetery and its associated public sensitivities, combined with a construction programme which is fully exposed to the public (as is typical with public infrastructure projects) to tight programme and budget constraints, right in the heart of London. All possible lines of evidence may therefore be critical in this context to understand how archaeological finds could affect project performance, professional reputation, and the needs of the public, well in advance of the main construction phase of the project. Whilst the documentary sources may be studied with minor investment to great effect, the advanced investigation in the public highway required agreement with the City of London Highway office to divert bus

and taxi routes, and to commission multi-disciplinary teams to plan and execute the work alongside the archaeological contractor. The investment therefore was significant. However, we suggest that it is justified. We have considered that the impact of delays and unexpected finds on multi-million euro construction contracts can lead to delay damages of extraordinary sums that have to be paid for by the public purse. €200,000 per day can be expended to cover the cost of major plant and construction teams stood still. The exercise of full data integration and site specific investigation for large engineering projects in areas with complex archaeology is therefore a risk management tool and an insurance policy for the funding agency; as well as fulfilling the public agenda to know and appreciate the value of archaeological remains in advance of large public projects going ahead.

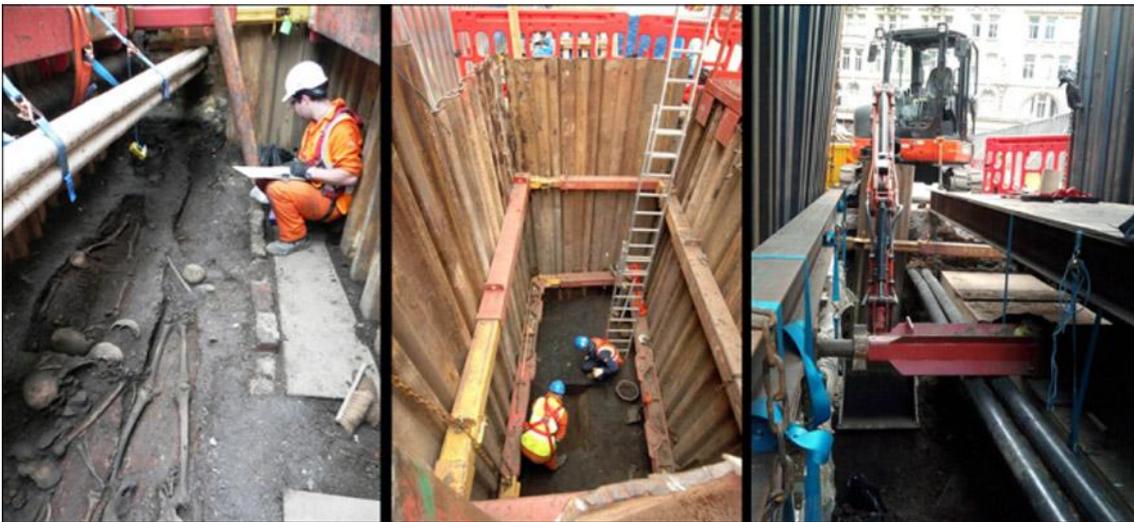


Fig. 20 – Liverpool Street archaeology site evaluation in progress 2011. The works required significant temporary sheet piling. Despite the careful siting of the investigation holes the density of cables and pipes on the site often meant cramped working conditions (Copyright: Crossrail Ltd).

Acknowledgments

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Urban Archaeology – Village Archaeology?

Utility trenches through villages as archaeological prospection

Elisabeth Ida FAULSTICH

Abstract: Villages are generally less well researched than towns. Their history often begins only with their first documentary reference. Do archaeological findings confirm this or are the villages older? Prehistoric remains are often found underneath medieval site settlements.

Many examples from the south of the German Federal State of Brandenburg show that the history of the villages stretches much further back in time. Archaeological interventions continue to reveal prehistoric and early historical sites. In many cases the villages' histories go much further back than their first mention in a foundation charter. Evidence for this is often produced by archaeological projects monitoring the narrowest of utility trenches.

Over the last 10 years an excavation company carried out more than 200 archaeological interventions in the South of Brandenburg, which provides the basis for archaeological evidence for the 'real' age of many villages. These interventions included trenches for electricity cables usually no more than 30 cm wide and 60–80 cm deep, that give us a glimpse of the structure of the layers in the soil. Archaeological findings are truncated or even completely destroyed by them. Larger projects such as drains for rain water and sewage or gas pipes are also monitored for archaeological remains. They usually provide a complete overview of the historical stratigraphy of the settlement.

Completely unexpected findings will be presented. A statistical analysis of trenches for electricity will show the necessity of archaeological monitoring of small linear projects.

Keywords: urban archaeology, village archaeology, archaeological monitoring, archaeological prospection.

Urban Archaeology – Village Archaeology?

Is archaeological monitoring of small linear projects in villages worthwhile?

Villages are generally less well researched than towns. Their history often begins only with their first historical record and continues with a seemingly fragmented history marginally mentioned in the context of important historical events. Archaeological reports about villages were for a long time rare in scientific research. The villages and also smaller towns with less historical importance did not seem to deserve closer attention by archaeologists. The last decades of the 20th century brought a change in Germany. New and revised laws were legislated for heritage, especially in the east of Germany after 1989. The main aim of the law in the so-called "Neue Länder" is to protect the archaeological remains. Where this is impossible the remains have to be excavated and the costs for this have to be paid by the awarding authority. In this context archaeological monitoring was introduced and is being practiced frequently until today.

Projects such as drains for water and sewage, gas pipes or renewal of roads are being archaeologically monitored.

In the city of Lübben in the state of Brandenburg (Germany), founded in the Middle Ages, a road was rebuilt (fig. 1; LEHMANN 1979).¹³ Although the buildings along the street and the street itself are new, archaeological finds have remained undiscovered until today. Despite the fact that the archaeological remains have been partly damaged and destroyed, they still provide enough substance for scientific examination. Only about half a meter below the modern street level an ancient construction was found. It was a wooden substructure for a medieval road. The archaeological remains were examined while the street was being modernized at the same time.



Fig. 1 – Lübben, wooden structure (E. I. Faulstich).

There are also smaller projects than street modernization where monitoring can provide us with new or additional information about already well known sites – like the Roman castellum and vicus from Großkrotzenburg (WOLFF 1903). Großkrotzenburg was founded in the Roman period at a strategically

¹³ Results of the excavation in the archive of Ortsakten, Archiv Wünsdorf.

important place. It is situated at the site where the Limes changes over from the built construction to a natural border, the river Main. The ancient name of the settlement is unknown. After the Roman period Großkrotzenburg became a small medieval village within the walls of the castellum. An enormous increase of the settlement area in the 20th century resulted in the ancient castellum and vicus being completely covered. Despite the building boom in the last century archaeological remains were found in 2010, when gas pipes were laid in an already disturbed ground. An example of these remains is a Roman pit (fig. 2). In order to record this archaeological feature the construction work was interrupted so that the archaeologists could take photographs, measure, draw plans and sections and do all the necessary work to save the archaeological record and avoid the finds being destroyed by the digger.

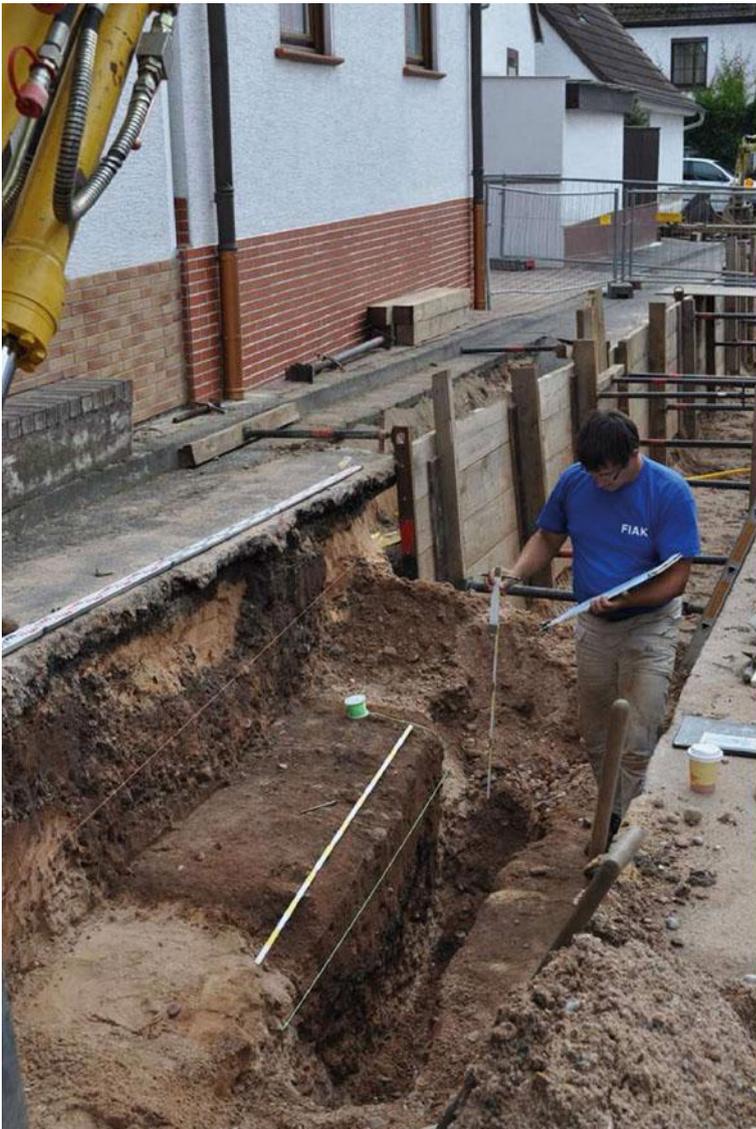


Fig. 2 – Großkrotzenburg, roman pit (E. I. Faulstich).

The examples of Lübben and Großkrotzenburg show the necessity of archaeological monitoring during road modernisation projects and the laying of gas pipes and rain water drains. However, there are even smaller

trenches for electricity cables (fig. 3). The dimensions of these trenches are about 30 cm wide and about 60 to 70 cm deep.



Fig. 3 – Hindenberg, electricity cable (I. Ertner).

It is difficult to imagine that a small trench like this can reveal any archaeological finds at all.

Examples – only of the smallest trenches – will show that archaeological interventions in these cases do make sense. If they are useful in getting archaeological information all the bigger trenches, such as for gas and water, must be equally important.

Since the last quarter of the 20th century nearly all modern power cables have been laid underground. Any remaining power masts will disappear in the future. This work is being carried out by the big energy companies, such as Eon, Vattenfall and RWE. In Brandenburg these energy companies are obliged to pay for any archaeological projects. The lengths of these projects differ and can take between one day and over two weeks, with an average between 5 and 10 days.

The studied region – called Niederlausitz – is located between Berlin and Dresden and is very close to the Polish border. The area is about 80 km long and 60 km wide. Over the last 10 years the archaeological company Freies Institut für Angewandte Kulturwissenschaften (FIAK) Cottbus carried out archaeological watching briefs in 57 villages of Niederlausitz. These watching briefs were done in parallel with the laying of

power cables (fig. 3). The total number of watching briefs in the region was higher however: 57 watching briefs carried out by FIAK, which should be a strong enough sample for statistical analysis. A few of these villages and especially their small trenches for electricity cables will be introduced in the following part. The first example is a cable trench in the village of Saßleben.¹⁴ It shows a rather common stratigraphy (fig. 4).



Fig. 4 – Saßleben (E. I. Faulstich).

The brown layers on the top are the result of this floor level being used as a road for two centuries without any construction material. The grass above is from the last 10 years. It is the result of changing the course of the old road and renewing it. Below the layers from the 18th and 19th century there is a grey layer. Chronologically, it belongs to the layers above, although the soil contained medieval finds. These medieval finds within the grey soil were brought here from near the center of the village in the 18th/19th century. The

¹⁴ Saßleben, Ortsakten Archiv Wünsdorf.

bottom layer is just made up of sand. This means that a road was constructed in the 18th/19th century and the medieval ceramic found in the layers belonged to the earliest settlement of the village nearby.

As a result of this watching brief in Saßleben it was possible to determine the size and extension of both the medieval and the later village. The second example is the village of Groß Leuthen¹⁵, which was first mentioned in historic records in the 14th century. However, due to a general assumption of the village being older than the 14th century archaeological monitoring was required.

The construction works of the past had already destroyed the historical stratigraphy (fig. 5).



Fig. 5 – Groß Leuthen (S. Nitzschke).

On top of this modern intervention is the modern pavement. A backfilled modern trench can be seen on the left. Fortunately, in spite of the construction works from the past years, some archaeological finds remained undisturbed. In Groß Leuthen layers from the late Middle Ages and the late Bronze Age were found, including ceramics of both cultures. Prior to this archaeological watching brief two years ago a Bronze Age settlement was unknown.

Another example is Horlitz. In written documents Horlitz was mentioned in 1540 (LEHMANN 1979).¹⁶ During the archaeological monitoring it was noticed that most of the archaeological stratigraphy had been destroyed. Remains of a prehistoric layer were preserved only at the bottom of the trenches (fig. 6).

¹⁵ Ortsakten Archiv Wünsdorf.

¹⁶ Results of the excavation in the archive of Ortsakten, Archiv Wünsdorf.



Fig. 6 – Horlitzta (I. Ertner).

The ceramics found in this layer suggest a date in the early Iron Age. However, not only was a prehistoric layer found – remains of a prehistoric settlement were discovered in a half-destroyed pit measuring about 60 cm in diameter (fig. 7).

The center of it is darker, which is due to small remains of organic material. Another new finding was that Horlitzta is older than 1540. Archaeological evidence – ceramics found in medieval layers – suggests that the village must have been founded around the 14th century. Like in Groß Leuthen the prehistory of Horlitzta had been unknown; but thanks to the archaeological investigations in 2008 we now have evidence of human activity in Horlitzta from as early as the Iron Age.

In most cases the archaeological remains are not well preserved. This is due to past building works in the surrounding area that did not involve an archeologist. Preventing the archaeological evidence from being destroyed by modernizing roads or digging trenches is one of the main aims of the heritage preservation trust that has been active in several countries over the last decades. Although a lot of archaeological evidence has been destroyed there are still notable remains. Similar to the previous examples of Horlitzta and Groß Leuthen with little evidence of the past, is the village of Lauchhammer.¹⁷ Among other archaeological findings a prehistoric post was found in Lauchhammer (fig. 8).

¹⁷ Ortsakten Archiv Wünsdorf.

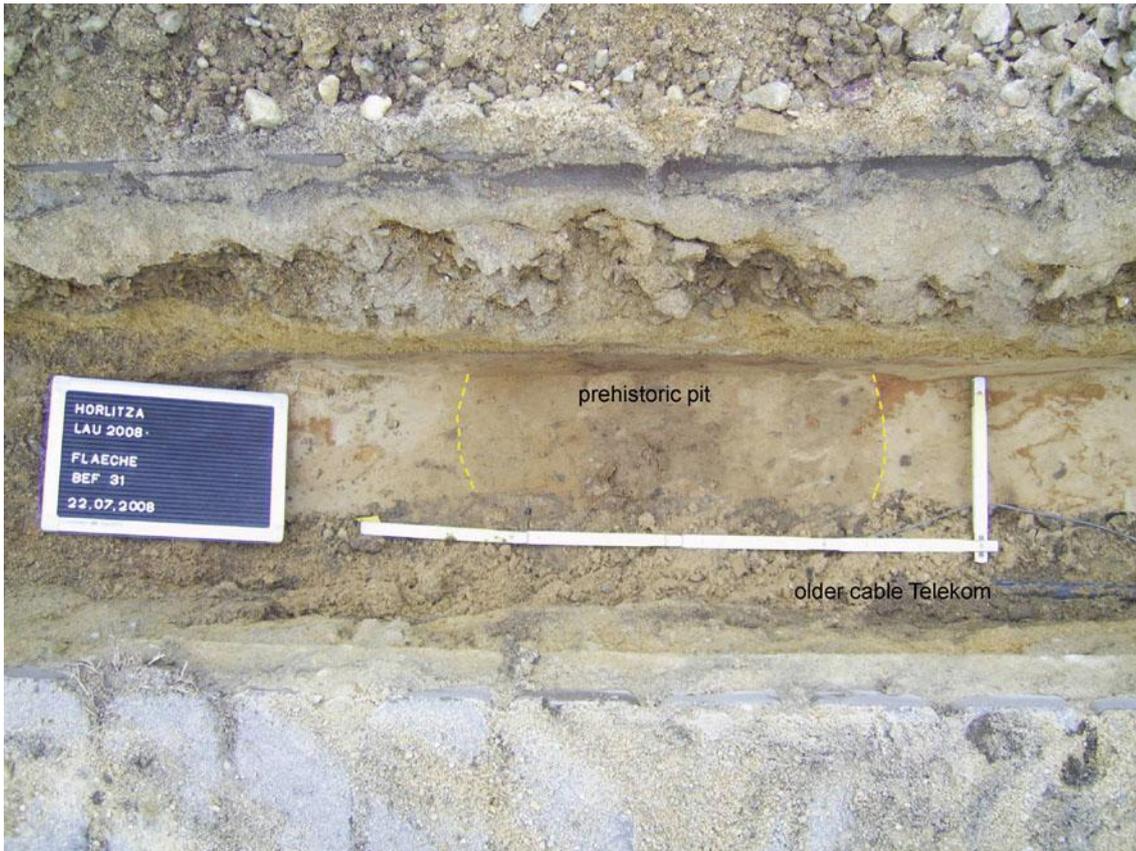


Fig. 7 – Horlitz (I. Ertner).



Fig. 8 – Lauchhammer (N. Schmidt).

The prehistoric post was partly cut by a modern trench, which was dug to lay gas pipes. Above the prehistoric post – and on either side of and above the modern trench – there is a modern grey layer with pebbles and organic particles.



Fig. 9 – Milkersdorf (N. Schmidt).

Generally, it is easy to find prehistoric settlements in villages, because their stratigraphy is relatively non-complex. At the same time, the risk of destroying them by modern construction works, even by power cables, is rather high. The same observation can be made in medieval settlements. In villages the medieval period did not leave a dense stratigraphy like in historically important cities, where a stratigraphy of two meters and more can often be seen. The number of medieval layers in the villages is small and often consists of only one layer. Villages tended to expand outwards and they were not restricted by a city wall. A typical example of medieval layers can be found in Milkersdorf.¹⁸ Milkersdorf appeared very late in history. It is first mentioned in the 17th century. A few fragments of medieval ceramics were found in the past without any stratigraphical link. In 2008 the first medieval pit and other archaeological remains were investigated (fig. 9, 10). In addition, prehistoric evidence could be documented.

Even walls can be found in these narrow cable trenches. This might not seem to be an important archaeological find, but walls like this are not that often found in villages. The cable trenches can provide

¹⁸ Ortsakten Archiv Wünsdorf.

important clues when piecing together a village's history. The remains of walls can be used to reconstruct dwellings or historic buildings that are no longer visible today.



Fig. 10 – Milkersdorf (N. Schmidt).

The final example of the 57 villages is Schwarzbach¹⁹, first mentioned in the Late Middle Ages (fig. 11). On top of the stratigraphy the well-known modern layer can be seen. Below the modern layer we have grey soil with organic material, which dates between 17th and 18th century. During this time the area was used as a settlement. The original extension of this layer remains hypothetical because of modern construction works in the past century, which destroyed the original historical layer. The layer underneath is a blow sand or blow sand layer without any finds in it. We think that this layer represents a period of time in the village's history, when the settlement became smaller or was abandoned – sometime between the Middle Ages and the industrial era. During this period of desertion sand was blown onto the medieval settlement, which is well preserved at the bottom of the cable trench containing dark organic material.

¹⁹ Ortsakten Archiv Wünsdorf



Fig. 11 – Schwarzbach (Chr. Britze).

Conclusion

The results of each watching brief are written up in a report supported by photographs, drawings and plans. Over the last 10 years our field unit carried out archaeological watching briefs of electricity cables in 57 villages in the south of the German Federal State of Brandenburg.

The results of archaeological monitoring of electricity cable trenches are (fig. 12):

- ▶ In 17 villages the historical date of foundation has been confirmed.
- ▶ In 23 cases we found out that the villages were actually older than previously assumed consulting the first historical record; this is more than 45 %.
- ▶ In 22 villages the archaeological finds are of a younger age than the historical record.
- ▶ In only 12 cases the stratigraphy was too damaged for us to be able to identify any original archaeological layer. Older trenches had already destroyed any archaeology.
- ▶ In 16 of the villages – nearly 25% – we discovered a new archaeological site.
- ▶ In 5 villages we even discovered 2 new archaeological sites.

When comparing the different data sets (historic records about the foundation of villages, finds, excavation reports, maps and photos) statistically; one notices an interesting accumulation of data.

In the late Middle Ages villages were founded on prehistoric settlements, especially on settlements founded in the Bronze Age. Though not true for all villages, this phenomenon occurs predominantly in the 15th century. Prehistoric settlements were obviously favorable at that time. The reason is perhaps the change of climate – the so-called little ice age at the end of the Middle Ages – which made higher areas preferable for settlements. This is only a hypothesis, but it would be interesting to do further research on this subject – not

only on the change of climate, but also on the villages in general. There is no doubt that this will shed even more light on the villages' history.

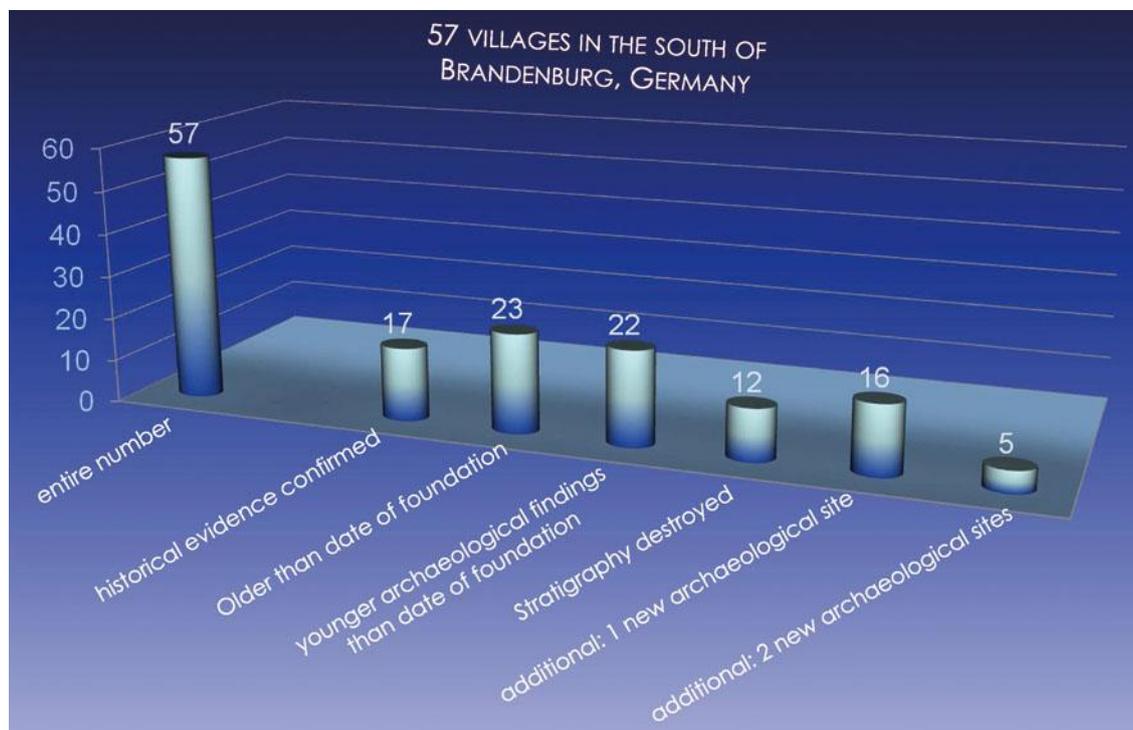


Fig. 12 – Statistic of archaeological monitoring of electricity cables in the south of Brandenburg (E. I. Faulstich).

Carrying out watching briefs in these extremely narrow cable trenches is not a “beautiful archaeology”; it is quite unattractive from a practical point of view. There is a lot of debate about whether this kind of archaeology is necessary or useful for the scientific research.

Clearly, you need a lot of experience to be able to recognize the archaeology in such confined spaces.

Perhaps, one might argue, it is more difficult to understand the archaeological context when presented with such small pieces of evidence as opposed to excavating a big prehistoric settlement.

It is my opinion that this archaeological work has to be done, because modern construction work has a deeper impact into the ground than in the past. Every day we lose archaeological substance, which is then irretrievable. However, being able to use small – or bigger – trenches cutting through villages and towns as a means to carry out archaeological surveys we are able to deepen our knowledge about history.

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Archaeology in the Maastricht A2 project: a tunnelvision

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Outline: In the city of Maastricht (NL) a tunnel is to be constructed. In this project archaeology is in a difficult position. On the one hand it is almost impossible to attain data from traditional prospection methods due to the fact that the project is lying in an urban environment and on the other hand it will be impossible to stop the caterpillar train of the constructors of the tunnel due to the expensive consequences. How to tackle this as an archaeologist?

Abstract: On the route from Amsterdam to Milano (Italy) on the national motorway A2/E25, drivers are confronted with 6 traffic lights. 4 of them are in Maastricht! Time to dig a tunnel to secure an improvement of the traffic flow. The tunnel covers approximately two kilometres. After decennia of negotiations the works will start in 2012. Archaeology was and is a main condition of this gigantic infrastructural project, right from the start. The problem is however that this project is lying in a former alluvial plain and that the most part of it is in an urban environment, full of buildings and infrastructure.

The main part of the project is in and on the border of a former late Dryas Maas river channel. This itself is difficult enough to predict where archaeology can be found considering the possibilities of erosion and sedimentation. Archaeological research in similiar settings revealed a broad and rich spectrum of sites from different periods in different stratigraphies.

How do you tackle this as an archaeologist without frustrating the very expensive building of a tunnel and with hardly the possibility of using traditional prospection methods as archaeological drillings? Which information sources are available and do they give enough information to come to a deliberate strategy for excavations?

A research framework on landscape archaeology and the use of different geophysical methods such as seismic research, geotechnical drillings and gis applications will hopefully reveal the expected archeological results. In 2012 we know if we were right!

Keywords: prospection, tunnel, urban environment, alluvial floodplain.

Introduction

The city of Maastricht is well known for its Treaty in 1992. Accidentally 1992 is also the year the Valletta Treaty was signed. The archaeology and history of Maastricht go back to the middle palaeolithic site of Belvédère (KOLFSCHOTEN and ROEBROEKS 1985; ROEBROEKS 1988), followed by neolithic settlements and graves (MEURKENS and VAN WIJK 2009), settlements and graves from the Bronze Age and Iron Age (MEURKENS and VAN WIJK 2009), a Roman settlement with a bridge over the River Maas (PANHUYSSEN 1996), an early medieval central place to, ultimately, a high medieval religious centre (DE JONG et al. 2001). Maastricht is situated at the cross-point of three landscapes being the Belgian Ardennes,

the Dutch and Belgian Campina sand plateau and the Maas valley (Fig. 1). The River Maas originates in France at the Plateau de Langres and ends near Rotterdam in the North Sea. The transition of the foothills to the lightly undulating river valley makes Maastricht such an interesting archaeological location.

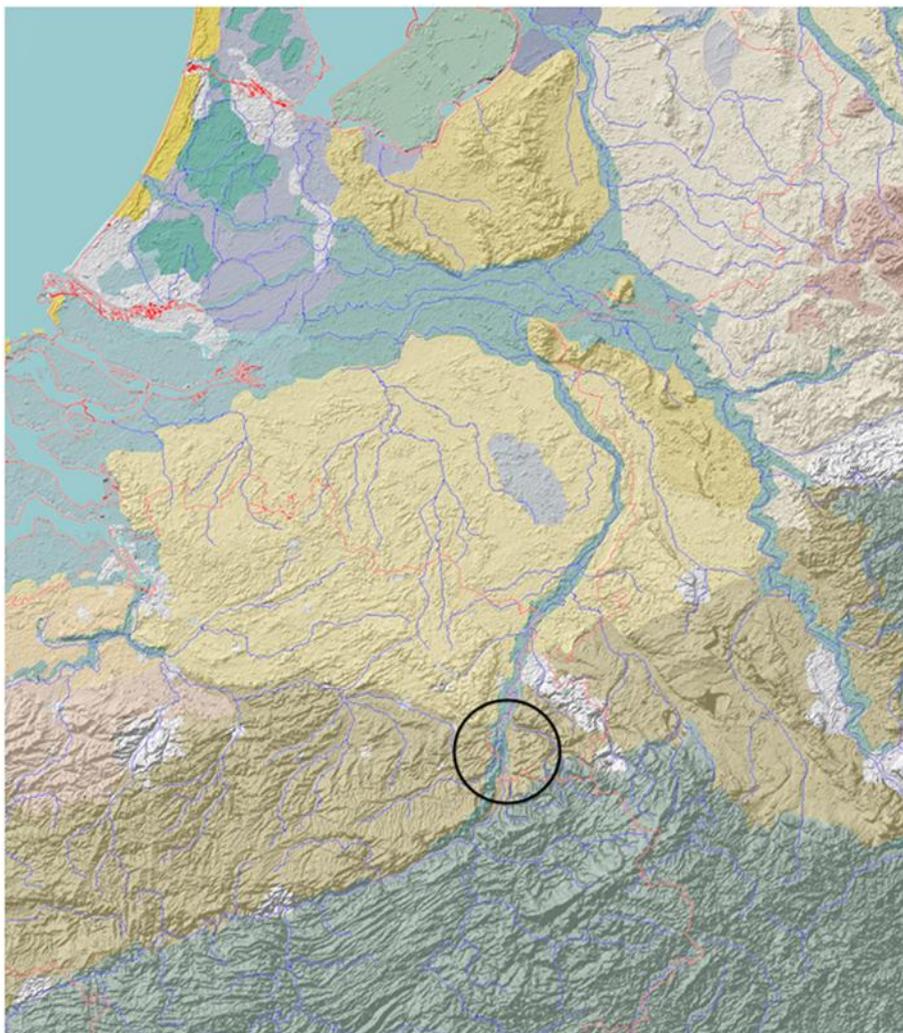


Fig. 1 – Digital Elevation Model of North-western Europe landscapes (Used with kind permission of Rijksdienst voor het Cultureel Erfgoed).

When travelling from Amsterdam to Milano by car, taking the E25/A2 via Maastricht, one will encounter only six traffic lights of which four are in two kilometres of Maastricht territory. For about 30 years numerous different governments debated about the traffic jams and considered only a handful alternatives. In 2004 the decision was made to build a tunnel.

In this paper we aim at describing the way archaeology is integrated in the 165 hectare tunnel project, which includes not only the tunnel itself (Fig. 2) but real estate, nature, reconstructed highway junctions and new public space (Fig. 3). Secondly, we describe how we assessed and reconstructed complex archaeological-historical landscapes in a true urban environment thus fulfilling the legal, 'Maltese' task of incorporating archaeology in spatial developments.

The Tunnel Project

The aims of the A2 Maastricht project (www.a2maastricht.nl) are optimizing both A2 traffic and the accessibility of Maastricht, promoting the quality of life and creating opportunities for urban development. The project organisation consists of the Municipalities of Maastricht and Meerssen, as well as The Ministry of Transport, Public Works and Water Management (RWS). Three consortia were invited to subscribe for the works. Ultimately Avenue2 (www.avenue2.nl) was awarded the assignment for having the best overall plan.

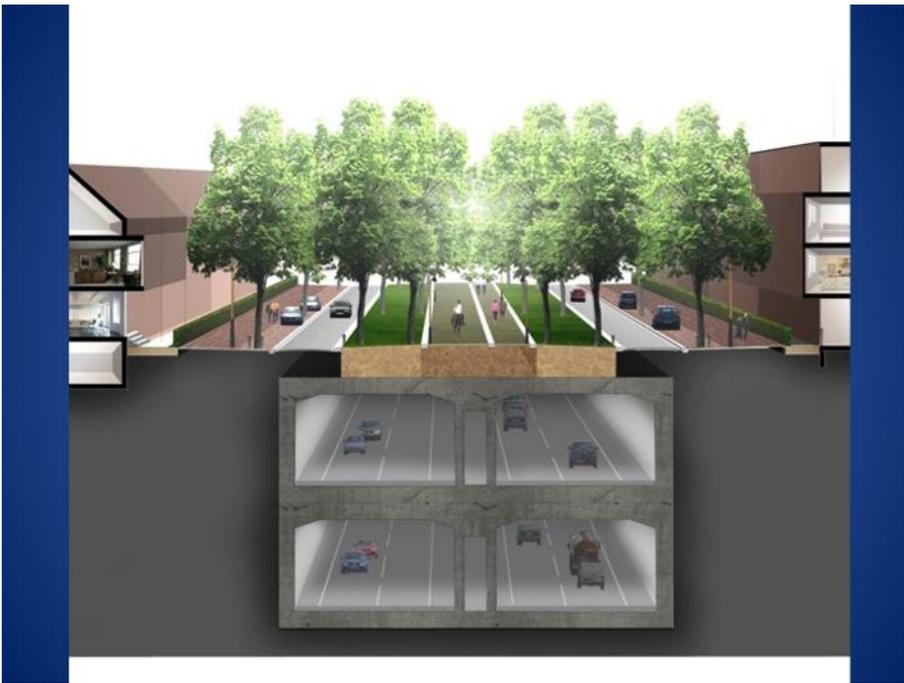


Fig. 2 – Artist impression of the A2 tunnel and public space.

Infrastructural projects initiate works that require entering the soil thereby disturbing or destroying potential archaeological remains. Therefore, right from the start archaeology was considered an important aspect, condition or environmental issue of the project, which had to be properly dealt with. To protect the different interests all three involving parties – the A2 project organisation (being the appointing authority), the contractor (Avenue2) and logically the competent authority (the Municipality of Maastricht) – have their own archaeological consultant. The interests differ since Avenue2 ‘focuses’ on limiting the cost of archaeological research, whereas the project organisation aims at getting it all done within the time frame. Finally, the Municipality’s interest is the quality of the research executed, being responsible for correct heritage management.

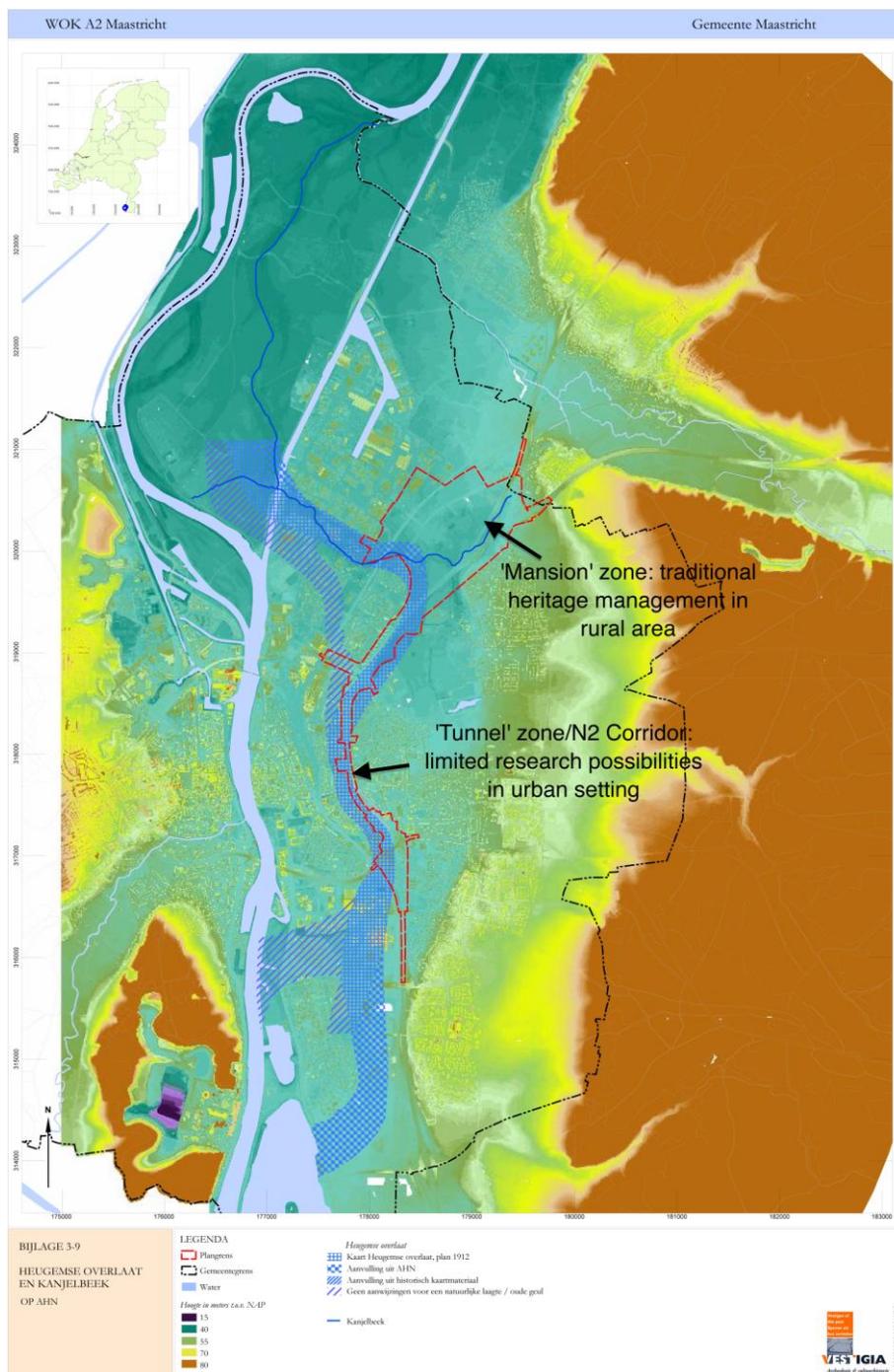


Fig. 3 – Plan area plotted on elevation model (After QUADFLIEG and VISSER 2008). Brown (relatively high), Green (relatively low). In blue the approximate location of the Heugemse Maas.

Process and organisation

Because the necessary (e.g. legal) preparations started already in 2005, we were given ample time to follow the process of Archaeological Heritage Management prescribed and followed in The Netherlands (Fig. 4). For example, a project of such a scope is legally bound to execute an environmental impact assessment (2007). This assessment (MER in Dutch) lead to the not surprising conclusion that the planned infrastructural, civil, real-estate and landscape interventions and works in the area would have a large

negative impact on the earth-scientific, geological and cultural-historical values. Furthermore, the obligatory Alignment Memorandum was signed in 2010.

The archaeologist from the project organisation formulates requirements and research designs, directs the fieldwork and assesses the archaeological reports. The decision what archaeology is ultimately worth preserving is left to the competent authority, the Municipality of Maastricht. The Competent Authority's task is to look after and guard the archaeological interests in the project and to ensure that the contractor follows the steps of the so-called Archaeological Heritage Management process.

The framework for the archaeological process is on the one hand formed by the factors 'money' (in Dutch state-governmental projects frequently archaeological budget is 1% of the total project costs, in this case that would be ca. 6 million euro's) and 'time' as imposed by the A2 project (the infrastructure has to be ready before 2017), and on the other side by the Archaeological Research Framework (Dutch: WOK) as drawn up in close consideration with the archaeologists of the Municipality of Maastricht (QUADFLIEG and VISSER 2008). In this framework we have chosen for an area-specific, landscape-archaeological approach. This means that when an area is assessed, the extent to which the archaeological-historical landscape is still available and in tact, is of great importance. The main criteria for assessing the areas of intervention were therefore the geological values, the development of the landscape and the influence of people on this biotic and a-biotic landscape.

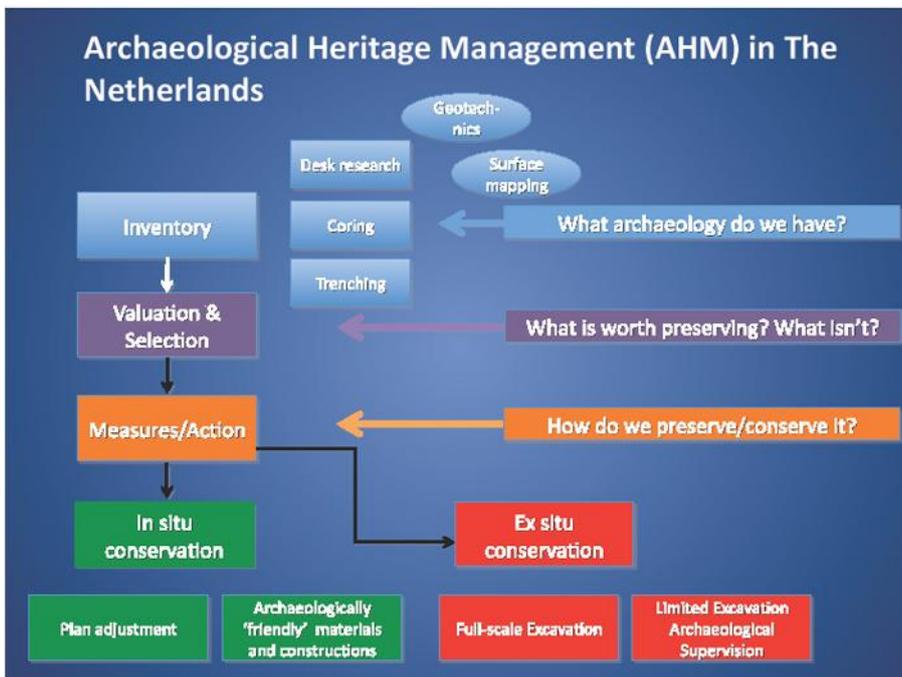


Fig. 4 – Process of Archaeological Heritage Management (AHM) in The Netherlands.

The project follows the research steps of the Archaeological Heritage Management process (Fig. 4). After an inventory phase, including mapping with boreholes and valuation by trenching, an assessment is made of the archaeology worth preserving. From that a selection of sites and landscapes is made. Finally, measures have to be taken to actually preserve the selected archaeology and landscape: *in situ* conservation by

environmental planning or applying archaeologically friendly building practices, or otherwise *ex situ* conservation by excavation or supervision. Focus is on the conservation of archaeological values *in situ*.

Landscape archaeology

The archaeological scientific objectives of the A2 Maastricht project are the following:

- ▶ The archaeological research must result in a more complete overview of, and a better understanding of the occupation and the utilization of the landscape of the Holocene and Pleistocene Maas valley in the past. In other words: the aim is to fill archaeological gaps in the research area;
- ▶ Wherever possible, the outcome of the archaeological research must lead to effective and durable conservation and management of archaeological values in the plan area and the adjacent area;
- ▶ The research results from the Maas valley can be linked to those of other areas and features of the landscape, so that ideally an integrated picture of occupation and other land utilization in the past can arise.

The landscape archaeological perspective that enables us to achieve the scientific objectives is defined as 'the combined physical-geographical, archaeological and historical-geographical research, which aims at describing the development of, and consistency between culture and the physical landscape in the Maas valley through time.' More specifically, the research aims at studying the relation and interaction between people and biotic and a-biotic landscape and the changes that occurred from the earliest occupation up to recent times.

Important advantages of such an integrated, interdisciplinary approach are:

- ▶ Landscape archaeology combines the landscape genesis with human occupation during a very long period of time. It does therefore not aim on a specific period, but on the total time depth of human presence in the Maas valley. The approach enables a broad and coherent insight in occupation and land utilization in the Maas valley by people in the past;
- ▶ The results of landscape archaeological research can be studied and interpreted in a supra-regional context. The research can contribute to the reconstruction of the occupation history and adjacent areas. The Maas valley is no autonomous landscape entity, but a part of the environment in which pre - and proto-historic people lived;
- ▶ The results of landscape archaeological research can be used in an appropriate manner to indicate where site- or area specific management and conservation of archaeological values in the direct surroundings of the plan area are advisable.

As points of interest and research topics, we defined (1) development of the biotic and a-biotic landscape, with special attention for the dynamics of the Maas, (2) different types of sites, such as settlements and burial forms, and other forms of land utilization (for example fields and meadows) and their mutual relations, both in synchronous and in diachronical respect, (3) synchronous and diachronical relations between occupation and other forms of land use and the presence of natural sources, (4) changes in occupation and other forms of land use in the course of time, (5) the infrastructural role of the Maas and (6) hoards in, and directly adjacent to the Maas and affluents.

The physical landscape

In addition to the research of the former topics, descriptions of the physical landscape and palaeogeographical reconstructions are essential components of area-specific archaeological research. They are preconditions for the research of the relation between mankind and its natural environment and for the description of the occupation history in various areas. After all, the physical landscape forms the setting in which people lived in the past (Fig. 5). From an archaeological perspective, especially the Late-Pleistocene and Holocene landscape developments are important. Three types of landscapes can be distinguished:

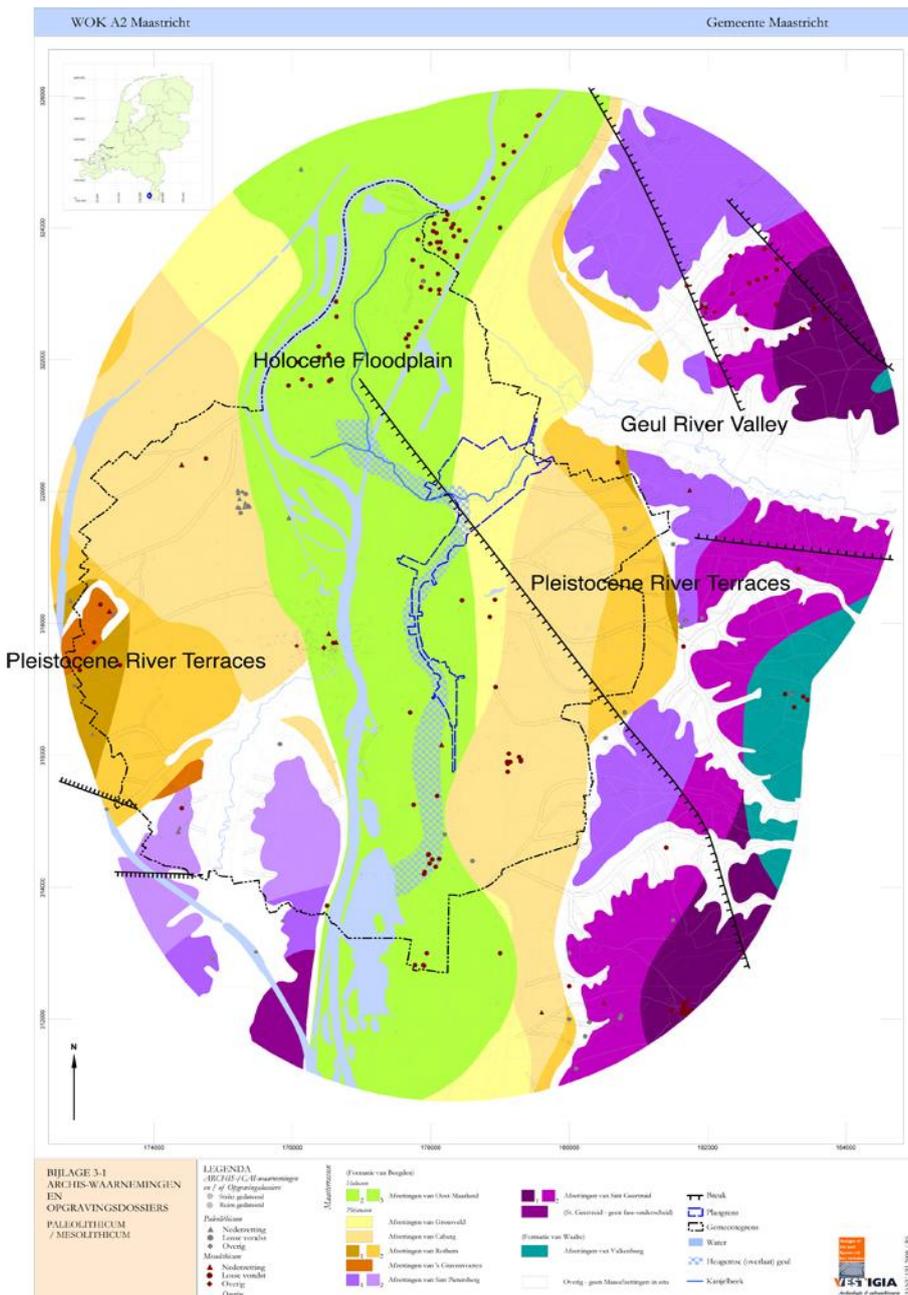


Fig. 5 – Simplified geomorphological map (after QUADFLIEG and VISSER 2008). Holocene flood plain (green), Late Pleistocene river terraces (brown), Middle Pleistocene river terraces (purple), Alluvial valleys (white). Dots represent archaeological sites. Note the fault lines.

- ▶ The Late-Pleistocene terrace landscape (braided river deposits) on both sides of the Holocene Meuse valley;
- ▶ The landscape of late glacial and early Holocene alluvial clays;
- ▶ The Holocene landscape of point bars, marshes and channels (meandering river).

The aim of the physical landscape research is primarily obtaining insight in (changes in) the geological, geomorphologic, pedological and hydrological qualities of the areas during successive phases of human occupation. Among other things, the results of the research are important for the reconstruction of the topographical position of settlements, burial places, and other land use related features in the former landscapes. Secondly, it aims at obtaining insight in the spatial potentials for human occupation and exploitation.

Risk management

The area-specific, landscape archaeological approach sounds scientifically fantastic but how does one value an archaeological and historical landscape? In this project the landscape is an alluvial plain, hard enough on itself to predict where archaeology is to be found considering the landscape dynamics of sedimentation and erosion. In a project like this they, that is to say the people responsible for all the building and constructing activities, want to know right from the start (1) where archaeology is at stake, (2) whether 'archaeology' will remain within the financial limits and (3) whether there is a risk of delay. With other words, it is necessary to predict not only how the process will evolve in terms of time and money but also where the archaeological sites are and how to make sure 'archaeology' won't interfere with the building activities. In other words, risk management! So, our task was to predict the location of the archaeological sites in an as early as possible stage of the project and deal with it.

At first we had of course the information from our Archaeological Research Framework (QUADFLIEG and VISSER 2008). This framework it is not only a scientific statement. It is also a state of the art inventory of archaeological sites for the Maastricht and adjacent area, including information on historical, geological and geomorphological features, such as river terraces and the recent alluvial plain. The framework was our starting point and we had to test hypotheses from the framework with each investigation. As we already knew right from the start, there was a great difference between the southern part (90% roads, buildings, houses and pavements) and the northern part of our research area (90% grasslands, pastures and woodland) in terms of possibilities for research (see also Fig. 3).

Plan area

At first, focus was at the northern part, the so-called Mansion zone. Here, traditional prospection methods could be applied easily. Furthermore, there was ample time to execute our research following the Archaeological Heritage Management process: Desk-research (NALES et al. 2005), corings (VAN DIJK 2007; PAULUSSEN et al. 2010), trial trenches (MEURKENS et al. 2009) and ultimately excavations (HAZEN and VANNESTE 2011). The research revealed an extended and divers landscape including an old branch of the river Maas acting as an old floodplain (the Heugemer Maas), terraces, riverbanks and small streams. The landscape contained several archaeological sites spanning different periods and being different in nature

and origin: from Mesolithic and Neolithic flint, via Bronze Age and Iron Age settlements, Roman infrastructure (the Roman highway from Bavay to Cologne and two diverticulae), settlement structures and graves to early and high medieval structures. The research showed how rich this research area is, and not likely to stop where the recent urban settlement starts.

In the southern part of the project, the so-called N2 Corridor, the actual 2300 meter long tunnel is planned. On average it is only ca. 100 meters wide. The N2 Corridor is an urban environment with buildings and infrastructure situated on the former alluvial plane of the Heugemse Maas, mentioned before. Obviously, there is hardly any room for traditional prospection (without blocking the intense 24 hour traffic flow). So, the main issue is how does one predict the archaeological potential (in terms of probability and value) of an urban environment like that of the N2 Corridor?

Methods and some results

The key product of our landscape archaeological approach is the palaeogeographical reconstruction of the landscape. But what exactly are we going to reconstruct, and how? What information did we have to reconstruct the landscape in this area? What did we need to come to a reliable reconstruction? What sources of information are available and what possibilities do we have to get new data?

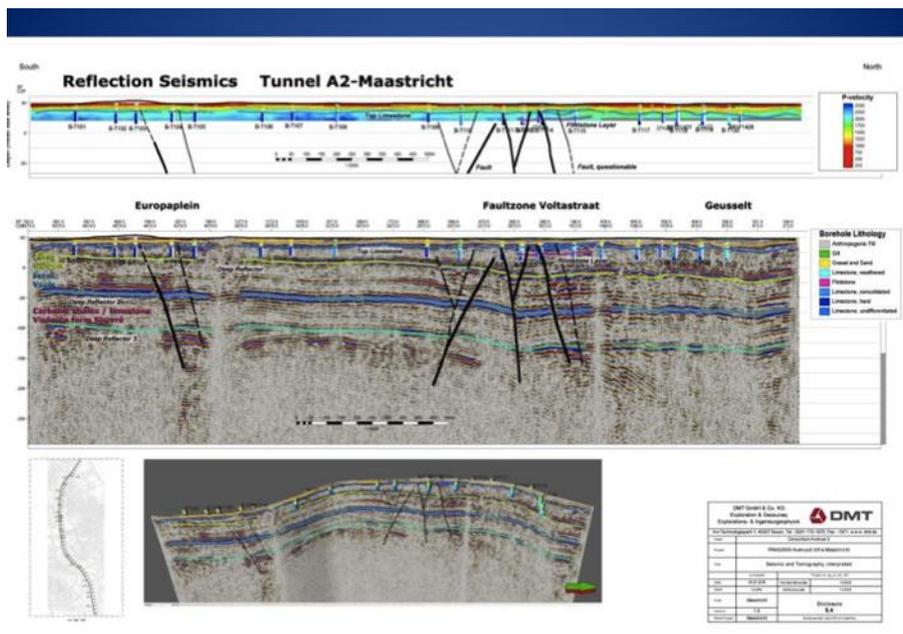


Fig. 6 – Un-interpreted seismology and tomography. Example of geotechnical data, used in this project. Used with kind permission by DMT GmbH & Co.

The main question was the exact location and dimensions of the Heugemse Maas. At the start of the project only little was known about this phenomenon. Ultimately we discovered that this former (palaeo)channel of the Maas developed when at the Pleistocene (Palaeolithic) – Holocene (Mesolithic) transition the aggrading braided river Maas gradually changed into a incising (eroding) meandering river as a result of the well-known

climate change (e.g. BECKERS and ZUIDHOFF 2011). The river responded to climate-induced changes in the discharge, sediment load and vegetation by incision of the braided river deposits. Possibly, two or three channels in the braided plain incised, of which the present-day Maas ultimately became the actual active river. The incision that led to the Heugemse Maas lasted briefly leaving an incised palaeochannel parallel to the then and now active Maas river channel. Thus, the Heugemse Maas may be considered an active river channel from the end of the Late-Dryas period up into the Mesolithic. From then on, it started to fill up and silt up with fine-grained sediments introduced by the active Maas at peak flows. The Heugemse Maas meanders through the landscape and probably there were several branches lateral to each other. But how did we come to this reconstruction and where was the Heugemse Maas located?

For the reconstruction, we first of all needed information about the top of the braided river deposits (primarily gravels). With this information it should be possible to reconstruct the exact location of the incision. However, how do we map these gravels in our urban environment? Luckily, there was geophysical research carried out, not for archaeology, but for assessing the geotechnical problems due to underground faults to be encountered during construction of the tunnel. The available sonic drillings, up to 35 meters deep, gave an insight in the structure of the geology and soil. Furthermore, seismic measures, so called CMP-Refraction, Refraction Tomography and Seismic Reflection, gave a clear picture of the required top of the gravels (Fig. 6). Together with very precise actual altitude data (Dutch: AHN), the geotechnical information gave us an indication where to locate the Heugemse Maas.

A complicating factor was a flood channel created in the 19th century, the Overlaat, partly dug and partly being the palaeochannel of the Heugemse Maas. Sometimes the two features got mixed up in the discussion about the palaeogeographical landscape and genesis. Both features are of course affected by the building activities of the 20th century, but we were not sure in which degree. It was for that reason and the urge for information about the depth of (sub-)recent soil distortion due to e.g. sewer pipes, cables and pipelines and foundations that we executed a research with historical maps, documentary of the building activities and known geological data as stated before (Fig. 7). The desk research by Orbons (2010) showed that initial ideas on the location of the Heugemse Maas, as described in our Archaeological Research Framework, could be questioned.

Next, we initiated a geo-archaeological coring program to prospect the location of the incision and with that, the archaeological potentially rich riverbanks (BECKERS and ZUIDHOFF 2011). During one night, traffic was redirected and coring took place along the future tunnel. Ultimately, we reconstructed the profile of the Heugemse Maas and its banks at different places (Fig. 8).

Furthermore, at some spots where an investigation with trial trenches was possible during construction activities, we were able to check some of our hypotheses on the expected location of the Heugemse Maas. We also organised an expert meeting with physical-geographers and archaeologists to check if we were on the right 'landscape' track. Our picture and ideas on landscape development altered slightly after a day of fruitful discussion.

The integration of the seismic information, the deep geotechnical and geo-archaeological corings, the trenches, documents and also the historical maps, gave us a sound idea where archaeology could be at stake when building the tunnel and related and adjacent construction works. The palaeogeographical

reconstruction showed that the position of the Overlaat did not coincide with that of the Heugemse Maas (Fig. 9).

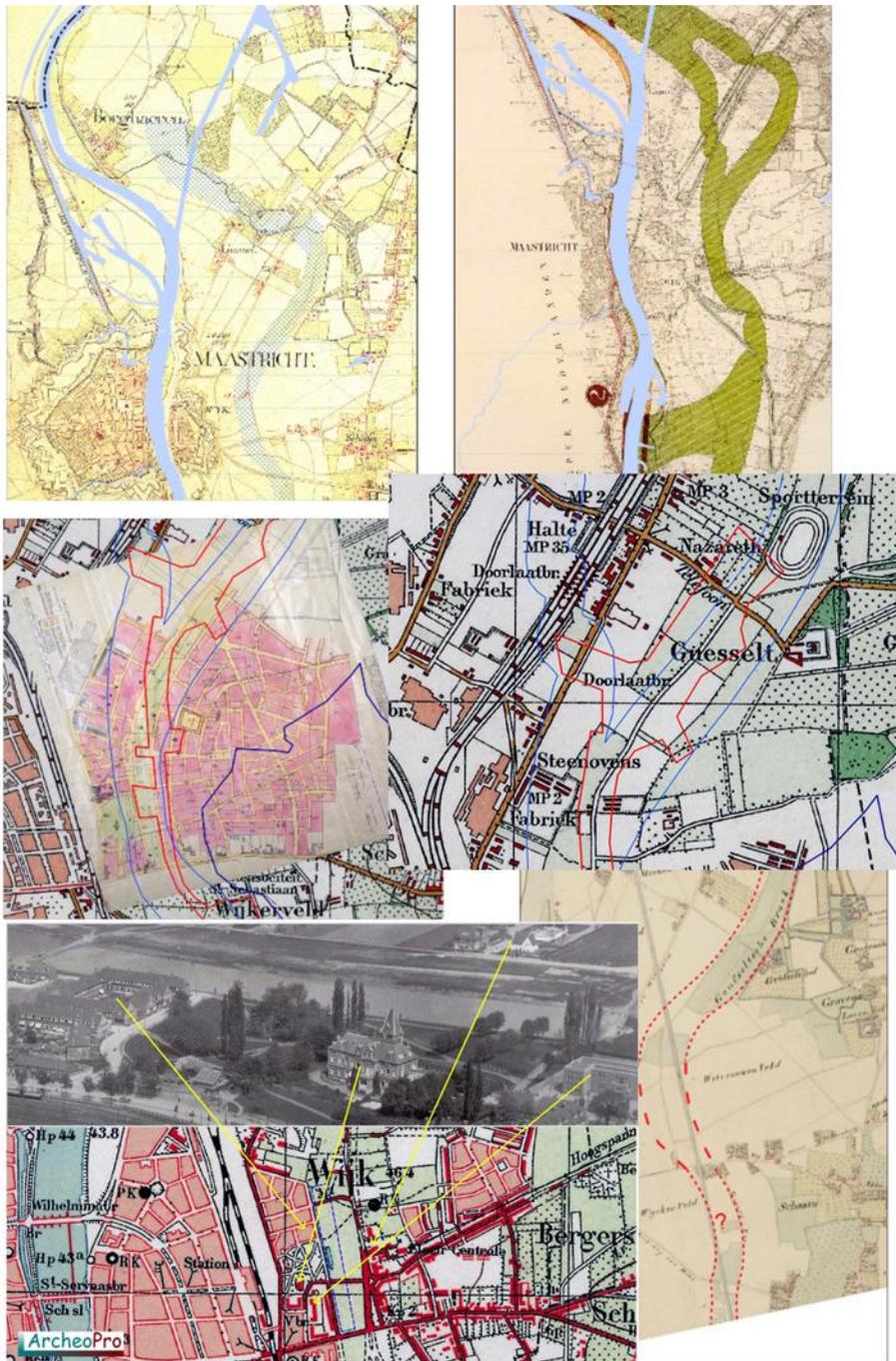


Fig. 7 – Examples of various map analyses (ORBONS 2011).

In other words, more intact locations were to be expected, where archaeology could be present and well-preserved. The main part of the tunnel lies in the old Heugemse Maas stream and therefore is considered to have a relatively low archaeological potential. On the other hand, a significant part of the plan area (500 m) covers the banks of this stream. We know, from the excavation in the Mansion Zone, that the banks may contain sites from different periods.

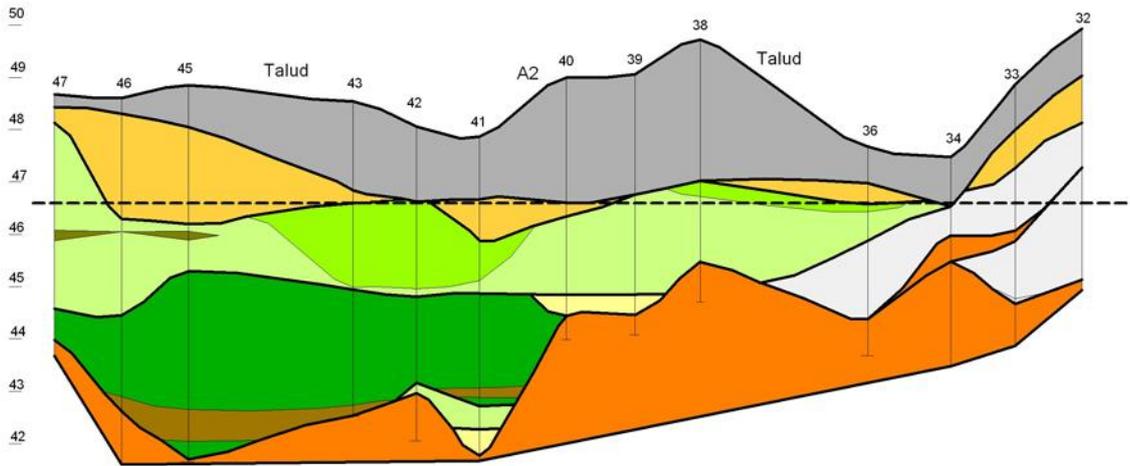


Fig. 8 – Litho-genetical cross-section based on borehole data. Orange: Late Dryas braided river deposits (gravels). Dark green: Early – Mid Holocene infilling after down cutting (BECKERS and ZUIDHOFF 2011).

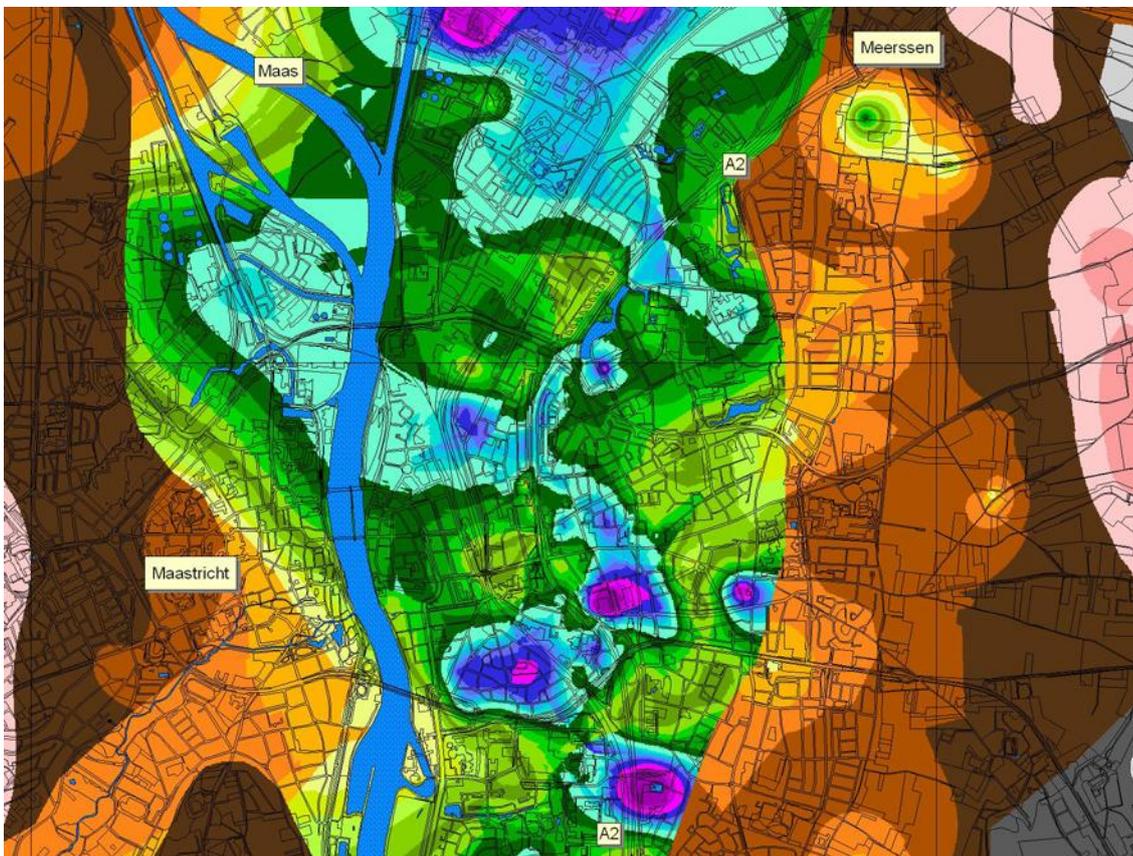


Fig. 9 – Height of gravel in meters above sea level based on geotechnical and borehole data (used with kind permission of Bjorn Vink, Projectbureau A2Maastricht). Brown tones, ≥ 47 m above sea level; green to purple: 41 to 47 m above sea level.

Final words

By combining various research techniques we are able to predict where archaeology is at stake in the true urban environment of Maastricht and preserve a truly rich archive by excavation and supervision. Mission accomplished! Unfortunately, there will be almost no chance of investigating during construction. The way the tunnel is constructed is in a tight scheme and there is hardly any (safe) room or possibility to intervene

for research. If we would do so the risks for the projects are immense, in terms of (delay) time and money. The question we asked ourselves was: is it that necessary to investigate in the tunnel? Our answer was a no. We can answer a lot of the questions we defined in our Archaeological Research Framework in the adjacent areas where new buildings (the real estate programme) or new infrastructure for cables and pipelines are and will be constructed. And of course, when there is an incredible archaeological find during tunnel construction, we have the legal opportunity to stop the process (that is to say at our costs!!) assess and if necessary excavate properly. The construction of the tunnel will start early 2012 and will continue until 2016. All the activities related to the tunnel in the adjacent area will take place simultaneously. The new real estate and public space will be realised after the construction of the tunnel. It is then that we will have some new opportunities to test if our hypotheses were right.

When the project is ready and all the work is done, somewhere after 2022, we have a clear understanding of the landscape and occupation history of the eastern bank of the present-day river Maas. Ultimately, we will connect all our new insights and knowledge to create a new picture of Maastricht through time. Then after all, that is our job: to create new stories of our history and not to get caught up in a tunnelvision!

Acknowledgements

The authors would like to thank the anonymous reviewer for the useful comments on an earlier version of this paper. We further thank Bjorn Vink (Projectbureau A2Maastricht) and the communication department of the Avenue2 consortium for their help realizing the 2011 presentation in Vienna and this paper. Finally, Henk Baas of the RCE provided the Digital Elevation Model of North-western Europe landscapes (Fig. 1).

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SESSIONS

Newbies

Multimedia Reconstruction Techniques to communicate the past

A study about the Homeric Epic

Panaiotis KRUKLIDIS

Architect of Mandarino Blu

Abstract: Even though in our time the traditional drawing has been left backward by the computer graphic, the research presented here is a full fusion and interaction between digital and manual artistry techniques. The traditional approach will give a legacy of tension, warm signs, expressive traces, while the digital approach will allow rethinking, unlimited attempts, rich variation and higher performance.

The direct reference at the base of this work is the art from eighteenth century artists inspired by archaeological discoveries, represented in their lost time, with a great richness of details, capable to communicate the deep meanings of that age. Thanks to the experience of those painters it is possible to talk about an "archaeological image", developed starting from the information coming from the knowledge of the ancient times.

Taking from them the importance of lighting and the scenic level of detail, this research tries to underline how an image can evoke the "sense of sublime" and inspire the observer behind the simple sight of the shape and size of a town or of an armor in a reconstructive representation.

Originally developed as the author's degree thesis in Architecture, under the direction of prof. Giorgio Verdiani and prof. Anna Margherita Jasink, this research has been taken to the world described by Homer in the *Iliad* and *Odyssey* to follow an articulated path between drawing, representation, architectural and archaeological studies to define a sort of "image periegesis", going behind the narrative aspect to underline and to bring back the cultural depth needed to create a real learning experience.

Keywords: representation, reconstruction, traditional drawing, digital drawing, computer graphic.

Multimedia Reconstruction Techniques to communicate the past

A study about the Homeric Epic

Outline the main objective, ideas of the project/work:

The contemporary digital solutions for the representation allow an almost real way to show the image of the past; this can be done creating realistic environments aimed to virtual or static image creation. This process allows a better and enhanced approach to the learning of the past and at the same time, when combined to the tools for the investigation and for the analysis, creates the conditions to go forward in the knowledge about an age or a period or even about a single fact or item. The object remains to find the best learning path using various learning tools, in the pure "spirit of multimedia", which means the total interaction between multiple media in a single environment. The approach proposed here will not be limited to the simple use of digital graphic tools, but it will include the traditional drawing techniques enhanced in the computer graphic environment to create livelier, more suggestive and communicative representations. At the same time, the

development of common and intelligent representation rules becomes quite important while this must be balanced between the language of archeology and the architecture one. In this research, the world from the ancient Greece, narrated by Homer in the *Iliad* and *Odyssey*, will be the ideal base ground to develop a special experience aimed to produce high quality representation, supported by a correct scientific background.



Fig. 1 – Ancient navigation in the Bronze Age (copyright: Panaiotis Kruklidis).



Fig. 2 – Various reconstructions (copyright: Panaiotis Kruklidis).

The setting of the Homeric Epic has always been a fascinating matter for intellectuals of every period (Fig. 1). Even though this argument is one of the most well-known and analysed topics, the intent of our research is that of up dating the information available with the use of new graphic instruments (the contemporary digital solutions).

The different type of competence, an architectural point of view, offers a new possible approach to the matter, which at present is almost exclusively archaeological (Fig. 2).

The graphic method and the architectural approach to the structures, can help to fill the gap in the available information (Fig. 3). The aim of this new representation, together with the use of the computer, is to produce credible virtual or static reconstructions.

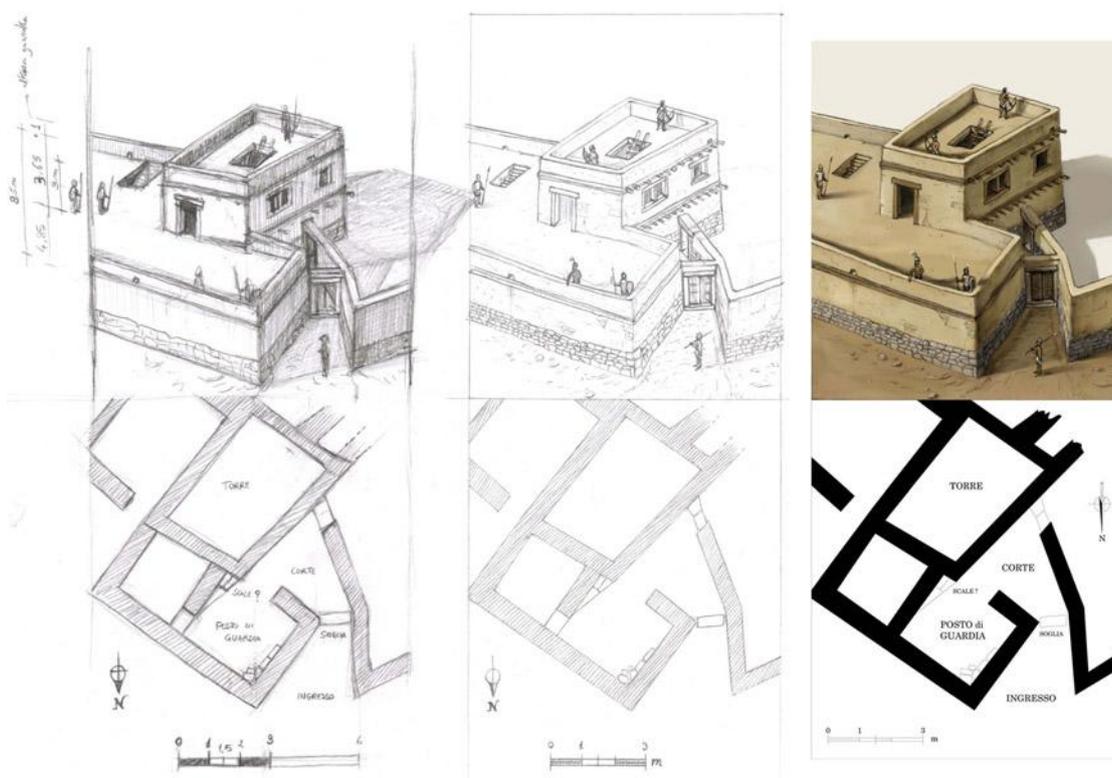


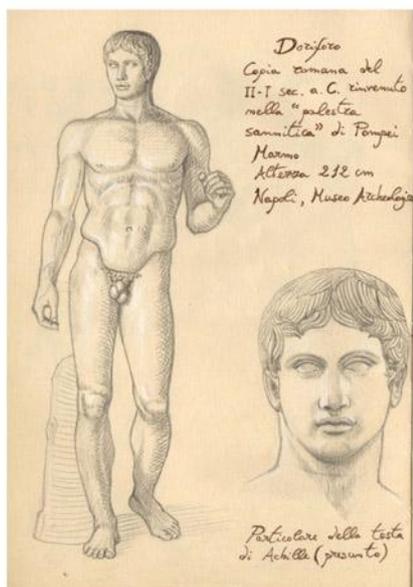
Fig. 3 – Salamina Building IB (copyright: Panaiotis Kruklidis).

Although in our time the traditional drawing has been left backward by the computer graphic, the research presented here is a full fusion and interaction between digital and manual artistry techniques. The traditional approach will give a legacy of tension, of warm signs, of expressive traces, while the digital approach will allow change of mind, unlimited attempts, rich variation and higher performance (Fig. 4).

This process allows a better and enhanced approach to the learning of the past, and at the same time, when combined to the tools for the investigation and for the analysis, create the conditions to go forward in the knowledge about an age or a period or even about a single fact or item. The final purpose is to find the best learning path using various tools, in the pure spirit of multimedia, which means the total interaction between multiple media in a single environment.

Digital and manual artistry techniques

Traditional drawing



Computer graphic



Fig. 4 – Digital and manual artistry techniques (copyright: Panaiotis Kruklidis).

The direct reference at the base of this work is the art from the eighteenth century artists inspired by the archeological discoveries, with a great richness of details, capable to communicate the deep meanings of that age. Thanks to the experience from those painters it is possible to talk about an “archaeological image”, developed starting from the information coming from the knowledge of the ancient times. The main examples come from the work of Lawrence Alma-Tadema, John William Waterhouse, William Bouguereau, and from all the artists of the *École de France in Rome* taking part to the *Grand Tour*. All their work, great example of quality in communication and an incomparable experience, creating a sort of “image periegesis”. Taking from them the importance of lighting and the scenic level of detail, this research aims to underline how an image can evoke the “sense of sublime” and to inspire the observer behind the simple sight, of the shape and size of a town or of an armour in a reconstructive representation.

There are several instruments including: a vast bibliography with appropriate guide lines for the research, various notions learned on site, free-hand drawings and computer graphic with tablet which together may produce the creation of 3D models compatible with the evidenced hypotheses of reconstruction.

During the elaboration, both virtual and graphic, several problems have to be faced and well-interpreted (Fig. 5). In the past, during the studies of this argument, some typological choices have been made in order to identify a better approach. In a field where there is scant archaeological evidence and the possibility of various interpretations, it is really necessary to have specific skills. A collaboration for a more modern and scientific archaeology is very important, giving voice to specialists of different fields.

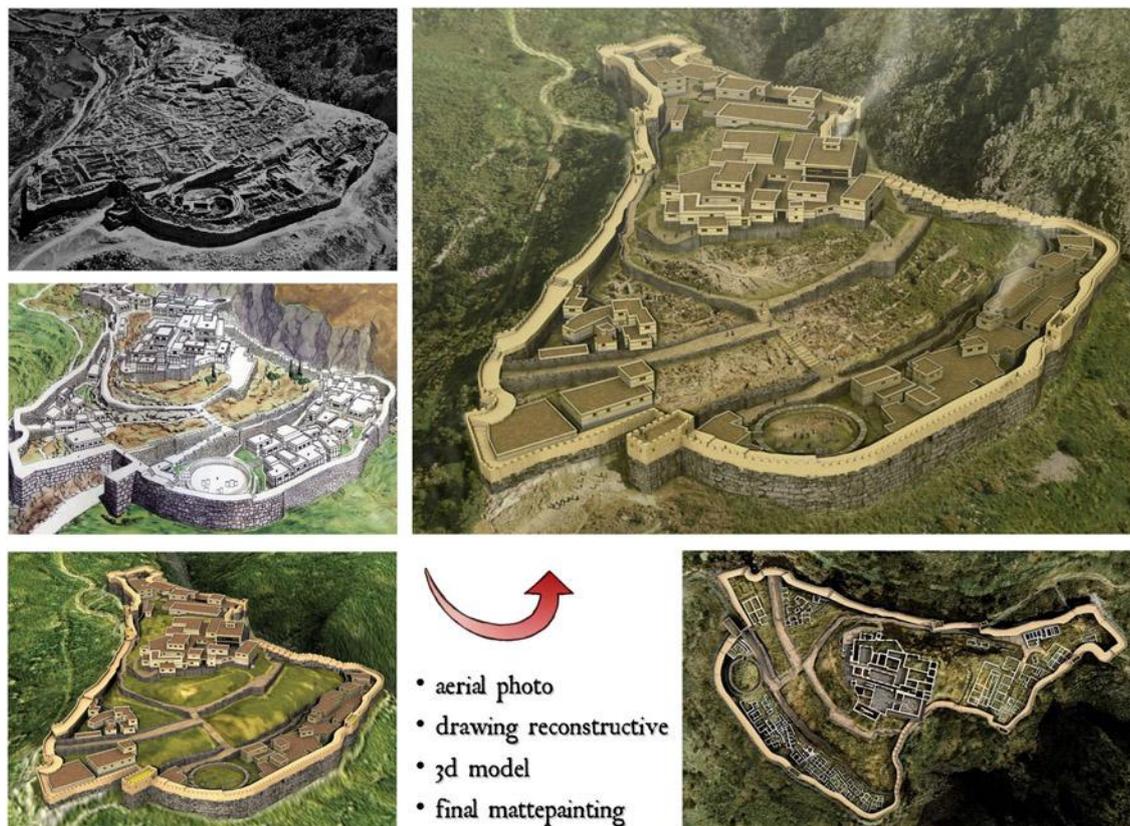


Fig. 5 – Digital and manual artistry techniques (copyright: Panaiotis Kruklidis).

In the first part, our research aims to select a bibliography which reduces to the minimum the contrasting opinions, so as to choose the guide-lines for the reconstruction. In this way all the information obtained can contribute to the development of various topics.

According to recent studies, we have been made virtual reconstructions in 2D and 3D. Remembering that, these places are alive, rich of history twisted with myth, characterized by their heroes, whose deeds are often plaited with the common people, with their own customs and traditions. All these aspects have been expressed in each drawing, trying to restore the “mood” of the place, the soul that characterizes the environment and makes it alive with little signs. It is part of the mood of the place the people who live, and also crossing gives a happy proportion, “a human scale”. Only the birds’ flight in the distance give us a sense of depth, or a sword or a jar left in the ground are perfect to communicate one of the aspect of the settlement (Fig. 6).

The single results will produce tables that are merely graphic and which are not the the final result but just a step in the attempt of putting in evidence the typological choices carried out.

The historical period being analysed comprehends the events that paved the way to the *War of Troy* (which took place in 1200 B.C. ca.). Therefore the reconstructions will deal with a period of time going from one hundred years before and one hundred years after the presumed “fall of Troy”.

The elements to be analysed are various like: the common houses (Fig. 7), the Palace with the *megaron*, the fortifications, the monumental necropolises, the people’s customs and finally the City as a whole.

A corrected city by the reconstructive point of view may be obtained (Fig. 8):



Fig. 6 – House of Lebes building of the Neopalatial period of Haghia Triada (copyright: Panaiotis Kruklidis).

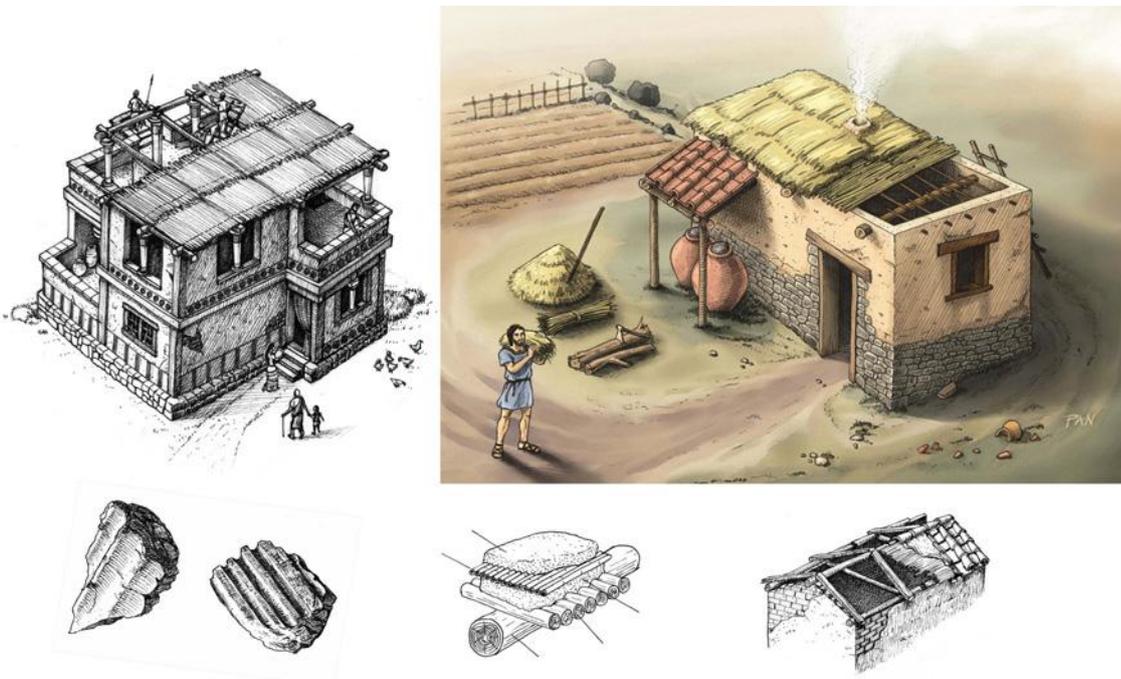


Fig. 7 – The common houses of Bronze Age (copyright: Panaiotis Kruklidis).

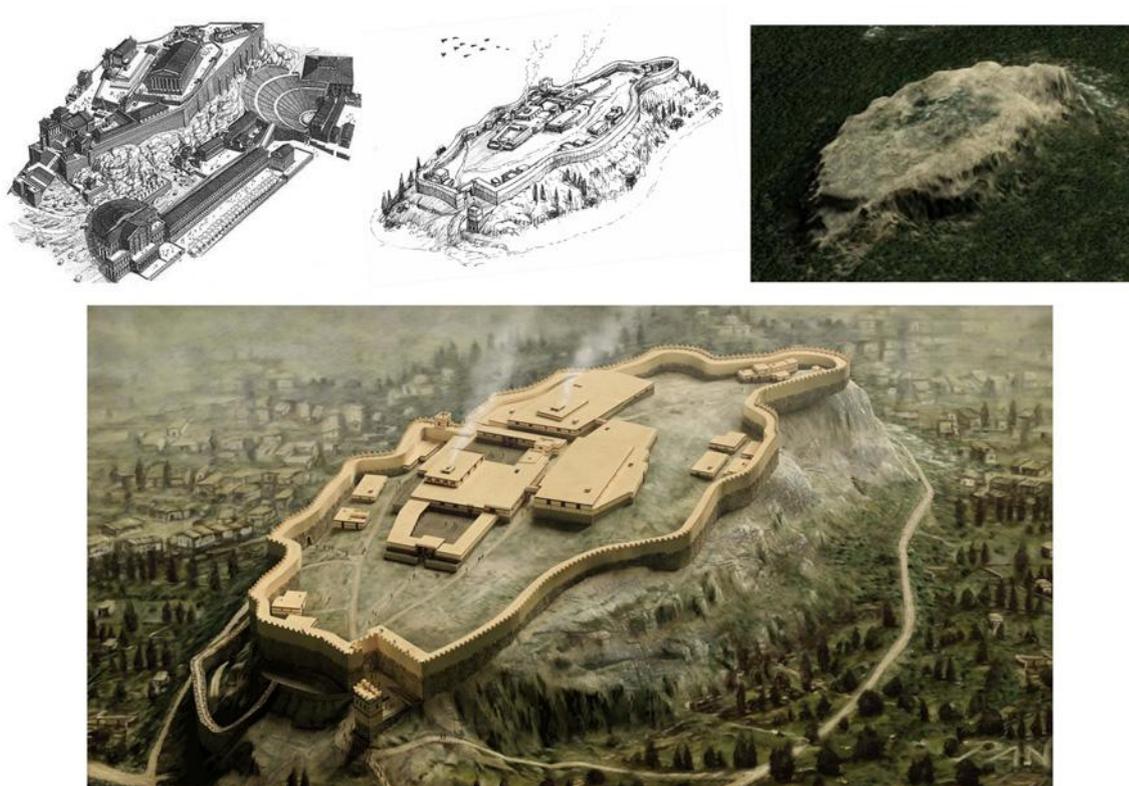


Fig. 8 – Reconstruction of Athens around 1200 b.C. (copyright: Panaiotis Kruklidis).

Generating a terrain with the level.

For terrain modeling in 3D, we started from a basic cartography found on specialized texts, proceeding with the acquisition and import into *AutoCAD*.

The contour lines and the plants have been thoroughly redesigned, taking into consideration not only maps but also the aerial photographs of archaeological surveys more targeted (for buildings of particular importance as the *megaron*).

Once obtained the complete acquisition 2D, at each contour line has been assigned a height scale, thus creating a vector model of the ground. Exported to other programs, this model has allowed a three-dimensional reconstruction, easily accurate (Fig. 9).

Through the programs used for modeling and photorealistic rendering we made other tests in *Bryce*, *Terragen*, *Prosite*, and finally *3DStudio Max* and *Rhinoceros*. These last two programs were found to be more flexible to make and integrate the city's reconstruction.

Creating maps of the latest archaeological discoveries.

An operation similar to that for the realization of the contour lines was made through *AutoCAD*. We started from obtaining archaeological detailed plants with larger scale. With the use of *Photoshop*, the plants were integrated by the details of small excavation (the scale of single unit) to the scale of the city (the whole area inside fortification walls). The final result was a collage of plants of different detail, returned in the same scale (Fig. 10). Finally, the plant was imported on vector program for redesign the sectioned and sometimes even not sectioned.



Fig. 9 – Generating a terrain with the level (copyright: Panaiotis Kruklidis).

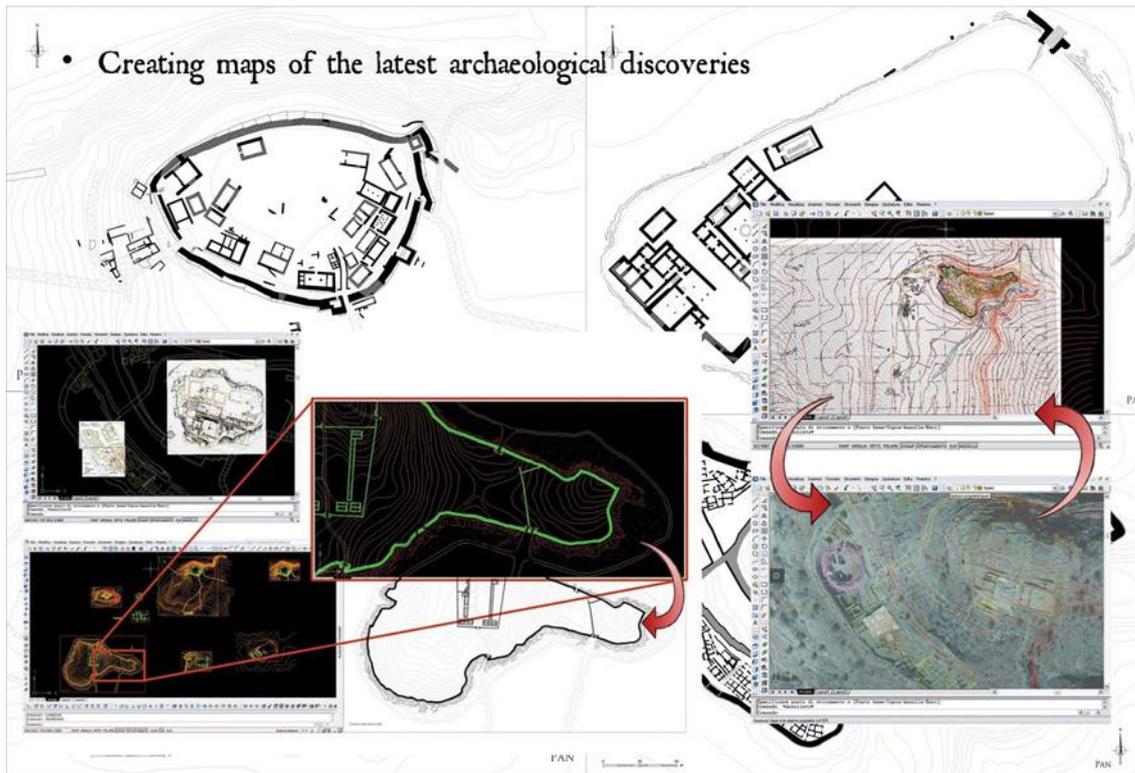


Fig. 10 – Creating maps of the latest archaeological discoveries (copyright: Panaiotis Kruklidis).

Deepening the documentation with proposals reconstructions (Fig. 11).

The modeling was made entirely on *AutoCAD*, through major commands extrusion and *boolean operation*. Only a few details have been changed more rapidly after importing the model *Dwg* of *3DStudio Max*, acting on modifiers of solids.

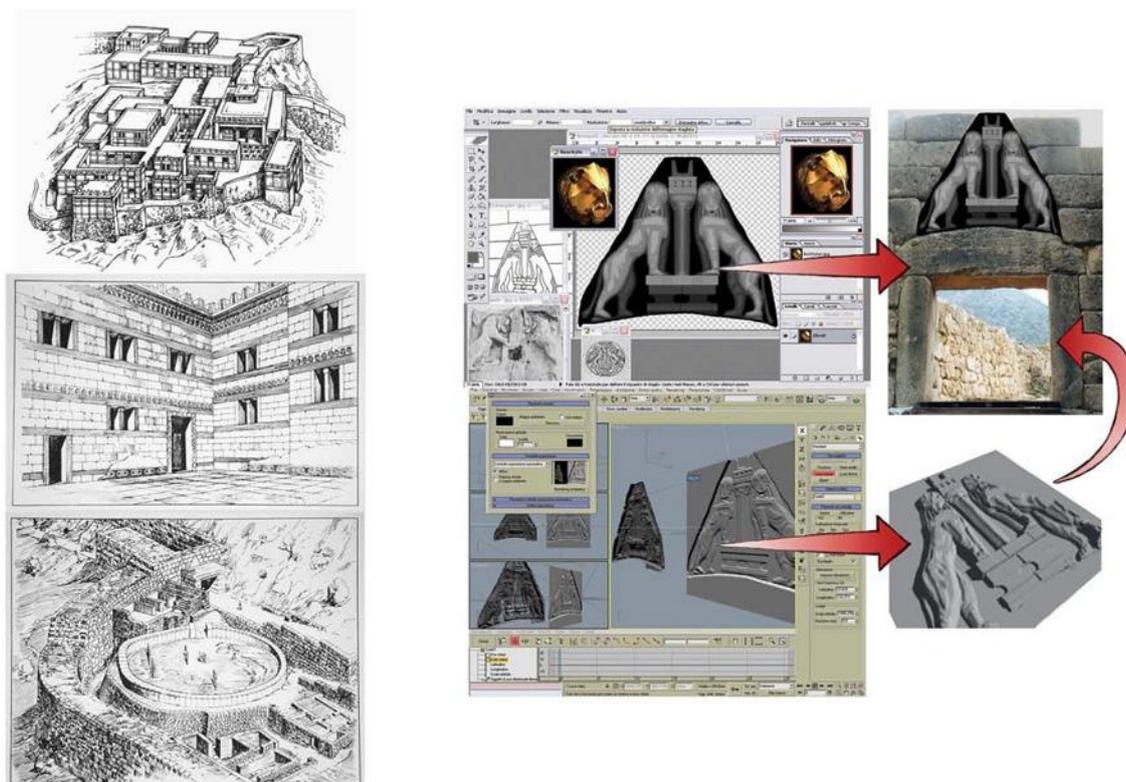


Fig. 11 – Deepening the documentation with proposals reconstructions (copyright: Panaiotis Krukliadis).

One of the first phases of the project concerns the creation of 3D terrain. Once imported the *layer* contour lines as *splines*, using the command generates a *terrain mesh* surface that reproduces the ground. To this is applied a modifier *UVW map* with *planar mapping*, which allows to place correctly the *texture*. The mesh, finally, is associated with the *texture* prepared with *Photoshop*. This is made entirely with the help of the tablet, using a *Dwg* base of the level curves obtained with the *Cad*. In this way you can save time during application and sizing of the *texture*, maintaining excellent and professional results. In addition, retouching by hand is useful to give at the map some details, like rocks, rivers and roads, respecting the shape of the territory (Fig. 12).

The maps, once finalized, are used on the channel specifically dedicated of *3DStudio Max*. Each has its place: in the *diffuse channel* is added the colored texture (which becomes the basis for the map), to accentuate the effect of material relief is used the channel with a *bump map* similar (in size and detail) to the previous one but appropriately retouched, in black and white. Other channels may be used, but of great visual impact is the *displacement channel* maintained on very low values, or exponentially increase the duration calculation.

Creating photographic texture on site.

Starting with photographs of the materials made *in situ*, with the help of digital camera, through *Photoshop*, cutting out the portion in frontal axis, when adjusted by the *Lens Correction* filter. Sometimes it's necessary to proceed with rectification with *ImageAlign Pro*, a specific program for this type of treatment (Fig. 13). Cut the useful part is passed to the correction and contrast color to make the photo more readable, by the

method *Color Balance*, *Brightness/Contrast*, *Hue/Saturation*, *Selective Color Correction*. Then it makes perfectly *seamless textures*, clipping small portions of the side and using the *clone stamp* element to stabilize the joint. The result is a map that does not present the classic effect of repetition in the render. We create a separate *bump map*, usually by changing the image to grayscale, then adjust the *Brightness/Contrast* or *Levels*, trying to obtain an effect that shows the depths and heights of the relief material. Additionally you can proceed with the *Burn* and *Dodge Tools* to enhance or reduce relief. The map can be modified to add elements not in the picture (in the map of the Cyclopean walls was added on the crest of a mud-brick trim).

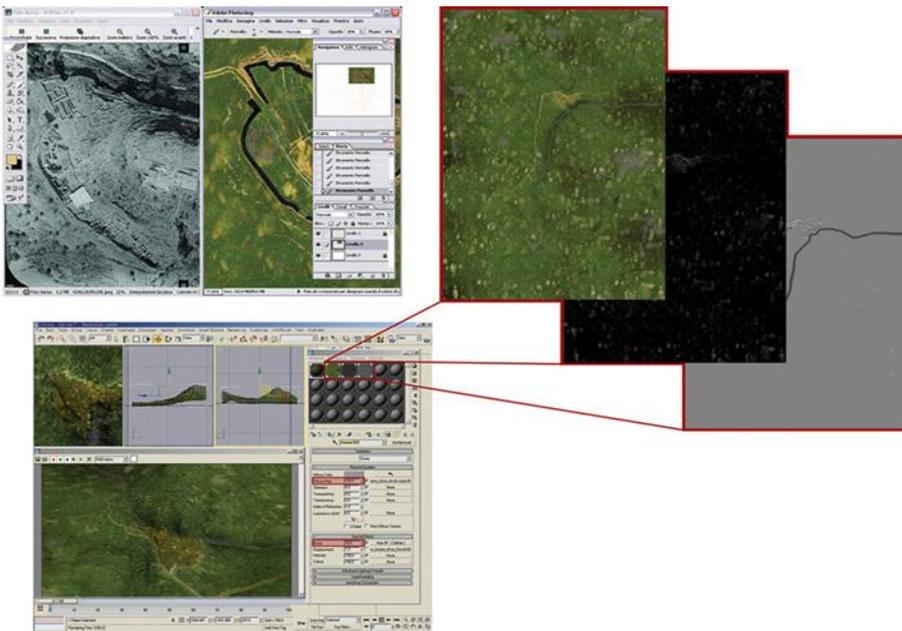


Fig. 12 – Creating texture map with some real details (copyright: Panaiotis Kruklidis).

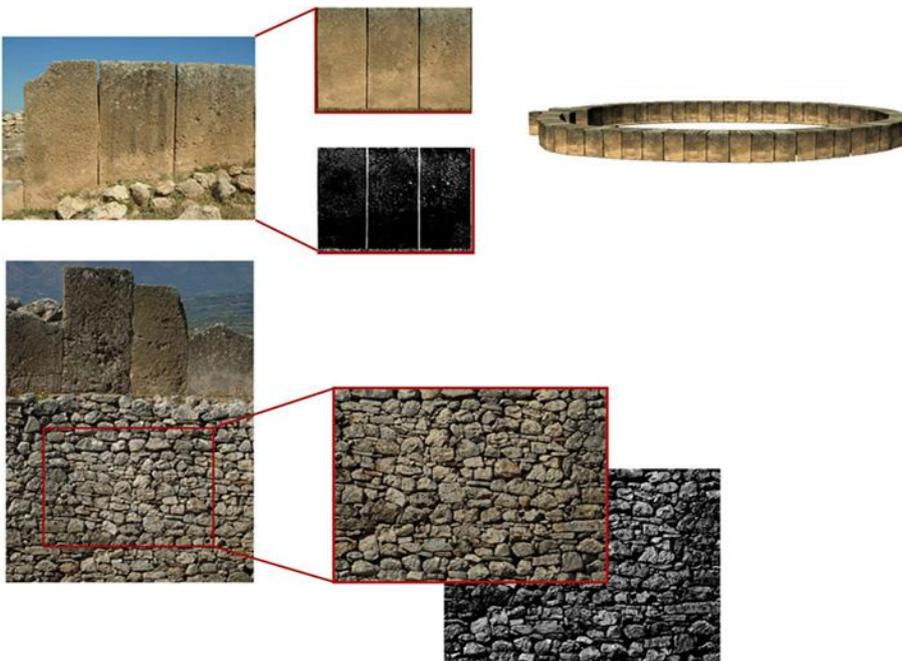


Fig. 13 – Creating photographic texture on site (copyright: Panaiotis Kruklidis).

Generating the render with high resolution.

An important phase is the final *render*. At first you must do several tests (using low resolution for the calculation) to create the desired environment in the reconstructions, placing correctly the maps and give the better lights and shadows. Later, once established the view through the use of the *camera*, you decide the window size. The calculation procedure is laborious for the computer and the devices to be used are many. First of all, it creates a 3D model with fine detail displayed only in the view. We use a good quality *rendering engine*, reduces the calculation parameters for the lights and shadows, using the *Global Illumination* for intermediate parameters, and avoids the *Caustics* (not necessary for the materials used here), the vegetation is excluded from the model, made separately and then placed on *Photoshop*.

Ending retouch of the image.

A process that should not be underestimated is the *rendering post-production*. The image obtained by the *rendering engine* sometimes has defects, which are here adjusted appropriately. It is not, however, only with corrections, each work must be enhanced through the implementation of details and effects (Fig. 14).

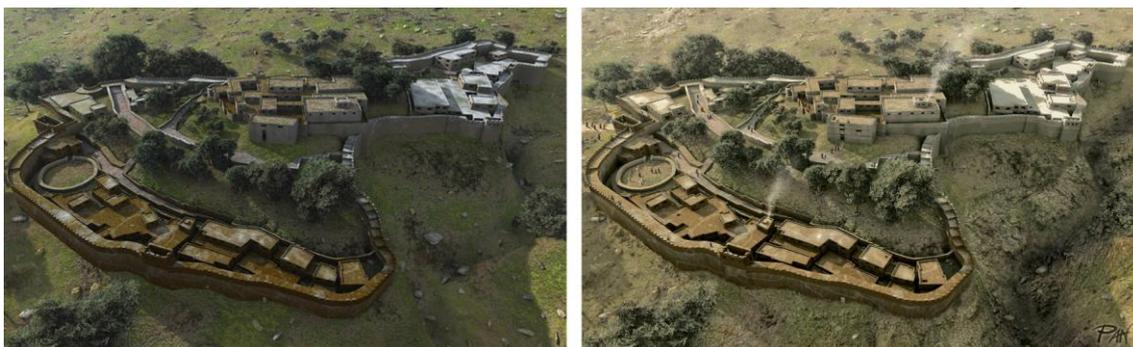


Fig. 14 – Retouch of the image of Mycenae around 1200 b.C. (copyright: Panaiotis Kruklidis).

At the end, the image will be transferred on *Photoshop* and almost indispensable, the tablet must be followed by retouching itself. The colors are correct, the method with *Color Balance*, *Brightness/Contrast*, *Hue/Saturation*, *Selective Color Correction*. The errors will be masked with the *Clone stamp tool*. With *Burn* and *Dodge Tools* you reduce or accentuate highlights and shadows. Finally, you add details that are primarily for the "mood of the place" like: people, vegetation, animals and objects.

After this procedure we are ready to deliver the final image.

However simplified, a corrected illustration by the historian point of view (Fig. 15):

Studying equipments and customs narrated by Homer and ancient sources.

Searching archaeological material.

Studying iconographic sources, ancient and modern.

Finally, creating a sketch, a drawing with colour on a software of retouch image.

Adding various techniques of texturing (Fig. 16).



Fig. 15 – Example of reconstruction of Ajax Telamon and Agamemnon (copyright: Panaiotis Kruklidis).



Fig. 16 – Example of reconstruction of Clytemnestra with techniques of texturing (copyright: Panaiotis Kruklidis).

Originally developed as a degree thesis in Architecture, under the direction of prof. Giorgio Verdiani and prof. Anna Margherita Jasink, this research moves within the world described by Homer in the *Iliad* and *Odyssey*. Our proposal is to follow an articulated path between drawing, representation, architectural and archaeological studies to define a sort of “image periegesis”, going behind the narrative aspect, to underline and to bring back the cultural depth which is necessary to create a real learning experience, supported by a correct scientific background.

This work is also connected with MUSINT (interactive museum of Aegean collections in Tuscany) of which Anna Margherita Jasink spoke in a previous lecture in this Conference. In that section you have seen the drawing and 3D dimensional of two Minoan sites: Phaistos (Fig. 17) and Haghia Triada (Fig. 18). Now you have seen Mycenaean sites. In this way, you have an idea of the palatial buildings and the people's customs in the Aegean civilizations of the Greek areas in the Second Millennium before Christ.

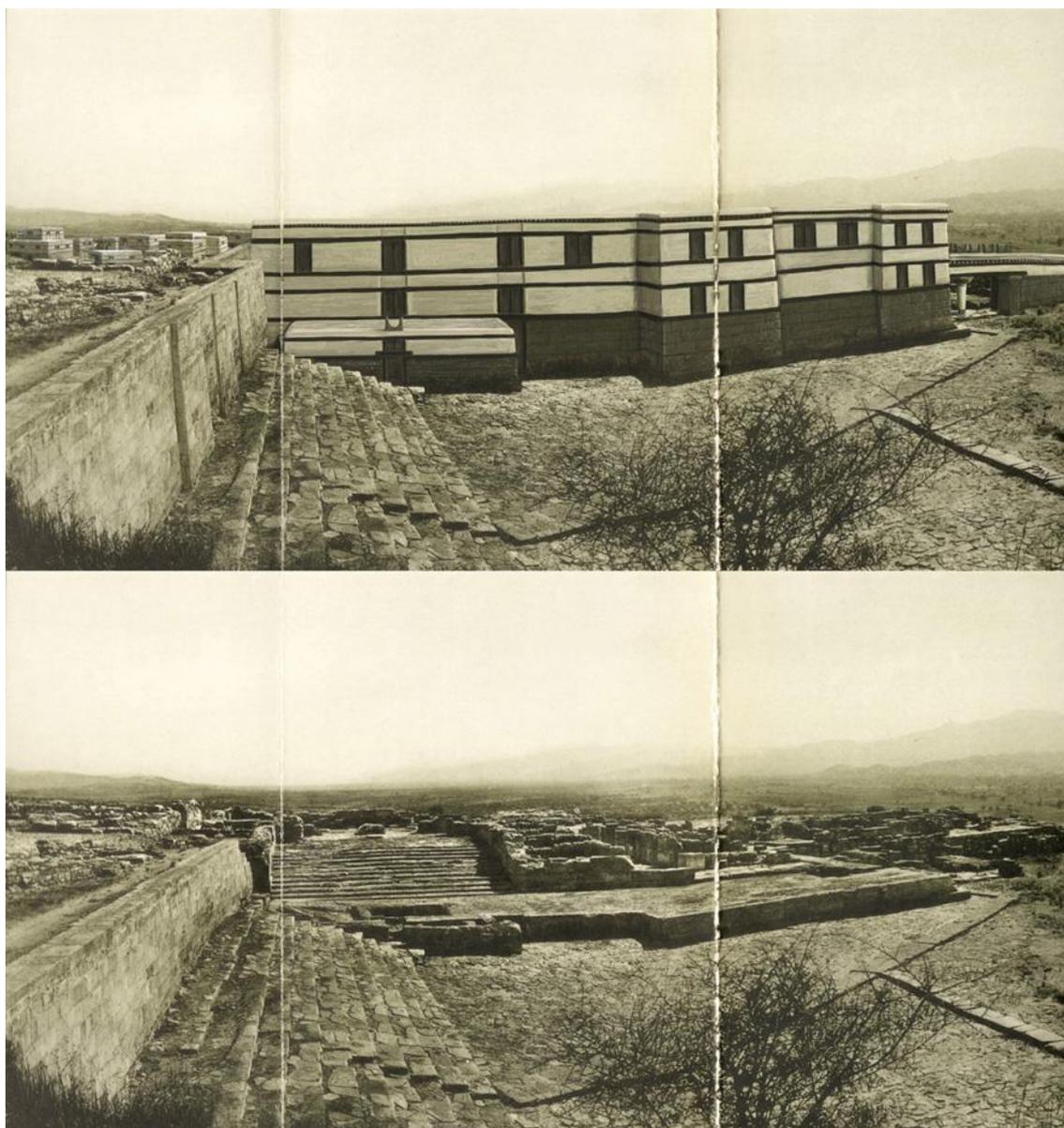


Fig. 17 – Portion of the Protopalatial period palace of Phaistos (copyright: Panaiotis Kruklidis).

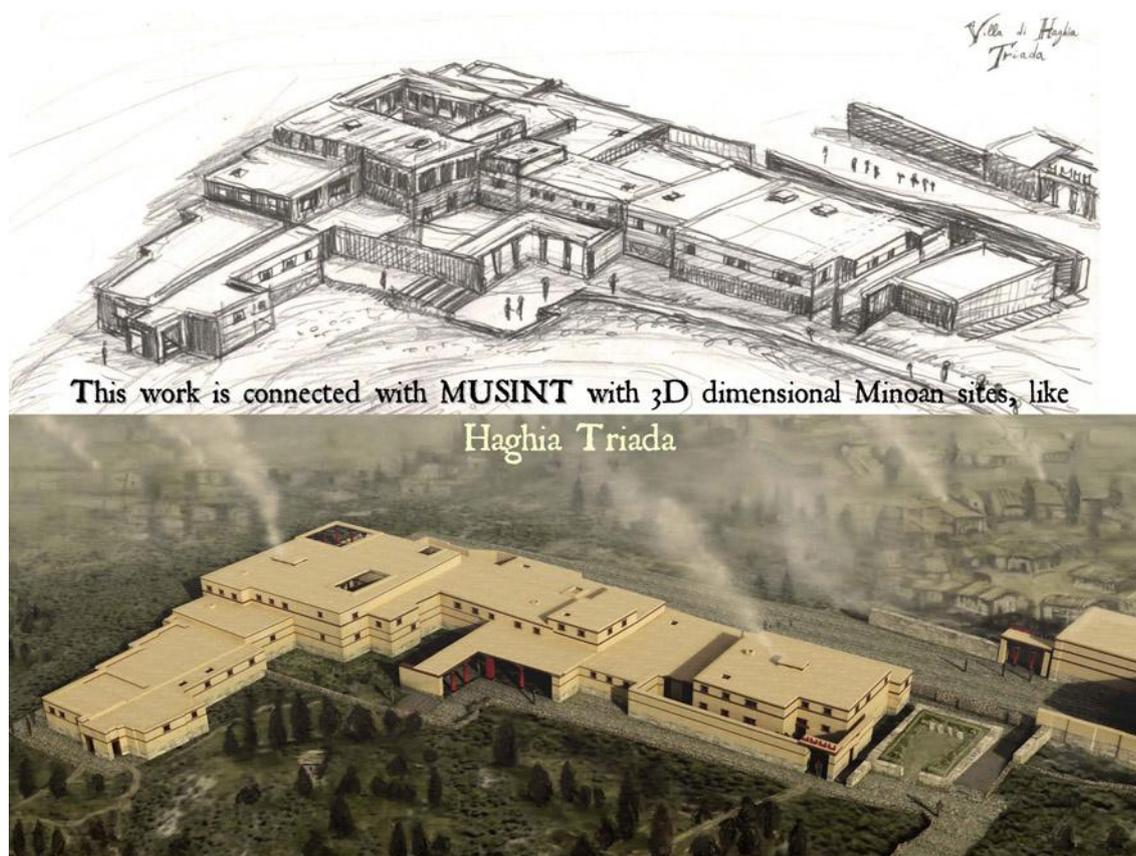


Fig. 18 – Villa of the Neopalatial period of Hagia Triada (copyright: Panaiotis Kruklidis).

All images are property of the author Panaiotis Kruklidis. Many of this are visible on his personal blog: <http://iltaccuinodipan.blogspot.it/>.

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An Augmented Reality Framework for On-Site Visualization of Archaeological Data

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Abstract: This work is focused on using augmented reality (AR) technologies for visualizing information in the context of urban sites. After a brief overview of several approaches to implement AR-applications we will concentrate mostly on the vision based approach. We established a prototype platform for onsite augmented reality visualizations that meet different levels of presentations. This applies for information such as simple points of interest, displayed as overlay symbols over the perceived camera image. These displayed points of interests can be used as a user interface to explain certain findings with texts and images. A more advanced presentation technique will be the implementation for complex 3d models that can be placed at the actual location of the archaeological site. The Unity3d game engine is hereby used as the main development environment because of its high graphical 3d performance, the possibilities to implement interactivity and multimedia content and to publish the final application to different mobile platforms. Our prototype implementation is demonstrated with the location and content from the site of Michaelerplatz, Vienna. However the framework can easily be adjusted for different locations and different content using a web-based database.

Keywords: Information Visualization, Augmented Reality, Archaeological Visualization, Location Based Services.

Introduction

The analysis and interpretation of an archaeological site is a complex process and many layers of data and interpretations of it are generated while performing an excavation and studying the findings afterwards. Very often at urban sites, the excavation is closed again and most of the data is represented in publications, the findings themselves may be exhibited in different locations or are stored in special archives. To visualize the complexity of all available information at the context of the site is very difficult. The idea of blending the perceived remains of a site digitally with computer rendered images is the key element for the use of augmented reality technology within an archaeological context. As the available AR-devices get more accessible for archaeologists as well as for an interested public audience, because of the wide availability of smart phones and tablets, this technology could generate many new and different applications for on-site visualizations.

Augmented Reality as a Visualization Technique

Nowadays new media and technologies get more and more accepted in museums and play an essential role in many modern archaeological exhibitions. Furthermore a lot of research has been done in projects such as

ARCHAEOGUIDE – a system offering augmented reality tours on archaeological sites (VLAHAKIS, IOANNIDIS et al. 2002; VLAHAKIS, KARIGIANNIS et al. 2002), ARCO – a one-stop-solution for museums to create, manage and present both content and context for virtual exhibitions (WHITE et al. 2004; WOJCIECHOWSKI et al. 2004), LIFEPLUS – a project adding realistic renderings of virtual flora and fauna to historical sites using AR technologies (PAPAGIANNAKIS et al. 2004) and (MAGNENAT-THALMANN et al. 2006) or AR-View – an AR device for digital on-site reconstruction (LIU and WANG 2009) showing how technologies like virtual reality (VR), augmented reality, 3D simulation and other tools can be used to present archaeological content to the audience inside museum environments as well as on site. While for museums and archaeological parks these technologies seem feasible, the necessary hardware and infrastructure is clearly a limiting factor when it comes to showing archaeological content in an urban environment. With a constantly growing distribution of smart phones and tablet computers containing the necessary technical infrastructure for augmented reality applications and multimedia content we therefore tried to create a framework suitable for archaeological AR on-site visualization in an urban environment running on consumer devices. In order to build such an AR application there are three generally necessary steps. First evaluation of the current position of the users camera, second rendering of the content that should be displayed from the current point of view and third merging camera live view and virtual content and displaying the augmented view. To do this today mainly two different methods are used that vary in the way the current position of the camera is calculated. These methods are called sensor based AR and vision based AR and will be described further below.

Location Based Augmented Reality

This method is most common at the moment. It requires input from multiple sensors to evaluate the position and rotation of the camera used for the background image in space (SUTHERLAND 1968). A stationary system using this approach was built in AR-View giving visitors of the site of Yuanmingyuan, China, the possibility to see a 3D stereoscopic reconstruction of destroyed elements from a fix point of view. The user could thereby rotate the viewing device horizontally and vertically which was measured to calculate the current camera orientation.

More mobile AR systems running on contemporary smart phones usually use the built in sensors like GPS, compass and accelerometer or gyroscope to calculate the camera pose. The main field of application of this method is to present roughly positioned GPS-referenced information about certain topics. Layar and Wikitude, two among smart phones widely available augmented reality browsers, are examples for platforms showing GPS positioned info tags, loaded from a database at runtime. While both of them have a very limited amount of datasets (so called layers or worlds) dedicated to archaeological content available, the main source for that kind of information in both applications is Wikipedia.

The biggest advantages of sensor based AR are its simplicity and reliability as well as the fact that it can be used globally as long as a GPS signal or any other technology to calculate the current position of the user is available. However the main problem about this solution is the inaccurate positioning of the augmentation. GPS on contemporary smart phones typically has accuracy of just about 10 meters. In more problematic

situations like inside a city the accuracy is often even less and the necessity to combine it with other sensor data comes with additional possible sources of errors.

Vision Based Augmented Reality

Vision based AR uses a different technology to determine the current camera orientation. By applying computer vision (CV) algorithms the current camera image is processed in order to find known patterns. Once such a pattern is found the spatial relation between it and the camera can be calculated. In ARCHAEOGUIDE a vision based approach was used to present 3D reconstructions of Greek monuments in Ancient Olympia, Greece at their exact position in the natural scene using a wearable computer and a head-mounted display.

On mobile devices mainly two subcategories of this technology are used relying on either artificial markers or natural features.

Vision Based AR with markers

The patterns searched for in this method are predefined 2D markers (REKIMOTO 1998). These markers are usually black and white patterns that follow certain rules, in some cases QR codes have been used as markers. Due to their unique shapes they can be detected very easily and in some sorts of markers like QR codes further information can be embedded. AR functionality using markers has been implemented for example in the previously mentioned ARCO project as part of an Augmented Reality exhibition (WHITE et al. 2004). While it delivers by far more precise results in calculating the current position of the camera compared to using GPS, the necessity to apply artificial markers to the environment in order to use this method is a disadvantage.

Vision Based AR with natural features

The advantage of this solution is that it allows using a textured planar target, preferably a contrast rich image, as references to calculate the camera position (WAGNER et al. 2008). This implies that this system is not bound to predefined patterns or QR codes. It gives the possibility to use basically any planar surface as a reference as long as it contains a certain level of detail. Also offering a very high level of accuracy this method seems to be well suited for inner urban AR visualization.

Urban Archaeology Site – Michaelerplatz, Vienna

As the site for our demo application we chose Michaelerplatz. Situated at the intersection of Schauflegasse, Herrengasse, Kohlmarkt and Reitschulgasse Michaelerplatz is a calm, generous and beautiful square in the first district of Vienna surrounded by a handful of interesting buildings. Because of its location and historic background it is a frequently visited hotspot for tourists. The history of the area however goes back as far as to Roman ages where in the 1st Century it was part of the so called canabae legionis which was part of the Roman camp Vindobona and was located at the intersection between two important streets at that time. After the Romans left the area around Michaelerplatz in the 5th Century it seemed to be abandoned until it was included in the medieval city in the 13th Century and the Church St. Michael was built before 1525 as a second church besides St. Stephan. After that the slow development to an actual square was characterized

by imperial-private and public use until the Loos-House concluded the development into a square (RANSEDER et al. 2011).

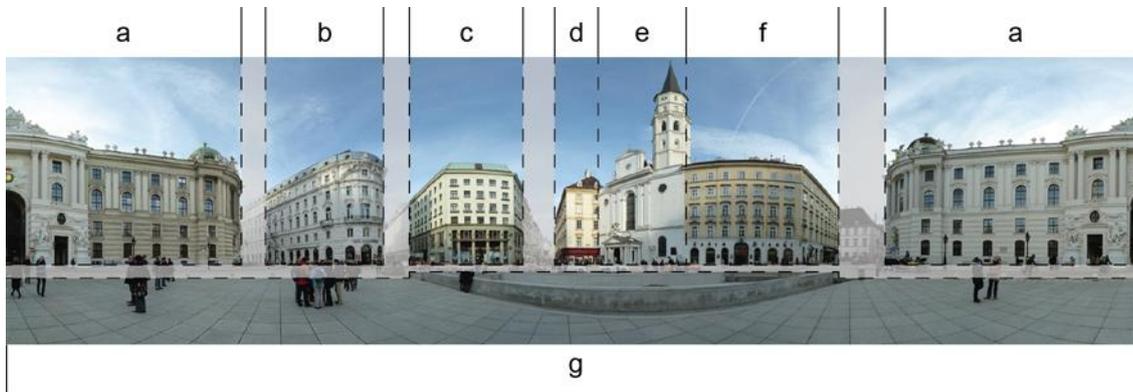


Fig. 9 – Panoramic image Michaelerplatz, Vienna (Copyright: Stefan Niedermair).

a. Hofburg – Michaelertrakt (Hofburg Palace – St. Michael's Wing)

As a part of the Hofburg the wing oriented towards Michaelerplatz was intended to be a representative entrance form the city center. Planned by Joseph Emanuel Fischer von Erlach, who followed Johann Lucas von Hildebrandt as lead Architect, the southern part of the St. Michael's wing was built between 1728 and 1734 as seat of the Winterreitschule. After running out of money the rest of the wing stayed unfinished until the years 1818 to 1824, when the gate was built. The rest of the building was finished between 1889 and 1893 mainly following the original plans by Joseph Emanuel Fischer von Erlach but a dome was added on top of the rotunda (KRAUSE 2007).

b. Palais Herberstein

Palais Herberstein was built in 1879 by Architect Carl König and commissioned by the counts of Herberstein and replaced the Dietrichsteinpalais after it was bought by them in 1861. The building played an important role in the development of the square in the late Historicism and was criticized for stylistically referring to the palace rather than the church and the other buildings around the square (KRAUSE 2007).

c. Loos-Haus (Loos house)

Built between 1909 and 1911 by Architect Adolf Loos the so called Loos-House contained business and living areas for the tailor company Goldman & Salatsch. Loos used real marble for the lower floors where the business rooms were situated while he used simple plaster for the facade of the living floors which gave a clear visual differentiation between the two areas. While there was criticism about the facade at first nowadays it is recognized as one of the most important buildings of early Modernism and was declared cultural heritage in 1947 (KRAUSE 2007).

d. GroÙes Michaelerhaus (Big Michaelerhouse)

This house is a high baroque apartment building built by the Barnabites as a way to earn some money for their Order. Its ground plan is already visible in a plan from 1710 (KRAUSE 2007).

e. Michaelerkirche (Church St. Michael)

The Church itself goes back to the 13th century and got its name from Saint Michael. After parts of the church got destroyed several times through fires and an earthquake its nowadays appearance is mainly

based on the state of the 16th century. The porticus for the main entrance was added in 1724 and the facade was redesigned in an early classicistic style in 1792. Since 1626 the church belongs to the Order of Barnabites which was an important impulse for the development and design of the complex (KRAUSE 2007; RANSEDER et al. 2011).

f. Kleines Michaelerhaus (Small Michaelerhouse)

This house is a high baroque apartment building built in 1732 which still exists with minor modifications and it was topped in 1848. The Small Michaelerhouse was commissioned by the Barnabites as part of the building complex including the Church St. Michael and the Big Michaelerhouse (KRAUSE 2007).

g. Excavation Site Michaelerplatz

In 1990 and 1991 Vienna Urban Archaeology made two excavations to investigate the remains under the square. During these excavations parts of buildings and basements that helped to understand the history and development of the square from Roman and medieval times until the modern era have been documented. Besides that numerous other items of daily use have been found. Among these findings are pottery, coins, glass, jewelry and different items made of bone from different epochs (RANSEDER et al. 2011).

Natural Feature Tracking for Inner Urban Augmented Reality

The goal of our application will be to display accurately positioned information about the archaeological site and the surrounding buildings indicated by tags as well as 3d models overlaid on the live image provided by the phones built in camera in order to allow the user to explore Michaelerplatz with the help of his own mobile device.

In order to do this we have chosen to use natural feature tracking, as sensor based AR alone is too imprecise to achieve accurate positioning of the virtual content over the natural environment. While marker based tracking would deliver precise enough results, in most scenarios it is not feasible to apply large scale markers to a public environment like Michaelerplatz.

Photographing Facades as Reference Images

Even though the facades of buildings are typically not perfectly planar surfaces in most cases the majority of their elements are almost part of a single plane. Considering this, planar trackables can be generated from orthographic images of the facades of a building.

The common approach to get these images would be to take a picture of the facade and apply distortion correction techniques to it. This however results in a quality loss due to unequal pixel distribution over the image. In our project orthographic photos of the facades have been taken directly by using a digital camera together with a tilt-shift lens, providing a high quality, distortion free image.

A high amount of contrast rich points, so called feature points, is essential for natural feature tracking to deliver good results. Because of that additional contrast enhancement using image processing software might be necessary to increase the performance for tracking.

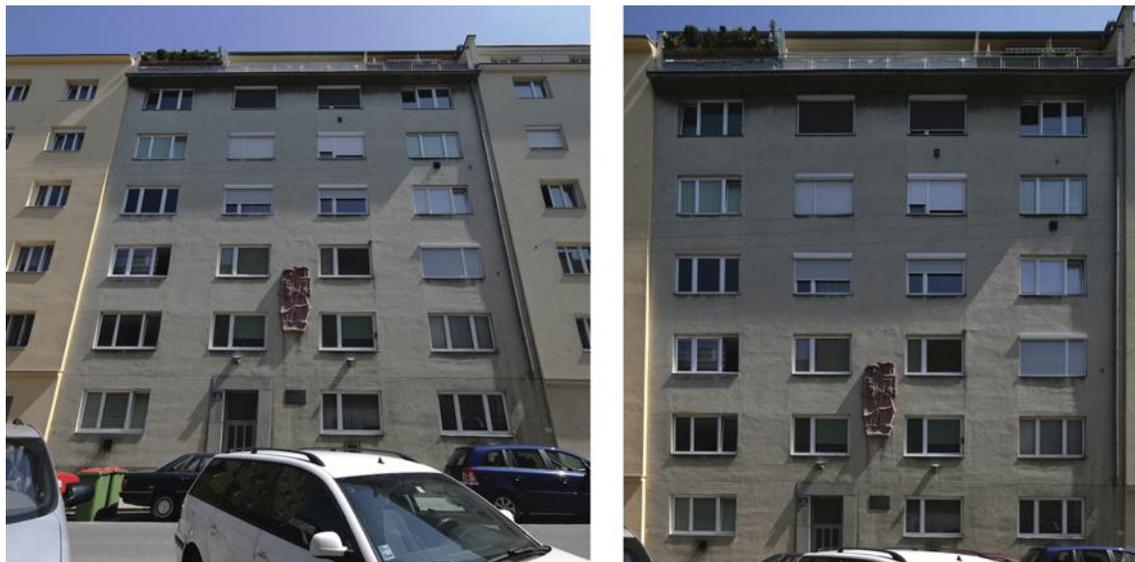


Fig. 10 – Orthographic pictures for trackable facades. Left: normal lens; right: tilt-shift lens (Copyright: Stefan Niedermair).



Fig. 11 – Image of a facade with indicated feature points (Copyright: Stefan Niedermair, QCAR web service).

Technical Background

The framework we built for on-site visualization consists of the game engine Unity as the main development environment together with the Qualcomm Augmented Reality (QCAR) plug-in (aka Vuforia). The QCAR plug-in provides a very user friendly way to take advantage of its great natural feature tracking capabilities and therefore seemed ideal for our case. The first tests with the application however showed that even though many of the facades around Michaelerplatz delivered sufficient tracking capabilities they were by far not perfect. Therefore also some sensor based AR features were implemented as a backup in case vision based AR is not available.

In vision based AR the 6 necessary degrees of freedom (DOF) of the camera – position in x-, y- and z-axis as well as rotation around x-, y- and z-axis are calculated by the QCAR plug-in. Considering that a typical user would stand somewhere on the square it proved to give a more pleasant experience to set the y-value (height) of the camera to 1.5 m above the ground, which is about the height that a typical user would hold his

device in resulting in a system with just 5 DOF. Therefore as long as facades in the surrounding are recognized and vision based AR is available the user can move freely on the square. As soon as the tracking is lost the position of the camera is considered as static and the accelerometer or if available the gyroscope of the device is used in a sensor based approach in order to keep track of the user's rotation in a system with just 3 DOF. Convincing AR at that point is still possible as long as the user doesn't change his position by more than about a meter. Therefore once the user changes his position without being in vision based AR mode the application has to recognize one of the facades again in order to deliver precise positioning.

Creating a 3D Model as Spatial Reference

In order to build a spatial reference between the real world environment and the 3D scene in Unity the whole surrounding of the square was rebuilt with trackables representing the single facades.

Based on the previously mentioned orthographic facade images the trackables themselves were created by the Qualcomm Target Management System. It requires images in PNG or JPEG file format and a file size not larger than 2MB. The system then automatically evaluates and processes the images uploaded and gives feedback on the quality of the trackables. Contrast enhancement of the pictures increased the available feature points for tracking. Once the Qualcomm web service reported sufficient tracking quality, the processed files could be downloaded and directly imported into Unity.

The actual spatial layout of the 16 single trackables for Michaelerplatz was based on the multipurpose map of Vienna ("Mehrzweckkarte", MZK provided by MA41), a digital plan containing all the necessary elements for this task. While all referenced facades contribute to the positioning in the final application early tests showed that only some of them were actually suited for initial detection and therefore to start the vision based AR. Additionally an almost frontal position ($\pm 20^\circ$) and a distance of at least 15 m to these facades were usually necessary in order to recognize them. Considering those restrictions vision based AR can still be started from almost everywhere on the square (Fig. 4).

Referenced to this model of the surrounding different types of content can then be placed either in direct spatial relation to one of the facades or anywhere on the square (Fig. 5).

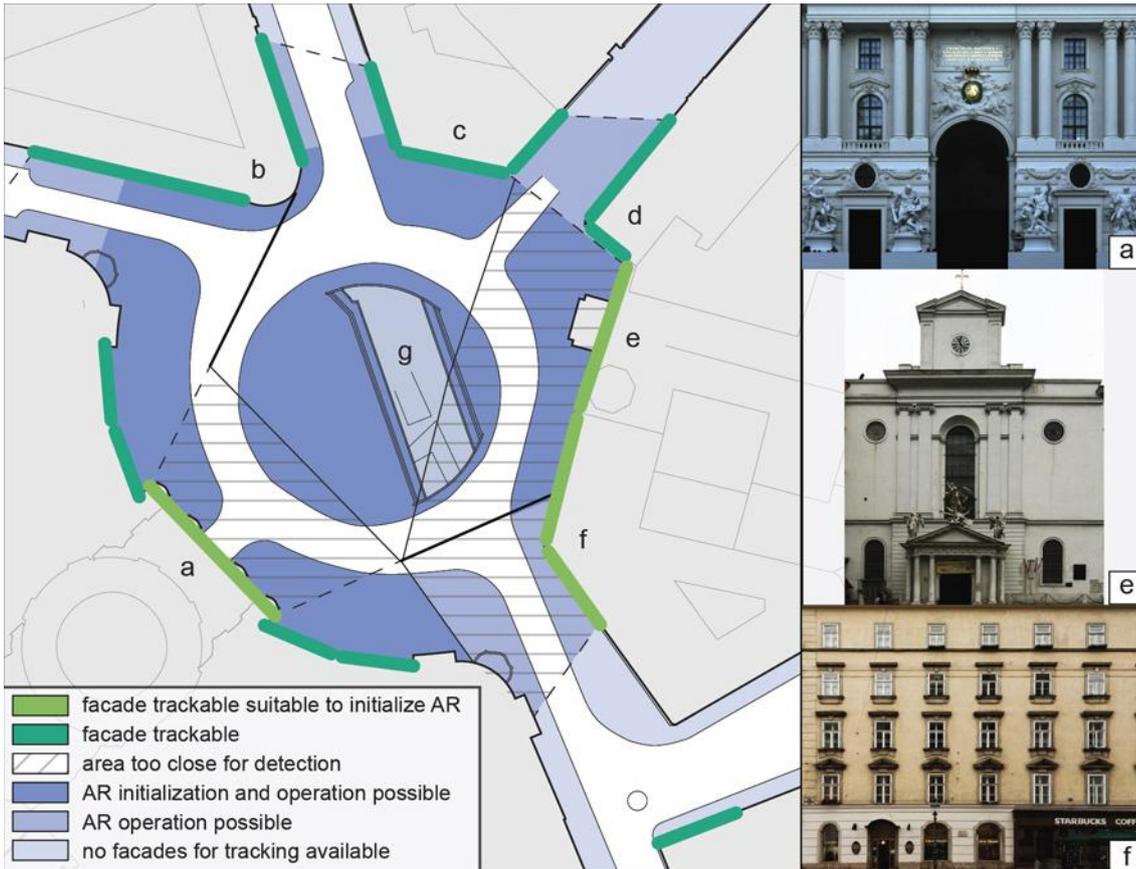


Fig. 12 – Trackable layout and AR capabilities at the site (Copyright: Stefan Niedermaier, based on data from: Stadt Wien - ViennaGIS, www.wien.gv.at/viennagis/).



Fig. 13 – 3d layout of referenced facades and information to display based on MZK provided by MA41 (Copyright: Stefan Niedermaier).

An Augmented Reality Cultural Heritage Information System

Once the application is started on a mobile device the user will see a start screen asking him to start the AR functionality by pointing the devices camera at one of the previously described facades to start the vision based positioning. As soon as one of these facades is recognized by the application, which in most of our tests didn't take more than a few seconds, the system is running and the user can start to explore his surroundings. The user can thereby see different types of information, texts, images, videos, web pages and 3d models that are related to the historical development of the square, indicated by info tags for each category (Fig. 6). While the user moves and typically rotates around to see all the available information the tags stay at their right position (Fig. 7).



Fig. 14 – Info tags for different content – from left to right: text, image, video, website, 3d model (Copyright: Stefan Niedermaier).



Fig. 15 – Running application showing 2d info tags (Copyright: Stefan Niedermaier).

To find out more about one of the tags the user has two interaction possibilities. The first way is to rotate the device towards a particular marker bringing it into the center of the monitor which will change the marker to a preview of the available content if available. In addition to that further information about the item is displayed in an info-box at the lower end of the screen (Fig. 8, left). The user can then either click on that preview or

directly on a tag to get access to the whole information. Depending of the type of content this is done in different ways. While texts and images are displayed in a pop-up window (Fig. 8, right) videos can either be played by the devices integrated media player or they can be streamed from the internet using a platform like YouTube or Vimeo. Web pages, typically linked to Wikipedia or other articles will be opened in the standard web browser. For 3D models we have to differentiate between two different types. Findings from the site will be opened in a new window allowing the user to further investigate it using standard gesture controls to rotate it as well as to zoom in and out. Models like building reconstructions etc. from the site will be shown as part of the augmentation over the camera image. This is the most critical case for calculating the position as it requires the model to be placed very exactly in three dimensions (Fig. 9).

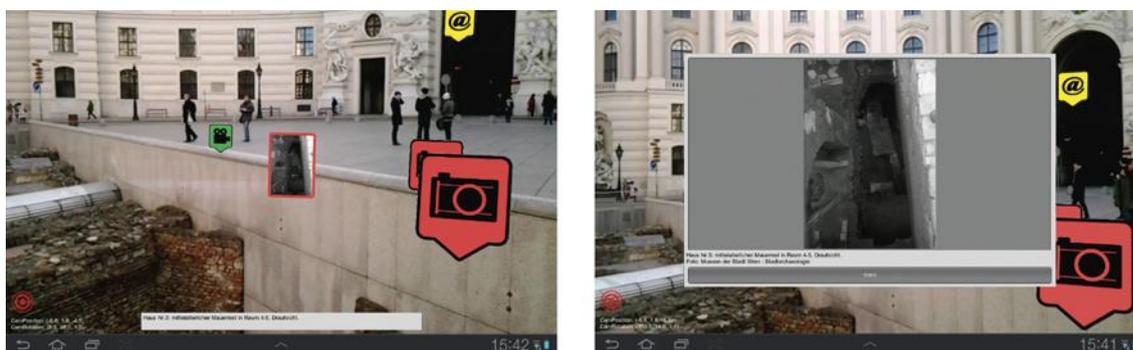


Fig. 16 – Screenshots of the application showing image preview (left) and detailed view (right) (Copyright: Stefan Niedermaier; Museen der Stadt Wien – Stadtarchäologie).



Fig. 17 – Running application showing 2d info tags and 3d content (Copyright: Stefan Niedermaier).

Discussion

We were able to implement a solution for on-site visualization of archaeological content in an urban environment. Our approach used natural feature tracking with facades which was demonstrated on the site of Michaelerplatz, Vienna and allowed precise positioning of 2D and 3D content.

While the tracking system in most cases worked quite well we encountered a number of issues that need further development. One of the most critical factors for the system is the lighting condition. A bright, overcast sky resulting in diffuse light and almost equally light facades delivered a high accuracy and robustness of the visual tracking system while especially a strong direct sunlight causing hard shadows and changes in brightness on the facades made it in some cases almost impossible to deliver a sufficient user experience. Thereby it took either quite long (more than 10 seconds) until the first facade was recognized or the system delivered inconsistent positioning data resulting in incorrectly positioned elements, an effect that increased with distance to the trackables. Furthermore due to limitations of the camera it is currently not possible to use the system in the dark. Other issues that came up during our tests were temporary architecture occluding parts of the facades or changes in a facade making it necessary to take new reference images.

Currently our system is not capable of visualizing elements that are located under the pavement so a solution for such cases has to be developed.

Even though it is not yet a perfect system, using AR with facades as a reference for inner urban visualization of archaeological data seems to be a very promising approach and opens a wide range of new possibilities.

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<http://www.wien.gv.at/stadtentwicklung/stadtvermessung/geodaten/mzk/index.html>.
- QCAR: Plug-in for Unity providing natural feature tracking capabilities for mobile platforms. <https://ar.qualcomm.at/qdevnet/>.
- UNITY: Game Engine supporting multi platform publishing. <http://unity3d.com/>.

Documentation system for digital reconstructions

Reference to the Mausoleum of the Tang-Dynastie at Zhaoling, in Shaanxi Province, China

Mieke PFARR-HARFST

Abstract: The starting point for the researches about a documentation system for digital reconstruction as a contribution to the preservation of knowledge within the digital cultural heritage was the Charta “For the Preservation of Digital Cultural Heritage” issued by UNESCO in 2003.

Digital reconstruction is a digitally based reproduction of a no longer visible or no longer existent building, urban complex, structural environment or events influencing structural environment. It is based on scientific findings and other sources of human knowledge. According to this and the UNESCO Charta, digital reconstructions are regarded as part of digital cultural heritage.

Based on a basic theoretical study of the science of documentation, the digital reconstruction and investigation of past reconstruction projects an appropriate system of documentation was developed. It is called Four-Level-System and it includes all necessary levels of a digital reconstruction project and leads to a complete, transparent and editable documentation.

The Four-Level-System as a common documentation system for digital reconstructions was transferred into a reference project the digital reconstruction of the Mausoleum of the Tang-Dynastie at Zhaoling, China, a subproject of the main project “The Digital Reconstruction of the Imperial Tombs of Xi’an”, realized at the Department of Information and Communication Technology in Architecture at Technische Universität Darmstadt.

The result is a first detailed documentation of a digital reconstruction. All sources, references, background informations and the project process are shown by this documentation. This new developed methodology of documentation makes the knowledge of a digital reconstruction available for subsequent generations of researchers. The results of a digital reconstruction can thus be reviewed at any time and the current state of knowledge to be adapted.

Keywords: Digitale heritage, digital reconstruction, documentation system.

The UNESCO Charta

The Charta “For the Preservation of Digital Cultural Heritage” issued by UNESCO in 2003 was the starting point for the researches about a documentation system for digital reconstruction as a contribution to the preservation of knowledge within our digital cultural heritage.

The UNESCO Charta defined digital cultural heritage as follows: Digital heritage consists of unique sources of human knowledge and human means of expression. It encompasses sources from all areas of daily life that are available in digital form (UNESCO 2003).

Furthermore in this Charta the UNESCO has clearly warned against the loss of this knowledge and has called for the development of strategies and solutions for its preservation (UNESCO 2003).

Digital reconstructions

According to this UNESCO definition, digital reconstructions are regarded as part of digital cultural heritage. They are essential for the preservation of the knowledge contained therein. As a crossing point of various scientific disciplines, especially architecture, history of architecture and archaeology, they consolidate knowledge and become a scientific tool and a medium for cultural heritage.

In effect, the definition of digital reconstructions and reflection upon their fundamental principles underscore their affiliation with cultural heritage.

Digital reconstruction is a digitally based reproduction of a no longer visible or no longer existent building, urban complex, structural environment or events influencing structural environment. It is based on scientific findings and other sources of human knowledge. The extensive interest in the architectural structures to be reconstructed, the fusion of sources as well as discussion among experts is the content basis, while the technical system consisting of hardware and software is the technical basis. Digital reconstruction is a synthesis of sources from the historical and cultural context, the project background and the process of reconstruction. All available information is collected, consolidated, filtered and assembled into a coherent picture. The result is a digital dataset that can be processed for research as well as for the transfer of knowledge (GRELLERT 2007; KOOB 1995; PFARR 2010).

A short cross-section of digital reconstructions from the Department of Information and Communication Technology in Architecture at Technische Universität Darmstadt will illustrate in terms of context, goals and project partners how much expertise exists here.

First example is the project: „Ephesus during the Byzantine Period“, following project partners were involved: Austrian Archaeological Institute, Austrian Academy of Sciences, Romano-Germanic Central Museum, Mainz, Technical University Munich, Vienna University of Technology (TU DARMSTADT, FG IKA 2010).

The main goals of this project were to bring together all information like text sources, archaeological findings, drawings, plans to consolidate and visualize knowledge garnered in 100 years of excavations and at least to substantiate the level of knowledge on the basis of digital models (Fig. 1).



Fig. 1 – Basilica St. John in Ephesus (Copyright TU Darmstadt, FG IKA, 2010).

The project „Reconstruction of the Dresden Castle“ (TU DARMSTADT, FG IKA 2011) is the next example and here were involved: State Art Collections – Green Vault, State Office of Historical Preservation, Saxony and Archaeological Heritage Office, Saxony and others. To visualize the castle from 1678 and six further stages of construction was the goal of this project (Fig. 2).

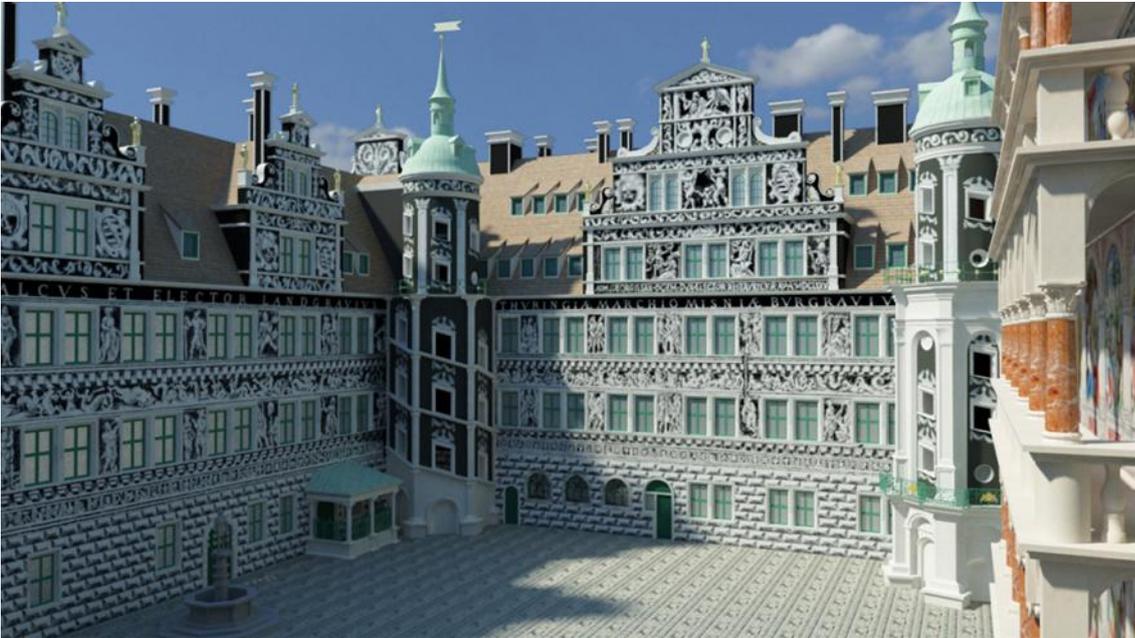


Fig. 2 – Dresden Castle 1678 (Copyright TU Darmstadt, FG IKA, 2011).



Fig. 3 – Crystal Palace in London (Copyright TU Darmstadt, FG IKA, 2011).

The newest project and the last example of a scientific digital reconstruction shown here is the project “Digital reconstruction of the Crystal Palace in London” (TU DARMSTADT, FG IKA 2011). Here the goal was the visualization of a no longer extant building and a spatial perception that would have been fascinating at

the time by means of a film using 3-D technology. The main project partner was the "Art and Exhibition Hall" in Bonn.

The knowledge potential of digital reconstruction has become even clearer through these three examples of a scientific digital reconstruction (Fig. 3).

This knowledge contained in such digital reconstructions as described before has to be served through an appropriate system of documentation in terms of the UNESCO Charta.

The documentation system

The lack of strategies for knowledge retention promotes the loss of knowledge on the level of content as well as on the technical level. For that reason on the level of content the verification of the sources and the derivation of the results must be guaranteed, on the technical level the backup of data. Keyword: long term archiving.

A basic structure for the new documentation system has been developed for the retention of knowledge. It encompasses all components of digital reconstruction and is based upon the basic principles of scientific documentation (GAUS 2005; HENZLER 1992). An example for this is the principle "transparent documentation", that in the case of digital reconstructions would mean that all sources, decisions, workflow, possible misinterpretations and methodology must be presented comprehensibly (PFARR 2010).

The so called Four-Level-System (PFARR 2010) arises as documentation structure for digital reconstructions results from this transfer. In the first level, called Level 1, the background with general information and parameters for the reconstruction project are comprised. After that level 2 contents basic and important information about the project from the cultural, historical and architectural point of view. The third level involves the methodology, the specification of individual provisions such as nomenclature, classifications and structuring, which must be coordinated with the question at hand. The fourth level is the level of objective evidence that constitutes the focal point and that fulfils the demand for scientific documentation, first of all the clear correlation of object and document. In the case of digital reconstructions the object is the building, the complex or structure to be reconstructed and the document consists of the scientific sources. The focal point of the documentation system, the level of objective evidence, contents three main parts. The starting point is the text-based building description, an overview of the most important parameters of the building with cross-references to the two other main parts, the source catalogues and the methods catalogues.

In the source catalogue (Fig. 10) of each individual building the source is directly assigned to the object and in the methods catalogue the object is assigned to the sources and the process (Fig. 11).

The level of objective evidence is based on a functioning methodology with regard to the objects and sources. So an appropriate nomenclature for all objects and documents that means for all buildings, sources and the process has to be developed and defined.

The reference project

The Four-Level-System as a common documentation system for digital reconstructions was transferred into a reference project the digital reconstruction of the Mausoleum of the Tang-Dynastie at Zhaoling, China (Fig. 4).

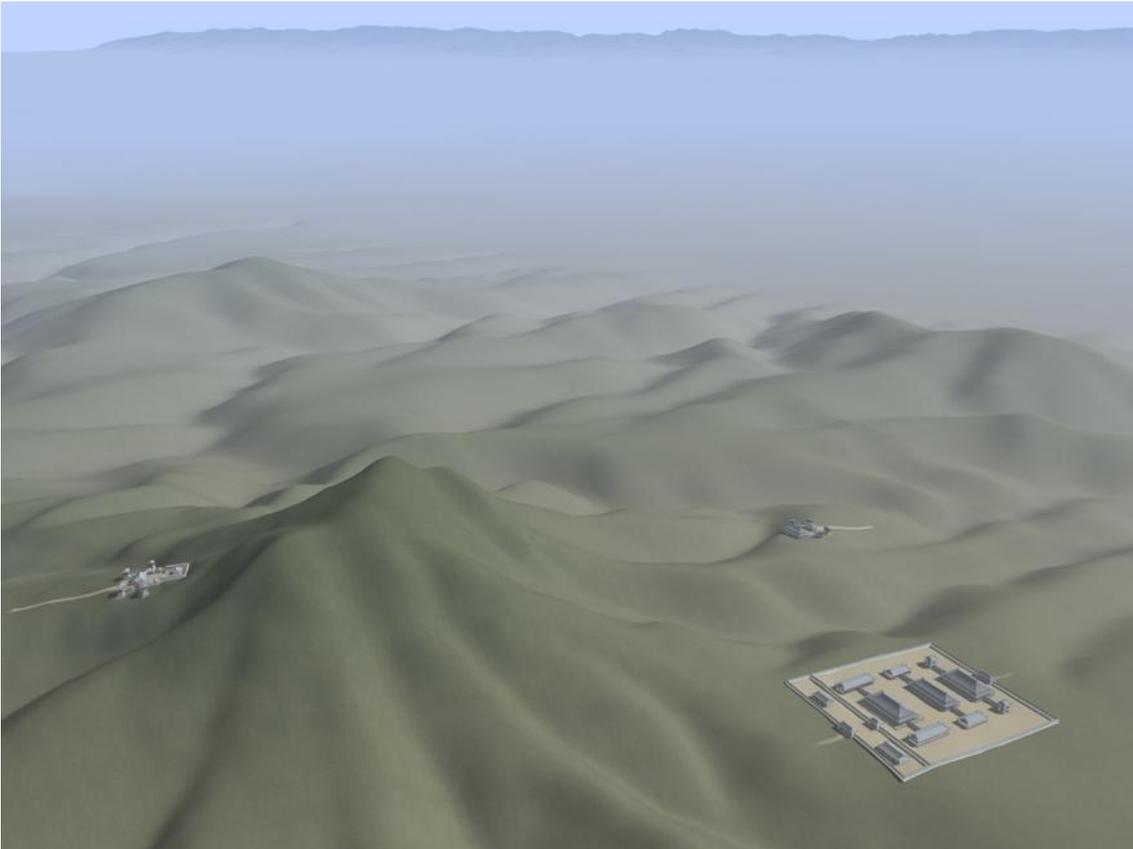


Fig. 4 – Area of the Mausoleum Zhaoling (Copyright TU Darmstadt, FG IKA, 2006).

In this case level 1 contents the project background and is the incorporation of the subproject “Zhaoling Mausoleum” in the major project “The Digital Reconstruction of the Imperial Tombs of Xi’an” (TU DARMSTADT, FG IKA 2006). The goal of the major project was to visualize the immense spatial dimensions of the area and the archeological sites in situ. The results were shown in an exhibition in the Federal Art and Exhibition Hall in Bonn. The project partners are important, as well, and can be found at this level, too. The second level, the project context, includes a brief side trip into Chinese history, architecture and the prevailing conception of the hereafter, for without a comprehension of these aspects, because it is impossible to reconstruct Chinese architecture and burial complexes.

The systematic of the documentation especially for the reference project is established in Level 3. The main structures of the 3d model and the scientific sources were transferred into appropriate classifications and nomenclature. The focal point of the documentation in case of the reference project is also the level of objective evidence, level 4.

The burial site consists of the complex as a whole with four major sectors and a total of 29 individual buildings. A documentation was conducted for all of these buildings at the objective evidence level. That amounts to the entire complex including the 187 ancillary graves (Fig. 4) and the four main sectors, the North Ceremonial Complex with 11 buildings (Fig. 5), the South Palace with 12 buildings (Fig. 6), the South Gate with 6 buildings (Fig. 7), and the grave itself within the mountain (Fig. 8).



Fig. 5 – North Ceremonial Complex (Copyright TU Darmstadt, FG IKA, 2006).

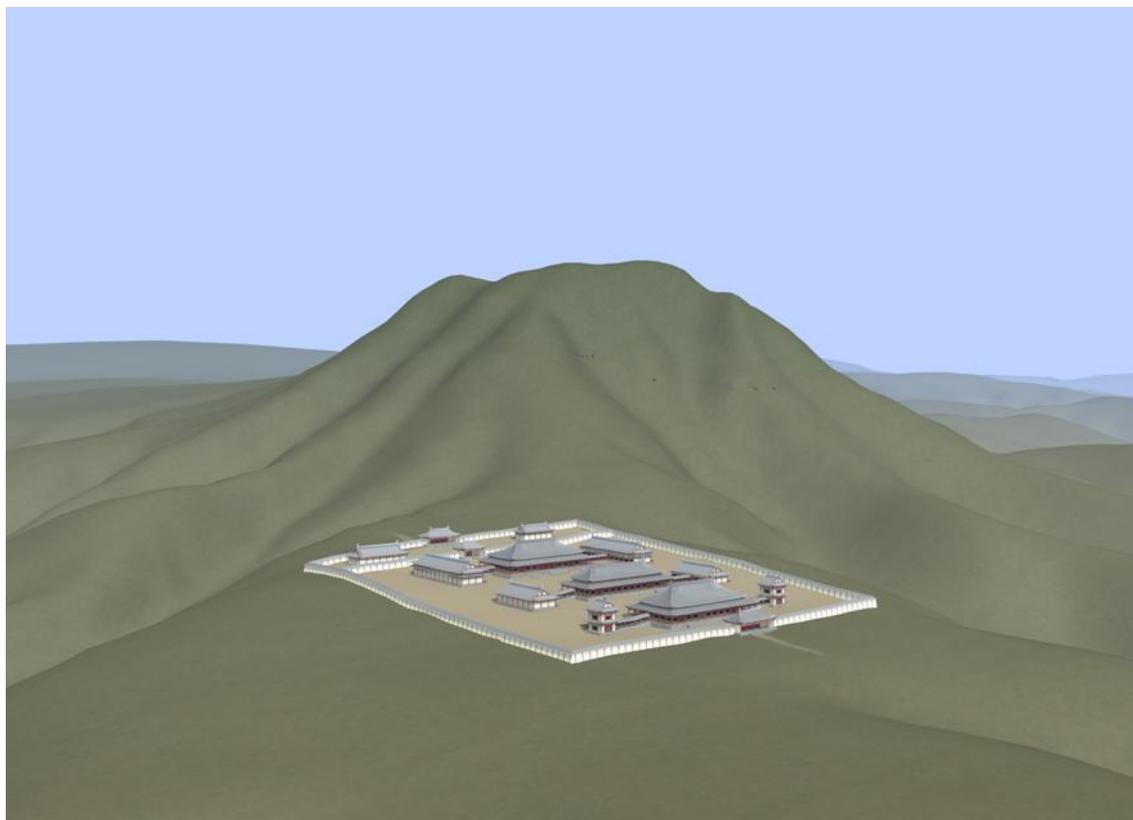


Fig. 6 – South Palace (Copyright TU Darmstadt, FG IKA, 2006).

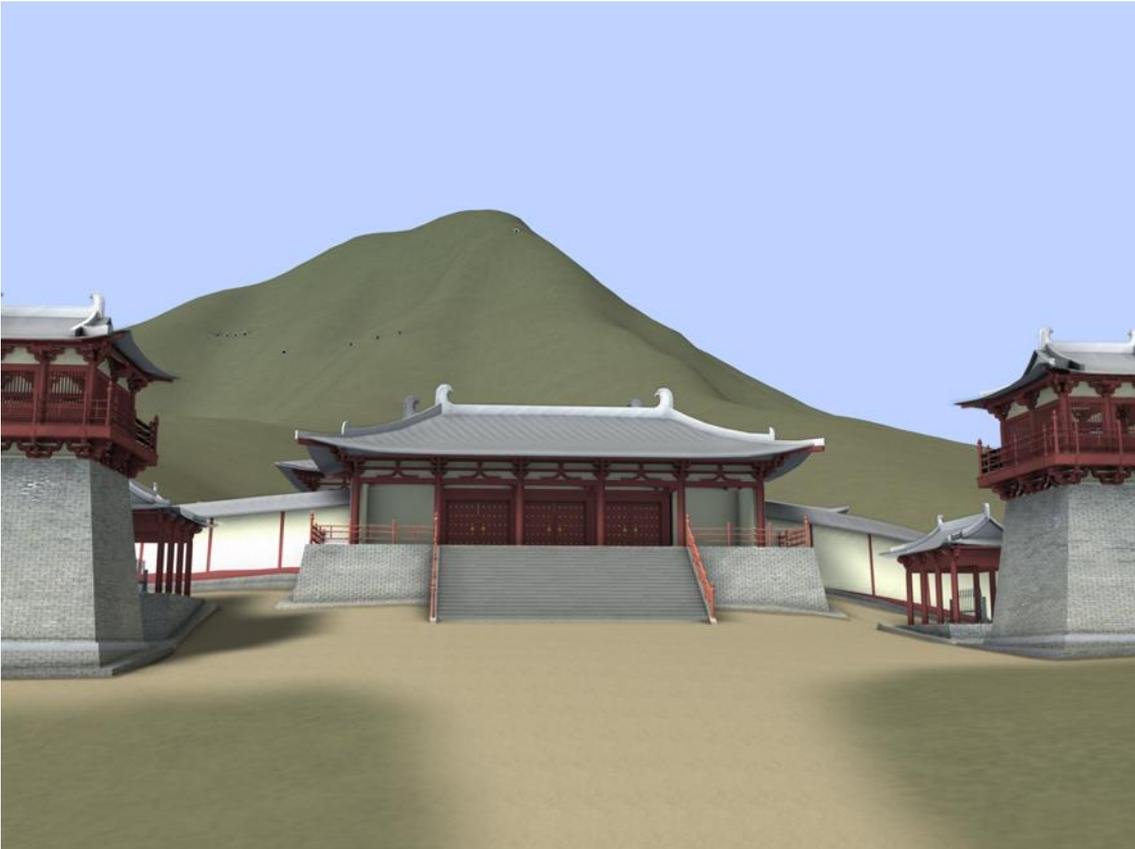


Fig. 7 – South Gate (Copyright TU Darmstadt, FG IKA, 2006).

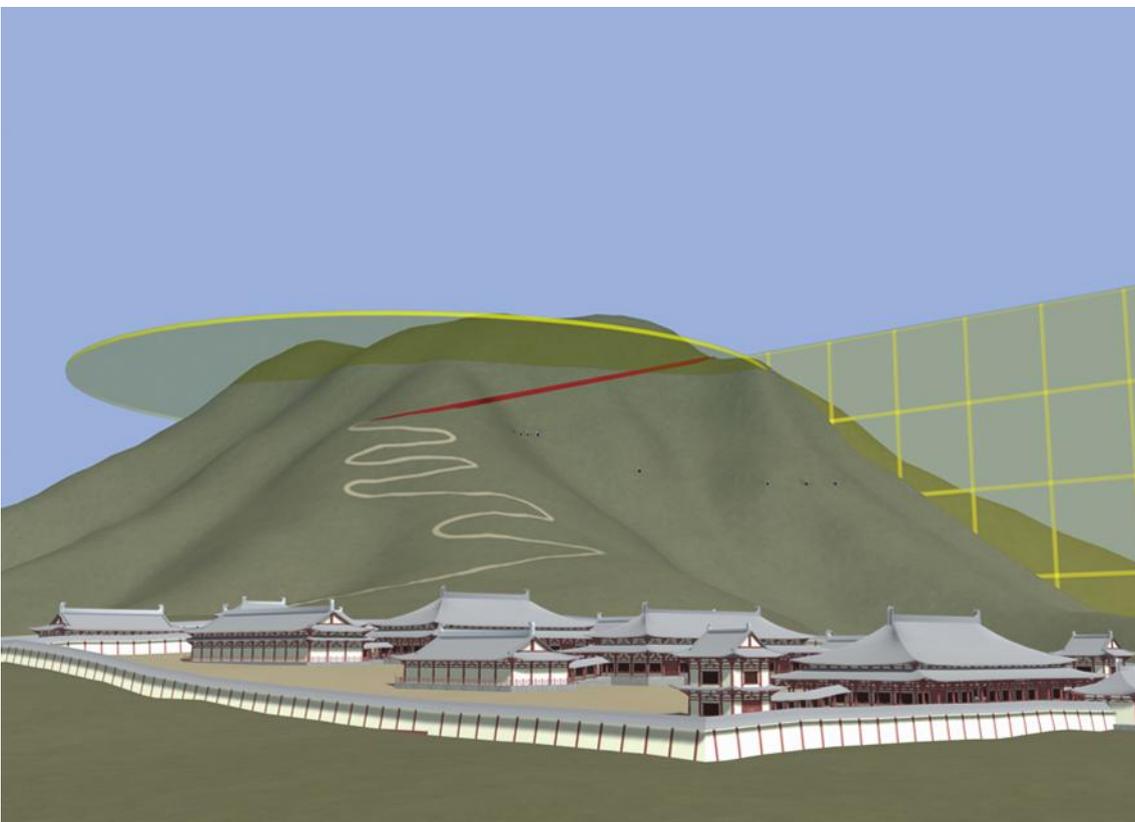


Fig. 8 – The grave (Copyright TU Darmstadt, FG IKA, 2006).

These buildings and complexes were provided with appropriate nomenclature to facilitate a clear assignment of object to document. For example, the nomenclature for the North Ceremonial Complex is nz, because in German it is called "Nördliche Zeremonialanlage". After that the numeral of the building is added. The buildings of each sector of the complex were brought together in a building catalogue, a sort of index. The catalogue provides an identity number for the building and gives further information, for example about the shape of the roof and the number of storeys (Fig. 9).



Fig. 9 – Building Catalog (Copyright Mieke Pfarr-Harfst, 2010).

In addition to the objects, that is the buildings, the documents or sources were structured and divided into classification and groupings of sources. The most frequent source groupings are in case of the reference project archeological findings, drawings and comparable structures. The nomenclature follows the German version of the words. The classifications of the sources are hard and soft sources. Hard sources are the primary sources such as archeological findings, soft sources, such as comparable structures, are subject to interpretation. This structuring of sources was transferred into an appropriate nomenclature which indicates the part of the complex, the source classifications, the source groupings and the number of the data.

The definitive assignment of document to object takes place in the source catalogue (Fig. 10).

The source with its nomenclature and designation can be found here and information as to its significance and application as well as its origin. Information concerning source classification and source grouping can be found here as well.

The results of a digital reconstruction can be made comprehensible, in addition to sources, only through the disclosure of the reconstruction process. However, in order to be transferrable, the reconstruction process must first be generalized within a sort of guideline. The process consists of the four working phases: preparation, reconstruction, verification and finishing. The preparation phase includes preliminary work concerning content, administration and technology. The reconstruction and verification phases are run

through several times during the procedure and are in a process of constant change. The development of the finishing phase is based on the goal and purpose of the project. A film requires a different approach than a creation of a plot model. The four project phases were adopted for the reconstruction process of the reference project. The reconstruction and verification phases were run through several times. An appropriate nomenclature was defined that demonstrates the relationship to the complex, the process, the project phase, as well as to the type of data.

The summary of the reconstruction process is given in the methods catalogue (Fig.11).



Nördlicher Zeremonialbezirk

nz01 – Kaiserliche Türme

Quellenkatalog

| Nr. | Bild | Bezeichnung | Bauteil | Beschreibung/Verwendung | Herkunft |
|----------------------------|---|---|---------|--|--|
| Harte Quellen | | | | | |
| Funde, Ausgrabungen | | | | | |
| a_gesamtanlage | | | | | |
| nz_qh_agr_a_017 |  | Ausgrabung Gebäude Nr.03 im Hintergrund Gebäude Nr. 01/02 | S | Socket des Eingangsgebäudes und Detail eines Stützfundamentes Zeigt die Einpassung und Lage im Gelände und die Größenverhältnisse der Gebäude Nr. 01-03 zueinander | Ausgrabung Nördlicher Zeremonialbezirk Fotodokumentation während des Workshops I |
| nz_qh_agr_a_019 |  | Luftbild Ausgrabung | G S | Position der einzelnen Gebäude sichtbar Größenverhältnisse Gesamtanlage dadurch rekonstruierbar Als Textur auf Geländemodell gelegt, so dass die Einzelgebäude positionierbar waren | Ausgrabung Nördlicher Zeremonialbezirk Prof. Zhang |
| nz_qh_agr_a_020 |  | Ausschnitt Luftbild | G S | Zeigt den unteren Teil des Bezirkes, v.a. Turm/Waffengebäude/Eingangstor Als Textur auf Geländemodell gelegt, so dass die Einzelgebäude positionierbar waren | Ausgrabung Nördlicher Zeremonialbezirk Prof. Zhang |
| nz_qh_agr_a_023 |  | Ausgrabung Blick vom Berg aus | G S | Für die Positionierung und die Lage der Gebäude zueinander; Während des Rekonstruktionsprozesses als Realbild in das Modell eingeladen, um das Modell, die Gelände und die Gebäude zu prüfen. Als Realbildüberblendung in das Exponat übernommen | Ausgrabung Nördlicher Zeremonialbezirk Prof. Zhang |

Fig. 10 – Source Catalog (Copyright Mieke Pfarr-Harfst, 2010).

The sources, the individual operations and their results are displayed in terms of input-output diagrams. For purposes of clarification on a specific example, the Imperial Towers of the North Ceremonial Complex, the way through the system will be demonstrated.

Using the building catalogue of the Northern Ceremonial Complex the identification number of the building will be found, and besides, that the building consists of three parts and has a simple Xieshan roof shape (Fig. 9). The function of the towers as a characteristic trait of an imperial complex as well as its position in the compound and further background information is contained in the building description. Certain sources and milestones in the reconstruction process as well as the source catalogue and methods catalogue are also referred to.

The source catalogue for the building (Fig. 10) indicates the actual on-site situation. Only the plinth is verifiable through excavation findings. The wooden construction above it is based on comparable structures as well as outlines from the archeologist in charge. The methods catalogue of the building (Fig.11) contains the different working phases, the inputs and the results – the various stages of the model which become increasingly detailed.

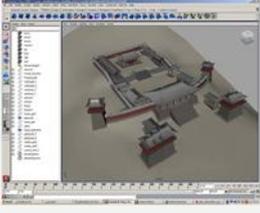
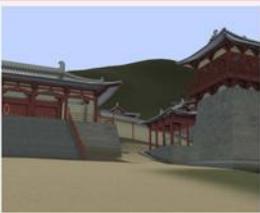
| Phase /Zeitraumen | Input/ Quellen | Tätigkeit/Beschreibung | Output/ Ergebnisse | Beteiligte |
|---------------------------------|--|--|---|--------------------------------------|
| Rekonstruktion III | | | | |
| August 2005 bis Februar 2006 | <ul style="list-style-type: none"> Digitale Protokolle nz_proz_wkIII_scr_002 nz_proz_wkIII_mod_001 nz_proz_wkIII_mod_002 | <ul style="list-style-type: none"> Einarbeiten der Korrekturen aus Workshop III | <ul style="list-style-type: none"> Abgabe Wissenschaftsatelier Oktober 2005 nz_proz_rekIII_ppt_001/002 nz_proz_rekIII_mod_001 bis nz_proz_rekIII_mod_003  | TUD, FG IKA Archinst. Prof. Zhang |
| | <ul style="list-style-type: none"> Abgabe Wissenschaftsatelier Oktober 2005 nz_proz_rekIII_ppt_001/002 nz_proz_rekIII_mod_001 | <ul style="list-style-type: none"> Einarbeiten der letzten Verbesserungen, v.a. genaue Geländeanpassung Erstellen eines Fragenkataloges in Bezug auf die endgültige Farbgebung als Vorbereitung der Modell zum Rendern Verschicken der Modelle aus Input via Internet zur Korrektur | <ul style="list-style-type: none"> Modellzwischenstand Dezember 2005 nz_proz_rekIII_scr_003 Weiche Quellen <ul style="list-style-type: none"> Workshop nz_qw_work_c_001 nz_proz_rekIII_fra_013  | |
| | <ul style="list-style-type: none"> Abgabe Wissenschaftsatelier Oktober 2005 nz_proz_rekIII_ppt_001/002 nz_proz_rekIII_mod_001 Neue Quellen aus Output nz_qw_work_c_001 | <ul style="list-style-type: none"> Erarbeitung des Lichtsets Anpassung der Texturierung erste Renderversuche Bereinigung der Modelle Erste Überlegungen zum Drehbuch (nicht mehr als Datei oder Protokoll vorhanden) | <ul style="list-style-type: none"> Präsentation der Ergebnisse Februar 2006 nz_proz_rekIII_ppt_004  | |

Fig. 11 – Methods Catalog (Copyright Mieke Pfarr-Harfst, 2010).

The three sections of the documentation level, the building description, as well as the source and the methods catalogues of all 29 individual buildings are available in a digital attachment – a sort of data bank – that includes all digital data.

Conclusion

Through the documentation of the reference project the complexity of a digital reconstruction and the contained knowledge have become clear. All described levels of the documentation structure are important and indispensable from the scientific point of view. The demonstration of the reconstruction process is essential, as well as the clear interpretation of the underlying sources. Prof. Zhang, the Chinese archaeologist of the reference project tellingly summed this up at the end of our joint efforts: “In such visualization projects we do not simply reconstruct, but we also do research together. Thus new research develops in the form of new knowledge.” (Prof. Zhang, February 2006 in Xi’an). This makes digital reconstructions part of the digital world cultural heritage and thus a comprehensive retention of knowledge in the form of documentation become indispensable.

The described documentation system represents a basis for further absolutely necessary research in the area of digital reconstruction. This maximum of documentation must now be minimized in order to become more usable. The documentation system will be further developed in a large-scale research project that includes project partners from various scientific disciplines and institutions and then transferred into a practicable methodology. Practicable in this case means easy to use without requiring additional staff and financial resources. In future the problems of technical retention of knowledge through archiving, administration and processing of data can only be solved within an interdisciplinary team.

However, as long as there is no change of awareness among all parties involved with regard to the impending loss of knowledge, the number of digital reconstructions will increase and knowledge will rapidly be lost.

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Recording Excavations with a Metrology Tracking System

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Abstract: This paper is both “theory” and “application” in that we begin by reviewing one of the authors search for better recording instruments for excavations and finish with the other authors experiences of applying the resulting technology to commercial archaeology.

The second author (GA) has worked for over a decade on digital instruments for improving the recording of archaeological excavations and creation of 3D digital excavation models. Recently, technology from Nikon Metrology looked like it might provide a significant breakthrough in the acquisition of digital excavation data. The author will describe his aims, the workings of the newly applied technology and the results of the first field trials.

As a consequence of these field trials Nikon Metrology released a new version of their tracking system called the iSpace for Archaeology, specifically for making excavation drawings. We will describe its current functioning and briefly consider its potential future uses.

The first author (MS), in his capacity as director of the company Studiebureau Archeologie, conducted an excavation of a housing development site with remains of a 13th Century Beguinage in Tienen (Belgium, prov. Vlaams-Brabant). This was the first commercial excavation to use the new Nikon “iSpace for Archaeology” recording system, by which it was possible to reduce the duration of the excavation from (a projected) 50 days to 30 days. The author will discuss aspects of using the iSpace recording system on the excavation including learning to use the system, the speed of data acquisition, how the data is used, time savings that were realised and his views on the potential impact of the system for urban and commercial archaeology.

Keywords: digital, drawing, excavation, commercial, archaeology.

Introduction

While computing has had a large impact on the way we work with the records originating from excavations (site databases, intrasite GIS analyses, web pages and excavation blogs, etc.), it has made far less of an impact on the way we actually make these records at the excavation, despite attention to this field by authors over the last decade or more. Since at least the turn of the millennium, many authors have sought to make the creation of the graphical records of excavations faster by using digital acquisition methods such as photogrammetry (BARCELO et al. 2002), orthocorrection of photographs (REALI and ZOPPI 2001), tracing from photomosaics (AVERN 2001a), using total station points for drawings (SCHAICH 2002), 3D Modeling (AVERN 2001b) and laser scanning (DONEUS and NEUBAUER 2004). Yet none of these methods have become mainstream techniques because, we suggest, none have proved to be a complete solution in terms

of speed, simplicity, accuracy and affordability, leaving many, if not most, excavations resorting to the traditional tools of permatrace, pencil, drawing frame, string line and tape measure.

One of the authors has previously proposed a theoretical recording system (AVERN 2001a) which attempted to address these issues (Fig. 1).

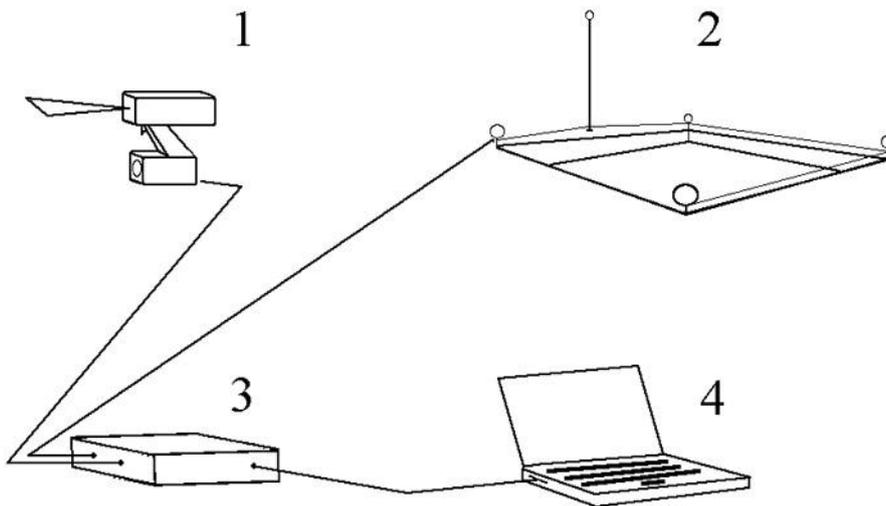


Fig. 1 – Theoretical 3D recording system incorporating 1) hand-held laser scanner, 2) large-volume tracking system (set up around excavation trench), 3) dedicated data processor, 4) laptop for viewing results. From AVERN 2001a.

This system would have acquired the topography and colour information to record archaeological contexts with a hand-held laser scanner whose position and orientation would be determined through time by an accurate large-volume tracking system. At that time, an appropriate tracking technology was not available to realise the concept. However, today there is a system which meets these needs. It is the iSpace tracking system from Nikon Metrology NV (a branch of the Nikon Corporation). This system is most commonly used in the aerospace and automotive industries, where precise setting-up of the system results in measurements accurate to 0.2mm.

One of the authors (GA) reasoned that this tracking system alone, without any laser scanner, could still be a very useful tool for archaeology for both surveying and drawing. For surveying, a single receiver unit would report its position in 3D space at a single point in time. For drawing, the receiver would continue reporting its position as it was used as a “digital pencil” to trace the lines, boundaries and interfaces that the archaeologist wishes to record.

Further, it seemed that the system would have four significant advantages over other drawing methods:

- ▶ the very rapid speed at which drawing might be done,
- ▶ the greater accuracy of the system and the resulting drawings,
- ▶ drawings would be inherently geo-referenced since they would be composed of thousands of geo-referenced 3D coordinates,
- ▶ the very simple and intuitive recording tools used to gather the data.

An approach to Nikon Metrology NV (Leuven, Belgium) to explain the potential application met with enthusiasm and led to one of the authors trialling the iSpace system for excavation drawings at the

excavations Mont Beuvray (ancient Bibracte), France. The results (AVERN and FRANSSENS in press) demonstrated that we could draw 10x faster than the archaeology students and at least twice as fast as the experienced excavators. From this successful trial, Nikon Metrology has developed an archaeology-specific version, called Archaeology iSpace.

These results also suggested that Archaeology iSpace should be of interest to commercial excavation companies who might stand to gain significantly from its high recording speeds. One of the authors (MS) represents the first commercial archaeology company to use the Archaeology iSpace system.

In the following, we describe how the system functions and report on our experiences of using this new archaeological recording tool in the area of commercial archaeology.

The Nikon Archaeology iSpace system

The Archaeology iSpace, was released by Nikon in April 2011. It is a large-volume, outside-in tracking system. Four tripod-mounted transmitters are set up around the area to be recorded. They can cover an area up to 50m x 50m. Two probes, which carry arrays of sensors, are the hand-held "digital pencils" which will record up to 40 coordinates per second with sub-millimetre accuracy.

The great value of an outside-in system is that many hand-held probes can be used simultaneously within the transmitter space (the theoretical number is in excess of 100 probes). The volume of the Transmitter space can be increased by simply adding more transmitters. In practice, there is no limit to the number of transmitters used.

Timing Signals and Determining Coordinates

Each transmitter emits two infrared signals; a pair of rotating infrared "fans" and a strobed timing pulse. The fans are projected at $\pm 30^\circ$ from horizontal (Fig. 2). Additionally, each is tilted 30° from vertical, one clockwise, the other anticlockwise (Fig. 3).

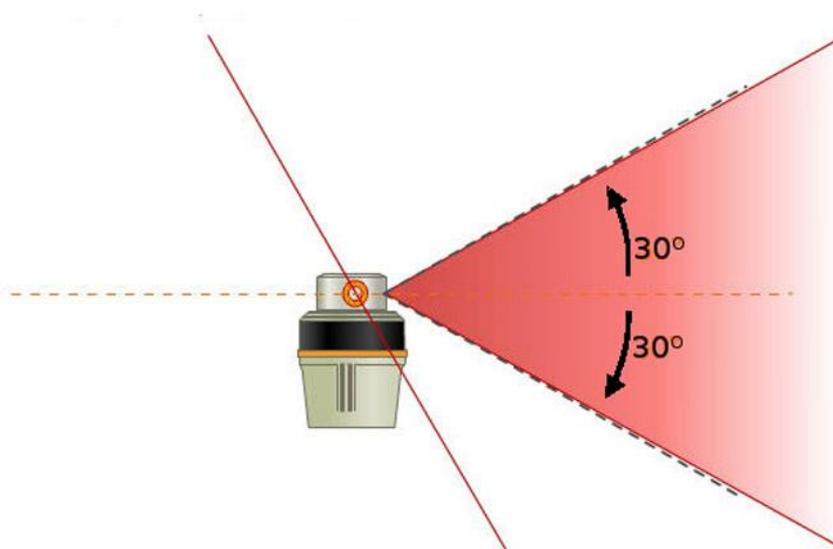


Fig. 2 – Transmitters emit a fan of infra-red light, $\pm 30^\circ$ from the "horizontal" projection axis.

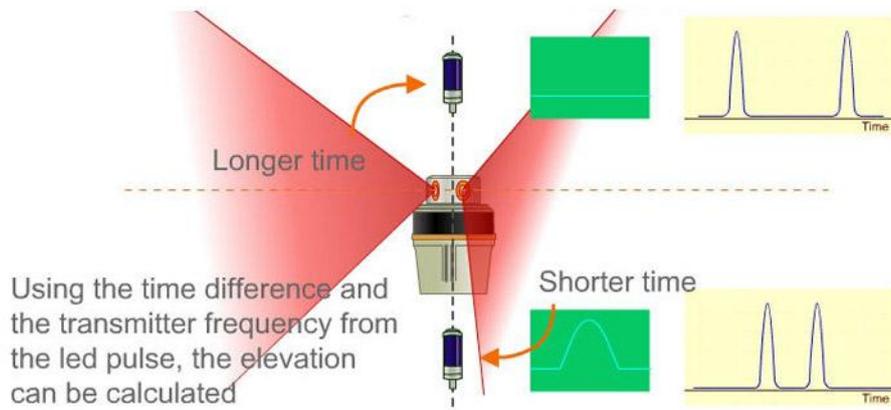


Fig. 3 – The two laser fans are also rotated by 30° from vertical in opposite directions. The time difference between detection of each fan is a function of the vertical angle from the “horizontal” projection axis to the sensor.

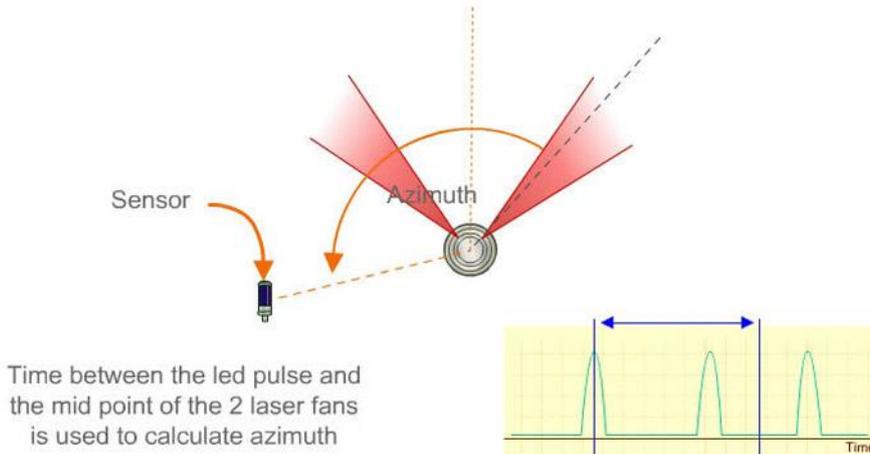


Fig. 4 – The time between the strobe pulse (left on the graph) and the mean of the signals from the two rotating fans (to the right of the graph) is a function of the position of the sensor relative to the transmitter and gives the azimuth.

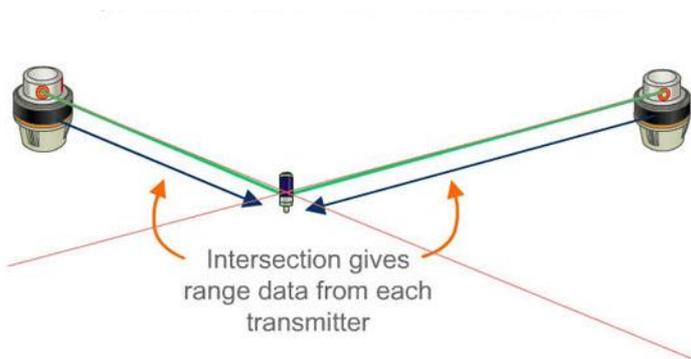


Fig. 5 – Sensors lie along a calculated ray from each transmitter. The position of the sensor will be at the intersection of these rays.

Given the fixed rotational velocity, the measured time difference between detection of the two rotating fans gives the vertical angle (elevation) between the transmitter and the receiver.

The horizontal angle (azimuth) is calculated from the time difference between the 40Hz strobed timing pulse (visible for 360° around the transmitter) and the mean of the two timing fan signals as they rotate (Fig. 4). Together, these two angles provide a ray from the transmitter, along which the sensor must lie. The sensor will lie at the intersection of two or more of the four calculated rays (Fig. 5).

While, technically, only two rays are needed to obtain a result, a third ray gives veracity to the measurement and allows an estimate of the accuracy of the calculation. A fourth ray allows for any occasional or temporary line-of-sight between a sensor and any of the transmitters. The archaeology version of iSpace manages sub-millimetre accuracy, far greater accuracy than dGPS and standard total station theodolites.



Fig. 6 – The iJavelin is a 1m configuration of 4 sensors, a trigger and radio communications, under which is fitted a 1m-long probe tip.

Sensors

The sensors are small, “lipstick-sized” cylinders connected to radio frequency transmitters. They convey timing data, collected from those transmitters to which they have line of sight, to a tablet workstation for calculation of the rays from each transmitter and the coordinates of the point at which the rays intersect. Coordinates are calculated 40 times per second (this can be reduced in the proprietary workstation software).



Fig. 7 – The iProbe is a smaller configuration of 4 sensors with trigger and radio communications, under which a 40cm-long probe tip is fitted (Photograph: Antoine Mailler, BIBRACTE EPCC).

Hand-held Probes

The iSpace system comes with two hand-held probes, both fitted with 4 sensors in a fixed and calibrated configuration, meaning that the system calculates not just the positions of the four sensors but also the position of the probe tip and the orientation of the probe (measurement with 6 Degrees of Freedom). Accordingly, the probes do not need to be held vertically and so eliminate the major source of error in using the traditional total station with staff-mounted prism. The probes are also fitted with buttons to trigger recording episodes. Recording can be done in two modes; single point mode (for surveying, taking spot heights, find localities, etc) or in continuous mode (for tracing around outlines of contexts or features). The two probes differ in their size; the 2 metre “iJavelin”, which is convenient for point surveys and for working in holes or pits (Fig. 6), and the 40cm “iProbe”, useful for drawing contexts, features, sections, etc. (Fig. 7).

Drawing Software

Archaeology iSpace currently includes an iPhone/iPad/iPodTouch application called MobiGage for Archaeology from Titansan Engineering Inc. which allows data to be attributed as it is collected and the result exported as an AutoCAD .dxf file. Clearly, while iSpace saves time on drawing, the attributed .dxf files save further time in comparison to the digitising of hand drawings and adding of attributes.

Nikon iSpace in Commercial Archaeology

Government Requirements

Commercial archaeology in Flanders (Belgium) is very young, having begun in 2005. Although a legal framework was available since the Decree of the 30th of June 1993 regarding the protection of the archaeological patrimonial, the Flemish government only started in 2005 to set the conditions for each archaeological excavation done in advance of commercial or community developments. Importantly, these conditions include the methodology to be used, the number of excavators and the expected duration of the excavation.

Clearly, "time is money" for construction companies and there is considerable opportunity for commercial archaeology companies who are able to shorten the length of excavations. All parties should, therefore, be interested in techniques that make excavations shorter.

Studiebureau Archeologie bvba had the opportunity to renew contacts with Nikon Metrology while tendering for a big project in the grounds of the Great Beguinage of the city of Tienen (VANDER GINST and SMEETS 2011). Time was a major problem with this project as the Flemish government had projected the excavation to last 50 days, while the construction company wanted to commence building after only 32 days. The Flemish government was approached with a proposal to use Nikon Archaeology iSpace as a means of reducing the recording times and, hence, the total excavation time, and Studiebureau Archeologie was awarded the contract. Archaeology iSpace exceeded the expectations in cutting the recording times and the project could be finished in just 30 days, that is, 40% faster than the expected time.

Old Drawing Methods

Before Archaeology iSpace, plans were registered manually or by drawing with a robotic total station. Clearly, registering plans on paper takes a long time in the field (usually by at least two persons) and even more time to make a digital, geo-referenced plan which can be used in publications. For example, in an excavation at the Fochplein in Leuven, registration of all the traces and the walls took about one third of the total work (28 days) while the subsequent digitalization of the drawings took about 40 days. As much as 50 days might have been saved if iSpace had been used on this excavation.

The use of a robotic total station is usually much quicker than manual drawing. It can be done by one person and a digital plan is available very soon after the data is gathered. The downside is that the accuracy of the system is affected by the experience of the topographer and the correct use of the measuring rod (and hence it is quite slow if very precise drawings of complex traces are required), and there remains a lot of work in the subsequent editing of the plans. At the site of Kontich-Babbelkroonbeek, the registration of 2500

square meters took 3 days (from a total of 21 working days) and the editing another 2 full days. The expectation is that the recording time would have been halved if the iSpace was used.

However, it is necessary to point out that the big advantage of the robotic total station is its range; for work in very long trenches, it is arguably still the best tool.

Experience of using iSpace

At the beginning of May, 2011 Studiebureau Archeologie purchased the Nikon Archaeology iSpace as a means of measuring and drawing on commercial excavations. As mentioned previously, it was first used on the site of the Great Beguinage in the city of Tienen (Fig. 8, 9).

From May until November 2011, it has been used on twelve other commercial excavations in central and eastern Flanders (Tab. 1) including excavations inside churches, in constricted urban sites and in open rural sites up to 6 hectares in size. Traces have ranged in period from Bronze Age to Iron Age, Roman and Mediaeval. With such extensive experience with this new recording system, Studiebureau Archeologie feels well-qualified to comment on its performance compared to other recording techniques.

| | |
|---------------------------------|---|
| Great Beguinage, Tienen | Medieval beguinage |
| Saint-Jacobschurch, Leuven | 2 by 8 meter trench |
| Emblem-Campus Vesta | Iron Age site. approx. 3000m ² |
| Kontich-Groeningenlei | Iron Age/Roman site. approx. 3000m ² |
| Poederlee-Schrieken | Medieval site, approx. 1.6ha, rural |
| Saint-Willibrordchurch, Meldert | Church interior and exterior |
| Beerse-Holleweg | Medieval site, approx. 2.2ha, rural |
| Maasmechelen-Mottekamp | Bronze Age to Medieval, > 6ha |
| Minderbroeders, Mechelen | Part of medieval monastery |
| Borsbeek-Herentalsebaan | Iron Age cremation burials |
| Kontich-Rozengaard | Roman, 2000m ² |
| Saint-Gudulachurch, Hamme | Church interior |

Tab. 1 – Commercial excavations recorded with Archaeology iSpace, May to November, 2011.

While Archaeology iSpace has a slower setup time than the robotic total station (one person can do this in around 20 minutes), drawing is done much faster. It is quite possible for one person to use iSpace but we find it easier to work with two.

Importantly, any drawing of a trace with Archaeology iSpace is far more accurate than other ways of drawing, both because each point is measured far more precisely and because the drawings contain an order of magnitude more coordinate points, or more, than would be used to make both manual drawings or with the robotic total station.



Fig. 8 – Archaeology iSpace in use at the excavation at the Great Beguinage, Tienen.

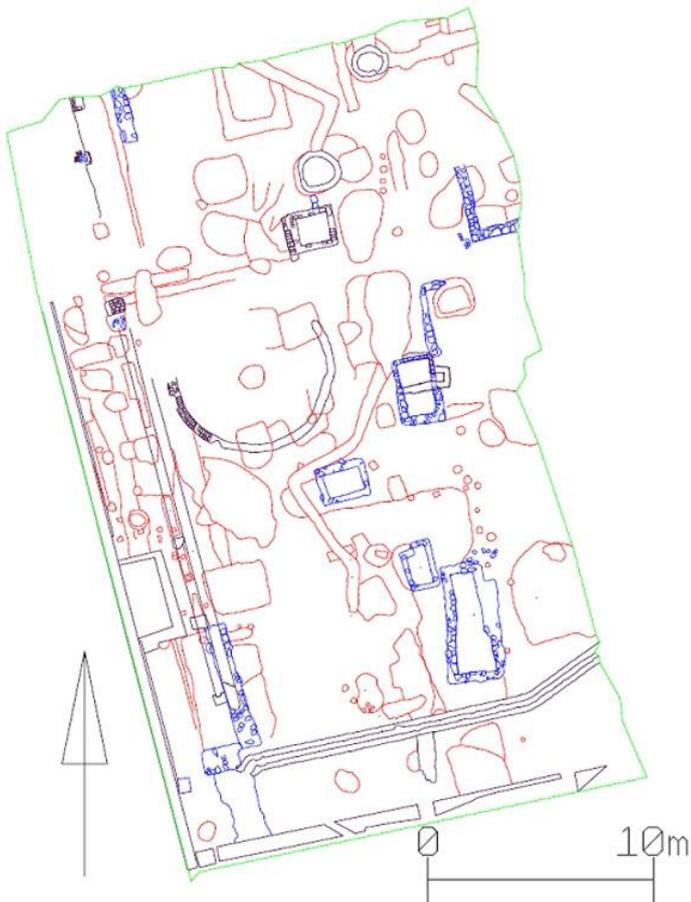


Fig. 9 – Archaeological plan of the excavation at the Great Beguinage, Tienen, recorded with the Archaeology iSpace.

A big advantage is that the plan drawings are immediately available as a .dxf file. If any mistakes are made or traces missed, they can be added while the setup remains in place during check-up. Later the plan is put upon the iPad for consultation on site. The plan is inherently geo-referenced since each point in the drawing is a geo-referenced coordinate. This assumes the transmitter arrangement was geo-referenced in the setup stage but, if that was not the case, the plan can be geo-referenced later by measuring interim survey points that are subsequently established by a topographer.

The very fast speed of drawing with iSpace has seen the archaeologists establish a new routine at the excavation sites. They are able to open up a zone on an excavation, to plane it by shovel, then to register the entire area in just the last hour of the day ready for cross sections of traces to be done at the start of the next day. With some good planning, it is even possible to do the recording of 2 (and on one occasion even 3) different sites on one day.

In open, rural excavations the transmitters are placed in the trenches in a rough square (up to 50 meters between transmitters). The excavators have experienced the problem of the sensors being “flooded” by the strong signal when the probes are used within 1,5 meter of a transmitter, resulting in no measurement. The solution is to mask that signal by placing yourself between the transmitter and the probe and relying on the signal from the other 3 transmitters to determine the probe coordinates.

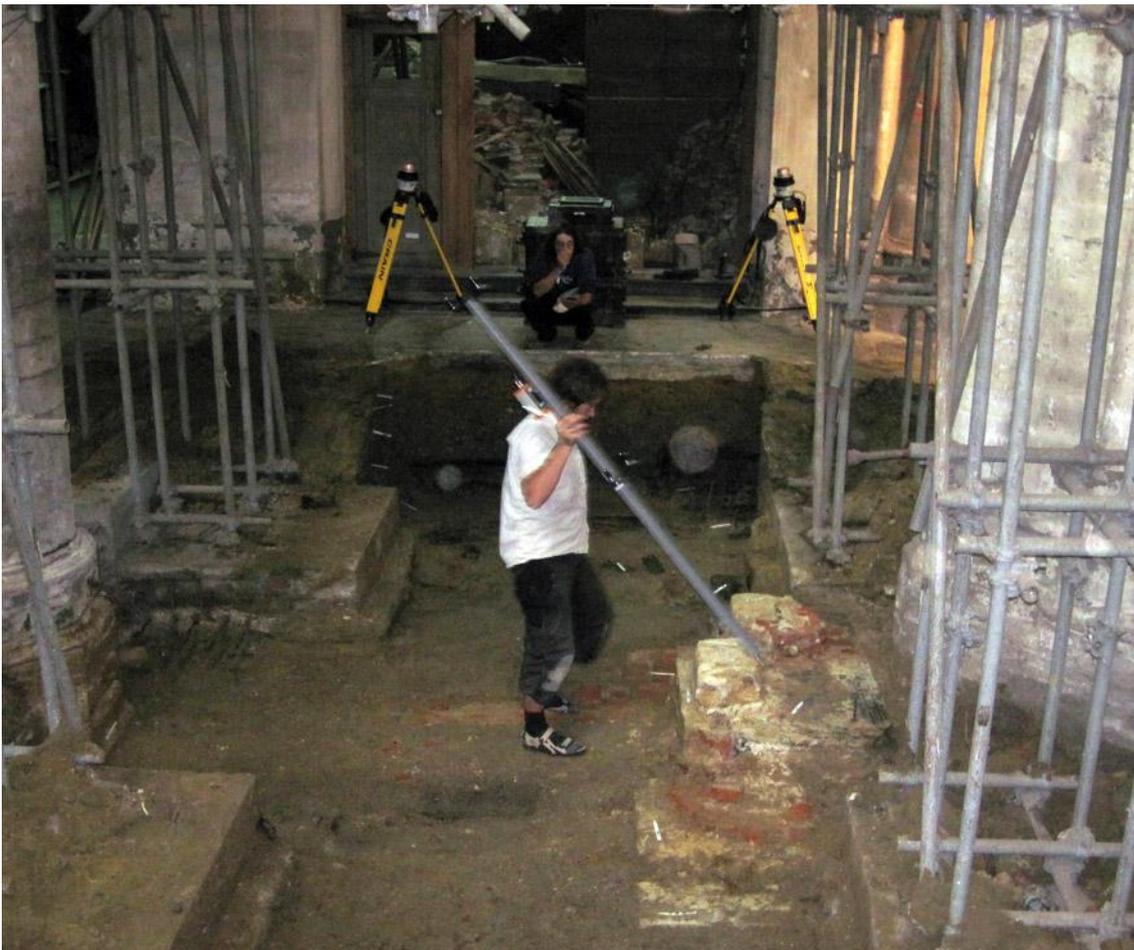


Fig. 10 – The use of the Archaeology iSpace inside a building. The transmitters are placed to 'look' down into the trench.

In urban excavations there is seldom space in the trenches for the transmitters, so they are placed outside and angled down so that they 'look' into the trench (Fig. 10). Since the surface area of urban excavations is usually much less than 50m x 50m, it is possible to repeatedly set the transmitters at the same fixed points which can be easily be geo-referenced.

Although Archaeology iSpace comes with a long and a short probe, in 95% of the cases, the archaeologists of Studiebureau Archeology are using the larger iJavelin (in the streaming mode of measuring) like a giant pencil (Fig. 11). The Javelin can be used in a standing position and so is more ergonomic than using the smaller iProbe, which is only used for drawing in more detail, as for individual stones of a wall, skeletons, etc. Over 40 points each second are measured, but the software is adjusted only to keep 4 per second. Even for a relatively small trace, like the circumference of a large posthole, this means that around 50 points are recorded to make the drawing. This would be unrealistic to attempt by hand or by robotic total station. During the measuring it is possible already attribute traces, walls, loose findings, etc. to separate layers in the CAD file. This forces the archaeologists to think more about what they are excavating during the registration. The main benefit of attributing traces to layers at the recording is that it dramatically reduces post-processing and makes it a lot quicker to finish a plan. So just minutes after coming off the site, a plan is finished and imported into the global plan, as at the site of Maasmechelen-Mottekamp, where new site plans are available for use on site barely minutes after the excavator had finished drawing the traces, because the plans are imported into the iPad on the field.

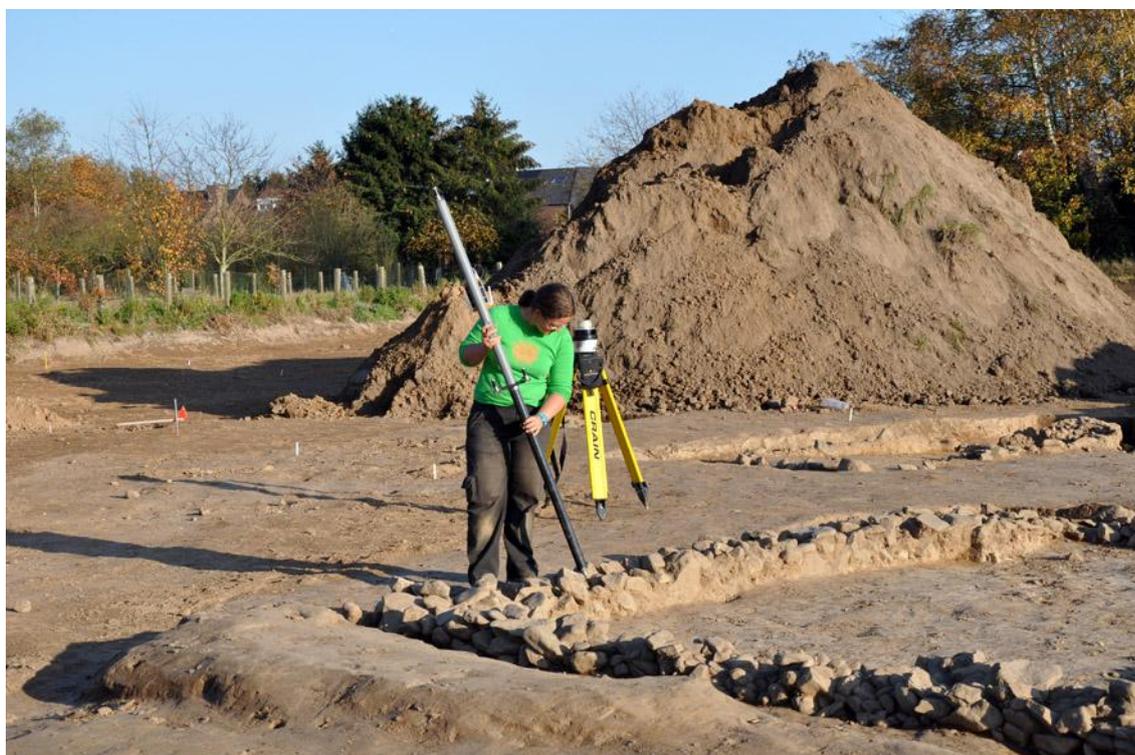


Fig. 11 – The use of the iJavelin as a giant digital pencil.

Conclusions

The Archaeology iSpace makes the drawing of excavations very much faster as well as much easier and more accurate. It provides the archaeologists with an updated site plan almost immediately. It makes them think more about, and understand better, the archaeology they are recording. It has proven itself over many excavations to record much faster than other methods and reduce the total excavation time.

For Studiebureau Archeologie the purchase of Archaeology iSpace has proven a good investment which has paid for itself because of the ability to estimate for shorter periods of excavation and thus winning more contracts and giving a distinct competitive advantage over other commercial archaeology companies.

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Modelling Urban Ceremonial Performance in Late Formative Peru

The Case of Jatanca

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Abstract: Quantitative analysis of architectural spaces designed for ritual or ceremonial purposes has the potential to reveal the intended physicality of these spaces while elucidating the ideological structure of a given community. As has been widely established, the retroactive application of space syntax methods to archaeological settings is notoriously difficult, with the notable exception of a handful of uniquely well preserved sites such as at Pompeii and Akrotiri that have attracted much attention. When available avenues of quantitative spatial analysis are applied to the two-dimensional plans of architectural remains from most archaeological contexts, the results have proven to be equally as flat and theoretically reductive. This paper utilizes DepthMap software in a manner that treats quantitative output not as final result, but as an interpretive layer within a three-dimensional consideration of ritual architectural space as emotive places imbedded within the topography of a surrounding landscape. By building fully navigable three-dimensional digital models of the complex ceremonial compounds of the Late Formative Period (ca. 500BC–1AD) early urbanized site of Jatanca in northern Peru, the output of DepthMap analysis within these spaces is applied as the floor level of the models. This allows for a qualitative and quasi-experiential comparison of the quantitative computational results as they relate to the landscape that was clearly fundamental to the experience of these spaces. Considering the importance of mountains and astral alignments to Andean cosmology, the orientation of these compounds in relation to their terrestrial and celestial setting is considered using Google Earth, highly accessible software that is capable of recreating the position of the sun and stars at any time of day and any date throughout the year. With movement through these ceremonial compounds as highly choreographed, this study tests the interpretive potential of computational approaches to the analysis of architectural remains in archaeological settings beyond the limits of the built environment, opening a dialogue on the need for increased consideration of three and four dimensional aspects that largely go unattended in current spatial analyses.

Keywords: Pre-Colombian Andes, Ceremonial architecture, Landscape archaeology, DepthMap, Three-dimensional modelling and analysis, Phenomenology.

Introduction

Structural approaches in archaeological theory have established that many ancient cities, particularly those that were central capitals, were built landscapes that instantiated and expressed key elements of the dominant social order and cosmology (WHEATLY 1971; ELIADE 1959). In efforts to analyze the architectural remains of ancient cultures without the filter of modern architectural conventions and Western concepts of spatial use, there is a clear need to develop a method by which the architecture of a given culture can be

quantified and thus compared consistently throughout the corpus of research dedicated to that group. As will be discussed in the subsequent sections of this paper, my approach to this fundamental concern involves the application of particular elements of the suite of quantitative methods known together as 'space syntax analysis' to a collection of ritual complexes at the site of Jatanca, a site dating to the Late Formative Period (ca. 500BC–1AD) in the Cañoncillo region of Northern Peru.

Developed by sociologists Bill Hillier and Juliette Hanson, space syntax analysis considers that the organization of the built environment reflects the social, economic and cultural characteristics of a society (HILLIER and HANSON 1984; HILLIER 1996). Space syntax analysis is a method by which the internal organization of a given structure or urban network can be quantified and thus compared to others in a more removed and unbiased manner than by visual comparison and interpretation alone. By mapping distinct points in space on structural floor plans or maps generated following excavation or survey, the relative interconnectedness and the ease of movement between rooms or distinct areas can be quantified, presenting a unique design signature that can be compared to other similarly mapped spaces.

Although space syntax analysis has been applied to archaeological contexts since the early 1980s, most of these studies have exploited this potentially valuable tool to analyze and compare only the most well-defined and fully excavated architectural contexts. Limited not only by the state of preservation of archaeological remains, the prohibitive expense and considerable effort required to properly uncover buried architecture on a scale necessary for meaningful analysis, the practicality of space syntax analysis for most archaeological investigations is perpetually questionable. With increased interest in the application of space syntax analysis to a variety of fields, a number of computer programs and practical theories have been developed in recent years, mainly within architectural community. As a quantitative system designed and elaborated on by contemporary sociologists and architects, conclusions drawn from these analyses cannot avoid being based on very modern spatial concepts that likely have no relation to those in antiquity. However flawed in their application, these same tools have been used retroactively by archaeologists seeking to define lost cultural ideals through the analysis of architectural remains. The following study joins a growing body of scholarship that attempt to use elements of space syntax analysis and its variants to bridge a fundamental conceptual gap regarding the built environment across a wide range of temporal and geographic settings. With initial and continuing exploitation in diverse areas of the Old World (BANNING 1996; BANNING and BYRD 1989; BONANNO et al. 1990; CUTTING 2003; FAIRCLOUGH 1992; FOSTER 1989; LAURENCE 1994; PLIMPTON and HASSAN 1987; PERDIKOGIANNI 2003; THALER 2005), New World archaeology has risen to adopt similar methodologies seeing increasing application in areas ranging from the Canadian Arctic (DAWSON 2002), Mesoamerica (HOPKINS 1987; HOHMANN-VOGRIN 2005) and South America (MOORE 1992, 1996a; CZWARNO 1989; SPENCE-MORROW 2009) with particularly strong emphasis in the American Southwest (BRADLEY 1992, 1993; BUSTARD 1996, 1997; COOPER 1995, 1997; POTTER 1998; SHAPIRO 1997, 1999; VAN DYKE 1999).

I will limit my discussion of the details of the mathematics on which space syntax analysis is based, as through the use of computer software called DepthMap developed at the University College London, there is relatively little contact with the computational inner workings of this analytical system. As such, simplified plan drawings of structures are processed so that the results of the various forms of spatial analyses, namely Visibility Graph Analysis (VGA), Axial Analysis and Agent Analysis, are depicted graphically in a manner that

groups value ranges along a colour-based scale that allows for intuitive visual comparisons between specific tests as will be explored in the results section of this paper.

Theoretically, the methods and rationale of space syntax analysis presents itself to archaeologists as an incredible tool with great potential to clarify the internal dynamics of the ancient built environment. However, the computational nature of this technique seems to draw too heavily on culturally normative assumptions about how people interact with space that entirely disregards the impact of the topographic and geographic setting of the built environment. Although this is a major concern for any practical application of these methods, the information generated is still of considerable use as a viable tool to guide and inform interpretation, as will be attempted in the following comparative investigation of the ceremonial complexes at Jatanca as anthropomorphically situated constructions that are fundamentally inseparable from their landscape, both topographic and celestial.

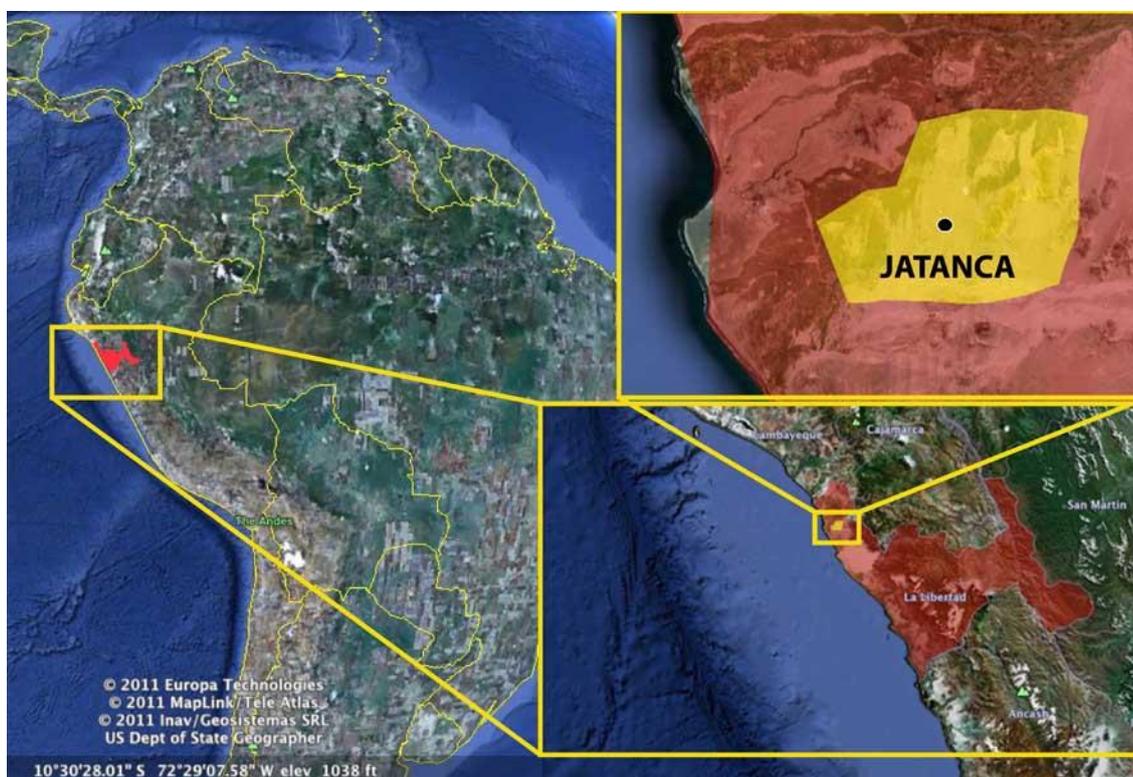


Fig. 1 – Context map showing the location of the site of Jatanca in the greater Cañoncillo region (yellow) within the Province of La Libertad (Red) in northern Peru (Google Earth).

The Jequetepeque Valley and the cultural-historical context of the study

The Jequetepeque Valley is located on the North Coast of Peru 600 km north of Lima, a landscape that is characterized by a rich archaeological record and one of the highest concentrations of ancient urban centres in South America (CASTILLO 2010; DILLEHAY and KOLATA 2004a; DILLEHAY et al. 2009; DONNAN 2007; DONNAN and COCK 1986, 1997). Irrigation agriculture supported high population densities in an otherwise extreme desert environment, and inhabitants of this region contributed to the florescence of pan-coastal cultural traditions since the Formative Cupisnique (Guañape) Period (1500–300 BC) (BURGER 1992; KOSOK 1965). The valley is situated at a critical geographical and cultural juncture, forming an

important route to the highlands and representing a purported cultural frontier separating the northern and southern sub-regions during Moche times (ad 100–800) (CASTILLO and DONNAN 1994; MCCCELLAND et al. 2007; KOSOK 1965).

The architectural data base for the following analysis derives from the Late Formative centre of Jatanca, a component of the larger urban settlement system of Cañoncillo (Fig. 1) (DILLEHAY et al. 2009; WARNER 2010). The greater Cañoncillo region covers large portions of the Pampa de Mojucape, an area of more than 25 square kilometres on the southern bank of the Jequetepeque Valley. It comprises diverse and interlocking landscapes, including contiguous domestic zones, large-scale relic fields and irrigation systems, and the administrative-ceremonial centres of Jatanca, Huaca Colorada and Tecapa (DILLEHAY et al. 2009; ELING 1987; HECKER and HECKER 1990; UBBELOHDE-DOERING 1960, 1967; SWENSON et al. 2008, 2009, 2010, 2011; WARNER 2010). Jatanca, located in the central area of the Pampa de Mojucape, consists of a ceremonial core of roughly 3 sq.km and is made up of seven principal monumental compounds surrounded by a dense residential area that dates to the end of the Formative Period (300–100 BC) (WARNER 2006, 2010) (Fig. 2).

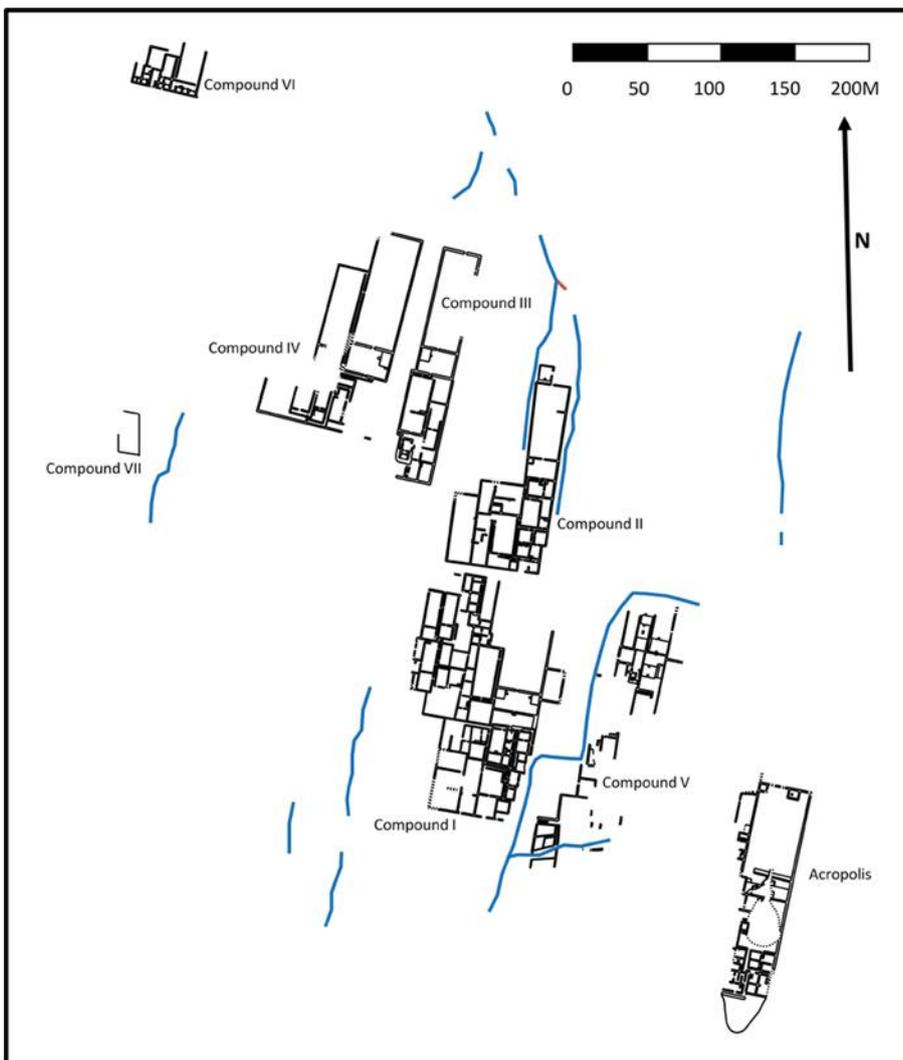


Fig. 2 – Map of the monumental core of the site of Jatanca showing the relative locations of compounds discussed in the text (Warner 2010).

The horizontally configured compounds contain a mass of rectilinear chambers, patios, corridors and large plazas delineated by solid walls built of poured adobe (called *tapia*) with contemporaneous canals meandering between the five principal complexes (ELING 1987; WARNER 2006). Beyond this central nucleus, contiguous domestic zones, canals and relic fields cover much of the donated plain and date predominantly to the Lambayeque and Chimú Periods (ad 1100–1450). Recent dissertation research conducted by John Warner confirms UBBELOHDE-DOERING's earlier reconnaissance work (1960, 1967) suggesting that the site is associated primarily with material culture traditionally identified as Salinar and Gallinazo and reached its height at the end of the Late Formative Period (300–100 BC) (WARNER 2006, 2010). Radiocarbon dates obtained by Dillehay and Kolata, Warner and Swenson confirms that the site was occupied 2300–2100 years ago (DILLEHAY and KOLATA 2004b: 277; WARNER 2006, 2010; SWENSON et al. 2010). Warner's seminal study was the first to systematically map and interpret Jatanca's elaborate spatial layout, and subsequent research directed by Edward Swenson, Jorge Chiguala and Warner represents the first-large scale excavation of the settlement that clarified many of the emerging architectural patterns and exposed nine structures with ramps, the principal architectural subject of this paper (SWENSON et al. 2008, 2009, 2010).

Jatanca's horizontally-configured architectural ensemble, characterized by northern plazas, long corridors, multiple quadrilateral rooms, baffled entries and inner courtyards, is enigmatic, for it appears strikingly precocious and is much more reminiscent of later Chimú architecture of the thirteenth to fifteenth centuries than the vertically-oriented *tapia* pyramids of the Gallinazo heartland located in the Virú and Moche Valleys more than 100 km to the south (MILLIAIRE 2009; WARNER 2006, 2010). Indeed, Jatanca has been the source of considerable confusion among archaeologists, several of whom have attributed its construction to the Late Intermediate Period (ad 1100–1400) (HECKER and HECKER 1990; WARNER 2010).

The five largest constructions at Jatanca comprise expansive and elongated north plazas circumvallated by high walls built of poured adobe that conjoin multichambered precincts to the south. These open plazas (ranging from 80 x 40 m to 60 x 35 m in area) could have contained hundreds of spectators. Although the easternmost structure, the so-called Acropolis (UBBELOHDE-DOERING 1967), has been considered the ceremonial nexus of Jatanca given its elevated preeminence and the likely presence of ancient burials (HECKER and HECKER 1990: 27), the large rectilinear compounds to the northwest share similarities in spatial layout and orientation, suggesting interrelated ritual and administrative functions. In fact, despite discrepancies in size and internal configuration, strict adherence to established spatial codes dictated the construction and use of five major ceremonial structures at Jatanca. For instance, the expansive north plazas characterize the Acropolis and four of the other major compounds to the west. Proceeding south through the plaza of the five major constructions, one invariably comes to a demarcated elevated terrace that separates the large open court from the mass of internal rooms, corridors and patios that constitute a considerable volume of each complex (WARNER 2006, 2010) (Fig. 3).

These elevated terraces (occupying an area of 15 x 20 m to 25 x 32 m in area) housed two platforms with ramps in mirror opposition and served as the ceremonial nerve-centre of Jatanca's separate compounds; their liminal placement connecting (or separating) the vast public plazas from the more private and exclusive suite of internalized rooms signals the political and ritual preeminence of this mediating space. Elaborate but constricted ramped passages often connect the plaza to this ceremonial strip, further highlighting the pivotal

and 'threshold-like' symbolic qualities of this ritual stage. In truth, Jatanca's ceremonial architecture can be accurately described as 'scenographic,' and this centrally-placed staging area is somewhat analogous to a proscenium in Greek theatrical architecture (SWENSON 2011) (Fig. 4).

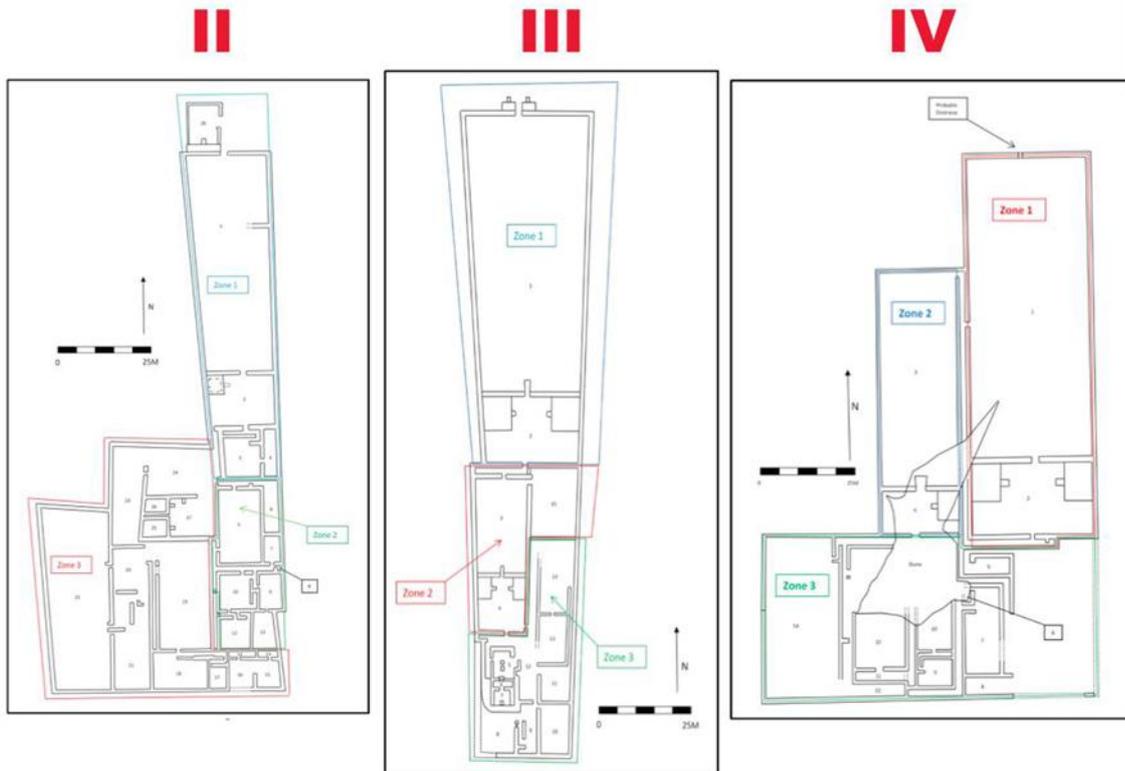


Fig. 3 – Comparison of the plans of Compounds II, III, and IV (WARNER 2010).

Evidently important political and religious ceremonies were orchestrated here (with the principal performers possibly entering from the private sectors to the south) in full view of a large assembled crowd in the plaza (WARNER 2010). The platforms, which measure roughly 9–14 m long on average, form paired dyads and prominently overlook the plazas at their southern terminus. In the four compounds situated to the west of the Acropolis, they are constructed facing each other on either ends of the elevated stage.

In Compound 2, an anomalous platform with central ramp is directly associated with the open court but abuts the northern wall of the closed plaza. A dyad of two ramped structures also frames the narrow and restricted doorway leading to the enclosed plaza of Compound 3. These platforms are the only examples not constructed on the staging terrace, and they likely regulated movement in and out of the monumental courts. The platforms built on the staging terrace and overlooking the plazas undoubtedly staged important religious and political rites given that similar structures with ramps would become prominent spaces of ceremonialism in both urban and rural settlements during the Late Moche and Lambayeque Periods (SWENSON 2004, 2006, 2007, 2008). In fact, comparable platforms are depicted as keys arenas of elaborate ritual events in both Late Formative and Moche ceramic art (WIERSEMA 2010: 262).

It is noteworthy that a salient progression from inclusive to more exclusive space is experienced in every compound as one proceeds south from the monumental plaza through the staging ground with platforms and

into the internal mass of labyrinthine chambers, corridors, and patios. In fact, recent excavations have revealed that this pronounced spatial gradation corresponds with salient functional differences; the four principal architectural zones (plaza, staging area, internal southern rooms aligned with the public plaza, and peripheral southern rooms) were consistently associated with distinct features and artifacts.

Recent excavations have further revealed that Jatanca's monumental architecture is marked by the intense nesting of ceremonial space (SWENSON et al. 2009). Compounds 3 and 4, for instance, located in the western portion of the site, are defined by two interconnected plaza complexes with their own separate stages, each associated with dual ramped platforms placed in mirror opposition. In other words, the two westernmost precincts are distinguished by a duplication of Jatanca's iconic ceremonial space. The replicated and scaled-down plazas are smaller in size than their larger counterparts and are situated at a greater depth within their respective compounds. Therefore excavations demonstrate that the reiteration or replication of key rites in a formalized spatial and temporal sequence characterized the orchestration of spectacle at Jatanca (WARNER 2010; SWENSON 2011) (Fig. 4).

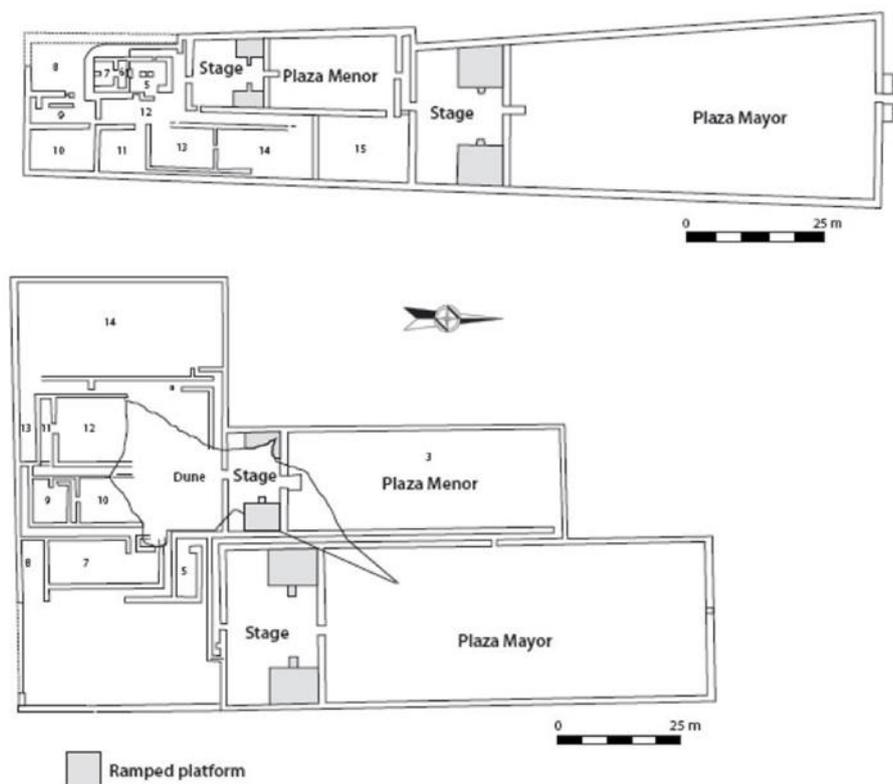


Fig. 4 – Architectural plans of Compound 3 (upper) and Compound 4 (lower register) at Jatanca, illustrating the nested relation of northern plazas to opposed ramped platforms with the “stage” areas of each precinct (WARNER 2010).

In both complexes, the smaller plaza and associated staging strip could only have been accessed by proceeding initially through the larger courts to the north. The architectural design of these precincts appears ideally suited to stage rites of procession and perhaps even initiation, wherein the built environment was complicit in conferring distinctions, shaping identities and creating or transforming subjectivities. The greater depth and seclusion of the internal plaza of Compound 3, for instance – which would have held three to four

times fewer individuals than the great court dominating the north of the complex – reveals that movement through the enclosure became increasingly more restricted. Space becomes even more exclusive and elaborate as one moves south from this internal plaza into smaller, higher and more secluded precincts in the southern extreme of the compound (that are directly aligned with the more public ceremonial spaces to the north). In these chambers excavation revealed an enclosed patio associated with two aligned daises and an elevated bench-like platform. Large *Spondylus* shell beads that originate from the warm waters off of the coast of Ecuador and are known to have served as a sacred dedicatory material were placed in postholes within this precinct, and Warner's traditional space syntax 'gamma analysis' demonstrates that this sheltered space was associated with a high depth value that is often interpreted as a marker of social exclusivity (WARNER 2010). To reiterate, it could only be reached by passing through the interconnected chain of monumental plazas. The intimacy and secrecy or mystery of ritual performances would have intensified as individuals moved from the sole entrance at the north end of the vast open plaza through the concatenation of nested ceremonial arenas to the south. Although lacking a replication of plazas with opposed ramped platforms, a similar architectural pattern was identified for Compounds 1 and 2 to the east.

Centrally placed chambers in the more private, southern sectors that lie on direct axis with the northern plazas are consistently associated with elaborate furnishing, specialized activities and high-status artifacts. These include: *Spondylus* shell bead caches; monumental roofs as indicated by large aligned postholes; circular dimples built into plastered floors to support ceramic vessels; baffled (indirect) entries; raised daises or benches; thickly plastered walls; and, in one instance, a sub-floor burial (SWENSON et al. 2008, 2009). Finally, the standardized compartmentalization of activities at Jatanca is further corroborated by the excavation of nine of the ceremonial platforms overlooking the monumental plazas. Unlike the plaza or excavated rooms in the compounds' southern sectors, evidence of burning and accumulated detritus was rare on the tested platforms.

Comparative excavation of the ramped complexes reveals that these focal ceremonial structures were kept clean and free of debris. This evidence supports the argument that these elaborate structures served first and foremost as veritable, open 'stages' of ceremonial performance. As mentioned above, these platforms closely resemble the depiction of ramped structures in Moche ceramic art and iconography suggesting that these paired and opposing structures served as important ritual foci, a highly charged spatial 'bottleneck' of sorts as elemental to the highly choreographed movement through the nested plazas of the compounds. Elevated as they are above the northern plazas of Compounds II, III and IV, it is the view from these particular vantage points on the opposed ramped platforms that becomes the principal focus for the remainder of this paper. The interpretation of these platforms as being powerful locales of high emotive value is undeniable and likely speaks not only to our own contemporary spatial sensitivities. As will be made clear in the remaining section of this paper, this interpretation is further supported by the quantitative measures that are detailed below, tools that attempt to mitigate western spatial ontological biases to a degree by clarifying and quantifying the underlying structure of the built environment.

Practical and Theoretical Foundations of the DepthMap Program

Woven together from two strands of thought, the original concept behind DepthMap was based on a combination of isovist analysis (BENEDIKT 1979) with space syntax analysis (HILLIER and HANSON 1984). Benedikt created maps of properties of the visual field at points within plans of buildings. He drew contours of equal visual area within the plan and called the resulting map an 'isovist field', believing that these maps would give an insight into how people navigate actual buildings. Since closely packed contours would indicate a rapidly changing visual field, he reasoned that these would indicate decision points within the building. Independently, Hillier and Hanson developed the theory of space syntax in which they created various representations for the components of space, drew maps of these components, and crucially, the relationships of the components with each other. Within the present space syntax academic community, the representation that has become most used is the axial map. The actual mathematical derivation of an axial map is quite complex, but essentially it involves drawing a set of lines through the open space of an architectural plan. Hillier and Hanson then created an interesting twist to established theory at the time. They created a graph using the axial lines themselves as nodes, so that each line was considered connected to others that it intersected. From this graph, they calculated how well 'integrated' each line was with respect to all the others in the graph, that is they calculated a measure of the average number of steps it takes to get from one line to any other within the axial map. The integration of axial lines is of particular interest to researchers as it correlates well with the number of pedestrians found to be walking along the axial line (HILLIER et al. 1999).

Since Benedikt had theorized that isovist fields would correspond in some way to movement patterns of people and Hillier et al. had shown that the relationship between lines through the space does correspond with movement patterns within space, it was decided to combine isovist fields with space syntax to provide a measure of how well integrated isovists themselves are within a plan of an environment (TURNER and PENN 1999). The methodology was later formalized more simply as "Visibility Graph Analysis" (VGA) (TURNER 2001). In VGA, a grid of points is overlaid on the plan. A graph is then made of the points, where each point is connected to every other point that it can see. The visual integration of a point is based on the number of visual steps it takes to get from that point to any other point within the system (TURNER 2004). Various graph measures, not just integration, may be made. The idea was that all possible occupiable locations within the built environment would be categorized by their visual relationships to other occupiable spaces through a continuous map. Due to its providence, it was hypothesized that VGA would give a good indication of how people might interact with space either moving through it (DESYLLAS and DUXBURY 2001), standing, or generally occupying a space.

DepthMap was the tool created to perform these analyses by Alasdair Turner and his team at the VR Centre for the Built Environment in the Bartlett School of Graduate Studies at the University College London. Whether or not VGA actually succeeds in its aims is open to debate. For "people movement", a recent study has shown that other methods based on space syntax seem to correlate better with pedestrian count rates in cities (TURNER 2003), although an earlier result from a large department store was promising (CHAPMAN et al. 1999). Regardless of the outcome of the debate, there does appear to be a promising avenue of research for modeling people movement that uses the visibility graph at its core, if not a direct measurement of the graph. PENN and TURNER (2002) proposed an agent-based analysis with an underlying visibility

graph. In this analysis, “agents” (automata within a computer representing people) are released into a plan of the environment and navigate using the visibility information directly available to them through the visibility graph. A simple method of path selection which approximates choosing the longest line of sight as the direction of travel is applied (TURNER 2005). The results of the analysis have correlated well with pedestrian movement both within a building environment (TURNER and PENN 2002) and within an urban environment (TURNER 2003). The agent-based analysis proposed by Penn and Turner has been produced as a plug-in module to DepthMap and will be employed in this study to compliment both VGA and axial analyses. With these three analytical avenues at our disposal, the following section will briefly outline the method and workflow by which three compounds were digitized, analyzed, reconstructed, georeferenced and compared in relation to their actual geographic settings over time in terms of solar position. Due to the similarity of the layouts of Compounds II, III and IV in regards to the position of the ramped platforms in relation to the northern plazas in these three compounds were chosen for analysis, however as will be seen, it is very likely that the same observations would be made in every compound of Jatanca if analyzed in the same manner.

Methods

- 1) All plans of the three target compounds (II, III, IV) were digitized as vector graphics in Adobe Illustrator.
- 2) Resulting plans were converted into the vectorized .DXF file format required by DepthMap.
- 3) All plans imported into DepthMap where each was scaled appropriately followed by the definition of open navigable space within the compounds.
- 4) Visibility Graph Analysis, Axial Analysis and Agent Analysis were conducted for each compound and the resulting analyses exported as separate .JPG files.
- 5) Using these analytical results as the basis for 3D reconstruction, each plan was imported into Google SketchUp Pro 8 wherein all walls, ramps and platforms were reconstructed in a simplified manner that reflect the likely wall heights of the original construction (WARNER 2010).
- 6) Completed 3D models were then imported into Google Earth, where each model was appropriately scaled and georectified in their exact geographic and topographic position.
- 7) By using the “walkthrough” tools in Google Earth, particular target areas were chosen as specific vantage points within each compound, positions that were informed by the results of DepthMap analyses.
- 8) With the “Sun” tool turned on, the position of both sunrise and sunset at various dates throughout the year were observed from those target areas of the compounds in relation to the surrounding landscape, and similarities noted.

Results and Discussion

When the resulting DepthMap analyses were compared over all three compounds, it was clear that with minimal variations, similar patterns of visibility, axiality and agent movement arose. In terms of the VGA output, the highest levels of visual integration (shown in red in Fig. 5) occurred in the space located directly between the opposing ramped platforms at the southern end of the northern plazas in all compounds. From these positions, an individual moving from the plaza onto the raised “stage” would be able to see the entire plaza while having a privileged view of both ramps. As the plans analysed did not take the changes in

elevation into account as per the limitations of the software itself, one could imagine that the level of visual integration from the elevated position of the stage and platforms would be even higher than depicted.

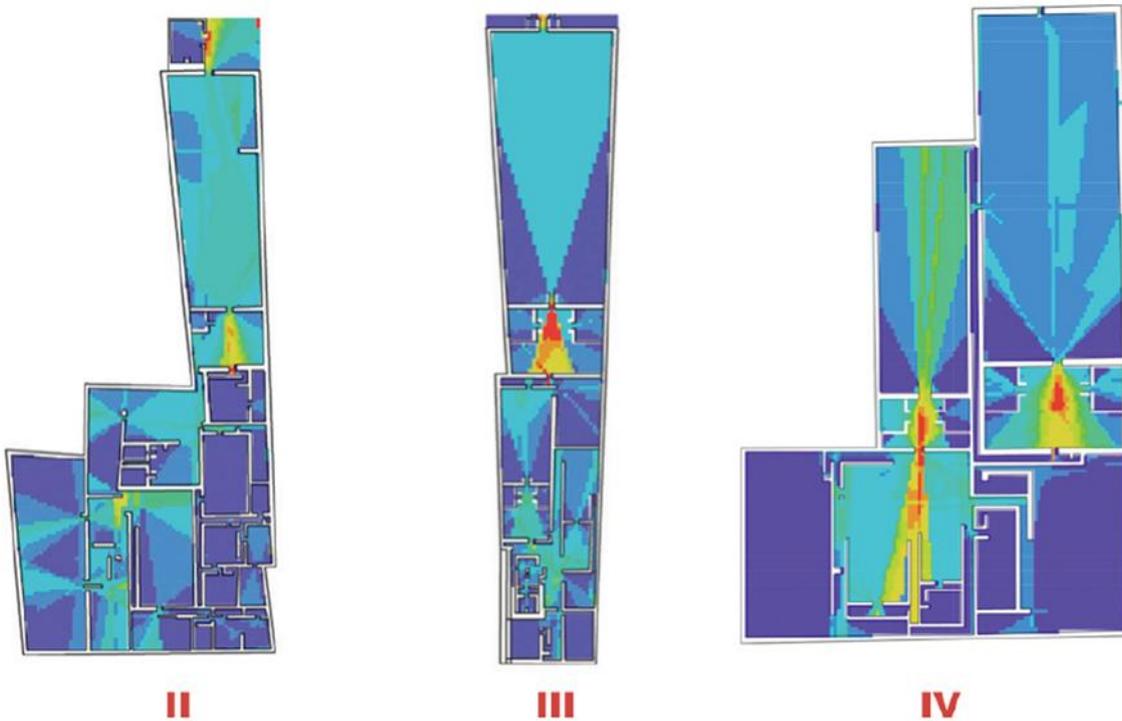


Fig. 5 – Results of the Visibility Graph Analyses (VGA) of Compounds II, III and IV.

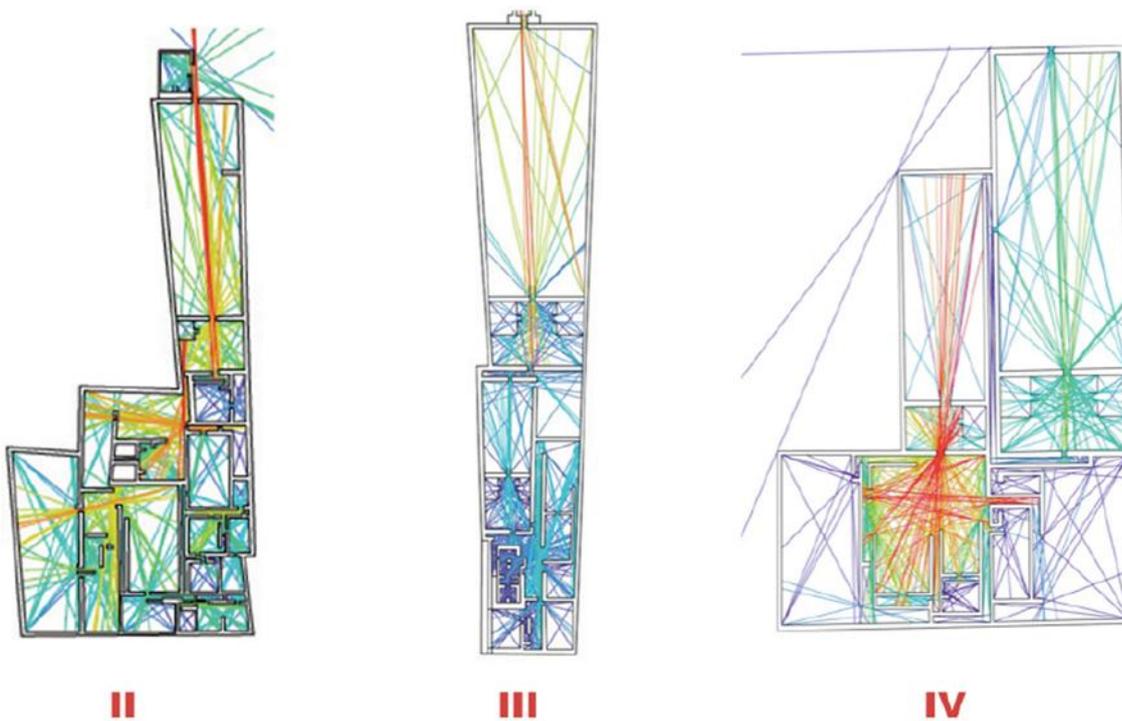


Fig. 6 – Results of the Axial analyses of Compounds II, III, and IV.

Mirroring this finding, the results of the axial analyses of the compounds clearly shows that the longest unbroken lines (shown in red in Fig. 6) in every case would have led ritual participants directly down the centre of the northern plazas through the central ramp of the “stage” and between the opposed ramped platforms found there.

Finally, the results of the agent analyses strongly support the marked separation of the exterior/inclusive plaza spaces from the interior/exclusive inner sanctums to the south of each compound. As indicated by colour in the agent maps, with grey being areas being those left unexplored, blue as lightly travelled and green and yellow areas seeing the highest traffic, showing that the plazas were by far the most accessible areas of the compounds (Fig. 7). Not surprisingly, it is clear that all of these findings support the initial qualitative interpretations of structure and function the compounds as controlled ceremonial spaces that exploited increasingly nested inclusion along a distinct route. However, when results are considered from within the 3D reconstructions produced of each compound, new interpretations come to light that elucidate a potential function of these spaces, with particular focus on what can be seen from the opposed ramped platforms.

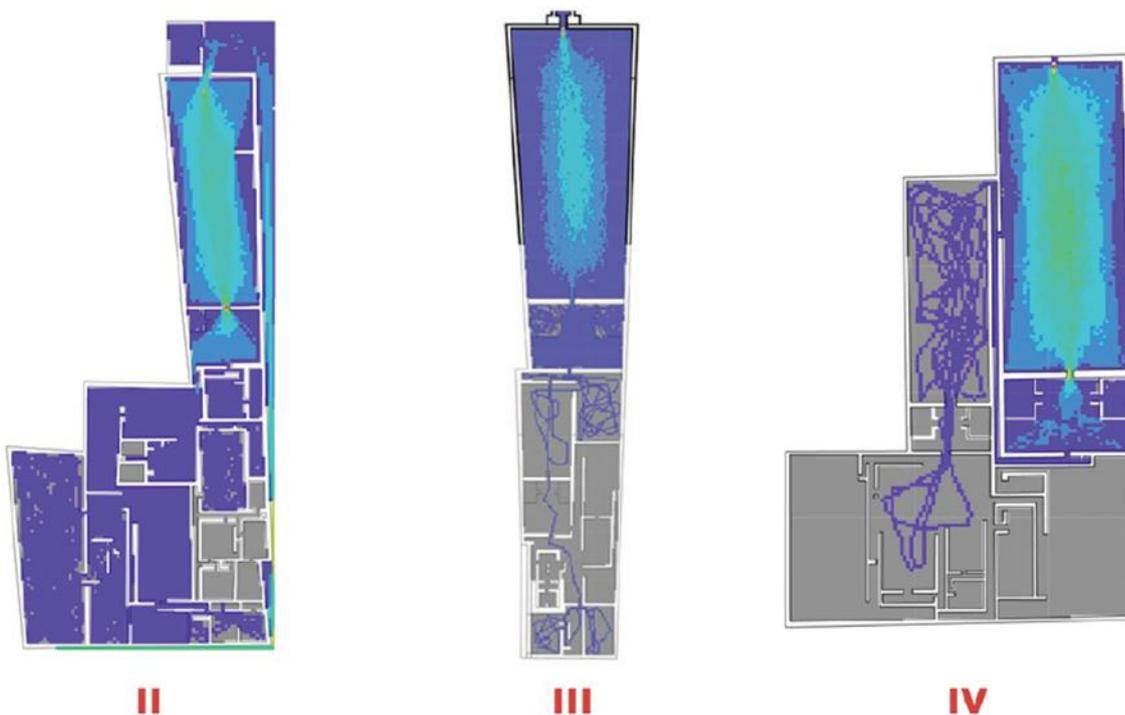


Fig. 7 – Results of the Agent Analyses for Compounds II, III and IV.

With the bounding walls of each compound limited to a height of approximately 2–2.5m in each of the 3D reconstructions when imbedded into their proper position in Google Earth, it is clear when standing within the centre of the plaza of each compound, these walls restricted the view of a participant to focus on the plaza alone, effectively removing the most notable feature of the surrounding landscape, the Cañoncillo mountain range located directly east of Jatanca, from the field of view. It is only when one exits the plaza and onto the stage area to the south that the change in elevation allows for a glimpse of the upper reaches of the Cañoncillo range over the top of the easternmost walls. This privileged view of the mountains becomes even

more distinct if one were standing on the western ramped platform facing east, a position that allows the entire range to be seen while still restricting any view of the rest of the landscape, effectively directing and focusing one's gaze on the mountain exclusively (Fig. 8).

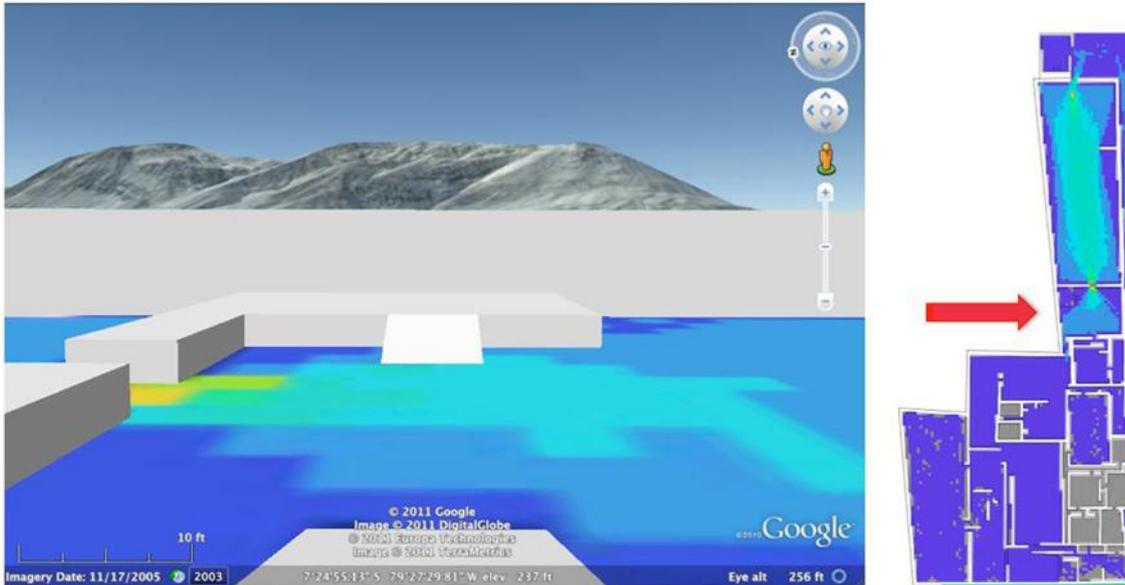


Fig. 8 – Google Earth view looking East towards Cerro Cañoncillo from the western ramped platform of Compound II as indicated in the architectural plan seen on the right side of the figure, with the results of the agent analysis as floor level.

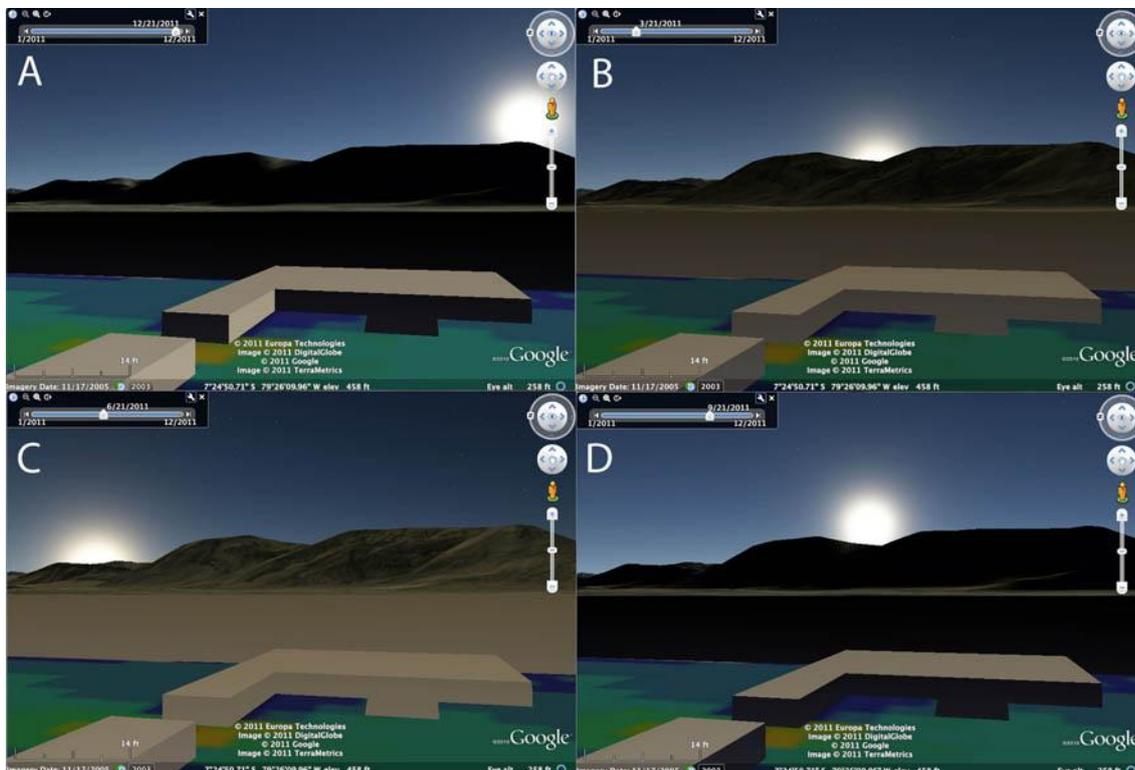


Fig. 9 – East-facing view of Cerro Cañoncillo from the western ramped platform of Compound II (see Fig. 8 for position) illustrating the position of the sunrise above the mountain range on the summer solstice (A), autumn equinox (B), winter solstice (C) and vernal equinox (D).

As Cerro Cañoncillo is by far the most distinct topographic feature in the immediate area, it is not surprising to note that the highest peak of this range (at an altitude of approximately 400masl) is known to have been considered a local *huaca*, a term used to describe distinct sacred objects or places across the Andes, both ancient and modern (BASTIEN 1978). Due to the close proximity of the compounds to each other on the Pampa de Mojucape, this unique view of the mountain from the western ramped platforms of each compound considered in this study was nearly identical in each case.

Appreciating the enduring importance of calendric rituals that continue to be celebrated on the solstices and equinoxes throughout the Andes (SEOANE 2011; COOK 1977, 1990; BAUER and DEARBORN 1998; KOLATA 1993, 2003), by toggling the date and time in Google Earth the changing positions of the sunrise over the year in relation to the Cañoncillo was investigated. As can be appreciated best from figures 9 and 10, it appears that from the privileged viewpoint of the western ramped platform of each compound that directs the gaze due east towards the rising sun, the portion of the horizon over which the sun rises throughout the year is framed perfectly by the full visible extent of the Cañoncillo range. Following this hypothesis, it was observed that the sunrise on the summer solstice (December 21 in the southern hemisphere) was directly over the southernmost peak of the Cañoncillo range (Fig. 9A, Fig. 10 right arrow), and the winter solstice (June 21) occurring directly over northernmost peak of the range (Fig. 9C, Fig. 10 left arrow) with sunrises of the vernal and autumnal equinoxes occurring over precisely the same valley between the central peaks of the mountain (Fig. 9B, 9D, Fig. 10 central arrow). As such, one could suggest that the position of the rising sun in relation to particular peaks and valleys of the range could easily serve as an accurate calendric guide used to observe and control closely correlated ritual and agricultural cycles over the course of the year. It is only from this very specific part of the Pampa de Mojucape that this relationship between the sunrise and mountain range can be seen, suggesting that the placement and orientation of the compounds of Jatanca is related to this particular observational vantage point. As mentioned, all of the compounds are quite close to one another, appearing almost crowded together in a manner that perhaps exploited the unique observational viewpoint from that general area to unify the communities that likely used these structures as places of communal gathering throughout the year (Fig. 10). Notably when considering the same hypothesis from a viewpoint less than 200m east of the ceremonial core of Jatanca towards the base of Cerro Cañoncillo near to the later Moche period site of Huaca Colorada, the resulting view creates a completely different vista that does not exploit the natural features of the Cañoncillo range in the same ways, with the sun rising midway along the mountain at the summer solstice.

As this preliminary interpretation only considers the position of the rising sun, similar investigations could be undertaken that investigate possible architectural and topographic alignments with the position of the setting sun on the horizon, events that would be visible from the opposed eastern ramped platform. More elaborate studies in future could extend investigations to consider the position and phase of the moon or particular constellations at various positions along the horizon in relation to architectural and topographic elements. Such studies could further develop an understanding of the potential relationship between architectural and ideological structures as they are oriented to and designed to reflect the situated bond between geographic locales and natural cycles that may define them as places of social and ritual importance. This interpretation would not have been possible without the use of the various computer programs used, however it must be stated that although these tools have become increasingly more accessible to the archaeological community,

they must be exploited as interpretive guides, not definitive measures that reduce exceedingly complex social systems to quantitative spatial abstractions. The role of the archaeologist should not focus on technical or methodological aspects of research without very specific interpretive questions in mind. By bogging ourselves down with the daunting task of maintaining enormous data sets within powerful yet somewhat obtusely complicated computer programs such as ArcGIS and GRASS, often more time is spent processing the output of analysis than seeking creative ways to combine more accessible programmes and avenues of investigation that would lift the gaze and consideration of the researcher from reductive statistical measures to the situated and observational. As an experimental example of this sort of theoretical and methodological direction, by expanding upon traditional survey, excavation and interpretation to inform two-dimensional spatial analyses based on measures of visibility and movement, this paper begins to address the need for a form of three-dimensional spatial analysis that considers built and natural environments in tandem.



Fig. 10 – East facing oblique aerial view of the Cerro Cañoncillo range illustrating the relationship between the monumental core of Jatanca (in blue) to the locations of the sunrise on the summer solstice (right arrow), autumn and vernal equinoxes (central arrow) and winter solstice (left arrow).

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