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A ROMAN HARBOUR GATE IN COLOGNE

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Abstract: In connection with the construction of the north-south city railway of Cologne, an archaeological investigation of the Roman "harbour gate" was undertaken during 2007-2008, not far from the choir of the city's cathedral. It was one of the five gatehouses that faced the Rhine along the city-wall of Colonia Claudia Ara Agrippinensium (CCAA). The structural remains at Kurt-Hackenberg-Platz were documented with detailed hand-drawings. On the basis of the hand measurements, georeferenced plans and elevation-drawings were prepared that enabled a three-dimensional reconstruction of the "harbour gate". During a further operation, the gatehouse was recorded as part of the 3D-visualisation of the Roman town. The digital reconstruction, called "Colonia3D", does not have the format of a film with a predetermined sequence of images; instead, it comprises a so-called "realtime application" that allows one to access and experience any sequence of pictures and perspectives of the Roman town. The realtime application functions like a Geographic Information System (GIS), in as much as archaeological contexts and finds are linked to the reconstruction, so that the digital model of the town can be evaluated critically.

Keywords: Roman Cologne; fortification; harbour; laser scanning; 3D reconstruction.

Rezumat: În perioada 2007-2008, cu ocazia construirii liniei ferate pe linia NS a orașului Köln, s-a cercetat intrarea în portul roman, zonă situată nu departe de corul catedralei orașului. A fost cercetat unul dintre cele cinci turnuri care supravegheau Rinul de-a lungul zidului orașului Colonia Claudia Ara Agrippinensium (CCAA). Au fost realizate desene detaliate ale structurilor păstrate în Piața Kurt-Hackenberg. Pe baza măsurătorilor s-au întocmit planuri georeferențiate și relevee, ceea ce a permis reconstruirea tridimensională a intrării în port. Ulterior turnul a fost inclus în proiectul de vizualizare 3D a orașului roman. Reconstituirea digitală, denumită "Colonia3D", nu are formatul unui film prezentând o succesiune predeterminată de imagini, ci conține o așa-numită "aplicație în timp real" care permite accesarea și experimentarea succesiunilor de imagini și perspective ale orașului roman. Aplicația în timp real funcționează ca un Sistem Informațional Geografic (GIS) referitor la multiple contexte arheologice și vestigii conectate la reconstituire. Astfel, se poate face evaluarea critică a modelului digital al orașului.

Cuvinte cheie: Köln-ul roman; fortificație; port; scanare laser; reconstituire 3D.

For the last ten years, the archaeological research stemming from the construction of the NS city railway in Cologne has dominated the work of the archaeology department of the Römisch-Germanisches Museum[1]. The four kilometre-long route runs from the Central Station into the southern part of the city. At a depth of 20 to 27 m, the tunnel lies far beneath the archaeologically relevant layers, meaning that the ancient structural remains are exposed only in the areas of stations, access shafts and service shafts. Nevertheless the archaeological investigation was undertaken in a zone of 30.000 m^2 as a whole - roughly corresponding to the area of 3-4 football pitches.

[1] Trier, Naumann-Steckner 2012.

The archaeological layers extend to a depth of 13 m, because parts of the modern construction pits were built in the area of the former Roman harbour. For that reason the archaeological volume amounts to circa 150.000 m^3 as a whole. The construction of the NS Urban railway represents the most extensive intervention in the city's underground history so far.

1. Revealing a Roman harbour gate in Cologne

The archaeological investigations can be shown exemplarily on the basis of the excavations on the Kurt-Hackenberg-Platz not far from the choir of the city's cathedral (Pl. I). At this place a Roman harbour gate was excavated during 2007–2008[2]. It was the northern one of five gates that faced the Rhine along the city wall of *Colonia Claudia Ara Agrippinensium* (CCAA) (Pl. II). An almost 3000 m^2 large and 13 m deep excavation was being produced on the Kurt-Hackenberg-Platz. The square – a result of the reconstruction process following World War Two – is located, as the topographical-archaeological investigations showed, on top of an old secondary arm of the Rhine, which existed in the 1st century AD (Pl. III)[3]. 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.

The secondary Rhine arm was about 60–70 m wide and more than 1000 m long. Towards the west the area rises from the Rhine bank to a higher area protected against high water. On this plateau the Roman town was founded shortly before the birth of Christ[4]. The Rhine-side Roman city wall runs along the foot of this protected area. In the choice of site for the first settlement at Cologne, the topographical situation – comprising a middle fluvial terrace of 1 km^2 on the Rhine's left bank, the old Rhine channel and the river island – would have played a decisive role.

Nearly one meter 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[5]. A section of the Roman town wall, ca. 25 m long, traversed the modern construction pit in a north-south direction. The view from the south records the town wall and the outlet of the main sewer located in the foundation of the gatehouse (Pl. IV/1). The passageway through the "harbour gate" 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*. The projecting sewer outlet comprises ashlar blocks of tufa resting on a foundation of *opus caementicium*, and its face is contained within limestone blocks. An impression of the high quality of Roman building techniques is conveyed by the red sandstone blocks to be found in the wall bond above the level of the slabs covering the sewer. The blocks border the sewer and are a structural element of the fortified tower's gate jamb.

How may we imagine the harbour gate at Kurt-Hackenberg-Platz?

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[2] Trier 2008; Schäfer 2012; Schäfer-Trier 2013.

[3] Berthold et alii 2011; Kempken, Nehren 2012.

[4] Eck 2004; Spiegel 2006.

[5] Neu, Riedel 2002; Eck 2007; Berthold et alii 2011; Kempken, Nehren 2012.

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 (Pl. IV/2). A manhole cover associated with a maintenance shaft corresponds to the level of the pavement within the gatehouse. 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 (Pl. V). Beneath the passageway of the gate ran a drain with an outlet in front of the town wall.

2. A sensational state of wood preservation

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 the level of the groundwater, the foundation's wooden shuttering remains almost fully preserved (Pl. VI/1–2). An analysis by Cologne University's Dendrochronology Laboratory established that this shuttering was of fir timber[6]. 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; they had a length, on average, of 8 m, a width of ca. 30 cm, and thickness between 3.5 and 4 cm. The width and thickness hardly varied, reflecting a very high quality of craftsmanship, but despite this, the wood was left in the ground.

A contiguous row of oak stakes in the area of the river bank were found in the construction pit at Kurt-Hackenberg-Platz (Pl. VII/1). This plank wall was situated 4 m before the town wall and ran parallel to it (Pl. VII/2). 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[7].

Analysis by the Cologne University's Dendrochronology Laboratory of 150 oak stakes from the plank wall confirms that all the trees from which they crafted were felled in AD 89. Around AD 90–91, Cologne's bank of the Rhine was a building site. Responsibility for the erection of the town wall was not only the *colonia* itself, but also the Roman army of the Rhinelands under the reign of Emperor Domitian (AD 81–96).

Soon after the construction of the town wall the harbour basin was already fully silted up (Pl. VIII/1). By the middle of the 2nd century AD the river island, formerly close to the bank, was now joined to it[8]. It is very likely that the main harbour of Roman Cologne was located on the side open to the Rhine, making the area of the river island the most important transhipment point. The Roman settlement was extended to the eastern bank of the "island" and shored up by walls in the north and south of the island in the 4th century AD. How many constructions were made in medieval times in the former Rhine channel area would be another story of the archaeology of the NS underground line of Cologne.

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6 Schmidt 2005; Schmidt, Frank 2012.
7 Kempken, Nehren 2012.
8 Trier 2012.

3. The digital reconstruction of the northern Harbour gate

For the visualisation of the archaeological contexts of the harbour gate and to make possible a 3D-reconstruction for the project Colonia3D, basically two sources were analysed and integrated: firstly, 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. The following sections summarise the process by which the various data were combined.

Dipl.-Ing. Jost-Michael Broser from the Institut für Baugeschichte und Denkmalpflege of the Fachhochschule Köln 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 (Pl. VIII/2). 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 (Pl. IX). Polygon meshes depict surfaces comprising contiguous triangles (polygons). The greater the density of polygons, the finer the details of the surface. However, the higher level of detail created by the higher number of polygons creates problems: the quantity of data the computer has to process increases with the number of polygons which, in turn, leads to a slowing of the frame rate in real time; secondly, it is more complicated and time-consuming for the computer operator who works on the mesh. The basic aim is to find a balance between the density of data (thus the level of detail) and manageability.

In the real case of the "harbour gate", a 3D scan was available that had captured the area of the wooden stakes south of the drain outlet so accurately that the grain of the wood was visible – an unnecessarily high resolution for the 3D visualisation of Colonia3D. Our task was to derive a 3D model from the scan that depicts the volume and position of the individual structural elements, such as planks, posts and stones.

The entire process from 3D scan to solid model can be summarised as:

1. Importing the point cloud.
2. Thinning the point cloud.
3. Cleaning the point cloud.
4. Conversion into a polygon mesh.
5. Regularization (the closure of interiors).
6. Intelligent reduction of surfaces.
7. Exporting to a conventional 3D mesh format (*.OBJ).
8. Retopologization[9].

This process is not fully automatic because the reduction requires a conscious interpretation of the data, but it is strongly simplified through the use of software. In this case the software Geomagic was applied from the import of the point cloud to the export as a *.OBJ file, since it was designed specifically for this field of application. Basically any polygon modelling software can be used for the retopologization, but for

[9] Retopologization means to manually superimpose a completely new mesh on the surface of the exported 3D mesh. The advantage is that the new mesh has a better polygon structure (also called topology).

the "harbour gate" we employed Blender[10]. Subsequently, the data were exported into 3D Studio Max, where all the 3D models from Colonia3D can be worked on.

The 3D scan captured only a relatively small part of the archaeological situation at the "harbour gate" site. 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 (Pl. X). The CAD drawings also had to be transformed into a polygon model in order to combine them with the retopologized scan, for which two basic steps were required:

1. All the individual drawings were combined and exported from a CAD format into a 3D Max-capable format and thus brought together within a 3D file.

2. The drawings were extruded[11] in 3D Studio Max.

The individual CAD drawings were already spatially organised (georeferenced) in the CAD format, so that a good overall impression of the site was already available with the first step. A hurdle was represented by the georeferenced coordinates that comprised eight digits: programmes like 3D Studio Max are unable to handle such large numbers. Consequently, before exporting, the coordinates in CAD were offset to a predetermined value towards the zero point. Because the degree of the offset is known, the plans remain, in principle, georeferenced. In step two, the main task was to determine the depth of the extrusions. Since the majority of the objects were made up of views from multiple angles, this permitted their volumes to be easily deduced.

Before the above described modelling of the site took place, a reconstruction of the "harbour gate" in the model Colonia3D already existed. The older version, based on earlier records, could now be amended by the new and exact data. The most important changes were related to the proportions of the structures, the size of the passageway through the gate, and the form of the gate jamb in red sandstone. It was possible to recreate the gate jamb with stone-by-stone accuracy.

The completed 3D model of the northern harbour gate (Pl. V) was promptly integrated within the application Colonia3D, which may be viewed in Cologne's Römisch-Germanisches Museum (Pl. VIII/1). The flexible structure of the application allows the easy integration of new data.

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[10] Blender is an open-source 3D software (www.blender.org).

[11] To extrude means to give three-dimensional form to a surface; for example, a cylinder is an extruded circle.

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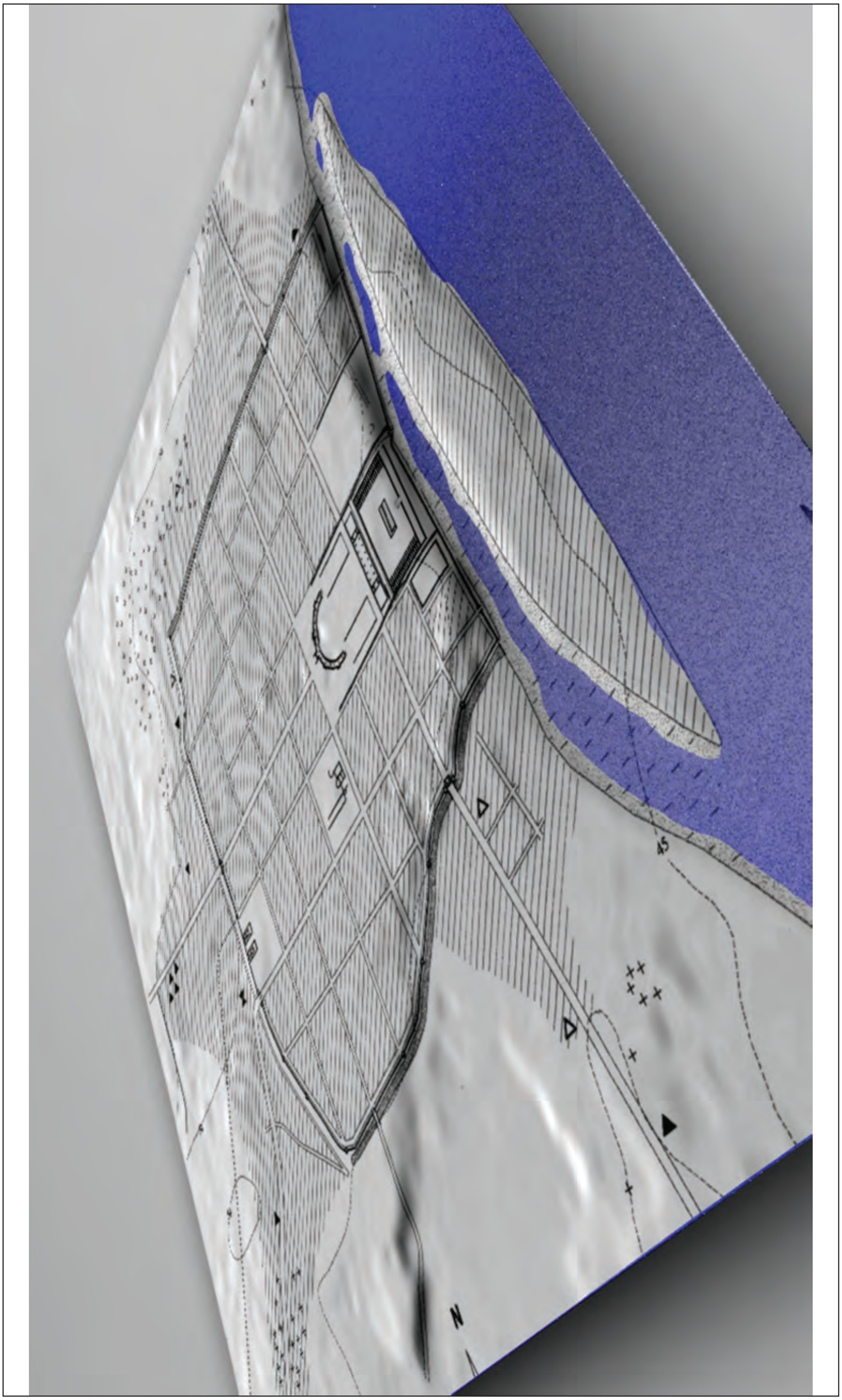
Pl. I. Cologne, Kurt-Hackenberg-Platz (RGM, photo A. Schäfer).

Pl. II. Roman Cologne in the middle of the 2nd century (RGM digitized plan P. Otten).

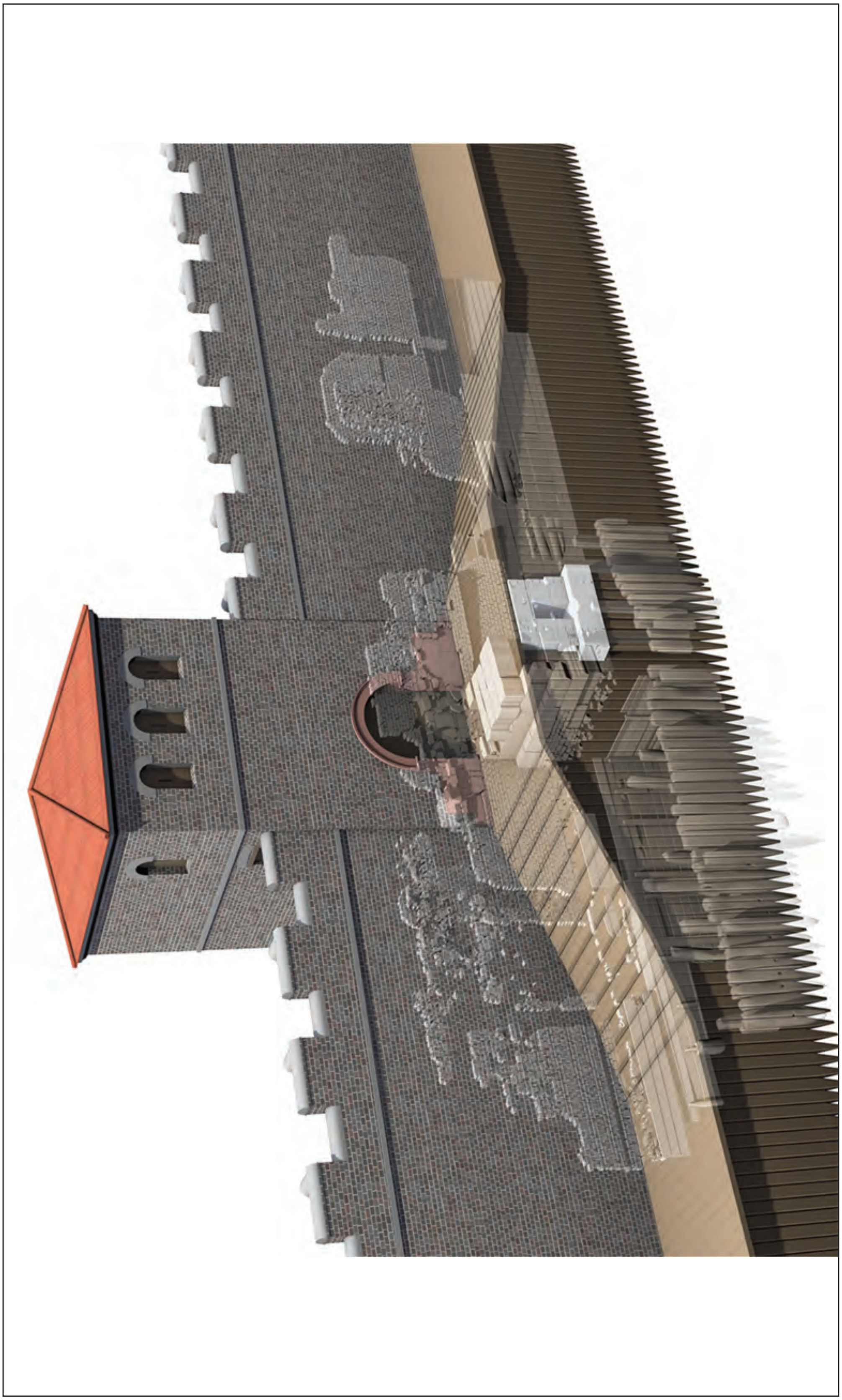


Pl. III. Digital terrain modell of Roman Cologne in the end of the 1st century AD (RGM, Colonia3D).

1

2

Pl. IV. Cologne, Kurt-Hackenberg-Platz. **1.** Roman town-wall with front of the harbour gate and sewer; **2.** Substructure of the northern harbour gate on the inner-face of the Roman town wall (RGM, photos A. Schäfer).



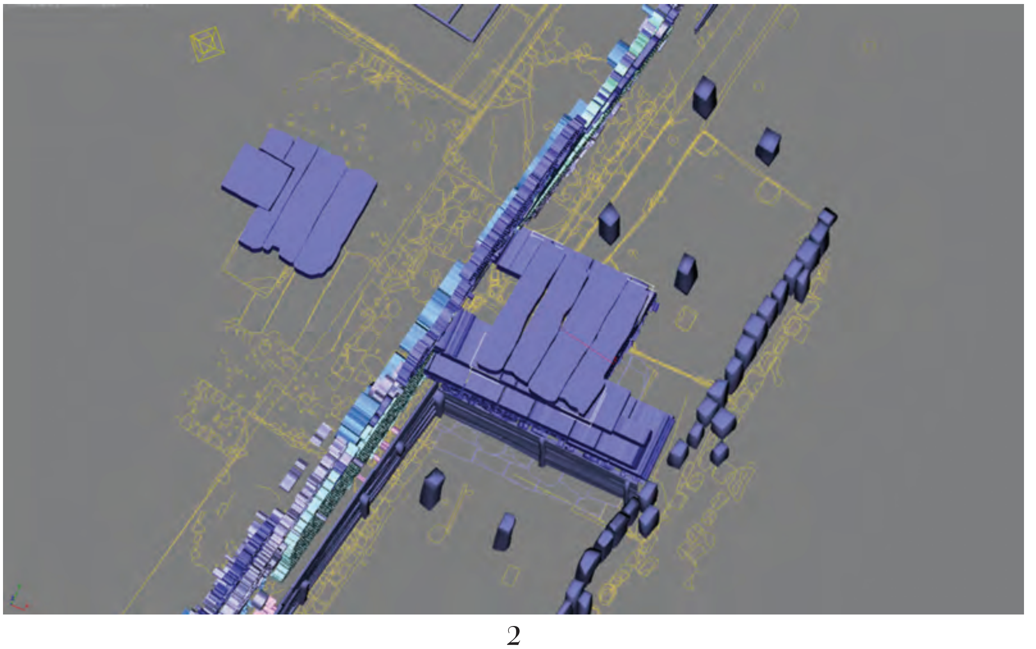
Pl. V. Digital reconstruction of the northern harbour gate of Roman Cologne (RGM, Colonia 3D).

1

2

Pl. VI. Cologne, Kurt-Hackenberg-Platz. Wooden shuttering from the foundation of the Roman town wall (RGM, photos A. Schäfer).

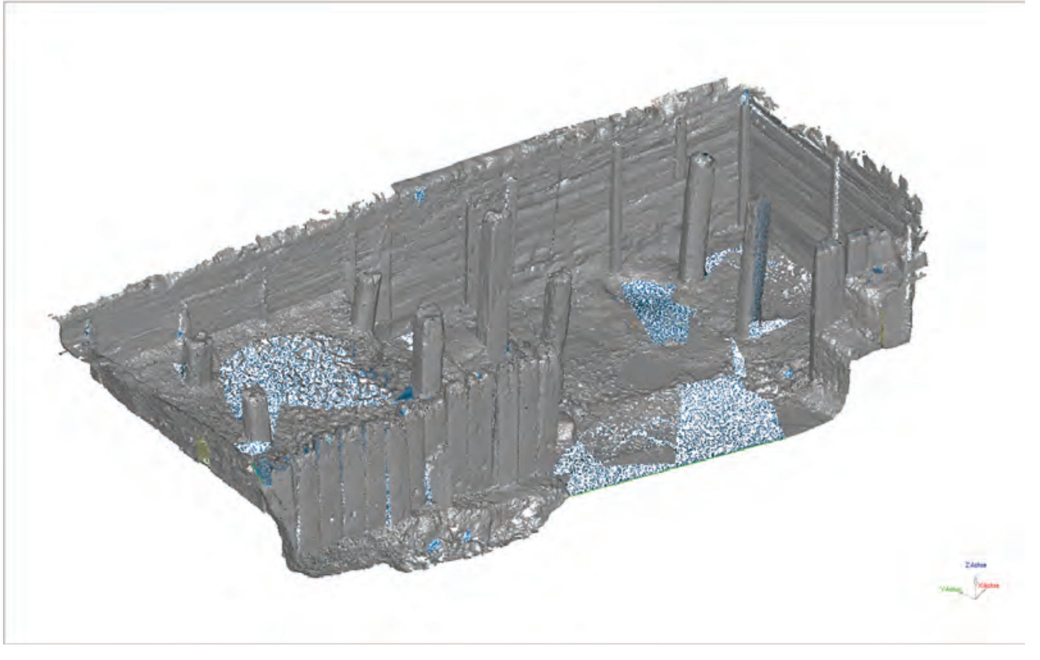
1



2

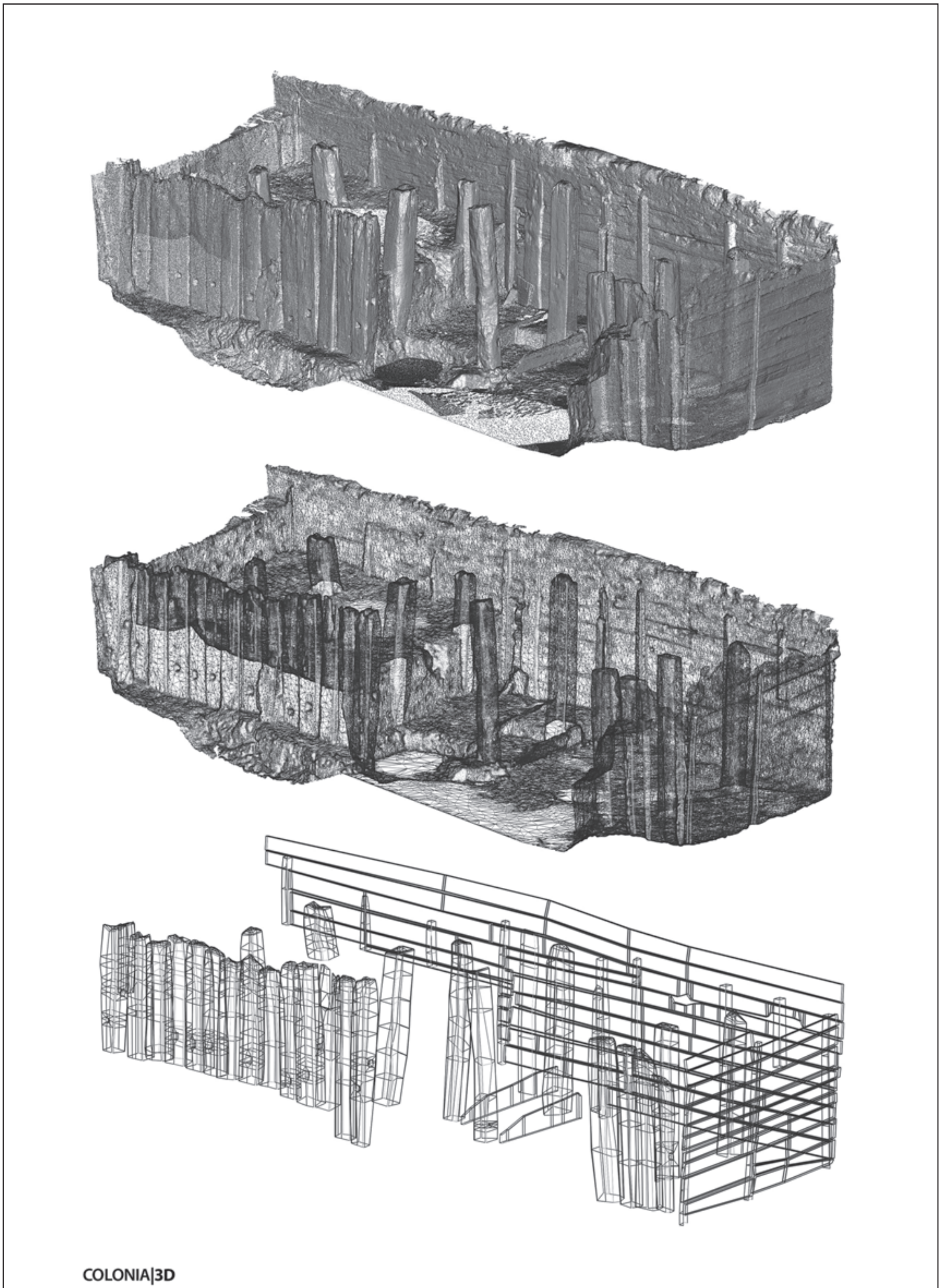
Pl. VII. 1. Cologne, Kurt-Hackenberg-Platz. Row of oak stakes functioned as shoring for the Roman town walls construction trench (RGM, photo A. Schäfer); **2.** 3D-Plan of the northern Roman harbour gate in Cologne (RGM, Colonia 3D).

1

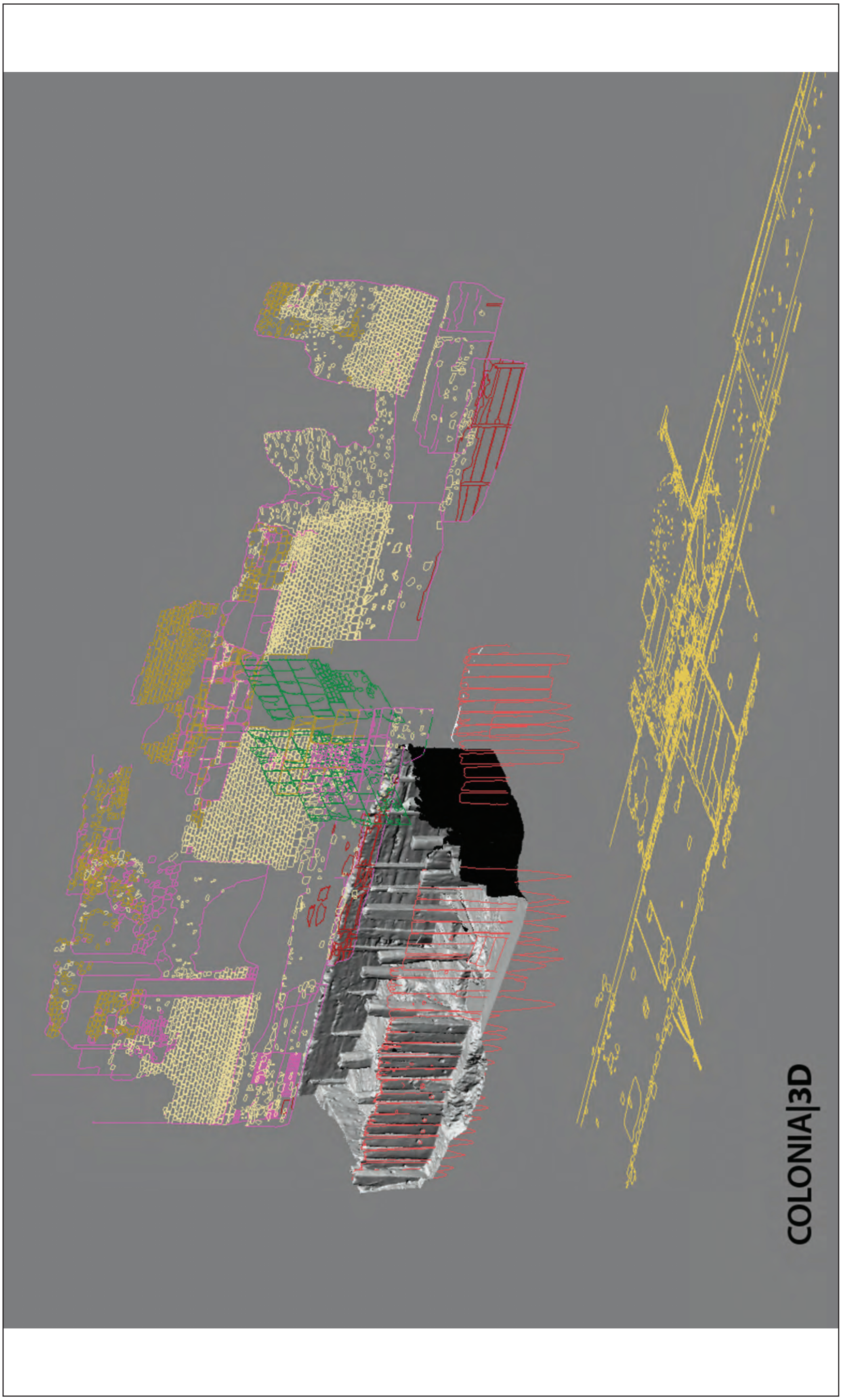


2

Pl. VIII. Ideal Reconstruction of Roman Cologne. **1.** Central town without suburbia and harbour district (Colonia 3D); **2.** Point cloud of oak stakes in the underground beneath Kurt-Hackenberg-Platz, Cologne (RGM, Colonia 3D, J. Broser, C. D. Herrmann).



Pl. IX. Polygon meshes from the oak stakes in the underground beneath Kurt-Hackenberg-Platz, Cologne (RGM, Colonia 3D, C. D. Herrmann).



Pl. X. Northern harbour gate of Roman Cologne. CAD drawings and polygon model (Colonia3D).