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The Udhrūḥ Intervisibility: Antique Communication Networks in the Hinterland of Petra

Adjacent to this region is Arabia, which on one side adjoins the country of the Nabataei, a land producing a rich variety of wares and studded with strong castles and fortresses, which the watchful care of the early inhabitants reared in suitable and readily defended defiles, to check the inroads of neighbouring tribes. (Ammianus, 14,8,13, translation by J.C. Rolfe).

Introduction

Reliable and swift communication and information systems are pivotal for modern life. In these globally connected times some of the world's leading corporations produce neither tangible goods, nor assets, but merely assist in sharing knowledge and information. The rapid transfer of information over certain distances has always been a crucial factor throughout history.

For the military states and empires of the antique world the existence of sophisticated systems for communication were ubiquitous, as is evidenced through antique literary sources¹ and the archaeological record. Many studies have been conducted in the last decades on espe-

cially military signalling and observation systems throughout the Roman Empire. Although his work on Roman military signalling might have received some initial scepticism, the seminal studies by David Woolliscroft (2001) along Hadrian's Wall and the Roman Wetterau-limes in southern Germany are now widely endorsed. Woolliscroft showed that great effort and ingenuity was invested in Roman military communication systems, which relied predominantly on sight lines. Clark and Parker (1987) investigated a Late Roman signalling system around the legionary fortress of al-Lajjūn of the *Limes Arabicus* by means of a field experiment in the 1980's. Alistair Killick carried out several archaeological excavations and survey campaigns in the Udhrūḥ region in the same period. He mentions recording over 60 – in a second publication even more than 150 – watchtowers (Killick 1986a, 1986b) eastward of Petra around the village of Udhrūḥ, which according to him were constructed as part of an exclusive Roman military defensive system. Besides then countered forts and watchtowers, this system also comprised inroads and walls, and was

1. For extensive references to antique literary sources see Clark/

Parker 1987:166-168; Woolliscroft 2001: 159-171.

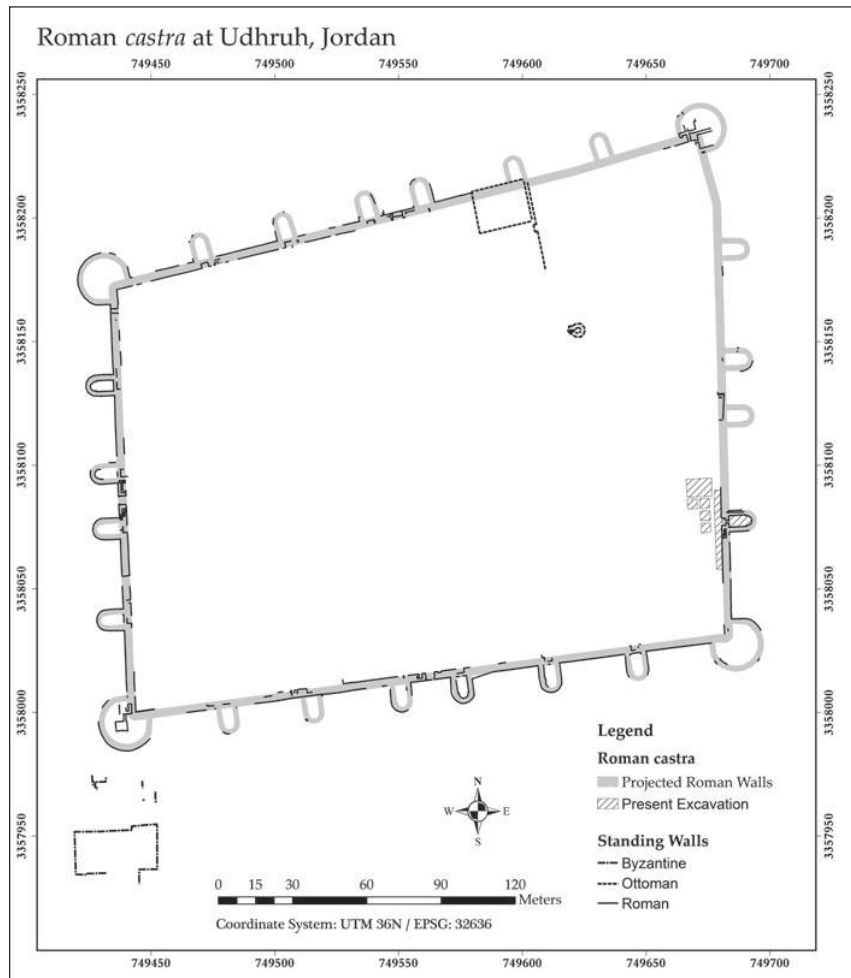
according to Killick similar to the *Fossatum Africae* and a splendid example of Luttwak's Defense-in-depth.

Following many years of archaeological field campaigns we consider that the antique communication system in the Udhruh region was initiated in the Nabataean period, most probably not as elaborate as Killick proposed, and serving a wider variety of purposes than purely military defence.

The Udhruh Archaeological Project

Udhruh was an almost forgotten archaeological site until Fawzi Abudanah (2006) drew again attention to it. In 2011, the authors started a joint effort to study the site and its environs. The central place of the region is the town of Udhruh, 12km to the east of Petra. Udhruh

housed an important Nabataean settlement (Killick 1990), but is best known for a Roman *castra* 4.7 hectare in size (FIG. 1). The curtain walls of this fort - still standing up several meters high - served as the perimeter of a town in the Byzantine and Islamic periods. Byzantine Udhruh - identified with Augustopolis - was one of the most important towns of South Jordan. Classical sources and archaeological evidence point to a long-term development throughout the Nabataean, Roman, Byzantine, Early and Late Islamic periods². This development concerns intriguing cultural, socio-economic and religious transformation processes. These processes can be noticed, not only on the site itself, but also in the surrounding landscape where a wide variety of archaeological structures largely survived the ravages of time. The



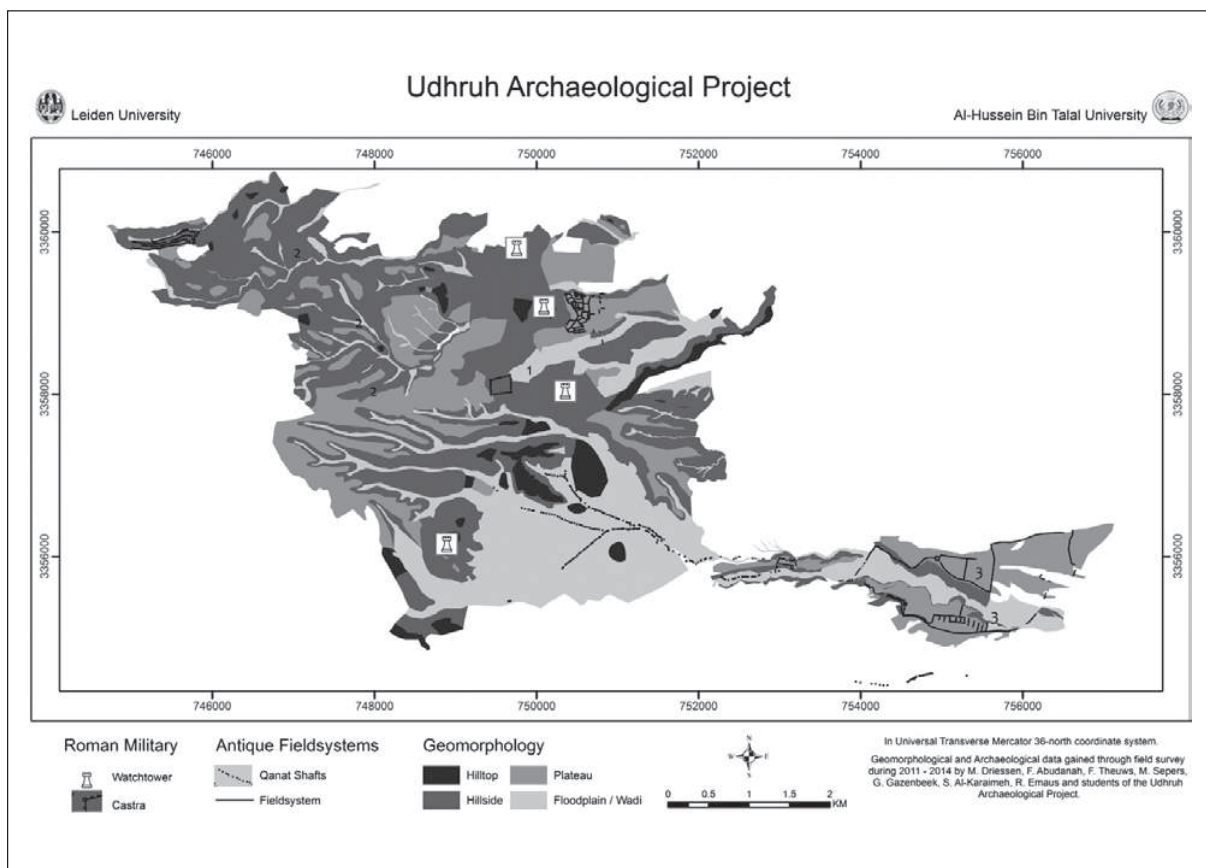
1. Udhruh Roman fortress (illustration by Roeland Emaus).

2. See e.g. Fiema 2002: 209-10; Kennedy/Falahat 2008; al-Sala-meen et al. 2011.

promising site itself, the archaeological diversity and excellent preservation of the surrounding landscape, were important criteria for launching the Udhruh archaeological Project (UAP) in 2011³. The UAP, a joint venture between Leiden University and Al Hussein Bin Talal University, started with a field-survey program, small-scale excavations and diverse GIS-related and subsurface-detection techniques in order to reconstruct the geomorphology of the landscape and the location of observed archaeological *immobilia*. After five years of archaeological campaigns we have reconstructed a significant part of the 48km² Udhruh region, which reveals an actively exploited landscape reflecting antique investments of great effort and ingenuity in agro-hydrological intensification, building

material procurement, communication and security networks, military dominion and settlement development (FIG. 2).

The Udhruh Archaeological Project can significantly contribute to the understanding of rural development and major societal transformations in Nabataean, Roman, Byzantine and Islamic times in the wider region of Petra, by focusing on the development of the nearby secondary centre of Udhruh and its environment. The central research question for the Udhruh Archaeological Project is: What transformations can be observed in the hinterland of important centres like Petra that contributed significantly to their rise, development and decline? To understand the dynamics of the region, the project will focus on water resource



2. Geomorphological map of the 48 km² research area of the Udhruh Archaeological Project showing only Roman military structures, antique hydro-agricultural systems and cairns, made on base of 2011-2014 field seasons. 3 antique agro-hydrological systems: 1) Irrigated horticulture - Byzantine; 2) Floodwater farming - Nabataean and Byzantine; 3) *Qanats* plus large field systems - Roman/Byzantine (illustration by Roeland Emaus).

3. For an earlier, more basic version of the Udhruh watchtower research see Driessen/Abudana 2013, and for the initial methodology and results of the UAP see Driessen/Abudana 2015.

management, agricultural innovations, trade logistics, communication-security systems, religious transformations and settlement development from the Nabataean era to Islamic times⁴.

Field Work, Selection and Approach

During the 2011-2015 field surveys, several strategic landmarks with rectangular or square structures on summits were encountered and have been analysed by GIS-modelling. Some of these structures are already mentioned in earlier studies, while others are not. The identified structures are associated with ancient signalling systems because of the perfect views over the landscape and their intervisibility. The authors attempt to answer the following questions: Are these outposts part of a regional, and possible larger communication network? If so, when were these systems implemented, and for which periods were they or parts of them reused? We would also like to clarify the *modus operandi* and the purposes of these information transfer networks, seen from a diachronic perspective. To answer these questions fully we need to excavate (parts of) the presumed structures. Such excavations have not been carried out yet. However the results of our surveying and analyzing the 48km² research area do allow us to come up with sound assertions regarding such ancient communication systems. For this, certain additional landmarks beyond the boundaries of the research area have also been surveyed. These were selected on their tactical locations, and observed and analysed viewsheds and intervisibility, and therefore were considered to be part of a connectivity network, fitting in the setting of the palimpsest landscape around Udhruh. At these locations we also searched for the remnants of built structures, like small fortlets and towers, and collected and sampled material culture in order to get a basic idea on the practiced

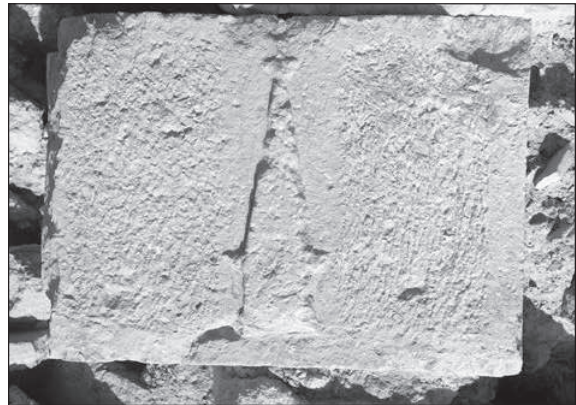
activities through time. The observed sightlines and visibility can however be misleading and part of a modernistic interpretation of the landscape. More scholars have been struggling with this. Kennedy (2013) analyses the possibilities of a Nabataean communication system in the direct surroundings of Petra, and refers to viewshed analyses and culturally different perceptions in visibility. Kennedy leans – like others working with archaeological visibility and landscape perceptions (*e.g.* Wheatley and Gillings 2000) – on quantifiable distance values of visibility perceptions as introduced by Higuchi (1988). In Higuchi's viewshed model three visibility ranges are distinguished: short-, middle- and long-distance views. The first is part of the immediate surroundings of the observing point whereby visibility aspects are not crucial. In the long distance view the topography is part of the horizon, and have visible features no direct impact on the observer. The middle-distance view range deals with a wide spacing over a distance whereby topographical features are to be perceived, but the recognition of individual details tend to become difficult, and whereby weather conditions can play a decisive role in perception. Changes in vegetation coverage remains a factor that has to be considered as well. Kennedy (2013: 282-287) bases his viewshed analyses on Higuchi's method, whereby a standardized height of 4m is chosen for the watchtowers and fortlets in the Petra region. Landscape and climatic conditions, as well as a description of the retrieved structures and setting are also to be considered of importance. In order to come up with a uniform approach of the analysis of the communication systems in the Petra region, we decided to follow Kennedy's (2013: 286) choice of a crucial middle distance range between 240 and 4400 meters.

4. The preliminary results of the research of antique water resource management and agricultural innovations in the Udhruh region which was part of our presentation at the 13th International Conference on the History and Archaeology of Jordan, will be presented in the proceedings of the University College of London April 2016

Workshop: Comparative Water Technologies and Management: Pathways to Social Complexity and Environmental Change (Driessen and Abudanah 2018). That is the reason why we decided to hand in this paper on another aspect of our research program for present volume.

The Udhruh Antique Communication Systems

The site of Udhruh is a nodal centre for the region and for this study. Udhruh hosted one of the most reliable perennial springs in the entire region⁵. Abudanah (2006: 201) links the continuity of human activity predating the Persian period to this spring. The site is best known for a Roman legionary fortress of 4.7 hectares, which with its large external U-shaped towers, is clearly late Roman. This is supported by a building inscription found near the western gate, mentioning the rebuilding of the fortress by the Legio VI Ferrata, which could be dated to 303-304 AD (Kennedy and Falahat 2008: 159-160). Udhruh must have housed a Nabataean settlement of some importance before it was redesigned as a Roman military base. This settlement was most probably integrated, and/or (partly) destroyed by the construction of the latter. Glueck (1935:m 76-77) already mentions large quantities of Nabataean pottery surface finds at Udhruh, and on a spot outside the southern wall of the fortress, Killick (1990: 249) has excavated one and a half ton of Nabataean pottery fragments. This is interpreted by the Killick's as the location of a large Nabataean pottery kiln. During the last years no proof of such a kiln has been retrieved during the surveys, but we are planning for a trial with several geophysical techniques for this area during the 2018 campaign. However, we suspect that part of the Nabataean settlement was located at the southwest part of the still standing curtain walls of the Roman fort. An abundance of surface finds of Nabataean pottery was also retrieved by the UAP in this area. Also some iconographic evidence was discovered here during our surveys: a cut and worked limestone block with a *nefesh* (FIG. 3) and a rectangular sandstone block with a *betyl*. These were retrieved as *spolia* at respectively the southwest corner tower and the adjacent Byzantine church at Udhruh. The limestone is likely of local provenance, but

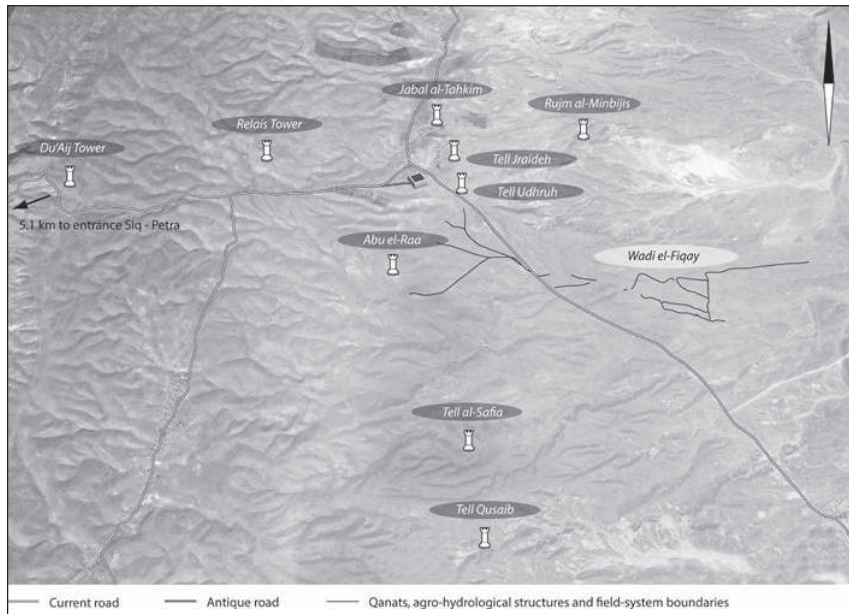


3. *Nefesh* found near the southwestern corner tower of the Udhruh fortress (picture by Mark Driessen).

the sandstone block most probably comes from the Petra area as no sandstone quarries or outcrops have been noticed around Udhruh. Marie Killick (1990:251) mentions that 13% of the coins found in/around Udhruh are Nabataean, with a peak of the reign of Aretas IV (9 BC – 40 AD), but the earliest dating from the early 1st century BC. Tholbecq (2013: 299) endorses earlier ideas that Udhruh developed as a second Nabataean nucleus in the hinterland of Petra. Most probably both the perennial spring and the elevated location, where the later southwest corner tower of the fort was built and which is 19 meter higher than latter, were important criteria for as well the Nabataeans as well as the Roman troops to settle here. The connectivity of Udhruh becomes especially clear through the survey of several hilltop sites in the region. Ten of these were finally selected based on the following criteria. They are having elevated and strategic locations with wide views over the region, connecting Udhruh and Petra to each other through sight lines and view sheds (FIG. 4). On the tops of these hilltops remnants of fortlets and watchtower-like structures were retrieved which were probably part of a signalling system, and these were surveyed for relevant material culture. During the 2011-2015 field surveys many structures were encountered that might have been part of what Killick thought to be an elaborate Roman signalling system with 60-

5. Since a few years this Udhruh spring is unfortunately no peren-

nial source of water anymore.



4. Map of the Udhrūḥ region with *castra*, watchtowers and the water and irrigated field system in Wādī al-Fiqay (illustration by Joanne Porck).

150 watchtowers in the Udhrūḥ region. Most of these were the sort of cairns that archaeologists tend to encounter everywhere around the world on or near landmark locations. Some might be prehistoric burial mounds, others were pointed out by locals as being recent Bedouin graves or cadastral land demarcations⁶. Others were deselected as being part of the ancient communication systems because they lacked the earlier mentioned criteria. We are fully aware that by these decisions some of the elements originally belonging to these systems might have been ruled out. This is however an ongoing project and new insights can hopefully rectify these omissions. This may well be the case for watchtowers integrated in contemporary and/or later complexes or homesteads like the ones mentioned in Serila (πυργοφρουρίου; Koenen *et al.* 2013: 85-86), Khirbat Salantah (Hirschfeld 1995: 71-73) or Mampsis (Negev 1988: 85-88).

The above discussion clearly shows that the study of the selected sites will only lead to preliminary results which we still have to test through future field research with non-destructive geophysical exploration techniques, sondages and possibly through excavations.

Description of the Surveyed Structure

Three of the surveyed hilltops with built structures have a visibility field including an overview of Udhrūḥ and its spring.

The first one is Tall Udhrūḥ, which not only overlooks the complete fortress of Udhrūḥ, but also has also visual control over the water systems and the irrigated fields in Wādī al-Fiqay (FIG. 4). The visibility from this 1300m hilltop reaches most of the other selected sites in this study (TABLE 1). On bright days even the inter visibility with the Du'ayj tower on Zubayriya hill, the nearest watchtower to Petra in our system, is attested (FIG. 5). However, the distance between these hilltops (8200 m) overstretches the chosen middle-distance view range of 4400 meters. On top of Tall Udhrūḥ (also called Dubais), 700m eastwards of the fortress of Udhrūḥ, a 12×25m rectangular structure made of limestone blocks can still be distinguished (FIG. 6). The structure consists of impressive walls with a width of 0.8-1.1m. Killick (1986a: 444) who excavated parts of the structure mentions that he encountered the remains of 'a two-storied tower structure of Roman foundation built on top of an Iron II settlement'. These blocks resemble in provenance, dimensions and

6. See for antique field markers *e.g.* Koenen *et al.* 2013: 17.

THE UDHRUḤ INTERVISIBILITY

Table 1. Visibility and distances between (possible) watchtowers in the Udhrūḥ area and the legionary fortress of Udhrūḥ. Y = yes; N = no; NA = not applicable; SWT = southwest corner tower castra; F = overview castra. Distances in km.

Visibility	Castra Udhrūḥ	Jabal at-Taḥkīm	Tall Juraydah	Tall Udhrūḥ	Abū ar-Ru'āḥ	Tall aṣ-Şafiyyah	Tall Qasīb	Relais Tower	Du'ayj Tower	Rujm al-Munbajis
Castra Udhrūḥ	NA	1.6 (SWT)	0.7 (F)	0.7 (F)	2.0 (F)	5.6 (SWT)	7.3 (SWT)	3.5 (SWT)	7.5 (SWT)	N
Jabal at-Taḥkīm	1.6 (SWT)	NA	0.9 (Y)	1.8 (Y)	3.7 (Y)	7.3 (Y)	9.0 (Y)	4.0 (Y)	8.1 (Y)	3.2 (Y)
Tall Juraydah	0.7 (F)	0.9 (Y)	NA	0.9 (Y)	N	N	N	N	8.3 (Y)	2.8 (Y)
Tall Udhrūḥ	0.7 (F)	1.8 (Y)	0.9 (Y)	NA	N	5.5 (Y)	7.2 (Y)	N	8.2 (Y)	2.9 (Y)
Abū ar-Ru'āḥ	2.0 (F)	3.7 (Y)	N	N	NA	3.9 (Y)	5.6 (Y)	3.8 (Y)	7.1 (Y)	N
Tall aṣ-Şafiyyah	5.6 (SWT)	7.3 (Y)	N	5.5 (Y)	3.9 (Y)	NA	1.7 (Y)	N	9.9 (Y)	N
Tall Qasīb	7.3 (SWT)	9.0 (Y)	N	7.2 (Y)	5.6 (Y)	1.7 (Y)	NA	N	11.8 (Y)	N
Relais Tower	3.5 (SWT)	4.0 (Y)	N	N	3.8 (Y)	N	N	NA	4.2 (Y)	N
Du'ayj Tower	7.5 (SWT)	8.1 (Y)	8.3 (Y)	8.2 (Y)	7.1 (Y)	9.9 (Y)	11.8 (Y)	4.2 (Y)	NA	N
Rujm al-Munbajis	N	3.2 (Y)	2.8 (Y)	2.9 (Y)	N	N	N	N	N	NA



5. Picture taken from Du'ayj tower in eastward direction (picture by Mark Driessen).



6. Aerial picture of Tall Udhrūḥ taken from the south. At the right of the rectangular structure the circular ditch is very clear, and at the top Jabal at-Taḥkīm can be distinguished (picture by Stafford Smith: APAAME_20101016_SES-0263 (C) Stafford Smith, Aerial Photographic Archive for Archaeology in the Middle East).

finishing the ones used for the curtain wall of the Udhrūḥ fortress. A ditch around the structure was most probably dug for defensive purposes. A modern cemetery is laid out on the western part of the hill. At Tall Udhrūḥ, Early Bronze age II-III, Nabataean, Roman and Byzantine pottery was collected, and during earlier investigations also fragments of Edomite ware were found⁷.

Tall Jurayda, a crescent shaped hill 700 m northeast of Udhrūḥ, has an undisturbed view over the fortress of Udhrūḥ. On the eastern side of this 1324 m high hilltop, a quarry, several caves and two built structures are found. The caves seem to have been used throughout a long

period, as is the case with many caves in the research area. The best preserved of the two built structures measures 40×47m and is located on the southeast side of the hill. The structure is built of quarried and finished coquina and limestone blocks, which resemble the ones used for the fortress of Udhrūḥ. The ceramic evidence corresponds with the most prominent periods of use of the fortress and later town of Udhrūḥ, and dates to the late Roman, Byzantine, Umayyad and Ayyubid/Mamluk periods (Abudanh 2006: 422, Appendix 4D). This is one of the rare hilltop sites that lack the presence of Nabataean ware. We expect that Tall Jurayda possessed only a local function in connection with Udhrūḥ and the irrigated fields in Wādī Udhrūḥ because of a limited visibility to the other watchtowers in the region (TABLE 1).

The third hilltop with an overview of Udhrūḥ and its spring is Abū ar-Ru‘āh, which lies 2000m southwest of the fortress of Udhrūḥ. As is the case with Tall Udhrūḥ and Jabal at-Taḥkīm, this 1372m hill overlooks the water and field systems in Wādī al-Fiḡay. From the summit of Abū ar-Ru‘āh 2012-2013 field teams working 6km away in Wādī al-Fiḡay could be followed on bright summer days. This regionally strategic territorial marker connects visually with most of the other surveyed hilltops, except for the above described Tall Jurayda east of Udhrūḥ. The most remote watchtowers of our system are clearly visible on bright days, although the distances overstretch the chosen middle-distance view range. At the top of Abū ar-Ru‘āh the remains of a watchtower or fortlet with massive walls were observed. The dimensions of the structure are not clear at this stage, since its upright walls were toppled and scattered around. Geophysical research and possible sondages are planned for the coming field seasons. Killick (1986a: 436-438) interpreted a rectangular enclosure on this hill –which he called Tall ‘Abāra– as a possible temporary Roman camp. This enclosure –which consists

7. For earlier visits of the site see also Glueck 1935: 76; Killick 1986:

444 and for the ceramics: Abudanh 2006: 141; Glueck 1935: 76.

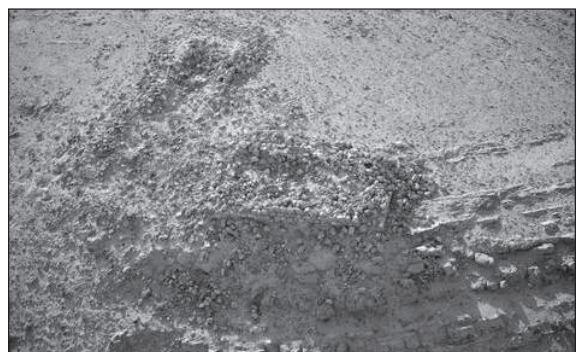


7. Picture taken from Jabal at-Taḥkīm in southward direction (picture by Mark Driessen).

of modest earthen walls— lies halfway on the very steep slopes of this hill, which makes it less suitable as the location for a Roman camp. No ceramics or other material culture linking it with a possible military use was found in and around this enclosure. North and northwest of Udhruḥ many similar structures most probably belonging to Nabataean and Byzantine dryland farming systems are being surveyed as part of our research (Driessen and Abudanah 2018). The pottery found near the collapsed structure on top of Abū ar-Ru‘āh can be assigned to the Nabataean, Roman and Byzantine periods.

Another territorial marker in the Udhruḥ area is Jabal at-Taḥkīm, which lies 1600 m north of Udhruḥ. This hill, also called Jabal al-Ash‘arī or Khirbat aṭ-Ṭamiyyah, has an elevation of 1364m and excellent and wide views over the surrounding landscape. On clear days the Nabataean-Roman stronghold of Khirbat al-Qirāna (40km to the south) and the hilltop of Jabal al-‘Aṭā‘taḥ near Dānā (37km to the north) are within the long-distance visibility range (FIG. 7). Jabal at-Taḥkīm lies within the network of middle- and long-distance visibility ranges of

almost all the other examined hilltop sites and the irrigated field system in Wādī al-Fiḡay. The view to the Udhruḥ fortress is blocked by the western part of Tall Jurayda. Only the southwest corner tower can be seen clearly from the L-shaped structure on top of Jabal at-Taḥkīm (FIG. 8). The both sides of the stronghold on Jabal at-Taḥkīm measure 40×10m, with the outer two-faced walls still standing around 2m high. The inner and outer faces of these walls consist of roughly cut quarried blocks of brecciated chert and limestone. The blocks and the



8. Aerial picture of Jabal at-Taḥkīm taken from the east (picture by David Kennedy:APAAME_20101016_DLK-0426 (C) David L. Kennedy, Aerial Photographic Archive for Archaeology in the Middle East).

construction technique and finish of these walls do not resemble the characteristic construction of the Roman fortress of Udhrūḥ, but are comparable with Nabataean structures from the wider region. This is not a solid and empirically diagnostic observation, but something we might take in consideration. The odd shape of this 0.08ha structure seems anomalous for the layout of a Roman fortlet or watchtower. We are only aware of one other L-shaped Roman military structure at Halton-Chesters at Hadrian's Wall, which is the result of a later addition (Breeze 2006:178-183). It cannot be excluded—without excavating—that the odd shape of this structure is also the result of a later alteration. The 1.0-1.2 meter wide outer walls were re-used as burial chambers in later periods. At certain sections of the wall, the inner filling has been removed to create chambers, which were covered by slabs of brecciated chert and hold human skeletal remains⁸. The ceramic ware collected at the L-shaped building during our field survey consisted almost entirely of pottery from Nabataean period (1st century BC – 2nd century AD) and the Roman era, with only a few Byzantine fragments. Earlier research also recovered late Byzantine, early Islamic and Ottoman wares⁹.

On a hill between two *wadis* 3500m east of Udhrūḥ stands a square structure made of nicely cut limestone blocks. Largely demolished by looters, only parts of some walls remain standing. The 1140m hill called Rujm al-Munbajis connects visually with only Tall Udhrūḥ, Tall Jurayda and Jabal at-Taḥkīm. The ceramic finds from this structure point to the Byzantine period. This possible tower overlooks two *wadis* which were exploited for irrigated agriculture. Therefore it was suspected to have a local security function in connection with these field systems in Wādī

Udhrūḥ and the northern Wādī al-Buraykah.

Southward of Udhrūḥ, two prominent landmark hills were investigated for visibility and connectivity patterns. The first hill—5600m south of Udhrūḥ—is locally known as Tall aṣ-Ṣafiyya. This steep 1310m hill with a north-south outcrop of coquina-limestone on its ridge is a striking feature surrounded by a relatively flat area with several *wadis*. The top of the outcrop has been cleared to make place for a 6×6.5m structure composed of cut limestone blocks. These blocks were probably quarried from the outcrop on the hill. The southern side of the hill was most certainly used for access, as this is the only passable slope. Older members of the local community remember a water reservoir at the eastern base of the hill (Abudanh 2006:148-434). Several nicely cut limestone blocks that might have belonged to this reservoir can be seen on eastern foot of the hill. Tall aṣ-Ṣafiyya connects visually with many of the other hilltops; the southwest tower of the Udhrūḥ fortress—although 5600 meters away and beyond the limits of the middle-distance view range—can be seen on most days by the naked eye. The rest of the fortress is not visible, not even with binoculars. The collected pottery consists mainly of Nabataean and Roman wares, although earlier surveys did also produce some late Byzantine/early Islamic sherds (Abudanh 2006:434).

Tall Qaṣīb, 1700 meters further south of Tall aṣ-Ṣafiyya, lies at a distance of 7300m from Udhrūḥ. On the hilltop of 1285m a built complex was discovered, one square room of which had been exposed as a result of looting by treasure hunters. This subterranean room of 3.9×4m with walls 1.5m high is built of a mixture of limestone, sandstone and brecciated chert blocks. The remaining parts of the

8. Jabal at-Taḥkīm is an important historic Islamic site and hosted, according to al-Salameen *et al.* (2011: 233), 'the famous arbitration... [that finally] resulted in the establishment of the Umayyad state based in Damascus'. It is not clear yet if there is any relation between this historic event and the burials here. These likely date to more recent periods, as can be derived from the condition of the osteoarchaeological remains and remarks by members of the local community.

9. The pottery of our survey was analysed by Sarah Wenner (NCSU) and Mark Driessen. The Nabataean ware ranges from phase 2a till phase 3b painted fine ware and other forms (following Schmid's (2000) pottery determination). Glueck (1935: 77) also mentions large quantities of Nabataean ware and Killick (1983: 127) collected late Byzantine/early Islamic pottery from the site. Abudanh (2006: 175) also found some Ottoman ware.

complex were still largely covered, but for how long? South and east of the structure, 14 graves had been looted leaving human bones lying scattered around. A natural spring can be recognized by the pockets of lush natural vegetation at the north-western base of Tall Qaṣīb. During an earlier survey two parallel walls could be seen here, which had been exposed by seasonal flooding once more. During our later survey they had been buried under alluvial deposits. These walls might have been part of a water reservoir (Abudanh 2006: 507). Tall Qaṣīb connects visually with many other hilltops of the survey on bright days, although most of them are beyond the middle-distance view range. The southwest corner tower of the Udhrūḥ fortress could also be seen with the naked eye, but this was again during some clear summer days. During the survey, predominantly Nabataean wares, but also some Roman and Byzantine sherds were discovered. Earlier surveys also recovered some pottery fragments from Edomite, Umayyad and Ottoman periods (Abudanh 2006: 150).

The following hilltops cover the western connection in the direction of Petra. A Structure of 5×5m was located on a hill more or less half-way and just north of the road between Udhrūḥ and the Zubayriyya ridge towards Petra. This watchtower is probably the one that Killick refers to and illustrates in his publication (1986a: 440 and pl. 24.14). We are however not sure, as he did not give more details. With a height of 1450 m, this is the most significant hill in this area, lying 3500 m west of Udhrūḥ and has an unblocked view of the southwest corner tower of the legionary fortress. Because it can serve as a connection between Udhrūḥ and the more western Du‘ayj Tower (on Zubayriyya ridge) towards Petra, it is called the Relais Tower. This rectangular structure is made of roughly cut brecciated chert blocks and was likely a piv-

otal part within the communication system. It has however also a clear view over an ancient settlement and parts of elaborate Nabataean and Byzantine dryland farming systems¹⁰, a mere 1000m north of the tower. It might have served multiple functions, as is expected to be the case with other hilltop sites. Only a few body sherds were collected at the site, with fabrics that could only be determined as roughly belonging to the Nabataean-Roman-Byzantine periods. It is suspected that previous archaeological surveys such as those of Killick may have cleaned the site of its ceramic surface remains, and this reason justifies the need to continue our future research here with sondages and other techniques.

A 5×5m structure (Du‘ayj Tower) on the Zubayriyya ridge, just north of the road connecting Udhrūḥ with Wādī Mūsā, is the most western connection in the communication system with the city of Petra. The remnants of what must have been a tower-like structure are to be found at a height of 1575m and at a distance of 7.5km from the fortress of Udhrūḥ. The southwest tower of the Roman fortress, Tall Udhrūḥ (8200m) and Jabal at-Taḥkīm (8100m) are visible on clear days with the naked eye, as well as other hilltop structures (TABLE 1). Towards Petra –at a distant of 5.7km from Du‘ayj– a visual connection with Jabal Hārūn and Umm al-Biyāra¹¹ is easily made on clear days, although again this lies beyond the limits of our determined middle-distance view range. The structure is called Du‘ayj Tower as it lies at the end of the old Du‘ayj-road¹². Du‘ayj tower connects visually within the middle-distance view limits with the eastern watchtowers and fortlets of the Jabal ash-Sharāḥ Survey: JSS86 on Ṭal‘at ‘Iyad, JSS89 on Q(u)lay‘ah, JSS122, and JSS123 on Abū al-Baqī¹³. The retrieved cultural artefacts from the Du‘ayj tower point to Nabataean and Roman use.

The last structure operating in the Udhrūḥ

10. This dating is again based on surveyed material only, recent studies in the Petra area show that scientific dating techniques as OSL and 14C endorse the establishment of agricultural terraces as from the 1st century AD (Beckers and Schütt 2013).

11. For the last see Kennedy 2013.

12. For the Du‘ayj-road see Abudanh 2006: 102-3; 403.

13. For these see Tholbecq 2013: 300.

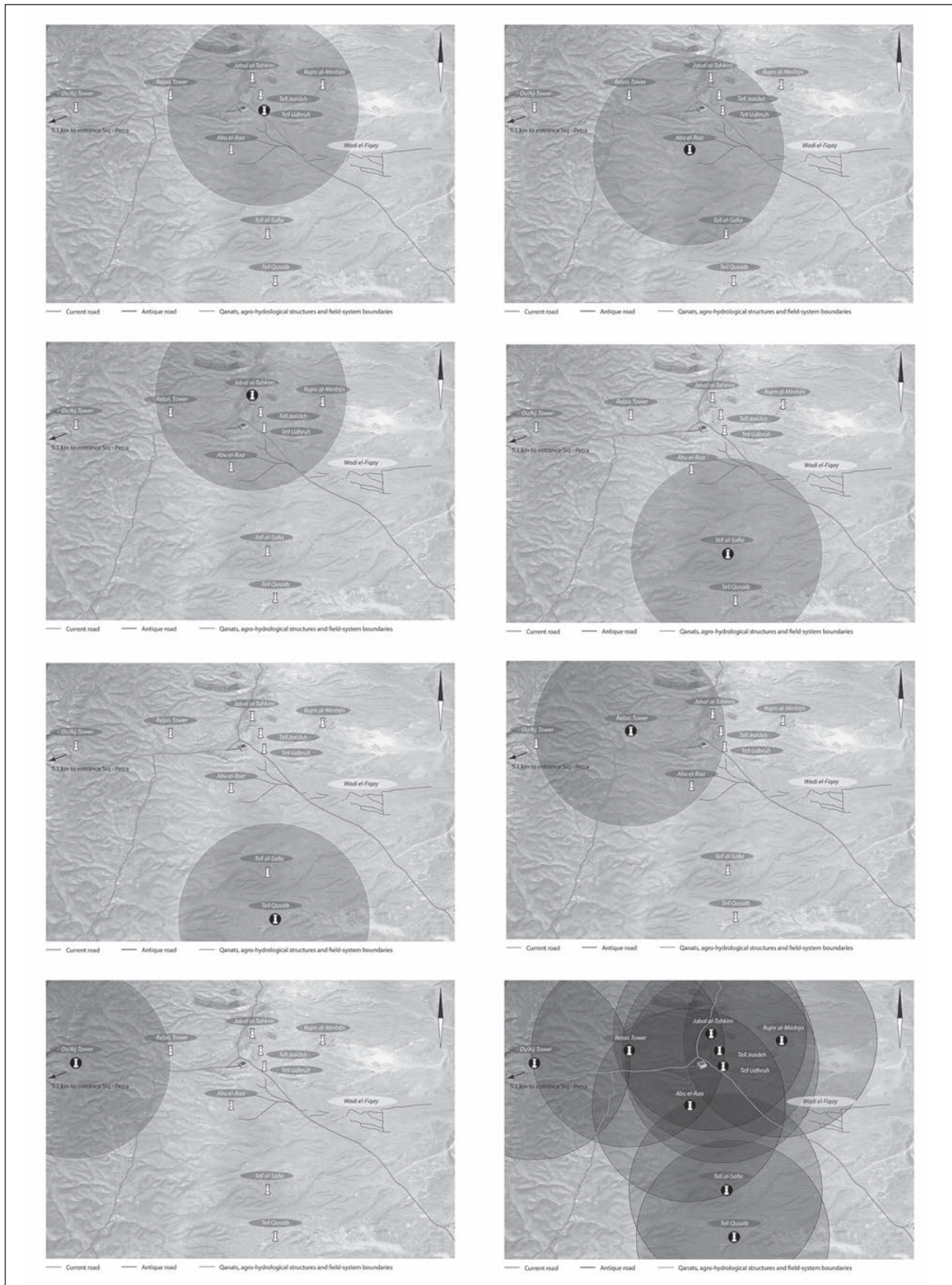
communication system is Udhruḥ itself, with the location around the southwest corner tower of the Roman *castra* playing a pivotal role. For the Roman period this tower was most probably part of the system. For the Nabataean period we suspect that there was a fortlet or watchtower structure on this spot, as this location links visually with most Nabataean hilltop structures in the region. This would also explain why the Romans laid out their fortress in such an anomalous way on a slope with a difference in height of almost 20m over a distance of 330m. The above surveys and visibility studies were carried out during summer periods with predominantly clear days and sometimes amazing inter visibilities covering dozens of kilometres. These visibilities could have been different in the past, due to different climatic, environmental and/or anthropogenic conditions. Climatologically, no dramatic changes are to be expected when comparing the current conditions with those in antiquity, although it should have been more humid than in present (Finné *et al.* 2001; Gilbertson *et al.* 2006:406-409). A wet phase in the classical period was followed by a drier phase in Islamic times (Gilbertson *et al.* 2006: 406-408; Besançon 2010: 67). The area around Petra and in the direction of ash-Shawbak must have been partly covered with woodland species like Palestine oaks and Juniper (Besançon 2010: 62). The deforestation of these trees must have started already well before the Roman period (Fall 1990:275). For the region of Udhruḥ –due to the climatic and hydrological circumstances– no high trees are to be expected in classical times, which could have affected the antique sightlines. The chosen hilltops are outstanding markers in the landscape and even nowadays anthropogenic structures do not block the sight from these hills, and there is no evidence that this might have been different in ancient times. Weather conditions, and hence the visibility, change throughout the year. In order to tackle this and to come up with a uniform approach for the analysis of the com-

munication systems in the Petra region it was decided to follow Kennedy's (2013: 286) criteria. This means that a standard height of 4m was chosen for the structures on the hilltops. Some of these buildings must have been much higher, as can be surmised from the surviving foundations; thickness of the walls and the overall layout, but this height of 4 m remains the standard. With this average height a short-distance of less than 240m, a middle-distance range between 240m and 4400m, and a long-distance range of more than 4400m was calculated (Wheatley and Gillings 2000: 16-19). The middle-distance range between 240m and 4400m is decisive for visibility, as within this range structures such as watchtowers and phenomena such as lights, fires and larger beacon signals can be seen, though details cannot be discerned.

Nabataean Connectivity in the Udhruḥ Area

What already becomes very clear from the surveyed hilltops is that on almost all of them (except for Tall Jurayda and Rujm al-Munbajis) Nabataean ceramic wares were found. Based on the quantities of this surveyed material the Nabataean era seems to be the most dominant period of use for many of them. When the middle-range limits for these hilltops with a Nabataean usage are plotted on a map, it becomes apparent that the visibility fields of these lie perfectly within these boundaries (FIG. 9). A network of communication appears, connecting on the one hand Udhruḥ with Petra in an east-west direction and on the other hand Udhruḥ with a north-south line of control. For the east-west connection the highest part of the ancient settlement –which is the location of the later southwest corner tower of the fortress– is directly connected to the Relais Tower over a distance of 3500m, which falls within the middle-distance radius. Indirectly, Udhruḥ is connected via Tall Udhruḥ and Abū ar-Rūa'a, both with an overall view over what we think are the outer limits of the ancient settlement, with the Relais Tower. With a distance of respectively

THE UDHRUH INTERVISIBILITY



9. The middle-range limits for several watchtowers of the Udhruh communication system (Illustrations by Joanne Porck). N.B.

4200m and 3800m these fall within the middle-distance *radii*, and all of these possess unblocked views towards each other. As a back-up in cases of emergency or blocked views, Jabal at-Taḥkīm could be put in operation with a clear visible connection over a distance of 4000m towards the Relais Tower. It is situated only 1600m north of Udhrūḥ and from this Nabataean stronghold Udhrūḥ's SW corner tower can be seen. The Relais Tower connects visually with the Du'ayj tower on the Zubayriyya ridge towards Petra, and here too the middle-distance range with a distance of 4200m is maintained. The Du'ayj tower connects visually with some structures in the direction of Petra that fall beyond our research area. Tholbecq (2013:300) describes the structures JSS 89, JSS 122, JSS 86 and JSS 123 as possible actors in a system of 'visual long-distance communications'. The distances to these from Du'ayj tower are respectively 2100m, 3200m, 1500m and 4100m, and are thus all situated within the chosen view range.

The north-south connection starts for this study from the north with Jabal at-Taḥkīm. As mentioned above, on clear days the views from this summit reach out far and even the Dana hilltops and Khirbat al-Qirāna are within the long-distance visibility range. We have not yet surveyed hilltop structures north of Jabal at-Taḥkīm, but the Nabataean settlement on the hills near Khirbat al-Jarbā can be considered. These connect visually with each other and the distance of 2600 m makes Khirbat al-Jarbā a plausible candidate. On Rujm al-Jarbā –300m south and on the same hill as Khirbat al-Jarbā– a rectangular 15×11m structure made of limestone blocks, has been observed by Abudanh (2006: 413).

During a more recent visit no ceramic evidence has been retrieved here, so more research is required here. Jabal at-Taḥkīm links in a southern direction, as has already been seen

with Udhrūḥ's SW corner tower, but also with Tall Udhrūḥ and Abū ar-Rūa'a with distances of 1800 and 3700m. These all fall within the calculated middle-distance range, as are the two southern hilltops –Tall aṣ-Ṣafīyya and Tall Qaṣīb– with a span of 3900m and 1700m.

The authors think that Nabataean Udhrūḥ and its communication system played a role in the Nabataean military defense system. Such a system can be confirmed by various ancient literary sources. Diodorus of Sicily (19, 96, 3) describes a very early Nabataean network of watchtowers, relating to a late 4th century BC situation. The Nabataean settlement and the retrieved communication network in the Udhrūḥ region could have played a role in the protection, control, provisioning, trans-'ship'ment and taxation of the trans-Arabian caravan trade. Through this trade in aromatics the Nabataeans accumulated part of their wealth and power, and became part of an antique globalised network for certain period¹⁴. The trade in myrrh and frankincense was a lucrative, but also a hazardous enterprise. In the arid no man's land of the desert and steppe travellers were prone to different dangers and challenges. The caravans had not only to venture the drought, but also the perils of desert-piracy. It is not clear if armed escorts were sent along the entire route, most probably the chain of fortlets and watchtowers played a role in guarding and controlling the safety of the caravans. The members of these transport and trade communities were not allowed to enter the Nabataean capital, so these 'services' had to be carried out at satellite stations in the vicinity of Petra (Zayadine 1992: 230). For the required services places were needed with sufficient supplies of water, food and fodder in a secure setting along or near the trade routes. Udhrūḥ that developed according to Tholbecq (2013: 299) as a second Nabataean nucleus in the hinterland of Petra could have been pivotal in this.

14. For the Nabataean incense trade see inter alia Young 2001: 112-117 and Zayadine 2007. Globalisation as seen by Versluys (2015) as part of a dynamic approach to a world of cultural connectivity

with emphasis on social values, balances and connections whereby diachronicity can be integrated.

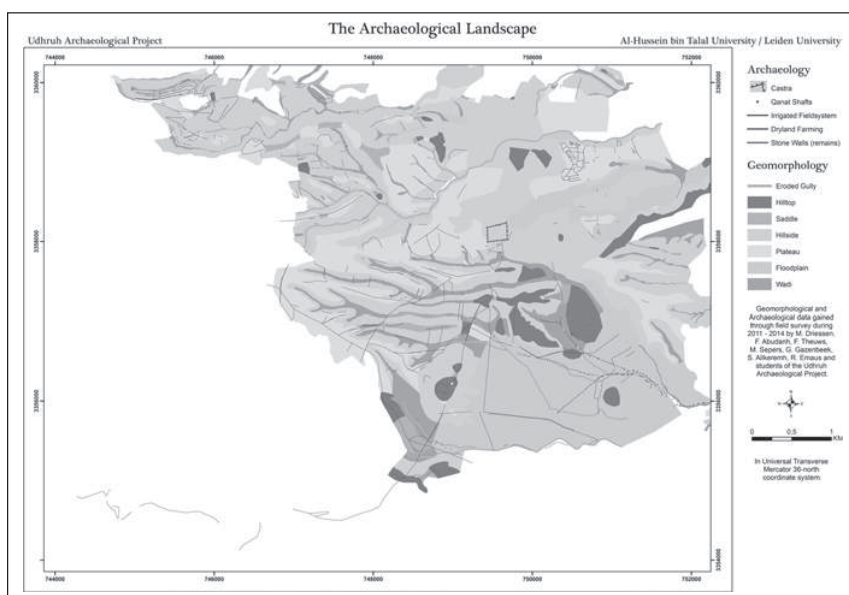
The 4th century AD Roman historian Ammianus Marcellinus (14, 8, 13) mentions that the early inhabitants of the Nabataean country watchfully took care of the safety of their well defended territory from strategically positioned posts. These were installed to control the roads from neighbouring territories into their land where according to Ammianus a rich variety of goods were produced. Archaeological evidence for the Nabataean agricultural intensification shows that this took place predominantly west of Udhrūḥ (Kouki 2012: 84ff; 2013). The eastern boundary of this is located almost along the north-south line of the Udhrūḥ communication system as described above. Is it possible that we are looking at one of the defensive lines of the Nabataean territory? On the one hand this might have had an external function directed towards neighbouring territories and incoming routes.

On the other hand it is directed internally, possibly to protect and control the local supplies of water and the established agricultural schemes such as the Nabataean dryland farming systems that were encountered west and northwest of Udhrūḥ. In the hilly area northwest of Udhrūḥ a combination of ancient rainwater-catchment and floodwater-harvesting techniques is observed. These terraced fields cover a vast area of most probably dozens of square

kilometers and provide surface finds dating from predominantly Nabataean and Byzantine times (FIG. 10). The location of Udhrūḥ with its perennial spring, its surrounding Nabataean hydro-agricultural schemes and communication network underline Tholbecq’s proposition (2013: 299) that Udhrūḥ can be labelled as a secondary Nabataean centre next to Petra.

Roman and Byzantine Connectivity in the Udhrūḥ Area

In the 3rd and 4th centuries a revitalization of military structures took place under Roman control in Jordan. Many of these military installations were already in use throughout the preceding centuries (Kennedy 2000), but others, such as the legionary fortress at al-Lajjūn, were newly constructed. The legionary fortress of Udhrūḥ was probably, according to the west gate building inscription, rebuilt by the Legio VI Ferrata in 303-304AD (Kennedy and Falahat 2008: 159-160). It is not clear if this rebuilding refers to an earlier Roman legionary camp, an earlier Roman military fort of another character, or to earlier defensive installations of non-Roman origin. Till now, no literary or archaeological proof has been found pointing to a long lasting Roman occupation of the site before the second half of the 3rd century AD.



10. Geomorphological map of the western research area of the Udhrūḥ Archaeological Project showing the fortress and the water management and field systems, whereby the structures part of the western dryland farming area are mapped (illustration by Roeland Emaus).

Except for a few 1st century AD *terra sigillata* sherds from the South Gaulish production centre La Graufesenque and some Trajanic coins, which could still have been in circulation in later periods, the evidence for this is very meagre¹⁵. In a trench carried out in the *intervalum* at the eastern side of the legionary fortress it was noticed that the Roman curtain wall was constructed on top of different foundations. The upright parts of this wall were made of nicely finished coquina limestone blocks, carried out in what can be described as clearly Roman practise while the foundations were made of more roughly cut and ditto finished brecciated chert and flintstone blocks. Such building practices do resemble the method of construction seen at the L-shaped fortlet on Jabal at-Taḥkīm and other Nabataean structures in the region. It seems that the Roman curtain wall was constructed on top of initial Nabataean walls or foundations. At this stage it is not clear when this was carried out and if the Roman curtain wall that still stands is part of the 303/304 rebuilding or of another earlier Roman building campaign. The layout and realization of these defensive works and the dozens of beautifully articulated architectural elements retrieved on the surface of the fort, which most probably belonged to its headquarter building, indicate that the legionary base of Udhrūḥ was definitely of a more monumental stature than its counterparts along the *limes Arabicus*. Why is this the case at Udhrūḥ and not at the other Roman legionary fortresses? This most probably has to do with its location near Petra, and this monumental refurbishment could have been part of a function as desert gateway to the capital of the Nabataeans. Several aspects of continuity from Nabataean days and ongoing connectivity with the centre of the Nabataean world can be noticed in Roman Udhrūḥ. This can also be derived from the following. The spring of Udhrūḥ was most

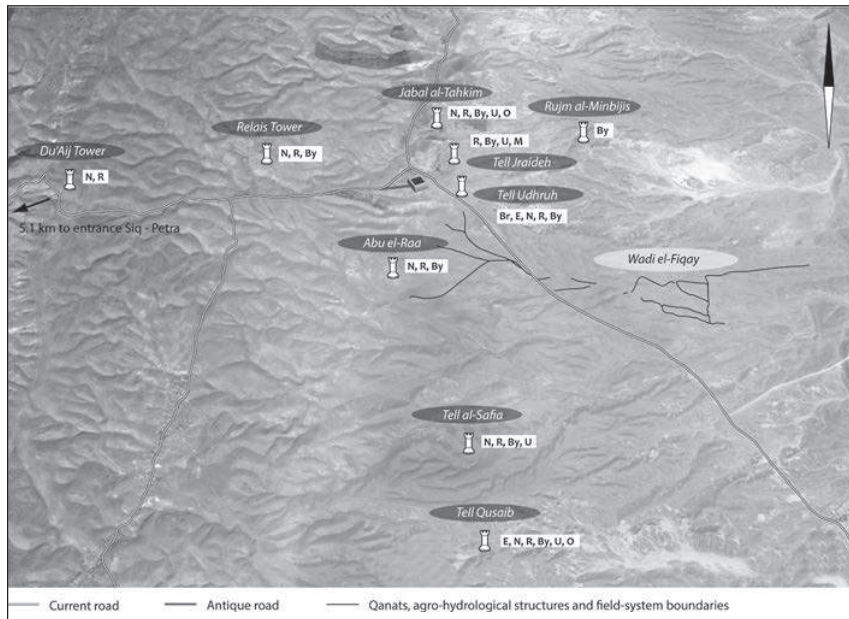
certainly an important factor for the choice of location for this Roman camp as had been for the preceding Nabataean structure¹⁶. In Roman times access to this water resource was located at the northeast side of the fortress, where a natural depression leads to the present-day spring. This connection to the spring and the control of this important water source is most probably the reason why this side of the *castra* has an atypical trapezoidal shape. Another unusual feature that struck us immediately, as has already been mentioned, was the slope on which the fort was built. The reason for this became clear when the location of what we suspect to be the Nabataean settlement and the *castra* southwest corner tower, proved to be a territorial marker connected to all the watchtowers identified in the region of Udhrūḥ. This seemed to be the case for the Nabataean, as well for the Roman signalling and communication system.

If we look at the ceramic evidence of the hilltop sites in the Udhrūḥ area it becomes clear that all of the surveyed Nabataean watchtowers were still in use or reused in the Roman period (FIG. 11). Most of the Roman sites in Jordan discussed by Kennedy (2000) exhibit ceramic evidence from the Nabataean period. A well-functioning communication system is of vital importance for any military organization, and the Roman military system was no exception. That the Roman military authorities put emphasis on military communication can be seen from both the archaeological and the historical record all around the empire. It looks like that for Udhrūḥ the connection with Petra as well as the north-south link were still of vital importance. Does the last link coincide with the routing of the *Via Nova Traiana* – a highly debated issue among archaeologists and historians – or with Roman eastern frontier? We are not going to give an answer in this paper, but leave this issue open to discussion. Does the system – as

15. Such South Gaulish terra sigillata sherds have also been recorded at several sites in and around Petra. The globalised distribution patterns of this ware in the whole antique world in the 1st century AD is considered as an early example of mass consumption and com-

moditisation (Woolf 1998: 185-205; Pitts 2015).

16. For the locational analyses of Roman military sites based on classical sources and archaeology, see e.g. Driessen 2007:28-35, tables 2.1 - 2.3.



11. Map of the Udhrūḥ region and watchtowers with ceramic finds (illustration by Joanne Porck).

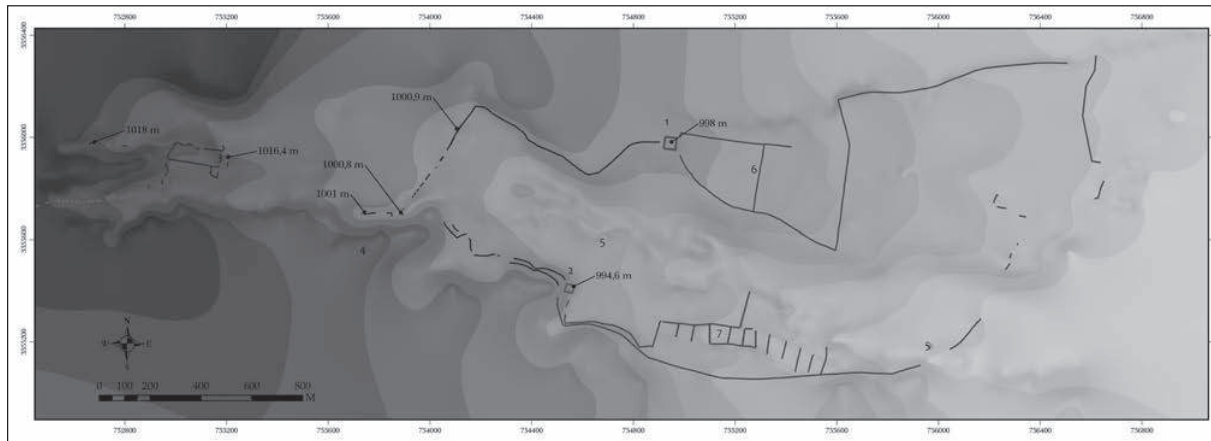
we think of being the case in the Nabataean period—also has an internal control function on the nearby agricultural schemes in the Roman era? If we look at the ceramic evidence from the combination of ancient rainwater-harvesting agricultural schemes in the area to the west and northwest of Udhrūḥ we see a strong Nabataean and also a Byzantine component, but Roman material seems to be lacking from these areas. Southeast of Udhrūḥ however, an impressive network of well-preserved ancient subterranean and surface-water conservation measures and associated irrigated fields – a *qanat*-system - was recorded in a large flood plain largely covered by alluvial deposits (FIG. 4 and 12). The basis of these *qanats* consist of four aquifers or water levels, tapped by subterranean canals which are constructed and maintained through more than 200 vertical *qanat*-shafts, probably hacked out of the limestone bedrock over an overall distance of more than 8.5km. The surface transport of the water is through more than 2000 m³ of solidly built channels and aqueducts, and it accumulates in large reservoirs with capacities of millions of litres of water,

constructed to irrigate an extended agricultural field system with at least 35 hectares of tilled land. These fields seem to consist of pockets of very fertile, though not easily cultivable soils. It became clear through observations in erosion gullies, small scale excavations and a combination of non-destructive geophysical ground-based and airborne exploration methods that the long-lived Udhrūḥ *qanat* and field systems are perfectly conserved. OSL dating of the mortars used for the construction of the large reservoirs shows that these were most probably built in the Roman period, with what seem to be adaptations and/or renovations in Byzantine times (Versendaal in Driessen/Abudanah 2017)¹⁷.

If this landscape was actively exploited this landscape with the investment of great effort and ingenuity in such an agro-hydrological intensification, would it not be logical to identify some sort of control over the safety of such investments? We would like to think so, and we suggest that the agro-hydrological systems in the region of Udhrūḥ are secured by the above described communication network. From the summits of Abū ar-Ru‘āḥ and Tall Udhrūḥ

17. 14C analyses of charcoal twigs found in the mortar of a later added supporting wall on the outside of one of the reservoirs dates in the Umayyad period. This might be evidence that the *qanat*- and field systems were still in use or were reused during early Islamic

times. The early Islamic periods are probably also very important in this context, but these are beyond the chronological range of this volume.



12. The antique water management and irrigated field systems in the Wādī al-Fiḡay, which is fed by the *qanat* system. 1) Northern reservoir - 50×50m; 2) Southern reservoir – 34×36m; 3) Smaller western reservoir – 15×15m; 4) Settlement Khirbat al-Fiḡay; 5) Large lime kiln ovens; 6) Northern field system; 7) Southern field system. The darker lines left of reservoirs 1-2 are surface channels, now partly covered with alluvial deposits. The lighter lines right of the reservoir are irrigation channels and field walls (drawing by Roeland Emaus).

we could follow our field teams working on these field systems in Wādī al-Fiḡay on some bright summer days. The distances of 6000 and 5100m between these are, however, beyond the calculated middle-distance range of 4400 m. In order to reconstruct the complete layout of the communication system in relation to these agricultural schemes we are still searching for the connecting spots between the above mentioned summits and the field systems. We might expect to find this connection within the boundaries of the middle-distance range of 4400m at an intermediate part of the water management system connecting the *qanat* shafts with the fields in Wādī al-Fiḡay. A possible candidate is a reservoir with clear views from and to Tall Udhrūḡ and Abū ar-Ru‘āḡ, with a distance of respectively 3500 m and 4250 m. The dimensions of this reservoir, that has been partially demolished by looters armed with a bulldozer, have been reconstructed to approximately 15×15m by means of research with a ground penetrating radar. As the remnants are retrieved just below the current ground level only the bottom 0.3-0.5m of the reservoir remains, in a flood plain filled up with alluvial deposits. A concentration of nicely cut rectangular and sometimes decorated coquina blocks –comparable to those of the Udhrūḡ *castra*– make clear

that a large structure can be suspected here. A 4 m high structure at this spot would visually also connect to the most prominent agricultural field systems at a distance of 1800-2600m. As seen before watchtowers in the studied region are not only positioned as solitary structures on the top of summits, but can be also part of homesteads or other structures (Negev 1988: 85-88; Hirschfeld 1995: 71-73; Koenen *et al.* 2013: 20, 85-86).

In Byzantine times the agricultural intensification seems to continue in the region around Udhrūḡ. In contrast, most of the other locations around Petra where in decline as can be observed in settlement continuity and/or agricultural use (Kouki 2012: 90-91). Several Byzantine literary sources mention Udhrūḡ (Adroh) as a large and important town (Fiema 2002: 209-210 plus references). According to one of these, the Beersheva Tax Edict, Byzantine Udhrūḡ had a provincial standing as it was taxed for 65 *solidii*, which is the highest on the list of places in the province of Palaestina Tertia (di Segni 2004: 151-152). Some of these sources, especially the 6th century Petra Papyri, refer to a place called *Augustopolis*, a town with (regional) jurisdictional powers situated not far from Petra (Frösen/Arjava/Lehtinen 2002; Arjava/Buchholz/Gagos 2007). Many scholars

accept the identification of Augustopolis with Byzantine Udhrūḥ (Fiema 2002: 209; Kouki 2012: 90, 99). One may well ask why this place was renamed prestigiously as *Augustopolis*, and how did it obtain the status of such a wealthy town? The Petra Papyri offer some hints indicating that the regional economy was based on agricultural production— with complex issues of hereditary-taxed landownership – in the Byzantine period. The agricultural intensification of the Udhrūḥ region can also be archaeologically attested. The *qanat*- and adjoining field systems in the Wādī al-Fiqay were still active in Byzantine times, as demonstrated not only by the OSL-dating but also by the establishment of an adjacent settlement¹⁸. The dry-land farming areas west and northwest of Udhrūḥ were reinstated in the Byzantine period, and the small fields in the Wādī Udhrūḥ which were under irrigation of Udhrūḥ's spring seem –according to the ceramic evidence– to be actively cultivated at this time.

In this period the communication system seems to focus again on the control of those fields that provided the landowners with their wealth. All hilltop structures yield Byzantine pottery, and two extra watchtowers seem to have been established for the guarding of the fields in the Wādī Udhrūḥ: Tall Jurayda and Rujm al-Munbajis. These had most probably only a local function in connection with Udhrūḥ and its bordering irrigated fields, as their visibility towards the other watchtowers in the region is very limited. The survey at the Du'ayj Tower towards Petra did not yield Byzantine material, may be this connection was not important any more. However the survey generated only a limited amount of pottery, so conclusions should not be drawn without further research.

Conclusions

The antique communication system in the area of Udhrūḥ –consisting in fortlets and

watchtowers on prominent summits– was established in the Nabataean period, and was not as some earlier researchers thought constructed as exclusive part of the Roman military defence.

Although the authors only studied this based on surveys, observed inter visibility and quantifiable visibility perceptions with a 240-4400m radius, it becomes already clear that it is a well laid out regional system which was most probably part of a larger communication network. The Nabataeans took care of the safety of their well defended country from strategically positioned posts –as also some antique authors mentioned– whereby they watchfully controlled the incoming roads. Most certainly also to safeguard the incoming caravans loaded with aromatics by which the Nabataeans accumulated part of their wealth and consequently power. The Nabataean people did transform the steppe region around Petra in an agricultural landscape consisting in new settlements, water harvesting and conducting works, and arable fields. The authors think that the Udhrūḥ communication system was a multi-purpose system through which the communication and control for military, trade, and agricultural settlements was combined. Udhrūḥ itself played a central role in the communication with its perennial spring located not far from a higher point that connected visibly to almost all regional summits. We even think that through we might have located the Nabataean settlement, but this has still to be further examined and is part of our research for the coming years. In the Roman period this perfectly laid out security system dating from the Nabataean period was reused, and most probably adapted to the wishes of the Roman authorities. Such an information network is on the one hand pivotal for a formal organization as deployed by the (late) Roman armies. The connection with Petra remains important in Roman days. On the other it can be observed that it might have played a role in controlling and safeguarding a

18. This settlement Khirbat al-Fiqay (site 44 in Abudanh 2006) – which was damaged severely by looters with bulldozers – will be part of future GPR-research and has till now produced fragments

of Nabataean, but especially Byzantine pottery. Here also many finished rectangular coquina limestone blocks have been found.

newly established agro-hydrological intensifications to the east of Udhrūḥ which was laid out with great effort and ingenuity. In the Byzantine period the region of Udhrūḥ was, in contrast with many other locations and settlements in the Petra vicinity, an area with agricultural intensification. The communication system was also in this period actively exploited, and most probably used to control and safeguard the wide variety of water harvesting and field systems in the area around Udhrūḥ. Further research on the Udhrūḥ communication system by means of non-destructive geophysical methods and destructive excavations is however necessary to produce more conclusive results, which are planned for future field campaigns.

About the Authors

Fawzi Abudanah and Mark Driessen are the directors of the Udhrūḥ Archaeological Project – a joint venture between the Petra School of Archaeology and Tourism of the Al-Hussein Bin Talal University from Wādī Mūsā and the Faculty of Archaeology of the Leiden University – and both are lecturers / researchers at their respective universities.

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Bibliography

Ancient Sources

Ammianus Marcellinus. 1950. Translated by John C. Rolfe. *Ammianus Marcellinus*. History. Books 14-

19. Cambridge Mass: Loeb.

Diodorus of Sicily. 1954. Translated by Russel M. Geer. *Diodorus Siculus*. Library of History. Books 19.66-20. Cambridge Mass: Loeb.

Modern Sources

Abudanh, F. 2006. *Settlement Patterns and Military Organisation in the Region of Udhrūḥ (Southern Jordan) in the Roman and Byzantine Periods*, Unpublished PhD-thesis Newcastle upon Tyne University: Newcastle upon Tyne.

Arjava, A., Buchholz, M. and Gagos, T. 2007. *The Petra Papyri III*, Amman: American Centre of Oriental Research.

Beckers, B. and Schütt, B. 2013. The Chronology of Ancient Agricultural Terraces in the Environs of Petra. Pp. 313-322 in W. Mouton and S.G. Schmid (eds.), *Men on the Rocks: The Formation of Nabataean Petra*. Berlin: Logos Verlag.

Besançon, J. 2010. Géographie, Environnements et Potentiels productifs de la Région de Pétra (Jordanie). Pp. 17-91 in P.L. Gautier, B. Geyer and M.O. Rousset (eds.), *Entre nomads et sédentaires, prospections en Syrie du nord et en Jordanie du sud*: Lyon (Travaux de la Maison de l'Orient 55).

Breeze, D.J. 2006. *Collingwood Bruce's Handbook to the Roman Wall*. Society of Antiquaries of Newcastle upon Tyne: Newcastle upon Tyne.

Clark, V. and Parker, S.T. 1987. The Late Roman Observation and Signalling System. Pp. 165-181 in S.T. Parker (ed.), *The Roman Frontier in Central Jordan: Interim Report on the Limes Arabicus Project 1980-1985*. Oxford: Archaeopress (BAR International Series 340).

Driessen, M.J. 2007. *Bouwen om te blijven: de topografie, bewoningscontinuïteit en monumentaliteit van Romeins Nijmegen*, PhD-thesis University of Amsterdam. Amersfoort (Published as Rapportage Archaeologische Monumentenzorg 151, with summaries and conclusions in English and German).

Driessen, M.J. and Abudanah, F. 2013. The Udhrūḥ Lines of Sight: Connectivity in the Hinterland of Petra, *Tijdschrift Voor Mediterrane Archaeologie* 50:45-52.

— 2015. The Udhrūḥ Archaeological Project – the 2011 - 2012 Field Surveys. Pp. 297-306 in L. Vagalinski and N. Sharankov (eds.), *Proceedings of the 22nd International Congress of Roman Frontier Studies Ruse, Bulgaria 2012*. Sofia: National Archaeological Institute / Bulletin of National Archaeological Institute 42.

— 2018. The Udhrūḥ Region: A Green Desert in the Hinterland of Ancient Petra. Pp. 127-156 in Y. Zhuang and M. Altaweel (eds.), *Water Societies and Technologies from the Past and Present*. London: UCL Press.

Fall, P.L. 1990. Deforestation in Southern Jordan: Evi-

- dence from fossil Hyrax middens. Pp. 271-282 in S. Bottema, G. Entjes-Nieborg and W. van Zeist (eds.), *Man's Role in the Shaping of the Eastern Mediterranean Landscape*. Rotterdam: Balkema.
- Fiema, Z. 2002. Late-antique Petra and its Hinterland: Recent Research and New. Pp. 191-252 in J.H. Humphrey (ed.), *The Roman and the Byzantine Near East*. Ann Arbor: *Journal of Roman Archaeology Supplement Series 49*.
- Finné, M., Holmgren, K., Sundqvist, H.S., Weiberg, E., Lindblom, M. 2011. Climate in the eastern Mediterranean, and Adjacent Regions, during the past 6000years – A review. *Journal of Archaeological Science* 38: 3153-3173.
- Frösén, J., Arjava, A. and Lehtinen, M. 2002. *The Petra Papyri I*, Amman: American Centre of Oriental Research.
- Gilbertson, D., Barker, G., Mattingly, D., Palmer, C., Grattan, J., Pyatt, B. 2007. Archaeology and desertification: the Landscapes of the Wadi Faynan. Pp. 397-421 in G. Barker, D. Gilbertson and D. Mattingly (eds.), *Archaeology and Desertification: The Wadi Faynan Landscape Survey*. Oxford: Levant Supplementary Series 6.
- Glueck, N. 1935. Explorations in Eastern Palestine II, *AASOR* 15: 60-80.
- Higuchi, T. 1988. *The Visual and Spatial Structure of Landscapes*. Cambridge MA: MIT Press.
- Hirschfeld, Y. 1995. *Palestinian Dwelling in the Roman-Byzantine Period*. Jerusalem: Franciscan Printing Press (Studium Biblicum Franciscanum, Collectio Minor 34).
- Kennedy, D.L. 2000. *The Roman Army in Jordan*. London: Council for British Research in the Levant.
- Kennedy, D.L. and Falahat, H. 2008. Castra Legionis VI Ferratae: A Building Inscription for the Legionary Fortress at Udruh near Petra. *Journal of Roman Archaeology* 21: 150-169.
- Kennedy, W.M. 2013. The Hills Have Eyes: GIS-based Studies on a Possible Watchtower on Umm al-Biyara. Pp. 271-293 in W. Mouton and S.G. Schmid (eds.), *Men on the Rocks: The Formation of Nabataean Petra*. Berlin: Logos Verlag.
- Killick, A.C. 1983. Udruh. The Frontier of an Empire: 1980 and 1981 Seasons, a Preliminary Report. *Levant* 15: 110-131.
- 1986a. Udruh and the Southern Frontier. Pp. 431-446 in P.W.M. Freeman and D.L. Kennedy (eds.), *The Defence of the Roman and the Byzantine East*. Oxford: Archaeopress (BAR International Series 297).
- 1986b. Udruh – eine Antike Städte vor den Toren Petra. Pp. 44-57 in M. Lindner (ed.), *Petra: Neue Ausgrabungen und Entdeckungen*. München/Bad Windsheim: Delp Verlag.
- Killick, M. 1990. Les Nabatéens à Udruh. *ARAM Periodical* 2, 1-2: 249-252.
- Koenen, L., Kaimio, J., Kaimio M. and Daniel, R.W. 2013. *The Petra Papyri II*, Amman: American Centre of Oriental Research.
- Kouki, P. 2012. *The Hinterland of a City: Rural Settlement and Land Use in the Petra Region from the Nabataean-Roman to the Early Islamic Period*. PhD-Thesis University of Helsinki: Helsinki.
- 2013. The Intensification of Nabataean Agriculture in the Petra Region. Pp. 323-333 in W. Mouton and S.G. Schmid (eds.), *Men on the Rocks: The Formation of Nabataean Petra*. Berlin: Logos Verlag.
- Negev, A. 1988. *The Architecture of Mampsis, Final Report I: The Middle and Late Nabataean Periods*. Jerusalem: MIT Press (Qedem 26).
- Pitts, M. 2015. Globalisation, Circulation and Mass Consumption in the Roman World. Pp. 69-98 in M. Pitts and M.J. Versluys (eds.), *Globalization and the Roman World: World History, Connectivity and Material Culture*. New York: Cambridge University Press.
- al-Salaameen, Z., Falahat, H., Naimat, S. and Abudanh, F. 2011. New Arabic-Christian Inscriptions from Udruh, Southern Jordan. *Arabian Archaeology and Epigraphy* 22: 232-242.
- Schmid, S. 2000. Die Feinkeramik der Nabatäer. Typologie, Chronologie und Kulturhistorische Hintergründe, Petra ezZantur II 1. Ergebnisse der Schweizerisch-Liechtensteinischen Ausgrabungen. *Terra Archaeologica IV*, Mainz: Philipp von Zabern.
- Segni, L. di, 2004. The Beersheba Tax Edict Reconsidered in the Light of a Newly Discovered Fragment. *Scripta Classica Israelica* 23: 131-58.
- Tholbecq, L. 2013. The Hinterland of Petra (Jordan) and the Jabal Shara during the Nabataean, Roman and Byzantine Periods. Pp. 295-311 in W. Mouton and S.G. Schmid (eds.), *Men on the Rocks: The Formation of Nabataean Petra*. Berlin: Logos Verlag.
- Versluys, M.J. 2015. Roman Visual Material Culture as Globalizing Koine. Pp. 141-174 in M. Pitts and M.J. Versluys (eds.), *Globalization and the Roman World: World History, Connectivity and Material Culture*. New York: Cambridge University Press.
- Wheatley, D. and Gillings, M. 2000. Vision, Perception and GIS: Developing Enriched Approaches to the Study of Archaeological Visibility. Pp. 1-27 in G.R. Lock (ed.), *Beyond the Map: Archaeology and Spatial Technologies*. Amsterdam: IOS Press.
- Woolf, G. 1998. *Becoming Roman. The Origins of Provincial Civilization in Gaul*. Cambridge: Cambridge University Press.
- Woolliscroft, D.J. 2001. *Roman Military Signalling*. Charleston SC: Tempus Books.