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**PRELIMINARY REPORT ON THE RESEARCH  
OF THE JU INSTITUTE OF ARCHEOLOGY AND THE AGH UST FACULTY  
OF GEO-DATA SCIENCE, GEODESY, AND ENVIRONMENTAL ENGINEERING  
AT THE DAJANIYA AND TUWANEH SITES IN JORDAN – SEASONS 2018-2019**

**ABSTRACT** The article presents the preliminary results of research conducted by the expedition of the Institute of Archeology of the Jagiellonian University and the Faculty of Geo-Data Science, Geodesy, and Environmental Engineering of the AGH University of Science and Technology in the south-western Jordan at Dajaniya (Ma'an Husseiniyeh) and Tuwaneh (Tafila Hessa) sites in 2018-2019. The main aim of the research was to create plans for both sites and document the state of preservation of architectural remains using photogrammetry (both pole- and kite-based) as well as terrestrial laser scanning. Additionally, robber pits were recorded at both sites. A surface prospection was also conducted, collecting ceramic and metal artifacts, which, in the case of Tuwaneh, covered the central part of the site (the area around the so-called caravanserai) and part of the robber trenches and their waste piles. In 2019, three trial trenches were also excavated in the vicinity of the ancient baths at Tuwaneh.

**Key words:** Tuwaneh, Dajaniya, archaeological survey; archaeology of South Jordan; laser scanning; Nabatean archaeology, photogrammetry, Roman archaeology

**ABSTRAKT** W artykule publikowane są wyniki badań ekspedycji Instytutu Archeologii UJ i Wydziału Geodezji Górniczej i Inżynierii Środowiska AGH w południowo-zachodniej Jordanii na stanowiskach Dajaniya (Ma'an Husseiniyeh) i Tuwaneh (Tafila Hessa) z lat 2018-2019. Badania miały na celu wykonanie szczegółowych planów stanowisk oraz zadokumentowanie stanu zachowania pozostałości architektonicznych z użyciem fotogrametrii (z wysięgnika oraz latawca) oraz skaningu laserowego. Ponadto zarejestrowano również wkopy rabunkowe na obu stanowiskach. Przeprowadzono również prospekcję powierzchniową zbierając materiał ceramiczny oraz pojedyncze zabytki metalowe, która w przypadku Tuwaneh objęła centralną część stanowiska (w okolicach tzw. karawanseraju) oraz część wkopów rabunkowych i ich hałd. W 2019 roku wykonano również badania wykopaliskowe w obrębie trzech wykopów sondażowych w Tuwaneh na terenie starożytnych term.

**Introduction**

In 2018 the expedition of the Institute of Archaeology of the Jagiellonian University (JU) in Kraków in cooperation with the Faculty of Geo-Data Science, Geodesy, and Environmental Engineering of the AGH University of Science and Technology (AGH UST) in Kraków started research at two archaeological sites located in the south-western part of Jordan: Dajaniya (Ma'an-Husseiniyeh)<sup>1</sup> and

Tuwaneh (Tafila-Hesa)<sup>2</sup> (Fig. 1). The area of South Jordan has been subject of intensive archaeological research by the Institute of Archaeology of the Jagiellonian University for several years now. The research conducted so far, however, has focused on sites from the Bronze Age – the HLC Project<sup>3</sup> led by P. Kołodziejczyk (Kołodziejczyk 2015, 2019; Kołodziejczyk et al. 2018a, 2018b, 2019),

<sup>1</sup> Ar. الدعجانية; also Da'ajaniya, MEGA Number 5983; GPS coordinates: 30.5527, 35.7618.

<sup>2</sup> Ar. تـوانه; also at-Tuwāna, et/at-Twāne, eth-Thuwāneh, MEGA Number 9824; GPS coordinates: 30.7494, 35.7242.

<sup>3</sup> <http://www.hlcproject.org/>

and from Medieval times at Qasr ed-Deir led by P. Nocuń (Nocuń, Ochał-Czarnowicz 2019) (Fig. 1). The aim of our expedition – called ArTu-DTu, standing for the Archaeological Study of Dajaniya and Tuwaneh, South Jordan – is focused on the Hellenistic and Roman periods in this region.

The actual research was preceded by a visit to several dozen Roman and Byzantine sites located in this part of Jordan by J. Bodzek, K. Kopij and Ł. Miszk in 2017 with invaluable cooperation of P. Kołodziejczyk (cf. Bodzek, Kopij, Miszk 2019).<sup>4</sup> Finally, we decided to conduct research on the above mentioned two sites. The choice was determined primarily by the existing state of the research, potential scientific value, and the threat of destruction by looters (cf. Bodzek, Kopij and Miszk 2019).

## Methods

Photogrammetric measurements performed using unmanned aerial vehicles (UAVs) are an effective and widely accepted method used in the documentation of archaeological sites (Nex and Remondino 2014). Unfortunately, the restrictive laws on the use of UAVs in Jordan made it impossible and forced us to develop an alternative solution that allowed for the documentation of the sites under investigation with an equally high resolution and accuracy.

At both sites, surveying was started by marking the points of the control network. Their coordinates were determined in the coordinate system ED50/Jordan TM (EPSG:3066) based on the results of satellite measurements (i.e. precise point positioning [PPP] global navigation satellite systems [GNSS] method, real time kinematic [RTK] GNSS method and real time extended [RTX] GNSS method) and total station measurements. The spatial accuracy of coordinates of control points was 3cm. The control network was used to tie all the measurements carried out, the aim of which was both to document the area of both archaeological sites and a detailed inventory of architectural remains.

One of the main tasks carried out in order to create plans of the sites was to create their orthomosaics and digital surface models (DSMs). For this purpose, in 2018, photogrammetric data were collected for both research areas, i.e. the entire



Fig. 1. Map of the region. Sites under investigation by archaeologists from the JU Institute of Archaeology. Petra and Amman were also marked (Made using GPSVisualizer.com by K. Kopij)

Dajaniya site and the central part of the Tuwaneh site with an area of about 2.5ha (the caravanserai with adjacent areas) (Figs. 2-3). The photos were taken on the surveying stations forming a regular grid of 5m x 5m. Eight oblique images with a resolution of 12MP were taken at each of these stations, oriented in eight different directions (Fig. 4). The data was collected with the GoPro HERO 6 Black action camera with a wide-angle lens mounted on a five-metre-long pole. A total of 4000 photos were taken at the Dajaniya and 4800 photos at Tuwaneh.

During the field work on both sites, we also established ground control points and check points (160 points in Dajaniya and 100 points in Tuwaneh). Their coordinates were determined by the RTK GNSS method with an accuracy of about 2cm in relation to the control network. Thanks to this it was possible to georeference and verify the accuracy of the generated photogrammetric products at the stage of developing the data in Agisoft Metashape software.

Field work in 2018 also included a detailed inventory of architectural remains, i.e. the walls of the fort in Dajaniya and the caravanserai in Tuwaneh. For this purpose, terrestrial laser scanning performed with the use of the Faro Focus M70 was introduced. Measurement data in the form of high-resolution point cloud were collected

<sup>4</sup> We would also like to thank Ahmed Marafi for his help during our visit.

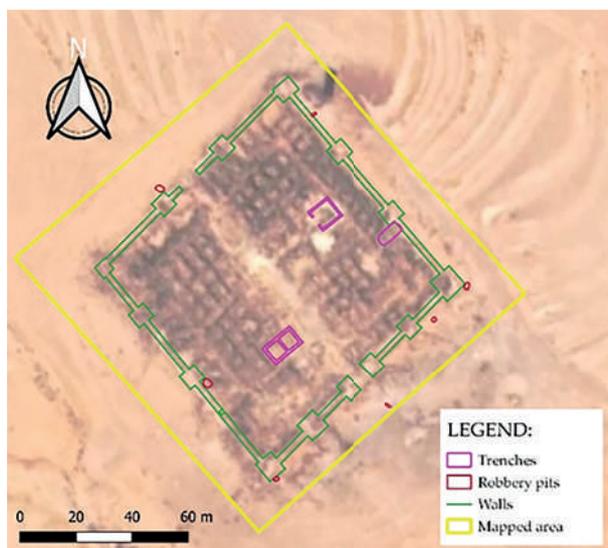


Fig. 2. Dajaniya: documented elements of the site  
(author: E. Puniach)

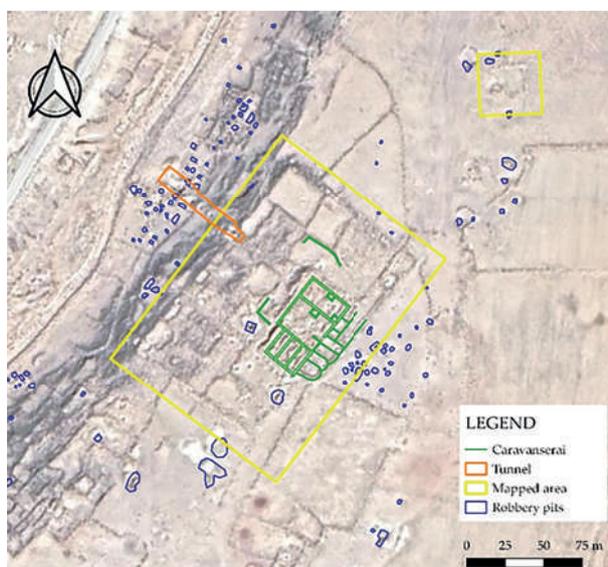


Fig. 3. Tuwaneh: documented elements of the site.  
Robbery pits marked blue  
(authors: P. Ćwiąkała, E. Puniach)

on each of the archaeological sites examined on several dozen scanner stations. Their registration and georeferencing were possible thanks to reference targets, whose coordinates were determined with an accuracy of 2cm in relation to control network. Similarly, in Dajaniya test trenches T.1, T.2 and T.3 made as part of the *Limes Arabicus Project* (cf. Parker 1976; 1987; Godwin 2006), were also documented using the terrestrial laser scanning.

In addition, in Tuwaneh we documented fragments of a storm drain and the remains of

a bathhouse using close-range photogrammetry. For the measurement of the storm channel, a GoPro HERO 6 Black camera mounted on a boom was used to record data on the underground part of the structure. The D60 Nikon camera with a 20mm lens took pictures of the inlets to the canal, which were visible on the surface of the site. The second device was also used to record parts of the bathhouse. An independent network of ground control points was established for both objects.

Parts of the bathhouse were also measured using a Faro Freestyle 3D handheld scanner, whose principle of operation is based on taking photographs, processing them automatically and visualizing them in real time. The result of the measurement was a point cloud representing the object, which was then georeferenced (based on the coordinates of ground control points).

The measurements carried out in the 2018 season also included an inventory of the location of the robber pits, which was measured using RTX GNSS or RTK GNSS methods. In addition, all the robber pits had photographic documentation consisting of at least four photographs. For the larger robber pits a full set of photogrammetric data was collected (photographs taken with Canon EOS 700D camera with 35mm lens and the coordinates of ground control points), which allowed us to create their three-dimensional models later.

### Research at Dajaniya

Dajaniya is a site located on the territory of Ma'an Highland, in its northern part called El Jibal, on the plain of Ifjeij, about 4.6km from the present town Al-Husseiniyeh in the administrative district of Ma'an-Husseiniyeh. About 3.5km to the east runs the modern Desert Highway and 13km to the west another road – the King's Highway. The site is situated on the bank of the Wadi Dajaniya, where periodically a river flows. An all-year water reservoir is located in the vicinity.

Wadi Dajaniya serves as a traditional communication route connecting the former Roman road leading from the fort Lejjun to the fort Udruh (today the aforementioned Desert Highway) situated less than 3.7km to the east, with the ancient Via Trajana Nova (now the King's Highway) situated less than 13 km to the east (cf. Thomsen 1917: 57f; Findlater 1990). About 10km to the west is also located on the shore of the Wadi Dajaniya fort Khirbat Qannas and 18km to the north-east of the fort in Jurf ed-Darawish. The main, but not the only, structure visible on the site of Dajaniya are

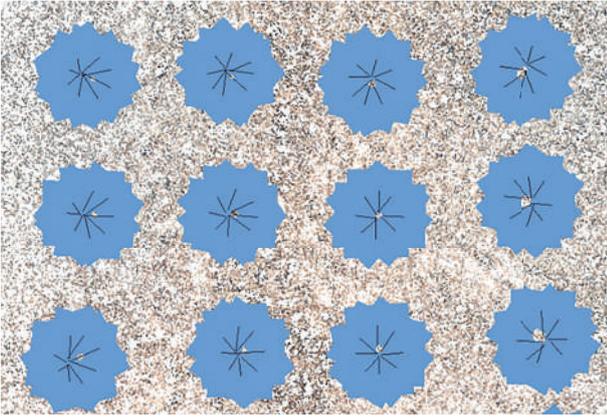


Fig. 4. Arrangement of surveying stations and orientation of images taken to create orthomosaics and DSMs of both sites (author: P. Cwiąkała)

the remains of the Roman fort.

The first mention of the fort at Dajaniya in western sources comes from the works of nineteenth-century travellers (cf. Doughty 1921, p. 29f). Whereas the first scientific description of the remains of the fort and, among others, the first planning and photographic recording of the fortification we owe to Brünnow and von Domaszewski, who visited this place during their expedition to Arabia in the 1890s (Brünnow, von Domaszewski 1905: 8-13). The location of the site in relation to the Roman road network was outlined several years later by Thomsen in his publication on the local road network and milestones (Thomsen 1917). Information about the fort and its location was also included in Glueck's publications based on his travels through eastern Palestine in 1934, 1935 and 1939 (Glueck 1933-1934; 1935; 1940). Another wave of interest in the site took place only in the late 1970s and 1980s. In the years 1984-1985 the site was studied by Freeman, who made corrections to the plan drawn up by Brünnow and von Domaszewski and the interpretation of buildings by the same authors, and also the concepts concerning, function, and dating of the fort they presented (1990). A description of the fort, together with a discussion of the possible heightening of the walls, was also given by Welsby (1998).

In turn, Kennedy and Riley's research resulted in the inclusion of this Roman camp in publications more widely discussing the remains of the *Limes Arabicus*, among others in the context of the aerial reconnaissance (Kennedy and Riley 1990: 168, 172-175, 192-193; Kennedy 2002). The site was also visited by Findlater under the *Dana Archaeological Survey* project, who presented a number of interesting insights in his publication

(2002). However, it seems that the most important research on the fort has been the research carried out by Parker and his team since the 1970s and is part of the larger *Limes Arabicus Project* (Parker 1976; 1986; 1987; Godwin 2006). Rucker's most recent research is focused on the area around the fort (Rucker 2007).

The fort in Dajaniya is located on a small hill on a plan of an irregular (rhomboid) quadrilateral oriented north-west to south-east, the dimensions of which, according to previous research, ought to be about 102.20×99.15×99.75×101.10m (Freeman 1990; Godwin 2006: 276). The area of the fort is 1.02ha. The walls and towers are erected from irregular blocks of black basalt joined by mortar and stone rubble. In the case of the northern wall, the presence of reused sandstone was also recorded, which was used to make up cavities. The building material was probably obtained partly on site, and partly (the limestone) perhaps from a quarry in the Wadi al-Muqta, 7.5km away (Godwin 2006, 276). The walls of the fortification were reinforced with 14 towers. The walkway of the rampart, which was still preserved at the end of the 19th century, was supposed to be about 4.7m high, which implies that the original height of the walls was about 5.0m. The average thickness of the walls was about 2.25m. The towers erected in the corners and within the walls of the fortifications were estimated to exceed the crown of the walls by about 2.5m and differ in dimensions (Gregory 1996: 378). In the case of the north-eastern, north-western and south-western walls, two towers each were built approximately between 22.5 and 25m apart. The southeast wall is reinforced by four towers located about 13m apart, of which the two central towers are flanked by *porta principalis sinistra*. Two gates lead into the camp – the eastern and western (*porta principalis dextra* = north-western and *porta principalis sinistra* = south-eastern). Both are in very poor condition unlike the side exit to the south. The internal structure of the fort is determined by the *via principalis* running south-east to north-west, linking the two main gates, and the *via sagularis*, running along the inner façade of the wall. The latter, however, is separated from the ramparts by one- or two-rooms structures interpreted by some scholars as stables (Brünnow and von Domaszewski 1905, 8-12; Freeman 1990, 182-183, 185; Kennedy, Riley 1990, 173). The *via principalis* divides the interior of the fort into two parts. On its south-western side there are three blocks of two-room barracks, separated by alleyways. The structures on the north-eastern side present a similar layout, with the exception of the

central block, which is occupied by a building interpreted as *principia*. In the northern part of *via principalis*, there is a deep, rectangular cistern (12.8 x 5.5m) originally covered with a roof.

In addition to the fort, other structures have been identified. First of all, there was a large reservoir on the south-eastern side, about 150m south of the south-eastern corner of the fort. According to Brünnow and von Domaszewski it had a square plan with a side length of 48 feet (Brünnow and von Domaszewski 1905, 12f, figs 566-567; Gregory 1996, 379). The aerial photograph published by Kennedy indicates a more rectangular plan of the reservoir, which can be explained by later alterations (Kennedy 2004: 170f, figs 16.7; Godwin 2006: 275). The current shape of the reservoir is the result of a recent modern reconstruction with the use of heavy equipment.

Brünnow and von Domaszewski also noted the presence of two other structures outside the fort near its south-eastern wall, which they interpreted as free-standing towers (Brünnow and von Domaszewski 1905, 12f, fig. 568). However, later research has shown that these structures should be interpreted differently. One of them, oval in plan (about 9.5m in diameter), not yet excavated, has been interpreted as the remains of a lime kiln (cf. Godwin 2006). The second structure, rectangular (10.41 x 7.48m) has been excavated and interpreted as the remnants of a farm building with three quern stones and several storage rooms (Godwin 2006, 277). The structure was contemporary to the fort.

At present the opinion prevails that the fort in Dajaniya was functioning in the late Roman and early Byzantine periods approximately between 284 and 502 (Gregory 1996: 380; Kennedy and Riley 1990: 175; Parker 1986: 93-94; Godwin 2006, 276-8). Its origins are probably related to the reorganisation of the eastern border of the Roman Empire during the Tetrarchy at the turn of the 3rd and 4th centuries AD. This is supported by the ceramic material coming from the site, mostly late Roman, and the few coin finds (from the period of the Tetrarchy and the times of the Constantinian dynasty) and the lack of architectural remains that can be dated to earlier Roman periods (Godwin 2006, 276, 285). Surveys carried out at the fort confirm its late use. The Roman beginnings of the fort were considered to be earlier by some researchers (Brünnow, von Domaszewski 1905: 311; Lander 1984: 144-45; Godwin 2006: 285). Indeed, the early Roman pottery has also been recorded at the site, which may indicate an earlier use of the site, but not necessarily such an early existence for the fort. Trial trenches excavated by the *Limes Arabicus*

*Project* also showed that relatively quickly (about the middle of the 4th century) some rooms ceased to be used (e.g. Rooms T2, T3), and about the beginning of the 6th century (after 502), some of the rooms still in use changed their purpose (Godwin 2006, 280, 283). The regular occupation of the fort ended probably at the time of the earthquake in AD 551, when the T.1 vault collapsed (before AD 502 the camp's *principia*). In some test trenches layers later than AD 551 were recorded, but they only testify to the periodical use of some rooms in the fort. These could be, for example, the remains of campfires. In addition, traces of several modern burials were found – a practice known from other sites in Jordan (Godwin 2006, 284-5).

#### Aims

Our research is the last phase of interest displayed in this site so far. The aim of our expedition was to make photogrammetric records and laser scans of the Roman fortifications, photogrammetric records of the survey trenches left by the *Limes Arabicus Project*, robber pits and to collect the surface material within the Roman fortifications, the *Limes Arabicus Project* test trenches, and the robber pits in the immediate vicinity of the fort, as well as to verify information about other structures located according to the information of previous researchers outside the fort's walls in close proximity to it.

The 2018 survey lasted four days. From the JU's Institute of Archaeology J. Bodzek (head of the expedition), K. Kopij, Ł. Miszk and M. Kajzer participated in the campaign. Surveyors from the Faculty of Geo-Data Science, Geodesy, and Environmental Engineering of the AGH UST in Kraków were invited to cooperate. Thanks to the merger of the expedition with the traditional, cyclical "BARI Expedition" of surveying students, seven students and PhD students<sup>5</sup> from AGH UST under the direction of P. Ćwiąkała and E. Puniach took part in the research.

#### Results

The research of the JU Institute of Archaeology at Dajaniya was carried out on 3-6 November 2018 on the basis of permission issued by the Jordanian

<sup>5</sup> Agnieszka Ochałek, Dawid Mrocheń, Aleksandra Słodowska, Katarzyna Sawicka, Kacper Widuch, Hubert Dec and Maciej Bernaś.

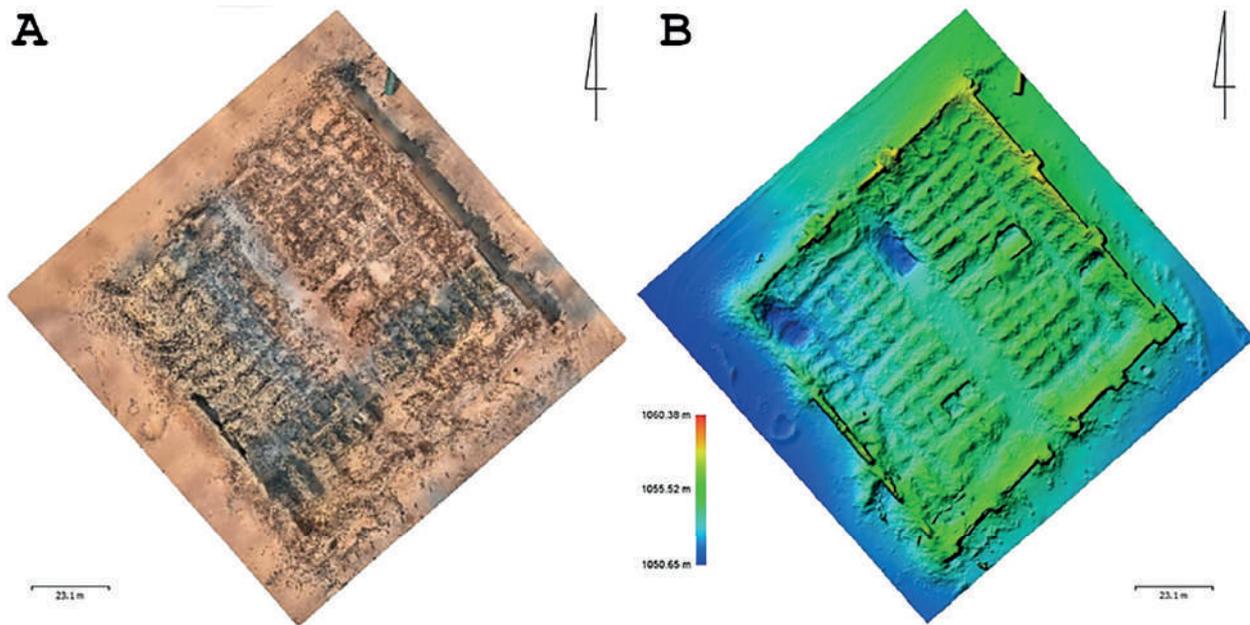


Fig. 5. Orthomosaic (a) and DSM (b) of Dajaniya  
(authors: P. Cwiakała, P. Cierpich, J. Ruchała) (Bodzek et al. 2019a, 60, figs. 6-7)

Department of Antiquities. The archaeological survey covered the area of the fort and its immediate vicinity. The area of the fort was divided into 10 sections, from which surface material was collected (cf. Bodzek et al. 2019a, 58, fig. 4). Areas 1-3 covered the test trenches excavated under the *Limes Arabicus Project*, area 4 covered the area adjacent to the east of T.2-3, areas 9-10 covered the *via principalis*, areas 5-8 other parts of the fort and areas 11-14 were located immediately beyond the fort's walls. The result of the survey is almost exclusively ceramic material, mainly in the form of fragments of vessels and CBM (tiles, a pipe). Moreover, a single fragment of a lamp, a spindle whorl, a bronze object, glass and one flint object were also recorded. Individual areas have brought a very varied number of ceramics. Most of them come from the area outside the fort's walls, with area 12, located on the north-western side of the fort, dominating (730 ceramic fragments, 14 tile fragments, and one lamp fragment). A noticeably smaller but also significant number of fragments were obtained from areas 11 (south-west: 385 pottery fragments and 20 tile fragments), 13 (south-east: 237 ceramic fragments, 68 tile fragments), and 14 (northeast: 119 ceramic fragments, 24 tile fragments) respectively.

All diagnostic fragments selected from the whole ceramic assemblage (n=172) were designated for further recording and investigation and will be published separately. At the moment, preliminary study suggests the chronological variety of the finds, from the Early Roman/Nabatean, through the

Late Roman, Byzantine until the Ottoman period as indicated e.g. by a fragment of clay pipe found to the E from the fort. The heterogeneous character of the pottery material correlates with previously published results (Godwin 2006, 278-284). Most of the vessels may be classified as coarse ware pottery which clearly dominates over the fine ware.

The purpose of our recording efforts was to create: a new site plan, a 3D model of the architectural remains and recording the robber trenches. One of the most important products of our work are the orthomosaic and the DSM of the entire site (Fig. 5). They are the result of the processing of the photogrammetric data obtained using the Structures from Motion method, which is implemented in Agisoft Metashape software. The resolution of the generated products is very high and is 4mm for the orthomosaics and 16mm for the DSM. Their accuracy is estimated at 3cm. Although the data acquisition and processing was time-consuming, the results are satisfactory.

As part of the recording carried out, the external facades of the fortress walls and the internal facades of the south-western and north-western walls were scanned. As a result, a high-resolution point cloud representing all architectural remains at the site was obtained, the accuracy of which was estimated at 2cm. Its fragment is shown in Fig. 6.

Six robber trenches at the site have also been recorded. For each of them, a three-dimensional metric model (Fig. 7) has been created and its location in the external reference system defined for the whole site has been determined.



Fig. 6. High-resolution points cloud representing part of a wall façade, Dajaniya (authors: A. Ochalek, E. Puniach)

## Conclusions

The material collected and described above confirms in general terms the chronology of the fort established by previous researchers. In this respect, however, further research is needed, and above all, a larger sample of material recovered from archaeological contexts, i.e. further surveys or generally excavations on and in the immediate vicinity of the fort.

The documentation work resulted in the DSM and the orthomosaic of the fort, which will enable us to produce a corrected and accurate plan of the fort in the future. The current (2018) state of preservation of the fortifications and the interior of the fort was also recorded, which is important due to the progressive damage caused by unintentional and intentional activity on the site. The latter is confirmed mainly by the robber trenches recorded photogrammetrically by the expedition. The laser scanning in combination with photogrammetric recording is the basis for the 3D reconstruction of the fort, and in the next step for an analysis of the founding function. The recorded state of preservation will also be the starting point for monitoring the progress of the degradation of the fort.

## Research at Tuwaneh

The second site where we worked, Tuwaneh, is of a completely different character. It was one of the largest towns of the region in ancient times covering ca. 55ha. Its remains are situated on two hills separated by a wadi along which the ancient trail ran, transformed into *via Traiana Nova* in Roman times. The site is located in a distance of approx. 5km south of today's road between Tafilah and Jurf ad-Darawish. The site is identified with Thana/Thoana of Ptolemy (V.17) and Thornia of the Tabula Peutingeriana (Bowersock 1983: 174-75). The best known monument on the site is the so-called caravanserai located at the top of the south-eastern hill.

The chronology of the site is not quite clear. The site has been inhabited since at least the Iron Age as demonstrated by the pottery sherds. Its occupation is confirmed for the Nabataean, Roman and Byzantine periods. It is not clear to what extent the site functioned during the Islamic period, although it is usually assumed that it lost its importance during the early Islamic period, and, greatly reduced in size, continuing to a limited extent into the Mameluke period (cf. Fiema 1993: 549; 1997: 315; MacDonald et. al. 2004: 351-352).

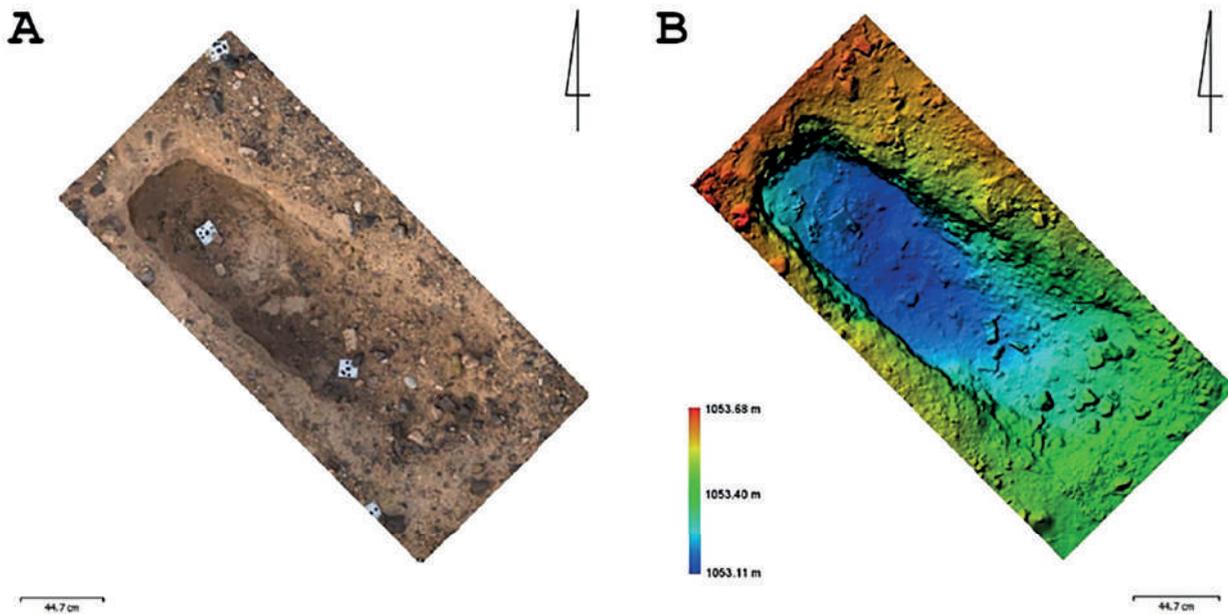


Fig. 7. Documentation of one of robbery pits in Dajaniya (author: K. Sawicka) (Bodzek et al. 2019a: 63, fig. 12)

## Aims

Although Tuwaneh is one of the largest Nabatean-Roman-Byzantine sites in southern Jordan (Fiema 1993, 1997; MacDonald et al. 2004: 351-352) and attracted the attention of travellers and scholars alike (Brünow and von Domaszewski 1904: 88-91; Musil 1907-1908, I: 31-32; Glueck 1935: 80-81; Negev 1977: 608; Hart 1987: 340; Wenning 1987: 87) it has not been properly mapped so far. The main aim of our project therefore, is the recording of the visible remains of the site using the most advanced modern tools. The recording of the architectural remains in their present state of preservation with high precision will allow us, not only to create the first plan of the site, but also a 3D model of the visible architectural remains of the town. Since the final goal is to create a complete plan of Tuwaneh, the task of recording the remains which started in 2018 (cf. Bodzek *et al.* 2019b) are foreseen to last for several further seasons.

## Results – Season 2018

The 2018 survey lasted eight days, from 8 to 15 November on the basis of permission issued by the Jordanian Department of Antiquities. It involved archaeologists from the JU Institute of Archaeology: J. Bodzek (head of the expedition), K. Kopij, Ł. Miszk and M. Kajzer as well as surveyors from the AGH UST Faculty of Geo-Data

Science, Geodesy, and Environmental Engineering: P. Cwiąkała, E. Puniach, A. Ochałek, D. Mrocheń, A. Słodowska, K. Sawicka, K. Widuch, H. Dec and M. Bernaś.

As a part of the field prospection conducted in the area of Tuwaneh, surface pottery material was collected. The survey may be divided into three parts:

- 1) the area of supposed caravanserai: 5 718 pottery sherds
- 2) 150 looting pits located in the surroundings of the caravanserai: 3 519 pottery sherds
- 3) the area of a bathhouse: most of the finds were the remains of the walls and the hypocaust construction. 153 hypocaust tiles and 482 fragments of box-flue tiles, 44 vessels fragments.

Altogether 9 281 ceramic sherds (excluding tiles) were recorded, of which 1 542 were diagnostic fragments selected for further research. In general, the assemblage included small fragments of Nabatean pottery, some *terra sigillata* sherds and other fine wares, as well as coarse ware pottery and a few lamp fragments. The material collected dates between the Nabatean and (at least) Byzantine periods. Further study will focus on typological and chronological identification of the finds, identification of the fabrics and their provenance. Subsequently, the similarities and differences between the pottery found in the three areas mentioned above will be identified and discussed. As in the case of Dajaniya, the documentation of Tuwaneh included an orthomosaic and a DSM

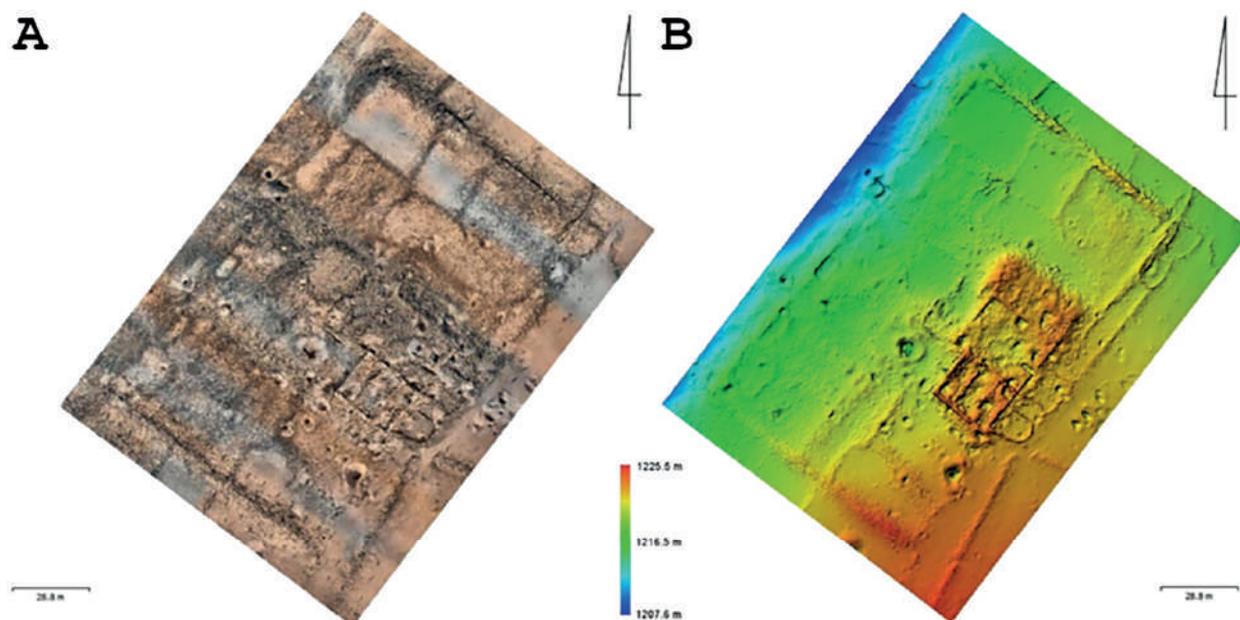


Fig. 8. Orthomosaic (a) and DSM (b) of part of Tuwaneh (author: P. Cwiąkała)

with resolutions of 4mm and 16mm respectively. Due to the size of this site, in 2018, only a fragment of the site with an area of about 2.5ha was recorded (Fig. 8).

Other results of this recording effort are also detailed models representing the remnants of the so-called caravanserai (Fig. 9), as well as parts of the storm drain and the bathhouse (Fig. 10).

An important element of the documentation work carried out at the site was also the inventory of robber pits, as this site is currently subject to intensive looting activity. Both orthomosaic and DSMs were used for this task. In addition, in 2018, we were able to make independent documentation (including photos and location data) of more than 150 robber trenches located in and near the area of the so-called caravanserai (cf. Fig. 3). Unfortunately, it was not possible to measure all the robber pits at the site due to its size and the scale of the illegal excavations.

#### Results – Season 2019

The 2019 survey lasted seven days (21-27 October) on the basis of permission issued by the Jordanian Department of Antiquities. It involved archaeologists and archaeology students from the JU Institute of Archaeology: J. Bodzek (head of the expedition), K. Kopij, Ł. Misk, S. Jellonek and A. Głowacka as well as surveyors and surveying PhD students from the AGH UST Faculty of

Geo-Data Science, Geodesy, and Environmental Engineering: P. Cwiąkała, E. Puniach, A. Ochałek and D. Mrocheń and M. Bernas a student at the National Film School in Łódź.

In the course of the week-long work, we managed to record photographically the part of the site with visible architectural remains using kite-based photogrammetry. These results will be used to create an orthomosaic and a DSM of the site. This in turn will be the basis for establishing the first archaeological plan of the site.

The second aim of the 2019 season was to excavate a trial trench in the area of the baths in order to establish their stratigraphy and chronology. We were forced to modify our original plans when it turned out that the first designated test trench (TT.I) was located in the backfill of a robber pit. As a result, we decided to backfill the trench in day 2 of the survey (Fig. 11-12). In order to avoid another failure, we designated two more trenches (TT.II and TT.III) (Fig. 11). In both cases, it turned out that we have found intact layers associated with the functioning and destruction of the baths. On the bottom of both trenches, the remains of hypocaust systems in the form of hypocaust pillars were found.

#### TT.II

TT.II was located in the SW part of R.2, it was adjacent to the wall W.1 dividing R.1 and R.2. This



Fig. 9. Part of a point cloud of the so-called caravanserai obtained by terrestrial laser scanner (authors: A. Ochałek, E. Puniach)



Fig. 10. Part of a point cloud of baths (author: E. Puniach)

place was chosen because it contained apparently intact layers adjacent to a robber pit. A total of eight stratigraphic units were excavated (cf. Fig. 13, Table 1). Layers k.51 and k.52 were the remains of piles of spoil extracted during the illegal excavations of R.1 and R.2 in the late 20th or early 21st centuries. It seems that the top of the layer k.53 was the surface layer prior to the activities of the robbers. The layer itself consisted of soil mixed with boulders and a large number of stones. The layer was created by fluvial accumulation and is interpreted as a layer associated with the bath's

destruction mixed with an accumulated non-anthropogenic layer associated with processes of slope erosion. At the bottom of the layer we found the remains of a wall (W.7) running perpendicularly to W.1. To the west of the W.7 wall, the context was designated k.55 as a new room (R.3) was distinguished. The small dimensions of the test trench, as well as the presence of large stones made the exploration difficult which resulted in k.55 being the only context explored in this part of the TT.II. Excavation was finished at a depth of 145cm from the surface.

Table 1. Stratigraphic units recorded in TT.II

k.51	DESCRIPTION	Grey-brown soil with stones and stone rubble
	INTERPRETATION	Surface layer. The waste-pile created by the robbery exploration of rooms R.1 and R.2
	DATING	Late 20 <sup>th</sup> -early 21 <sup>st</sup> century
k.52	DESCRIPTION	Brown soil with stones and stone rubble
	INTERPRETATION	Bottom part of the waste-pile created by the robbery exploration of rooms R.1 and R.2
	DATING	Late 20 <sup>th</sup> -early 21 <sup>st</sup> century
k.53	DESCRIPTION	Grey-brown soil with boulders and a large number of stones
	INTERPRETATION	Fluvial accumulation. Surface layer before the creation of the waste-pile. A layer of baths destruction mixed with non-anthropogenic layer associated with processes of slope erosion
	DATING	Late antiquity-20 <sup>th</sup> /21 <sup>st</sup> century
k.54	DESCRIPTION	Brown soil with large stones and stone rubble to the E of wall W.2
	INTERPRETATION	Destruction debris mixed with accumulated soil
	DATING	Late antiquity
k.55	DESCRIPTION	Brown soil with large stones and stone rubble to the W of wall W.2
	INTERPRETATION	Destruction debris mixed with accumulated soil
	DATING	Late antiquity
k.56	DESCRIPTION	Brown soil with large stones and stone rubble to the E of wall W.2
	INTERPRETATION	Destruction debris mixed with accumulated soil
	DATING	Late antiquity
k.57	DESCRIPTION	Loose, light brown sand with fragments of plaster, box-flute tiles, pottery to the E of W.2
	INTERPRETATION	Destruction debris
	DATING	Late antiquity
k.58	DESCRIPTION	Loose, light brown sand with large quantities of building ceramics, mortar and plaster to the E of W.2
	INTERPRETATION	Destruction debris mixed with thin soil layer accumulated during the use of baths
	DATING	Late antiquity
k.59	DESCRIPTION	Remains of <i>pilae</i> stacks consisting of round <i>pilae</i> tiles with a diameter of ca. 180 mm and ca. 45 mm thick
	INTERPRETATION	Remains of <i>suspensura</i> supporting a floor of the room heated by a hypocaustic system
	DATING	Uncertain (late Roman?)

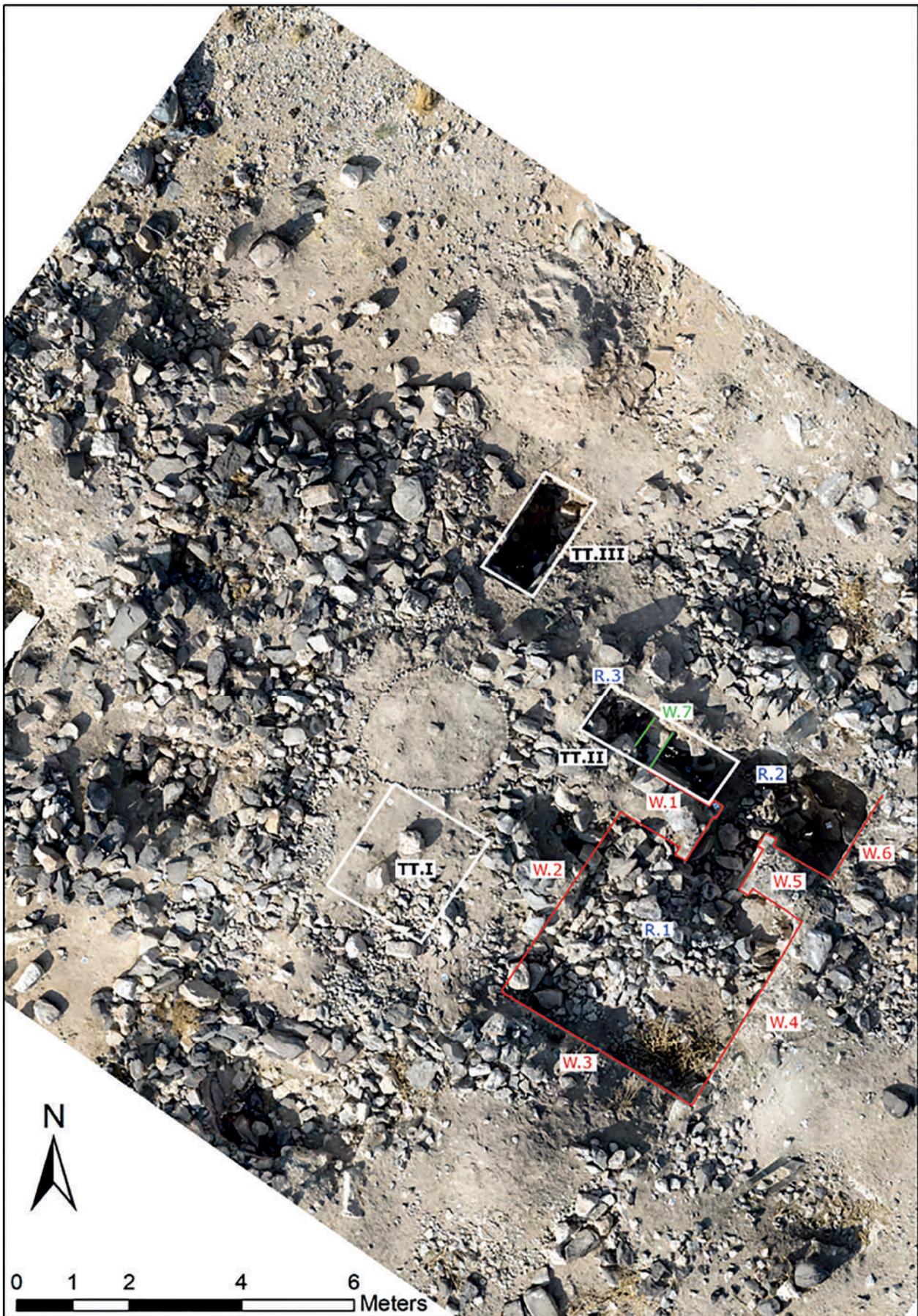


Fig. 11. Orthomosaic of the area of baths. Trial trenches of 2019 marked white, visible walls marked red, wall W.7 discovered during excavation marked green (authors: P. Cwiąkała, K. Kopij, Ł. Misk)



Fig. 12. TT.I (Photo: M. Bernaś)

On the eastern side of the W.7 wall (in. R.2), due to the fact that it was adjacent to the robbery trench, excavation was easier. After the removal of two layers of destruction debris of a similar nature (k.54 and k.56) we reached lower layers of destruction with different characteristics (k.57 and k.58). The number of stones has definitely decreased and the soil has become looser. We recorded large quantities of fragments of plaster, box-flute tiles and pottery within these units. The bottom part of k.58 could have consisted of soil layer accumulated during the use of baths. If this was the case, it must have been so thin that it could not be observed in the field as a separate layer. During the exploration of k.58 we found remains of *pilae* stacks consisting of round tiles with a diameter of ca. 180mm and ca. 45 mm thick being the remains of *suspensura* supporting a floor of the room heated by a hypocaust system (k.59). Excavation was ended at a depth of 215 cm from the surface reaching the floor under the *pilae* stacks (Fig. 14)

### TT.III

TT.III was located N of TT.II. This place was chosen because it seemed undisturbed by robbers. A total of nine stratigraphic units were excavated (Table 2). K.101 was a surface layer partially created as a result of the illegal excavation of nearby robber pits. Beneath this lay an original surface layer (k.102) created before the surrounding robbery pits were made. The layer (k.103) was the first layer of destruction debris. The subsequent ones should also be included in the category of destruction debris, although their characteristics are slightly different, which may indicate a somewhat different provenance. K.104 and k.108 were grey, hard, silty sand layers mixed with cobbles and a large quantity of stones and plaster. On the basis of this, it may be hypothesized that they were created as a result of the collapse of the roof and partly of the walls of the building. K.105 and k.107 that lay beneath were greyish brown and contained, apart from the above mentioned, fragments of *pilae*. This suggests that here we were dealing with a layer of destruction, not only of the walls or the ceiling of the building, but also the floor. K.106 and k.109 were reddish brown and contained fragments of tiles, plaster and hydraulic

mortar. As these layers were adjacent to k.110 they can, therefore, be considered that these are mainly remains of the floor and *suspensura*. During the exploration of the k.106/109 we found remains of *pilae* stacks consisting of round tiles of similar size

as those of TT.II that were the remains of *suspensura* supporting a floor of the room heated by a hypocaust system (k.110). Excavation was halted at a depth of 162cm below the surface reaching the floor under the *pilae* stacks (fig. 15).

Table 2. Stratigraphic units recorded in TT.III

k.101	DESCRIPTION	Stones and cobbles
	INTERPRETATION	Surface layer partially created as a result of exploration of nearby robbery pits
	DATING	Late 20th-early 21st century
k.102	DESCRIPTION	Loose sand mixed with cobbles and small stones
	INTERPRETATION	Fluvial accumulation. Surface layer formed before robbers' activity in the area. A layer of baths destruction mixed with non-anthropogenic layer associated with processes of slope erosion
	DATING	Late Antiquity-Modern
k.103	DESCRIPTION	Grey, hard, silty sand mixed with cobbles and stones
	INTERPRETATION	Destruction debris
	DATING	Late Antiquity
k.104	DESCRIPTION	Grey, hard, silty sand mixed with cobbles and a large quantity of stone and plaster
	INTERPRETATION	Destruction debris (walls and ceiling of the building)
	DATING	Late Antiquity
k.105	DESCRIPTION	Greyish brown, silty sand mixed with cobbles, a large quantity of stone, plaster and <i>pilae</i> (walls, ceiling of the building mixed with floor)
	INTERPRETATION	Destruction debris
	DATING	Late Antiquity
k.106	DESCRIPTION	Reddish brown, loose, silty sand mixed with tiles
	INTERPRETATION	Destruction debris ( <i>floor and suspensura</i> )
	DATING	Late Antiquity
k.107	DESCRIPTION	Greyish brown, silty sand mixed with cobbles, a large quantity of stone, plaster and <i>pilae</i> .
	INTERPRETATION	Bottom part of k.105: destruction debris (walls, ceiling of the building mixed with floor)
	DATING	Late Antiquity
k.108	DESCRIPTION	Grey, hard, silty sand mixed with cobbles and a large quantity of stones and plaster
	INTERPRETATION	Bottom part of k.104: destruction debris (walls and ceiling of the building)
	DATING	Late Antiquity
k.109	DESCRIPTION	Loose, reddish brown, silty sand mixed with fragments of tiles, plaster and hydraulic mortar
	INTERPRETATION	Bottom part of k.106: Destruction debris (mostly floor and <i>suspensura</i> )
	DATING	Late antiquity
k.110	DESCRIPTION	Remains of <i>pilae</i> stacks consisting of round <i>pilae</i> tiles with a diameter of ca. 180 mm and ca. 45 mm thick
	INTERPRETATION	Remains of <i>suspensura</i> supporting a floor of the room heated by a hypocaustic system
	DATING	Uncertain (late Roman?)

During the exploration, ceramic material both fragments of vessels (n=527) (cf. Table 3) and CBM was collected as well as pieces of glass (n=8) and of plaster (n=3).

Table 3. Quantitative information on pottery fragments recorded in 2019

Pottery		
Trench	Context	Quantity
I	1	181
I	2	40
II	51	31
II	52	6
II	53	8
II	54	24
II	55	1
II	56	39
II	57	71
II	58	54
III	101	22
III	102	13
III	103	8
III	104	6
III	105	11
III	107	4
III	108	8

During exploration and surface survey we also found three special finds: two bronze coins and a bronze ring. At the moment, however, we cannot exclude the possibility that these are modern objects.

Additionally, we have made an inventory of the robber pits using photogrammetry, which will allow us to compare any changes in the status of the site in relation to previous years.

### Conclusions and perspectives

The research in Dajaniya carried out by our team produced a number of results:

- First of all, the first orthomosaic and the DSM of the site were created. Secondly, laser scanning of selected architectural remains of the fort was performed. Together with the

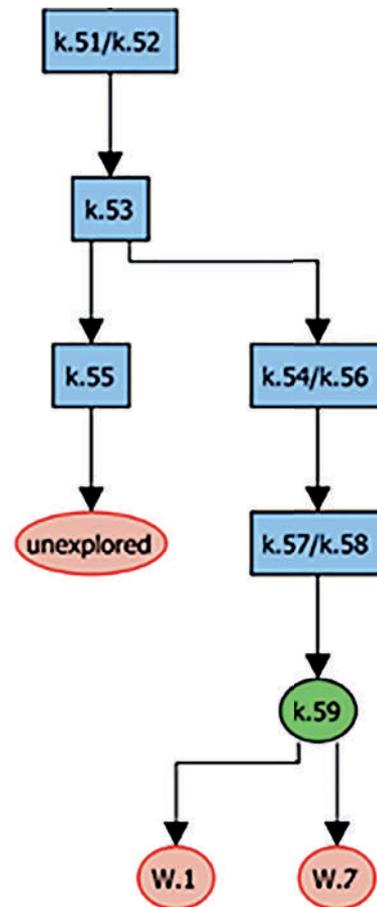


Fig. 13. Harris matrix for TT.II (K. Kopij)

photogrammetric documentation of the fort’s architecture, they form the basis for the architectural reconstruction of this complex, which is currently being prepared. In addition, we have created a virtual tour of the fort using a spherical camera<sup>6</sup> (cf. Bodzek et al. 2019a: 62-63).

- Another achievement is the photogrammetric recording of the robber pits in the castellum and its immediate surroundings. Together with the documentation of the current condition of the fort itself, they allow for the exact determination of the level of destruction of the site in 2018. This, in turn, will allow us to track the progress of the destruction of the site on an ongoing basis. Documentation activities of this type may, in a broader perspective, serve as a model for works aimed at documenting and protecting Jordan’s cultural heritage.
- The collection of the surface material, mainly in the form of ceramics, made it possible

<sup>6</sup> For the time being available only in the Polish at: <https://viar.live/tour/txsy9m>

to pre-confirm the dating of the position proposed in the earlier literature. The material will still be subject to detailed research in the near future.

- In addition, we had the opportunity to confirm both the accuracy and usefulness of RTX GNSS measurements for archaeological site documentation as well as to develop a new photogrammetric measurement method, the Ultra-Low Altitude Photogrammetry (ULAPh) (cf. Bodzek *et al.* 2019a: 57-61).

Despite the aforementioned achievements, there are still no answers to a number of important questions related to the fort and its surroundings. They can only be obtained by further research on the site. First of all, the fort's surroundings should be examined using geophysical methods, which will perhaps allow us to answer the question about the civilian settlement, specifically if it accompanied the castellum or not. With regard to gathering further information that may help us resolve this problem one should always bear in mind that surface survey will prove to be difficult due to the surface destruction of the surrounding area of the fort by heavy construction equipment.

Based on the above, the next step should be regular archaeological work carried out inside and outside the fort. As a result, it should be possible to verify and clarify the earlier assumptions regarding the chronology of the site. The results of the excavations may allow us to give a definitive answer to the question of what type of military unit was stationed in the castellum. A further step in our research should be the reconnaissance of the wider surroundings of the fort, and thus its placement within the network of the Roman *Limes Arabicus*. As was written above, the architectural reconstruction of the fort is currently underway.

As has been discussed in the pages above, in the case of the research carried out in the Tuwaneh settlement, slightly different problems had to be faced. The main one is the large area of the site. For this reason, our previous research, with limited time and resources was focused on selected fragments of the remains of the town. Our main goal was, on the one hand, to document the current state of the site and, on the other, preparatory work necessary for the creation of the overall plan, the orthomosaic and the DSM of the site.

- First of all, we tried to document the area of the so-called caravanserai and its immediate surroundings. As a result, an orthomosaic and a DSM of this part of the site was made.
- An important aspect of our research was testing on the same part of the site of the kite-based photogrammetry that we will use in the upcoming seasons to create an orthomosaic and a DSM of the whole site.
- Point cloud of fragments of the storm drain leading from the top of the southeast hill towards the bottom of the wadi.
- Recording of the baths currently being destroyed by illegal excavations was made. First of all an orthomosaic and DSM of the remains of the structure. Secondly, three test trenches were excavated, two of which recorded intact archaeological layers. We also made a sampling of the surface material in the baths area.
- An orthomosaic and DSM of the quadrangular structure north of the so-called caravanserai was made.
- Photogrammetric documentation of the robber trenches on the SE hill was also made.
- Last but not least a sampling of the surface material (mainly pottery sherds from robber pits), the analysis of which will allow a preliminary verification of the chronology of the site.

Despite the results achieved, the research conducted so far in Tuwaneh should be treated as initial. Future efforts must focus primarily on the execution of a solid whole site plan, its orthomosaic and DSM. We plan to do this in future seasons using kite-based photogrammetry, as we have successfully tested this method in 2019. Recording of other visible architectural structures will be continued using laser scanning and photogrammetry. We also plan to record the looting and other destructive activities on the site on an ongoing basis. This will make it possible to monitor the destruction processes and threats to sites of this type in Jordan. The collection of movable artifacts from the site and its further processing will be continued. The finds already collected is currently subject to detailed investigation. We also plan to continue excavation of the baths.



Fig. 14. Ortophotomap of TT.II at the end of exploration  
(M. Bernaś, Ł. Misk)



Fig. 15. Ortophotomap of TT.III at the end of exploration  
(M. Bernaś, Ł. Misk)

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