German Protestant Institute of Archaeology
(GPIA)

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Biblical Archaeological Institute Wuppertal
(BAI)

TALL ZIRA'A

Tall Zirāʿa

The Gadara Region Project (2001-2011)

Final Report

Volume 8.1

Wādī al-ʿArab Survey

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To Prof. Siegfried Mittmann

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List of Abbreviations

Abbreviated Journals and Series

AA	Archäologischer Anzeiger
AAJ	Annual of the Department of Antiquities of Jordan
AASOR	The Annual of the American Schools of Oriental Research
ADPV	Abhandlungen des Deutschen Palästina-Vereins
AJA	American Journal of Archaeology
AW	Antike Welt
BASOR	Bulletin of the American Schools of Oriental Research
BibAr	The Biblical Archaeologist
BSOAS	Bulletin of the School of Oriental and African Studies (London)
DaM	Damaszener Mitteilungen
GrRomByzSt	Greek, Roman and Byzantine Studies
IEJ	Israel Exploration Journal
JA	Journal Asiatique
JNES	Journal of Near Eastern Studies
JRS	Journal of Roman Studies
LA	Liber Annuus
MEFRA	Mélanges de l'École française de Rome. Antiquité
MKT	Menschen – Kulturen – Traditionen
NEAEHL	The New Encyclopedia of Archaeological Excavations in the Holy Land
OrA	Orient-Archäologie
PEQ	Palestine Exploration Quarterly
PSAS	Proceedings of the Seminar for Arabian Studies
QDAP	Quarterly of the Department of Antiquities of Palestine
RB	Revue Biblique
SHAJ	Studies in the History and Archaeology of Jordan
ZDPV	Zeitschrift des Deutschen Palästina-Vereins
ZOrA	Zeitschrift für Orient-Archäologie

Abbreviated Periods

Paleol.	Paleolithic
Neol.	Neolithic
Chalcol.	Chalcolithic
BA	Bronze Age
EBA	Early Bronze Age
MBA	Middle Bronze Age
LBA	Late Bronze Age
IA	Iron Age
IA I	Iron Age I
IA II	Iron Age II
IA IIC	Iron Age IIC
Hell.	Hellenistic
Rom.	Roman
E Rom.	Early Roman
L Rom.	Late Roman
Byz.	Byzantine
Isl.	Islamic
E Isl.	Early Islamic
L Isl.	Late Islamic
Um.	Umayyad
Abb.	Abbasid
Maml.	Mamluk
Ayy.	Ayyubid
Ottom.	Ottoman

Preface

by Dieter Vieweger/Jutta Häser

Fig. 0.1 Tall Zirāʻa. View from east to west. Photograph taken in 2011 (© APAAME, David Kennedy).

When the German engineer G. Schumacher explored Transjordan in 1885, Tall Zirāʻa was among his discoveries[1]. He was the first European since the time of the Crusaders to enter the region. However, after thousands of years of prosperity, the valley had changed dramatically during the Ottoman period. The bedouins told Schumacher that the wādī had declined to become a "popular shelter for all sorts of refugees and criminal scum".

Except for a few sugar mills, operated by water power, there were only a few small hamlets. A water flow of about 0.75 m^3 per second flowed through the Wādī al-ʻArab in June 1885, and the Wādī az-Zaḥar added the same amount of spring water. C. Steuernagel wrote:

> "Where the valley widens and the water becomes shallow, there are large numbers of trout that are easy to catch. Once while bathing, Schumacher saw a black water snake, almost a metre long. These are said to be very common here and are highly dreaded"[2].

The archaeologist N. Glueck visited Tall Zirāʻa in 1942. He reported the

> "singularly imposing and completely isolated hill of Tall Zeraʻah (...)"[3]

and mentioned a water source on the plateau of the tall as the

> "result of a natural siphon phenomenon leading the underground flow of the water from the high-

1 Schumacher 1890, 110. 142 f. Schumacher visited Tall Zirāʻa and described remains of rectangular buildings. His obeservations are published by C. Steuernagel (1926, 81).

2 Steuernagel 1926, 80. Citation is given in English translation; cf. also Schumacher 1890, 142 f. For Schumacher's travels see in general: Schumacher 1886.

3 Glueck 1951a, 182 Fig. 71.

er level of the hills beyond down to below the bottom and, as through a pipe piercing its center, up to the top of Tall Zera'ah".

Although the tall[4] had already attracted attention due to its location and imposing appearance, no intensive research was conducted at this time, because of the hill's location close to the border of Israel in the west (*c*. 7 km) and Syria in the north (*c*. 14 km). During the foundation of the State of Israel in 1948 and again during the Six Day War in 1967, the western part of the Wādī al-'Arab was declared by the Jordanians as a military zone. A passage which had been open in all directions for millennia was thus essentially cut off from sections of its surroundings. The territory around Gadara and the Wādī al-'Arab, in the triangle where Jordan, Syria and Israel meet, became the north-westernmost corner of the Hashemite Kingdom, and there was not even a paved road to the tall.

Also the construction of the Wādī al-'Arab Dam in 1978 did not make a significant difference to the *status quo*. The archaeologists who investigated the area within the scope of a rescue survey prior to the dam construction did not appreciate the archaeological potential of the tall, which majestically overlooked the future reservoir.

Another period of time passed until the Oslo Peace Agreement was ratified in 1993, but it was only after the peace treaty between Jordan and Israel, which King Hussein and Prime Minister Yitzhak Rabin signed on October 26, 1994, that the area again became accessible to the public.

D. Vieweger, director of the Biblical Archaeological Institute Wuppertal (BAI) and since 2005 also of the German Protestant Institute of Archaeology (GPIA), travelled many times through the north-western part of Jordan between 1998 and 2000, exploring the area for a suitable tall site, which would serve as an authoritative chronological record for the region's long and important cultural history. He found it in the Wādī al-'Arab.

Tall Zirā'a is located in the middle of the Wādī al-'Arab (*Figs. 0.1* and *0.2*), was continuously occupied for at least 5,000 years, and offers an unique insight into the way of life of the region's people. Its outstanding archaeological significance results from the artesian spring in its centre, which created optimal settlement conditions over thousands of years. For this reason, Tall Zirā'a offers an unusual opportunity to compile a comparative stratigraphy for northern Jordan from the Early Bronze Age to the Islamic period, while also making it possible to trace cultural developments in urban life, handicrafts and the history of religion over long periods. Moreover, here it is possible to study abundant remains from the Biblical periods in a broad cultural and historical context.

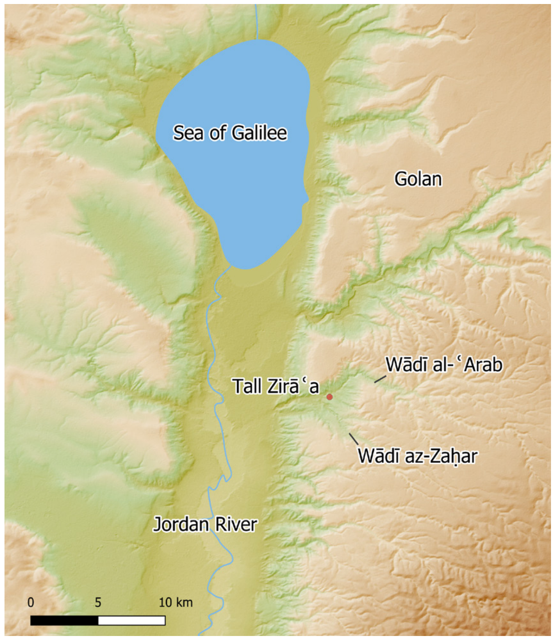

Fig. 0.2 Map showing the area around Tall Zirā'a (P. Leiverkus © BAI/GPIA).

As mentioned above, a major trade route passed through the valley, connecting Egypt in the south with the Syrian-Mesopotamian region in the north (*Fig. 1.22*). The Wādī al-'Arab also connects the Jordan Valley to the Mediterranean coast via the northern Jordan ford at Ǧisr al-Maǧāmi' (Gešer), as well as the plains of Jezreel and Tall al-Ḥiṣn (Beth Shean) to the eastern Jordanian highlands. It was possible to climb from the Jordan Valley, at some 290 m below sea level, to the fertile and very early populated Irbid-Ramtha basin, which lies around 560 m above sea level. Direct routes led from the Irbid-Ramtha basin to Dimašq (Damascus) in the north, Baġdād in the east, and 'Ammān in the south.

4 The Arabic word 'tell' or 'tall' as well as the Hebrew word 'tel' will be written in this publication in the standard literary Arab version 'tall' or 'Tall NN'.

Because the Yarmuk Valley to the north and the Wādī Ziqlāb in the south are too steep and narrow to serve as major transport routes, the Wādī al-ʿArab played a prominent geopolitical role. Not surprisingly, economic success and the hard work of residents across the millennia have left a profusion of traces in the valley. More than 200 sites of human habitation, from the very earliest settlements to the Islamic period, provide an eloquent testimony to the history of this region: settlements, channels, water mills, cisterns, oil presses, wine presses, watchtowers and grave sites.

Tall Zirāʿa offered good living conditions for a settlement. The artesian spring offered an unfailing water supply, and the hill provided security. The tall rises impressively (depending on the direction) between 22–45 m above ground. As the only prominent natural elevation in the lower Wādī al-ʿArab, Tall Zirāʿa dominates the valley. From here one cannot only see Gadara, but also easily monitor the narrow entrance of the wādī to the west.

The adjacent fertile wādī ensured adequate nourishment, with potentially arable land in the western and central valley, terraced slopes and spurs suited for rainfed agriculture in the east, as well as the wādī slopes that are suitable for grazing small livestock, forming a broad semicircle from the east and south to the west. As a result of his observations, D. Vieweger decided to implement preliminary investigations here from 1998 to 2000.

The ʻGadara Region Project' was launched in 2001 by the Biblical Archaeological Institute Wuppertal (BAI), Germany. In the first season, the surface of Tall Zirāʿa was explored[5], the tall was accurately surveyed, and more than 22,000 pottery sherds and many other finds were systematically collected and analysed. The survey findings helped to formulate the objectives of the excavation program, and to select suitable areas (residential, religious, administrative and craft production) for investigation.

The first excavation season on the tall was in 2003. The team was financed by the ʻSociety of Friends of the BAI Wuppertal' and travelled by Volkswagen bus from Wuppertal to Amman via Turkey and Syria, under the direction of D. Vieweger. An Ottoman period house inside the Gadara/Umm Qēs archaeological site was used both as living and working quarters; it was in a state of very

Fig. 0.3 Tall Zirāʿa and its geographic location (P. Leiverkus © BAI/GPIA).

poor repair at that time, but has been systematically restored during later seasons, providing modern bathroom and kitchen facilities. The results of the first season on Tall Zirāʿa were so promising that the ʻGadara Region Project' was inaugurated, with a planned timeframe of between ten to twenty years.

In 2004, the Biblical Archaeological Institute Wuppertal (BAI) under the directorship of D. Vieweger, and the German Protestant Institute of Archaeology (GPIA) in Amman (which also served as the research unit for the German Archaeological Institute [DAI]), under the directorship of J. Häser, agreed to a close partnership, which ensured ongoing archaeological and interdisciplinary collaboration for the remainder of the archaeological seasons. The German Protestant Institute of Archaeology in Jerusalem (GPIA), run by D. Vieweger since 2005, also joined the work in 2006. The cooperation with the GPIA Amman was confirmed by the new director of the institute, F. Kenkel, from 2013 to 2016, and by K. Schmidt since autumn 2016.

5 See *Vol. 1., Chap. 2*. For this survey see also Vieweger et al. 2003, 191–216.

During the course of the subsequent 18 seasons, twenty-five strata in three areas have been uncovered, and several scientific processes and archaeological experiments have been carried out; archaeological surface surveys were also completed for the area surrounding Tall Zirāʻa, the Wādī al-ʻArab, and the Wādī az-Zaḥar.

The slopes of Wādī al-ʻArab from Tall Zirāʻa upwards to the region of Ṣēdūr and Dōqara, and the region around the Wādī al-ʻArab Dam were surveyed in 2009; large parts of this region had not been studied in detail before. In total, 78 locations were documented, 30 of which were previously unknown. The survey was continued until 2012. All in all 327 sites were registered which cover an area from Tall Zirāʻa to North Šūna.

All finds were stored at the excavation house in Umm Qēs. Some of the more important finds were exported to the Biblical Archaeological Institute Wuppertal (BAI) and restored by M. Blana; they were returned to the 'Department of Antiquities of Jordan' (DoA) over several stages, with the final delivering to Jordan in the spring of 2015. Furthermore, more than 50 objects discovered during the project are on display in the Jordan Museum in Amman.

Excavation results have been presented as articles in several journals, together with separate publications and dissertations[6]. In addition, the Tall Zirāʻa website provides information about current activities on and around the tall in German and English[7].

After 18 intensive seasons of work researching the tall and its environment, it was decided to interrupt excavation and survey activities in order to publish a complete record of the results thus far. To this end, it was decided that from 2012 until 2020 work would be comprised of study seasons in the excavation house at Umm Qēs, to process data and results gathered to date (for the excavations carried out see the film in *App. 0.1*).

A total of nine volumes are planned on the following topics:

Volume 1: Introduction.
Aims of the 'Gadara Region Project'; Tall Zirāʻa and the Wādī al-ʻArab; Research History of Tall Zirāʻa; the 2001 Tall Zirāʻa Survey; Scientific Methods; Framework of Archaeological Work on Tall Zirāʻa.

Volume 2: Early and Middle Bronze Age (Strata 25–17)

Volume 3: Late Bronze Age (Strata 16–14)

Volume 4: Iron Age and Persian Period (Strata 13–9)

Volume 5: Hellenistic to Umayyad Period (Strata 8–3). Stratigraphy

Volume 6: Hellenistic to Umayyad Period (Strata 8–3). Ceramic, Glass and Metal Finds

Volume 7: Abbasid to Ottoman Period (Strata 2–1)

Volume 8: Wādī al-ʻArab Survey

Volume 9: Archaeometry

All nine volumes will be published online in English, in order to make the results free of charge and accessible to a wide audience. In addition to this, publishing online enables the 3D-images and reconstructions, together with digital films, to be included with the material, which can thus be integrated and used interactively. Furthermore, an online publication will enable the attachment of original data from the excavations, such as plans and database extracts, which would be otherwise impossible.

6 See e.g. Vieweger et al. 2002a, 12–14; Vieweger et al. 2002b, 157–177; Vieweger et. al. 2003, 191–216; Vieweger et al. 2016, 431–441; Vieweger 2003a, 10; Vieweger 2003b, 459–461; Vieweger 2007, 497–502; Vieweger 2010, 755–768; Vieweger 2013, 231–242; Häser et al. 2016a, 121–137; Häser et al. 2016b, 497–507; Häser – Vieweger 2005, 135–146; Häser – Vieweger 2007, 526–530; Häser – Vieweger 2009, 20–23; Häser – Vieweger 2012a, 693–696; Häser – Vieweger 2012b, 251–268; Häser – Vieweger 2014, 640; Häser – Vieweger 2015, 20–23; Vieweger – Häser 2005, 1–30; Vieweger – Häser 2007a, 1–27; Vieweger – Häser 2007b, 147–167; Vieweger – Häser 2009, 1–36; Vieweger – Häser 2010, 1–28; Vieweger – Häser 2015; Vieweger – Häser 2017a; Vieweger – Häser 2017b; Kenkel 2012; Kenkel 2013a, 1–24; Kenkel 2013b, 301–308; Kenkel 2016, 765–781; Kenkel – Vieweger 2014, 12; Schwermer 2014; Gropp 2013; Lehmann – Schulze 2015, 28–30; Schulze et al. 2014, 13; Soennecken – Leiverkus 2014, 14; Soennecken – Leiverkus 2016, 509–518; Soennecken 2017.

7 For an overview of publications see www.tallziraa.de.

These additional documents will be published in German and will provide professional researchers with the ability to access the primary data itself, not only as they are interpreted.

General remarks regarding systems and processes used within the publications follow herewith:

- The Israel or Palestine Grid 1923 is the basis for the geographical grid system used for the project. It was first used in autumn 2001 for 5 m x 5 m squares on Tall Zirāʻa, and was consequently applied for excavation and survey work alike (see *Vol 1., Chap. 4.1.*).
- Citation styles are based on the directives provided by the German Archaeological Institute (DAI), but have been adapted to the conventions of English language publications.
- In order to minimise misunderstanding, the problem of transliterating Arabic and Hebrew words into English spelling using Latin letters for local sites and family names is dealt with by using the transcription system of the 'Deutsche Morgenländische Gesellschaft', based on the directives of TAVO (see the Tübinger Bibelatlas).
- For detailed explanations of the chronology of the Southern Levant in the scope of the history of Egypt, Syria and Mesopotamia, see Vieweger 2012, 459–507 (*Vol. 1., Chap. 4.3.*).
- In this report the name of the site is called *Tall Zirāʻa*. Other transcriptions are e.g.: *Tell Zerʻah* (MEGA Jordan; Jadis; Kerestes et al. 1977/1978; Glueck 1951a; Glueck 1951b); *Tell Zerʻa* (Reicke – Rost 1979); *Tell Zara'a/ Tell Zaraʻa* (Schumacher 1890 and Steuernagel 1926); *Tell Ziraʻa* (Hanbury-Tenison 1984).
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Introduction and Acknowledgments

by Katja Soennecken/Patrick Leiverkus

Fig. 0.4 The Wādī al-ʿArab.

To really understand a site, knowledge of its surroundings is essential. How was the site connected to its vicinity? What was its position? Which settlements surrounded the place? How did trade routes run? Who were the neighbours? To get closer to the answers to these questions, we conducted a survey of the surrounding area of the Tall Zirāʿa. The first results and an extensive collection of material are presented in the now available volumes 8.1 and 8.2.

Volume 8.1 is divided into two large chapters: The Wādī al-ʿArab Survey and related research projects in the Wādī al-ʿArab. The first chapter provides an overview of previous surveys in the region, methodology and objectives of our survey and the individual campaigns. *Chap. 1.5.* offers a rough description of the sites through the ages and *Chap. 1.6.* presents special finds (pottery by Katja Soennecken, lithics by Benjamin Schröder, stone vessels by Katja Soennecken, glass by Stefanie Hoss). Unfortunately, we also have to write a chapter about the observed destruction in the examined area.

All this does not represent a final evaluation, but rather presents highlights that require further in-depth research. *Chap. 2.* is dedicated to landscape archaeology and geobotany (Linda Olsvig-Whittaker), archaeobotany (Avi Shmida, Linda Olsvig-Whittaker, Katja Soennecken) as well as geology (Sabine Kraushaar et al.).

In volume 8.2 the catalogue of the sites is presented.

The authors would like to extend their heartfelt thanks to Prof. Dr. Dr. Dr. h. c. Dieter Vieweger and Dr. Jutta Häser for enabling them to conduct this survey and also for their support in the process. Likewise, the authors wish to thank the Volkswagen Foundation, whose financial support made this publication possible.

This kind of venture is not possible for a single person, but requires a strong team.

This team consisted of the following persons (in alphabetical order):
Kim Adam; Antje Cassel (release of the find photos); Dr. Jutta Häser (small finds); Dr. Stefanie Hoss (glass); Dr. Frauke Kenkel (pottery); Dr. Sabine Kraushaar (geology); Anke Laderick; Patrick Leiverkus (director/technical support/database); Dr. Linda Olsvig-Whittaker (landscape archaeology and archaeobotany); Alina Quentmeier (photography in the field); Benjamin Schröder (flint); Anne Schürmann; Dr. Andrea Schwermer (pottery); Dr. Avi Shmida (archaeobotany); Dr. Katja Soennecken (director/documentation).

We would like to take this opportunity to thank them all!

The realization of a survey in a previously surveyed area is—in retrospect—a surprisingly rewarding task, even if it is less of a pioneering endeavour. It is more about maintaining the records, filling the gaps, recording the losses, trying to clear up the picture by using most recent knowledge and modern techniques. So we like to look upon this survey not just as an individual venture but rather as part of an ongoing long-term survey. We stood on the strong shoulders of our elders like Nelson Glueck and Siegfried Mittmann. The work has to continue with refined knowledge and better techniques—by us and hopefully by many others to come. In this volume we present all sites and finds. A detailed analysis, i.e. a settlement archaeological investigation also making use of current methods of geostatistics and testing their applicability for archaeological research, is planned.

Fig. 0.5 Survey team walking along the Wādī al-ʻArab.

1. The Wādī al-ʿArab Survey

by Katja Soennecken/Patrick Leiverkus

1.1. Introduction

During the summers of 2009 to 2011 a survey was conductes in the Wādī al-ʿArab and its vicinity by the Biblical-Archaeological Institute Wuppertal and the German Protestant Institute of Archaeology. This survey is an integral part of the "Gadara Region Project". It was planned to be a hinterland survey for the Tall Zirāʿa excavation. The aim was to get a thorough understanding of the landscape in which Tall Zirāʿa is the most prominent archaeological site. At the very heart of such an exploration are the questions of settlement pattern, distribution, relation and relative importance through time. Furthermore, Wādī al-ʿArab is one of the easily passable ascents from the Jordan valley to the Irbid-Ramtha-basin and so has been part of trade routes from the Mediterranean coast to Damascus, Mesopotamia, or Amman. Questions of the actual trade routes crossing this area and their shifting importance throughout time arise. This survey is focused on evidence that could help answer these questions. It is clear that the information of the sites in the wādī and its vicinity has to be as detailed and up to date as possible.

This volume merely presents the find material; an investigation of the settlement archaeology with a detailed evaluation is forthcoming. The area under inspection comprises the catchment area of the Wādī al-ʿArab except for the wider area of the modern city of Irbid.

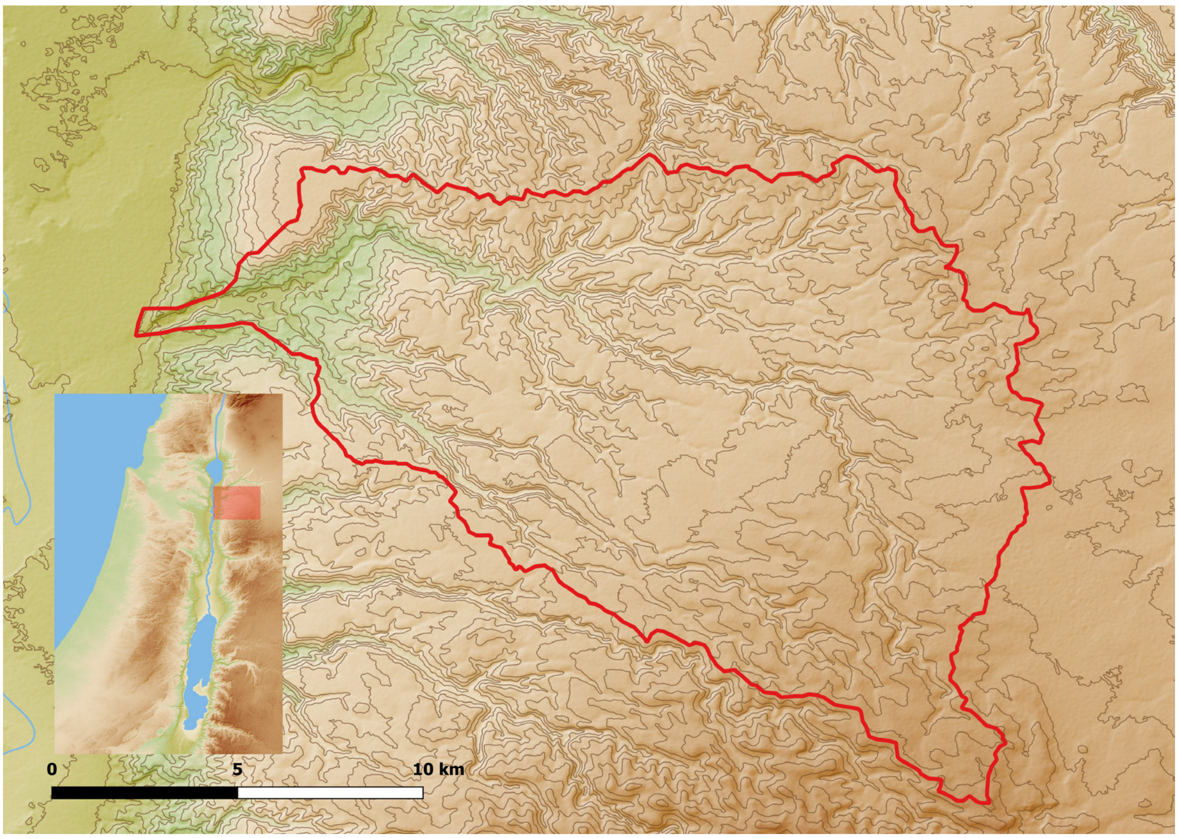


Fig. 1.1 The survey area (P. Leiverkus © BAI/GPIA).

1.2. Previous Surveys in the Area

Wādī al-ʻArab had already been the object of several previous surveys, starting with G. Schumacher's in 1889[1]. Not all of the archaeological surveys in the region explored the Wādī al-ʻArab as a whole. Some of the researchers focussed on sub-regions, like C. Lenzen and A. McQuitty[2], who investigated the area around Bēt Rās, or L. El-Khouri[3], who studied the region west of Irbid. Others, like S. Mittmann, conducted their survey on a much larger geographical scale and thus confined their research in the Wādī al-ʻArab to its more prominent archaeological sites. In the following text, only those studies will be outlined that proved to be of particular relevance to the current Wādī al-ʻArab survey.

1.2.1. N. Glueck—1932–1947

In the course of the 1930s and 1940s, N. Glueck[4] documented more than a thousand archaeological sites across the entire territory of Transjordan. During World War II he was employed by the American Forces in Transjordan and was able to continue his work as an archaeological surveyor. In this period of time, he listed more than 200 settlements in the north of the country. In the investigation area of the Wādī al-ʻArab, 42 locations were registered, 34 of which were revisited and documented in the course of this survey.

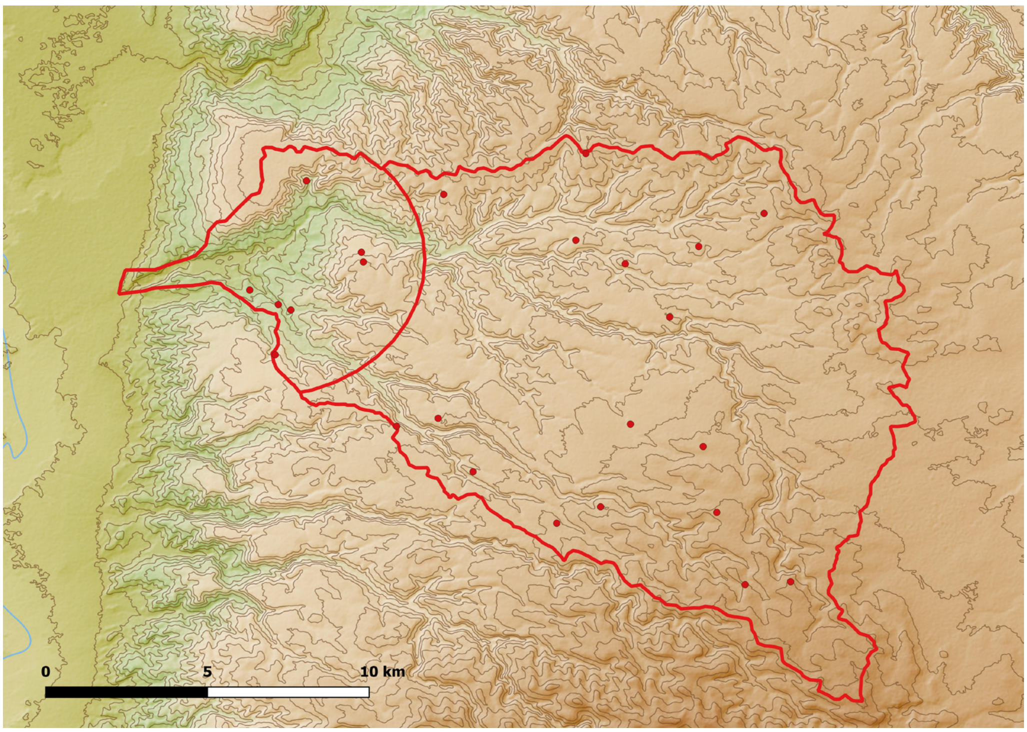


Fig. 1.2 Sites documented by N. Glueck (P. Leiverkus © BAI/GPIA).

1 Schumacher 1893.

2 For example Lenzen – McQuitty 1983; Lenzen – McQuitty 1985; Lenzen – McQuitty 1988.

3 El-Khouri 2007a.

4 Glueck 1939; Glueck 1942; Glueck 1951.

1.2.2. S. Mittmann—1963–1966

On behalf of the German Protestant Institute of Archaeology, S. Mittmann[5] conducted a survey in northern Transjordan from August 1963 until January 1966. In doing so, Mittmann focussed on the regions not included in Glueck's documentation and explored an area that reached as far as the Wādī Ǧaraš. For the investigation area of the Wādī al-ʿArab, 43 locations were listed, 33 of which were revisited and documented in the course of this survey.

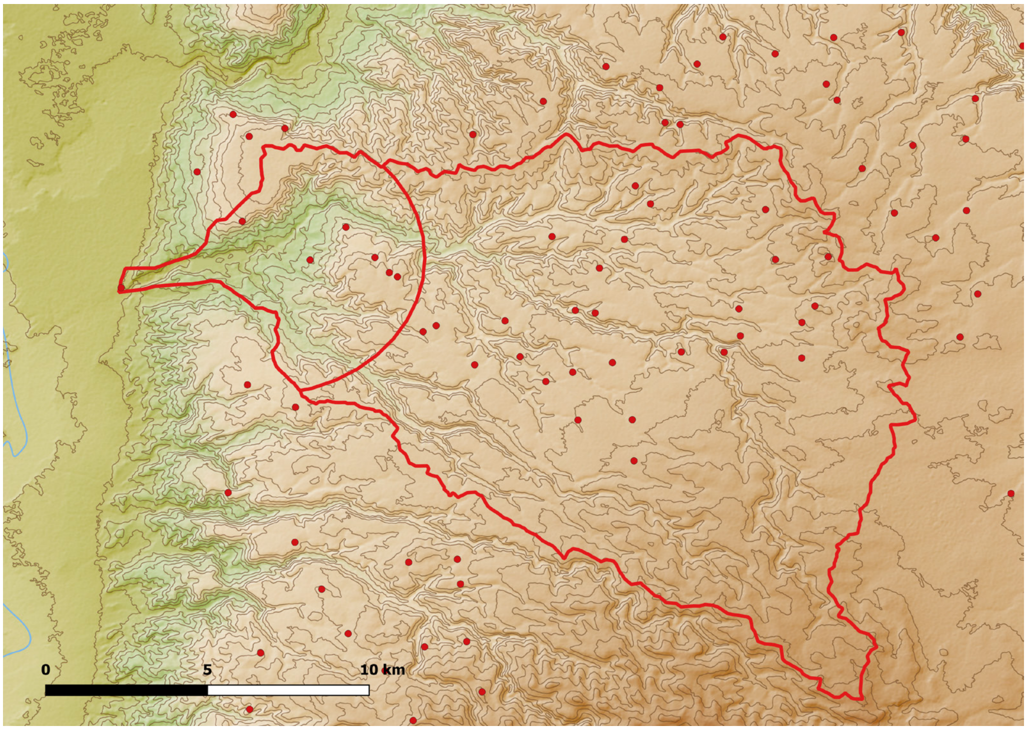


Fig. 1.3 Sites documented by S. Mittmann (P. Leiverkus © BAI/GPIA).

5 Mittmann 1970.

1.2.3. J. W. Hanbury-Tenison—1983[6]

In September 1983, three survey areas were explored in the course of 18 days: a) to the west, 11 km² across the entire mouth of the wādī, b) central, 8 km² in the area of the ridge near Umm Qēs (Gadara), and c) to the east, 6 km² in the area of the modern village of Sōm. A total of 25 km² were covered and 102 archaeologically relevant sites were documented. The survey was limited to representative areas in order to demonstrate the total potential of the wādī. The area of the Bēt Rās survey was excluded, as was the Jordan Valley. As the survey's objective was getting a general overview, no detailed pictures or descriptions of the sites were provided even though pieces of pottery were collected (all of them at smaller locations while only a choice selection was deliberately assembled at larger sites).

For the investigation area of the Wādī al-ʿArab, 93 archaeologically relevant sites were listed, 13 of which were revisited and documented in the course of this survey. Unfortunately, the substantial discrepancy between the numbers of locations named and those revisited is largely due to destructions and particularly to the new construction of terraces for olive tree plantations during the past 20 years for which many of the archaeological sites were sacrificed. However, the very sparse site descriptions by J.-W. Hanbury-Tenison were not very conducive to relocating them, either.

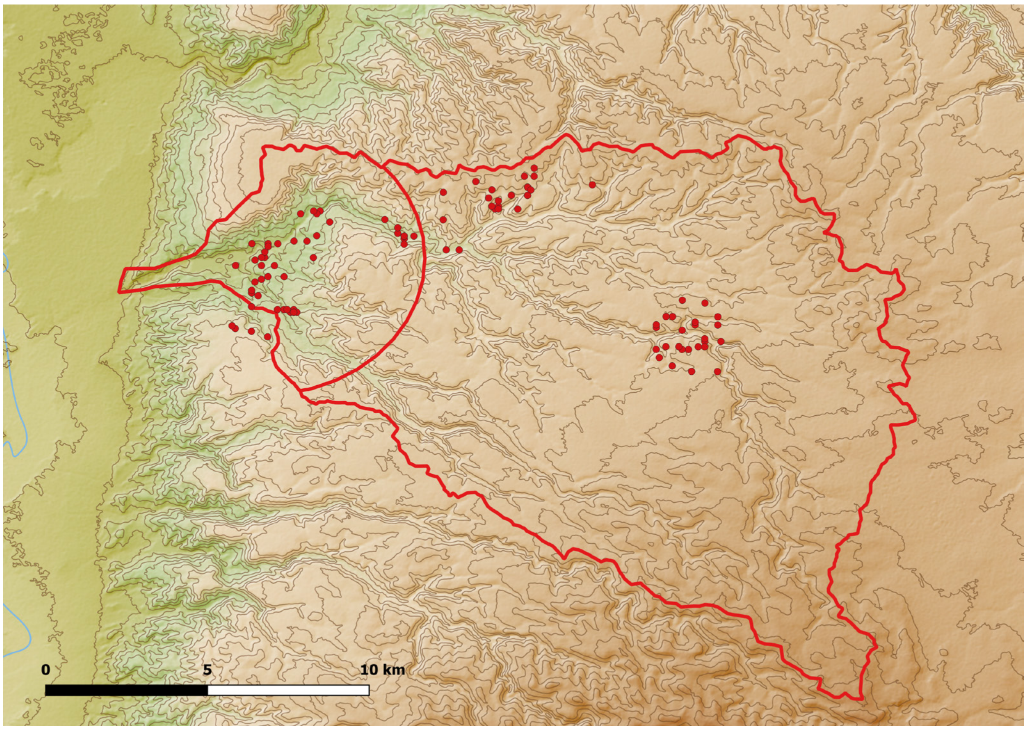


Fig. 1.4 Sites documented by J. W. Hanbury-Tenison (P. Leiverkus © BAI/GPIA).

6 Hanbury-Tenison 1984; Hanbury-Tenison et al. 1984.

1.2.4. L. El-Khouri—2005

The "West Irbid Survey" was conducted by L. El-Khouri and her team in September 2005 in an area of 71 km^2 located west of Irbid. This survey had three objectives: first, registering the larger archaeological settlements, including dolmens, and understanding their connection with the nearby chalcolithic and Bronze Age settlements. Second, the researchers wanted to better understand the rural nature of the Classical period settlements and their social and economic context. Finally, a comprehensive documentation (description, photography, collection of artefacts, and GIS-mapping of the area) of the settlements during the different eras was undertaken[7].

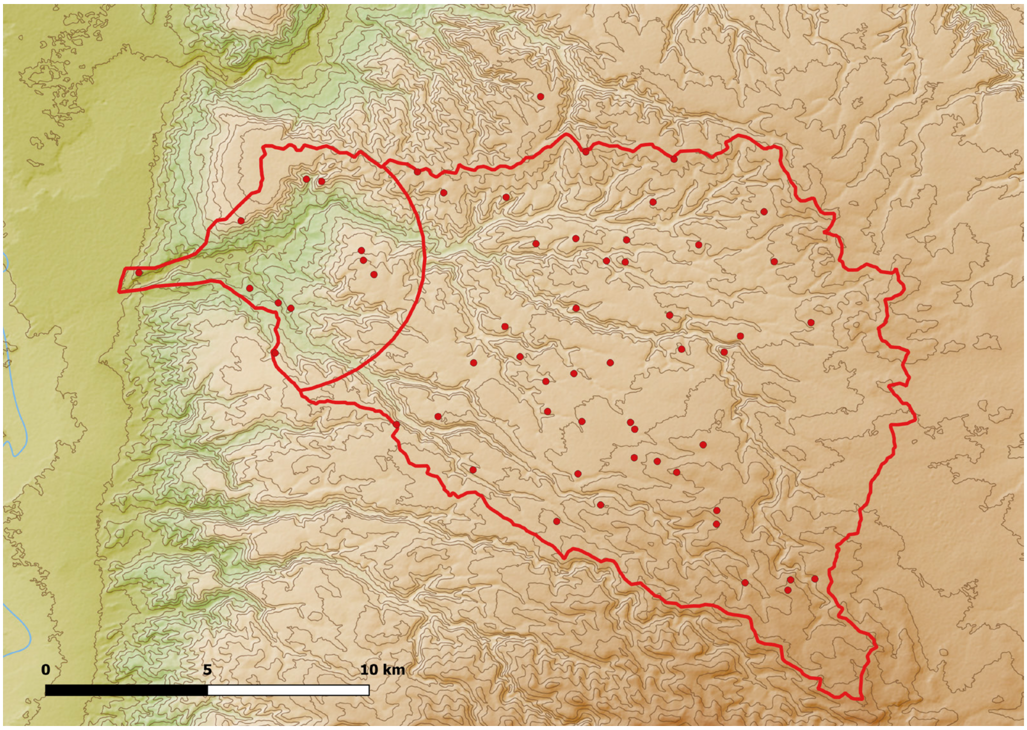


Fig. 1.5 Sites documented by L. El-Khouri (P. Leiverkus © BAI/GPIA).

1.2.5. T. Kerestes, J. Lundquist, B. Wood, K. Yassine—1978

For the purpose of securing archaeological information prior to the planned construction of several reservoir dams in northern Jordan, a survey was conducted in 1978[8]. In the process, three sites were documented in the area of the Wādī al-ʿArab.

7 El-Khouri et al. 2006; El-Khouri 2009.

8 Kerestes et al. 1978.

1.3. Methodology and Aims of the New Wādī al-ʿArab Survey

In this chapter, the targets of the Wādī al-ʿArab survey from 2009 to 2011, and the methodology applied, will be expounded. In spite of the fact that the region as a whole had already been subject to several explorations and all related publications were and still are valuable and constitute abundant sources of information, neither of them provided the completeness and level of detail necessary for the purpose of the "Gadara Region Project".

Glueck and Mittmann had a much broader area in view and could therefore only cover the major sites of the area of interest. J. W. Hanbury-Tenison's survey, due to its level of detail, is restricted to only three areas and does not cover the entire Wādī al-ʿArab. Furthermore, as this survey is now one generation old, a fresh look on all the given data seems appropriate, considering the much more elaborate stratigraphy and typology of the region today due to the continuing efforts of the "Gadara Region Project" and other projects.

Given the knowledge acquired during the previous surveys and with the target of a hinterland survey in mind, the approach chosen was two-fold: On the one hand revisiting the known sites, and complementing and enhancing the information about them, and on the other hand filling the gaps by surveying the areas that had not been surveyed before. During the three seasons in question, the hinterland of the Tall Zirāʿa was examined completely—the area of investigation was divided into the zones A and B. Zone A is the area in the vicinity of Tall Zirāʿa, and Zone B comprises a broader range that reaches as far as Irbid. We tried to cover Zone A completely and without a gap, whereas in Zone B we concentrated on the known or larger sites.

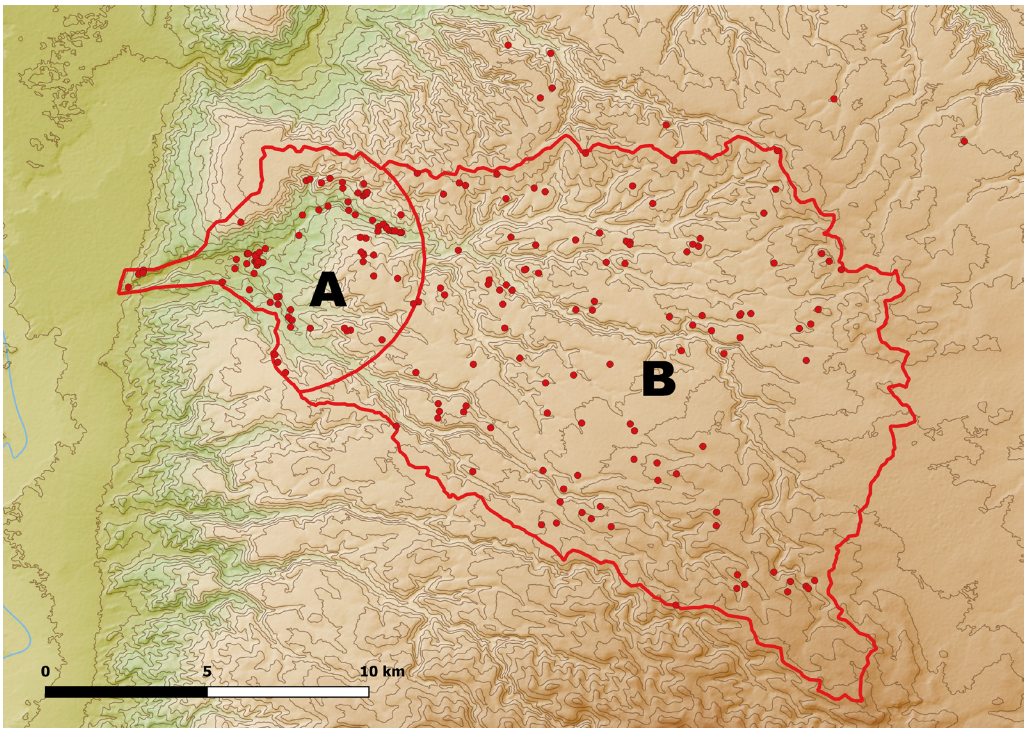


Fig. 1.6 Zones A and B with documented sites (P. Leiverkus © BAI/GPIA).

Within the boundaries of Zone A, the area was inspected on foot, the participants spreading out at a distance of 10 m from each other. If a (new) site was discovered, this distance was reduced to 5 m on large sites, and to arm's length on smaller ones. The exact location of each site was identified by GPS. In addition, the area or expanse of a site was documented, as were its topographical position and its exact properties and condition.

Single contexts inside one site were measured and described individually. These contexts were mostly tombs, cisterns, or agricultural installations—but also larger single finds that were not removed from the site, such as hewn ashlars, millstones, or sarcophagi. Smaller single finds (grinding stones, flints, pieces of pottery, or glass) were collected. If the site was already known, only randomized pieces of pottery were taken in order to compare them to the specifications found in the literature. Place descriptions were updated.

An overview photo was taken from each site, and every context was also photographed. All information gathered was entered into a database. In addition, bibliographical references and possible divergences of coordinates were recorded in this database.

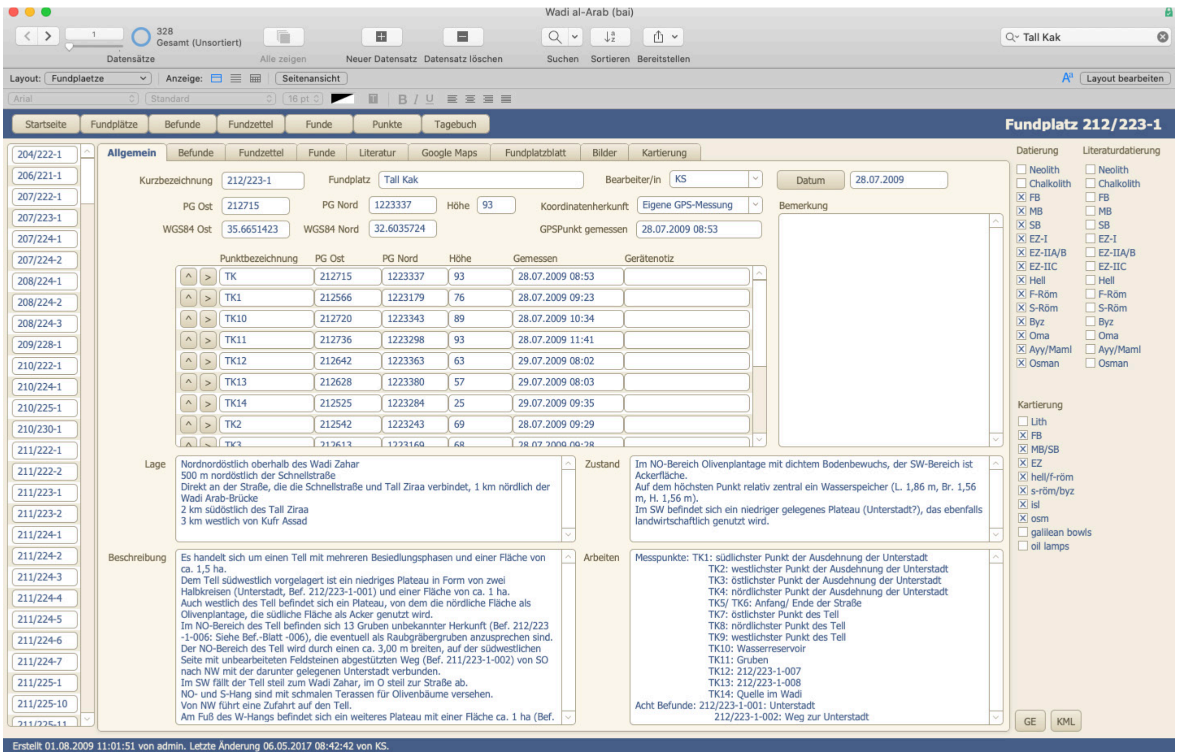


Fig. 1.7 Excerpt from the database.

The typological differentiation of the ceramics and their attribution to different ware groups were made in keeping with the categories and classifications devised for the Tall Zirāʻa. The flint finds and the glass finds were typologized accordingly. Identification of the individual pieces of pottery was carried out by Dr. Andrea Schwermer[9] (pre-classical eras) and Dr. Frauke Kenkel[10] (classical eras). The flint finds were categorized by Benjamin Schröder[11], and the glass finds by Dr. Stefanie Hoss[12]. Dr. Jutta Häser made all the drawings of the small finds, and Antje Cassel helped to provide all the find photographs. Our most sincere thanks go to all of them.

9 For a detailed typology of cooking pots, cf. Schwermer 2014.

10 For a detailed typology of classical ceramics on the Tall Zirāʻa, cf. Kenkel 2012; Kenkel 2020.

11 For a detailed typology of flints, cf. Schröder (forthcoming).

12 For a detailed typology of glass finds, cf. Hoss (*Chap. 1.6.3.* in this volume) and Hoss 2020.

Combined with the knowledge of the previous surveys, we are now able to map 327 sites and installations. Each of the sites was dated and categorized based on its ceramics and/or its architecture. The categories are: settlement, single complex, installation, cistern, tomb, cave, and sherd find. For definitions of the individual categories, please confer *Chap. 1.5.3.*

It is of course important to keep in mind that the numbers cannot be regarded as absolute since naturally younger sites can be more easily found whereas more ancient ones bear a higher likelihood of being buried. We must therefore assume that the absolute number of prehistoric and early settlements was much larger.

1.4. Seasons

1.4.1. 2009 Season

The first season took place from 28 July to 13 August 2009 with the following participants: Kim Adam, Antje Cassel, Anke Laderick, Patrick Leiverkus, Anne Schürmann, Andrea Schwermer, Benjamin Schröder, Katja Soennecken, Alina Quentmeier—supported on some days by the participants of the training course, Eva Fricke and Peter Voss, and the GPIA trainee, Felix Demandt.

Fig. 1.8 Participants mapping an Ottoman mill.

During the first campaign, 71 sites were recorded, 30 of them not previously published/known. More than 80 percent of the sites date from the classical periods. The other sites were inhabited during the Bronze Age, the Iron Age or different Islamic periods. Lithic sites could not be discovered. The large talls, Tall Qāq (Ḫirbat Bond) and Tall Ra‘ān (Tall Kinīse), were revisited. The area around the Wādī al-‘Arab Dam, which was in part surveyed by T. Kerestes in 1978 and by J.-W. Hanbury-Tenison in 1983, was covered as well. Furthermore, the slopes of the Wādī al-‘Arab from Tall Zirā‘a upwards to the region of Ṣēdūr and Dōqara were surveyed. The larger part of this area had not been surveyed in detail before. While Ṣēdūr and Dōqara themselves were mentioned by S. Mittmann the surroundings revealed many sites that shed new light on the settlements’ agricultural subsistence.

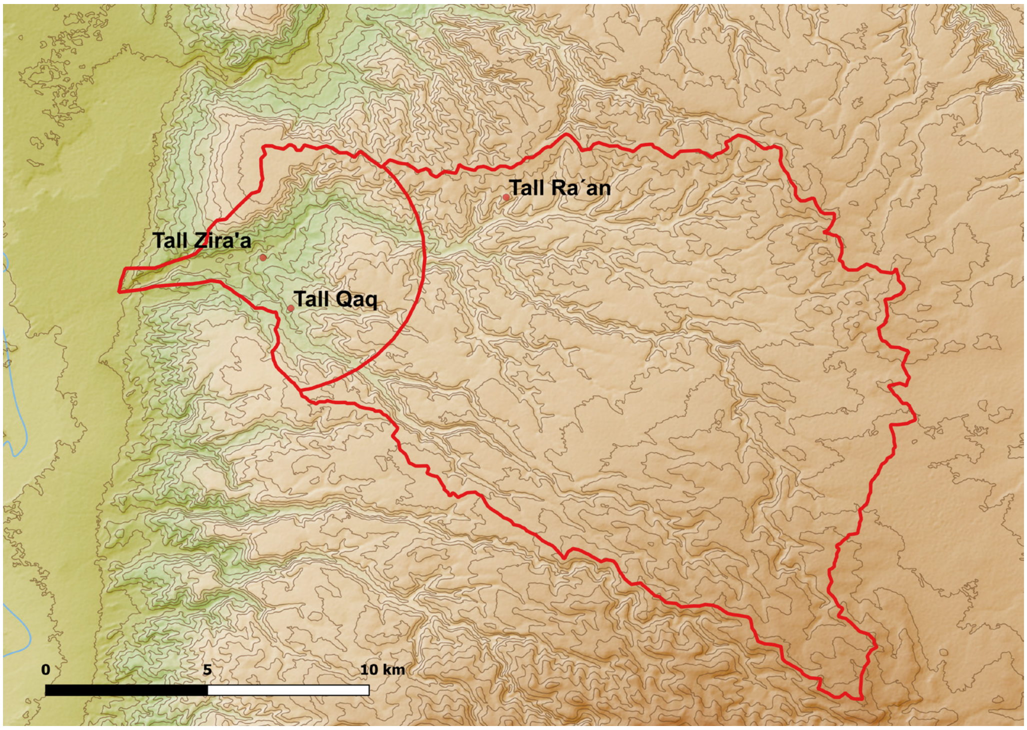


Fig. 1.9 The three large talls within the survey area (P. Leiverkus © BAI/GPIA).

The northern slopes of the wādī directly upwards from Tall Zirāʿa are characterized by a dense occurrence of water sources. Many of the sites found there relate to them. This can shed further light on the Roman water management in the region. One smaller site on the other side of the wādī, directly across from the Tall Zirāʿa, is particularly worth mentioning. This site was first published by T. Kerestes in 1978 (Site 2 in the Wādī al-ʿArab; 211/225-8) and dated to the Middle Bronze Age.

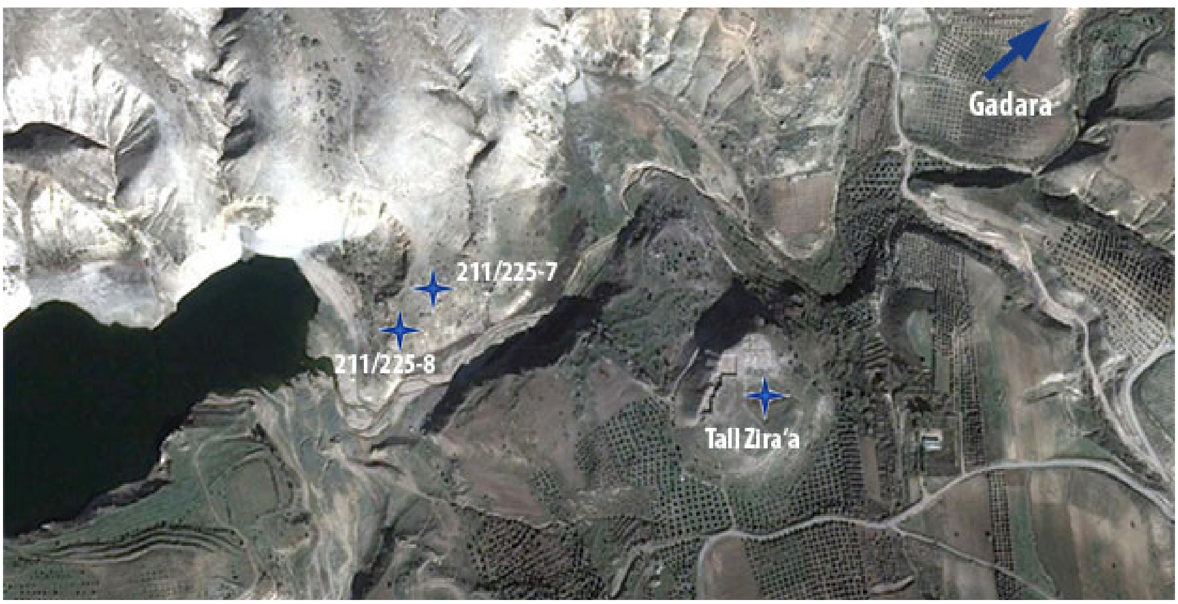


Fig. 1.10 Sites 211/225-7 and 211/225-8 in relation to Tall Zirāʿa and Gadara.

Its position puts this site in direct relation to Tall Zirā'a. Together they control a narrow passage in the wādī and of course there is an unimpeded line of sight between this site and the tall. Just 50 m up the slope of the spur another previously unknown/unpublished site could be recorded with architectural remains of the Roman period (211/225-7). This site does not only overlook the lower wādī, as does the nearby older site, but it also has a direct line of sight to Gadara, which is lacking in the lower position. This hints at the shift of centrality from Tall Zirā'a to Gadara during the Roman period.

Fig. 1.11 Sites 211/225-7 (Roman-Byzantine) and 211/225-8 (Bronze Age).

Further along the Wādī al-'Arab, upwards from the Tall Zirā'a, five penstock mills were recorded along with two dams. J.-W. Hanbury-Tenison only mentions three mills. All of them can be dated to the Ottoman period.

1.4.2. 2010 Season

The second campaign took place from 19 July to 7 August 2010 with the following participants: Sabine Kraushaar, Patrick Leiverkus, Katja Soennecken, Anne Schürmann, and Alina Quentmeier—supported on some days by the teaching course participants Oliver Gussmann and Ursula Rudnick, and Marie Schulze.

During the 2010 season, 74 sites were recorded. While during the first season in 2009, the lower part of the Wādī al-ʿArab from North Šūna up to Dōqara was surveyed, in this season the survey covered the area from Dōqara up to the vicinity of Irbid. The nature of the landscape changes while approaching the upper part of the Wādī al-ʿArab. The wādī is cut deeper and the settlements can mostly be found at the edges high above it. Most of the ancient settlements were known even before the surveys of N. Glueck and S. Mittmann were conducted.

The 2010 season was also special in that our team was accompanied by Sabine Kraushaar from the Helmholtz Centre for Environmental Research. Apart from some "communication problems" at the beginning (we learnt that archaeologists and geologists look at the landscape in completely different ways, and whenever the geologist got excited about something, the archaeologists had no idea why this should be worth looking at, and *vice versa*), it did not take long to discover how useful working together can be. The results of this cooperation are presented by Sabine Kraushaar in *Chap. 3.3*.

We would like to extend our warmest thanks to all our fellow campaigners during the years of 2009 and 2010.

Fig. 1.12 S. Kraushaar during the campaign in 2010.

1.4.3. 2011 Season

This year, the close inspection of the hinterland of the Tall Zirāʻa (Zone A) was complemented by a broad look at the Wādī al-ʻArab region by revisiting the major sites in the entire area (Zone B). The exact location of each site was measured by GPS, pottery was collected for comparison, and descriptions were updated to the current state of the sites.

During this season, 68 sites were recorded. This time, the team comprised only Patrick Leiverkus and Katja Soennecken.

Fig. 1.13 K. Soennecken.

Fig. 1.14 P. Leiverkus.

1.4.4. 2012 and 2014 Seasons

In 2012 and 2014, the summer campaigns of the "Gadara Region Project" were used for reviewing and verifying individual sites. Thus, eight new sites were recorded in 2012 and three further ones in 2014. Apart from that, a photographic documentation of all finds was conducted and the sites were typologized.

1.5. Sites

1.5.1. General Remarks

There are two types of sites: those whose location has been ascertained by GPS (number: 224), and those whose coordinates have been taken from the literature (number: 103). Due to the sparseness of information or because they have been completely overbuilt in the meantime, most of the latter ones could not be rediscovered.

Our own GPS measurements were conducted with the handheld devices by the companies Garmin and Magellan. The coordinates are indicated in the Palestine Grid[13], which is the commonly used coordinate system for archaeology in this region. It is a Cassini-Soldner projection with metrical unit lengths and was established by the British mandate administration in 1922. The central meridian passes through the Mar Elias Monastery near Jerusalem. The 100,000/100,000 point was placed on the Ali el-Muntar hill overlooking Gaza. Metre-perfect specifications are given with six digits per coordinate. Thus, if three digits per coordinate are given, a kilometre grid is obtained. The place names in this publication are indicated in this grid.

1.5.2. Zones

A total of 100 sites were newly recorded, which had all neither been documented nor mentioned in any of the previous surveys. Of course, the possibility cannot be ruled out that some of them may coincide with sites of the Hanbury-Tenison Survey, but given the inaccuracy of coordinates and lack of descriptions, we decided against an identification in cases of doubt.

The area under inspection can be subdivided into three zones: the area covering a radius of 500 m around the Tall Zirāʻa, the immediate hinterland of the Tall Zirāʻa (Zone A), and the catchment area/watershed of the Wādī al-ʻArab as a whole (Zone B). These were included with a decreasing claim to being exhaustive.

13 Also called "Israel Grid" or, nowadays, "Old Israel Grid" in Israel.

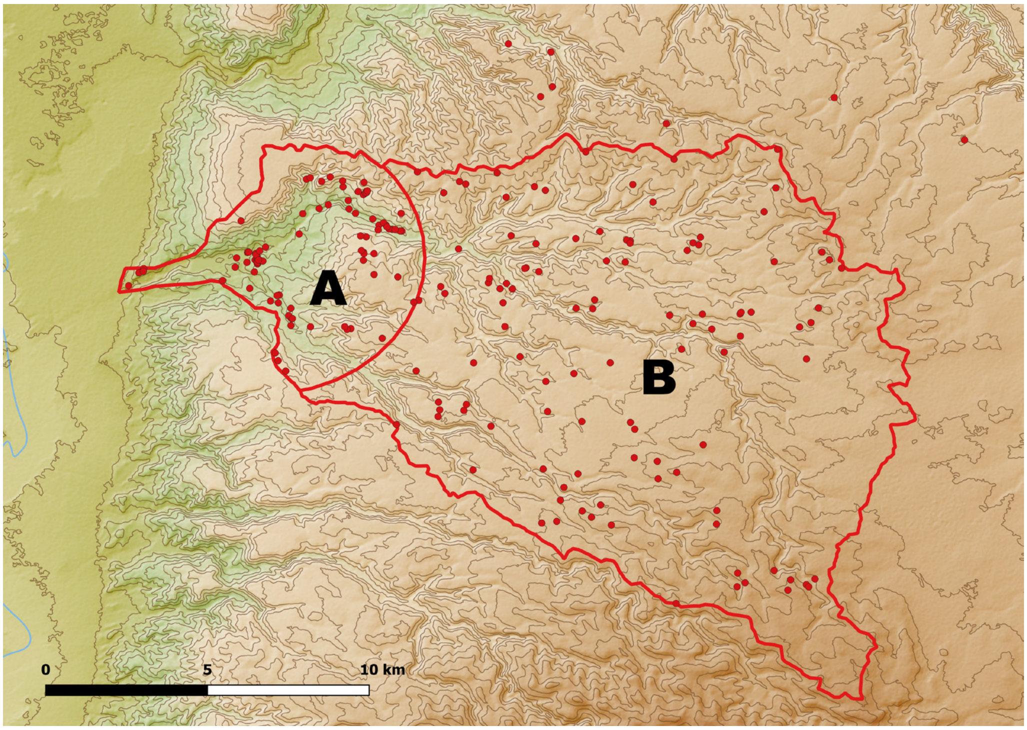


Fig. 1.15 Sites newly recorded during the Wādī al-ʿArab survey (P. Leiverkus © BAI/GPIA).

1.5.2.1. Tall Zirāʿa

There are 25 sites within a radius of 500 m around the Tall Zirāʿa; 20 of these were newly documented while five had been previously known from the literature—none of them to the east of the tall. All of these sites seem to be related to the tall: two low-er towns are located to the north-west and to the west, while a little farther to the south-west there are tombs, and the entire area to the south-west seems to have been used for agricultural purposes. On the other side of the wādī there are several sites, in all likelihood sentinels' shelters—some from prehistoric times located at the wādī's mouth and directly related to the tall, and two more from the classical era that are related to Gadara.

1.5.2.2. Zone A

Zone A of the area under inspection delineates a distance buffer with a maximum distance of 5 km from the Tall Zirāʿa. It extends over 43 km^2 and comprises 89 sites. It was attempted to document this area in its entirety.

1.5.2.3. Zone B

The second zone inside the area under inspection is termed Zone B and covers an area of 222 km^2, comprising 108 sites. Taken together, the two zones extend over 265 km^2. The total number of sites is 197—complemented by nine sites that are located outside the boundaries of the actual survey area.

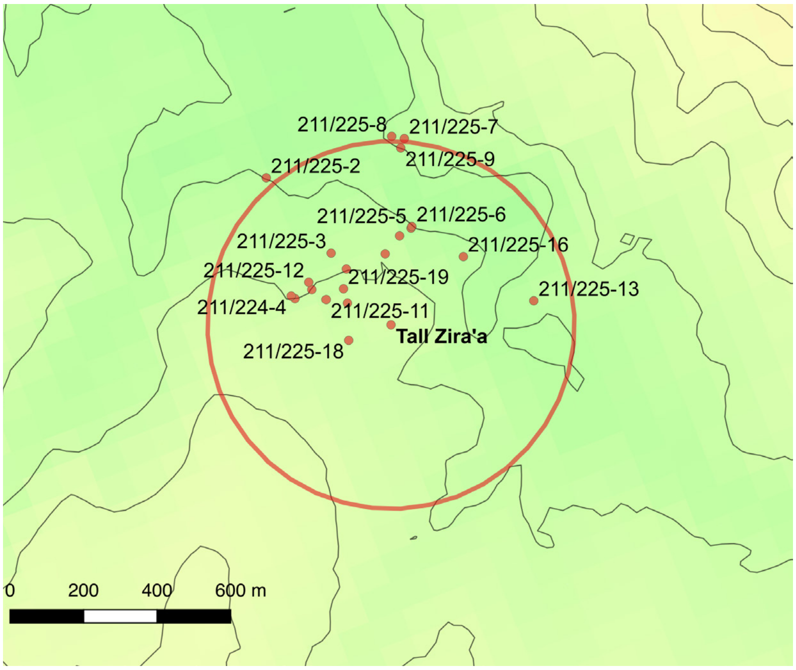


Fig. 1.16 Sites in a 500 m radius around Tall Zirāʿa (P. Leiverkus © BAI/GPIA).

1.5.3. Outline of the Settlement Types Characteristic of the Different Periods

The applied chronology follows Vieweger[14] and, regarding the Hellenistic to Byzantine periods, Kenkel[15]. The majority of sites were chronologically classified on the basis of their ceramic evidence or their architecture and processing traces in the natural rock. This resulted in a broad division into Paleolithic/Chalcolithic period (although the question remains open whether the dolmens must be in fact dated to this period or rather to the Early Bronze Age), Bronze Age (Early, Middle, and Late Bronze Age), Iron Age (Iron Ages I, IIA, IIB, IIC), Hellenistic-Roman period, Late Roman-Byzantine period, and Islamic period (Umayyad to Ottoman). However, the limitations of such a division are soon apparent as many of the pottery forms and wares were continuously in use from the Bronze into the Iron Age and also from the Byzantine into the Umayyad period, and the material remains give no evidence of any disruption. While knowing about these inaccuracies, nevertheless this division has been adhered to as it allowed to give a broad outline of the settlement development. Based on the archaeological findings, it was impossible to distinguish the period of the Abbasids and Fatimids from the Umayyad and the Ayyubid-Mamluk periods, respectively.

14 Vieweger 2012, 44. 468–488. Specified: Tall Zirāʿa *Vol. 1*, 243.

15 Kenkel 2012, 276. 315.

Period	**Chronology**
Paleolithic-Chalcolithic	Before 3600 BC
Bronze Age	3600–1200/1150 BC
Early Bronze Age	3600–1950 BC
Middle Bronze Age	1950–1550 BC
Late Bronze Age	1550–1200/1150 BC
Iron Age	1200/1150–332 BC
Iron Age I	1200/1150–980 BC or 1200/1190 –930/20 BC
Iron Age II	980–520 BC or 930/20–520 BC
Persian (Iron Age III)	520–332 BC
Hellenistic-Early Roman	332 BC–135 AD
Hellenistic	332–63 BC
Early Roman	63 BC–135 AD
Late Roman-Byzantine	135–636 AD
Late Roman	135–324 AD
Byzantine	324–636 AD
Islamic	636–1918 AD
Early Islamic – Umayyad	636–750 AD
(Abbasid-Fatimid)	(750–1171 AD)
Ayyubid-Mamluk	1171–1515 AD
Ottoman	1515–1918 AD

Tab. 1.1 Chronology of periods in the survey area.

The individual sites were not only chronologically classified but also typologized or categorized: "Settlement" denotes an assemblage of buildings or the settling on a larger area, often over the course of several historical eras. This often applies to a tall or a ḫirba in the area. By contrast, "single complex" denotes a detached building or an individual complex consisting of several buildings (a watch tower, a villa, a homestead, a hamlet). "Installations" usually comprise agricultural installations such as mills or presses, but also those whose function is unclear, most of them hewn into the natural rock (basins, chutes). "Cisterns" and "tombs" require no further definition. "Caves" can either be of natural origin and may have been used as shelters or cattle sheds, or they can be tombs—in this case, the site is attributed to both categories. "Sherd scatter" or "lithic scatter" denotes a site where only ceramic sherds or flint flakes and tools were found, lacking any discernible architectural context or any other related installation. Depending on varying applications over the course of time, some sites belong to different categories.

Regarding the category "sherd scatter" it should be noted that sites with only a few washed-out Roman-Byzantine sherds (like, e.g., 224/228-1 or 225/223-1) are often located in an agricultural area (olive trees or agricultural crop land) and it is doubtful whether these pieces of pottery were originally left behind at this exact place or whether it is not more likely that they were transported there along with the fertile soil from a different location (for instance, the Gadara plateau).

The subsequent tabular overview comprises not only the sites that were newly documented in the course of this survey but also those that were only evidenced by the literary sources. If one of the latter sites was revisited during the "Gadara Region Project" and a representative number of ceramics has been collected, the project's own chronological classification is used in cases of discrepancy to the data in the literature. "Lithic scatter" is classed with the Paleolithic-Chalcolithic sherd scatters. It has to be pointed out that, due to the lack of ceramics, an installation or a looted tomb could often not be dated precisely and thus appears under both "Late Roman" and "Byzantine" in the table. Neither can it be ultimately ascertained whether every tomb or sherd scatter from the literature that was dated as "Byzantine" can actually be classified as such with certainty or whether some or even all of them may not in fact be Late Roman-Byzantine. Moreover, the possibility cannot be ruled out that some of the cisterns classified as Late Roman or Byzantine were in fact already built in Early Roman times—given the lack of ceramic evidence, this question cannot be resolved.

Typology	Paleolithic-Chalcolithic	Bronze Age			Iron Age			Hellenistic-Roman Period		Late Roman-Byzantine Period		Islamic Period		
		EBA	MBA	LBA	IA I	IA II	IA IIC	Hell.	Early Rom.	Late Rom.	Byz.	Um.	Ayy./ Mam.	Ottom.
Settlement	-	15	12	14	14	14	3	15	18	26	29	24	17	10
Single complex	-	8	9	11	20	14	3	16	29	82	90	66	30	7
Installation	-	-	-	-	-	-	-	2	6	61	77	28	6	17
Cistern	-	-	-	-	-	-	-	-	1	58	66	34	6	1
Tomb	9	1	-	-	-	-	-	2	3	39	52	4	1	-
Cave	-	2	-	-	1	1	-	1	2	11	11	4	1	-
Sherd scatter	21	15	14	15	15	13	1	5	9	40	57	31	18	1

Tab. 1.2 Number and type of sites for each period in the survey area.

1.5.3.1. Paleolithic/Chalcolithic Period

Only few sites from times preceding the Early Bronze Age could be identified. As expected, no settlements or single complexes were found, and the sites only comprise 21 sherd or lithic scatters and eight tombs (dolmens).

1.5.3.1.1. Lithic Scatter

Of the altogether 21 sites, 16 were previously known from the Hanbury-Tenison survey. However, only four of these could be confirmed or located[16]. There were moreover the sites 222/216-1 (Barsīnā) and 228/213-4 (Ruğm al-Ġurābiat).

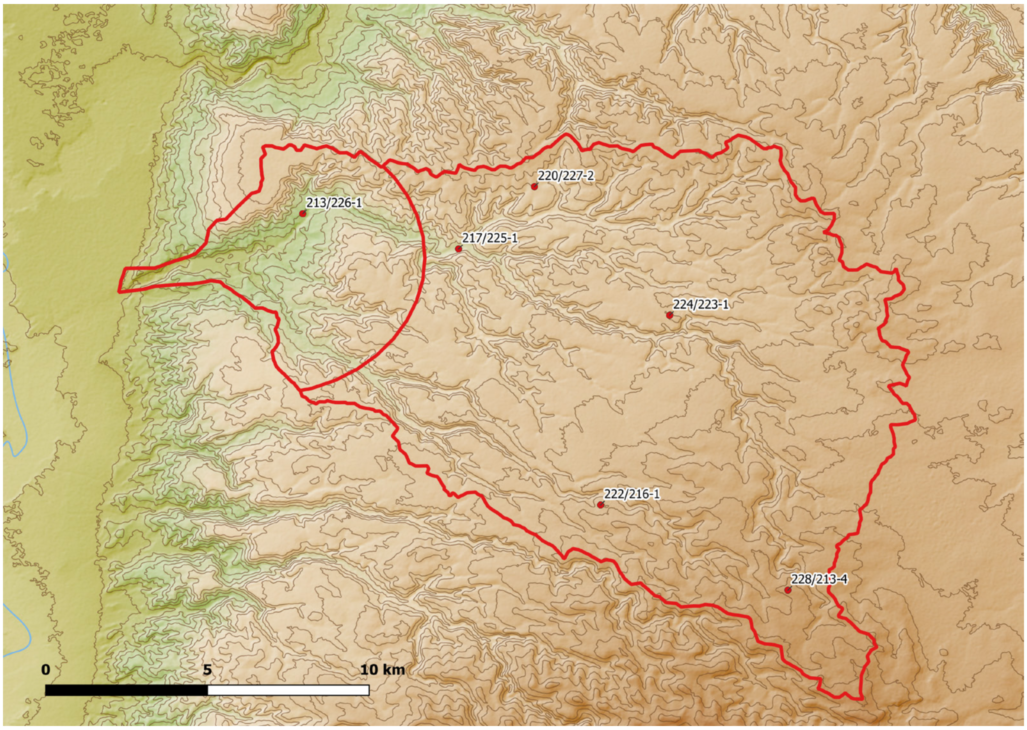


Fig. 1.17 Sites with lithic scatter (P. Leiverkus © BAI/GPIA).

1.5.3.1.2. Dolmens

Only few sites with dolmens or remains of dolmens could be located: two that were described in the literature have meanwhile been destroyed or are untraceable, while three could be newly documented. All of them are located to the west of the modern city of Irbid, on both sides of the Wādī al-'Arab. Three dolmens were found in an erect position whereas at the other four sites, megaliths that were moved to the edges of fields are the only remaining evidence of the dolmens of former times. An exact dating of these dolmens is not undisputed but they seem to go back to the time between 4500 and 3800 BC[17]. Only one site contained ceramics; these, however, came from the nearby Late Roman-Byzantine settlement area and were not related to the dolmen.

16 The sites 213/226-1 = HT 016; 217/225-1 = HT 066; 220/227-2= HAT 040-043; and 224/223-1 = HAT 095.

17 Note the publication by J. Fraser, who dates the dolmens to the Early Bronze Age (ACOR, J. Fraser curator British Museum) http://www.acorjordan.org/2017/04/08/visible-dead-dolmens-landscape-acor-video-lecture-dr-james-fraser/

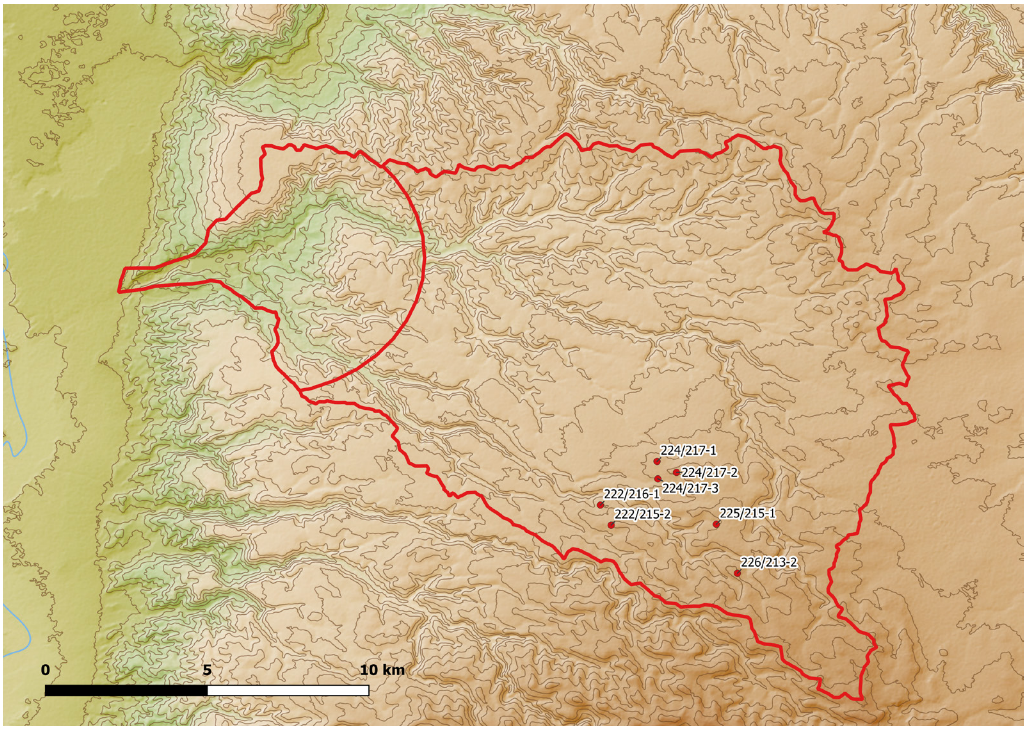


Fig. 1.18 Dolmens in the survey area (P. Leiverkus © BAI/GPIA).

1) 222/215-2: dolmens, one of them still standing, at least two destroyed; megalith size *c.* 2 m x 1 m; elevation 538 m.

Fig. 1.19 222/215-2.

Fig. 1.20 222/215-2 overview (looking south).

2) 222/216-1: Megaliths in an agricultural field, possibly remains of a dolmen; elevation 494 m.

Fig. 1.21 222/216-1.

3) 224/217-1: Dolmen remains; megalith size 2 m x 1 m, one megalith 2.50 m x 2.50 m (identical with Ḫirbat ʿAwār, El-Khouri Site 9), elevation 546 m.

Fig. 1.22 224/217-1 overview.

4) 224/217-2: An area of approximately 2 ha; strewn with stones; tomb; cistern; flint, but no sherds found. L. El-Khouri describes an agricultural field with 44 dolmens, most of them destroyed. Apparently, the dolmens have meanwhile been completely destroyed, and the remains were pushed to the edges of the area or put to a different use entirely. Or identical with site 224/217-3. Al-Ġawāyib, elevation 556 m.

Fig. 1.23 224/217-2 overview.

5) 224/217-3: Dolmen tomb near al-Ġawāyib; two erect megaliths, each approx. 3 m long, roofed by another one of equal size, thus creating an interior space with a width of 70 cm. Elevation 502 m.

Fig. 1.24 224/217-3.

Fig. 1.25 224/217-3 overview.

6) 225/215-1: Agricultural field with megaliths that have been pushed to the edge of the field or to that of the modern road; the largest megalith has a size of 3.50 m x 2.50 m. Elevation 582 m.

Fig. 1.26 225/215-1.

Fig. 1.27 225/215-1 overview.

7) 226/213-2: Megaliths (most of them 2 m x 1 m), probably one dolmen *in situ*, otherwise megaliths pushed to the edges of the field. Elevation 651 m.

Fig. 1.28 226/213-2.

Fig. 1.29 226/213-2 overview (looking north).

8) 227/215-1: Located on the east side of Wādī al-Ġafr, south-west of Zibda. A large area of agricultural fields. A complete dolmen and well-preserved rectangular and oval structures were found. They were most probably part of a cemetery[18]. Could not be located any more.

9) 227/216-1: Located *c.* 1.4 km northeast of Tall Kafr Yūbā, on a flat hill on the west side of Wādī al-Ġafr, surrounded by a large area of agricultural fields. This is a large area of agricultural fields overlooking Wādī al-Ġafr. Two destroyed dolmens and ten oval or circular structures were found[19]. Could not be located any more.

18 El-Khouri et al. 2006, 125; El-Khouri 2009, 81.

19 El-Khouri et al. 2006, 125; El-Khouri 2009, 84. Also: Glueck 1951, 155.

1.5.3.2. Bronze Age

A first look at the Bronze Age findings of the survey does not reveal any surprises: During the Early Bronze Age, the first larger settlements emerge, which, despite a minor decline, continue to exist throughout the Middle Bronze Age into the Late Bronze Age.

Typology	Bronze Age		
	EBA	MBA	LBA
Settlement	15	12	14
Single Complex	8	9	11
Installation	-	-	-
Cistern	-	-	-
Tomb	1	-	-
Cave	2	-	-
Sherd scatter	15	14	15

Tab. 1.3 Number and type of Bronze Age sites in the survey area.

1.5.3.2.1. Early Bronze Age

The Early Bronze Age sites are scattered across the entire survey area but they are always located in the vicinity of the wādīs. The individual sites are usually more than 2 km apart from each other (unless they are separated by a wādī; in these cases the distance can be only 1 km). Curiously, no settlements could be verified along the main branch of the Wādī az-Zaḥar.

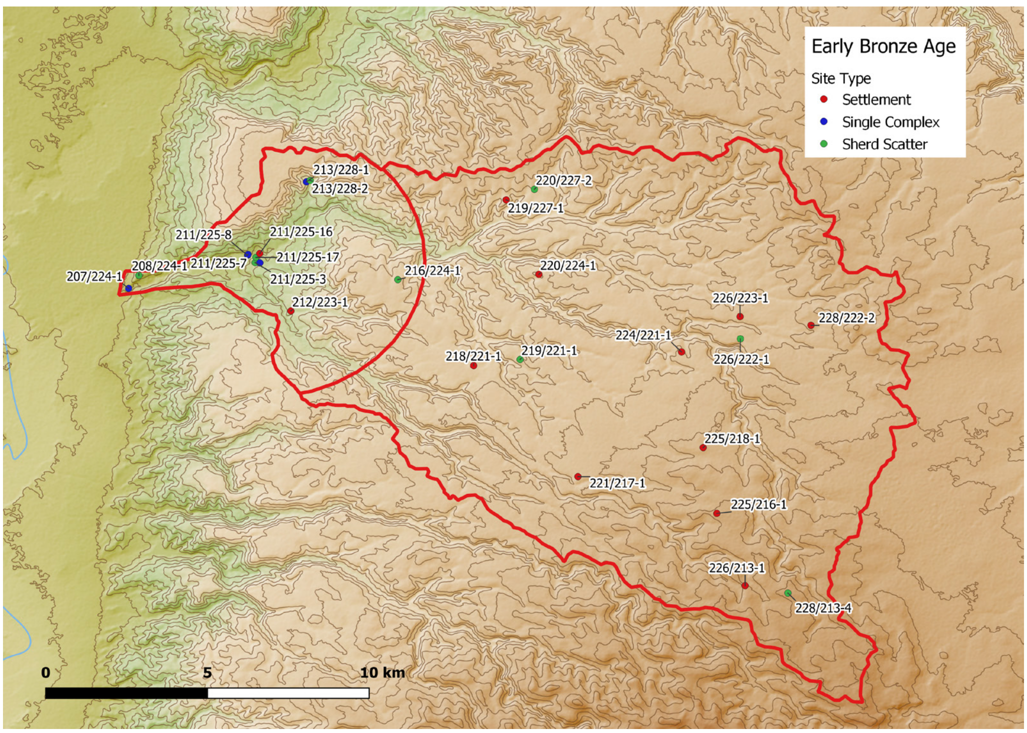


Fig. 1.30 Sites with Early Bronze Age remains (P. Leiverkus © BAI/GPIA).

1.5.3.2.2. Middle Bronze Age

Only one site yielded solely Middle Bronze Age ceramics and none from the Early or Late Bronze Age (225/225-1); the other sites either came into being during the Early Bronze Age or they were still in existence in the Late Bronze Age, or it was altogether impossible to class them with any one specific Bronze Age phase on the basis of the ceramics found.

1.5.3.2.3. Late Bronze Age

The Late Bronze Age settlements are also concentrated close to the wādīs, many of them coinciding with the Early Bronze Age locations. However, the sites located in the centre of the survey area (in the greater area around the modern city of Kafr Asad) were being abandoned during the Late Bronze Age while new settlements were founded in the area of the Wādī az-Zaḥar.

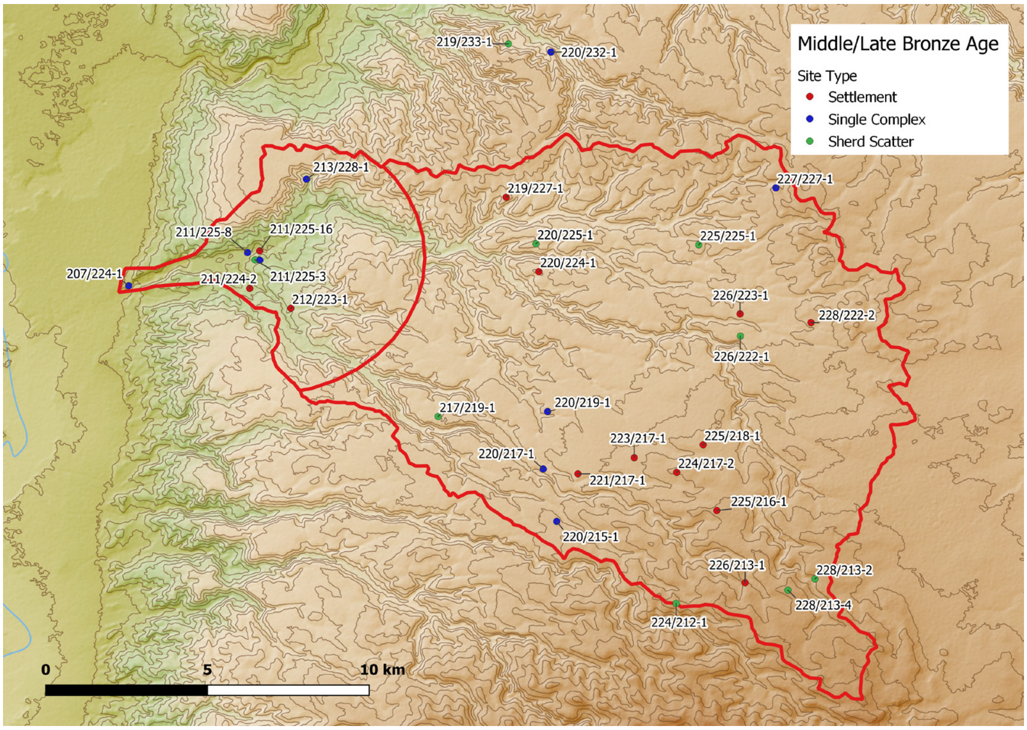


Fig. 1.31 Sites with Middle and Late Bronze Age remains (P. Leiverkus © BAI/GPIA).

1.5.3.3. Iron Age

Typology	**Iron Age**		
	IA I	IA II	IA IIC
Settlement	14	14	3
Single complex	20	14	3
Installation	-	-	-
Cistern	-	-	-
Tomb	-	-	-
Cave	1	1	-
Sherd scatter	15	13	1

Tab. 1.4 Number and type of Iron Age sites in the survey area.

1.5.3.3.1. Iron Age I

Even though the number of settlements remains the same compared to the Late Bronze Age, the quantity of ceramic evidence is clearly on the decline, suggesting a population shrinkage in the major settlements. By contrast, the number of single complexes almost reduplicates. This finding is in accordance with the general historical picture of a decentralisation that took place during the Iron Age I.

1.5.3.3.2. Iron Age II

It is difficult to subdivide the Iron Age II: Although a few characteristic Iron Age IIC ceramics can be identified, a clear distinction between the Iron Ages IIA and IIB solely on the basis of the ceramic evidence is not possible. The number of settlements during the Iron Age IIA/B again remains the same as compared to the Iron Age I; this time, however, the quantity of ceramics is on the rise. Unsurprisingly, the number of sites that can be positively dated to the Iron Age IIC has declined.

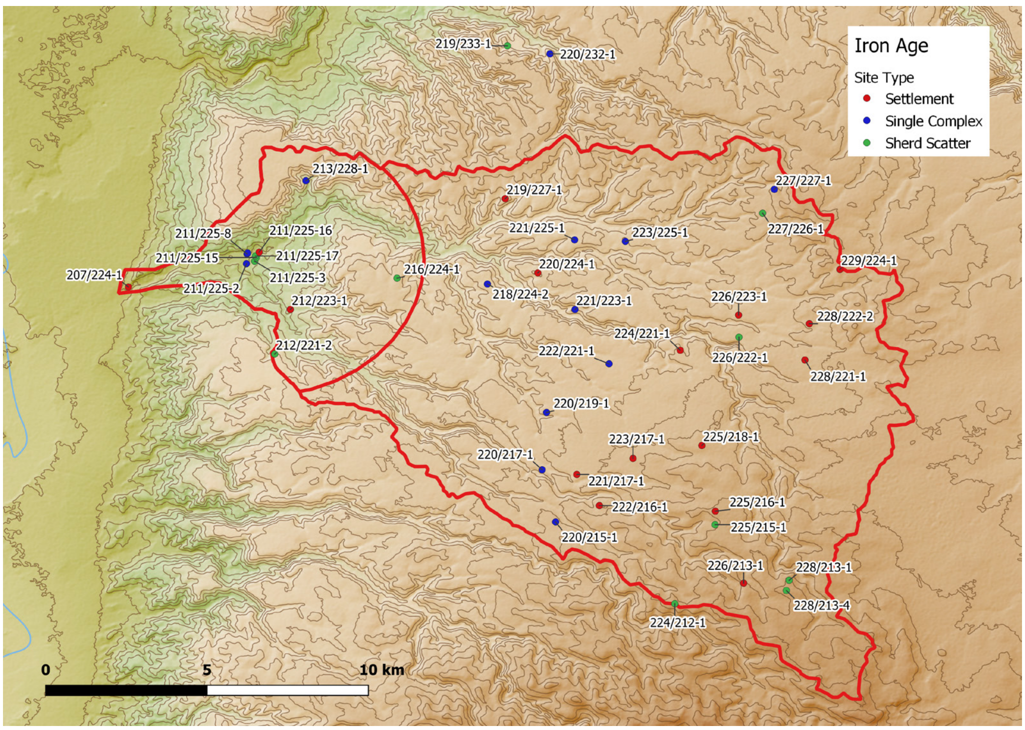


Fig. 1.32 Sites with Iron Age remains (P. Leiverkus © BAI/GPIA).

1.5.3.4. Hellenistic – Roman Period

Typology	**Hellenistic-Early Roman Period**	
	Hellenistic	Early Roman
Settlement	15	18
Single complex	16	29
Installation	2	6
Cistern	-	1
Tomb	2	3
Cave	1	2
Sherd scatter	5	9

Tab. 1.5 Number and type of Hellenistic and Roman sites in the survey area.

1.5.3.4.1. Hellenistic Period

A large number of the Hellenistic sites appear to be either new foundations or re-established former settlements. In most cases, no continuous settlement can be discerned. On the other hand, almost all of the settlements that were populated in Hellenistic times continued to be so in Early and Late Roman times, and only few were abandoned. The Hellenistic sites are scattered across the entire survey area.

1.5.3.4.2. Early Roman Period

Not a single site was only populated in Early Roman times. Most of the sites were established during the Hellenistic period (or earlier). Many of them were maintained even in Late Roman times.

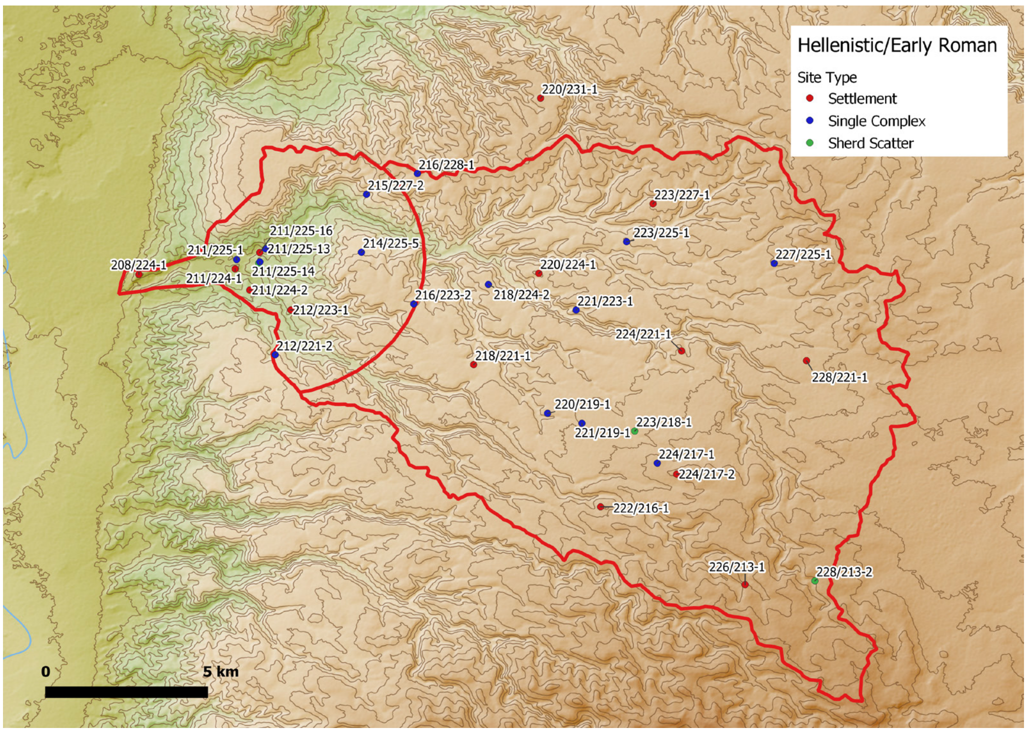


Fig. 1.33 Sites with Hellenistic to Early Roman remains (P. Leiverkus © BAI/GPIA).

1.5.3.5. Late Roman – Byzantine Periods

The increase of Late Roman sites does not come as a surprise—it should be noted, however, that the sites lacking ceramic evidence are hard to date precisely and may thus have been first settled or used either in the Early Roman or in the Byzantine period.

Typology	**Late Roman – Byzantine Period**	
	Late Roman	Byzantine
Settlement	26	29
Single complex	82	90
Installation	61	77
Cistern	58	66
Tomb	39	52
Cave	11	11
Sherd scatter	40	57

Tab. 1.6 Number and type of Late Roman and Byzantine sites in the survey area.

1.5.3.5.1. Late Roman Period

Roman rule brought about agricultural advancement: cisterns and water supply systems were built, thus making it possible to turn hitherto unusable areas into arable land. A network of cisterns rendered the people independent of springs, rainwater, or the changing water flow of the wādīs. As a consequence, they could lay out and cultivate fields and also build houses, mansions, or watchtowers in more remote locations. It has already been pointed out that a large number of sherd scatters cannot be reliably dated and it must also be assumed that some of the sherds were not found at their original locations.

1.5.3.5.2. Byzantine Period

The Late Roman period is immediately succeeded by the Byzantine period. With respect to their ceramic finds and the few surviving architectural remains, these two eras can hardly be told apart which is why, when in doubt, installations or tombs are listed in both periods. Prosperity as well as the demographic growth seem to have continued in Byzantine times, and it is now, if not before, that

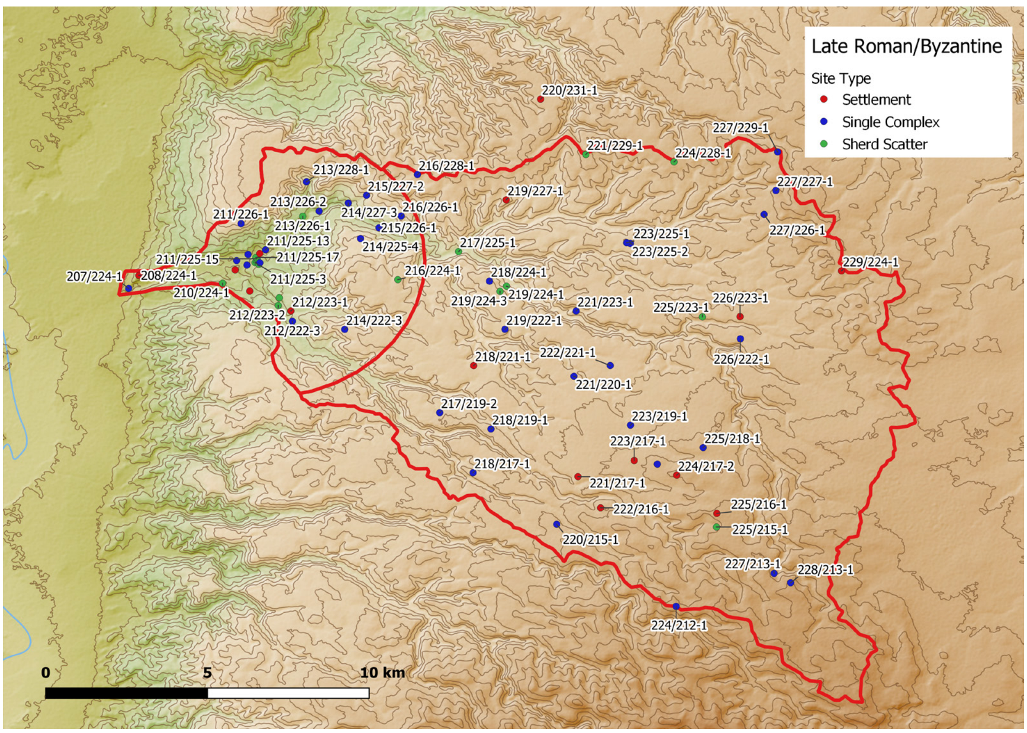


Fig. 1.34 Sites with Late Roman–Byzantine remains (P. Leiverkus © BAI/GPIA).

many smaller settlements were established that to this day define the local settlement structure.

1.5.3.6. Islamic Period

The Islamic period starts with the beginning of the Islamic conquest and comes to an end with the decline of the Ottoman Empire, the subsequent period being regarded as the Modern Age. This long time period can be divided into several historical-political entities—Ummayad, Abbasid, Ayyubid, Mamluk, and Ottoman. Also the pottery production and types change during this period and therefore, give hints for dating archaeological findings.

Typology	Islamic Period		
	Um.	Ayy.-Maml.	Ottom.
Settlement	24	17	10
Single complex	66	30	7
Installation	28	6	17
Cistern	34	6	1
Tomb	4	1	-
Cave	4	1	-
Sherd scatter	31	18	1

Tab. 1.7 Number and type of Islamic period sites in the survey area.

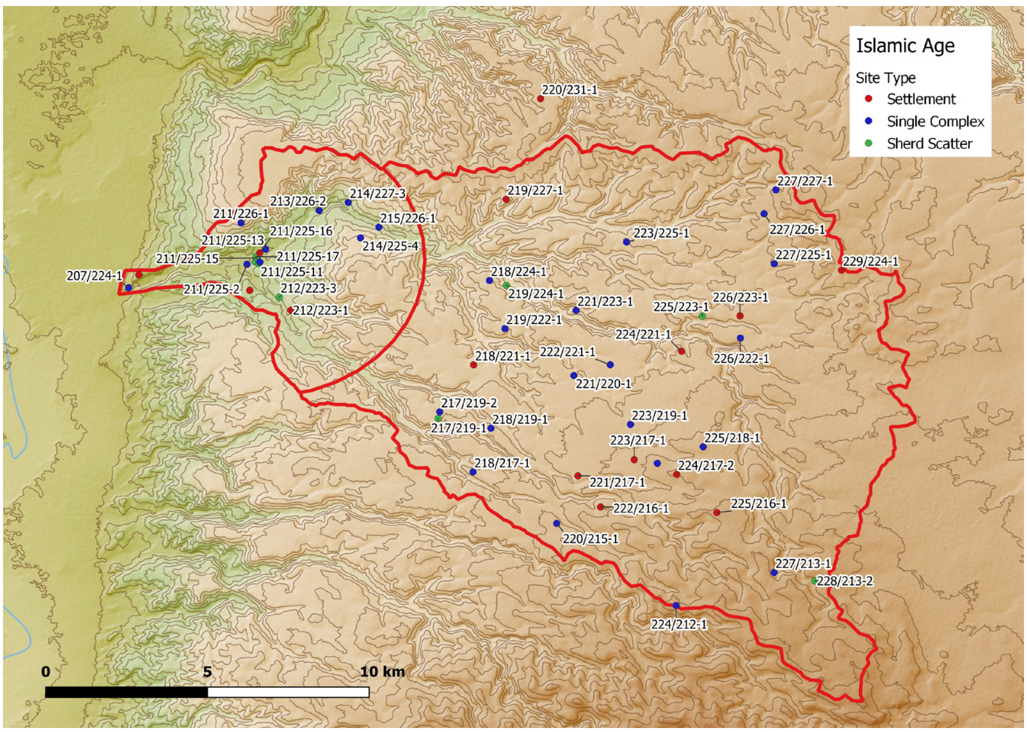


Fig. 1.35 Sites with Islamic remains (P. Leiverkus © BAI/GPIA).

1.5.3.6.1. Umayyad Period

Despite a slightly decreasing settlement density compared to Byzantine times, most of the sites populated during the Late Roman and Byzantine period seem to have been in continued use. Only the number of single complexes declined as apparently the agricultural utilisation of the land did. The ceramic finds give no evidence of any major changes from one period to the next and many forms and patterns stay the same. The archaeological findings suggest a comparably peaceful continuity.

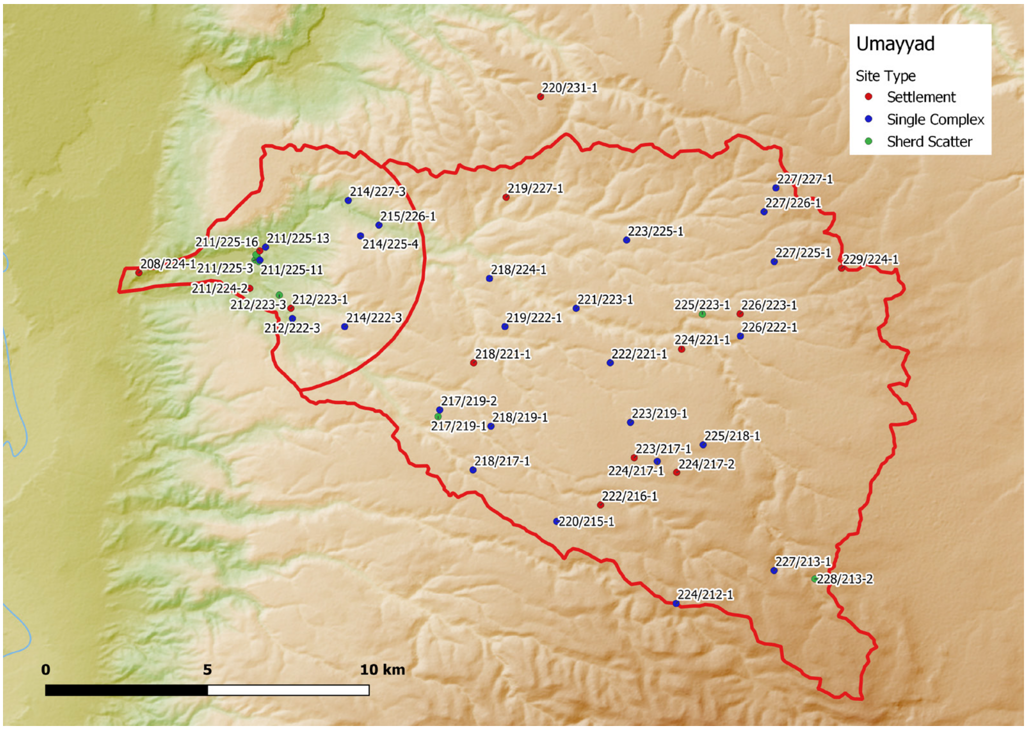


Fig. 1.36 Sites with Umayyad remains (P. Leiverkus © BAI/GPIA).

1.5.3.6.2. Ayyubid-Mamluk Period

In Ayyubid-Mamluk times settlement decreases to almost half the number of sites. This is particularly illustrated by the number of installations and cisterns still in use, which sank from 28 and 34, respectively, to six each. The termination of the use of cisterns is also confirmed by OSL dating (see *Chap. 3.3.*) – the closure of installations due to the absence of water supply, caused by the lack of operational cisterns, on the one hand and the absence of ceramics on the other stands to reason. Apparently, already pre-existing settlements were kept up and none were newly established during this period.

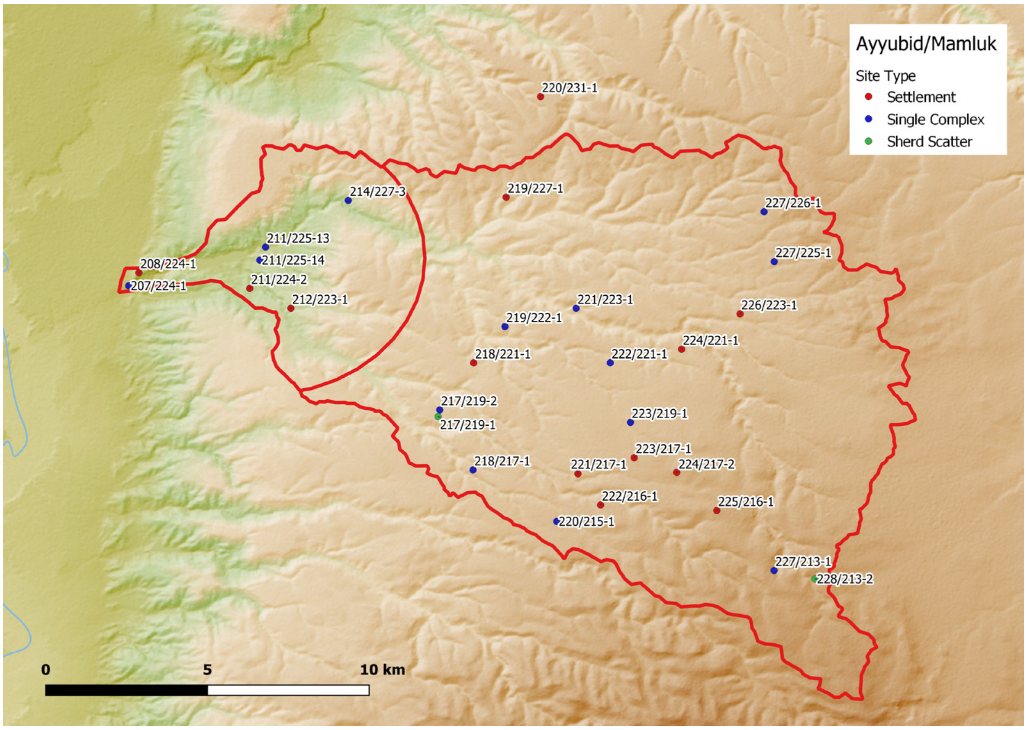


Fig. 1.37 Sites with Ayyubid-Mamluk remains (P. Leiverkus © BAI/GPIA).

1.5.3.6.3. Ottoman Period

Although S. Mittmann had registered many mosques from Ottoman times, in which he identified an abundance of spolia from Roman-Byzantine times that had been built into the walls, not a single one of them could be detected in the Wādī al-ʻArab. As a general rule, only very few remains from the Ottoman period can still be found in the area of the wādī, due to modern building activities which almost always replaced Ottoman structures.

The remains of six water mills from Ottoman times were recorded in the Wādī al-ʻArab Survey—five of them located in the main wādī of the Wādī al-ʻArab, and one in the Wādī az-Zaḥar[20].

Most of the water mills from the Middle East seem to belong to the *arubah* penstock type. As a rule, this type of water mill consists of a stone tower, rising up to 6 to 10 metres and housing a water duct—in the case of the mills from the Wādī al-ʻArab and Wādī az-Zaḥar even two. At the lower end of the duct(s), the water is channelled through a narrow opening, thus generating a jet of water strong enough to spur on a wheel. This guarantees the mill's reliable performance even in circumstances of low water flow[21]. Even though mills of a similar type were verifiably already in use during Roman times (e.g. in Ǧaraš or in the Wādī Fēnān)[22], the mills discovered in the Wādī al-ʻArab must be dated to the Ottoman period. The remains of a dam or a small retaining wall (sites 213/227-1, 215/226-4 and 216/226-2) were obviously related to the water mills.

20 J.-W. Hanbury-Tenison moreover mentions five penstock double shaft water mills. It is possible that 215/226-3 is in fact site HT 081 (215/226-10). Likewise, the dam 216/226-2 appears to be identical with HT 059 (216/226-5); however, given the considerable difference in altitude readings and the scarce information provided by J.-W. Hanbury-Tenison, a positive identification was omitted.

21 Kamash 2009, 232. http://archaeologydataservice.ac.uk/archives/view/kamash_2006/download.cfm?volume=figures

22 Kamash 2009, 234 table 10.3.

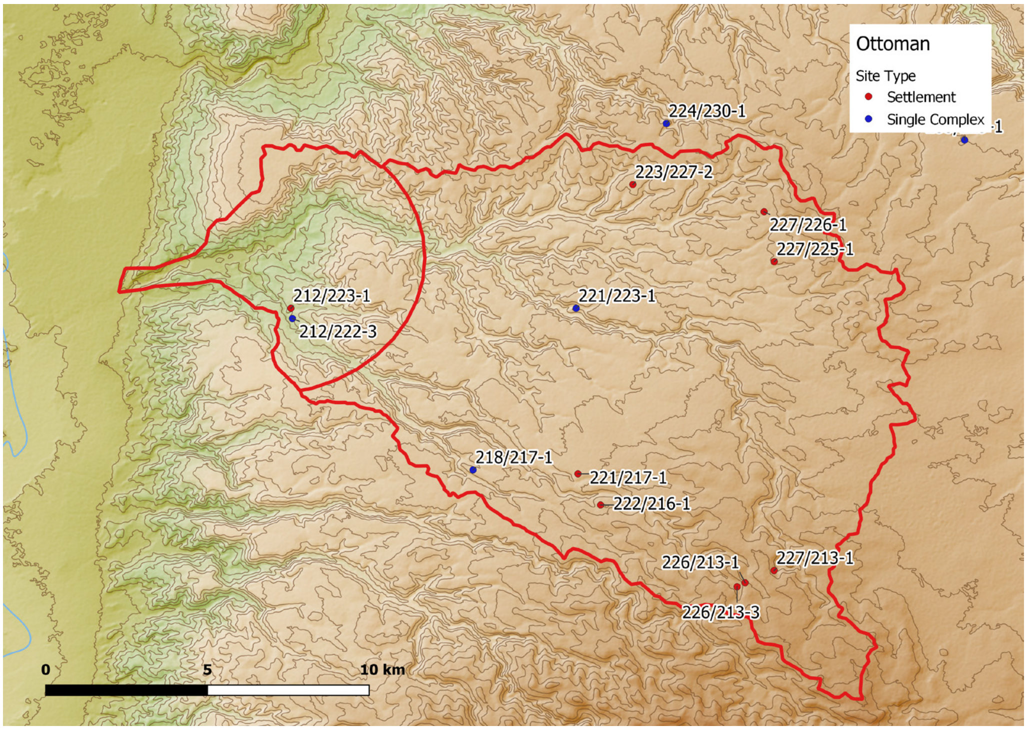


Fig. 1.38 Sites with Ottoman remains (P. Leiverkus © BAI/GPIA).

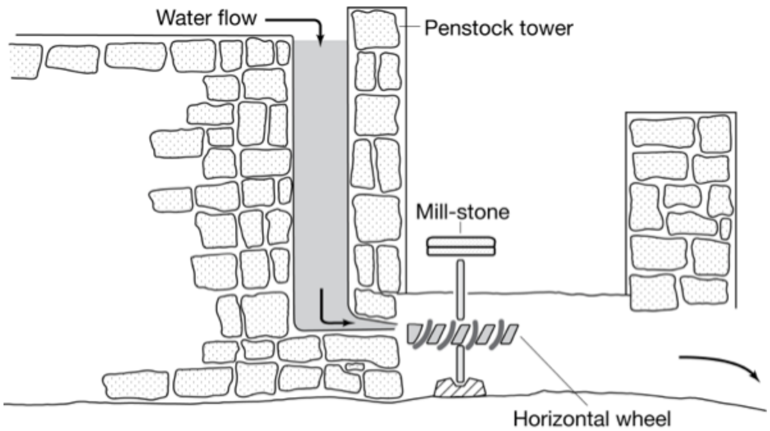


Fig. 1.39 Schematic drawing of a horizontal-wheeled mill with an *arubah* penstock (Zena Kamash).

1.6. Selected finds

In this chapter, a few selected groups of finds or single finds, respectively, from the categories ceramics, stone, and glass will be represented—there were no metal finds, except for one indefinable fragment. This selection is not intended to be exhaustive, and each of the finds will also be listed and described in the context of its individual site.

1.6.1. Ceramics

A complete overview of the ceramic finds can be found in the catalogue next to the respective sites. Given the specific nature of a survey, this can only be a general outline without any claim to comprehensiveness. In the following, a few selected specimens will be picked and described in detail.

1.6.1.1. "Galilean bowls"

"Galilean bowl" is the term used for a group of dark red, hard-baked ceramic ware that is characterized by a widening rim with two grooves on the top. A second, similar type is the Kfar Hananya ware[23]. In Galilee, it usually occurs in contexts from the 2nd and 3rd centuries AD, sometimes as late as the 4th century AD[24]. These "Galilean bowls" are a unique feature of northern Palestine[25]. They were particularly common in Galilee, but also on the Golan, during Roman – Early Byzantine times. Although cooking bowls such as these were mainly sold to the Jewish community they were not restricted to this clientele. On the Tall Zirāʻa, numerous specimens of these Galilean types of cooking bowls were found. They date from the period of the declining 1st century BC to the 2nd and 3rd centuries AD[26].

In the course of the survey, 24 pieces of this type were found at 12 sites. Even though this small number is definitely no solid basis for any representative statements, the distribution of the finds conveys the impression that they only occur along the main wādīs al-ʿArab and az-Zaḥar and are absent in the hinterland: six specimens come from the Tall al-Munṭār, four specimens from the sanctuary of al-Qabū, two from the lower city of the Tall Zirāʻa – and the others were also found in settlement contexts or in tombs. All this suggests that this ware group was given a particular significance.

Site	Number
208/224-1	6
211/224-1	3
211/224-2	1
211/224-5	1
211/225-16	2
215/222-1	1
215/225-1	1
215/226-1	1
216/228-1	4
218/219-2	1
220/225-1	2
228/222-2	1

Tab. 1.8 Sites with "Galilean bowls".

23 Adan-Bayewitz 1993, 91.
24 Adan-Bayewitz 1993, 95.
25 Kuhnen 1990, 287.
26 On "Galilean bowls" on the Tall Zirāʻa, also see Kenkel 2012, 161 f.; Kenkel 2020, 51 f.

1.6.1.2. Stamp Impression

One Hellenistic amphora (WaA 900084-31) carried a stamp impression on the handle, showing a figure in motion. The find came from site 218/221-1, a plateau south of the modern village of Qamm. There, it was excavated in the area of a building pit, which explains its good state of preservation as the find was obviously not exposed to the elements for a longer period of time. The stamp has a width of 1.9 cm and a height of 2.3 cm—the figure itself is 1.7 cm tall. The presumably female figure, judging from its garment with a distinctive drape, is represented in a walking motion towards the left, its left (heavily attrite) arm in front of and its right arm behind the body. Probably the figure used to carry some sort of object in its left hand. With respect to its modelling, the figure appears to be related to representations on Aegean seals (Wādī ed-Daliye finds from the period between 375 and 335 BC—Late Persian seals from Samaria; Daskaleion bullas from Satrapen archive; documents from an archive of a Punic temple in Carthage, both from the 5th and 4th century BC—Hellenistic style)[27]. This style was possibly passed on by Phoenicians. Regarding the shape of the stamp, the find WaA 900084-31 resembles a Classical stamp seal (in Hellenistic times, the seal rings become more oval in shape, with a metal ring as archetype). It appears to be the adaptation of a Greek motif. Presumably it is a Hellenistic or alternatively a "Greco-Persian" Prehellenistic-Hellenistic object.

Fig. 1.40 WaA 900084-31.

Fig. 1.41 WaA 900084-31.

27 Schroer – Lippke 2014; Leith 1997; Leith 2000; Keel 2010, 340–379.

1.6.1.3. Oil Lamps

A total of seven fragments of oil lamps were found during the survey, one of which dates back to the Iron Age, one to the Hellenistic, one to the Early Roman, and one to the Byzantine period. The other three specimens date back to Late Roman to Umayyad times. Except for WaA 900028-02, all fragments were found in larger settlements along the principal branch of the Wādī al-ʿArab (Tall Zirāʿa lower city, Tall Raʿān [Tall Kinīse], Ḥauwar, and HT 026).

Find Number with Add-on	Site	Type	Term	Decor	Ware Group	Annotation	Dating
900028-02	219/224-1	Mirror	Oil lamp	Relief decor	Cl C Bu2Br		Rom. Byz.
900041-215	219/227-1	Mirror	Oil lamp		Is WM R2B		Byz. Uma.
900054-96	219/227-1	Object, half of it preserved	Oil lamp		WM C R2B		Iron Age
900055-23	211/224-2	Mirror	Oil lamp		Is Grey		Rom. Byz. Uma.
900076-19	221/223-1	Mirror	Oil lamp	Relief decor	Cl H Bu2Br P	Floral relief decor with black, dull coat on its upper side	Hell.
900154-32	211/225-16	Snout	Oil lamp		Cl C Bu2Br	Fragments of a snout of a so-called "Herodian" oil lamp	Rom.
900154-46	211/225-16	Mirror	Oil lamp	Relief decor	Cl C Bu2Br-sl	Remains of a red brown, dull ornamental painting	Byz.

Tab. 1.9 Oil lamp finds in the survey area.

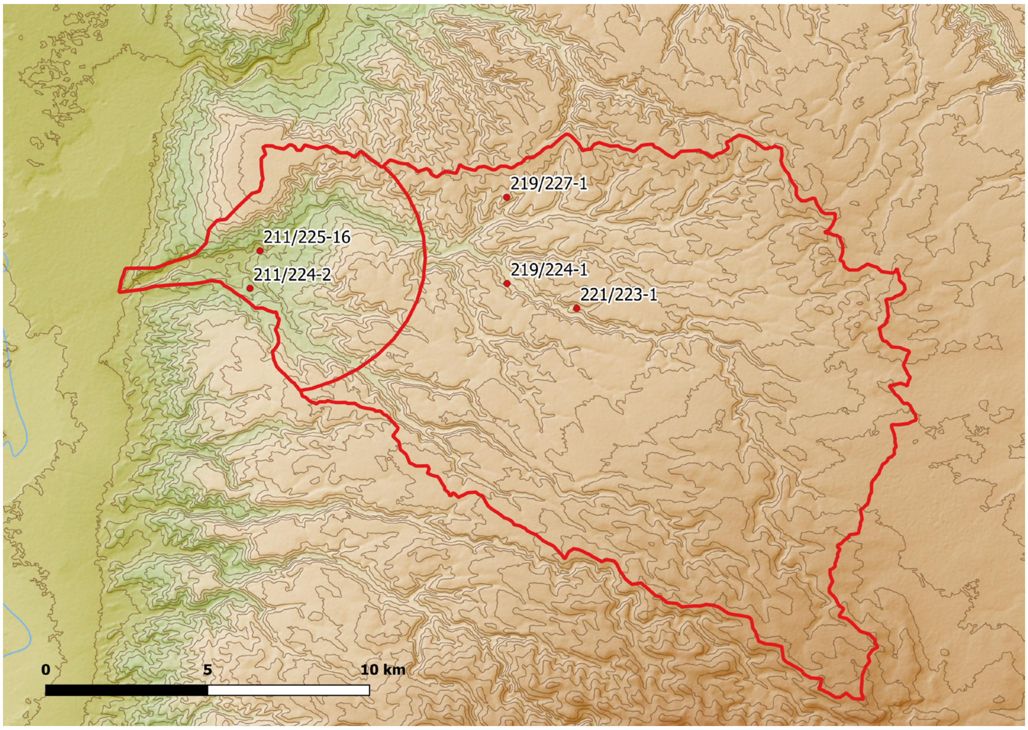


Fig. 1.42 Sites with oil lamps (P. Leiverkus © BAI/GPIA).

Find WaA 900154-32 is one of the so-called "Herodian oil lamps". This type was very common in Judaea during the Early Roman period (37 BC – 135 AD). Though less prevalent, it has also been found in the north (as far as Galilee), in the south (right into the Negev), and in Transjordan. Its basic form consists of a circular body with a usually flat bottom that has been manufactured on a potter's wheel. The characteristic arched snout with its concave sides was handcrafted and subsequently attached to the body. As a rule, the clay utilized is hard-baked and of good quality[28].

Fig. 1.43 WaA 900154-32.

28 Kenkel 2012, 276 f. Table 54.

1.6.2. Stone Finds

1.6.2.1. Assessment of the Lithic Finds

by Benjamin Schröder

1.6.2.1.1. Introduction

> “The landscape turned more and more rugged and mountainous; finally, we descended into a very narrow and deep valley, called Wuâdy el Arab, with a brook that is said to carry water all year long. On its edge there is a mill. On the other side, we had to master a steep ascent until we reached Mkês. The mountain’s slopes mostly consist of white, brittle limestone or marl lime with numerous black thin layers of flintstone. The mountain top, again, is made up by solid limestone.[29]”

These observations were made by the explorer U. J. Seetzen during his stay in Umm Qēs (Gadara) —which he calls Mkês—, where he arrived from Ṣēdūr in the year of 1806. Even though today the north-western access route from Umm Qēs down into the Wādï al-‘Arab may not run exactly the same course as the one described above, it is particularly the recent building activity for broadening the serpentines leading into the valley that have again brought to light the “black thin layers of flintstone” described by U. J. Seetzen *(Fig. 1.44).*

Fig. 1.44 Exposed flint deposits in the slope profile along the upper course of the access road in the direction of Umm Qēs (Photo: B. Schröder, autumn 2017).

29 Seetzen 2004, 368. Kindly pointed out by Dr. Jutta Häser (GPIA Amman).

Fig. 1.45 Fragment of a flint nodule and bands of dark brown and black flint in between layers of limestone and marl lime in the slope profile at the roadside (Photo: B. Schröder, autumn 2017).

The material at hand comprises the lithic finds discovered during the hinterland survey conducted by the Gadara Region Project in the Wādī al-ʻArab[30]. It provides an insight into the local production of lithic artifacts and the raw materials used in the process, which include the thin layers of dark flint described above *(Fig. 1.45)*[31]. The resource "Silex"—the word is used at least in archaeology as a generic term for various sedimentary pebble rock types—is formed by excretion and precipitation processes from organic and inorganic silicia dissolves respectively silicon dioxide (SiO_2). It is characterized by specific striking properties like a mussel break[32].

Its deposition in between sediments of limestone and lime marl is typical of north-western Jordan[33]. The layers may also contain larger nodules that are suited for the manufacture of blanks and more complex tools. Apart from these occurrences, the study area also provided additional other means of access to the material, e.g. the platesilex itself and wādī rubbles. It can therefore be safely assumed that flint was both widely available and easily accessible. This, in turn, is considered the factor essentially responsible for the continued use of lithic, "Stone Age" tools at the time when metallurgy was discovered, even into the Iron Age[34]. The resource occurrence in limestone deposited Eocene and Cretaceous material, such as described by S. A. Rosen and generally mapped for the southern Levant[35].

30 For the research history overview and the work of the "Gadara Region Project" including the surveys in the Wādī al-ʻArab cf. Vieweger – Häser 2017, 13–56.

31 The terms "flint" and "silex" as well as "chert" are due to different, regional research traditions often used inconsistently. For terminology cf. Hauptmann 1980, Hahn 1991, 7–11 and Helms 2017, 19. In this essay, "flint" and "silex" are used synonymously (cf. Helms 2017, 19–21).

32 Helms 2017, 19; Rokitta-Krumnow 2010, 83; Hahn 1991, 9.

33 For a general classification of the region from a geological point of view, cf. e.g. the study of Bender 1968 in general, summarizing Waitzbauer – Petutschnig 2004, 92 f. 100 as well as Rosen 1997, 15–17. 32–34. A recent study on the geological characteristics of the Wādī al-ʻArab was made by Kraushaar 2016, 13–32.

34 On the fundamental scholarly debate dealing with the technology of lithics during the metal ages, refer to the publications by Rosen 1997 and 2013. For further general classification cf. Hesse 2013, 931–942. The coloring can highly vary within a group of raw material, so the distinction made here is only to be understood as provisional.

35 Rosen 1997, 32–34. To emphasize are the limits of the here mentioned division and identifcations of raw material groups by macroscopic aspects. A representative classification in comparison with the finds of the Tall Zirāʻa is to be done subsequently (for a minimum standard of flint raw material descriptions cf. Gebel 1994).

The finds under discussion comprise 42 objects that were recorded as surface finds during the surveys between 2009 and 2014, and taken to the dig house in Umm Qēs for further examination and storage. Here, they were first entered into the project's excavation database by K. Soennecken. In the autumn 2017, the finds were inspected, documented, and evaluated by the author. Apart from photographing and drawing selected objects this also involved a general listing of attributes from a morphological point of view[36]. The material is moreover intended to form part of the author's doctoral thesis on the lithic finds on the Tall Zirāʻa. This evaluation, which to date is entirely based on macroscopic observations, aims at providing a fundamental classification of the finds with respect to their function and material properties. Some preliminary divisions of the silex varieties can be distinguished from each other for the present:

Group 1	black, fine-grained
Group 2	dark brown, fine to medium-grained
Group 3	beige, fine to medium-grained
Group 4	light beige, medium-grained
Group 5	grey-beige, fine to medium-grained
Group 6	purple-brown, fine-grained

Tab. 1.10 Silex varieties of the Wādī al-ʻArab

When evaluating lithic artifacts it is important to consider that they represent different stages of the manufacturing process, from the core preparation to the fabrication of blanks (primary production) to, finally, the completion of the finished tool (secondary product). Hence, not only the tools themselves have to be rated as finished products but also the preceding forms such as, for instance, flake chips must be included as artifacts[37]. In contrast, a blank (flake or blade) or debitage product showing distinct use-wear or after-use retouch can be classified as a tool[38].

The subsequent discussion aims at giving an overview of the find material, from the more complex examples of the secondary production to the more ordinary forms. The appended catalogue *(Tab. 1.11)* comprises all finds of the hinterland survey, listed in a thematic order. Objects that do not show any signs of intentional processing are listed as ecofacts and will not be considered below. The figures comprise a selection of objects and will be presented in size 1:2 in *Pl. 1.1* with corresponding references (a, b, etc.). Some tools that were classified as sickles will be illustrated by drawings, with the sickle gloss marked in light grey. They will be evaluated first.

1.6.2.1.2. The Finds

Lithic artifacts that exhibit a particular sheen on their functional area are traditionally defined as sickles[39]. This lustrous effect develops when a tool is regularly used. It is caused by the flint's reaction with the organic material, which can be discerned macroscopically on the tool's cutting edge and its functional area.

The first object from this category (Cat. No. 1, *Pl. 1.1.a*) is a larger, basal-medial blade fragment with trapezoid cross section. Its left-hand edge was the functional area. Here, the sickle sheen spreads more or less evenly and bilaterally and only becomes narrower towards the bottom on the ventral side. The cutting edge shows fine retouches, indicative of the attendant whetting, some of which, however, were caused by frequent usage. The lateral edge on the opposite side shows a small strip

36 The attribute query is based on the common classifications, which have been described i.a. by Andrefsky 2000; Hahn 1991, Inizian et al. 1992 and Nishiaki 2000. Further important orientations for a detailed recording system form i.a. the dissertations of Rokitta-Krumnow 2010, 75–80 and Helms 2017, 21–31. 399–404. The attached catalogue *(Tab. 1.11)* gives only some selected aspects to provide a first overview of the objects.

37 cf. Floss 2013a, 12 f.; Helms 2017, 23 f.

38 cf. Helms 2017, 166; Rokitta-Krumnow 2010, 125. Even in this context the problem of post-depositional factors must be pointed out. Some certain blurring must be taken into account, e.g. for irregular retouching in the edge area. For the German research J. Hahn developed the term "GSM-Retusche" ("Gebrauchs-Sediment-Museums-Retusche" corresponding a retouch that leads back to use, sediment or museum) for modifications on edges whose intentionality cannot be determined unambiguously (Hahn 1991, 167 f.).

39 Cf. e.g. Rokitta-Krumnow 2010, 208 f.

of cortex in its medial section and also shortens towards the basal end. It is assumed that larger blades such as this (sickle blades or harvesting knifes) were used solitarily and fitted into a handle made of wood or bone. The basal shortening mentioned above may thus be interpreted as an intentional adjustment with the purpose of mounting the blade to a handle.

Ten more objects with gloss comprise smaller blade segments that nevertheless constitute fully-fledged tools. Smaller sickle segments such as these are notably more common. Several of them are fitted into a bracket made of wood or horn as a group and sometimes additionally fixed with an adhesive[40]. Unlike sickles made of one single blade, here the necessary segmentation allows for a curved functional area that is similar to the typical shape of harvesting sickles made of metal that are still in use up to this very day. Differences of the gloss gradient and intensity are essential indicators of an individual segment's position and alignment and also of the manner in which the tool as a whole was handled[41].

Cat. No. 2 *(Pl. 1.1.b)* is a medial blade segment with trapezoid cross section that was carefully retouched circumferentially, mainly on the ventral face. The gloss completely covers the lateral areas of the dorsal side up to the parallel interior ridges. In the left-hand area of the ventral side, only the retouches have a similar sheen while the opposite edge has a thin additional stripe. The gloss's stronger intensity on both lateral edges is evidence of the longer use of this segment and of a dual functional area: obviously the tool was turned around and used in both directions.

Cat. No. 3 *(Pl. 1.1.d)* is a medial-basal sickle segment with triangular cross section and a finely retouched left-hand cutting edge. While there is only little sheen on the ventral side, it is similar to Cat. No. 2 in that dorsally the sheen spreads across almost the entire corresponding lateral area up to the middle ridge. It is therefore safe to assume that the tool was used over a long period of time. Only one gap at its upper end indicates the blade's mounting or maybe the bracket that kept it in place.

The following segment (Cat. No. 4, *Pl. 1.1.c*) was made from a basal-medial, vaguely triangular blade fragment. Its upper end was intentionally broken and both ends were then truncated. The segment's shape suggests that it used to be an end piece inside the shaft. Dorsally, the retouch of the left-hand area is comparatively coarse and steeply angled whereas the cutting edge on the opposite side shows finer dorsal retouches. On the dorsal side, the gloss runs beyond the right middle ridge and tapers very evenly towards the basal end. By contrast, the gloss on the ventral side is significantly less pronounced and a clearance at the segment's upper end is indicative of a former covering.

The same seems to apply to the subsequent segment (Cat. No. 5, *Pl. 1.1.e*). It is a rather small rectangular medial blade segment with a vaguely trapezoid to triangular cross section and dorsal retouch that was based entirely on the ventral side. On the left-hand functional area, the sheen is only visible on the retouches whereas it is more pronounced, even though noticeably irregular, on the ventral surface. Here, too, this seems to indicate a former covering, e.g. by the shaft or by some adhesive, particularly in the top part of the segment.

Cat. No. 6 *(Pl. 1.1.m)* is a larger, slim segment with triangular cross section. Similar to Cat. No. 4, its shape suggests an end piece. Its functional area is denoted by a continuous dorsal retouch along the left-hand edge. Although the sickle sheen is fainter on the dorsal side, it runs as far as the middle ridge in its lower area. On the ventral side, there is a very pronounced sheen running along the cutting edge, flanked by a gap area next to which is a faintly glossy strip on the inside as well as at the distal end: these, again, could be indicative of fastenings.

Cat. No. 7 *(Pl. 1.1.i)* is a full blade segment with triangular cross section. On its left side, there are coarse dorsal retouches, while they are more delicate and bifacial on its right-hand side. Its gloss runs on both sides and becomes fainter towards the blade's basal end.

Cat. No. 8 *(Pl. 1.1.j)* is a rather coarsely executed medial fragment with triangular to trapezoid cross

40 For a general definition cf. Drechsler 2013, 791 f.

41 For a selection of examples of the possible reconstructions cf. Hahn 1991, Fig. 82; Drechsler 2013, Fig. 5; Helms 2017, Fig. 3.90; Nishiaki 2000, Fig. 6.9; Rokitta-Krumnow 2010, Fig. 105.

section. In its right-hand area, it has a cortical reserved zone. The opposite cutting edge has been whetted more or less superficially be means of very basic retouching and has a faint bifacial sheen.

Even though Cat. No. 9 *(Pl. 1.1.k)* also has cortical zones on its dorsal side, this specimen was executed in a much more meticulous fashion. It is a rather broad and thick cortical flake that was fitted to its fastening with the help of steeply angled right-hand retouches. The segment was moreover truncated on both ends. The ventral side of the functional area was finely retouched whereas the retouches of the dorsal side were probably caused by frequent usage.

Cat. Nos. 10 *(Pl. 1.1.g)* and 11 are the last of the sickle parts. They are rather small, less ambiguous fragments. Cat. No. 10 is the medial fragment of a flat blade with trapezoid cross section and may be comparable to Cat. No. 2. There is one major difference, however, in that it shows retouches on its opposite lateral edges both on the dorsal and on the ventral side, indicating two separate functional areas. By contrast, Cat. No. 11 is only a rather small fragment displaying isolated patches of sickle sheen. In this case, these are interpreted as lateral or distal flaking.

Particular significance can be assigned to Cat. No. 12 *(Pl. 1.1.n)* which is the medial-distal fragment of a rather large, very flat flake or a blade with triangular cross section. Its left lateral section consists of a cortical zone whereas the opposite edge is slightly curved inwards and has small bifacial retouches. These might be interpreted as traces of re-sharpening of the functional area, at least, however, they are signs of usage. Like Cat. No. 1, this blade was most probably used for cutting, though not as a harvesting tool. It is therefore assumed that the object constitutes the fragment of a cutting tool.

Cat. No. 13 *(Pl. 1.1.q)* is another cutting tool. It is a rather large, sturdy, and slightly curved blade with triangular cross section. The retouches on both lateral edges are very different, presumably due to a concurrence of re-sharpening, wear and tear, and natural influences. As nevertheless quite distinct working edges can be identified the author is convinced that the tool can be defined as a very coarsely worked cutting tool. A modification at the distal end could also indicate a function as a coarse drill or pick[42].

The distally and medially fragmented blade Cat. No. 14 *(Pl. 1.1.o)* resembles the previous object in that it, too, presents rather coarse bilateral retouches; these, however, are placed more intentionally from the dorsal side.

The rather small blade Cat. No. 15 and the rather large flake Cat. No. 16 *(Pl. 1.1.r)* have also been laterally sharpened. The blade is made up by a rather coarse cortical flake with superficial retouches on its left side, at least part of which may also have been caused by natural forces. A tapering at its distal end, however, is less ambiguous. Cat. No. 16 constitutes an exception among all of the finds discussed as, strictly speaking, it does not consist of the raw material common for flint tools but rather of a conglomerate of various silicates and inclusions. Primarily, the object appears to be a single, possibly natural fragment which, due to its tapered shape, resembles a rather large biface. There is a conspicuous lateral retouch of non-natural origin, which may be indicative of an intentional sharpening of this edge area.

Cat. No. 17 *(Pl. 1.1.h)* is another uncommon object, a basal-medial fragment of a meticulously worked blade, which shows a fine retouch, primarily on its left side. Its possibly superior and definitely less abundant raw material, spotted purple to beige-brown, is remarkable and has been categorized here under the preliminary Group 6. Apart from this possibly more exclusive blade, this material can only be matched with the blade fragment Cat. No. 18 and the basic flake Cat. No. 19. The series of blades with edge retouches is complemented by Cat. No. 20, a basal fragment with left-lateral bifacial retouches.

Non-ambiguous blanks, i.e. target products of the core preparation process that are made into tools in a consecutive production step, can hardly be found among the survey finds, at least not if they are understood as crude and unused base products[43]. Only one rather coarse fragment appears to have been part of such a flake that was originally chopped off as a base form (Cat. No. 21).

42 Hahn 1991, 185 f.; Rokitta-Krumnow 2010, 148–152.

43 Rokitta-Krumnow 2010, 125.

As surface finds run a greater risk of being erroneously identified as artifacts it should be pointed out that the survey finds, too, cannot always be classified with absolute certainty. The Cat. Nos. 22–33 comprise an assortment of miscellaneous basic flakes and blades and also of objects that, in the opinion of the author, can be categorized with relative certainty as parts of the production process. Some of these objects show marks of retouches such as the fragment Cat. No. 22, which has a steep lateral retouch that seems to have been made during the core preparation process. The Cat. Nos. 23, 26 *(Pl. 1.1.p)*, 27, 29 *(Pl. 1.1.l)*, 32, and 33 also display various rather coarse or irregular retouches and indentations. The flat flakes Cat. Nos. 25 and 26 are clearly debitage material. They are flat, roundish flakes that present unmistakable negatives of previous chopping actions.

The Cat. Nos. 35–37 are less distinct pieces. These numbers comprise objects that are either too fragmented or too scattered to be clearly identified and classified. The remaining Cat. Nos. comprise objects that the author confidently considers to be ecofacts.

1.6.2.1.3. Assessment

Considered in context, the lithic finds of the hinterland survey convey a first, actually not representative access to the production and consumption of knapped stone tools that can be proved for the Wādi al-'Arab. The finds even correspond to the tools and debitage that have been found on the Tall Zirā'a and already have been examinated and evaluated by the author.

With a view of the raw material, it can be noted that the initially described groups must be understood at least in part as varieties of superordinated raw material groups whose division is not completed until now. Selective observations of the author by his own field surveys, the example flint deposits already described by U. J. Seetzen, and finally the adjustment with the finds of the Tall Zirā'a support this assumption in which leastways the groups 1–3 may illustrate the dominant one.

The form spectrum of the finds, even though it is incomplete, may provide some general hints for the comsumption of lithic artifacts. Insofar the sickle blade (Cat. No. 1) and the sickle segments (Cat. No. 2–11), which present themselves in a typical morphological range of variation[44], may suggest a certain versatility and flexibility which matches an intensive and epoch independent agricultural exploitation of the Wādi al-'Arab. Furthermore the flakes and blades like the described Cat. Nos. 29 and 13, as well as debitage products like Cat. No. 26, which have been collected as part of the hinterland survey, the widespread distribution of knapped stone tools of the daily usage. High quality and "finer" artifacts, such as Cat. No. 2, 5, 6, and 17 bear witness to the transmission of complex manufacturing techniques and sophisticated selections of resources.

According to the author´s estimation, the lithic finds of the hinterland survey in the Wādi al-'Arab presented here, even in comparison to the finds of the Tall Zirā'a, can certainly be seen as additional evidence of the assumption of an intensive cultivation of the Wādī al-'Arab through the ages.

44 cf. Drechsler 2013, 793–795 for further details.

Plate 1.1: Flint finds in the survey area—typical examples

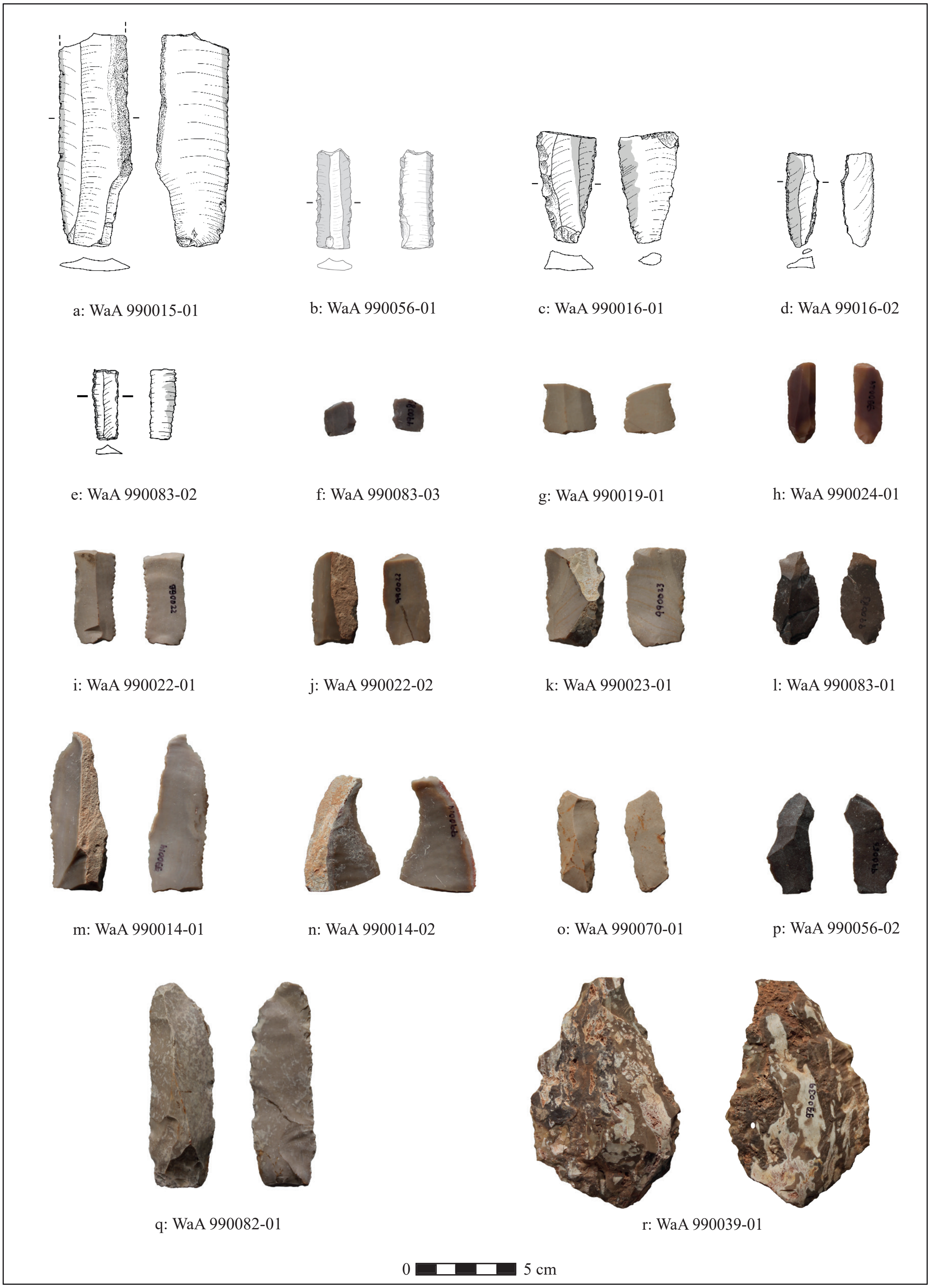


Plate 1.1.	Cat. No.	Inv. No.	Site	Form/Tool	Preserva-tion	Description
a	1	WaA 990015-01	219/227-1	sickle-blade	fragment	left-lateral bifacial retouched
b	2	WaA 990056-01	213/228-2	sickle	complete	bilateral bifacial retouched
c	3	WaA 990016-01	219/227-1	sickle	complete	bilateral dorsal retouched
d	4	WaA 990016-02	219/227-1	sickle	complete	bilateral dorsal retouched
e	5	WaA 990083-02	211/225-16	sickle	complete	bilateral dorsal retouched
m	6	WaA 990014-01	219/227-1	sickle	fragment	left-lateral dorsal retouched
i	7	WaA 990022-01	228/222-2	sickle	fragment	right-lateral bifacial retouched
j	8	WaA 990022-02	228/222-2	sickle	fragment	left-lateral bifacial retoched
k	9	WaA 990023-01	229/224-1	sickle	complete	left-lateral bifacial retouched
g	10	WaA 990019-01	221/225-1	sickle	fragment	medial fragment, bilateral retouched
	11	WaA 990020-01	223/225-1	sickle	fragment	small fragment, right-lateral bifacial retouched
n	12	WaA 990014-02	219/227-1	cutting tool	fragment	right-lateral dorsal retouched
q	13	WaA 990082-01	212/223-1	knife	complete	bilateral bifacial retouched
o	14	WaA 990070-01	221/216-2	blade	fragment	bilateral dorsal retouched
	15	WaA 990021-01	226/223-1	reouched blade	complete	circulating light retouched blade
r	16	WaA 990039-01	216/223-2	axe	complete	circulating light retouched, clear working edge
h	17	WaA 990024-01	229/225-2	blade	fragment	basal-medial fragment, bilateral retouched
f	18	WaA 990083-03	211/225-16	blade	fragment	bilateral bifacial use-retouched
	19	WaA 990083-07	211/225-16	flake	fragment	
	20	WaA 990066-01	211/225-16	blade	fragment	left-lateral bifacial retouched
	21	WaA 990064-02	211/225-14	flake	fragment	
	22	WaA 990068-02	223/225-4	flake		retouched on one edge
	23	WaA 990014-03	219/227-1	flake	uncertain	right-lateral bifacial retouched
	24	WaA 990067-01	213/226-1	flake	complete	right-lateral bifacial retouched
	25	WaA 990018-01	220/231-1	flake	complete	
p	26	WaA 990056-02	213/228-2	flake	fragment	
	27	WaA 990070-02	221/216-2	blade	fragment	bilateral irregular retouched
	28	WaA 990058-01	216/228-1	flake	complete	
l	29	WaA 990083-01	211/225-16	blade	complete	bilateral dorsal retouched
	30	WaA 990083-05	211/225-16	flake	complete	bialteral dorsal retouched
	31	WaA 990083-06	211/225-16	flake	fragment	
	32	WaA 990068-01	223/225-4	blade		bilateral retouched
	33	WaA 990083-04	211/225-16	flake	complete	bilateral dorsal retouched
	34	WaA 990058-04	216/228-1	flake	uncertain	burn marks and yellowish and light-blue deposits, recently influenced
	35	WaA 990058-03	216/228-1	flake		
	36	WaA 990058-05	216/228-1	flake		
	37	WaA 990058-02	216/228-1	flake		
	38	WaA 990069-01	224/217-2	ecofact		
	39	WaA 990065-01	211/225-11	ecofact		
	40	WaA 990064-04	211/225-14	ecofact		
	41	WaA 990064-03	211/225-14	ecofact		
	42	WaA 990064-01	211/225-14	ecofact		

Tab. 1.11 Catalogue of flint finds in the survey area.

Cross-Section	Colour	Gloss	L	W	H	D max	Wt
trapezoid	dark-brown	x	10.6	3.5	0.7		36.4
trapezoid	beige	x	5	1.8	0.6		7.5
trapezoid	beige, reddish banded	x	5.4	3	1		19.5
trapezoid	beige, reddish banded	x	4.9	1.7	0.7		
trapezoid	light-beige	x	3.5	1.3	0.5		3
triangular	grey-beige	x	8	2.9	1.2		21.2
triangular	light-beige	x	4.7	2	0,7		8,6
trapezoid	beige	x	4.5	2.3	0.8		9.7
trapezoid	grey-beige	x	4.8	2.9	0.8		15.1
trapezoid	light-beige	x	2.5	2.5	0.5		3.8
triangular	beige, reddish banded	x	2.6	1.4	0.4		1.5
triangular	grey-beige		5.8	3.9	0.6		10.6
triangular	light-beige		10.2	3.3	1.8		59
triangular	light-beige		4.9	2.1	0.9		8.8
triangular	light-grey		6.7	2.2	0.8		14.2
triangular	silicate-mixture		11.4	7.4	2.2		161.6
trapezoid	purple-brown		4	1.4	0.5		3.2
trapezoid	purple-brown		1.7	1.6	0.4		2
irregular	purble-beige				1.4	3.9	
triangular	grey-beige		2.7	1.8	0.8		4.6
rectangular	grey-brown		3.5	3.6	1.4		
	beige		4.4	2.8	0.9		10.5
triangular	light-beige		4.2	2.3	1		10.8
trapezoid	grey-beige		4	2	0.7		5
triangular	brown		3,7	1.9	0.7		4.4
irregular	dark-brown		5.2	2.4	0.7		4.9
rhomboid	grey-beige		3.3	2.2	1.2		7.5
irregular	grey-beige		7.8	5.9	2.9		89.2
triangular,	dark-brown		4.7	2.3	1		6
triangular	dark-brown		3.9	2.3	1		8.6
triangular	reddish-brown		2.8	2.6	0.9		5.6
	grey-beige		3.9	2.2	1		10.6
trapezoid	grey-beige		4.7	3	1.4		18
irregular	brown		4.2	2.3	1.5		
triangular	beige-brown		4.7	3.2	1.2		
irregular	grey-brown		4.8	2.5	1.1		
irregular	yellowish-brown		3.6	2	0.9		
triangular	beige		4.1	1.5	0.8		4
triangular	brown		1.7	2.5	4.2		16.8
rectangular	grey-beige				1.5	2.5	
leniticular	grey-brown		3.2	3	1.5		
irregular	grey-light-beige				0.4	3.6	4

1.6.2.2. Stone Vessels

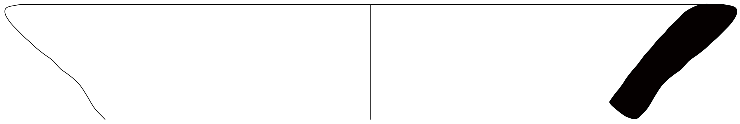
During the hinterland survey, a total of eight fragments of stone vessels were found. This relatively small number of stone finds is partially due to the fact that larger stone vessels were photographed but not picked up. Especially grinding and working stones as well as those that had been hewn were left *in situ*. The finds comprise seven basalt vessels and one limestone vessel. Of the basalt fragments, six belong to a bowl (three rims, two pedestals, and one bottom) and one formed part of a mortar.

Find number	Site	Material	Preservation	Term	Annotation	Dating
WaA 990013-01	219/227-1	Basalt	Foot	Bowl	Ornamented foot. Tripod bowl with elaborated legs[45]	Iron Age II
WaA 990042-01	215/224-1	Basalt	Rim and wall	Bowl	Slanted rim lip, rim slightly curved outwards	
WaA 990046-01	221/219-1	Basalt	Bottom	Bowl with flat base	Flat base of a bowl	
WaA 990048-01	227/225-1	Basalt	Rim to base	Bowl	Circular rim lip. Deep bowl with flat base. Diameter not measurable any more[46]	Iron Age to Persian period
WaA 990050-01	228/222-2	Basalt	Pedestal	Bowl with pedestals	Crafted very meticulously[47]	Iron Age to Persian period
WaA 990051-01	228/222-2	Basalt	Rim to base	Bowl	Circular bowl with thick base	
WaA 990078-01	214/227-3	Basalt	Fragment	Mortar	Half of a presumably circular mortar. D inside 20 cm, outside 32 cm. Wall thickness 7 cm, H 5 cm. Ring base[48]	Iron Age
WaA 990044-01	219/221-1	Calcite/ limestone	Rim and wall	Vessel	Roughly hewn deep bowl	Early Roman

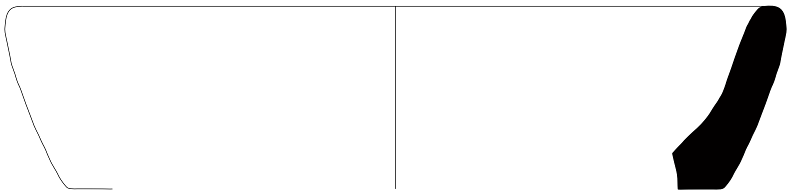
Tab. 1.12 Catalogue of stone vessels in the survey area.

45 Squitieri 2017, 62.
46 Squitieri 2017, 70.
47 Squitieri 2017, 72.
48 Squitieri 2017, 71.

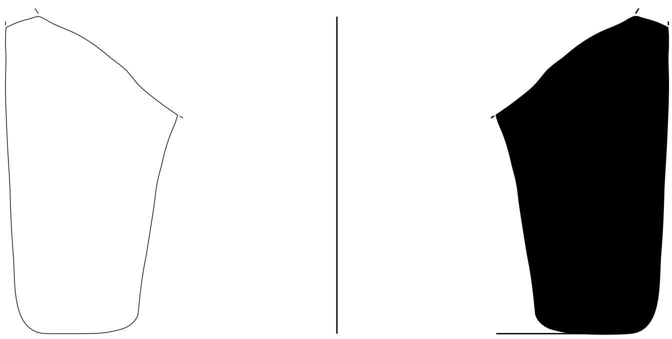
Plate 1.2: Stone vessels in the survey area



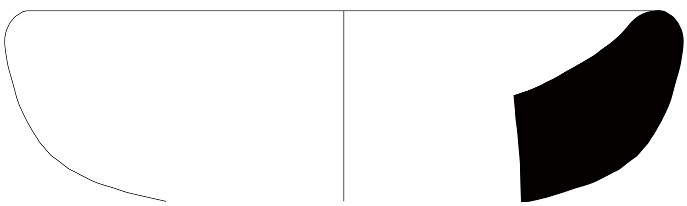
WaA 990042-01



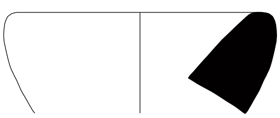
WaA 990048-01



WaA 990050-01



WaA 990051-01



WaA 990044-01

WaA 990046-01

0 5 cm

1.6.3. Glass Finds

by Stefanie Hoss

1.6.3.1. Introduction

The basis of this study is the collection of glass finds from the survey in the Wādī al-ʿArab performed by the "Gadara Regions Project" team.

The material was made scientifically accessible in several steps. During the survey campaigns 2009–2011 of the "Gadara Regions Project", all 109 glass finds from all periods of the surveyed area were recorded and put into a database with their excavation data, mainly by K. Soennecken. During the 2014 campaign, the author viewed all glass finds and supplemented and amended the records to include the type, literature and other information[49].

It was possible to determine 53 of the total of 109 finds, a remarkably high number and a testimony to the high proportion of diagnostic sherds in the assembly. Diagnostic sherds is the term used for the rims, necks, handles, stems, feet and bases of glass vessels. These can be assigned to a type—contrary to most body sherds, which can only be determined if adorned with a decoration unique to a specific type, a very rare occurrence.

The remaining 56 sherds were from unknown types. These finds are not included in the catalogue and are only recorded in the project database.

The determination of the glass finds from the survey was done with the help of the typology developed for the glass finds of Tall Zirāʿa. Accordingly the group numbers used here are the same as those employed in the publication of the Tall Zirāʿa glass finds[50].

In the following part, the different forms are presented and discussed. The vessels have been categorized into groups by their rim or base forms and decoration.

The catalogue of the determinable finds—presented as a table—follows the text, with the finds that were drawn and are presented in *Pl. 1.3* having been assigned a figure number (a, b, etc.). All drawings have a 1:2 scale.

1.6.3.2. The Finds

The first sherd, Cat. No. 1 (*Pl. 1.3.a*), belongs to a mould-made grooved bowl, either of conical or ovoid shape. Both the conical grooved bowls (Hoss group 1) and the ovoid bowls (Hoss group 3) belong to Grose's group A and were used as drinking bowls[51]. Bowls of these types are a common find and are often found in high numbers in the Southern Levant, while they occur less regularly and in much smaller numbers in Italy and Greece[52]. They have also occasionally been found in Syria (Dura Europos, Ǧabal Ḫālid) and even in the western part of the Mediterranean and beyond (Spain, Karthago, Marseille and even in Normandy)[53].

The oldest finds (from Athenian Agora) are dated to before 150 BC. Others from Ashdod come from contexts dated to the middle of the 2nd century BC. The linear cut bowls replaced both forms around the middle of the 1st century BC[54].

Cat. No. 2 *(Pl. 1.3.b)* was part of a free-blown bowl with a fire-rounded, everted rim on a tapering wall (Hoss group 10)[55]. Different variations of the type are known from the mid-1st to the 4th century in the Roman Empire, making the dating very vague. Comparable finds are dated by H. Hamel and S. Greiff in the 3rd and 4th century AD, but O. Dussart and Sh. Hadad demonstrate that similar rims were also found in Byzantine and Umayyad contexts[56].

49 In 2014, the German Research Foundation (DFG) granted the author a four-month research scolarship to write this article, for which she is most thankful.

50 Hoss 2015; Hoss 2020.

51 Hoss 2015, 23.

52 Dussart 1998, 51–54; Jennings 2006, 30–36; Keller 2006, 186 f.; Burdajewicz 2009, 168 f. (with further literature); Burdajewicz 2010, 265 f., fig. 1, 1–21, fig. 2, 22–27; Grose 2012, 28; Jackson-Tal 2013a, 102 (with further literature).

53 Davidson Weinberg 1961, 389 f.; Stern – Schlick-Nolte 1994, 284; Grose 1989, 194, footnote 34; Foy – Nenna 2001, 104; Keller 2006, 186 f.; O'Hea 2005; Honroth 2007, 35.

54 Keller 2006, 186 f.

55 Hoss 2015, 35.

56 Dussart 1998, 67. 69. 80 f.; Hadad 2005, 21, pl. 2, 39. 40;

The next sherd, Cat. No. 3 *(Pl. 1.3.c)* has a long outdrawn hollow fold on a straight wall (Hoss group 17)[57]. The fold follows the wall downwards until it turns in sharply to the base. This distinctive type of large bowl or platter enjoyed a wide distribution in both the western and eastern part of the Roman Empire during the 4th century AD[58].

The last three parts of bowls, Cat. No. 4–6 *(Pl. 1.3.e)* are ring bases, tooled out of glass by pinching and folding and then attached to the bottom of the bowl (Hoss group 24)[59]. The ring bases can be straight or more sloping, according to the bowl they are attached to. Bases like these are common throughout the Roman Empire; they first appear in the 2nd century, but continue into the Umayyad period[60].

The Cat. No. 7 has a fire-rounded rim on tapering walls (Hoss group 27)[61]. Rims of this description are found on several types of conical beakers. The first of these is a footless conical tumbler often decorated with wheel-cut incisions, trails or drops in a different glass colour[62]. It was also used as a lamp, probably set into metal or wooden tripoids or hanging candelabra.[63] It is a typical form of the 4th century in both the western and eastern Roman Empire[64].

Another form has a small, but fairly heavy foot (see below), dated to the 4th and 5th century, and possibly continuing into the Umayyad period[65].

A third type has a small, massive so-called pad base and also dates to the Late Roman and Early Byzantine (mainly 4th–5th century) period[66]. Several authors also date similar rims more vaguely between the 4th and 7th century or date the whole group of rims into the 3rd and 4th century AD[67].

The rims of the Cat. No. 8–10 *(Pl. 1.3.e)* are fire-rounded as well and straight or slightly incurving, they sit on straight walls (Hoss group 28)[68]. The type was widespread in the Roman Empire and had an extremely long period of use, from the late 1st to the 8th century[69].

The following Cat. No. 11–14 *(Pl. 1.3.f–g)* have everted fire-rounded rims set on straight walls (Hoss group 29)[70]. Rims of this form also occur on several types of beaker from different periods. The oldest of these was found in 1st to 2nd century contexts in Jericho[71]. The later forms have in common that they are well represented in Palestine and date to the Roman, Byzantine and Umayyad periods[72].

Hamel – Greiff 2014, 150, fig. 5. 6.

57 Hoss 2015, 38.

58 Isings 1957, 148, form 118; Davidson Weinberg – Goldstein 1988, 47 f., fig. 4–7; Cohen 1997, 400, pl. I, 10–12; Dussart 1998, BII 311, 75 (pl. 11, 2–10); Keller 2006, type VII 2, 201, pl. 7a; Hadad 2006, 626, fig. 19.2, 17; Jennings 2006, 75 f., fig. 4.7; Hoss 2015, 40.

59 Hoss 2015, 40.

60 Davidson Weinberg – Goldstein 1988, 58, fig. 4–20; Rütti 1991, Kat. Nr. 5057–5080 (pl. 180. 181); Cohen 1997, 401 f., pl. II, 9–11; Dussart 1998, BI 4212a, 66 (pl. 6, 10), BI 4222a2/b1, 68 (pl. 7, 11–18), BII 12, 74 (pl. 10, 13–15); Hadad 2005, 21, pl. 3, 72; Jennings 2006, 191–193, fig. 8.5; O'Hea 2012, 304, Cat. No. 44. 45, fig. 629. 630, Jackson-Tal 2013b, pl. 6.2,15—all with further literature.

61 Hoss 2015, 53 f.

62 Davidson Weinberg – Goldstein 1988, 87–89; Israeli 2003, 195 f., Cat. No. 228–231.

63 Jennings 2006, 135–137, fig. 6.10.

64 Davidson Weinberg – Goldstein 1988, 87–94, fig. 4–45 to 4-47; Cohen 1997, 407 f., pl. III, 7. 8; Israeli 2003, 193–196, Cat. No. 228–231; Keller 2006, type VII 24a/b, p. 213, pl. 13, h–I; Jennings 2006, 88–91, fig, 5.6.

65 Davidson Weinberg – Goldstein 1988, 62 f., fig. 4–24; Cohen 1997, 408–410, Pl. III, 9–13; Dussart 1998, BVIII 2112, BVIII 2113, 106–110, pl. 24; Cohen 2000, 168, pl. 14–16; Keller 2006, 24a/b, p. 213, pl. 13h-i.

66 Davidson Weinberg – Goldstein 1988, 60–62, fig. 4–23; Jackson-Tal 2013c, 54, Nr. 2, fig. 1, 2.

67 Keller 2006, 218 f., type 33a, 34a, pl. 15j, 15m; Hamel – Greiff 2014, 150, fig. 16, 3–7.

68 Hoss 2015, 54–55; for a complete example see Israeli 2003, 144. 159 f. Cat. No. 163.

69 Cohen 1997, 410, Pl. III, 20; Dussart 1998, BVIII 111/ 112, BVIII 15, BVIII 2111, 95–96, 104–106, pl. 21, 1–17, pl. 23, 8–35; Keller 2006, type VII 28a, VII 29 a/b, VII, 31a, VII 32a, pp. 215–218, pl. 15d, 15k–l, 16c, 16f; Jennings 2006, 71 f., fig. 4.1, 6–8, pp. 91–92, fig, 5.7; Jackson-Tal 2012, 184, fig. 8.2, 6–7; O'Hea, 2012, 305, Cat. Nr. 49–51, fig. 633–636—all with further literature.

70 Hoss 2015, 55.

71 Cohen 1997, 410, pl. III, 18–19; Cohen 2000, 168, pl. II, 14; Israeli 2003, Cat. No. 164, 167, pp. 161–162; Hadad 2005, 21, pl. 2, 37; Jennings 2006, 71 f., fig. 4.1, 2, 4–5 and 91 f., fig, 5.7; Jackson-Tal 2013a, 108, pl. 3.6, 52; Hamel – Greiff 2014, 157, fig. 16.5.25–26—all with further literature.

72 Dussart 1998, 103; Keller 2006, 217 f., Jennings 2006, 71 f., fig. 4.1; Jennings 2006, 88–91, fig, 5.5, 2, 4.

The two beaker bases Cat. No. 15–16 *(Pl. 1.3.h)* are fashioned with a long drawn-out fold and a high, pushed-in centre (Hoss group 34)[73]. Bases like these can be separated into rather flat ones, which belong to conical and straight-walled beaker types with everted rims of the 1st and 2nd century, and high bases with a high pushed-in concave centre belong to a type with a round rim, dating to the 4th century[74]. The base pictured in *Pl. 1.3.h* clearly belongs into the former group.

The following four Cat. No. 17–20 are rounded, everted rims on straight walls, which belonged to stemmed goblets (Hoss group 38)[75]. The form is very common in Palestine and is dated to the Byzantine and Umayyad periods[76].

13 bases of stemmed goblets were found (Cat. No. 21–33, *Pl. 1.3.i*). These are tubular folded goblet bases, with pushed-in concavities, often quite high and carrying a pontil mark (Hoss groups 40–42)[77]. Stemmed goblets are very common in Byzantine and Umayyad Palestine and the wider Levant[78]. They also occur in the rest of the Mediterranean, but were not used in the other regions of the Roman Empire[79].

One base from a polycandelabrum lamp was also among the finds (Cat. No. 35, *Pl. 1.3.k*). These lamps consisted of a metal frame with holes for several glass bowls, which would have been hanging from the ceiling. The glass bowls used in these lamps had long stems, sometimes tubular and sometimes tapering, to balance their fairly heavy contents (water with a surface layer of oil plus a little wick-frame) on the metal frames (Hoss group 44)[80]. The stem base preserved here is hollow, conical and formerly ended in a drop (now missing)[81].

The following four sherds are bottle rims. The first of these (Cat. No. 35, *Pl.1.3.l*) is fire-rounded and angled slightly to form a tapering neck (Hoss group 46)[82]. Tapering necks were used on several different types of bottles that were common from the Late Roman to the Late Umayyad periods[83].

The next two rims sherds (Cat. No. 36–37, *Pl. 1.3.m*) also have fire-rounded rims, which sit on funnel-shaped mouths and thin necks (Hoss group 47)[84]. Necks of this type could belong to several types of bottle and flasks, dating from the 2nd and 3rd century to the Abbasid period, with a marked emphasis on the Byzantine and Umayyad periods[85]. Some have necks decorated with trails winding around the exterior, as our Cat. No. 37[86].

73 Hoss 2015, 57.

74 Keller 2006, 220, pl. 16s (early) and 16t (late).

75 Hoss 2015, 66.

76 Israeli 2003, 197–198, Cat. No. 235–237; Jennings 2006, 131–134, fig. 6.7, 4–5, fig. 6.8, 7–9—all with further literature.

77 Hoss 2015, 67.

78 Cohen 1997, 405–407, pl. III, 1–5; Dussart BIX 1, BIX 2, 115–124, pl. 27, pl. 29, 7.37; Hadad 2005, 28, pl. 21, 400–411; Hadad 2006, 628, fig. 19.3, 56–57, fig. 19.4, 78; O'Hea 2012, Nr. 57–60, p. 306, fig. 641–644.

79 The following after: Jennings 2006, 123.

80 Keller 2006, 225; Hoss 2015, 73 f.

81 Cohen 1997, 404, Pl. II, 23–24; Dussart 1998, 88, BVII 22, pl. 16, 11–12; Jennings 2006, 256–257, fig. 11.11, 9. Hadad 2008, 174–175, pl. 5.8, 126–127.

82 Hoss 2015, 78.

83 Cohen 1997, 419–427, pl. VI, 6, 13, pl. VII, 4–5, pl. VIII, 11–16; Dussart 1998, type BX 1111b2–BX1121b, pp. 128–132, pl. 32–33, type BX 1125a1–BX1125a2, pp. 132–136, pl. 34,4–35,25, type BX 1143, pp. 138–139, pl. 37, 11–22, type BX 131–132, p. 140, pl. 38, 1–4, type BX 3111–3141, p. 142, pl. 1–6; Cohen 2000, 170, pl. III, 28–29, 34–36; Brosh 2003, 334, 346, 350, Cat. Nr. 431, 455, 462; Israeli 2003, 168–169, 242, Cat. No. 179, 181, 182, 184, 313; Keller 2006, type VII 54a, p. 226, pl. 19h, type VII 79a, p. 234, pl. 220; Hadad 2005, 24–27, pl. 12, 235–237, 244, 246, pl. 18, 352–354; Hadad 2006, 626–627, fig. 19.2, 19–21; Jennings 2006, 77–78, fig. 4.10, 12, p. 177–178, fig. 7.26, 15–20, 22; Jackson-Tal 2007, 487, pl. 8, 5; Hadad 2008, 170–171, pl. 5.4, 57, Jackson-Tal 2012a, 186, fig. 8.3,1,6; O'Hea 2012, Cat. Nr. 65, 68, 70–71, 77, pp. 307–308, Fig. 649, 652, 654–655, 661; Jackson-Tal 2013a, 114, 3.10, 3–5.

84 Hoss 2015, 78 f.

85 Dussart 1998, type BX 131, p. 140, pl. 38, 1–3; type BX 3212–type BX 3241a/b, pp. 143–147, pl. 40, 6–25, pl. 41, 1–29; Cohen 2000, 170, pl. III, 37, 39; Keller 2006, type VII 52, p. 226, pl. 19f, type 57a–d, pp. 227–229, pl. 20i–p, Typ 58, p. 229, pl. 20q; Hadad 2005, 23–24, pl. 7, 136–138, pl. 11, 201, Hadad 2006, 626 f., fig. 19.3, 37–39; Jennings 2006, 159–161, fig. 7.4–5, 167–168, fig. 7.14, 6, 13–14, 177–178, fig. 7.26, 1–3, 5, 9, 7, 12–14; Hamel – Greiff 2014, 154, fig. 16.4,14, 16.4.16, 16.4.17—all with further literature.

86 Cohen 1997, 419–425, pl. VI, 3–4, 7-8, pl. VII, 4–5; Dussart 1998, type BX 132, p. 140, pl. 38, 4; Keller 2006, type VII 56b–c, p. 228, pl. 20g–h; Hadad 2005, 24–25, pl. 12, 233–234, pl. 13, 251, 254–258, pl. 14, 272–273; Hadad 2006, 626–627, fig. 19.2, 26–27; Jennings 2006, 113, fig.

The last bottle rim sherd (Cat. No. 38, *Pl. 1.3.o*) is infolded and sits on a tapering neck (Hoss group 50). This is the most common design for bottle, flask or jar mouths and was used on a large variety of types from Late Roman times onwards until the Abbasid period, but it was especially common during the Byzantine and Umayyad periods[87].

The next seven sherds (Cat. No. 39–45, *Pl. 1.3.p*) are all round, free-blown bases, with a concave bottom and a pontil mark (Hoss group 56)[88]. These bases were used for a variety of types of bottles, flasks and jugs during the Late Roman to Umayyad periods[89].

The following rim sherd (Cat. No. 45) belongs to a jar. Jars are smallish vessels with a wide mouth that either have very short necks or no necks at all. They were used to hold substances too thick to be poured, like creams[90]. According to Dussart, jars of this form date into the Byzantine and Umayyad periods[91].

The next two sherds (Cat. No. 46–47, *Pl.1.3.r*) belong to small bottles, probably used for perfume (Hoss group 64)[92]. As they have rather universal forms, they cannot be dated accurately.

The next sherd (Cat. No. 48) is part of a handle for a twin phial. These vessels have a very distinctive form and were use for khol. They have small handles running into decorative trails, often in a different colour to that of the body. This very common regional form is dated to the 4th to 7th century[93].

Three different handles are among the finds recorded. The first (Cat. No. 49, *Pl. 1.3.s*) is smooth and has a simple round cross-section, often used for steep handles which are common in jugs and flasks (Hoss group 66)[94]. Two handles (Cat. No. 50–51) are ribbed along the longitudinal axis (Hoss group 67)[95]. They are also steep and it may be supposed that they were used on similar vessels to that of the former group.

Two fragments of bracelets were discovered (Cat. No. 51–52), one opaque dark blue, the other covered with white iridescence, but most likely also dark coloured. Both have a simple round and smooth exterior. They belong to Spaer's type A1, which occurs from the 3rd century onwards[96].

The last determinable find is a flat, colourless piece of window glass (Cat. No. 53). Because of its lack of colour, it is more than likely that the fragment is post-Umayyad.

5.271-9; Hadad 2008, 171, pl. 5.6, 91—all with further literature.

87 Cohen 1997, 413, pl. IV, 7–8, 424–427, pl. VI, 17–20, pl. VII, 1–3, 6, pl. VIII, 14; Dussart 1998, type BX 1111b2, p. 128, pl. 32, type BX 1125b1/2, pp. 132–135, pl. 35, 26–46, type 1132b1/2, p. 137, pl. 36, 14–22, pl. 37, 1–7, type BX 123, p. 141, pl. 37, 39, type BXIV 11, pp. 176–177, pl. 59, 6; Israeli 2003, 262, 266, Cat. No. 342, 353; Keller 2006, type VII pp. 61–62, 230, pl. 21b–e; Hadad 2005, 23–25, pl. 9, 165, 168–169, 171–172, 175–176, pl. 11, 200, pl. 13, 254–257, pl. 15, 292, 298, pl. 16, 309–311, 313–314, 316–317; Hadad 2006, 629, fig. 19.4, 72–74; Jennings 2006, 77, fig. 4.10, 11, 13; Jackson-Tal 2007, 486, pl. 9, 3; Hadad 2008, 170–171, pl. 5.5, 74–76—all with further literature.

88 Hoss 2015, 81.

89 Hadad 2006, 626–627, ig. 19.2, 49–50, Hadad 2008, 170–171, pl. 5.5, 83; Gorin-Rosen 2010, 226, pl. 10.2, 9–11.

90 Israeli 2003, 234.

91 Dussart 1998, type BVII 11, pp. 88–89, pl. 16, 20–23.

92 Hoss 2015, 87–88.

93 Cohen 1997, 417–418, pl. V, 13–16: Dussart 1998, type BVIII 211–BVIII 2232, 112–113, pl. 57,14–pl. 59,2; Israeli 230–231, Cat. Nr. 287–292; Hoss 2015, 88, group 65.

94 Davidson Weinberg 1988, 69, fig. 4–30, 257–258; Rütti 1991, Vol. II, 175–177, Kat. Nr. 4134–4203, pl. 162; Dussart 1998, BXIV 1221–BXIV 8, pl. 60–63; Israeli 2003, 175–184, Cat. No. 194, 197, 199, 204, 209, 213, 219, p. 239, Cat. Nr. 307–309, pp. 259–262, Cat. Nr. 333–334, 336–337, 339, 341, 342–343, p. 264, Cat. Nr. 348, p. 266, Cat. Nr. 353, p. 282, Cat. Nr. 379–381; Jennings 2006, 196–198, fig. 8.12; Jackson-Tal 2007, 486, fig. 10, pl. 9, 3; Jackson-Tal 2012, 189, fig. 8.4,3; Hoss 2015, 93—all with further literature.

95 Davidson Weinberg 1988, 69, fig. 4–30, 250; Rütti 1991, Vol. II, 177–181, Kat. Nr. 4226–4382, pl. 163–168; Cohen 2000, 171–172, pl. IV, 49–50; Israeli 2003, 175–184, Cat. No. 195–196, 198, 200–203, 205, 207, 212, 215–217, 218, pp. 237–238, Cat. Nr. 302–304, pp. 256–257, Cat. Nr. 328–332; Jennings 2006, 195–196, fig. 8.11, 5–11; Jackson-Tal 2007, 487, fig. 11, pl. 9, 4; Hoss 2015, 93—all with further literature.

96 Spaer 1988, 54.

1.6.3.3. Analysis

The oldest sherd in the collection is clearly Cat. No. 1, belonging to a mould-made grooved bowl dating to 150–50 BC. The rest dates mainly to between the Late Roman and Umayyad periods, with no finds dating to the 1st or 2nd century only (with the possible exception of Cat. No. 15). The earliest securely dated finds after Cat. No. 1 are from the 3rd to 4th century (Cat. No. 2). This leaves a conspicuous gap in glass finds in the Early and Middle Roman periods. Some forms continue into the Abassid period (Cat. No. 36–38), and a few finds are clearly modern and industrial-made (WaA 990002-01 to WaA 990002-03).

The dating of the finds is comparable with the dated finds from Tall Zirāʻa, where the earliest glass vessels also are mould-made grooved bowls, followed by a rather distinct gap in Early and Middle Roman period glass finds[97]. With the start of the Late Roman period, glass finds again begin to appear in greater numbers at Tall Zirāʻa, but the peak period is definitely in the Byzantine and early Umayyad periods. A very small number of finds may be Abbasid, while the few sherds of modern glass have not been studied at Tall Zirāʻa.

The forms found at the Wādī al-ʻArab survey are also comparable to those found at Tall Zirāʻa, with tableware predominating[98]. Here, the vessels used for drinking such as bottles, beakers, goblets and mould-made drinking bowls make up the overwhelming majority of 36 fragments, while other tableware is just represented with five fragments of bowls. The rest are small quantities of cosmetic vessels, lamps and handles or bracelets. The only caveat to this summary is that (some) goblets may have been used as lamps as well[99].

The high proportion of stemmed goblet bases (24 %, 13 fragments) among the glass finds is not unusual. Because of their thickness, these bases often survive the post-depositional processes rather better than other vessels with thin walls. The dominance of such parts can substantially distort the picture as it may give the impression that these forms made up a bigger percentage of the glass vessels used than was actually the case[100].

The overall picture of the glass finds from the Wādī al-ʻArab survey is thus that the inhabitants of the various smaller settlements in the Wādī al-ʻArab had similar preferences and probably also sources for their glass as those of its biggest settlement, Tall Zirāʻa.

97 Hoss 2015, 106–139.
98 Hoss 2015, 106–139.
99 Hoss 2015, 65 f.
100 Jennings 2006, 285.

Plate 1.3: Glass finds in the survey area

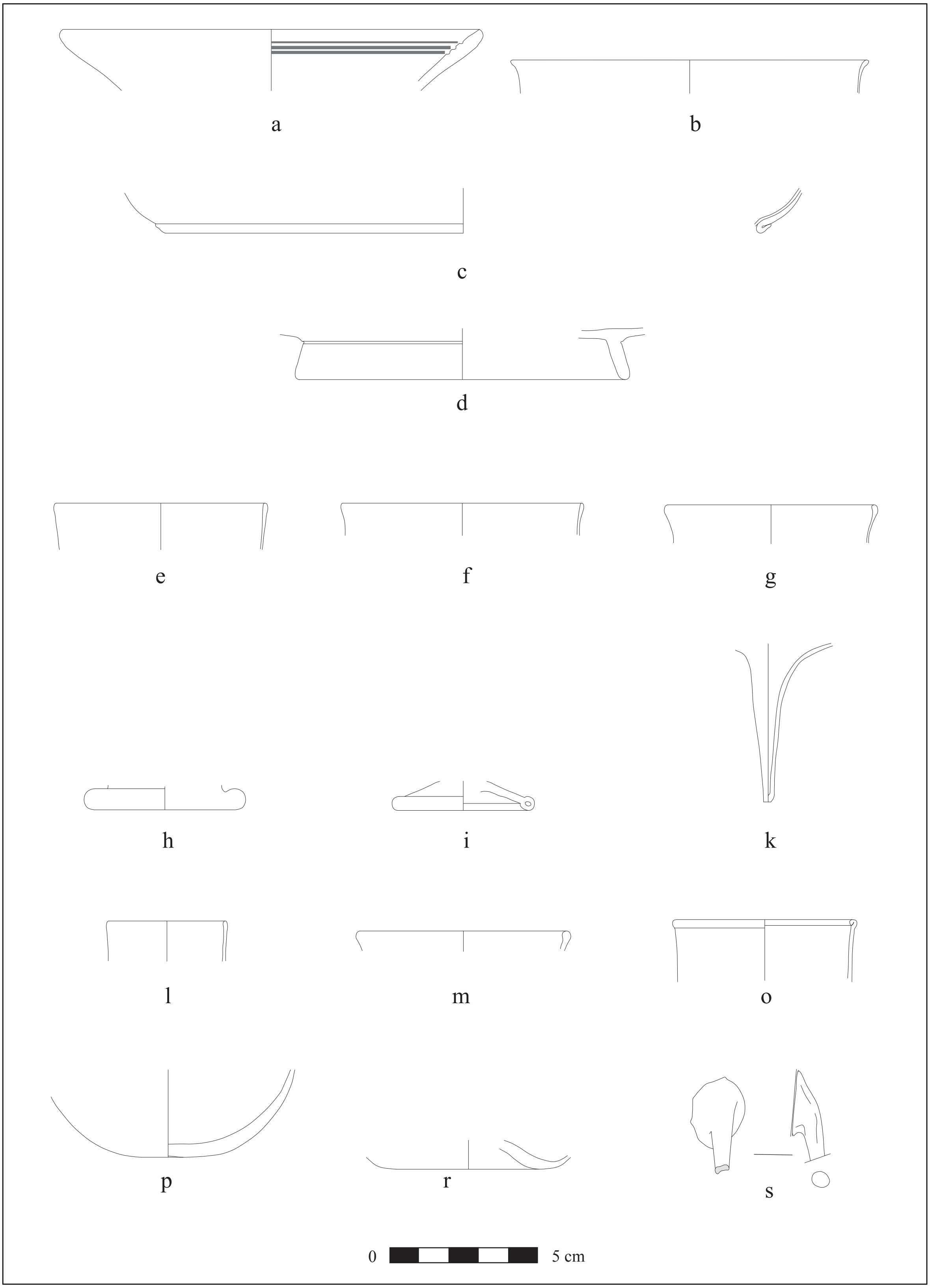


Fig.	Cat. No.	Inv. No.	Site	Form	Preservation
a	1	WaA 990030-01	221/223-1	bowl with grooves	rim
b	2	WaA 990038-06	228/223-1	bowl	rim
c	3	WaA 990031-01	221/225-1	bowl	
	4	WaA 990062-03	223/225-4	bowl	base – ring
	5	WaA 990009-02	220/227-2	bowl	base – ring
d	6	WaA 990029-03	220/224-1	bowl	base – ring
	7	WaA 990009-01	220/227-2	beaker	rim
e	8	WaA 990026-01	218/221-1	beaker	rim
	9	WaA 990038-05	228/223-1	beaker	rim
	10	WaA 990038-07	228/223-1	beaker	rim
	11	WaA 990006-12	214/227-3	beaker	rim
	12	WaA 990033-01	225/218-1	beaker	rim
f	13	WaA 990038-07	228/223-1	beaker	rim
g	14	WaA 990029-06	220/224-1	beaker	rim
h	15	WaA 990035-02	225/225-1	beaker	base – foot
	16	WaA 990005-02	214/227-1	beaker	base – foot
	17	WaA 990034-01	228/222-2	goblet	rim
	18	WaA 990002-06	208/224-1	goblet	2 rim fragments
	19	WaA 990084-03	211/225-16	goblet	rim
	20	WaA 990084-05	211/225-16	goblet	rim
	21	WaA 990005-01	214/227-1	goblet	base – foot
	22	WaA 990038-01	228/223-1	goblet	base – foot
	23	WaA 990026-03	218/221-1	goblet	base – beaker
i	24	WaA 990038-01	228/223-1	goblet	base – foot
	25	WaA 990029-04	220/224-1	goblet	base – foot
	26	WaA 990031-02	221/225-1	goblet	base – foot
	27	WaA 990032-02	224/221-1	goblet	base – ring
	28	WaA 990002-07	208/224-1	goblet	2 foot fragments
	29	WaA 990006-07	214/227-3	goblet	base – foot
	30	WaA 990006-08	214/227-3	goblet	base – foot
	31	WaA 990006-09	214/227-3	goblet	base – foot
	32	WaA 990006-10	214/227-3	goblet	base – foot
	33	WaA 990084-01	211/225-16	goblet	base – ring

Hoss group	Colour	L	W	H	D max	D open	D base
1/3	Almost colourless, very pale green		3	3			
10	Transparent pale blue		2.2	1		11	
17	Transparent pale green		3.9	2.1		20	
24	Translucent pale green	2.2	1.9	1.2			
24	Transparent pale green		4.9	1.9			8
24	Transparent pale green			1.7			12
27	Transparent pale green		3.4	1.8		5	
28	Transparent pale green			1,5	8	8	
28	Transparent pale blue		1.4	1.5		7	
28	Transparent pale blue		2.4	1.2		5	
29	Transparent pale turquoise		2.4	1.3		7	
29	Transparent pale blue		1.9	1.5			8
29	Transparent pale blue		2.4	1.2		5	
29	Transparent pale blue		1.8	1.3		7	
34	Opaque translucent brownish-purple			1.1			4.5
34	Transparent pale green	2.7	2.5	0.8			2.5
38	Transparent pale green		1.9	1.6	7	7	
38	Transparent pale blue		1.9	1.2		5	
38	Transparent bluish green		3.1	1.9		7	
38	Transparent bluish green		3.7	2.5		8	
41–42	Transparent pale green	2.9	2.7	1			2.5
41–42	Transparent pale blue			1.1			4
41	Transparent pale blue	2	2				6
42	Transparent pale blue			1.1			4
42	Transparent pale green			0.9			5
42	Transparent pale green	2	1.3				5
42	Transparent pale blue	2.4	0.6	0.7			8
42	Transparent pale blue		2.4	0.4			4
42	Translucent pale turqoise	2.9	1.6				2
42	Translucent pale turqoise	2.9	1.5				4
42	Transparent pale green	2.8	2				2.5
42	Transparent pale green	2	1.5				3
42	Transparent bluish green		1.6	1			

Fig.	Cat. No.	Inv. No.	Site	Form	Preservation
k	34	WaA 990032-01	224/221-1	lamp	base
l	35	WaA 990026-02	218/221-1	bottle	rim
m	36	WaA 990028-01	220/220-1	bottle	rim
	37	WaA 990084-02	211/225-16	bottle with thread decoration	rim
o	38	WaA 990038-04	228/223-1	bottle	rim
	39	WaA 990029-01	220/224-1	bottle	base
p	40	WaA 990029-02	220/224-1	bottle	base
	41	WaA 990038-02	228/223-1	bottle	base with part handle
	42	WaA 990005-03	214/227-1	bottle	base
	43	WaA 990005-04	214/227-1	bottle	base
	44	WaA 990005-05	214/227-1	bottle	base
	45	WaA 990006-11	214/227-3	jar	rim
	46	WaA 990084-04	211/225-16	bottle	rim
r	47	WaA 990035-03	225/225-1	bottle	base
	48	WaA 990028-02	220/220-1	twin phials	handle
s	49	WaA 990035-05	225/225-1	handle	handle
	50	WaA 990038-03	228/223-1	handle	handle
	51	WaA 990011-01	214/227-1	handle	handle
	51	WaA 990012-01	220/227-2	bracelet	2 fragments
	52	WaA 990008-01	219/227-1	bracelet	fragment
	53	WaA 990026-05	218/221-1	window	fragment

Tab. 1.13 Catalogue of glass finds in the survey area.

Hoss group	Colour	L	W	H	D max	D open	D base
45	Transparent turqoise			5.1	3.2		
46	Transparent pale blue		1.2	1.5			
47	Transparent pale green		1.8	0.8			5
47	Translucent yellowish green		1.9	2.1			
50	Transparent very pale blue		1.7	2.1		6	
56	Translucent turqoise	7	8.4	0.6			
56	Translucent turqoise	4.1	8.2	0.6			
56	Transparent pale blue			2.9			
56	Transparent pale green	2.7	2.5	0.8			
56	Transparent pale blue	3.8	2.8	0.8			
56	Transparent pale blue	2.8	2.2	0.4			
63	Translucent pale turqoise		2.8	1.4		5	
64	Transparent bluish green		2.6	3.2		1.5	
64	Transparent pale green	3.5		1			6
65	Tanslucent pale green			2			
66	Translucent turqoise			3			
67	Transparent pale blue			3	1		
67	Greyish mixed with pinkish-purple			2.7	0.7		
73	Opaque dark blue	4	0.5				
73	Covered in strong white iridescence, but dark coloured	3.3	0.9				
74	Transparent colourless		2.6	4.2			

1.7. Destructions

by Katja Soennecken/Patrick Leiverkus

One important result of revisiting the previously published sites during the survey in the Wādī al-ʻArab is that heavy destruction of many sites in the last decades could be recorded. The rapid increase of deterioration is alarming. Only recently a large tall with Roman, Byzantine, and Islamic settlements (no. 26 in the Hanbury-Tenison survey; 211/224-2) south of Tall Zirāʻa was completely destroyed by bulldozing. In an area of approximately 130 m x 90 m (maybe more before the destruction in modern times) ancient remains could be observed—some of the stones still *in situ*, but most of them shoved away. The section produced by a bulldozer showed at least two layers of a Roman-Byzantine settlement, divided by layers of ash.

Unfortunately, in spite of more recently increased awareness and a multitude of measures undertaken to promote this awareness, there has

Fig. 1.46 Lower city of Tall Zirāʻa, 211/225-16 in 2011.

Fig. 1.47 Lower city of Tall Zirāʻa, 211/225-16 in 2017.

been no decline in destructions such as these and even the Tall Zirāʻa (2016) as well as the north-westerly lower town (2017) have been affected.

Almost all of the modern villages turned out to date back at least to the Roman and/or Byzantine periods, some of them to the Iron Age or the Bronze Age. Only very few of the ancient settlements have not been covered and destroyed by modern settlements. That also includes most of the Islamic sites of the Wādī al-ʻArab. It is particularly sad to note that none of the old mosques in the area of the wādī—some of them dating back to the medieval period—are in existence any longer. To our knowledge, the last old mosque in the area can be found in the village of Ḫarğā. Even this one is in a very bad condition (site 233/229-1, *Fig. 1.48*).

Several smaller sites were destroyed by agricultural activities. Olive tree cultivation especially leaves sites in an unrecognizable state. These observations led the members of the "Gadara Region Project" to the firm commitment to this survey not only as a necessary complement to an excavation but also as an opportunity to salvage information on the history of the Wādī al-ʻArab, most of which will be lost in the near future.

Despite the continuing demolition of the ancient sites, we could collect a representative amount of pottery from all sites, from which we can derive a concise overview of the history of the Wādī al-ʻArab.

Apart from these heavy destructions another problem emerged very clearly: most of the unknown or at least unpublished sites showed traces of recent unauthorised excavations/digging. These mainly concentrated on tombs (metal detectors), and most of the finds were removed. Two examples:

One site was first described by Mittmann and called Ḫirbat Srīs (M 059; 228/221-1). When we visited the 1½ ha site, the vegetation was burnt down. We found pottery, tesserae, a cistern and a robber trench (3 layers of ashlar masonry visible). The pottery could be dated to Roman-Byzantine-Islamic (Umayyad) periods. Another site was not previously published and is located north of Fūʻarā, south-west of Wādī al-ʻArab (220/224-1). An area of approximately 2 ha (250 m x 80 m) was covered with pottery, tesserae and some pieces of glass. Additionally cisterns, a quarry, some natural caves and tombs were found. Most of the tombs were only visible because of recent robber trenches, and nearly all of them were shaft tombs. In one robber trench, ashlar blocks could be seen. The pottery dates to Roman-Byzantine-Islamic periods and suggests at least two phases of occupation.

Fig. 1.48 Site 233/229-1 Mosque with integrated Roman sarcophagus and architrave (© BAI/GPIA).

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2. Related Research Projects in the Wādī al-ʿArab

2.1. Landscape Archaeology

2.1.1. Landscape Archaeology in the Wādī al-ʿArab Region

by Linda Olsvig-Whittaker/Patrick Leiverkus

Archaeological sites are located within a landscape, the surrounding physical, cultural and biological environment which provides the context, driving factors and the system in which an ancient settlement functioned. The study of the archaeology of such environments, called landscape archaeology, attempts to describe and understand spatial and functional relationships of features such as settlements, roads, installations, fields, etc. with their physical, ecological and cultural environment. Important questions of this research discipline are, for example: What is the importance of water in determining site locations? How does political change drive the location of roads and sites? What are the patterns of land use by settlements?

The northern slopes of the wādī directly upwards from Tall Zirāʿa are characterized by a dense occurrence of water sources. Many of the sites found there relate to them. This can shed further light on the Roman water management in the region.

On the basis of this survey we used ecological approaches to see what correlation might exist between archaeological sites and habitat. Since more than half the sites in this survey had Roman occupation, we asked what difference, if any, was there in the distribution of Roman sites compared to previous occupations. A comparison was made of "new" Roman sites (those not previously occupied in the Hellenistic period) with those that had both Roman and Hellenistic occupation. Clearly there could have been other definitions such as "never previously occupied". Hence this analysis is preliminary.

As groundwork for further investigations, the boundaries of the survey area and the sites were mapped by their centroid coordinates on QGIS, superimposed on a Google satellite image. Polygons were drawn by hand at the 1:10,000 level (at times reduced to 1:5,000 when clarity was needed). The landscape observed by satellite was relatively simple and can be defined into crude categories. Originally the entire area was to be mapped to habitat, but this proved very time consuming. Instead, the area at 0.5 km radius around each site was mapped by eye as orchard, maquis, steppe, urban, riverine, field, bare, water, archaeological site, and development (not urban, can include military bases, water installations, etc.). Ground verification still needs to be done for the habitats mapped from satellite images. Hence these categories were preliminary. The immediate next steps will be to develop automated mapping on GIS of the habitats for the entire area, based on algorithms derived from the habitat polygons drawn by eye. This will make possible the analysis of all sites much more rapidly and with different scales of relation to environment.

For the multivariate analysis, categorical data were used as dummy variables. The habitat mapping provided the environmental matrix data as the percentage of the area around each site in each habitat category. The response "species" variables were of two types: epoch classification and size categories.

Epochs were used as provided from the survey database, but broader groupings were made as follows: Neolithic and Chalcolithic; Bronze Age; Iron Age; Hellenistic; Roman; Byzantine; Islamic; "undetermined" and "modern" not into a group. Three very coarse size categories are used in the analysis:

1. a few meters in area
2. a dunum in area or less, or
3. several dunums in area.

Multivariate analysis—indirect ordination and direct ordination—using Canoco 5[1] was selected as the analytical tool for assessing patterns and correlations in site attribute and habitat attribute data.

1 Šmilauer – Lepš 2014.

While ordination has long been in use in community ecology, its application to archaeological data is somewhat more recent.

There is a vast literature on the subject of ordination and many algorithms to do it. In general, ordination methods help to find structure in complex matrix data sets, i.e. site by attribute or habitat by attribute tables. In the case of direct ordination, this is a regression of the site data versus the habitat data, conceptually similar to multiple regressions.

Direct ordination can be used either heuristically or as a statistical test of correlation with measured driving factors, using Monte Carlo simulations. When a heuristic search for pattern is desired, indirect ordination is the proper tool. Most algorithms for indirect ordination calculate similarity/dissimilarity between habitats (or sites) and their attributes, from a single table. Results are projected onto two dimensions in such a way that similar habitats (or sites) and most closely correlated attributes are plotted close together, and dissimilar habitats (or sites) and their attributes are placed far apart. Most importantly, in both direct and indirect ordinations, the scatter plots for habitat and site values can be superimposed. In this way the habitats driving the pattern in sites can be seen, and *vice versa*.

Detrended Correspondence Analysis (DCA) was used on the habitat matrix, with site data carried passively, to determine major trends in variation of habitat distribution and the response of site factors to them. DCA is an indirect ordination method using only one matrix. It is an analytical approach in its own right, and is also is a necessary first step in every CANOCO analysis, regardless of algorithm. The first information obtained in DCA is the habitat turnover along the first gradient (Axis 1, horizontal), which is either short (less than 4 standard deviation units in habitat composition), in which case a linear model such as PCA or RDA can be used in subsequent steps. If the gradient is longer than four standard deviation units, a unimodal model such as DCA, or Canonical Correspondence Analysis (CCA) is used in subsequent steps[2].

Canonical Correspondence Analysis (CCA) is a direct ordination method which correlates two matrices using eigenvector methods. In this study we used habitat as the 'species' matrix and the two factors of sites (size and age) as the environmental matrix factors. Monte Carlo tests can be run to determine the significance of the correlation of habitat with site factors[3].

The ordinations, despite the lack of statistical significance of correlations, suggested interesting relationships. Open water, riverine habitats, and large archaeological sites all seemed connected. In addition, analysis indicated a correlation of older (more successful or established?) sites with open water. Analysis also suggested that new Roman sites were less related to water. We knew that Roman engineering both of cistern systems and aqueducts opened new areas (such as plateaus) for settlement and exploitation. Hence the weaker correlation of new Roman sites with water also made sense.

The results of this study are presented in detail in the following chapter.

2.1.2. Roman Settlements and Single Complexes in Relation to Habitat in the Wādī al-ʻArab region

2.1.2.1. Introduction

The Wādī al-ʻArab area in northern Jordan (map, *Fig 2.1*) is an area rich in historical and prehistorical settlement. The sites that were found in our study area range from the lithic epochs (until 3600 BC) to Ottoman era (ending 1918, at least 5500 years). The central site, Tall Zirāʻa, has a 5000 years occupation history. In Hellenistic times the city of Gadara developed as part of the Decapolis. There was some caravan trade using routes from Damascus across the lower Galilee to the Mediterranean, but most people lived by subsistence agriculture[4]. This changed when the Romans annexed Nabataea in 106 creating the province Arabia Petraea and gradually shifting the agriculture to industrial production of wine[5].

2 Šmilauer – Lepš 2014.

3 Šmilauer – Lepš 2014.

4 El-Khouri 2008, 71.

5 Tracy 1994, 225.

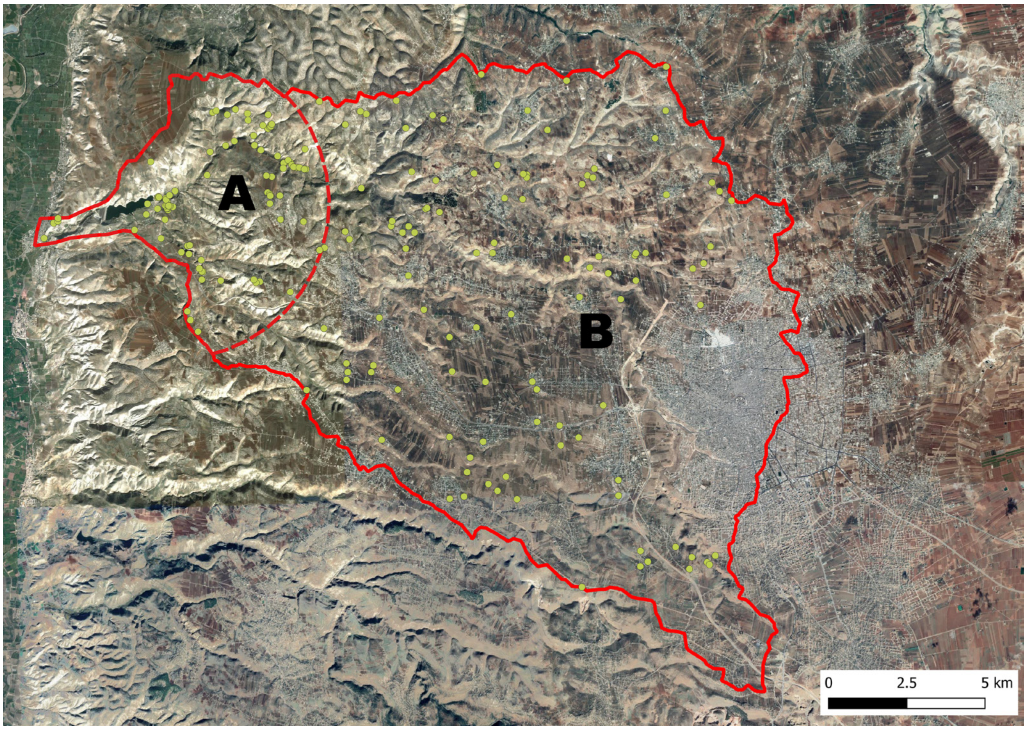


Fig. 2.1 Map of the study area with sites. Area A was completely mapped both for sites and for habitat. Area B was checked using historical records of sites, and mapped for habitat at ½ km radius from each site (© BAI/GPIA).

This was a typical Levantine landscape on the edge of the Jordan Valley. River and stream valleys were rich in plant species and there were many springs. Away from the valleys, the landscape was a mixture of shrubland and oak woodland[6]. Pre-Roman settlements were mostly close to natural water sources and the waterless upland plateaus were largely unused except for pastoralists. Some settlements were abandoned from the 3rd century BC until the Romans and Byzantine eras, as indicated in the survey[7].

Formulation of Questions

Working from the project database built for the Wādī al-ʿArab surveys of 2009-2011, it was evident that the Roman eras introduced many changes in land use. The surveys covered some 400 square kilometers, which gave the opportunity to study these changes as reflected in the distribution of sites in the landscape.

One interesting phenomenon was the increase in the number of new sites from Hellenistic – Early Roman (167 BC to 132 AD) to Late Roman – Byzantine (132 AD to 638 AD)—with a threefold jump in new agricultural complexes (farms). It is known that the Roman conquest of this area resulted in an improvement in water supply by construction of aqueducts and cisterns. It seems this opened a new range of opportunities for settlement. The question is what patterns of correlation between environmental and manmade factors and sites exist which cause site selections for new settlements and agricultural complexes.

2.1.2.2. Methods

Site Data

The archaeological and geographical data in this study were provided by the database created from

6 See *Chap. 2.1.2.2.*

7 See also chronology table in Vieweger – Häser 2017, 243.

the archaeological survey of Wādī al-ʿArab previously described in Volume 1 of this series[8].

Of the 206 known sites in the survey, 94 sites were hamlets, villages or larger settlements during the Roman/Byzantine period. The focus was on these. Those sites which had previous (Hellenistic – Early Roman) occupancy continuing into Roman – Byzantine occupancy (old sites) were compared to those sites which were new in the Roman/Byzantine period. There was a major development of "single complexes" (farm or hamlet) sites from 17 "old" sites versus 54 "new" sites. In contrast there were 14 "old" settlements, and 9 "new" settlements. It seems the expansion in the late Roman/Byzantine state was mainly in new farming estates.

Habitat Data

The following methodology on habitat analysis has been previously described in preliminary studies[9]. To summarize: habitat was mapped visually using Google Earth landsat images within the QGIS viewing software. Hence 'habitat' as provided from Landsat is not quite habitat as would be classified on the ground. Mainly it was possible to distinguish the following categories:

- Steppe – areas devoid of woody vegetation as seen from Landsat images.
- Maquis – shrub lands or areas of isolated woody plants and herbaceous vegetation.
- Woodland – initially marked as maquis, this type was first identified in the ground verification and then was corrected in GIS polygons, since woodlands could be distinguished.
- Riverine – a diverse mixture of usually lush vegetation often fed by raw sewage, very nitophilous.
- Open water – reservoirs, ponds.
- Orchard – almost all olive groves, very abundant and planted on all kinds of terrain. For this reason we did not think the pattern of orchard distribution would be informative about ecological relationships.
- Field – sometimes not distinct from bare ground, mainly identified by rectangular configuration.
- Bare ground – sometimes not distinct from fields, mainly identified by irregular configuration.
- Urban – ranges from city (Irbid) to suburban development and large single complexes. Complicated by the fact that in Jordan the fields and orchards are intermingled into urban areas, with a few orchards around every house. This made mapping difficult. In effect, if houses were more than 25 % of the area, it was mapped as urban.

Habitats in Zone A, the area around the main study side Tall Zira'a, were mapped over the entire area. This proved impractical to map by hand around the whole survey area so buffer zones of ½ km^2 were mapped around sites in Area B (map). These "habitat types" were mapped at the 1:10,000 level and in some case where more detail was needed, at the 1:5,000 or even the 1:2,500 level, and polygons drawn around them. Mapping was done by hand in QGIS.

Samples of such polygons were verified by ground verification in June 2017 by geobotanist Prof. A. Shmida.

Data on Cisterns

Information on cistern location and dating was obtained from the survey database, from field observations by P. Leiverkus and K. Soennecken (2017). Some of them were still in use and it was not possible to date them except by typology. The ones out of use and with pottery in them could be dated to Roman and Late Roman period. A total of 35 cisterns were found.

Data on Topography

Two calculations were made on elevation, using PostGIS from maps. Average altitude for each site was obtained, and total length of topographic lines within a stated buffer zone (500 m, 1,000 m). The latter attributes were used in this study.

8 Leiverkus – Soennecken 2017, 198–201.

9 Olsvig-Whittaker 2017; Soennecken et al. 2017.

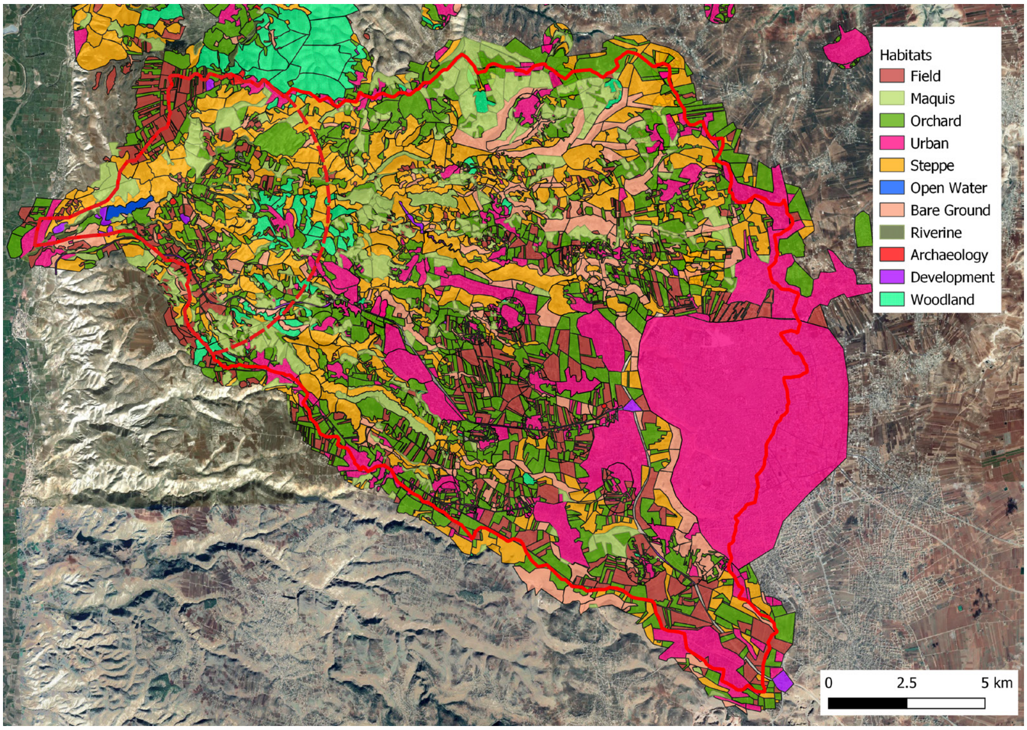


Fig. 2.2 Habitat mapping of the study area done by hand on QGIS (© BAI/GPIA).

Data on Distance to Water

Distance to the nearest major water sources was estimated by measuring the distance from each site to the nearest stream, using PostGIS.

Analytical Approaches

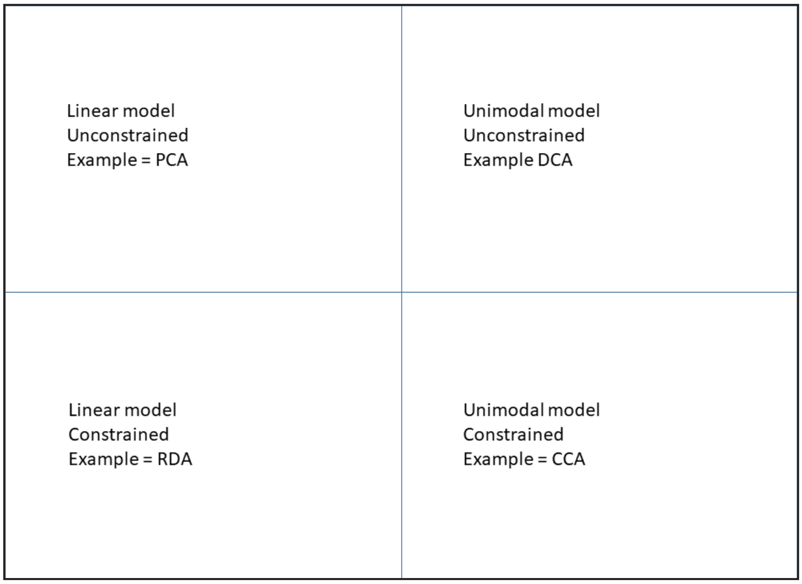
As a first step, it was asked which site types correlate with which explanatory variables. Since there are multiple response variables (four site types of interest) the appropriate analytical approaches are inherently multivariate. Multivariate analysis—indirect ordination and direct ordination—using Canoco 5[10] was selected as the tool for assessing patterns. While ordination has long been in use in other disciplines such as community ecology, its application to archaeological data is somewhat more recent[11]. There is a vast literature on the subject of ordination and many algorithms to do it[12]. In general, ordination methods help to find structure in complex community data sets, i.e. the predominant patterns in the response matrix.

The multivariate analysis software Canoco provides both linear and unimodal analytical models, and both constrained and unconstrained analyses. The choice of appropriate method looks like this:

10 Šmilauer – Lepš 2014.

11 But see Olsvig-Whittaker et al. 2015; Olsvig-Whittaker 2017; Soennecken et al. 2017.

12 See Jongman et al. 1995 for a review.



Graph 2.1 Multivariate algorithm options available in Canoco.

In the case of constrained ordination, this is basically a regression of the dependent variables versus the explanatory (driving) variables, conceptually similar to a stepwise multiple regression. Constrained ordination can be used either heuristically or as a statistical test of correlation with measured driving factors, using Monte Carlo simulations.

When explanatory data are unavailable, unconstrained ordination is used. Most algorithms for unconstrained ordination calculate similarity/dissimilarity between response and sites. Results are projected onto two dimensions in such a way that similar response and sites are plotted close together, and dissimilar response and sites are placed far apart[13]. In the case of indirect ordination, interpretation depends on expert knowledge of response variable distribution.

Canoco does some preliminary testing to determine whether linear or unimodal models are more appropriate, and we mostly were able to use unimodal models. After some patterns were discerned we checked them by looking at the distribution of parameter frequency or averages among the four site types.

Simple tabulation and graphing were also used to explore patterns of settlement versus elevation, cistern distribution etc. but the samples were too small to test statistically. Therefore, the patterns studied in this way remain only suggestive.

2.1.2.3. Results

The sites of interest are 94 settlements or complexes (single complexes or hamlets) occupied in the late Roman/Byzantine epochs. Some were previously occupied in the Hellenistic – Early Roman period (called “old”), and some were not (called “new”). The breakdown looks like this *(Tab. 2.1)*:

Site type	total
new settlement	9
old settlement	14
new complex	54
old complex	17

Tab. 2.1 Numbers for the site types in Late Roman – Byzantine period.

New settlements and new complexes are not previously occupied in Hellenistic/Early Roman period; while old settlements and old complexes were occupied in both Hellenistic/Early Roman and Late Roman/Byzantine periods. Spatial distribution looks like this *(Fig. 2.3)*:

13 Peet 1980.

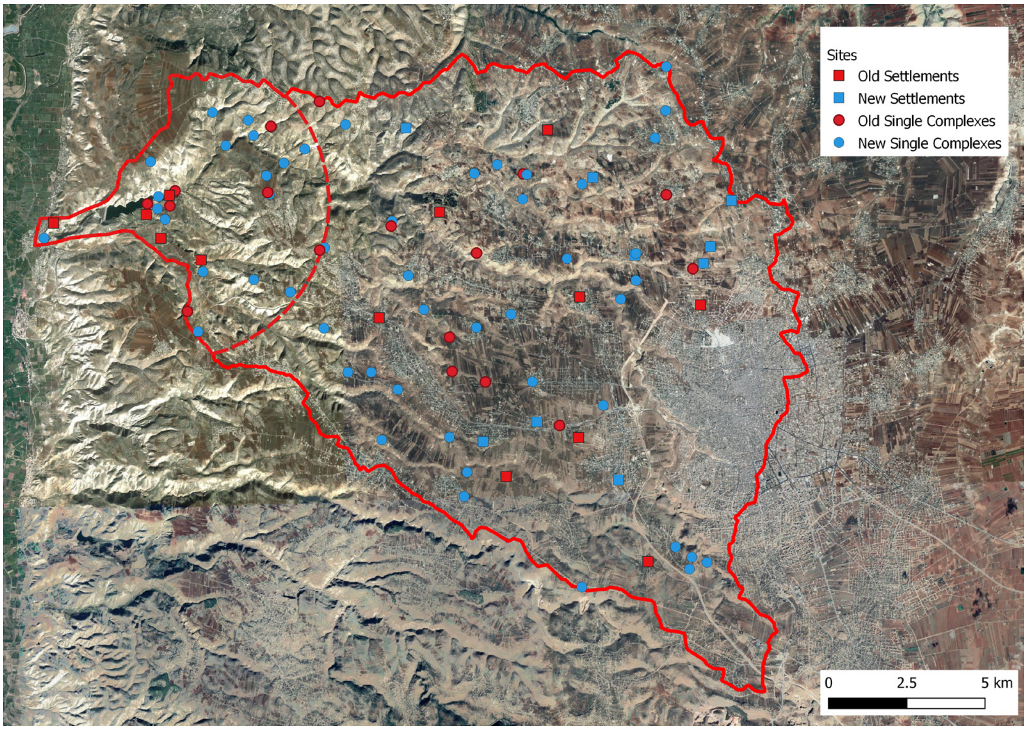
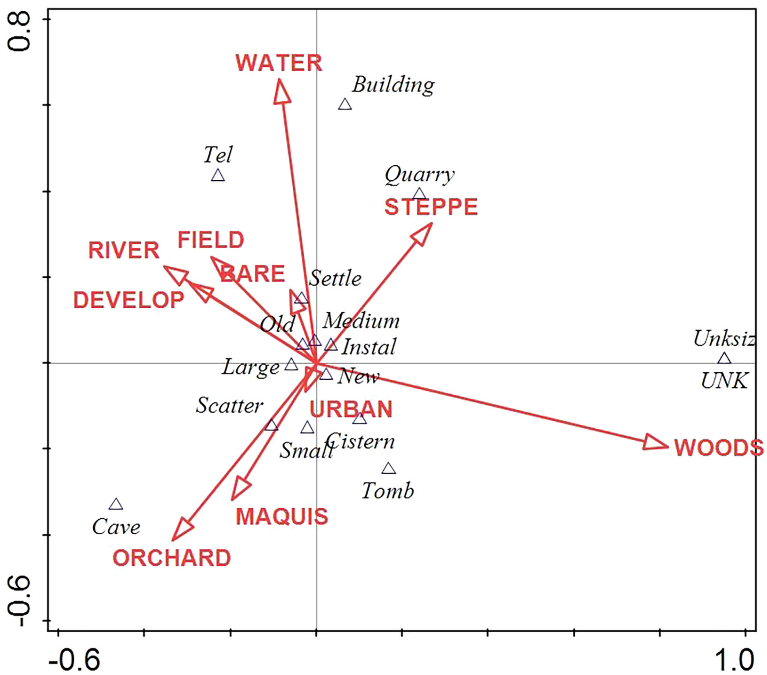


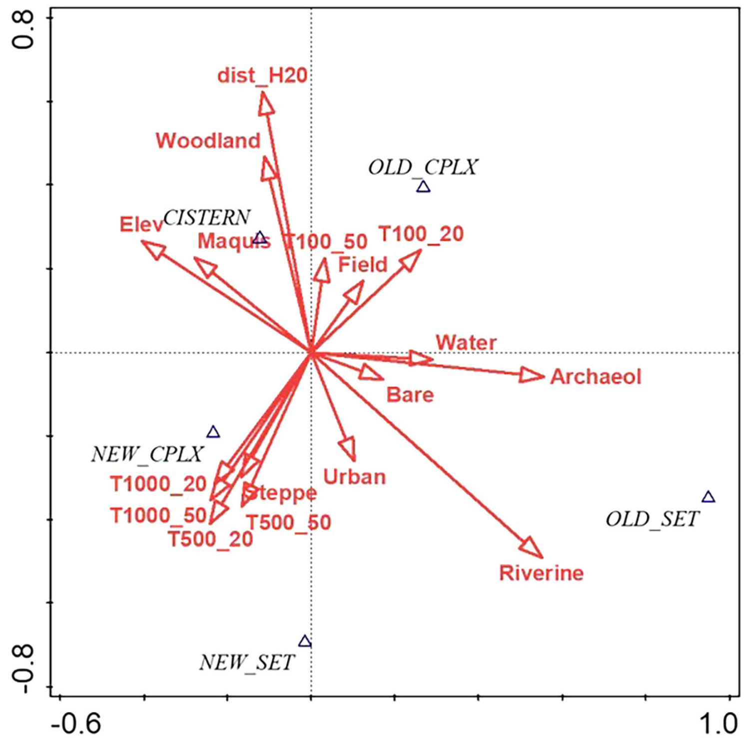
Fig. 2.3 Settlements and single complexes in the study area. Clearly there are many more new complex sites than old complex sites. Distribution tends to follow streams (© BAI/GPIA).

The habitats: ordination results

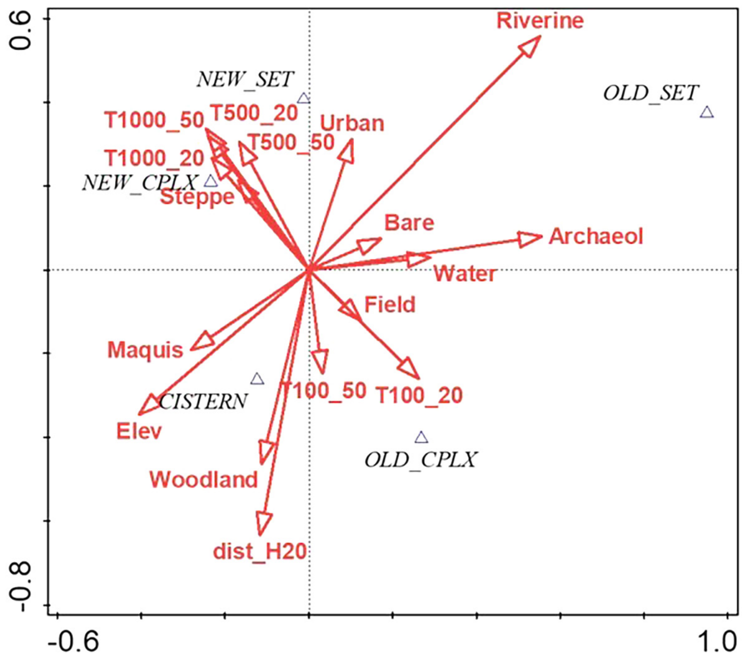


Graph 2.2 CCA results on natural habitat using all available habitat data.

But orchard, urban, development are not useful habitat types over long period of time (millennia). Since the focus is on Roman sites, the habitat factors have been limited to those which should have been con-stant between the present and the Roman era, so CCA was run again, this time removing ephemeral habitat types *(Graph 2.3)*.



Graph 2.3 CCA ordination using more permanent habitat types as environmental variables and new and old settlements and single complexes as response variables. The total variation in the data is 3.07210, explanatory variables account for 40.9 % Monte Carlo Permutation Test results on all axes: pseudo-F=1.2, P=0.238.



Graph 2.4 The same dataset, but using forward selection in CCA ordination to identify the variation explained by each environmental factor. Total variation is 3.07210, explanatory variables account for 35.2 %.

Name	Explains %	Contribution %	pseudo-F	P
Riverine	9.5	26.9	4.7	0.008**
Archaeology	3.3	9.5	1.7	0.152
dist_H20	4.1	11.6	2.1	0.112
T100_20	2.8	8.0	1.5	0.194
T1000_50	2.5	7.2	1.3	0.254
water	2.0	5.7	1.1	0.244
elev	3.3	9.3	1.8	0.15
T1000_20	1.8	5.1	1.0	0.382
T100_50	1.1	3.2	0.6	0.578
Bare	1.1	3.1	0.6	0.582
Woodland	0.9	2.6	0.5	0.634
Urban	0.8	2.1	0.4	0.786
T500_50	0.7	2.0	0.3	0.772
Maquis	0.4	1.2	0.2	0.902
Field	0.4	1.1	0.2	0.918
Steppe	0.3	0.8	0.1	0.96
T500_20	0.2	0.6	<0.1	0.984

Tab. 2.2 Forward selection results.

Interpretation: Riverine habitat has a significant correlation with the pattern of sites. Riverine, open water, archaeological sites, and modern urban areas are associated with old settlements (occupied prior to Roman conquest). Topographic heterogeneity and arid locations are associated with new settlements and new single complexes (created during the Roman – Byzantine period).

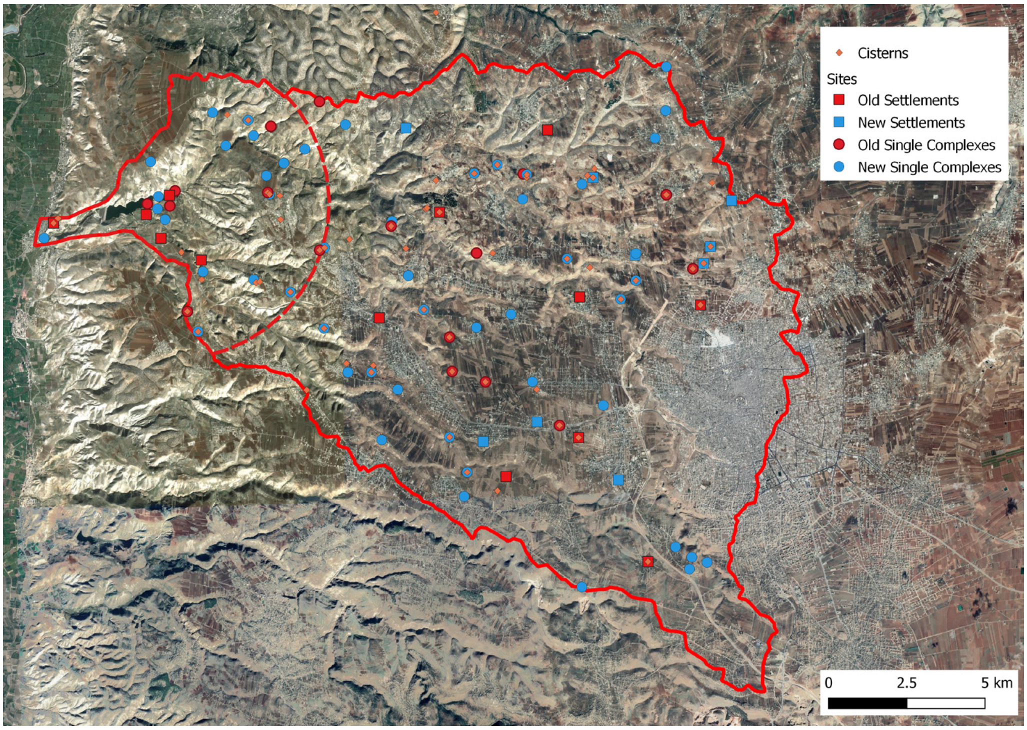


Fig. 2.4 Cisterns in relation to the categorized sites (© BAI/GPIA).

Riverine habitat

Values were calculated for riverine habitat association with the four major site types, expressed as an average percentage of the area within ½ km².

0.05	new settlement
2.84	old settlement
0.99	new complex
0.59	old complex

Tab. 2.3 Riverine habitat.

Site type	**total**	**cisterns**	**percent**
new settlement	9	3	0.33
old settlement	14	4	0.29
new complex	54	17	0.31
old complex	17	8	0.47

Tab. 2.4 Absolute and percentage of site types with cisterns.

Old single complexes had more cisterns per site, even though overall there were more cisterns in new single complexes. There just were more new single complexes.

Topography

Topography was calculated using PostGIS from maps. Two attributes were examined: average altitude, and total length of topographic lines within a stated buffer zone (500 m, 1,000 m).

For all measures which have complete data, new single complexes have the greatest topographic heterogeneity, suggesting new single complexes had to be constructed in the less desirable, hilly terrain—or new technology and infrastructure made these areas more desirable than before (perhaps for olive groves and viniculture?) In contrast, new settlements were on the flattest ground.

Site type	T1000_20	T1000_50	T500_20
new settlement	19,267	7,833	4,698
old settlement	27,517	11,105	6,104
new complex	28,923	11,538	7,263
old complex	26,257	10,309	6,243

Tab. 2.5 Topographig heterogenity of sites.

Distance to water

Nearest distance to a stream was calculated using PostGIS.

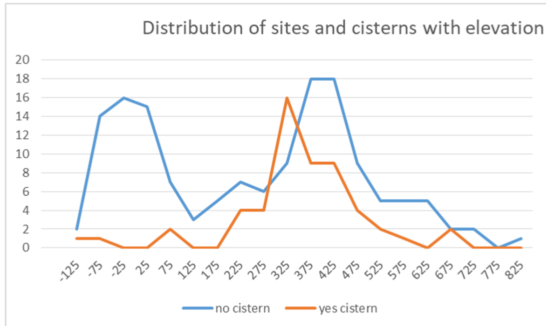
New settlements are almost twice as far from water as old settlements, not much difference in complexes.

Site type	Distance to stream
New settlement	1837.22
Old settlement	1028.14
New complex	1211.43
Old Complex	1253.76

Tab. 2.6 Average distance to water of different site types.

Elevation

The Pattern of Roman cisterns: Roman cisterns were being placed at the higher elevations. *Graph 2.5* shows the graph of all sites versus elevation, those with cisterns in brown, and those without cisterns in blue.



Graph 2.5 Distribution of sites and cisterns with elevation.

So there are two peaks in sites generally, but one peak in cisterns. The next question was the distribution of cisterns within these two zones. The ages and attributes of sites at -100 to 50 meters and 300 to 450 meters have been checked with a focus on the cisterns. Results:

Site type	-100 to 50 meters		300 to 450 meters	
	total	percent	total	percent
cisterns	1		34	
installation	14		28	
installation with cistern	0	0 %	13	46.40 %
single complex	8		31	
single complex with cistern	1	12.50 %	15	48.40 %
settlement	4		10	
settlement with cistern	0	0 %	3	8.80 %

Tab. 2.7 Distribution of cisterns in relation to the altitude of find sites.

Cisterns are mainly going to single complex sites (farms) and installations—which sometimes but not always are the same sites. Cisterns are not going to settlements. Most of the single complexes at higher elevation are Roman/Byzantine.

What we have is a settlement pattern from the Roman period of building or developing single complexes, about half the time with supporting cisterns. (Cisterns seldom appear alone.). There is also an equal percentage of cisterns associated with "installations". These installations are mostly for agricultural use (olive presses, wine presses, and channels) suggesting some irrigation was being done.

2.1.2.4. Summary and Discussion

What is known from the geographic analysis:

- Most site locations seem connected to water in some way.
- Old settlements are best connected to riverine habitat.
- The cisterns are more connected to single complexes.
- New settlements are markedly more distant from water, but received water from other sources such as aqueducts.
- New single complexes are found on the most topographically heterogeneous (hilly) areas—suggesting less desirable sites.
- But new settlements are on the flattest ground—the uplands away from the streams.
- There does not seem to be any significant connection to habitat apart from riverine habitat.

Combining this with the historical and archaeological knowledge, a narrative emerges.

In Hellenistic times Gadara was a city center with only a few settlements around. People needed security (walls etc.) because of political insecurity; some settlements were abandoned between the 3rd century BC and the Romans conquest.

With Pompey 63 BC Roman occupation started. Slowly infrastructure and agriculture were improved. In the first century AD pax romana (*Hadrian 117–138) offered a secure and peaceful surrounding and new settlements were established; in the 2nd century Roman government supported urbanization of cities in the eastern part of the Roman Empire; population growth during roman times and even more in Byzantine times.

A decision by Hadrian[14] changed the retirement benefits of Roman soldiers—rather than being settled together in *"colonia"* they were given land allocations on individual single complexes. This can be seen in the archaeological record in the increase in single complexes during the post-Hadrianic,

14 Ball 2000, 444.

Late Roman – Early Byzantine period (54 new versus 17 pre-existing single complexes in the study area).

Associated with the Roman farm building was a sudden development of cisterns. When most of the cisterns are at the same elevation, and most associated with single complexes and agricultural installations of the later Roman period, it suggests they were all part of a large project and that some Roman engineers planned and executed the building of the water infrastructure. This was probably part of a governmental project and not everybody doing it independently in his backyard. To determine the best places for cisterns and to build so many at the same elevation zone seems more like a "master plan" to cultivate the area. But was this just an investment to raise more food?

Our most likely guess: after gaining control of the area, veterans from the army were given land (as the Romans did everywhere) and they were supported by military engineers to make the most of the land. Why all the effort—and it was a lot of effort! Surely not just to grow a bunch of grapes.

This area was on the edge of the Empire, facing the desert nomads and the Parthians, a dangerous area[15]. It was in Roman interest to strengthen it. Settling veterans in this frontier area made military and strategic sense beyond the economic gain from developing the area. Hence the investment in individual farms for individual soldiers. This was not cost effective in economic terms but was cost effective in military terms. The veterans would be a line of defense.

Did this change occur in the 2nd century following a visit and assessment by Hadrian? Very likely. This would explain the changes observed between Early Roman and Late Roman (with the visit of Hadrian essentially dividing the two periods). Hadrian had the vision to think in geopolitical terms and also to identify the local changes needed to serve geopolitical needs. The timing would be right, and the emperor would have the ability to override local concerns about expense in order to invest in major infrastructure that did not have much immediate profit.

15 Freeman 2001.

2.2. The Vegetation of Northern Jordan: Two Transects from the Jordan Valley to the Eastern Highlands

by Avi Shimida/Linda Olsvig-Whittaker/Katja Soennecken

2.2.1. Introduction

There have been a few vegetation maps of northern Jordan in the past[16], but the ecological nature of the vegetation still needs proper explanation, which we will try to do here.

In northern Jordan, there are actually two gradients of vegetation running east and west, meeting at the highest elevation. The main one goes from the highest elevations eastward, and has the typical vegetation of the arid and semi-arid eastern Mediterranean Basin. The general macro-gradient comprises Mediterranean chaparral (maquis shrubland) in the more humid areas, moving toward dry woodland, then to a spiny dwarf-shrub transitional belt, reaching semidesert in the easternmost end of the gradient.

Because of the peculiar geomorphology of the Jordan Rift Valley, with its steep escarpments going below sea level in the valley on the west side of northern Jordan, the usual vegetation transect is inverted and goes from humid chaparral at its highest elevations, to a narrow oak woodland belt. This continues downward into a dwarf-shrub transition belt and finally an open pseudo-savannah in the foothills of the Jordan valley.

Northern Jordan is a terminus of the rich Mediterranean vegetation, which is gradually being replaced by transitional steppic vegetation with some relict Mediterranean elements further inland, and is the main southern outpost of Mediterranean vegetation and floral elements. South of Wādī Zarqā’ many Mediterranean elements disappear, such as *Quercus boissieri, Phillyrea media, Platanus orientalis, Fraxinus syriaca, Pinus halepensis* and many orchids.

Major early research about the vegetation of Jordan was initiated by N. Feinbrun and M. Zohary[17], who made the first detailed vegetation map of Jordan. However, some vegetation units described by them cannot be observed in the field and were more likely potential climax vegetation. The authors did not distinguish between potential climax vegetation and actual vegetation, unfortunately, but they did establish the basic framework and rationale of the geobotany of Jordan. Our current report essentially continues from their main findings.

The variation in vegetation is formed mainly by three geomorphological patterns that form northern Jordan’s landscape.

16 Feinbrun – Zohary 1955; Long 1957; Quézel – Barbour 1973.

17 Feinbrun – Zohary 1955.

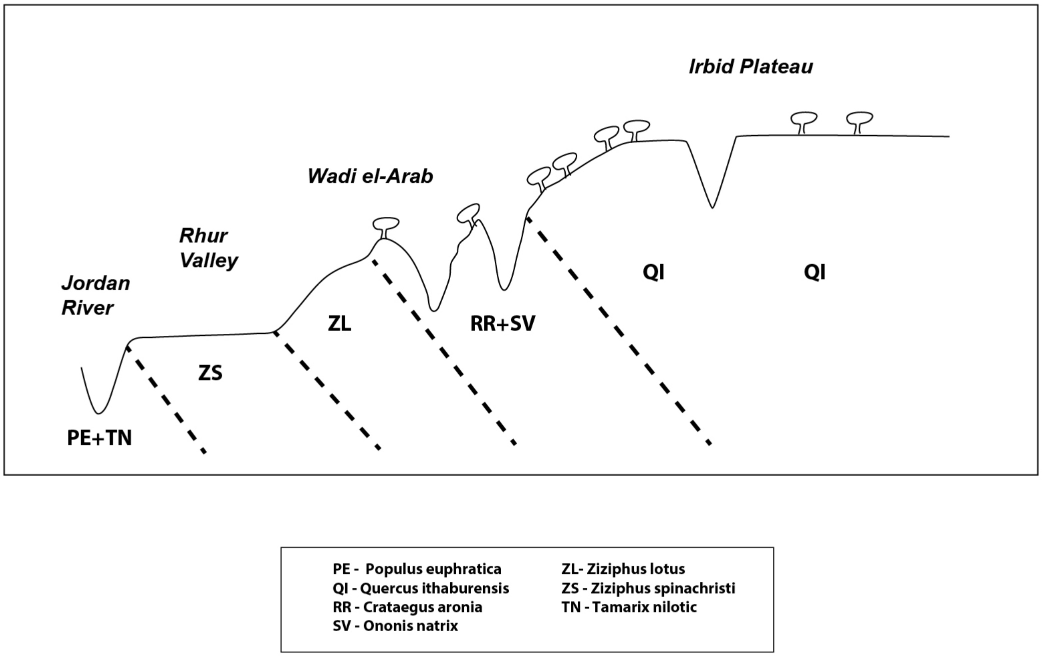


Fig. 2.5 Transect 1, from Šūna to the Irbid plateau. Geomorphological pattern 1: Zarqā' to 'Ağlūn mountains to Irbid plateau with basalt at the east end.

2.2.1.1. First Geomorphological Pattern

1. The main ridge is split into high mountains in the south (the 'Ağlūn mountains) at 1207 meters while the north is formed by the Irbid plateau at about 300–500 m, dissected by many wādīs toward the west and the north. Both areas are 99 % limestone, with hard limestone forming rugged, step like and stony areas. Where bedrock is soft limestone, it forms gentle slopes and valleys.
2. Nari/caliche (limestone formed by calcified soil) covers a large area around Ramat Irbid, forming hard limestone landscape even though the bedrock is soft.
3. In the Northeast, bedrock composed of basaltic rocks that do not produce a vegetation much different from the limestone.
4. Most of the water courses of the area briefly carry water in winter. There has been a major loss of water flow in the past century; what were formerly perennial streams until the 1950s are now dry (Wādī al-'Arab, Wādī aṭ-Ṭayyiba, Wādī Yābis). The only permanent rivers are the two that border this area: the Yarmūk on the Syrian border in the north, and Wādī Zarqā on the border between Gilead and Balka in the south. There is one exception—Wādī Rāğib still carries permanent water south of 'Ağlūn and still has *Platanus orientalis* growing along the river.

2.2.1.2. Second Pattern: From the Ridge, Moving East with Decreasing Rainfall

Moving east from maximum elevation there is a drop in rainfall, drop in humidity, and a warmer climate. There are many references on this, best summarized by Long[18]. This drop is very gradual from about 500 mm to 100 mm annual rainfall, from 1200 m elevation to 700 m. In Jordan, this does not end in extreme desert, but only semi-desert (the Syrian Desert[19]).

18 Long 1957.

19 Zohary 1973.

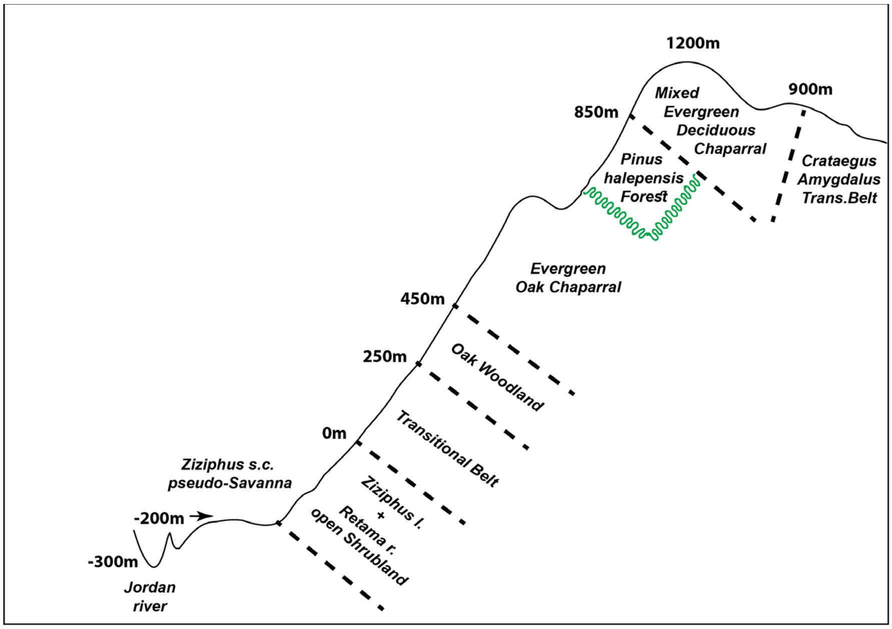


Fig. 2.6 West escarpments of the ʻAğlūn mountains, toward the Jordan valley.

2.2.1.3. Third Pattern: Rift Valley

The third pattern of northern Jordan is shaped by the geomorphology of the "Dead Sea Transform" of the African Syrian Rift Valley, forming a geomorphological "Graben" with Jordan moving north, Israel moving south. In geological time, this configuration is very recent. All research suggests that until the end of the Miocene, all northern Jordan was drained by rivers leading to the Mediterranean. In the Pliocene, about 5 million years ago, the Rift Valley was deepened in the Levant area, disconnecting the drainage system to the Mediterranean, and the paleo-Dead Sea was formed.

In the last 2.5 million years the Jordan Valley canalized drastically, forming deep, steep escarpments on the west side of the plateau and mountains along the entire west of Jordan, and deep soils developed in the Jordan Valley. It was only in the late Pleistocene, when the paleo-lake Lisan dried out, that the badlands of the Ẓor formation were created and meanders of the Jordan River were formed. Parallel to the forming of the badlands and the deep soils, steep rocky escarpments in the foothills of the ʻAğlūn mountains were also formed. This geomorphological unit of the Ẓor, the Jordan Valley deep soil, the escarpments and mountain is the framework in which the vegetation of this area developed. This third pattern is unique since part of it goes 200 m below sea level and forms a dry tropical vegetation in which many Sudanic elements penetrate to the north and reach their northern limit in this area, e.g. *Moringa peregrina* in Wādī Yarmūk.

Two vegetation transects will be presented as examples of the vegetation of northern Jordan. The first one, more northerly, is between Šūna and the Irbid plateau *(Fig. 2.5)*, and the second one is between Kufrinğa and the ʻAğlūn mountains *(Fig. 2.6)*.

2.2.2. First Transect: From Šūna to Irbid

Three vegetation belts can be distinguished in the area between the Jordan River to Šūna, and from Šūna to Irbid, at altitudes ranging from -250 m at the Jordan River to 450 m ASL in the Umm Qēs/ Gadara region.

2.2.2.1. Lower Belt: Pseudo-savannah of *Ziziphus Spina-Christi*

This belt is situated on alluvial soil over chalky substrate of the Lisan Formation (ref geological) in the floodplain of the Jordan (called "Ġōr" in Arabic). The first, lower belt (*Fig. 2.5*) is comprised of thermophilic pseudo-savannah. It occurs in the Jordan Valley and the lower foothills of the escarpments up to approximately ASL 0 m, i.e. sea level), but pseudo-savannah penetrates to the elevation of Tall Zirāʿa, in warm thermophilic wādīs.

Today this belt is mostly agricultural with a few remaining trees of *Ziziphus spina-christi*, and rare Sudanian elements (mainly grasses) have been found in this area, which normally belong to the *Z. spina-christi* community. Dominant species in agricultural areas are *Prosopis farcta* and *Alhagi maurorum*. Along water canals, *Arundo donax* and *Phragmites australis* are dominant. *Prosopis juliflora*, an aggressive American species, became invasive and widespread along roadsides and wet habitats. Along the Jordan River, a typical riparian community of *Tamarix nilotica* and *Populus euphratica* is most abundant, mixed with the reeds *A. donax* and *Phragmites*.

We should mention the special appearance of *Faidherbia albida* (*Acacia albida*). Although no record of *F. albida* was officially written, there are two important locations of this species on the lower belt. One is in the opening of Wādī al-Bīra in Israel on the west of the Jordan facing Šūna, and the other is cited by G. E. Post[20] and M. Zohary[21] in Wādī Tayyiba, which is south of Wādī al-ʿArab. We checked Wādī aṭ-Ṭayyiba during the last 20 years and did not find *F. albida*, but in the village of Samth many groves of *F. albida* are growing today, all vegetatively sprouting on nari and chalky slopes. The name Samth is the Arabic for *F. albida*. This species is a well-known Sudanian element reaching its northernmost distribution in the East Mediterranean.

Additional arboreal Sudanian elements are rare in this community since the climatic conditions, especially the winter temperature, are at the edge of their physiological range. Thus, at the northern margin of their range we find: *Calotropis procera* reaches the Yarmūk River and the southern shore of the Lake of Galilee. *Moringa peregrina* has an exceptional northern outpost in the Yarmūk gorge near Al-Ḥama. *Balanites aegyptiaca* reaches the area of the Šēḫ Ḥusēn Crossing on the Jordan[22].

2.2.2.2. Middle Belt: Open Shrubland

The major vegetation unit in the slopes is open shrubland of *Ziziphus lotus*, which is accompanied by subdominant *Capparis sicula* (*C. ovata sensu Zohary*). In between the shrubs is a rich annual community of annual grasses on deep heavy soil, dominated by Mediterranean-arid "transitional" chamaephytes (for example *Teucrium polium*) on shallow soil with stones. *Capparis sicula*, although formally a Mediterranean species definitely has an affinity with Sudanian elements in the Levant; here it is restricted to thermophilic parts of the Rift Valley.

In xeric habitats on bare chalky areas in the middle belt, two semi desert communities, of mixed Irano-Turanian and Sudano-Arabian elements are recognized. One is *Retama raetam* open shrubland. The other is the *Salsola vermiculata* dwarf-shrub community (steppe).

Both communities are very distinct on south-facing slopes with chalky substrates. Typical plant species in these communities are *Blepharis attenuata*, *Astragalus spinosus*, *Rumex vesicarius*, and *Medicago laciniata*. Two endemic species (endemic to Jordan and Israel) are typical to these communities: *Verbascum jordanicum* and *Onopordum jordanicolum*.

20 Post 1932.

21 Zohary 1959.

22 Shmida – Aronson 1986.

The *Ziziphus lotus* community is joined by the Sudanian grass *Hyparrhenia hirta*, in rocky south facing slopes. *H. hirta* is a Sudanian/Mediterranean element typical to thermophilic habitats and indicates the Sudanian savannah condition of the middle belt. Three more perennial grasses found in this community are *Aristida coerulescens*, *Pennisetum asperifolium* and *Tricholaena teneriffae*. This last is very rare and at the northern limit of its distribution.

2.2.2.3. Upper Belt: *Quercus Ithaburensis* Woodland

The upper belt is generally dominated by woodland in more mesic habitats and by open shrubland of different communities in xeric habitats. Where hard limestone crust (nari) is formed on north and west facing slopes and on ridges, there is an extraordinary and beautiful community of *Quercus ithaburensis*. This woodland is part of the famous "Forest of Gilead" from the Bible. Its composition is mainly of Mediterranean elements such as *Styrax officinalis* and *Pistacia palaestina* in mesic microsites. Surprisingly the tree canopy is extremely monotypic, with about 99 % *Q. ithaburensis* cover. A degradation facies which results from cutting and grazing is a community dominated by *Rhamnus palaestina* with similar composition to the *Q. ithaburensis* community but "antipastoral" (e.g. grazing-resistant) species are more abundant. On north-facing steep slopes in this belt, *Q. ithaburensis* is replaced by evergreen *Q. calliprinos*.

Two important regional tree species are scattered over the Tabor woodland: *Ceratonia siliqua* and *Pistacia atlantica*. They overtop this community without a clear pattern of distribution, overall rare, not natural here, and in the case of *C. siliqua* probably planted for the carob pods (but also "escape" individuals are noted). *P. atlantica* regenerates from seeds and we have seen natural saplings from seeds dispersed by birds.

The *Rhamnus palaestina* community is primary in dry habitats on nari on south and east facing slopes. It has more chamaephyte elements such as *Ballota undulata* and *Salvia graveolens* (both are typical marginal Mediterranean elements, transitional between Mediterranean and desert).

In the upper belt, not on nari, usually on steep slopes, open *Retama* shrubland occupies most of the area. It is typical to chalky steep slopes with shallow rendzina soil on east and south facing slopes. If there is a shallow soil there may be a carpet of *Stipa capensis*; if there is more than 30 % bare chalk, the desert and Irano-Turanian elements are abundant in the community: such as *Limonium lobatum*, *Rumex crispus*, *Noaea spinosa*, and *Astragalus spinosus*.

Sometimes in more mesic aspects, the *Retama* is overtaken by spiny *Genista* shrubs (garigue formation, also with *Calycotome villosa*). We suspect *C. villosa* is the result of overgrazing.

The most xeric habitat is dominated by *Salsola vermiculata* steppe. It occupies whitish bare chalk, usually in steep south or east facing slopes. It continues down to the "Rohr" valley (Jordan floodplain). Typical desert and Irano-Turanian elements occur between the *Salsola* plants, for example: *Atriplex leucoclada*, *Noaea spinosa* and *Gundelia tournefortii*. We also found *Cucumis prophetarum*. There are patches of *Sarcoptoterim spinosum* on the upper level of the upper belt on steep bare chalk usually with northwest aspect.

2.2.2.4. Wādīs within the *Q. Ithaburensis* Woodland

In the main large wādīs previously with permanent water, there is a community of *Tamarix nilotica* and *Arundo donax*. Today there is sewage flowing along Wādī al-ʻArab, which fertilizes the surrounding area, and many eutrophic weeds, mainly of New World origin, have established there. Several chenopods, *Ricinus communis,* and *Xanthium spinosum* are there.

If the steep slopes are very chalky (sub-cliffs), then *Atriplex halimus* is added to the community and can become dominant in small chalky ravines on south facing slopes. This species and *Retama raetam* are the most common shrubs in the Saharo-Arabian desert.

Most typical (small) wādīs are steep and run perpendicular to the slope. These are dominated by *Nerium oleander*, *Tamarix nilotica* and *Salix acmophylla*. They are seasonal streams usually fed by small springs. A dry version of the *Nerium* community is in runnels dominated by *Rubus canina* and *Tamarix nilotica*.

In very deep wādīs with very steep wall-like slopes, even without permanent water but with moisture all year round, there is a monotypic community of *Arundo donax* with a few *Tamarix nilotica*. *A. donax* forms an impenetrable stand in these communities. (Note: *A. donax* is typical to these steep walled habitats while *Phragmites australis* is found in areas that are more open and was not found in our survey.)

2.2.2.5. Anthropogenic Communities

Large areas here are wheat fields, usually located on gentle shoulders of the hills with deep rendzina soil. *Ziziphus lotus* and *Carthamus glaucus* are the typical species and will dominate on the field edges or in old fields. *Prosopis farcta* occurs if the field is cultivated.

Wasteland is common in this area, for example around Tall Zirāʿa or Tall Qāq. There a community of *Capparis sicula* and *Prospis farcta* occurs. Mixed with these species is *Erucaria sativa* due the high level of organic matter.

Olive groves which are not regularly plowed have a typically rich Mediterranean annual community of *Chrysanthemum coronarium*, and many legumes, crucifers, grasses and composites. If there is no cultivation for three years, secondary *Salsola vermiculata* takes over.

In the north-west of the Irbid plateau, there is a basalt outcrop. There does not seem to be an essential difference between the basalt and the limestone areas.

2.2.3. Second Transect: From the Area of Kufrinǧa to ʿAǧlūn

There are more vegetation belts on this transect because of the longer altitudinal range: a. *Ziziphus spina-christi* pseudo savannah, b. *Ziziphus lotus* and *Retama raetem* open shrubland, c. species rich transitional belt with scattered *Quercus ithaburensis,* d. *Quercus calliprinos* chaparral, e. *Q. calliprinos* mixed evergreen and deciduous chaparral, f. transitional dwarf shrub community *(Fig. 2.6)*.

2.2.3.1. Belt a

Generally, the vegetation in the Lower Belt is similar to that in the Lower Belt of the northern transect. *Ziziphus spina-christi* continues to dominate, but to the west, in the descent to the Jordan River, a new habitat and vegetation occurs (see *Fig. 2.6*). In the alluvium, we have *Ziziphus spina-christi* pseudo-savanna with distinctive associated species. For example: *Balanites aegyptiaca* (tree), *Loranthus acacia* (parasitic vine, now called *Plicosepalus acaciae*), *Boerhavia helenae* (vine), and *Moringa peregrina* (rare, but also occurs near the Yarmūk River, near Umm Qēs, the northernmost occurrence of this species). These are typical Sudanian elements. This was the primary vegetation unit, indicated by the evergreen condition of the *Z. spina-christi*. *Z. spina-christi* is secondary above ASL 0 in disturbed areas and abandoned fields; where it sheds its leaves[23]. We emphasize that there is no wild *Acacia raddiana* in this northern part of the Jordan Valley. *Acacia raddiana*, the most typical Saharo-Sudanian element, only penetrates as far north as the area of Šūna al-Ǧanūbīya and does not continue to the north.

There is a geomorphological environment of badlands transecting the Lisan Formation with many steep, highly erodible chalky Lisan hills. Two main communities dominate in these Lisan badlands. On the steep chalky slopes, *Salsola vermiculata* with the annual grass *Stipa capensis* dominates between the dwarf shrubs. Many desert elements are typical to this community, such as *Limonium lobatum*, *Trigonella stellata*, *Pteranthus dichotomus*, and *Reichardia tingitana* (all annuals). The second community is in the small runnels and in nearby depressions, saline vegetation dominates on the saline marls. Species include *Arthrocnemum macrostachyum* with *Suaeda fruticose* and *S. palaestina* that are endemic to the Levant.

2.2.3.2. Belt b. *Ziziphus Lotus* and *Retama Raetam* Open Shrubland

The basic structure of Belt b is the same as the vegetation of the middle belt of the northern transect.

23 Zohary 1973.

The vegetation is dominated by open shrubland of *Ziziphus lotus* and/or *Retama raetam*. Compared to the northern transect they are less chalky substrates and rendzina and terra rossa soils are more common, with hard limestone or dolomite bedrock. Thus the *Ziziphus* and *Retama* communities are enriched by many transitional elements (called semi-arid Mediterranean by G. Long[24]) such as *Ballota undulata*, *Salvia dominica*, and *Carlina corymbosa*.

2.2.3.3. Belt c: Species Rich Transitional Belt with Scattered *Q. Ithaburensis*

This belt occupies a narrow zone since the altitudinal gradient is very steep on the western escarpment of the ʿAǧlūn mountains. In most of the regions, the taller elements (trees) have been cut, but scattered *Q. ithaburensis* can be observed in areas remote from villages and urban areas. These scattered Tabor oaks connect the large Tabor woodland of the Irbid plateau with the large Tabor oak forest of the Balqāʿ area between Salṭ and Amman. The communities are very rich in different growth forms and species composition. Mixed dwarf shrub communities with perennial herbaceous and scattered shrubs give some of the highest species diversity records (species/0.1 hectare) in the world[25].

In the peak of the spring season, some sites have been recorded with 135 species, of which 50 % are annual. The outstanding endemic geophytes in this zone are the Oncocyclus irises, which are endemic and typical to the Fertile Crescent: *Iris nigricans* and *I. bismarckiana*.

2.2.3.4. Belt d: *Q. Calliprinos* Chaparral

Most of the ʿAǧlūn mountains above 400 m are occupied by 4–5 m evergreen multi-stemmed shrub/tree chaparral with mostly only one species, *Q. calliprinos*. In some areas especially around Aǧlūn or between ʿAǧlūn and Ǧabal Birqiš, the chaparral is very dense up to 95 % cover, but some areas are more open and there are agricultural plots of fruit trees. (Note that the grazing by goats is intense and has been a main environmental driver for centuries, but today more cows and sheep occur. This keeps the spaces between shrubs quite bare.) The community is poor in arboreal elements and only 3–5 species are added: *Pistacia palaestina*, *Styrax officianalis*, *Crataegus azarolus*, and *Ceratonia siliqua*. In open chaparral a rich community of annual, geophytes and dwarf shrubs are widespread, very similar to the vegetation structure of the Galilee. Compared to the flora of the chaparral in Galilee, some important Mediterranean elements are missing: *Pistacia lentiscus*, *Salvia fruticosa*, *Cercis siliquastrum*, *Laurus nobilis*, *Rhamnus punctata*, and *Acer syriacum*. *Phillyrea media* is very rare in the ʿAǧlūn mountains while quite common in Galilee.

Along running rivers such as Wādī Rāǧib, *Platanus orientalis* and *Fraxinus syriaca* are still present but becoming rare.

2.2.3.5. Belt d2 (Edaphic): *Pinus Halepensis* Forest

Large stands of natural pine forest are well preserved south of the towns of ʿAǧlūn and Kufrinǧa, growing on marls, usually between 700 and 1100 meters elevation. This forest is very famous and was examined and recorded by classic botanists such as G. Schumacher[26], G. E. Post (revised by J. E. Dinsmore[27]) and N. Feinbrun and M. Zohary[28]. Typical calciphylic species follow the pine forest: *Arbutus andrachne*, *Cistus villosus*, and many dwarf shrub Labiatae (mints). This probably reflects an ammonia based nitrogen economy as described on marl by A. Rabinovitch-Vin for the *A. andrachne* vegetation in Galilee[29].

2.2.3.6. Belt e: *Q. Calliprinos* Mixed Evergreen and Deciduous Chaparral

Above 850 m, the evergreen chaparral is enriched by deciduous elements such as *Quercus boissieri*, *Pyrus syriaca*, and *Prunus ursina*. While in

24 Long 1957.

25 Wisheu et al. 2000.

26 Schumacher 1889.

27 Dinsmore – Post 1933.

28 Feinbrun – Zohary 1955.

29 Rabinovitch-Vin 1983.

other equivalent altitudinal zones in Lebanon and north Syria the evergreen chaparral is replaced by deciduous oak forest with many species of deciduous Rosaceae trees, here in the 'Ağlūn mountains the *Q. calliprinos* continues to dominate until the peaks at 1200 m. Two reasons for this can be offered; (1) the 'Ağlūn mountains are more southerly and thus warmer and drier relative to the other areas (but recent climatological data do not support this), or (2) Long term cutting and grazing of the upper deciduous mixed oak/Rosaceae forest caused its replacement by *Q. calliprinos*. Such replacement is well known in other areas in the Mediterranean.

A degradation phase of the *Q. calliprinos* chaparral on the east facing escarpments of the 'Ağlūn mountains forms a pseudo-steppe forest community of *Crataegus aronia* and *Amygdalus korschinskii* with a mixed assemblage of Mediterranean and Irano-Turian elements: from Mediterranean, the *Sarcopoterium spinosum* and *Ononis natrix* and *Ballota undulata*; on the other side *Noaea spinosa* and *Achillea aleppica* and *Carex pachystylis*.

2.2.3.7. Belt f: Transitional Dwarf Shrub Community

East of the Ajloun ridge, a transitional dwarf shrub community becomes dominant toward the Syrian Desert. Without cutting and overgrazing, we assume the deciduous chaparral mixed forest will continue to dominate east of the ridge down to at least 900 m, but in reality the transitional dwarf shrub community penetrates up to the main ridge in the disturbed areas, which are quite large, and expanded dramatically since the 1950's.

These transitional communities are dominated by *Ballota undulata*, *Salvia dominica*, and many spiny perennial herbaceous species of the genera *Carlina*, *Onopordum*, *Echinops*, *Gundelia*, and *Cirsium*. *Eryngium glomeratum*, a spiny perennial herb, is the dominant element of the transitional dwarf shrub community along the ridge and Jordanian Plateau above 850 m from Mafraq area through Amman down to Rās an-Naqb in south Edom.

Beyond the study area, we have the Syrian steppe. East of the 'Ağlūn mountains begins the Syrian steppe, which comprises a large loessial area in a range of elevation between 700 and 900 m, dominated by *Anabasis syriaca*. In rocky slopes, the typical *Artemisia sieberi* (*Artemisia herba-alba*), the most typical Irano-Turanian element, characterizes this habitat and region.

2.2.4. Discussion

We would first like to acknowledge the previous geobotanical work done in this area[30]. Two general vegetation surveys were used for our references, accompanied by redrawn vegetation maps (*Fig. 2.7*[31] and *Fig. 2.8*[32]), which describe that the general formations of plant species distribution in Jordan in relation to climate and geomorphology can be crystallized as two main gradients: a north-south gradient which reflects the diminishing rainfall to the south and a west-east gradient which reflects a rain shadow east of the mountains. (97 % of the precipitation comes from the Mediterranean western cyclones). These two gradients are pronounced in the 'Ağlūn mountains (southern transect) while they are weak in the Irbid Plateau (northern transect). *Fig. 2.9* depicts a general schematic vegetation transect of north Jordan, from the Jordan River to the south-west corner of the Syrian Desert.

30 Feinbrun – Zohary 1955; Long 1957; Al-Eisawi 1985; Sharkas 1994.

31 Feinbrun – Zohary 1955.

32 Long 1957.

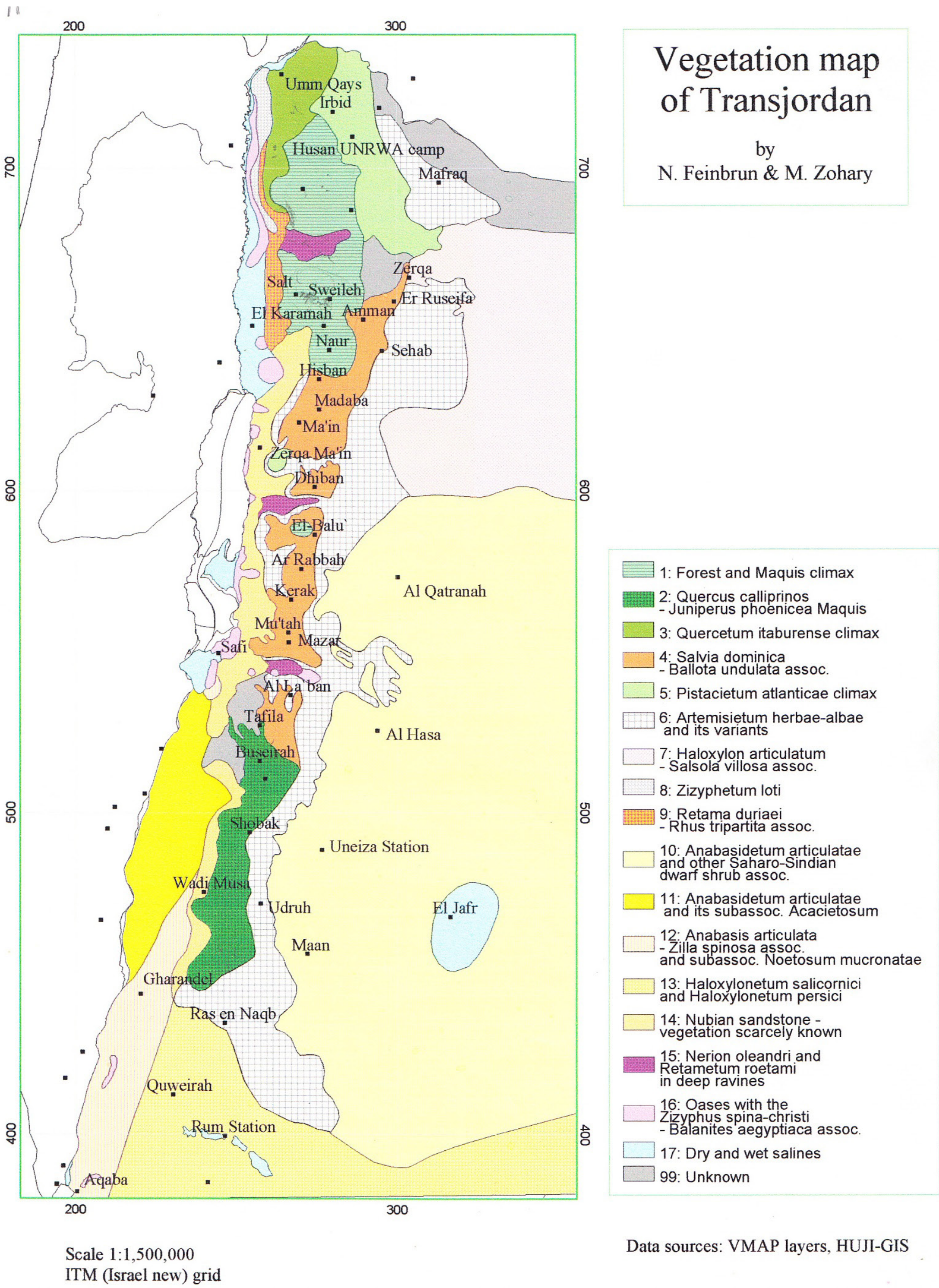


Fig. 2.7 Vegetation map of Transjordan (© Feinbrun – Zohary 1955).

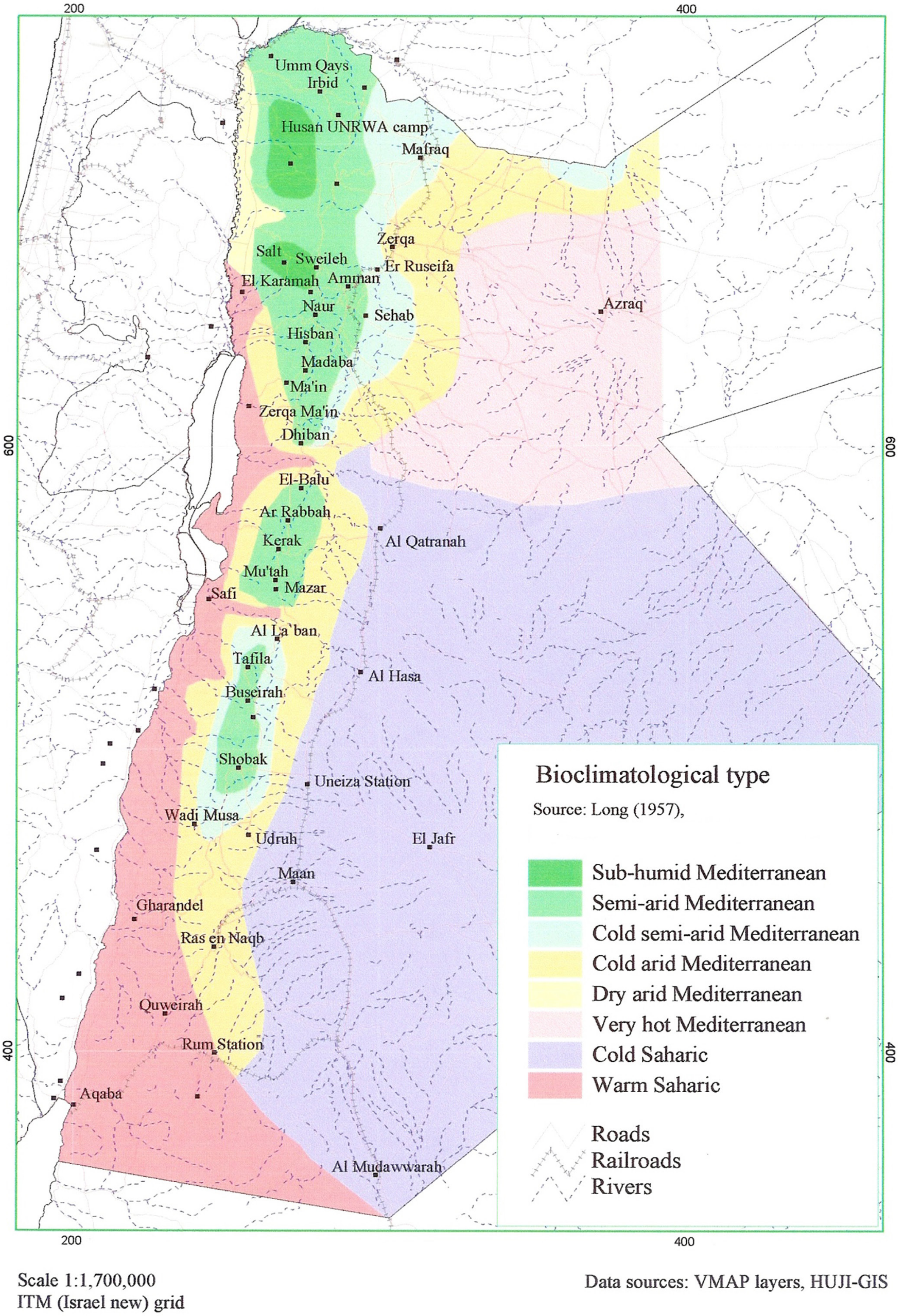


Fig. 2.8 Bioclimatical map of Transjordan (© Long 1957).

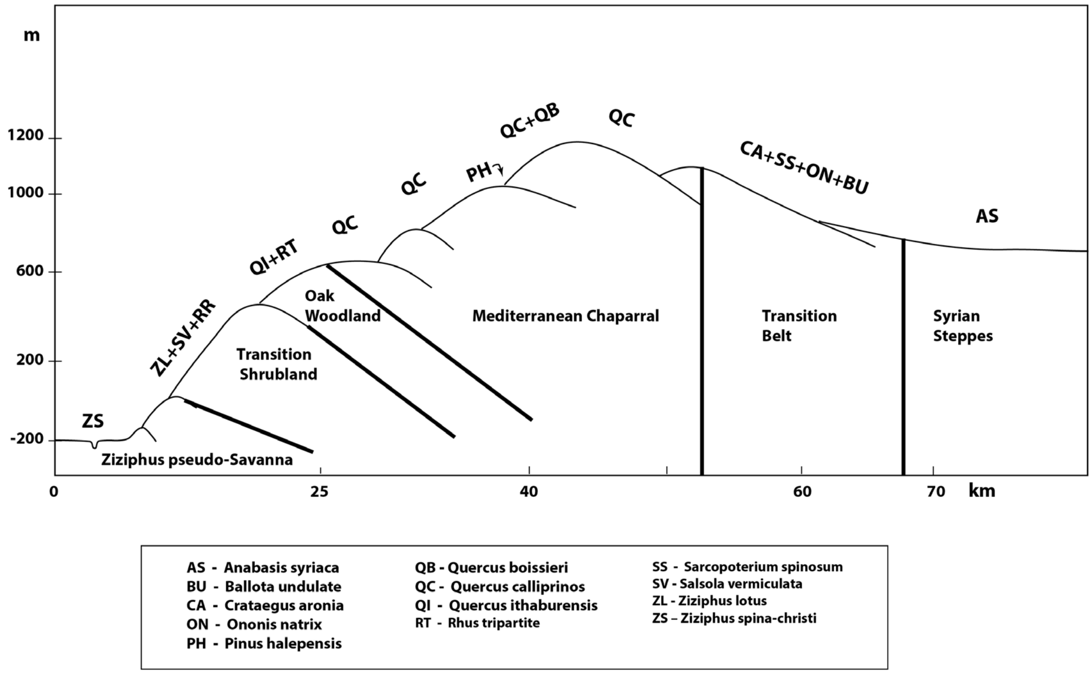


Fig. 2.9 Schematic general vegetation transect of north Jordan.

We do find discrepancies between the maps of N. Feinbrun and M. Zohary and what we observe in the field. For example, the *Quercus ithaburensis* woodlands mapped only in the north by N. Feinbrun and M. Zohary actually extend to the Balqā‘ area, while N. Feinbrun and M. Zohary mark Balqā‘ as dominated by *Quercus calliprinos*, which it is not. Only small stands of *Q. calliprinos* maquis occur in the Balqā‘ area.

Likewise, we do not see a belt of *Pistacia atlantica* forest in north-east Jordan (*Fig. 3.10*, Shmida personal data), but scattered *P. atlantica* trees occur along the entire Jordanian ridge and highlands overtopping many community types and extending toward the Eastern Desert. N. Feinbrun and M. Zohary interpreted these scattered trees as relicts of a former climax woodland or forest. We interpret these trees as a secondary introduction overriding different natural communities. Thus in the north we can see *Pistacia atlantica* within typical *Quercus calliprinos* chaparral, within *Pinus halepensis* forest, and *Quercus ithaburensis* woodland. *P. atlantica* continues southward within many different dwarf shrub transitional communities, and becomes widespread and dominant in the Petra area as a steppe forest, which may be the only place it is primary.

In contrast, N. Feinbrun and M. Zohary marked an area in north-east Jordan as *P. atlantica climax* forest, which we think is mainly semi desert of *Anabasis syriaca* (see *Fig. 2.9*, transect 3). The mismatch can be explained by understanding the geobotanical tradition of mapping potential climax vegetation rather than actual vegetation, which was done by earlier geobotanists like N. Feinbrun and M. Zohary. In contrast we interpret the *P. atlantica* occurrences as a secondary introduction as seen elsewhere in the Levant.

Relative to areas west of the Jordan River, most of north Jordan is Mediterranean but poorer in species diversity, reflecting its geographic position. There are no known Mediterranean species endemic to northern Jordan, which indicates a recent disjunction between the areas east and west of the Jordan. This is in striking contrast to south Jordan where many Mediterranean elements have been identified as endemic to Jordan.

Northern Jordan has experienced extensive disturbance by cutting and overgrazing[33] which has permitted the intrusion of more grazing adapted species from the eastern deserts. As rapid de-

33 Sharkas 1994; Al-Eisawi 1985.

velopment continues, we anticipate an increase in these species and a decline in the Mediterranean elements.

According to G. Schumacher[34] and H. B. Tristram[35] this area was known to be cut since Ottoman times (19th century). It is quite surprising to find large areas in which the woodland and maquis are preserved quite well. This can be explained by rugged topography in the 'Ağlūn mountain area but does not explain the woodlands in the Balqā' and Irbid plateau. Were these private, protected areas or do we see regeneration?

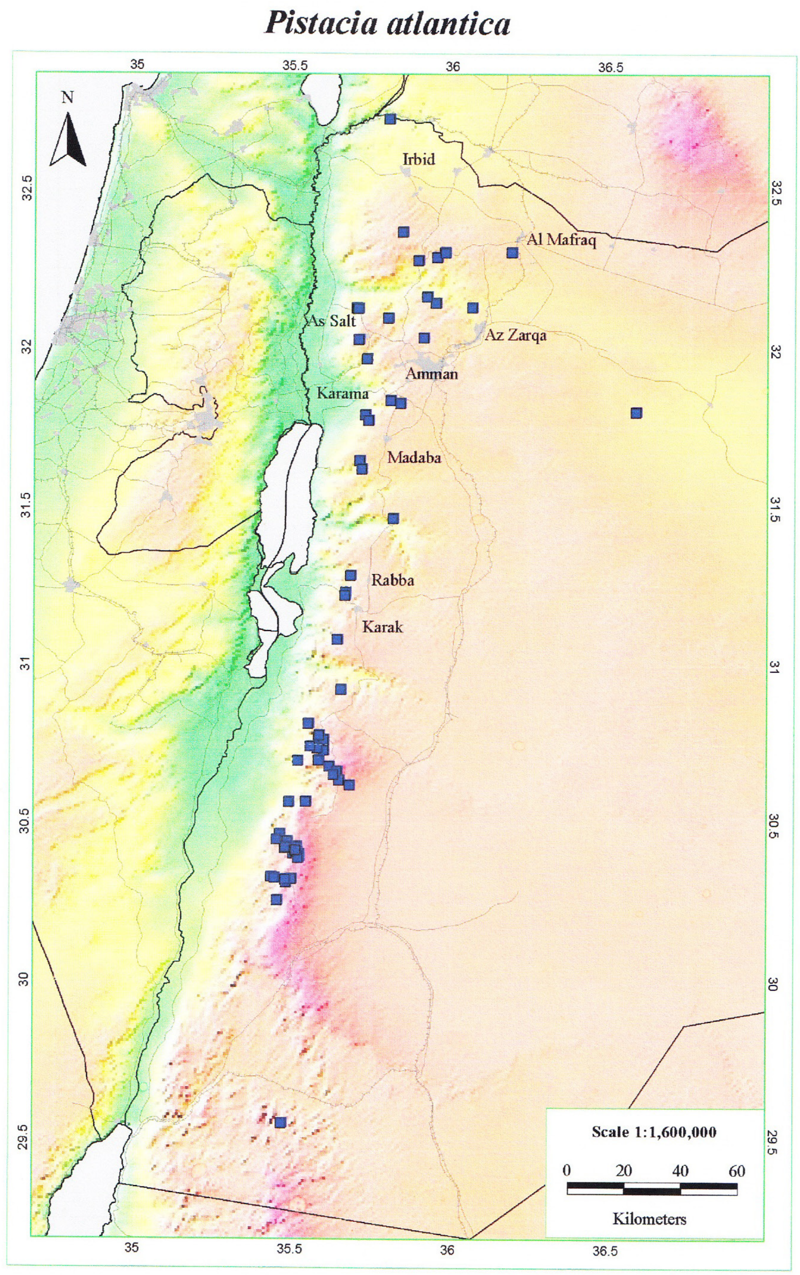


Fig. 2.10 Distribution of *Pistacia atlantica* in the west Jordan region (Shmida personal data).

34 Schumacher 1889.

35 Tristram 1873.

2.3. A Geoscientific View of the Natural Prerequisites of Wādī al-ʿArab

2.3.1. OSL Dating of Cisterns in Wādī al-ʿArab

by Sabine Kraushaar/G. Ollesch/C. SiebertH.J. Vogel/M. Fuchs

2.3.1.1. Abstract

Roman Cisterns served as rain water storage for hundreds of years and are densely spread in northern Jordan. In 749 a major earthquake hit the region and in short time many settlements were left abandoned until today. As a consequence, the cisterns were not maintained anymore and filled with sediments such that nowadays they provide a historical sediment record for the time since their abandonment. In two field surveys the locations of more than hundred cisterns were mapped and two of them chosen for detail analysis. Their individual catchments were topographically determined by differential GPS. The sediment profiles were recorded, including an OSL- and radiocarbon-based chronology. Sediment ages reveal that both cisterns were abandoned ca. 760–862 AD, which is confirmed by archaeological evidences. The calculated sedimentation volumes are translated to a long-term average soil erosion rate of 3.0–6.6 t ha-1 y-1, which is in good agreement with erosion rates from other studies within the Mediterranean. Due to the successful appliance of cistern sediments in northern Jordan, the presented approach can be used to calculate long-term soil erosion rates also in other regions within the Mediterranean.

2.3.1.2. Introduction

In Jordan, many archaeological findings give proof of the long settlement history since the Palaeolithic period. Particularly in northern Jordan many human traces date back to the era when Jordan belonged to the eastern frontier of the Roman Empire (64–324) and later to the Byzantine Empire. Archaeological findings proof the latter to be the most prospering era of the region[36]. Today, many settlements can be retraced by the abundance of Roman cisterns, which are sealed caverns that were chiselled in the ground for rainwater harvesting. Most of these cisterns are nowadays abandoned. If not damaged, they serve as undisturbed long-term sediment traps and hence, as a historical stratigraphic archive without temporal hiatus.

Due to their function as long-term, non-invasive observatory, data from cisterns are of high interest for the calculation of erosion but also for archaeologists as archives of remnants of the time of the cisterns' abandoning. The age of the lowest layer corresponds to the time of abandoning. Subsequent sedimentation takes place excluded from light, allowing OSL dating of the sediments and thus evaluation of erosion rates (t ha^{-1} $year^{-1}$) from the usually only few 10–100 m^2 large cisterns' catchments. The data can represent long-term average erosion rates from almost levelled surface positions, where erosion rates are quite low and erosion measurements are scarce. Furthermore, the method includes all major erosion processes as water and tillage erosion.

Over 36 sites with more than one cistern were recorded in the countryside of northern Jordan apart from the larger excavation in Gadara with 112 documented cisterns[37]. The abundance of the Roman cisterns in the region is a further advantage to the intentional use for estimating average erosion rates of flat agricultural fields.

Here, the first results from the two most suitable cisterns located in the Wādī al-ʿArab, northern Jordan, are presented, investigated during an interdisciplinary archaeological-geographical survey in 2010. The presented pilot study focuses on the cistern's suitability for reconstructing historical soil erosion and the potential for OSL dating.

36 Mittmann 1970.

37 Keilholz 2007; Keilholz 2012.

2.3.1.3. Historical Background

In the region around Gadara, a city nowadays known as Umm Qēs in northern Jordan, first settlement structures were founded in the middle of the 4th millennium BC. From 64 BC to 324 AD the area belonged to the Roman Empire and Gadara was part of the Decapolis—a federation of ten cities in the region were Roman and Greek culture prospered. In the larger settlements such as ancient Gadara the population density was assumed to reach around 400 inhabitants per hectare[38]. The demand of water in the region requested the construction of hydraulic structures as early as the Iron Age[39]. During the Roman period giant aqueducts were built in Gadara[40], which enabled socioeconomic development. Additionally, to overcome water shortages during dry summers and to guarantee the city a minimum of autarchy more than 100 handmade subsurface water reservoirs (i.e. cisterns) are documented for Gadara. They served the populations and agricultural need for water[41]. The cisterns were either fed by runoff from adequate anthropogenic surfaces (e.g. roofs) or from natural overland flow from the typically Mediterranean limestone landscape. Since water in cisterns is stored cool and dark, they prevent contamination and are used until today around the Mediterranean Sea[42], especially in Jordan.

In 749, a devastating earthquake destroyed large parts of Gadara and its hinterland and ceased its further development[43]. During the following Abbasid and Ayyubid-Mamluk (ca. 750–1500 AD) and especially in the late Ottoman period (19th/20th century AD), the area became re-pop-ulated, but the population density never reached the former size and importance again[44]. As a consequence, many of the cisterns were left idle after the earthquake and were since then filled up with sediments.

2.3.1.4. Study Area

Wādī al-ʿArab represents the northwestern part of Jordan and drains from the ʿAğlūn plateau (500 m mean sea level—msl) into the Jordan River at around -200 m msl. The climate is Mediterranean to semi-arid with an annual precipitation of ca. 380–530 mm, of which high amounts occur in the north-east. Geologically, the major strata are marls, lime- and dolostones of Upper Cretaceous and Paleogene age, resulting in alternating layers of aquifers and aquicludes[45]. Where marly sequences are missing, karst features (e.g. karren, dolines and caverns) are abundant.

Morphologically, a plateau with rolling hills and agricultural plains characterizes the east whereas towards west and south, relief energy is higher and agricultural areas are limited to top, saddle and foot slope positions or to paleo-terraces close to the wādī bed. Cisterns for agricultural needs are located at top or shoulder positions, but were neither detected close to the wādī floor, on steep slopes nor on marly unconsolidated bedrock.

Most of the cisterns are created in the Muwaqqar Chalk Marl (MCM, *Fig. 2.11*), an aquiclude that consists of surface-near hard brittle limestones and soft marly rocks in depth. Its low permeability and easy hewing characteristics are beneficial for the construction of cisterns as it is described by M. Klein for chalky formations on the Israelian/Palestinian side[46]. P. Keilholz[47] reports variable shapes of cisterns with different socket stones to close the inlet and storage volumes of 30–90 m^3.

The analysed cisterns c1 and c2 (*Fig. 2.11*) are naturally fed. Both are situated less than 50 m beneath a wheat field in shoulder positions of a limestone landscape with soil patches. The average annual precipitation reaches 520 mm at both sites.

C1 is located in al-Burz, around 4.5 km east of Isʿarā and is dug into the MCM with a northward exposition *(Fig. 2.11).* The eastward-exposed second cistern (c2) is carved into the Umm Riğām Chert, some 1.5 km west of Bēt Rās *(Fig. 2.11).* Both cisterns are about 4–5 m deep and while c1 was locked with a rock, c2 was merely sealed with a socket rock *(Fig. 2.12).*

Both cisterns show a lining with mortar, which makes it possible to distinguish cisterns from storage rooms or graves. The different layers of mortar show white, grey and red colours, indicating the

38 Keilholz 2007; Keilholz 2012.
39 Porath 1984.
40 Döring 2009; Döring 2010.
41 Keilholz 2012.
42 Klein 2007.
43 Bührig 2008.
44 Häser – Vieweger, personal communication, 2012.
45 Moh'd 2000.
46 Klein 2007, 187.
47 Keilholz 2007; Keilholz 2012.

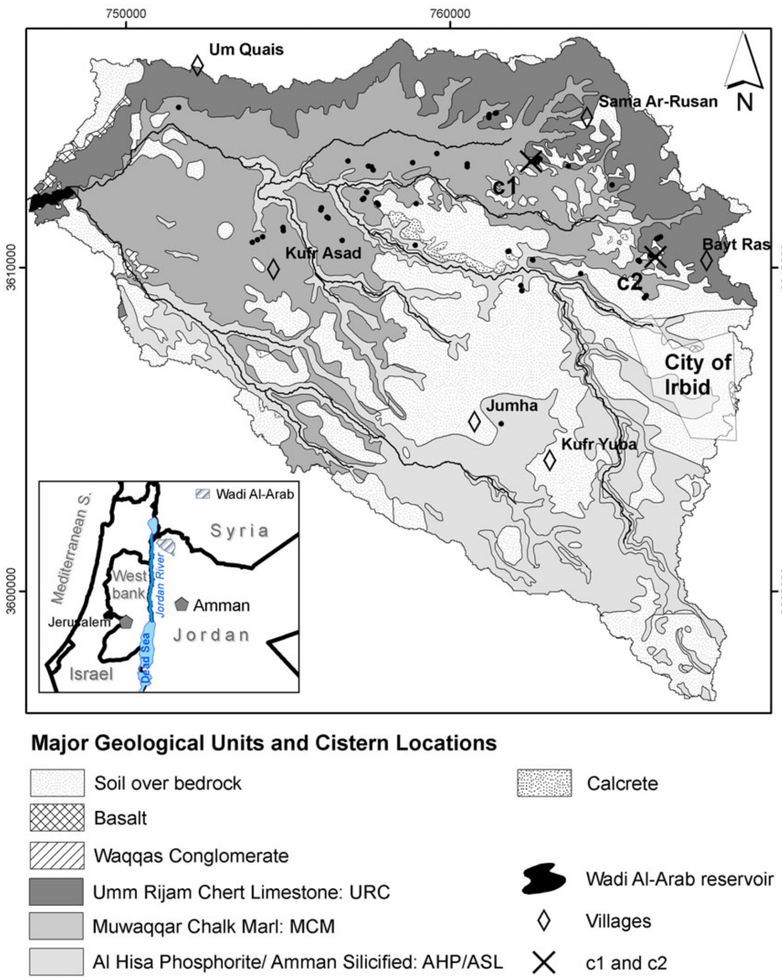


Fig. 2.11 Wādī al-'Arab catchment with the re-visited survey points of S. Mittmann[48].

use of pure lime mortar, coal or grinded ceramics as additives. Following J. Porath[49], white mortar was used in the early Roman period, coaly mortar refers to the 2nd century[50], whereas ceramic additives were common in the 3rd and 4th centuries. In later periods a re-use of early types and transitional formulas of mortar were implemented[51].

48 Mittman 1970.
49 Porath 1984.
50 Keilholz 2012.
51 Porath 1984.

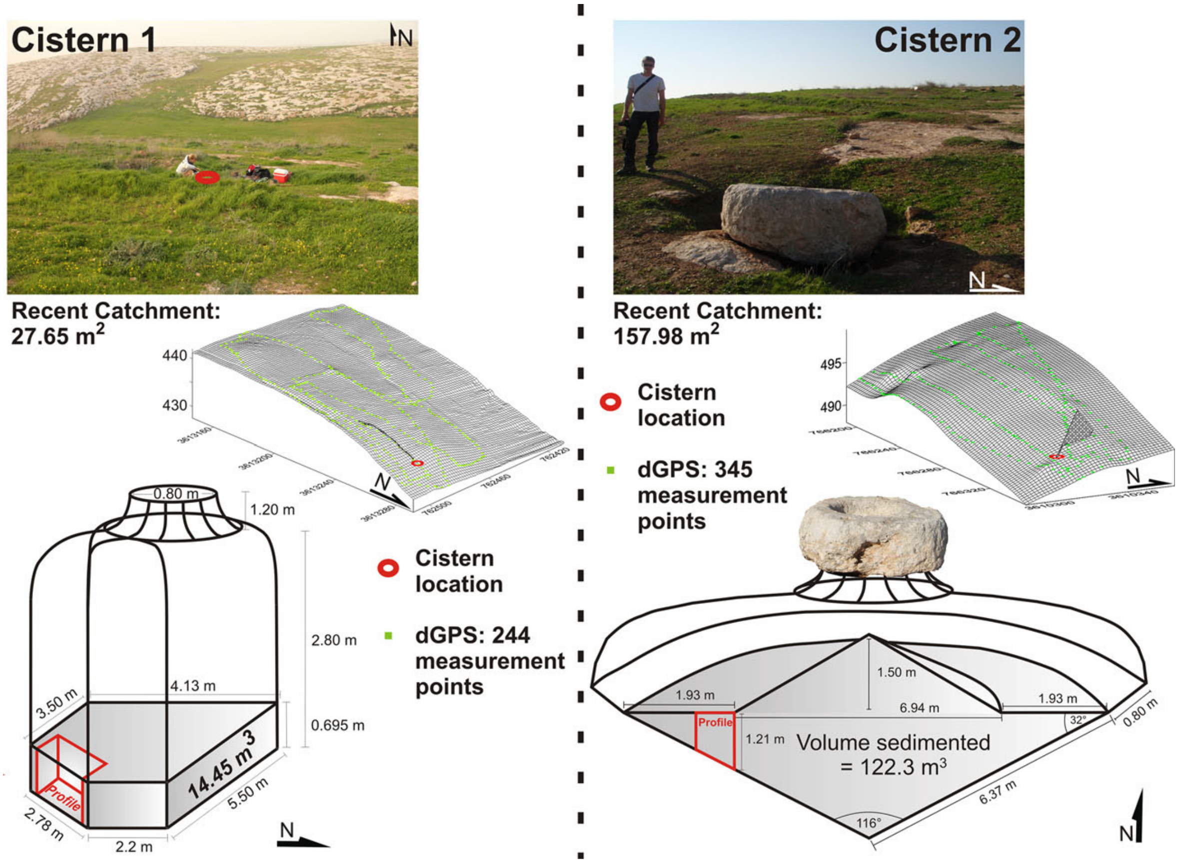


Fig. 2.12 C1 and c2 DEM, documented shape and profile position.

2.3.1.5. Methods

2.3.1.5.1. Field Analysis

During mid-2010 and early 2011, the cisterns were mapped and the interior of 35 cisterns was proved for suitability for further analysis. The applied criteria included: intactness of mortar and ceiling, no signs of anthropogenic disruptions, no water, and finally their accessibility and the possibility to work inside. Out of the 35 cisterns, 8 fulfilled these criteria and the most suitable two (c1, c2) were sampled. In both cisterns homogenous and clay rich sediments without any signs of discontinuity are deposited, promising to be suitable for OSL dating.

In the field, the sediment profiles were characterized by the parameters colour, carbonate content, structure, density and grain size, following the guidelines of the German mapping instructions[52] and the Munsell soil colour chart[53]. Sediment samples for laboratory analyses were taken from the upper and lower horizons of each profile. In addition, both the interior volume of the caverns and the sediment volumes of the cisterns were calculated.

Each cistern catchment was surveyed along transects using a Leica 900 dGPS with a vertical accuracy of <1 cm that day. From the 345 (c1) and 244 (c2) measurement points (= 1.6 point/m^2) digital elevation models of the area were generated with ArcGIS by interpolating, where ordinary kriging (trend removal of 2) yield smallest RMS error. Watersheds were calculated by implementing the hydrological toolset of ArcGIS.

2.3.1.5.2. Laboratory Analysis

Clay mineral composition was analysed using PANalytical XPert PRO X-ray diffractometer (Almelo, Netherlands) at MLU Halle. The grain size distribution was analysed with the SEDIMAT 4-12

52 Ad-hoc-Arbeitsgruppe 2005.

53 Munsell 1994.

(UGT, Germany) at UFZ Halle. Gamma emitting radionuclides were detected with GAMMA-X, N-type coaxial HPGe detector (type GMX90-S) (ORTEC spectrometry, USA).

2.3.1.5.3. OSL Dating

Five sediment samples for optically stimulated luminescence (OSL) dating were taken from the cistern sediments. From cistern c1, two samples were taken in 43 cm and 63 cm depth respectively, from cistern c2, three samples were taken in 34 cm, 71 cm and 117 cm respectively. Sampling took place during the night using red LED headlamps (640 nm), with sampling directly into opaque plastic bags, after cleaning the profile from the light exposed material.

To determine the equivalent dose (D_e), the quartz fine-grain (4-11 µm) fraction was prepared. The sediment was first wet sieved, followed by a treatment with HCl and H_2O_2 to remove any carbonates and organics. To get pure fine-grain quartz extracts, the polymineral samples were etched in 34 % pre-treated H_2SiF_6 for several days[54]. The purity of the quartz extracts was checked by IRSL measurements and aliquots with IRSL/OSL ratios greater than 3 % were rejected.

The luminescence measurements to determine the equivalent dose (D_e) were carried out on a TL/OSL-DA-15 Risø readers, equipped with blue LEDs (470±30 nm) for stimulation, a Thorn-EMI 9235QA photo-multiplier combined with a 7.5 mm U-340 Hoya filter (290–370 nm) for detection and a $^{90}Sr/^{90}Y$ ß-source (1.84 GBq) for irradiation. The single-aliquot regenerative dose protocol (SAR) proposed by A. S. Murray and A. G. Wintle[55] was applied for D_e determination. Therefore, six regeneration cycles were used with shine-down curves measured for 40 s at elevated temperatures (125°C), using a cut-heat for the test dose of 160°C. Based on dose recovery and pre-heat plateau tests, a preheat temperature in the range of 220–260°C was chosen for the natural and regenerated OSL signals. The result of the dose recovery and pre-heat plateau test indicates that the given dose could be reproduced for the used temperature range of 220–260°C.

Up to 24 aliquots per sample were measured for D_e determination. D_e calculations are the mean values of n aliquots for each sample, where n is the number of aliquots which passed the following criterion: a recycling ratio of 1±0.1 and a recuperation value of 5 %[56]. The standard error of the mean was used as D_e error.

The dose rates (*D*) were obtained from sediment samples taken from within a 30 cm radius of each OSL sample location. Low-level high-resolution γ-spectrometry were applied to determine the contents of ^{238}U, ^{232}Th and ^{40}K. Dose rate conversion factors were used from G. Adamiec and M. Aitken[57]. For all samples, an a-value of 0.035 was used to consider the α-effeciency.

The cosmic-ray dose rates were calculated according to J. R. Prescott and J. T. Hutton[58]. The water content of the samples was determined using the average value of the possible water content range, based on the porosity of the samples. An error for the water content value was chosen, which included the possible water content range. The values used for the water content were checked by measuring the in situ water contents of the samples.

From sample c1_63cm, no quartz for an OSL measurement could be extracted. However, an archaeological sherd, found in the depth of sample c1_63cm, was ^{14}C dated at the laboratories of Beta Analytic Inc. in Miami, Florida.

2.3.1.6. Results

Both cistern profiles show dark brown sediment of 7.5YR/5.6 colour. The upper 30–50 cm of sediment is subpolyedric bedded with small carbonatic rock detritus in between reflecting the youngest deposited material in the cistern. Below follows a layer of homogenous sediment of the same colour, which is interrupted by a carbonatic stone layer infilled with coarse sand at 80 cm depth in case of c2. The profile thickness reaches 69.5 cm (c1) and 121.0 cm (c2), respectively, with a consistent carbonate content of 10–25 %. C1 shows a 2 cm thick ceramic and charcoal mortar layer above the bedrock, whereas in c2 only a single charcoal layer of 1 cm exists.

The topographic measurements resulted in a catchment size of ca. 28 m^2 for c1 and ca. 158 m^2 for

54 Fuchs et al. 2005.

55 Murray – Wintle 2000.

56 Murray – Wintle 2000.

57 Adamiec – Aitken 1998.

58 Prescott – Hutton 1994.

c2. Estimated sediment volumes from cistern infillings are 14.6 m^3 (c1) and 122.3 m^3 (c2) respectively.

Sediment characteristics for the four sediment samples for OSL and radiocarbon dating and their analytical results are listed in *Tab. 2.8* and *2.9* and *Fig. 2.13*.

Sample_ depth	Geology	Clay [%]	Silt [%]	Sand [%]	Density [g/ cm3]	Water cont. [%]
c1_34 cm	MCM	46.5	51.4	2.1	1.15	24
c1_63 cm	MCM	n.a.	n.a.	n.a.	1.15	27
c2_43 cm	URC	36.7	44.3	19.0	1.14	27
c2_71 cm	URC	n.a.	n.a.	n.a.	1.12	25
c2_117 cm	URC	n.a.	n.a.	n.a.	1.14	26

Tab. 2.8 Sample characteristics from cistern 1 and 2. n.a. = not available.

Sample	U	Th	K	[Gy/ka]	De
c1_43 cm	7.04±0.24	4.44±0.25	0.64±0.02	2.92±0.16	1.83±0.10
c2_34 cm	7.59±0.16	5.18±0.25	0.68±0.02	3.16±0.17	3.61±0.40
c2_71 cm	7.31±0.08	5.42±0.25	0.93±0.03	3.31±0.18	4.02±0.15
c2_117 cm	6.96±0.08	4.44±0.25	0.69±0.01	2.94±0.16	3.39±0.24

Tab. 2.9 OSL analytical data: Sample code, 238U, 232Th and 40K-concentrations, total dose rate and equivalent dose. Note: For dose rate calculation, a water content of 20 % and an a-value of 0.035 was used.

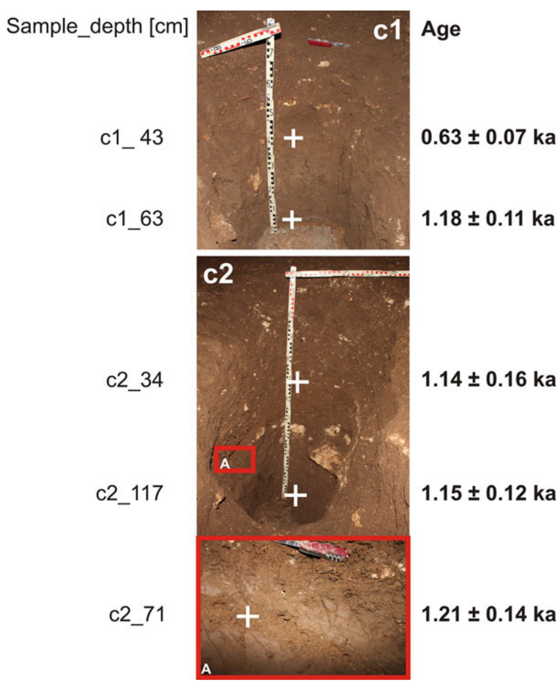


Fig. 2.13 Profile pictures, sample locations and sediment ages.

The start of sedimentation in cistern 1 at 1.19±0.03 ka cal BP (Beta-327418) is confirmed by cistern 2, where the basal sediment has an age of 1.15±0.12 ka (c2_117 cm), followed by OSL sample c1_43 cm, with an age of 0.63±0.07 ka.

Cistern 2 shows in the upper profile and age of 1.14±0.16 ka (c2_34 cm) respectively. From both cisterns, all sediment ages are within their errors in chronostratigraphic order, confirming their correctness. Sedimentation in cistern 2 shows with sample c2_71 cm a distinct fining-up of sediments. This characteristic indicates a single deposition event, with finer sediments on top, representing the end of the sedimentation event at 1.21±0.14 ka.

Based on the OSL ages and the single ^{14}C age, *Tab. 2.10* lists minimum and maximum erosion rate estimates, given in ton per hectare and year [t ha^{-1} yr^{-1}] for each cistern. For mass calculations, an average bulk density of 1.15 g cm^{-3} for c1 samples and a mean of 1.13 g cm^{-3} for c2 samples was used *(Tab. 2.8)*. All samples showed a standard deviation in bulk density of 0.012 g cm^{-3}. As the bulk density is the sensitive parameter for these calculations its standard deviation was used to estimate the error of the erosion calculations (*Tab. 2.10*). Calculations were performed in each cistern from the youngest age±SD (upper horizon; min. and max.) and from the oldest age±SD (lower horizon, min. and max.) calculated until 2012 (year of measurement) in respect to the sedimentation volumes in the cisterns. The results show a general mean of 5.07±0.15 t ha^{-1} yr^{-1} and range in total between 3.04 and 6.64 t ha^{-1} yr^{-1}.

Cistern and Period of Calculation	Catchment Estim.	Volume Sediment [m³]	Catchment [m²]	Sediment yield [t/ha]	Age±SD	Years	Sediment yield [t/ha/a]	Error [t/ha/a]
Cistern 1 upper horizon	dGPS	8.9	27.7	3063.6	Min	700	5.31	0.06
			27.7	3063.6	Max	560	6.64	0.07
Cistern 2 upper horizon	dGPS	55.2	158.0	3962.5	Min	1300	3.04	0.03
			158.0	3962.5	Max	980	4.03	0.04
Cistern 1 lower horizon	dGPS	14.4	27.7	4951.6	Min	1222	4.92	0.05
			27.7	4951.6	Max	1282	4.69	0.05
Cistern 2 lower horizon	dGPS	94.9	158.0	6812.5	Min	1030	6.59	0.07
			158.0	6812.5	Max	1270	5.34	0.06

Tab. 2.10 Parameters for the calculation of the erosion values in both cisterns.
Min = Age+SD; reference year 2012; Max = Age-SD; reference year 2012.

2.3.1.7. Discussion

2.3.1.7.1. Dating Reliability

The radiocarbon age shows the smallest error. However, the method demands the availability of organic matter in the sediment and its temporal close relation to the final deposition in the cistern. Thus, if old organic matter gets incorporated in the sedimentation process, the time of deposition would result in an age overestimation. In contrast, OSL dating determines the last process of sediment reworking and its final deposition, thus determines the last process of sediment reworking directly. However, OSL ages show a lower precision than ^{14}C ages. In this study, several indicators support the correctness of the OSL ages:

1. The OSL characteristics like brightness of the sample, OSL growth-curve behaviour and dose recovery tests are very good.
2. The one derived ^{14}C age and OSL results agree within errors (*Fig. 2.13*).
3. The OSL ages are in chronostratigraphic order.
4. The maximum age of the oldest sediments of ca. 1.2 ka correspond well with the age estimate from various archaeological proxy.

2.3.1.7.2. Erosion Rates

Although there are differences in catchment size and shape of the two cisterns, both catchments show similarities like morphometry (slope, aspect etc.), hydrology, time of abandonment and the assumed erosion processes that took place, namely water erosion in form of inter rills, rills, ephermal gullies and the translocation by the plough. The averaged erosion values of both cisterns cover a small range (3.0–6.6 t ha^{-1} yr^{-1}), supporting the robustness of the results. Furthermore, the deposited volume represents 0.5–0.6 t cm^{-2}, which equals for both cisterns a soil cover loss of 34 cm (c1) and 59 cm (c2) in height from the cisterns catchments in a maximum of 1300 years. These calculations are based on the recent catchment size calculations. However, due to changes in agricultural practices (direction of furrows) over time, catchment size might have somewhat changed. Such changes are not reproducible today and could be a source of error to the calculations but are assumed to be of minor effect.

The calculated erosion rate of 3.04–6.64 t ha^{-1} yr^{1} is difficult to compare with values from similar regions. Particularly in the Mediterranean, erosion rates are subject to remarkable uncertainty[59], since their calculation is strongly based on both the observed scale and the applied method of measurement[60]. Additionally, their estimations are prone to a variety of effects, including the connectivity of detached particles to small channels or intermediate storages in small catchments (<10 km^2) and periods of stronger precipitation or drought[61]. Hence, erosion studies in the circum-Mediterranean region reveal extremely variable erosion rates for agricultural fields. C. Kosmas et al.[62] report of 0.15– 0.9 t ha^{-1} yr^{1} on cereal fields, 1.0–6.8 t ha^{-1} yr^{-1} in fields that show ephermal gullies as major sediment exporters[63] and even 0.5–107 t ha^{-1} yr^{1} from fields in Spanish Navarra in comparison to fields from around the world[64]. The erosion rates derived from our cisterns (3.04–6.64 t ha^{-1} yr^{1}) fall into the lower range and document a reasonable soil loss. Results are coherent with recent field observations around the cisterns of slope parallel tillage practice triggering tillage erosion, canalizing runoff and increasing rill erosion.

The age estimation of cistern 1 suggests an accelerated sedimentation over time as 20 of 63 cm sedimentation occurred in the first 622 years and 43 cm from 0.63±0.07 ka until today. In contrast, the age results of cistern 2 can be interpreted in two ways:

1. The ages represent very strong erosion and hence deposition events within the first 10 years (1.15–1.14 ka cal BP). During that short period, 83 cm of the total 117 cm were deposited in cistern 2.
2. The interpretation of the sedimentation rate between the estimated ages at only two locations within one profile is afflicted with considerable uncertainty and therefore can only be interpreted with care.

Concerning periods of accelerated erosion a short review of the agricultural development in the region will help for a better understanding. S. Gibson[65]concludes from proxy data that a switch from lowland agriculture to highland agriculture in the region took place in the Early Iron Age (1200–500 BC). He further postulates on the basis of archaeological surveys that only during Iron Age II (1000–500 BC), a time of stronger organizational authority, economic stability, and population pressure, widespread terracing was implemented. During Roman times, the Decapolis region continued to prosper and Roman settlement patterns show that more or less every possible position was farmed and inhabited[66]. This leads to the assumption that during Roman times terraces must have been under continuous use and maintenance if not further expansion occurred. The abandonment of the area is a result of the weaker organizational authority of the post Roman Empire, the Abbasid and Ayyubid-Mamluk period (*c.* 750–1500), which due to this fact was less resilient to the devastating earthquake and its consequences. Recent land abandonments in southern Spain show that not maintained terraces eventually collapse and yield high sediment loss[67]. These considerations could attest periods of accelerated erosion after the abandonment of the region, which occur at different times. On the other hand, land abandonment can also result in succession and hence, reduced erosion rates[68]. Thus, until now, the obtained results cannot indicate precise periods of time with pronounced erosion events for the studied region. Therefore, further analysis of cistern sediments with higher temporal resolution are needed.

59 García-Ruiz et al. 2013.

60 Fleskens – Stroosnijder 2007.

61 García-Ruiz et al. 2013.

62 Kosmas et al. 1997.

63 Vandaele et al. 1996.

64 Santisteban et al. 2006.

65 Gibson 2001.

66 Glueck 1942; Mittmann 1970; archaeological survey Vieweger – Häser 2010.

67 Koulouri – Giourga 2007.

68 Grove – Rackham 2001.

2.3.1.8. Conclusion

Roman cisterns in northern Jordan serve since their abandonment as historical sediment traps. Sediment profiles of two cisterns were analysed and dated with OSL and radiocarbon dating. Both methods reveal maximum sedimentation ages of 760–862 AD and therefore agree well with archaeological findings, which lead to a time of abandonment of the area in the mid of the 8th century. Based on the dating results and detailed GIS-based topographical analyses of the cistern catchments, long-term average soil loss was calculated with an estimated erosion rate of *c.* 3.04–6.64 t ha^{-1} y^{-1}.

From the above stated uncertainties and boundary conditions for short-term erosion observations, the use of cistern sediments to calculate long-term erosion rates has considerable advantages. This type of sediments archive does not suffer from short-term weather fluctuations but covers all kinds of extreme events. Furthermore, the method is minimal invasive and no edge effects occur, as installations are not needed. The great abundance of Roman cisterns as mapped for this study and documented for the region constitute a further advantage when aiming at various long-term average soil erosion rates of nearly levelled positions and across regions.

However, suitable cisterns have to be chosen very carefully. Important indicators are (i) the existence and intactness of mortar referring to their use for water storage and prove impermeability and (ii) no signs of any anthropogenic disruptions. Still, a significant stratification could only be demonstrated for one out of two cisterns, raising important questions to the frequency of the erosion processes. Despite the considerable uncertainties we conclude that the analysis and dating of cistern sediments is a useful approach and with further implementation and method development could be a useful tool for the estimation of average erosion rates in areas around the Mediterranean.

2.3.1.9. Acknowledgements

The authors especially thank Dr. K. Soennecken and P. Leiverkusen from the Biblical Archaeological Institute in Wuppertal and Prof. Dr. Dr. Dr. h. c. D. Vieweger and Dr. J. Häser from the German Protestant Institute of Archaeology for giving the chance to accompany the Tall Zirāʻa hinterland survey. Further thanks go to S. Schulz for his help during the field campaign and Dr. M. Raggad for his local expertise and steady support. Special words of gratitude are devoted to the technicians at the labs of MLU Halle and UFZ, to Prof. Pöllmann (MLU), and to M. Fischer from the luminescence laboratory at the University of Bayreuth for OSL sample preparation.

Last but not least, thanks go to the countless Jordan farmers that allowed us to access their land and provided us company and provisions in breaks and the German tax payer for funding the SMART II project (FKZ 02-WM1080) through the Federal Ministry of Education and Research, the IPSWat and the Helmholtz Interdisciplinary Graduate School for Environmental Research (HIGRADE).
The research is implemented within the framework of the multilateral project SMART II (= Sustainable Management of Available Resources with Innovative Technologies). The project aims at the development of a transferable approach for an integrated water resource management (IWRM) in semi-arid regions with water shortage. Infiltration and therefore soil erosion are sensitive parameters for hydrological modelling.

2.3.2. Natural Resources in Wādī al-ʻArab

by Sabine Kraushaar/Marwan Al-Raggad

The following chapter is the linguistic attempt to communicate geological, pedological and geographical findings to the interested archaeological community. Therefore, technical terms were reduced and further explanations offered in order to communicate on common ground between the disciplines. Some details may be generalized or „lost in translation“. The authors hope readers will understand this as a necessary reduction to allow for an interdisciplinary dialogue.

Fig. 2.14 a Basalt bowl.

Fig. 2.14 b Flint tool.

Fig. 2.14 c Crude iron nucleoids.

Fig. 2.14 d Bitumen.

Fig. 2.14 Examples for the anthropogenic use of natural resources in the Wādī al-ʻArab. a: Basalt bowl, TZ 001209-001; b: Flint tool, TZ 001332-001; c: Crude iron nucleoids, TZ 006996-001; d: Bitumen from Dead Sea, TZ 007245-001 (© BAI/GPIA).

2.3.2.1. Introduction

The existence of natural resources in a landscape is an important factor in the establishment of permanent settlements. Many of the historically utilized resources in northern Jordan derive from the direct geographical environment and are a result of its geological history. Findings from Tall Zirāʻa und Gadara include tools and arrowheads made from flintstone (= silex), construction elements and handicrafts made of basalt and limestone, decorations on the ʻAin Ġāzāl figurines and sealing compound made of bitumen, iron nucleoids as potential iron resource and ammunition, as well as ceramics made from clay, obtained from the clay-rich soils in the region *(Fig. 2.14)*.

While known iron resources and basalt are a more local phenomenon in the region, others, such as flint can be found in different geological units throughout the hydrological catchment area of the Wādī al-ʻArab *(Fig. 2.15)*. Suitable clay for ceramic production can be found in many areas where the chemical weathering of the calcareous geology leaves a carbonate-poor soil, rich in weathered minerals with a grainsize not bigger than 2 µm—namely clay.

Hence, the occurrence of these resources is tightly coupled to the geological genesis of the Wādī al-ʻArab, as well as the subsequent soil formation in the area. The former will be explained in more detail in *Chap. 2.3.2.2*. The most important geological units in the region with their respective resources are illustrated in *Chap. 2.3.2.3.* Finally, clay *(Chap. 2.3.2.4.)* and soil development in the region *(Chap. 2.3.2.5.)* are discussed regarding potential natural repositories for suitable clays to use in ceramics production and the agricultural potential of the area.

2.3.2.2. The Geological Genesis of the Wādī al-ʻArab

The geological foundation of the Wādī al-ʻArab consists mainly of sedimentary rock in the form of different hard limestones as well as carbonate- and clay-rich (= marly) unconsolidated marl from the Eocene. The different geological units result from the deposition circumstances during the respective historical period and were mainly controlled by the advancing and retreating of the former Tethys-Ocean. In the following we provide a short summary of the geological developments of the Middle East and the Wādī al-ʻArab basin, including the Tall Zirāʻa, as well the Gadara/Umm Qēs plateau to the north. For more detailed information, the authors suggest reading F. Bender, A. Horowitz, and K. Bandel and E. Salameh[69]:

In the Precambrian, the region known as the Middle East today was formed as a stable continental margin[70]. The advance and retreat of the Tethys-Ocean and the Arabo Nubian Massif to the South as "stable nucleus" dictated the geological evolution of the area, and resulted in the accumulation of shallow marine sediments, such as marine organisms as well as the delivery of terrestrial sediments through rivers to the shorelines of the former continent[71]. S. Kraushaar et al.[72], as well as Al-Sharhan et al.[73] found clay minerals such as quartz in several soil, respective geological samples from Wādī al-ʻArab that hint either at an aeolian input through the air or support the assumption of terrestrial sediment input through rivers for example[74].

These marine sediments with terrestrial input were gradually lifted up to the Createceaous, a process that included strong formative tectonic phases, leading to the expansion of the Red Sea and the Gulf of Aden and the development of the Jordan Rift System[75].

In north-west Jordan, the ʻAğlūn plateau is built up of these marine sediments, which differ in their composition, and thus rock characteristics, depending on the differing sea levels of the Tethys-Ocean throughout time. When the ocean advanced between the Santonian and Late Eocene eras, shallow to moderately pelagic chalks were sedimented. Today, they form the geological foundation of the area (Amman Silicified Limestone/Al Hisa Phosphorites, Muwaqqar Chalk Marl and Umm Riğām Chert; *Fig. 2.15* and *Tab. 2.11*).

Most Roman stone quarries with a typical edge length of 30 cm x 70 cm were recorded during the Wādī al-ʻArab Survey in 2010 in the Muwaqqar Chalk Marl and Umm Riğām Chert, which supports the assumption that at least in the Wādī al-ʻArab, these geological units were mostly used as con-

69 Bender 1968; Horowitz 2001; Bandel – Salameh 2013.

70 Siebert 2005.

71 Flexer 2001; Moh'd 2000.

72 Kraushaar et al. 2015.

struction materials and for the production of cult objects (own observations Kraushaar).

The period of the Tethys advancement was followed by ocean retreat until the Oligocene/Miocene, forming a harder limestone unit. The final retreat in the Pliocene resulted in a lake-like sedimentation environment, where the geological unit today, classified as Waqqas Conglomerate, developed (orange, *Fig. 2.15*). The Waqqas Conglomerate display consolidated gravel in a carbonatic matrix, hinting at the transport of gravel in terrestrial rivers before they were deposited in the lake-like environment.

The young geological history of the area starts around 5.1 Million years ago and is marked by volcanic activity, which resulted in multiple basaltic lava sheets covering the aforementioned carbonatic rocks in the area today, known as the Gadara plateau, and protected it from further erosion (violet, *Fig. 2.15*)[76]. The plateau is situated 30 km north-west of Irbid and is 340 m above sea level. The upper 150 m consist of a total of eleven overlaying basaltic layers, built up over various eruption phases[77]. The basaltic layers once formed the southern part of the Syrian Mevo Hama Plateau, which was then parted by the in-cutting of the Yarmūk River, leaving the Zamlat Bẖila plateau with the Ǧolān Heights in the north and the Gadara plateau in the south.

The basaltic lava flows belonged to the Arabian Ḥarrat-volcanism, which covered a coherent area of 180.000 km^2 that extended from Syria to Jordan (here alone an area of 11.000 km^2), and from Saudi Arabia to Yemen[78].

At the end of the Oligocene/early Miocene, the Jordan-Dead Sea Rift system developed and resulted in the downward sinking (= subsidence) of the Jordan Valley. Perpendicular tributaries to the Jordan Valley, such as the Wādī al-ʿArab in the north, formed and reacted to this lowering of the erosion basis by deeply incising into the ʿAǧlūn plateau. The regional structural development (anticlinal structure) of the plateau led the layers of different geology to dip north-westwards, leaving the oldest rocks exposed in the south-east (Amman Silicified Limestone/Al-Ḥisa Phosphorite: blue, Wādī Umm Ġudrān: yellow, Wādī aṣ-Ṣīr Limestone: light green; *Fig. 2.15*) and the youngest formations in the northwest (Muwaqqar Chalk Marl: green; Umm Riǧām Chert: red; *Fig. 2.15*). Various faults, mainly aligning from north-east to south-west are present in the catchment and give proof to the ongoing tectonic movements[79].

2.3.2.3. The Geology of the Wādī al-ʿArab and their Resources

The main geological units in the research areas are marked in colour in *Fig. 2.15*: Amman Silicified Limestone/Al-Ḥisa Phosphorite (ASL/AHP; light blue), Muwaqqar Chalk Marl (MCM; green), and Umm Riǧām Chert Limestone (URC; red). These three units are composed of carbonate-rich marine deposits, such as limestone, dolomite, marl, and chalk. Wādī Aṣ-Ṣīr, Amman Silicified Limestone/Al-Ḥisa Phosphorite, and Umm Riǧām Chert *(Tab. 2.11)* show occasional layers, or tubers of silicified lime- or flintstone (= silex) respectively[80].

Silex is generated over million of years from inorganic silicate material and organic zoo- and phytoplankton in a marine environment. It was trimmed and used as a tool as well as for the production of arms and can be found as such throughout the catchment and especially in former settlements. Silex tools are easily identified by their characteristically sickle glee.

Besides the silex, the Umm Riǧām Chert as well as the Muwaqqar Chalk Marl occasionally feature bitumen occurrences. The usage of these organic hydrocarbon compounds is known from findings in Jordan. G. Rollefsen[81] found bitumen used to decorate limestone figurines in Ain Ghazal, D. Vieweger[82] reported the use of it to seal ship beams.

In the Muwaqqar Chalk Marl, close to the Tall Zirāʿa (*Fig. 2.15*, green), fist-sized iron nodules were discovered. These nodules were known from workshop area excavations and might be used for colouring ceramics or as gross mass for iron processing *(Fig. 2.14d* and *2.16).*

73 Al-Sharhan – Nairn 1997.
74 Kraushaar et al. 2015; Al-Sharhan – Nairn 1997.
75 Siebert 2005.
76 Moh'd 2000.
77 Mor – Steinitz 1985; Ponikarov et al. 1967.
78 El-Akhal 2004.
79 Moh'd 2000.
80 Moh'd 2000.
81 Rolefsen 1982, 44–47.
82 Vieweger 2012.

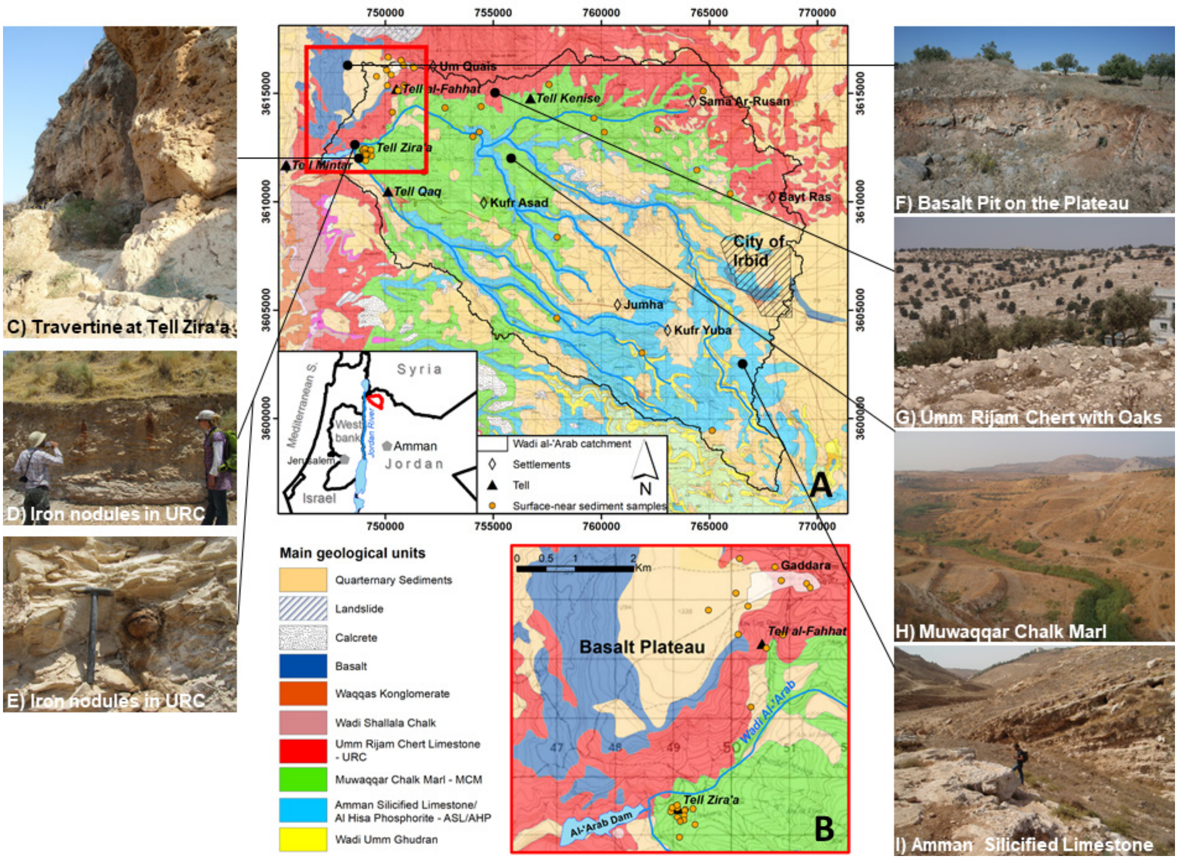


Fig. 2.15 Geological map of the Wādī al-ʻArab (MWI, Kraushaar 2018).

Fig. 2.16 Iron Age workshop, Tall Zirāʻa, Square AP 120, Context 4852, view from south (© BAI/GPIA).

The iron accretions come in the form of pisoids in the Wādī al-‘Arab, which are spherical shaped iron deposits, made of concentric rings of iron hydroxide. They probably chemically precipitated in a moving, high concentrated solution during the deposition of the sediment matrix that surrounds them.

K. Bandel and H. Khouri[83] report other iron nodule findings, also from Triassic limestone, as well as lenticular ore bodies from the ‘Ağlūn region (Warda mine) situated in the late cretaceous Wādī aṣ-Ṣīr Formation[84]. The lenticular ore body, which was discovered only 35 km south of Tall Zirā‘a, is the only known ore deposit in Jordan[84], and F. Bender[85] assumes a hydrothermal genesis. Hereby, water of high temperatures—probably due to magmatic activity in the subsurface—dissolve metals in the depth and transport them close to the surface. Al-Malabeh et al.[86] disagree with this theory today, and postulate a solution weathering of the iron and a consecutive precipitation of the Goethit. Whatever theory is correct, both forms of deposits provide an excellent and accessible resource for the prehistoric population to produce tools and arms.

In the north-western corner of the Wādī al-‘Arab the Gadara basalt plateau is situated partly covered by soil. This is the youngest geological unit and the basaltic stones of different porosity are used locally in Gadara as construction materials and for the manufacturing of cultural objects and are found as such throughout the catchment *(Fig. 2.14a* and *2.15F*).

Tall Zirā‘a itself is located in the wādī itself east of the Wādī al-‘Arab reservoir. The Tall is build on an artesian spring that is the result of underground-water flowing from higher levels of the surrounding hills into the depth contour of the wādī where it is pressured to the surface. With time sweetwater carbonates precipitated from this water and build up a hill of Travertine on top of the springs on which the settlement was built and retrieved its water from[87]. At one point either a drastic drop in precipitation caused the drying up of the spring or more likely, the Travertine hill had grown to a size that the pressure of the artesian spring was not sufficient to transport water to the surface anymore. The Travertine is a porous carbonatic rock that is found quite often along the depth contour of the wādī as well as around the tall, however no specific use is known through archaeological findings.

83 Bandel – Khouri 1981.

84 Bandel – Salameh 2013; Bender 1968; Al-Malabeh et al. 2008.

85 Bender 1968.

86 Al-Malabeh et al. 2008.

87 Bandel – Salameh 2013, 253.

Period	**Epoch**	**Stage**	**Age [MA (1)]**	
Quarternary	Holocene		0.0117	
	Pleistocene		2.58	
Neogen	Pliocene		5.33	Advancement and retreat of the Tethys ocean, which leads to the accumulation of marine sediments influenced by terrestrial depositions in the Precambrian. Then, gradual uplifting of the massive sediment package that is consolidated (hardened to rock) due to pressure and temperature.
	Miocene		23.3	
Paleogene	Oligocene		33.9	
	Eocene		56	
	Paleocene		66	
Cretaceaous	Upper Cretaceous	Maestrichtian	72.1	
		Campanian	83.6	
		Santonian	86.3	
		Coniacian	89.8	
		Turonian	93.9	
		Cenomanian	100.5.	
	Lower Cretaceous		145	
... (2) Precambrian			~4600.00	

Tab. 2.11 Timetable of the geological history of the Wādī al-ʻArab (Moh'd 2000, modified by Kraushaar in 2019).

Genesis of Northern Jordan	**Geological Unit**	**Characteristics (Moh'd 2000, MA) and resources used by humans**
	Basalt/Travertine/Calcrete/ Soil	
~5.1 Vulcanic activity starts, multiple basaltic lava sheets		Resources: Basalt stones for construction of houses and cultural object. Soils for the production of ceramics and as fundament for agriculture.
Tethys retreat: until the Miocene forming of harder limestone, then in the Pliocene lake-like sedimentation environment. Dead Sea Rift system develops, downward sinking of the Jordan valley, erosion of tributaries.	Waqqas Conglomerate	*C.* 200 m thick, 1. (calcerous) sandstone, 2. marl with gravel, 3. gravels and conglomerates with limestone elements.
Tethys advancement: shallow to moderately pelagic chalks were sedimented.	Umm Riǧām Chert Limestone	*C.* 220 m thick, 1. Marly Chalk, 2. chalky limestone, 3. upper chert unit, bitumen present. Resource: Silex and bitumen
	Muwaqqar Chalk Marl	*C.* 100 m thick, 1. Non bituminous chalk marl, 2. Bituminous chalk marl, 3. Nodular-bedded limestone, 4. Chalky limestone cliff. Resource: Rock for construction, iron and bitumen
	Amman Silicified Limestone / Al-Ḥisa Phosphorites	
	Wādī Umm Ġudrān	*C.* 40 m thick, Fossoliferous, 1. Chalk, 2. Chalk beds with coquina limestone and dolomitic chalky limestone.
	Wādī aṣ-Ṣīr Limestone	>200 m thick, stongly carstified, 1. Dolomitized limestone, 2. Limestone, 3. Peloidal limestone (sometimes marly or with cherts), 4. Micritic limestone.
	The geological units formed during the Jurassic (201.3 Ma) until the Cambrian (541.0 Ma) are not present in the Wādī al-ʻArab.	

2.3.2.4. Clays as Important Resource for Ceramic Production

Clay has a particle grainsize of <2µm and belongs to the smallest measurable grain size fractions. A sediment matrix is considered a pure clay if 65 % of the mass has the size of clay particles[88].

In most cases, clay derives as a chemical weathering product from silicate primary minerals and possesses a flake-like structure, resulting from stacked silicate layer packets[89]. Clay minerals exist as two- (kaolinite), three- (vermiculite, smectite etc.), and four layer minerals (chlorite). The ability of all clay minerals to accumulate water molecules and other ions on the outer surface of the layer packets in layer gaps, and with some minerals between the different layers, allows the clays to swell with the uptake of water and shrink when drying[90]. This is a prerequisite for the plasticity of the clay and necessary for the production of ceramics. Three layered clay minerals are characterized by a particularly high uptake and swelling potential. Furthermore, plants can access important ions at the edge of the layer packet easily, which is an important asset for fertile soil[91].

Clay minerals exists in the Wādī al-'Arab in different ways:

1. As consolidated claystone in the geology[92], which can become a clayey, unconsolidated, and carbonate-rich sediment after physical weathering.
2. As secondary clay minerals due to the chemical weathering of primary minerals during soil development. Especially in geomorphic stable positions, such as plains, levelled plateaus, saddle positions or foot-slope areas, sediments accumulate and may rest for centuries. Here, the most developed soils can be found, which correlates with the leaching of carbonates and the development of secondary clay minerals[93].
3. As non-local, wind-transported clay mineral aggregates, which enter the landscape recently in a limited extent in the form of diffuse carbonatic dusts[94].

An experimental archaeological test run by the excavation team on site, and under the lead of W. Auge (2006–2010), provided evidence that carbonate-rich clays from the region (1) are not suitable for the ceramic production. The carbonates incinerate during the firing process, which causes the ceramic to crumble. However, sediments that have undergone intensive soil development experience decalcification and secondary clay mineral formation. Therefore, these substrates (2) are carbonate-poor, and rich in secondary clay minerals and are suitable for the production of pottery.

Intensive soil development is favoured on geomorphic stable positions since geomorphic activity, such as landslides or strong erosion on slopes, prohibit or delay soil development. Hence, potential repositories are more likely to be found in stable localities, such as plateau, saddle and depression positions. *Fig. 2.17* shows an example of a recorded leading soil profile in plateau position in the Wādī al-'Arab. It shows 1.8 m of characteristic red, clayey (up to 46 % clay content) and homogenous soil, poor in carbonates (total inorganic carbon = 0.2 %) and stones—as is typical for Mediterranean carbonatic regions. In the lower part of the profile, just above the white bedrock, the clay content is the highest, whereas the carbonate content is the lowest. These clays are well suitable for the production of ceramics.

88 Ad-hoc-Arbeitsgruppe 2005; Blume et al. 2002, 13–16.
89 Blume et al. 2002, 13–16.
90 Semmel 1993.
91 Ad-hoc-Arbeitsgruppe 2005; Blume et al. 2002, 14; Semmel 1993, 14 f.
92 Moh'd 2000.
93 Blume et al. 2002, 448 f.
94 Jahn 1995.

Fig. 2.17 Vertisol above Umm Riǧām Chert Limestone with 0.2 % carbonate and 46 % clay content (Foto: Kraushaar 2010).

2.3.2.5. Soils in Wādī al-ʿArab and their Agricultural Potential

In the framework of a national soil mapping project, suitable soils were mapped in the region in two phases starting in 1989. On average, one soil profile was mapped per 3.5 km^2 in phase 2. The mapping focused on regions suitable for intensifying agricultural activity, like the Irbid basin west of Irbid[95]. The result was a strongly generalized soil type map following the FAO classification from 1974 with four main types (*Fig. 2.18*).

The map shows on geomorphic stable relief positions mainly medium developed soils such as Cambisols and fully developed Vertisols. Especially Cambisols still tend to be carbonatic, whereas Vertisols are characterized as red and clay-rich and therefore tend to turbate due to the swelling and shrinking of the clays (lat. vertere: turn over). On slope positions, less developed carbonatic and alkali-rich Litho- and Cambisols are common, as well as organic-rich Phaeozems. Generally, soils are more yellow than red on the slopes.

Lithosols are very shallow initial soils with a high stone content. Commonly, these soils are productive but prone to erosion due to their position on the slope, and often used for forestry[96] or, as is the case in the Wādī al-ʿArab, for the olive orchards.

Following the World Reference Base for Soil Classification[97], the alkali-rich Cambi- and organic-rich Phaeozems show the highest agricultural potential. Further developed soils with high clay content, as the aforementioned Vertisols on the stable relief positions, can have less favourable physical properties, such as the swelling and shrinking of the sediment matrix in regard to the soil moisture content. This causes soil gaps to tear open and roots to rip in the subsurface during dry phases in the summer months. Additionally, the water availability in clayey matrixes often results in "severe usage restrictions"[98]. Plants have trouble

95 Al Qudah 2001.

96 WRB 2007, 103.

97 WRB 2007, 103.

98 WRB 2007, 103.

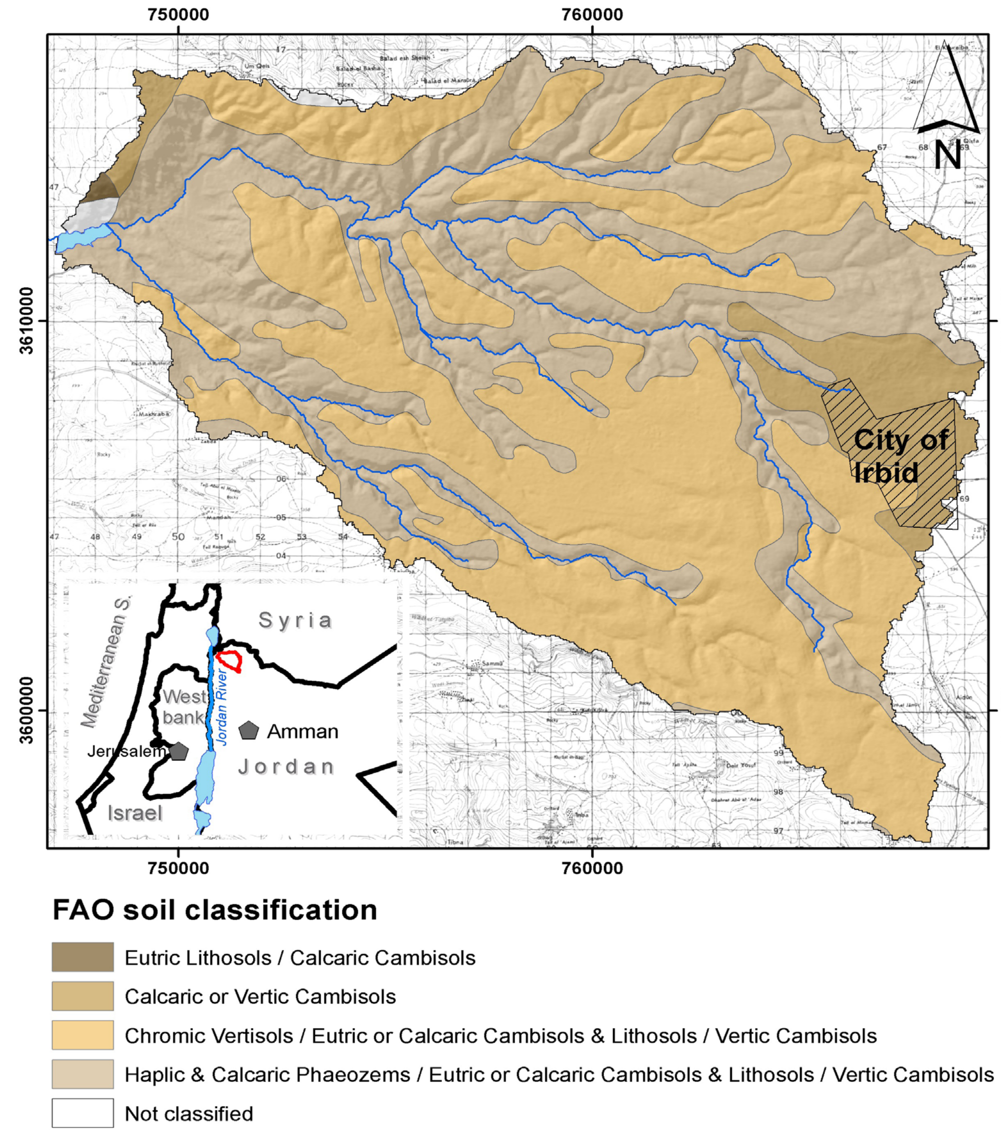


Fig. 2.18 FAO soil classification in Wādī al-ʿArab (Data: MoA 1993, Projection: UTM, WGS84, zone 36 N).

creating the necessary suction potential to retrieve the water from the fine sediment pores. Hence the unavailable water in the soil matrix is present but not useful for vegetation.

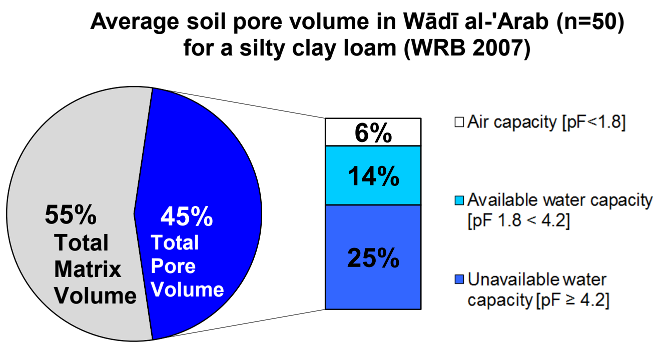
However, the author observed that even on levelled positions in the Wādī al-ʿArab, a high heterogeneity of clay contents exists, which does allow the cultivation of vegetables, wheat and olive orchards. Thus, a clay content of up to 50 % seems to pose no restrictions on agricultural use[99].

For a more thorough review of the ecological site conditions in the Wādī al-ʿArab regarding the agricultural potential and erosion susceptibility of the landscape, a more focused soil mapping was performed by the author following the Catena principle. Therefore, various soil profiles were dug in every geological unit on the plateaus, along the slopes, and down in the fluvial deposits—if existent. Samples from all profiles were analysed for their common physical and chemical properties.

49 samples from 28 leading profiles were taken, of which 16 profiles were on agriculturally used land in geomorphically stable positions. The rest was situated on steep slopes which are used for grazing of sheep and goats as well as for olive plantations.

The following ecological site evaluation is based on the analysis of these profiles and focuses on the classification of grainsize, pH, EC and different element concentrations in comparison to European and international standards as given by H.-P. Blume et al. and J. R. Landon[100]. It needs to be remarked that comparative literature values can vary strongly depending on the grain size, pH, precipitation intensity, management etc. of the soil and hence, can be only read as guiding values.

In average the analysed soil samples range between a silty (clay) loam to silty clay with around 32 % clay, 58 % silt, and ca. 10 % sand[101]. Thereof, an empirical pore volume can be derived of 45 %, which, because of the high clay content, only holds 14 % of plant available and 25 % of unavailable water *(Graph 2.6)*.



Graph 2.6 Average soil pore volume in sediments on carbonate and marly rock in Wādī al-ʿArab (n=50; silty clay loam [FAO 1990], own data).

The predominantly silty clayey grain size composition of the substrate also gives reason for the (very) slow hydraulic connectivity and hence infiltration potential of the soils on carbonatic and marly bedrock[102]. This results in increased surface runoff of rainwater and hence erosion.

The soil above basalt rock shows with only 16 % clay and 28 % sand an obvious shift to a coarser grain size, which reflects in a better but still moderate infiltration capacity[103]. Together with the lower stone content (3 %) compared to other soils from the region (30–50 % stone content) the soil on basalt appears favourable for agriculture.

99 Observations Kraushaar 2010–2014.

100 Blume et al. 2002; Blume 2004; Landon 1997.

101 FAO 1990 = Tu3; Ad-hoc Arbeitsgruppe 2005.

102 Landon 1991.

103 Landon 1991.

Concerning the electrical conductivity, as a value for the ion concentration in the soil solution, average value of 0.38 dS m-1[104] indicate no saliniation tendencies in the soils of the region. Furthermore, the plant available main nutrients, such as nitrogen, sulphur, and phosphor are deficient in soils on carbonatic, as well as on basalt rock. However, potassium, calcium, and magnesium are in excess available for plants in the region. The analysed trace elements (Mn, Fe, Cu, Zn, Ni, Mo) display suitable concentrations in comparison to common soil solution data from soils of different origins[105]. Molybdenum even shows with 0.59 mg l-1 available anions an increased value for basaltic soils.

Of all the measured heavy metals, the soluble lead values are elevated in the sediments on carbonatic rock. However, generally the sorption potential of the sediments is increased due to the high clay content, the raised iron concentration, and alkali pH values (in average 7.8)[106] and therefore the toxicity potential can be classified as low[107].

Over all, today the sampled lead-soil-profiles in the Wādī al-ʻArab seem suitable for agricultural use in regard to the measured physical properties and available nutrients. The only restriction to agricultural use on certain position is posed by the water availability of the more clayey sediments or possible strong soil erosion on slopes. The present samples of yellow sediments from less developed soils on the slope, and red sediments from more stable positions show in the analysis no significant difference. However, the sediments from the basalts have favourable physical conditions.

Since soils develop very slowly and the climate variability in the last 2000 years was neglectable, the assumption is valid that since the Holocene and with the working of people in the region the agricultural potential has not changed much. Thus, todays soils are about the status of agricultural potential the Romans found in the region as well, and agricultural yield is mainly dependant on amount, intensity and distribution of precipitation in the region[108].

104 Khresat – Taimeh 1998.

105 Blume et al. 2002, 329.

106 Khresat – Taimeh 1998.

107 Blume 2004.

108 Lucke 2007.

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