DISCOVERING EDOM

Polish archaeological activity in southern Jordan

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Kraków 2019

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Results of "Archaeological Study of Dajaniya & Tuwaneh" (ArTu:DTu) 2018 survey of Dajaniya (Ma'an-Husseiniyeh), Southern Jordan

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Abstract: Between 3 and 6 November 2018 our team conducted an archaeological survey at Dajaniya, Ma'an-Husseiniyeh district, Southern Jordan. The primary goal of the work was to document the architectural remains and to verify dating of the site. Documentation work was completed using laser scanning and close-range photogrammetry. In order to verify the dating, a surface prospection was carried out. Additionally, a virtual tour of the site was created using a spherical camera.

Keywords: Dajaniya, Roman fort, Roman Arabia, Limes Arabicus, archaeological documentation, photogrammetry, laser scanning

Introduction

The remains of the Roman fort in Dajaniya¹, Ma'an-Husseiniyeh (Fig. 1) are located 4.6 km from a modern settlement, Al-Husseiniyeh. The site is situated approx. 30 km north-east of the Udruh and 78 km south of the Lejjun legionary fortresses, in close vicinity to the remains of a *castellum* in Jurf ed-Darawish (located only 19 km to the north-east). The surveyed fort lies between two Roman roads running along the Empire's borders, 3.5 km west of today's Desert Highway, which runs along the ancient

¹ MEGA Number 5983; GPS coordinates: 30.5527, 35.7618.

Fig. 1. Map of the region with the location of the forts in Dajaniya, Udruh and Lejjun (author: K. Kopij using © CARTO)

border road, and 13 km east of the King's Highway, situated partially over the Roman *Via Nova Traiana*.

The site (Fig. 2) has riveted the attention of numerous researchers and travellers. Among the early scholars, the most important role was played by Brünnow and von Domaszewski, authors of the very first plan of the fort (Brünnow, von Domaszewski 1905: 8–13). Equally important was the work by Thomsen, concerning the region's milestones and roads (Thomsen 1917). Glueck also shared his observations concerning the fort in his two publications (1935; 1940). It was not until the 1980s, however, that further visits were paid to the site that resulted in scientific publications. The first of the then visitors was Freeman (Freeman 1990), followed by Kennedy and Riley,

Fig. 2. Satellite image of the site (source: Bing Maps)

authors of several publications devoted to aerial explorations of Jordanian antiquities (Kennedy, Riley 1990: 168, 172–75, 192–93). Subsequent studies were conducted under the supervision of S. Thomas Parker, who concluded the outcome of the *Limes Arabicus Project*, first in *Romans and Saracens* (Parker 1986) and then in several consecutive reports (Parker 1976; 1987; Godwin 2006) covering, among other things, survey works in Dajaniya. The site was also visited by Findlater (2002). The latest research to date was performed by Rucker (2007), who focused on the fort's immediate vicinity, mapping all sites within a distance of 5 km and collecting surface material.

The fort's walls make a rhombus measuring $102.20 \times 99.15 \times 99.75 \times 101.10$ m (Freeman 1990; Godwin 2006: 276). The building material (or at least the limestone) was probably taken from a quarry in Wadi al-Muqta'a, discovered in the 1990s approximately 7.5 km north of the structure (Godwin 2006: 276). The average thickness of the curtain wall is 2.25 m (Gregory 1996: 378; Godwin 2006: 276). Brünnow and von Domaszewski (1905: 12) inform that the wall-walk on top of the walls was at a height of 4.70 m, which leads us to believe that their total height was approx. 5 meters. The circumference of the walls was reinforced by 14 towers, probably two-storied (Brünnow, von Domaszewski 1905: 12). This, however, cannot be known for certain as the towers are more poorly preserved than the walls, a fact to be linked to the construction technology: the tower walls are half as thick as the curtain wall

(Gregory 1996). The towers significantly differ in size. The biggest of them is the eastern tower, measuring 8.80×8.50 m, while the smallest is the interval tower north of the SE wall, measuring only 4.80 m (Gregory 1996: 378). The towers are assessed to have been soaring approx. 2.35 meters above the walls, spaced every 22.5 to 25 meters. Here, the south-eastern wall stands out, with four towers instead of two and a spacing of 13 m (Gregory 1996: 378–79).

Adjacent to the internal wall façade was a row of one- and two-chamber structures, sometimes interpreted in literature to be remains of stables (Kennedy, Riley 1990: 173), separated from the rest of the fort's buildings by a communication route (*via sagularis*).

The interior of the fort was divided in two by a *via principalis*, a major communication route crossing the centre of the complex (southeast–northwest axis) and connecting its two main gates. The south-west part was composed of a row of two-chamber barracks. The similar-looking north-east part is disturbed by the presence of the *principia*. The north-east part of the main communication route housed a capacious rectangular water cistern measuring 12.8×5.5 m, originally roofed. Beyond the walls, to the south of the southern corner there is a 40 m^2 reservoir (Brünnnow and von Domaszewski 1905: 12–13, figs 566–567; Gregory 1996: 379). Judging by Kennedy's aerial photographs (2004: 170–71, fig. 16.7) it seems more rectangular in shape than assumed by Brünnnow and von Domaszewski, most likely as a result of modern-day modifications (Godwin 2006: 275). Archaeological verification may not be possible any longer because of the construction works performed at the site in recent years (construction of a new reservoir).

Moreover, outside the walls there are also two other structures. The oval one, situated more eastwards (diameter approx. 9.5 m), has remained unexplored to this day. Based on his observations, Parker believed it to be remains of a lime kiln or an iron smelting furnace. The other structure (Godwin 2006, fig. 14.4), situated to the south-east of the fort, is rectangular in shape (10.41×7.48 m). The excavations revealed foundations of three quern-stones and several warehousing rooms, in use at the same time as the fort (Godwin 2006: 277).

Although a number of researchers (Brünnnow, von Domaszewski 1905: 311; Lander 1984: 144–45; Godwin 2006: 285) suggested an earlier origin of the fort, the hitherto research indicates that the major part of the period in which the fort was functioning falls within the late Roman and early Byzantine periods, i.e. ca 284–502 AD (Gregory 1996: 380; Kennedy and Riley 1990: 175; Parker 1986: 93–94; Godwin 2006, 276–8). It must be noted that although fragments of early Roman ceramics, dating from the 2nd century AD, were found within the fort and in adjacent areas, no structures potentially linked to these findings have been reported (Godwin 2006: 285). The stronghold

probably originated in the times of Diocletian's reorganisation of the border at the turn of the 3rd and 4th centuries AD. Results of the survey (including trial trenches) performed as part of the *Limes Arabicus Project* indicate that the fortress shortly ceased to be used for stationing the army unit for which it was originally built. Room T.3 was turned into a refuse dump as early as the mid-4th century (Godwin 2006: 280). The garrison probably underwent rapid reduction. It seems that towards the end of the early Byzantine era (right after the mid-4th century), rooms T.2 and T.3 were no longer in use (Godwin 2006: 280). Late Byzantine strata (I–II; ca 500–551 AD) were only found in T.1 and T.6. Interestingly, in the early 6th century, a layer of dung formed in the south-west part of T.1, room interpreted as *aedes principiorum*. All this demonstrates that the facility's function changed, perhaps as a result of the earthquake of 502 AD, making it no longer the most sacred structure in the fort (Godwin 2006: 283). This phase of its use seems to have been short, whereupon the room ceased to be used at all. Eventually the vaulting collapsed, probably due to the earthquake of 551 AD (Godwin 2006: 283). Some of the trial trenches revealed strata older than 551 AD, but all they testify to is the temporary use of some rooms in the fort (Godwin 2006: 284–5).

One important fact has not been established yet, i.e. which military unit was stationed in the fort. Because of the atypical dimensions and plan of the site, even the type of the forces that occupied the structure remains unknown. Brünnow and von Domaszewski (1905: 8–12) thought it must have been the *cohors quingenaria equitata*, a unit composed of 120 cavalymen and 380 infantrymen, while other researchers tend to lean towards cavalry (Gregory 1996: 381). In the opinion of Kennedy and Riley (1990: 168), it was either several different units or one-half of the *cohors quingenaria equitata* that were stationed in the fort (hence its atypicality). They concluded that Dajaniya had been unable to accommodate a garrison composed of 500 soldiers plus a considerable number of horses, since there is no evidence suggesting that the buildings located within the fort area had more than one storey.

Season 2018

Objectives of study

The principal objective of works performed in 2018 was to develop comprehensive three-dimensional documentation of the archaeological remains. Due to the inability to use an Unmanned Aerial Vehicle (UAV), a decision was made to use a combination

of Ultra-Low Altitude Photogrammetry (ULAPh) and laser scanning. Additionally, the site's chronology was verified with a surface survey, and documentation of looting pits right outside of the fort's walls was developed. Finally, a spherical camera was used to create a virtual tour of the fort (Fig. 3).

Fig. 3. Areas of activity marked on satellite imagery (authors: A. Słodowska, E. Puniach)

Field prospection

Between 3 and 6 November 2018, acting based on Excavation Permit No. 2018/58 issued by the Department of Antiquities, Ministry of Tourism & Antiquities of the Hashemite Kingdom of Jordan, our team conducted surface prospection of the fort and its immediate vicinity. The territory was divided into 10 areas (Areas 1–10), with surface material collected from each (Fig. 4). Three of the zones (Area 1–3) coincided with the sample excavations performed as part of the *Limes Arabicus Project*. One (Area 4) adjoined to T.2–3 directly on the east side, while the other two (Areas 5–6) covered the *via principalis*. The remaining four zones (Areas 7–10) covered the rest of the fort. Beyond the fort, has been set four zones from which surface material was collected (Areas

11–14). Table 1 presents quantitative information concerning the material, organised into several groups. Results of a detailed analysis of the diagnostic pottery fragments collected during field prospection will be published in a separate study.

Table 1. Quantitative information on material collected during surface prospecting. The number of fragments has been specified

	Pottery fr.	Glass fr.	Roof tiles	Oil lamp fr.	Bronze fr.	Flint	Spindle whorl	Pipe fr.
Area 1	3	-	-	-	-	-	-	-
Area 2	7	-	1	-	-	-	-	-
Area 3	9	-	1	-	-	-	-	-
Area 4	121	-	7	-	-	-	-	-
Area 5	13	-	10	-	-	-	-	-
Area 6	51	-	7	-	-	-	-	-
Area 7	77	-	8	-	-	-	-	-
Area 8	91	-	10	-	-	-	-	-
Area 9	5	-	4	-	-	-	-	-
Area 10	271	-	22	-	-	-	-	-
Area 11	384	-	20	-	-	-	1?	-
Area 12	730	1	14	1	-	-	-	-
Area 13	237	-	68	-	1	1	-	1
Area 14	119	-	24	-	-	-	-	-

Plan of the site and 3D model of architectural remains

Among the main objectives of the 2018 research was to create a new plan of the site and a 3D model of the architectural remains. As it was impossible for us to use UAV-based photogrammetry, the method was replaced with Ultra-Low Altitude Photogrammetry (ULAPh), close-range photogrammetry and terrestrial laser scanning. All measurements were performed in connection with the control network established within the site. The network consisted of nine points with coordinates positioned in the ED50/Jordan TM (EPSG:3066) coordinate system, using the Precise Point Positioning (PPP GNSS), Real Time Kinematic (RTK GNSS) and tachymetric methods. Coordinates of individual control points were determined to an accuracy of 1 cm. Additionally, the control points were measured using Real Time eXtended (RTX) GNSS, a method suitable for real-time positioning of points with only one GNSS receiver and without access to terrestrial networks of reference stations. The accuracy of coordinate measurements declared by the manufacturer is

Fig. 4. Division of the fort into areas from which surface material was collected (author: M. Kajzer)

2 cm (horizontally) and 5 cm (vertically). At Dajaniya, we had an occasion to confirm both the accuracy and the usefulness of RTX GNSS for documentary measurements of archaeological sites.

The photogrammetric data used for the development of an orthomosaic and a digital surface model (DSM) of the entire site was obtained with a GoPro HERO 6 Black action camera with a wide-angle lens, mounted on a five-meter-long outrigger (Fig. 5). The 12 MP photographs were taken at previously mapped survey points, arranged in a grid with mesh measuring approx. 5×5 m. Eight oblique photographs (in eight directions) were taken at each point. All in all, more than 4,000 images were taken at 500 survey points. Additionally, a photogrammetric control network was established during the field works, composed of 160 control points with coordinates determined using the RTK GNSS method with an accuracy of 2 cm.

Fig. 5. ULAPh – measuring system (photo by M. Bernaś)

The data obtained was processed using the Structure from Motion (SfM) algorithms in Agisoft Metashape, to generate an orthomosaic (resolution: 4 mm) (Fig. 6) and a DSM (resolution: 16 mm) (Fig. 7) for an area of 1.7 ha. Although time-consuming, this method of obtaining and processing data, named ULAPh, produces satisfactory results, with an accuracy of 3 cm.

As part of the documentary work performed, a comprehensive 3D scan of the fort's outer façade wall was made, supplemented with a scan of the inner south-west and north-west façades. Additionally, 3D scans of the trial trenches (T.1, T.2 and T.3) excavated as part of the *Limes Arabicus Project* were obtained. The research was conducted with the use of a Faro Focus M70 terrestrial scanner. The measurement data, in the form of point clouds with a resolution of 3 mm/10 m, was collected from 47 stations, and then registered and georeferenced based on 100 targets with coordinates determined in connection with the control points using Total Station. The final product (accuracy: 2 cm) of the process is a high-resolution point cloud representing all the architectural remains of the Dajaniya site (Fig. 8).

To be able to reliably compare several measuring methods used for documenting archaeological sites, our team also turned to close-range photogrammetry (a Nikon D60 camera with a 24 mm lens) to develop 3D models of the fort's walls and the three trial trenches. All in all, 1,440 photographs (with a resolution of 24 MP) were

Fig. 6. Orthomosaic of the site (authors: P. Ćwikała, P. Cierpich, J. Ruchała)

Fig. 7. DSM of the site (authors: P. Ćwikała, P. Cierpich, J. Ruchała)

Fig. 8. Point cloud from terrestrial laser scanning representing architectural remnants at the Dajaniya site (authors: A. Ochalek, E. Puniach)

Fig. 9. Point cloud from short-range photogrammetry representing the south-western wall of the fort (author: E. Puniach)

obtained during the field works and nearly 160 control points were established and measured. The data was then processed using Agisoft Metashape software, to create models of the structures measured (Fig. 9) with an accuracy of 7 mm. Another device used for the documentation was a Faro Freestyle 3D hand-held scanner (Fig. 10), which allows real-time capturing, automatic processing and visualisation of data. The measurements produced a coloured point cloud generated in situ. The method was used for documentation of the T.1 trial trench and an opening in the fort's south-west wall (Fig. 11).

Documentation of looting pits

Close-range photogrammetry was used to develop three-dimensional documentation of seven looting pits. The photographs were taken with a Canon EOS 700D (35 mm lens) while the control points were measured with Total Station. The following operations were performed in the process of documenting the pits: establishing and measurement of control points (7 to 13), taking 50 to 200 photographs of the structure, data processing in the Agisoft Metashape software and generating the final product (point cloud, orthomosaic, DSM). Each model of the looting pits was georeferenced in the ED50/Jordan TM system, as illustrated by Figure 12.

Fig. 10. Faro Freestyle 3D hand-held scanner at work (photo by M. Bernaś)

Fig. 11. Cloud of points from a hand-held scanner representing a gateway in the south-western wall of the fort (author: K. Widuch)

Virtual tour

In order for a wider audience to be able to learn about Dajaniya, a virtual tour of the fort was created as part of the research. The work was performed on the ViarLive portal, with the outcome available at <https://viar.live/tour/txsy9m>². The virtual tour is

² There are two language versions available at the moment, the Polish and the English.

Fig. 12. Orthomosaic and DSM of H-burial dug at the Dajaniya post (author: K. Sawicka)

composed of 33 spherical images taken with a Ricoh Theta SC (Fig. 13), with each image positioned with the use of the RTX GNSS method. The images cover the entire site and visualise not only the ruins of fort and gate walls, but also the interiors, including *principia*, *aedes principiorum*, the cistern, *via principalis* and *via sagularis*.

Conclusions

Outcome of works conducted by our team in the 2018 season:

- development of orthomosaics and DSMs;
- partial laser scanning of the fort's architecture;
- photo documentation of seven looting pits located outside of the fort's walls;
- virtual tour.

Preliminary investigation of the ceramic material confirms the hitherto established chronological frames of the site, but more details will be presented in a separate study after examination of the fragments of vessels collected.

Yet another effect of our work was the development of a methodology for documenting large areas where UAV cannot be used. Time-consuming as it is, Ultra-Low Altitude Photogrammetry (or ULAPh) is one of the alternatives for preparing DMSs and orthomosaics in such conditions.

Fig. 13. Spherical photo of the fort (photo by A. Stodowska, A. Ochalek)

Fig. 14. Satellite image of the microregion with the localization of the four watchtowers (author: K. Kopyj using © CARTO)

Moreover, we had an opportunity to confirm both the accuracy and the usefulness of RTX GNSS measurements for documentation of archaeological sites.

Although the structure of the *Limes Arabicus* and the defence systems along the investigated section of the Roman Empire's border is very well-known, there is still a number of questions concerning the Dajaniya fort and its microregion. Therefore, in our opinion, further work is needed, focused on:

- investigation of structures along the inner façade of the curtain wall in order to verify whether they could have served as stables, as suggested by some researchers. The results are expected to answer the question about the type of military units once stationed in the fort;
- geophysical investigations of the fort's immediate vicinity in search of remains of structures connected with the fort and hidden beneath the surface. Judging by the fort's dimensions, it seems there may be more of them than have been revealed so far;
- excavation of the remains of four towers within several kilometres of the fort (Fig. 14). The results of the surface surveys performed so far indicate that at least two of them originated in the Iron Age and were restored and incorporated into the defence system (Rucker 2007: 55) during the late Roman period. Only by performing excavations it will be possible to define the relationship between these structures and the fort at the time of its operation.

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