The Past on its Way to a Digital Future – Urban Archaeology in Cologne

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Due to its rich history of more than 2000 years, the city of Cologne, once the capital of the Roman province *Germania inferior* and an important trading centre in the Middle Ages, has its own agency for archaeological monument conservation, which is located at the *Römisch-Germanisches Museum*. The urban area, which the agency is responsible for, has a size of approximately 400 km².

In the field of tension between the densely built-up inner city and the surrounding countryside with old village centres and remaining larger open spaces, mainly used for agriculture, Cologne's archaeological monument conservation is confronted with special requirements. A generally accelerated urbanisation process and the associated extensive construction activity pose special challenges. Due to the increasing settlement pressure, the existing settlement areas are becoming more and more densely built-up. In today's inner city, the need for efficient use of increasingly scarce and thus more expensive building plots leads to larger cubatures in new buildings, which includes the extension of the new buildings underground as well.

Therefore, in advance of construction projects it is important to forecast the expected archaeological monument substance for the affected areas as precisely as possible in order to be able to introduce a concrete action concept for the preservation of archaeological monuments into the planning process at an early stage. For this purpose, the archaeological potential of an area has to be determined by drawing on all available sources with archaeologically relevant content and, if necessary, the results of additional archaeological test excavations. Thus, it is possible to enforce the permanent preservation of archaeological monuments by designating appropriate, professionally substantiated protection zones. In areas where archaeological excavations are unavoidable, the prognosis result enables efficient planning and execution of rescue excavations and contributes to formulating scientific questions for these investigations.

The basis for a sustainable prognosis result is a detailed description of the already known underground monument stock. The most important source for the assessment of the archaeological potential of a planning area is the database of the local archive of the agency for archaeological monument conservation, in which all site-related information on archaeological sites in the urban area is archived by year and indexed by topographical sorting. The earliest written sources on archaeological sites recorded in the local archive date from the beginning of the 16th century, long before the establishment of a systematic urban archaeological monument conservation in 1923.[1] In addition to this data stock, all other available sources that provide information on the usage history of the affected areas are consulted within the scope of the evaluation of

Published in: Kristian Göransson (Ed.), Classical Archaeology in the Digital Age – The AIAC Presidential Panel, Panel 12.1, Archaeology and Economy in the Ancient World 51 (Heidelberg, Propylaeum 2021) 23–37.
DOI: *https://doi.org/10.11588/propylaeum.708.c10610*

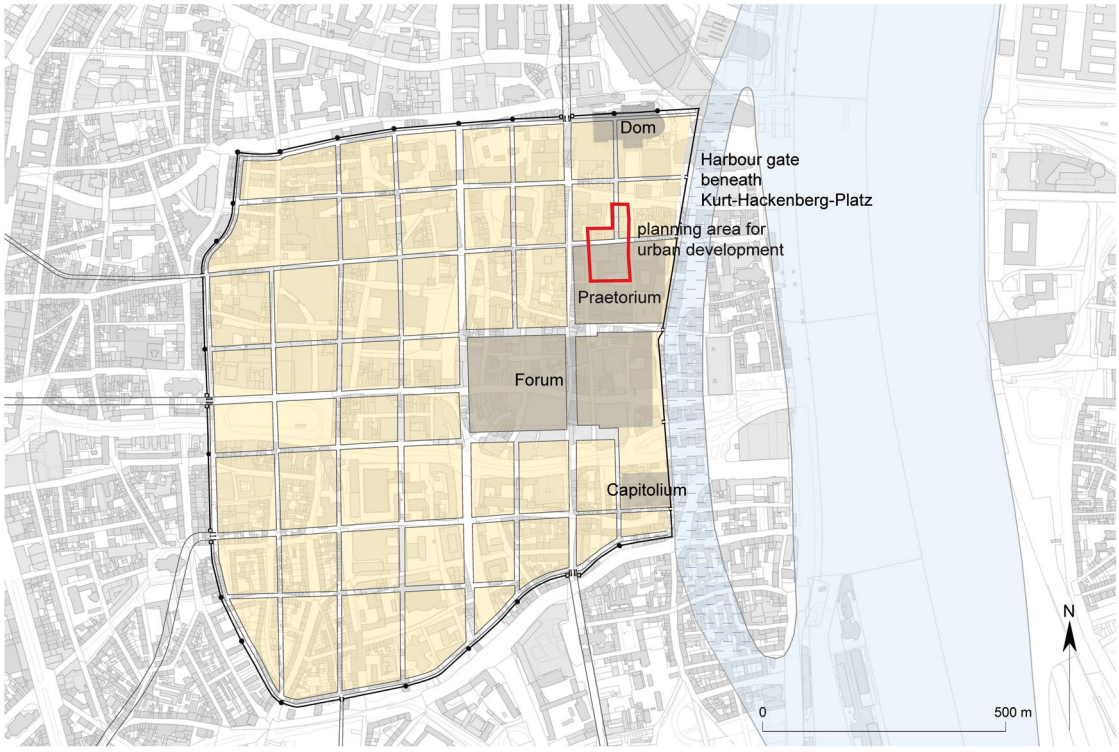

Fig. 1: Roman Cologne at the end of the first century with a current planning area for urban development (red line).

the archaeological potential. These are written records, old maps, cadastral maps as well as historical pictorial works and photographs.

For an efficient workflow, the existing archaeological data has to be available in a digital way, meaning that analogue data has to be made digitally accessible in a first step. The advantages of GIS-supported provision and processing of spatial archaeological data are used. Through the use of GIS technology, a comparative analysis and evaluation can be carried out, taking into account historical sources and maps as well as historical cadastral maps. In this way, layers with different thematic and chronological contents can be combined to overlay. It is possible to view and evaluate the available spatially related individual observations in their respective temporal and spatial context.

In the area of Cologne's historic city centre, the archaeological inventory to be expected on site is determined to a large extent by the spatial development of the city over time, which can be traced in its essential features with the help of the city fortifications. The Roman city wall essentially traces a natural flood-protected plateau on the edge of the lower terrace of the Rhine and encloses an area of 97 hectares (fig. 1). In the north, south and west, *suburbia* with residential and commercial use developed outside the city wall. After the fortified urban area had expanded to the east into the area of a former Rhine island in late Roman times, it was enlarged to at least 204 hectares in 1106 AD by the

integration of new medieval suburbs in the area of the former *suburbia*. In the course of Cologne's rise to a supra-regional economic centre in the High and Late Middle Ages, the former city area was extended again by a new landward semi-circular city wall. The medieval city centre now covered an area of 388 hectares, nearly four times the size of the Roman city within its walls. The core city of Roman times continuously remained the central area of the city. Therefore, the archaeological stratification sequence from Roman times to the most recent archaeological time horizons is most pronounced in this area.

Thickness of Archaeological Strata

An important parameter to be determined for a planning area in the city centre within the framework of the evaluation of its archaeological potential is the local thickness of the archaeological layer package. If this is known, it is possible to pre-evaluate the extent to which archaeological substance can be expected and from which periods of the city's history archaeological findings might be preserved. Approximately, the archaeological layer thickness for Cologne's Old Town can be determined as the difference between a digital terrain model of today's terrain surface and a digital surface model of the natural subsoil, which depicts the terrain surface in pre-Roman times.

Model of the Pre-Roman Terrain Surface

The model of the pre-Roman terrain surface of the inner city was interpolated from elevation data of the upper layer edge of the undisturbed soil, today usually covered by anthropogenic fillings containing archaeological structures that have developed in the course of settlement development (fig. 2). Particular attention was paid to height data for the upper edge of the natural subsoil recorded during archaeological excavations. Data from geological drilling and other subsoil investigations were also considered. The data used here are based on absolute altitude values compiled within the framework of two studies on relief development in the area of Cologne's Old Town.[2]

The digital surface model of the natural subsoil clearly shows the characteristic local topography before Roman occupation (fig. 2), which is assumed to have played an important role in the choice of the site for the foundation of the settlement in Roman times, the later *Colonia Claudia Ara Agrippinensium* (CCAA) and also influenced the spatial development of the medieval city. The Roman city within its wall lies on an elevated and thus flood-protected plateau on the edge of the lower terrace of the Rhine. Due to a convex riverbank, the plateau originally fell steeply towards the Rhine. Between the slope and a river island, accompanying the city plateau along its entire length, there was a tributary of the Rhine used as a port in Roman times and no longer existing today.

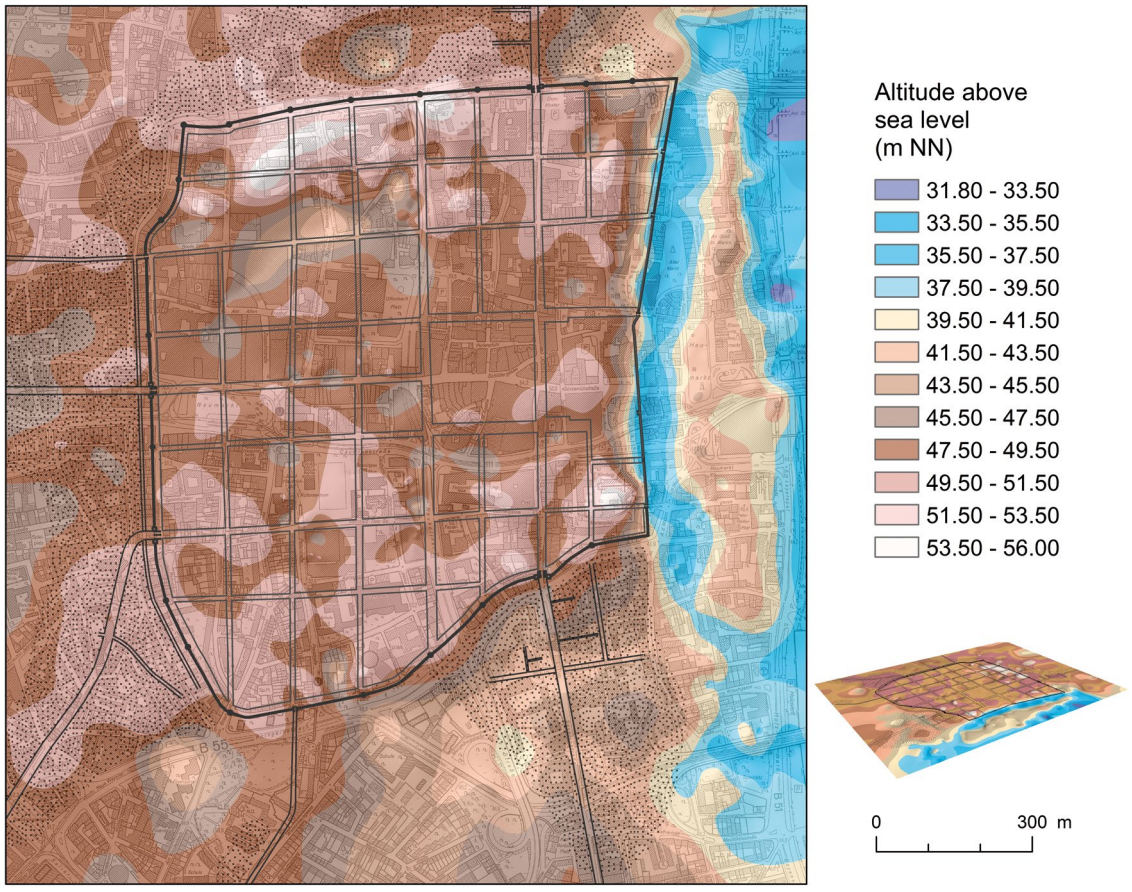

Fig. 2: Digital terrain model of the pre-Roman terrain surface in the inner City of Cologne (interpolation method: ArcGIS spline with tension).

Model of Today's Surface

The data basis for the terrain model of today's surface (fig. 3) is formed by area-wide height data acquired by the use of Airborne Laser scanning (ALS). Previously, vegetation and building structures were eliminated from the data. For taking into account the disturbances of the archaeological sequence of layers by modern buildings, a mapping of today's basements in the city centre, prepared within the framework of the project *Digitaler Archäologischer Schichtenatlas Köln* (digital archaeological layer atlas of the historic Old Town of Cologne)[3] was included in the calculation of the surface model.

The result is a prognosis map of anthropogenic fillings, which approximately represent the archaeological layer thickness in the inner city (fig. 4). As expected, the greatest filling thicknesses of up to 14 m lie in the area of the former Rhine channel. The filling of the Rhine channel with municipal waste and building rubble began in Roman times. In the course of the expansion of the settlement area to the former island

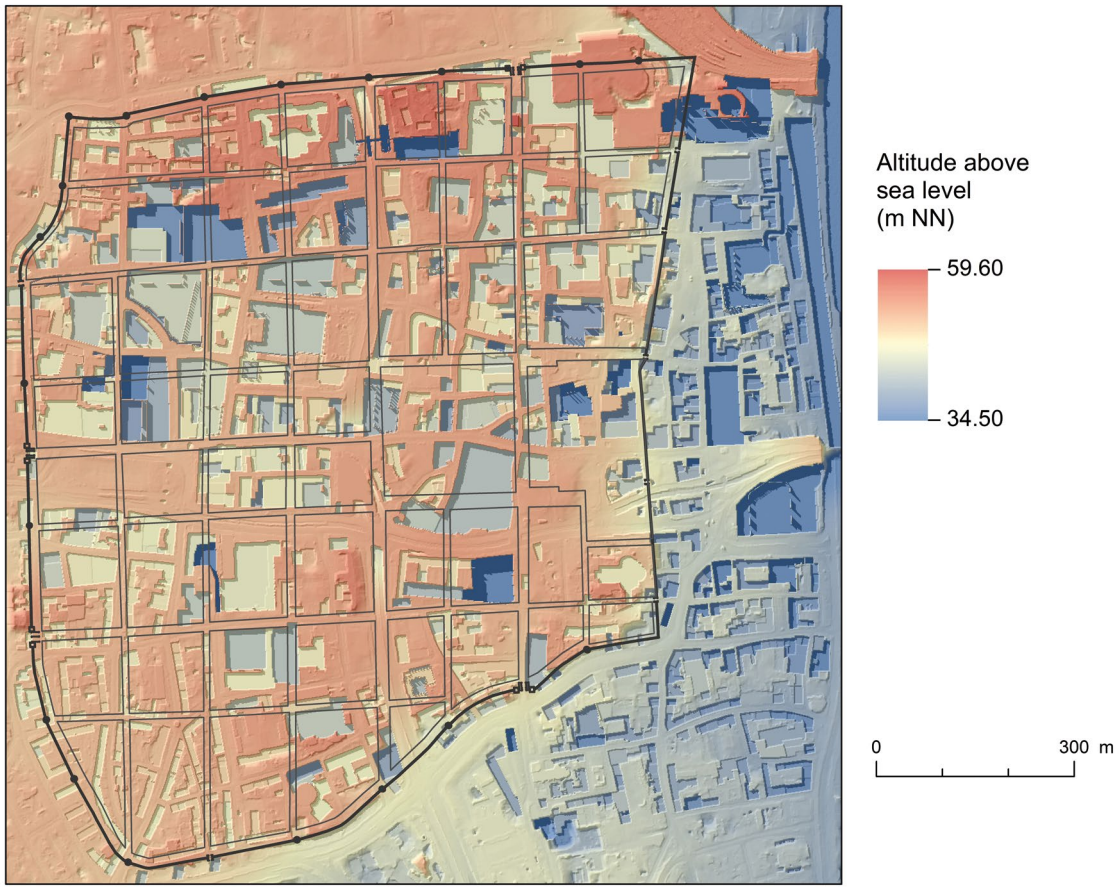

Fig. 3: Digital terrain model of today's terrain surface in the inner City of Cologne.

in late Roman times and in the Middle Ages, the fills were intensified in order to create sustainable building land.

In large parts of the Roman city there are layer thicknesses of up to 5 m, more rarely also up to 7.5 m. In several areas, however, the archaeologically relevant fillings have already been completely cleared out by modern buildings whose basements extend into the natural subsoil.

While the mapping of anthropogenic fillings already provides information on the expected local archaeological layer thickness, only the detailed evaluation of the entire archaeological and historical data available for a planning area and its immediate surroundings allows a forecast of the archaeological substance to be expected on site. The procedure can be sketched using a case study from the city centre of Cologne.

In the core area of the Roman city, a larger area is to be developed in terms of urban development (fig. 1). Based on an evaluation of expected archaeological findings, the agency for archaeological monument conservation enters requirements for the redevelopment of the site into the planning procedure.

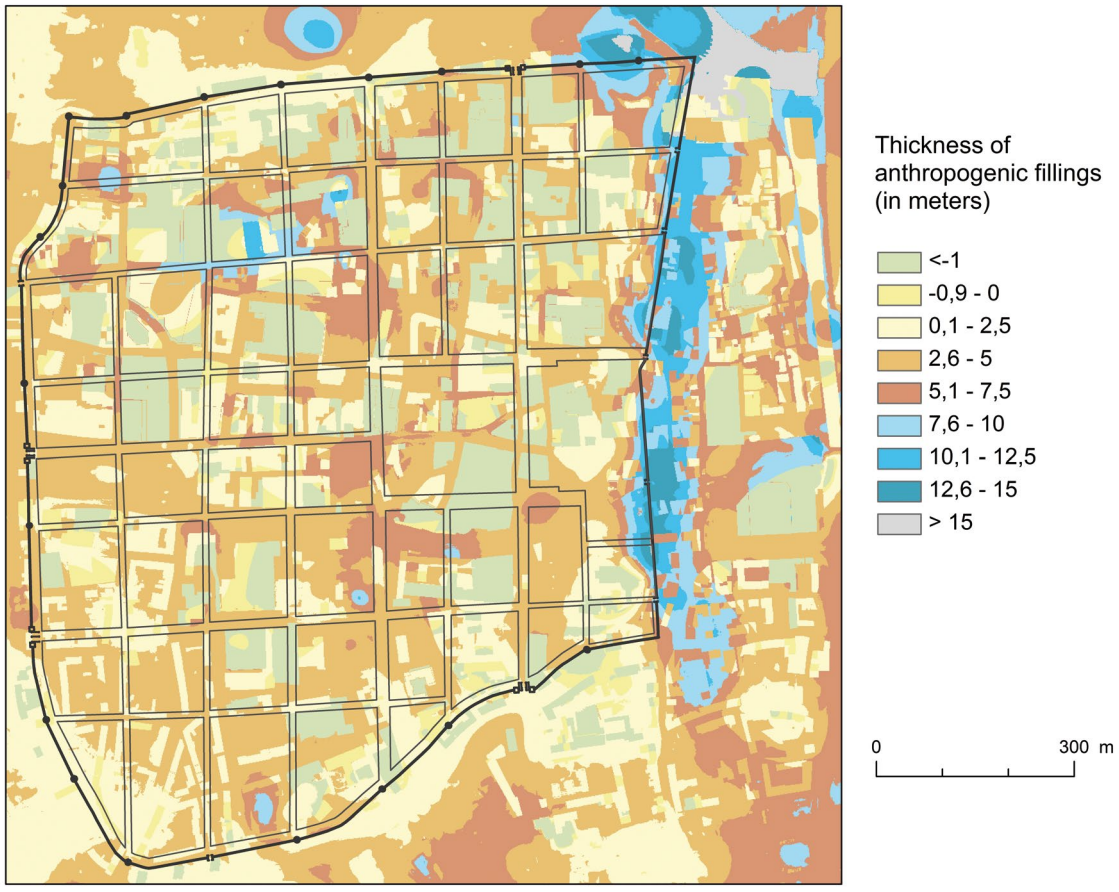

Fig. 4: Thickness of anthropogenic fillings in the inner City of Cologne.

In a first step the site-related archaeological data stored in the local archive of the Cologne agency for archaeological monument conservation concerning the planning area and its immediate surroundings are evaluated (fig. 5).

On the basis of archaeological features documented during earlier archaeological excavations it is possible to predict continuation of certain known archaeological features into the planning area and to estimate expected heights for contemporary archaeological findings in the planning area. By considering existing data on modern soil interventions, any existing losses of archaeological substance caused by modern buildings are taken into account. In order to get an idea of the archaeological findings to be expected in the planning area, it is helpful to be able to locate the investigated area precisely within the settlement topography of the affected settlement phases. The detailed reconstruction of the ancient settlement topography is facilitated by the GIS-supported recording and evaluation of the site-related archaeological data stored in the local archive of the Cologne agency for archaeological monument conservation. Regarding the layout of the Roman city (fig. 1), the planning area is situated in the Rhine side zone of the city, which is characterised by important public buildings. The

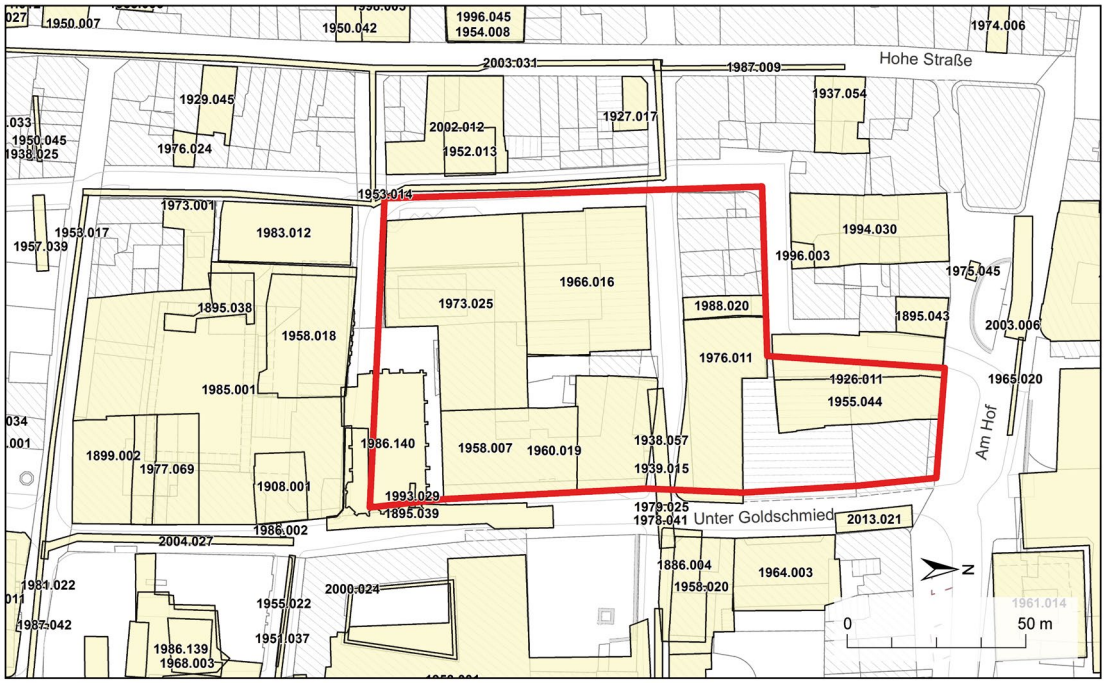

Fig. 5: Survey areas recorded in the local archive of the authority for archaeological monument conservation in a section of a current planning area for urban development in the inner City of Cologne.

planning area is partly within the area to be occupied by the *praetorium*, the governor's palace, between the city wall toward the Rhine and the *cardo maximus*, the north-south oriented main traffic axis of the CCAA. One of the main sewers of the Roman city runs through the investigation area in the route of a street leading to the cardo.

The remains of the post-Roman settlement phases are generally affected to a disproportionately stronger overstamping by more recent building activities.

For this reason, additionally historical sources must be consulted to open up larger sections of the city topography from the Middle Ages onwards.

Important information in this regard is provided by documents on real estate transactions, forerunners of today's land registers, dating back to the 12th century, as they contain important information on the development of individual land plots, which in many cases can be located to exact modern addresses. Other important sources are historical depictions of the city topography like the Mercator Plan from 1571 that gives an early overview of the city topography. Several buildings, some of them of medieval origin and described in written sources, can be identified in this historic plan. In many cases it is possible to link the results of excavations to buildings known from the pictorial and written sources.

The main features of the historical-topographical development over the last 300 years can be explored in Cologne's city centre on the basis of historical city plans and

Fig. 6: Cadastre Development in a section of a current planning area for urban development in the inner City of Cologne, a: Map of Johann Valentin Reinhardt 1752, b: cadastral map 1836/37, c: cadastral map 1938/49, d: cadastral map 2018.

cadastral maps. The Reinhardt plan of 1751 (fig. 6a) is the first precisely measured plan of Cologne's inner city. The cadastral map of 1836/37 (fig. 6b) and the cadastral map of the 1930s (fig. 6c) show the development of buildings and open spaces up to the current cadastral map (fig. 6d). By overlaying these maps, individual plots can be classified according to the intensity of construction activity. Since an increase in construction activity is to be expected with stronger disturbances of the subsoil, it can be determined, in which partial areas good preservation conditions for archaeological features near the surface, especially of the Middle Ages, are to be predicted and, in which areas these are presumably already destroyed by the more recent building development.

Based on the results of the evaluation of the archaeological potential, partial areas with different archaeological potential can be differentiated in the planning area (fig. 7). In the archaeological action concept to be developed, these sub-areas can be taken into account individually. The red areas in which an excellent preservation of the archaeological sequence has been proven or is to be expected are designated as archaeological monuments. These areas are to be permanently protected against destruction by ground interference. In the green areas, the archaeological layers have already been cleared out due to deep basements of modern buildings. In the remaining areas, archaeological excavations are to be carried out in advance of the construction of new buildings. The expenditure for archaeological fieldwork in the respective sub-

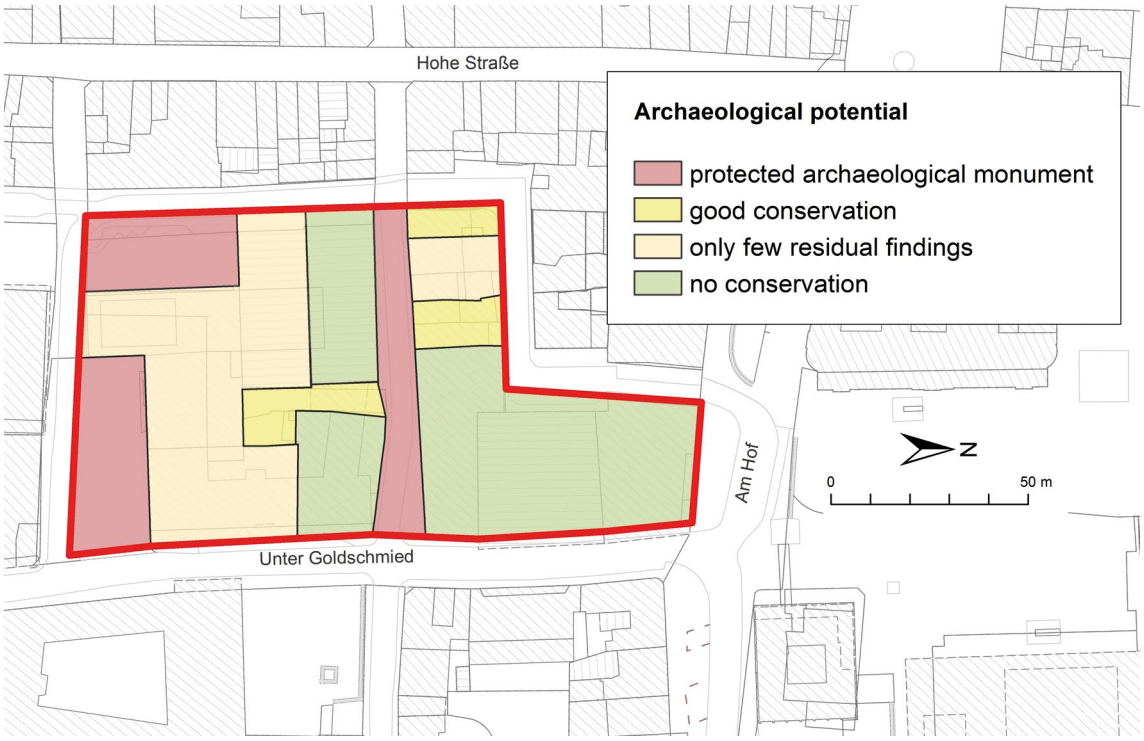

Fig. 7: Mapping of the archaeological potential for a current planning area for urban development in the inner City of Cologne.

areas can be estimated on the basis of the previously prepared detailed forecast of the archaeological stock to be expected.

Revealing a Roman Gateway to the Rhine

The second part of this article deals with the archaeology of the northern harbour gate of Roman Cologne, which was excavated during the construction of the north-south city railway 10 years ago. Individual steps of the documentation process will be presented, ranging from the accurate assessment of archaeological features, 3D laser scanning to digital reconstruction.

Not far away from the city's main cathedral a Roman harbour gate was excavated during 2007/2008.[4] It was the northern one of five gates that faced the Rhine along the city wall of *Colonia Claudia Ara Agrippinensium* (CCAA) (fig. 1). An almost 3.000 square metres large and 13 metres deep excavation was being produced on the Kurt-Hackenberg-Platz. This modern square is located on top of an old secondary arm of the Rhine, which existed in the first century A.D.[5] During the foundation of Roman Cologne the secondary arm of the Rhine could be used for shipping, but sedimentation processes started very early. So the main harbour of Roman Cologne should be located open to the Rhine.

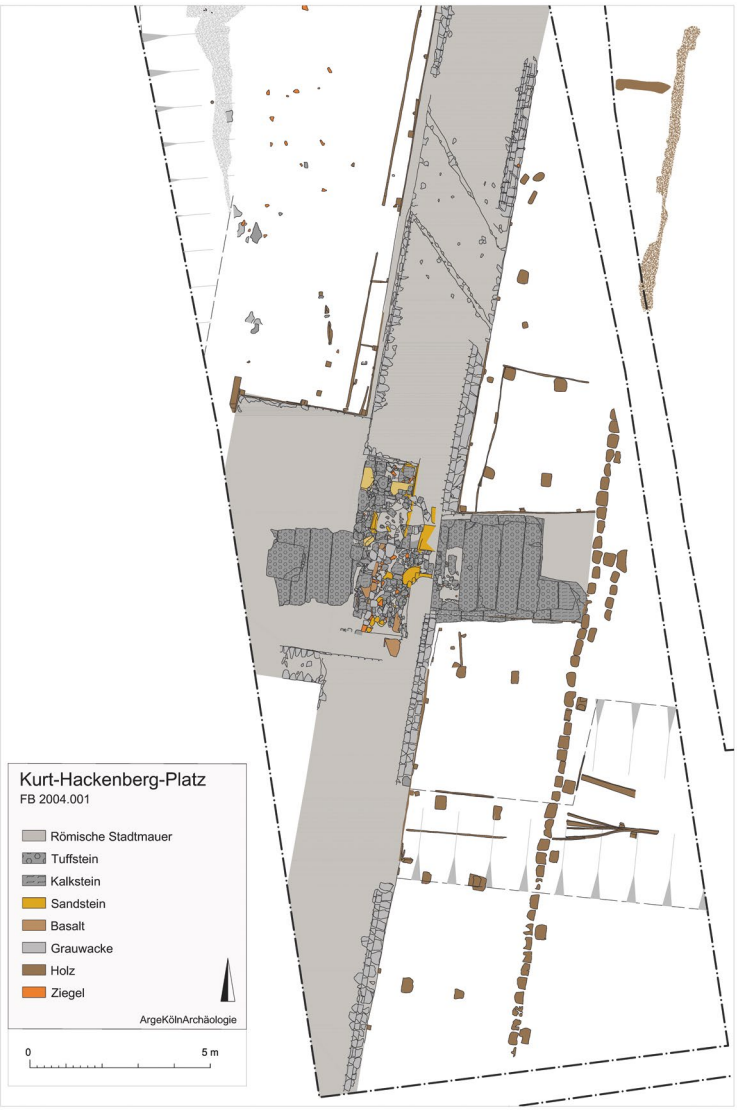

Fig. 8: Plan of the Roman contexts at Kurt-Hackenberg-Platz, Cologne (FB 2004.001).

The secondary Rhine arm was about 60–70 metres wide and more than one kilometre long. Towards the west, the area rises from the Rhine bank to the plateau, on which the Roman town was founded around the birth of Christ.[6] The Rhine-side Roman city wall runs along the foot of this plateau. Nearly one metre beneath Kurt-Hackenberg-Platz, the consortium KölnArchäologie, under the supervision of the *Römisch-Germanisches Museum*, came across the monumental remains of the town's fortifications facing the Rhine.[7] A section of the Roman town wall, c. 25 m long, traversed the modern construction pit in a north-south direction (fig. 8).

The view from the south records the town wall and the outlet of the main sewer located in the foundation of the gatehouse. The passageway through the 'harbour gate'

Fig. 9: Cologne, Kurt-Hackenberg-Platz. Wooden shuttering from the foundation of the Roman town wall.

is at the height of the slabs covering the sewer. In the late Roman period, the entrance was sealed with re-used worked stones; so-called spolia.

How may we imagine the harbour gate at Kurt-Hackenberg-Platz? There is evidence of a substructure for a 6.5 m deep and 7.4 m wide gatehouse on the inner face of the town wall. Between the red sandstone blocks, the inner width of the gate's opening was 2.7 m. The plan of the gatehouse permits a rough reconstruction of the superstructure. Including the elevation of the roof, an overall height of 13.5 m is likely.

The foundation of the Roman town wall rested on the firm gravel of the river-terrace. It comprises *opus caementicium* 3 m wide and over 4 m deep. Due to the wet soil near

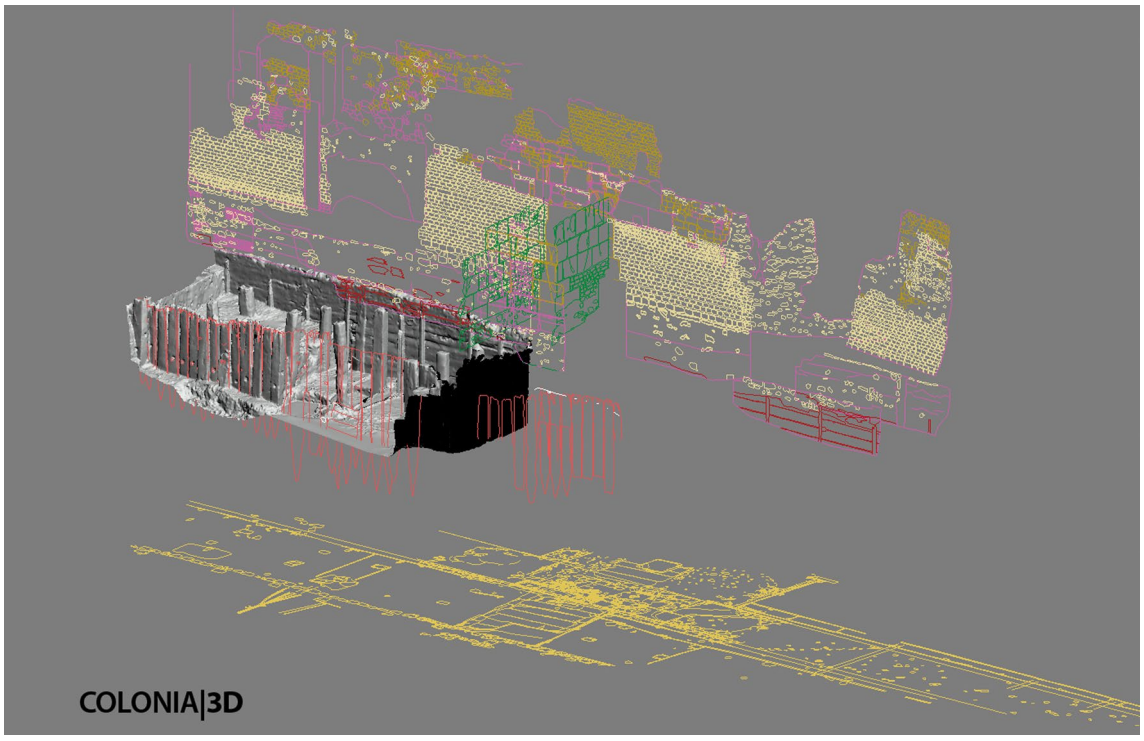

Fig. 10: Northern Harbour gate of Roman Cologne. CAD drawings and polygon model.

the level of the groundwater, the foundation's wooden shuttering remains almost fully preserved (fig. 9).

An analysis by Cologne University's Dendrochronology Laboratory established that this shuttering was of fir timber.[8] The firs were felled in the Black Forest, transported down the Rhine, and sawn to size at Cologne. The fir planks of the foundation's shuttering were in excellent condition. A contiguous row of oak stakes in the area of the riverbank were found in the construction pit at Kurt-Hackenberg-Platz. This plank wall was situated 4 m before the town wall and ran parallel to it. It functioned as shoring for the Roman town wall's construction trench, as clearly shown by the stratigraphic relationships. In addition, together with further posts, the plank wall also served as a pile-foundation grill supporting a wooden walkway situated at the same height as the base of the wall.

A ramp comprising fragments of greywacke was piled against the walkway that probably assumed the function of a quay during the building process of the wall. Analysis of 150 oak stakes from the plank wall confirms that all the trees, from which they crafted, were felled in 89 AD. In the last decade of the first century Cologne's bank of the Rhine was a building site.

The monumental remains of the harbour gate will be presented in a new museum in the underground. The planning process has just begun.

For the visualisation of the harbour gate and to make possible a 3D-reconstruction for the project Colonia3D, basically two sources were analysed and integrated: firstly,

Fig. 11: Digital reconstruction of the northern harbour gate of Roman Cologne.

a 3D-scan of the site and, secondly, CAD drawings containing plans and sections of the excavated town wall and the foundations of the gate. The resulting visualisation comprises a polygon model that lends volume to the archaeological remains.

Dipl.-Ing. Jost-Michael Broser from the Technical University of Cologne kindly supported the project with the provision of data from a 3D laser scan carried out on the site. The data from the scan were, as usual, in the form of a point cloud. Each measured point within such a cloud represents a three-dimensional coordinate and a colour value.

To be able to incorporate the scan within the digital reconstruction – the real time 3D model – a polygon mesh must be derived from the point cloud. Polygon meshes depict surfaces comprising contiguous triangles (polygons). The 3D scan captured only a relatively small part of the archaeological situation at the 'harbour gate' site (fig. 10). More than 50 individual CAD drawings recorded the remaining contexts, including the drain outlet, the sections of wall above the former street level, the wooden shuttering north of the outlet, and the gate foundations. The CAD drawings also had to be transformed into a polygon model in order to combine them with the (re-topologised) scan.

Afterwards the completed 3D model of the northern harbour gate (fig. 11) was promptly integrated within the application, Colonia3D, which may be viewed in Cologne's *Römisch-Germanisches Museum*. The flexible structure of the application allows the easy integration of new data.

Notes

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[1] Trier 2016.
[2] Mertens 2010; Holthausen 1994.
[3] Häuber et. al. 2004.
[4] Trier 2008; Schäfer – Trier 2013.
[5] Berthold et al. 2017.
[6] Eck 2004; Spiegel 2006.
[7] Neu – Riedel 2002; Eck 2007; Berthold u. a. 2017, Taf. I a.
[8] Schmidt 2005; Schmidt – Frank 2012.

Image Credits

Fig. 1: Copyright RGM; digital editing P. Fleischer. – Fig. 2. 4–5: RGM /G. Wagner. – Fig. 3: RGM /G. Wagner; elevation data DGM1, NRW Bezirksregierung Köln, Abt. Geobasis NRW, Land NRW, 2018. – Fig. 6: RGM; cadastral map 2018, NRW Bezirksregierung Köln, Abt. Geobasis NRW, Land NRW, 2018. – Fig. 7: RGM. – Fig. 8: Berthold et. al. 2017 Taf. I a. – Fig. 9: Photos RGM (A. Schäfer). – Fig. 10: Colonia3D. – Fig. 11: RGM/ Colonia3D.

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