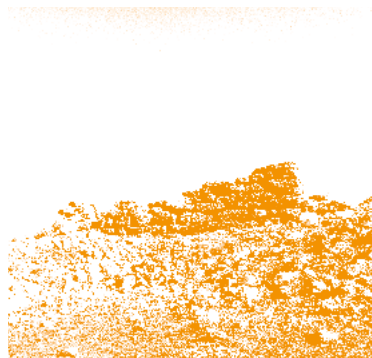


# Archaeological and geophysical survey at the site of Khirbat as-Sar (Sara), Jordan



**Abstract:** Archaeological and geophysical prospection of the site of Khirbat as-Sar (Sara) in Jordan, carried out by a team from the Polish Centre of the Mediterranean Archaeology (PCMA), University of Warsaw, has resulted in a comprehensive plan mapping all visible architectural remains. A Roman-period sacred compound appears to be a central feature of this site. Pottery collected from the surface has given a time range for the settlement from the late Iron Age through the Mamluk period. The electrical resistivity method using a probe array that allowed ground penetration to a maximum depth of approximately 1.50 m revealed meaningful information on the spatial organization of the site. Numerous high-resistance anomalies were interpreted as a reflection of building remains.

**Keywords:** Khirbat as-Sar, archaeological and geophysical survey, mapping, architecture, Roman compound, pottery, resistivity survey

Khirbat as-Sar is situated on the western outskirts of Amman, in the modern neighborhood of Bayader (31°56'39"N, 35°49'48"E; PG east 228.600, PG north 150.400), at 972 m ASL. The site, which has never been excavated, is coded JADIS 2215017 and MEGA-Jordan 3007 in the Jordanian antiquities databases.

The first reference to the site as “Khurbet Sar” was made in 1877 by Selah Merrill (1881: 404–405). Soon after that, in 1881, it was visited by Claude R. Conder, who described it as a large site, situated on “the ancient west road from Amman” (Conder 1889: 153). According to him, “six sarcophagi were found lying in a square enclosure” by the northern side of this road. One should understand this information as a reference to a built tomb

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Appendices

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(a “mausoleum”) which, logically, would be outside the limits of the settlement. Conder describes the tower as built “of great blocks of chert or flint”, and to the east of it, he notes “remains of a building with two parallel rows of arches”, remarking that “the piers beneath the arches are covered up”. This information, alongside the statement that the tower was situated in the “north-west angle of the site” (as it is today), prove that the state of preservation of the ruins has not changed substantially since the 19th century. Strangely enough, Conder states that “there are four arches in each row”, while there are more to be seen clearly even today (see below). He mentions also “a large pool or Birkeh in the ruins” and “masonry of Roman appearance”, and concludes with assigning a Roman date to the site.

The site was visited again in 1905 by Howard C. Butler (1919: 33, Fig. 21) who focused on the square structure (“qasr”) “surrounded by a mass of broken and half buried walls of rude workmanship and of various ages, from the period of considerable antiquity to a comparatively late Mohammedan date”. He noted the dimensions of the central structure which, in his opinion, would be a sanctuary “of great antiquity” renovated by the Romans, as well as the presence of a courtyard to the east of it, flanked by two rows of arcades (*arcosolia*), seven arches in each row. Butler mentions puzzling “sarcophagi under the arches”(!).

In 1937, the site was visited by Nelson Glueck (1939: 153–156, survey site No. 207) who knew it by the name of “Qasr es-Sar”. Glueck’s description of the main compound, consisting of the square “qasr” and the arcaded courtyard, sounds

fairly detailed; moreover, he compared the state of architectural remains in his time with what was reported by Butler 30 years earlier. In Glueck’s opinion, the square structure was initially a fortress, which was transformed by the Romans into (presumably) a temple by adding a “platform” on its eastern side, preceded by the courtyard with two rows of arches. Other site elements mentioned by Glueck were “numerous large, now filled-up cisterns and cave cisterns around the site”, as well as “remains of considerable settlement on the s.e. side of the *qasr*, and also on the n.e. side, where there are also the remains of the small reservoir”.

A short note on the site, called “Sareh (Kh. Sar)” by Lankester Harding lies in the archives of the Jordanian Department of Antiquities (vol. S: p. 20 [unpublished]). He mentioned only the “Kusr”, attributed by him to the “Late Bronze and Archaic Iron ages”, and “eight semi-circular arches (four on each side of a ruined building) ... obviously the handiwork of a later epoch, probably Roman and Byzantine”. The mention of eight(!) arches (while one can still see more today as said above) proves that Lankester Harding simply quoted information supplied by Conder years before him.

Finally, in 2000, the site (identified as Khirbat as-Sar, Site 210) was revisited by Chang-ho C. Ji of the La Sierra University, California, surveying the Iraq al-Amir and Wadi al-Kafrayn region (Ji 2000, unpublished report in the archives of the DOA). His report focused, again, on the “qasr” and courtyard east of it, but without any effort to understand the layout of the compound. He also mentioned “at least two to three

large building complexes on the eastern and southern areas of the site”, and identified the potsherds found on the

surface as pertaining to the Hellenistic–Roman, Byzantine, early Islamic and mid Islamic periods.

## SURVEY METHODOLOGY

The survey was conducted within the fenced area belonging to the Department of Antiquities, which covers 16,000 m<sup>2</sup> (it should be noted, however, that a part of the ancient site lies outside the fence). The aim of the survey was to:

- a) map visible architectural remains;
- b) test the area by means of non-invasive geophysical methods (electric resistivity);
- c) collect surface finds for the purpose of establishing a site occupation time range.

All features on the ground that could be identified with high probability as remains of walls were mapped with a Leica TCR 407 tacheometer, whereas the electric resistivity survey (see below, *Appendix 2*) revealed the presence of architectural features concealed under

the ground. The compound situated in the highest spot of the site constituted the focal point; it was composed of a square building, commonly described as a “qasr” or “Ammonite tower” [*Fig. 1*], and a courtyard with two rows of arches on the northern and southern sides [*Fig. 3*]. This architectural complex has been identified provisionally as a temple compound. Several walls were recognized and mapped in the other parts of the site, an especially dense concentration occurring in the southeastern and southern sectors. Combining data from the mapping and the electric resistivity prospection has given a more complete picture [*Fig. 2*]. It is to be noted, however, that there are several large and deep hollows in the ground, filled with stone blocks of different sizes, situated in the



Fig. 1. The “qasr” seen from the south (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)



Fig. 2. General plan of the site of Khirbat as-Sar: combined results of archaeological and electric resistivity surveys (PCMA UW Khirbat as-Sar Project/drawing M. Burdajewicz, M. Gostkowski and R. Ryndziejewicz)



Fig. 3. Arcaded courtyard looking east from the "qasr" (PCMA UW Khirbat as-Sar Project/photo M. Gostkowski)

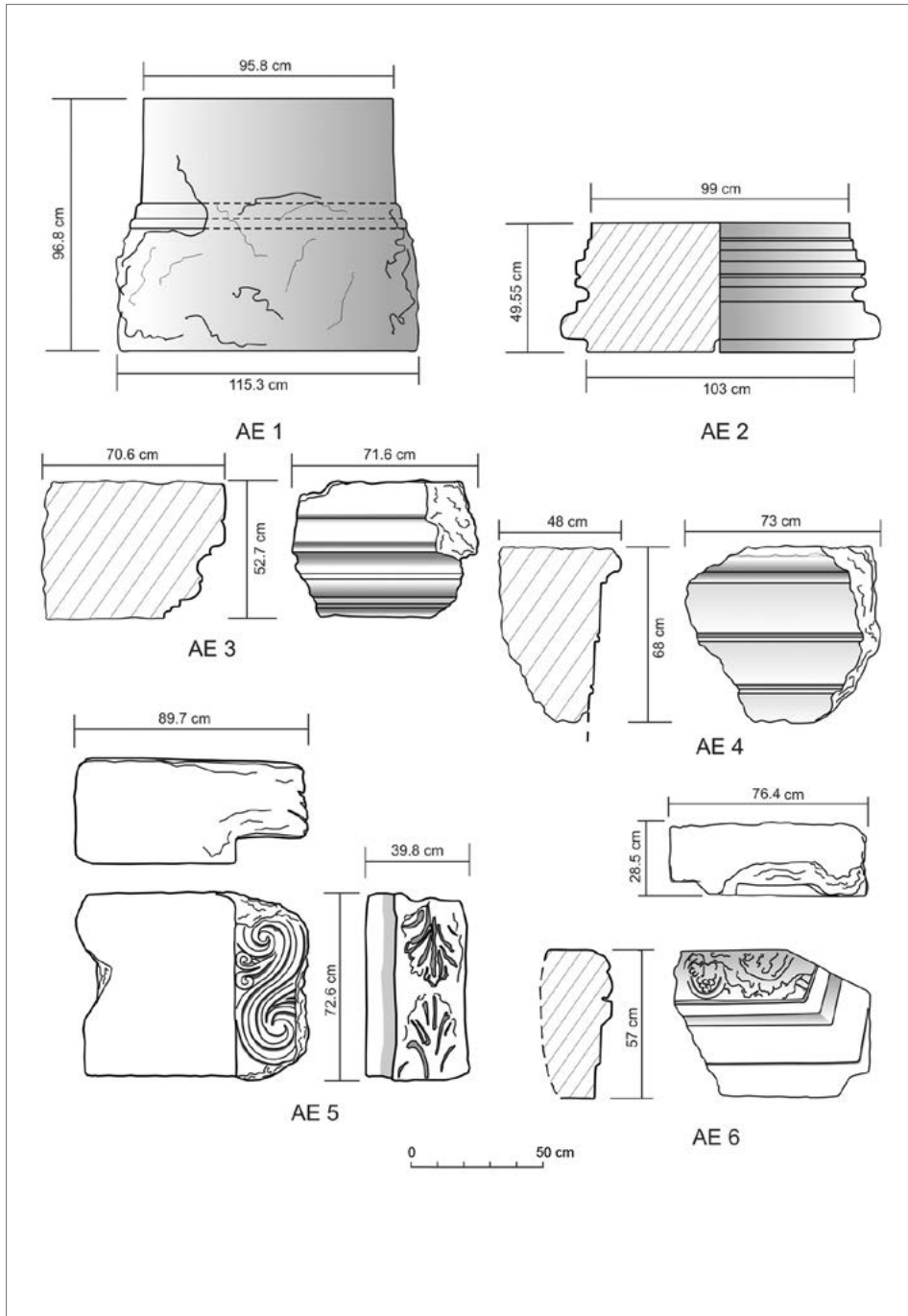


Fig. 4. Selected architectural fragments in limestone (PCMA UW Khirbat as-Sar Project/drawing and digitizing M. Burdajewicz)

eastern and southeastern parts of the site; these depressions appear as blank spots on the survey maps.

The data were subsequently compared with information from the past reports of Claude R. Conder, Howard C. Butler, Nelson Glueck, and Chang-ho C. Ji. Single elements of architectural decoration, pertaining mostly to the temple compound, were measured, drawn and photographed (for a selection, see *Fig. 4*). The surface collection of artifacts

followed a site division introduced in relation to the central structure (“temple compound”), specifically, areas east, southeast, south, west, and north of this complex. Most of the finds were pottery sherds (for a selection, see *Appendix 1*), but other items were noted as well: a few fragments of stone vessels, stone tools(?) and an iron “cake” of undetermined date, as well as a Late Roman bronze coin and pieces of painted wall plaster.

## RESULTS

The PCMA survey verified to a significant extent the data from earlier reports. The most important results refer to the layout of the temple compound (the “qasr” with its courtyard), of which the only, and, as it turned out, inexact plan published so far was that by Butler. In reality, the com-

pound consists of the “qasr”, a vestibule and courtyard with two side aisles sectioned off by rows of arcades. The “qasr” was square, built of semi-dressed blocks of flint conglomerate, from big to huge in size [*Fig. 5*]. Its dimensions as measured by the survey, 19.37 m (north–south)



Fig. 5. Interior of the “qasr” looking northeast (PCMA UW Khirbat as-Sar Project/photo M. Gostkowski)



Fig. 6. Fragment of column (AE 1 in Fig. 4) in the entrance to the “qasr”, view looking south (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)



Fig. 7. East wall of the vestibule looking north (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)



Fig. 8. Sunken area of the vestibule looking west (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)



by 19.34 m (east–west), corresponded to the measurements given by Glueck (20 m by 19.80 m) and Butler (19.50 m by 19 m), while differing substantially from those reported by Chang-ho C. Ji (16 m north–south by 17 m east–west). Two displaced column bases were found inside the “qasr” [see *Fig. 4:AE 2*] along with a monolithic base carved together with the column drum [*Fig. 6*; see *Fig. 4:AE 1*], standing perhaps *in situ* in the eastern entrance to the “qasr”. Unlike the walls of the “qasr”, these elements were made of limestone. It should be noted that more than one hundred years ago Butler saw, inside the building, as many as four large column bases “not *in situ*”, while Glueck mentioned only three.

The eastern side of the “qasr” is preceded by a vestibule (or *pronaos*). This feature was described by Glueck as a “platform” 6.80 m deep (from east to west), including its east wall, which is 1.80 m wide [*Fig. 7*]. According to survey measurements, the depth of the vestibule (that is, the space inside the parallel north–south walls) amounts to 4.50 m. The walls of the vestibule are constructed of mixed material: huge blocks of flint conglomerate completed with smaller dressed blocks of limestone. It was never noted before that the vestibule is sunk well below the floor level of the “qasr” [*Fig. 8*] and it is not possible to determine how the latter was accessed.

The most problematic part of the compound is the courtyard flanked by arcades on the north and south [*Fig. 9*], entirely built of limestone blocks, their faces bearing elaborate molding. This courtyard was mentioned in all the previous accounts of the site, none of

which was sufficiently precise. Conder reported “four arches in each row”, noting that their piers had been covered up with earth. Butler saw as many as seven arcades on each side of the courtyard, sketching their location on the plan of the compound, but without accurate dimensions. Judging by the third arcade in the southern row (counting from the east, *Fig. 10*), the one best exposed nowadays, the maximum width of an arcade is 1.80 m and not 1.60 m; the width/depth of the voussoir blocks (seven in each arcade) is 1.25 m (1.34–1.35 m at the molding) and not 1.15 m [*Fig. 10* top]. The arches rest on piers consisting of pairs of large dressed blocks.

Butler’s mention of “sarcophagi under the arches” does not seem to be reliable; indeed, the presence of sarcophagi was earlier noted by Conder, but with reference to an “enclosure” he had seen by the road and not to the arches which by then had been covered with earth up to the level of the piers (as they are today). Indeed, in Glueck’s report from 1937, the “sarcophagi under the arches which Butler saw” were not visible anymore.

As for the number of arches, Chang-ho C. Ji (2000) counted six arches on the south and five arches on the north of the courtyard. Our survey ascertained that originally there were seven arches in each row, as first noted by Butler. Today, the westernmost arcade in the northern row is missing, while the easternmost one apparently sank; in the southern row, the second arcade from the east is missing.

In Butler’s account, the information on the extent of the courtyard is misleading. He states that “toward the east the side walls of the building [by which he meant the “qasr”] are prolonged in ma-



Fig. 9. Arcades: top, northern row looking west; bottom, southern row looking west (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)

sonry of a wholly different character, to form a sort of courtyard, the east end of which is buried in soil and debris. These side walls are about two meters thick, are constructed of highly finished quadrated masonry, and contain a row of arcosolia". Indeed, in an accompanying drawing (Butler 1919: Fig. 21), the east–west walls close the rows of the arcades on their outer side. This seems to be Butler’s invention, hence it is no wonder that 30 years later Glueck could not see them and concluded that “since then, these walls have completely disappeared”.

The present survey definitely resolved the question of the layout of the courtyard. Two massive east–west walls were now recorded as the outer courtyard

walls on the outer side of each row of the arcades [Fig. 11 top left, see Fig. 2]. This design formed side aisles, of which the southern one was about 6 m wide,

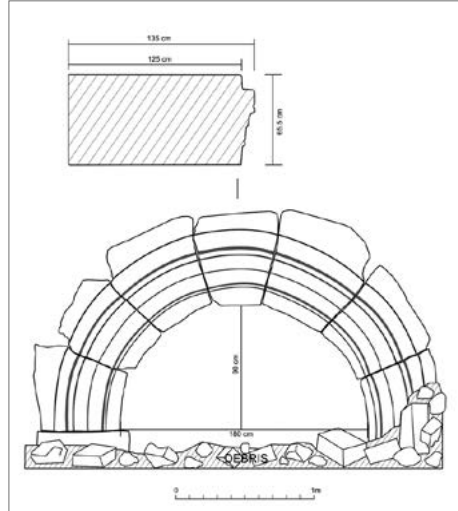


Fig. 10. Third arcade (counting from the east) in the southern row, looking southeast; top, view and section (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk, drawing and digitizing M. Burdajewicz)

and the northern one only about 5 m. These aisles, accessed from the courtyard through the arcades, must have been roofed, as attested by a fragment of roof-tile found by the southern aisle [Appendix 1: No. 18]. At their western end, the east–west walls turn at right angle to meet the outer corners of the “qasr” vestibule; this is particularly evident in the southwestern part of the compound [Fig. 11 bottom left]. At their opposite, eastern ends, the walls in question still feature well-defined corners, southeastern [Fig. 11 bottom right] and northeastern [Fig. 11 top right], of the “basilical courtyard”. The southeastern and northeastern corners of the “qasr” vestibule were also defined

[Fig. 12]. Measurements during the survey indicated that the “basilical courtyard” was planned as a perfect square, approximately 31.50 m to the side [see Fig. 2]; it was entered from the east, doubtlessly on the long axis of the compound. To reach the level of the vestibule from that of the courtyard (which in antiquity must have been about 3(?) m below the present-day ground level), there must have existed a stairway, as Glueck pointed out already, its location still visible today [Fig. 13].

The courtyard was built entirely of limestone, which was also the material used for the elements of architectural decoration. Butler mentions “fragments of column-drums, capitals and other de-



Fig. 11. Temple courtyard: top left, south wall looking northwest; top right, east wall near its northeastern end, looking northwest; bottom left, southwestern corner looking north; bottom right, southeastern corner looking north (PCMA UW Khirbat as-Sar Project/photos J. Młynarczyk)



Fig. 12. Temple vestibule: northeastern corner looking west (PCMA UW Khirbat as-Sar Project/  
photo J. Młynarczyk)



Fig. 13. Remains of a stairway from the level of the courtyard to the vestibule, view looking west  
(PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)

tails” without specifying their position on the site. After him, Glueck presumed that the entrance to the “qasr” “was probably under a massive entablature supported by limestone columns”; he mentioned also “column drums, voussoirs and other architectural elements ... both inside and outside the building”. Indeed, the PCMA survey recorded several architectural elements in various parts of the temple compound [for a selection, see *Fig. 4*]. However, the limestone used in Khirbat as-Sar seems to have been highly prone to weathering, which often rendered a proper identification of the architectural elements very difficult. Thus, while we have a few column bases and a part of a column drum associated with the “qasr” interior, the search for column capitals gave negative results with

one possible exception: a very weathered Corinthian capital(?) found upside down in the sunken vestibule to the “qasr” [*Fig. 15* top]. In the same spot there is a molded cornice block [*Fig. 15* bottom left, see *Fig. 4:AE 3*], probably coming from the monumental entrance to the “qasr” (either to the vestibule or the temple cella), and in the westernmost part of the courtyard, right in front of the vestibule, a long block which might belong to the framing of the monumental entrance to the vestibule [*Fig. 14*]. A decorated bracket [see *Fig. 4:AE 5*], found on the surface in the eastern part of the courtyard, must have supported a lintel of a very big doorway.

Single “rusticated” blocks with drafted margins and protruding central bosses can be seen in a few places of the ruined outer walls of the courtyard. This



*Fig. 14.* Door jamb(?) in front of the vestibule, looking northwest (PCMA UW Khirbat as-Sar Project/ photo J. Młynarczyk)



Fig. 15. Architectural elements: top, badly weathered Corinthian capital from a column in the sunken vestibule, view looking south; bottom left, fragment of a cornice (AE 3 in Fig. 4) and column (AE 1 in Fig. 4), view looking west; bottom right, displaced "rusticated" block (probably Hellenistic) found by the southeastern corner of the temple courtyard, view looking west (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)



Fig. 16. Remains of a north-south wall(?) added to the northern row of arcades in the courtyard, view looking west (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)



Fig. 17. Doorway preserved north of the courtyard, view looking north (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)





is a feature characteristic of Hellenistic masonry, especially of a defensive nature [Fig. 15 bottom right]. Since only a few examples have been noted, it should be assumed that such blocks come from an earlier (Hellenistic?!) architectural phase and were reused in the walls of the courtyard from the Roman period.

Walls mapped outside the “temple compound” cannot be interpreted prior to regular excavation. There is a doorway (1.00 m wide) north of the compound, apparently *in situ* [Fig. 17]; the same can be said of a north–south wall perpendicular to the third arch from the west, undoubtedly added at a later date [Fig. 16]. Of the remains of a “considerable settlement” mentioned by Glueck in 1937 the part southeast of the “qasr” [Fig. 18] was identified and mapped, while the section northeast of the “qasr” is probably already



Fig. 18. Fragments of undated walls: top, in the southern part of the site, view looking north; bottom, in the south/southeastern part of the site, view looking northeast (PCMA UW Khirbat as-Sar Project/ photos J. Młynarczyk)

outside the modern fence, either on cultivated land or even under modern buildings. The same applies to the “remains of the small reservoir” mentioned by Glueck and to the “Birkeh” of Conder’s account, as nothing corresponding to these features was recorded during the survey. Chang-ho C. Ji’s reported not being able

to see Glueck’s “small reservoir” anymore. Other site elements mentioned by Glueck and not located during the present survey are “numerous large, now filled-up cisterns and cave cisterns around the site”, including one assumed cistern inside the “qasr” proper, its mouth allegedly covered by a fallen column base.

## SITE CHRONOLOGY

To sum up the opinions of previous visitors to the site, which were based on the appearance of the architectural remains, it should be said that Conder assigned a general date in the Roman period, while Butler proposed a chronological sequence. He considered the square building to be “a structure of great antiquity, probably a shrine, which was renovated or restored by builders of the Roman period, by the introduction of classic columns and an entablature on the interior. The *arcosolia* are manifestly late, judging by the profile of their moldings, yet not Christian, if the absence of Christian symbols may be regarded as evidence”. Glueck developed this sequence in more detail, identifying the square structure as a fortress and dating it to the Iron Age (“EA I–II”). In his opinion, the “character of the ‘qasr’ was altered from that of a fortress to that of a temple (?)” in Roman times, which is when a “platform” (vestibule) and a courtyard with two parallel rows of *arcosolia* were constructed. Except for the architectural elements of limestone, which he rightly considered as being of Roman date, Glueck also mentioned numerous(!) Roman sherds, “as well as Byzantine and mediaeval Arabic sherds”. Probably it was the presence of the Byzantine sherds that led him to conclude that

the Roman temple(?) “may have been transformed into a church”. He also referred to a small quantity of worn Iron Age sherds and concluded that the very construction of the fortress points to its dating in the Iron Age I, continuing into Iron Age II.

Examination of the surface pottery collection (see below, *Appendix 1*) indicated an abundance of painted pottery types (mostly Mamluk, amounting to some 80%) in the eastern and southeastern areas of the site, with much fewer examples of medieval glazed wares, and extremely rare examples



Fig. 19. Pieces of wall plaster apparently of Roman date, found north of the “qasr” (PCMA UW Khirbat as-Sar Project/photo J. Młynarczyk)

of earlier pottery (Roman through Early Islamic). A different picture emerges with regard to the southern, western and northern areas, where Mamluk pottery sherds were definitely fewer, while Roman and Byzantine wares were prevalent. The area to the north of the “temple compound” yielded some small sherds of Hellenistic and early Roman date, as well as a few fragments of high quality wall plaster, both white and painted red, green and black, found outside the northern wall of the “qasr” [Fig. 19].

A small number of pottery sherds have been tentatively identified as pertaining to the Iron Age II (e.g., *Appendix 1: Nos 1–3*); this identification, however, will need further confirmation.

The analysis of the layout of the “temple compound” shows that it consisted of three distinct parts: a square “qasr” (probably the temple cella), a rectangular vestibule (*pronaos*) added to the “qasr”, and a courtyard designed as a perfect square. However, in view of the distance between the arches and the outer east–west walls of the compound differing in the southern and the northern aisle respectively, and the northern row of arcades being not exactly parallel to the southern one [see Fig. 3], it may be that the arcades were in-

serted into the courtyard at a later phase. There is no evidence coming from the survey to suggest a reuse of the compound as a church.

In general, the chronology of the site can be presented as follows:

- 1) Iron Age: the “qasr” and presumably some potsherds found on the surface (e.g., *Appendix: Nos 1–3*);
- 2) Persian period: no remains or artifacts were identified;
- 3) Hellenistic period: possibly “rusticated” blocks reused in the Roman structure, and some potsherds found on the surface (e.g., *Appendix 1: Nos 4–7*);
- 4) Roman period: extending the “qasr” to include a vestibule and square courtyard, with two rows of arcades added at a later period (pottery, e.g., *Appendix 1: Nos 12–13, 16–17*);
- 5) Late Roman/Byzantine and/or Umayyad to Abbasid(?) period: some changes and additions in the area north of the courtyard; many walls and potsherds all around the site (e.g., *Appendix 1: Nos 8–11, 14–15, 19–25*);
- 6) Medieval period: abundant pottery finds proving continued inhabitation during the Mamluk period (13th through early 16th century) (e.g., *Appendix 1: Nos 26–36*).

## SITE IDENTIFICATION

In terms of ancient topography, Khirbat as-Sar is situated in a region that can be identified as south Gilead, bordering on the land of Ammon. However, despite its apparent importance, the site remains anonymous. Merrill, who first recorded a visit to it, believed that it was located in the region of the Biblical Jazer. Conder

accepted this view, considering the site to be the same probably as Azor in the 4th century AD *Onomastikon* of Eusebius: s.v. Azōr (Iazer): “Boundary of the children of Ammon’ (border city of Ammon) which is called Philadelphia now. ... There is eight miles (about) from Philadelphia to a village Azer (Iazer) remaining to-

day”.<sup>1</sup> Other visitors to the site did not propose any specific identification; however, Glueck’s topographical description emphasized the natural strategic properties: “it nears the w. edge of the plateau overlooking the descent to the Jordan River valley ... it occupies the highest point in the vicinity and commands an excellent view over much of the surrounding country-side”. From this, it is clear that the site of Khirbat as-Sar must have been a station on the ancient road leading from the Jordan Valley via Wadi el-Kufrein (Kafrein) and Wadi Sir (Wadi el-Seer) to Rabbat Ammon (Amman). Therefore, we may propose a plausible identification of Khirbat as-Sar with “Birta of the Ammanitis”, mentioned in one of the letters in the Zeno archive (P. Cairo Zen. 1.59003, dated to 259 BC) in the context of Zeno’s business travel in the Transjordan (e.g., Gatier 2006). It has traditionally been believed that

this “Birta” (which means “fortress”) was, in fact, identical with Amman (Gatier 2006: 288). However, Amman appears in Zeno’s archive, as Rabbat Amon (*Rabbatamma*): letter PSI VI 616, dated to 258/256 BC). Neither can “Birta of the Ammanitis” be identical with Iraq el-Amir, because the latter was known in the Hellenistic period by the name of Tyros. Since for topographical reasons it is almost certain that Khirbat as-Sar was on the route of Zeno’s business trip in Transjordan, its identification with Birta of the Ammanitis (i.e., in the region of Amman) seems fairly acceptable. Yet the fact that the name of Birta would be current in the Hellenistic period does not preclude the identity of the site with the village of Azer (Iazer) mentioned by Eusebius a few centuries later. This issue may yet be clarified by the results of future excavations.

1 Translated by C. Umhau Wolf (1971), <http://www.tertullian.org/fathers#onomasticon> [accessed: 3.07.2018].

## APPENDIX 1

## SELECTED POTTERY FROM THE SURFACE SURVEY, 2018

[Figs 20:1–13; 21:14–18; 22:19–28; 23:29–36]

**a) Iron Age II(?)**

1 (E/9): rim of large bowl. Fabric yellowish beige with partial grayish core, small white and fewer larger pale grey and brown grits; pale red wash (self-slip?); many white eruptions. Iron Age II(?).

2 (E/10): rim of large bowl. The same fabric (and ware) as previous, the surface wash fired pale brown on exterior. Iron Age II(?).

3 (E/11): fragment of horizontal handle(?) of very large (cooking?) vessel. Fabric extremely hard, dark grey, abundant quartz(?) grits; surface (thin wash or self slip?) brownish grey to light brown. Iron Age II(?).

**b) Plain wares, Hellenistic and Roman**

4 (N/6): rim of table amphora(?). Fabric light brown with dark grey core and occasional white grit eruptions, pale brown wash. Hellenistic.

5 (N/10): rim of jug. Fabric light reddish brown, some fine white grits, pale brown wash (as that of N/6 [No. 4]). Hellenistic (Roman?).

6 (N/14): stem of goblet (incense burner?). Fabric hard, pale red, some tiny grits; smooth surface, fired pinkish beige. Hellenistic(?).

7 (N/15): rim of table amphora(?). Fabric pale pinkish beige, some voids and small white grits; surface porous, very pale brown. Hellenistic.

**c) Fine wares, Roman and Byzantine**

8 (E/8): rim of dish. Fabric hard baked pale red; slip orange-red, glossy. LRC form 3, 6th century AD.

9 (S/6): rim of dish/platter. Fabric pale orange/pink, with light brownish red self(?)slip. Roman (Byzantine?).

10 (N/9): rim of bowl. Fabric as that of S/6 (No. 9), light brownish red self(?) slip; upper exterior part fired yellowish beige, fine white grit eruptions. Roman (Byzantine?).

11 (N/8): rim of bowl/dish. Fabric yellowish pink, some small white grits and minute black ones (or voids?); slip brownish red and matt outside, light red and semi-glossy inside. Roman or Byzantine.

12 (N/12): rim of mug or cup, thin-walled with rouletting on the exterior. Fabric very hard light brown; slip very dark brown matt outside, reddish brown (with some gloss) inside. Early Roman.

13 (N/13): rim of bowl, grooved outside. Fabric as that of N/8 (see above, No. 11); slip light red, semi-glossy outside, matt inside. Roman or Byzantine.

**d) Cooking vessels: Roman and Byzantine**

14 (SE/2): rim of cooking pot. Fabric hard orange-beige, dark grey “skin” on exterior and orange inner surface. Byzantine?

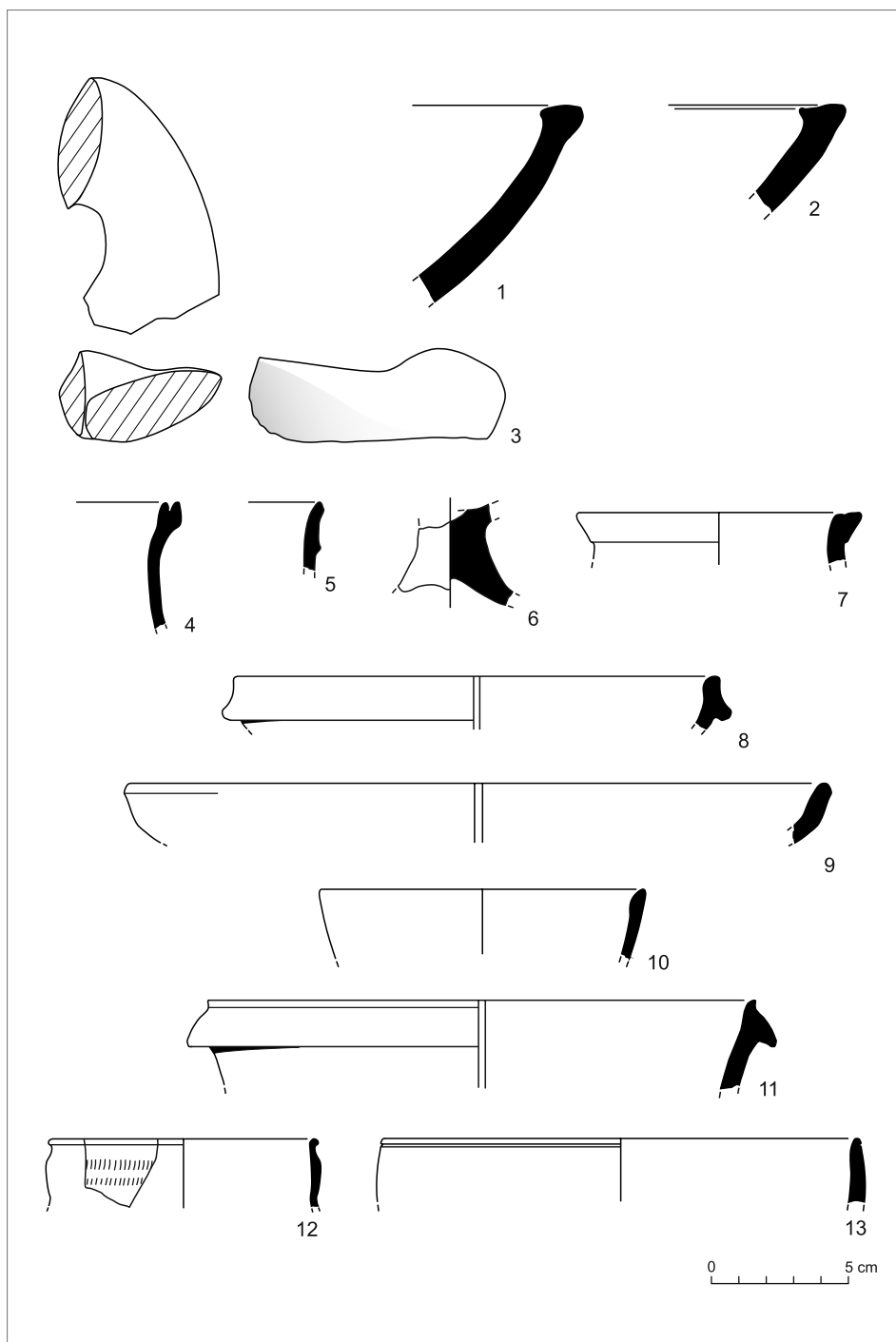


Fig. 20. Iron Age pottery (1–3); plain wares: Roman and Hellenistic (4–7), fine wares: Roman and Byzantine (8–13) (PCMA UW Khirbat as-Sar Project/drawing and digitizing M. Burdajewicz)

15 (N/4): handle and rim of cooking pot(?). Fabric very hard light orange, surface with reddish brown self-slip. Roman–Byzantine.

16 (N/7): rim of casserole (or of casserole lid). Fabric very porous dark reddish brown, some glossy particles and white grits. Roman period.

17 (N/11): rim of open(?) cooking pot. Fabric with “sandwich” firing (reddish brown outside to dark grey inside), fine white grits; surface “metallic” hard, fired reddish brown outside, brownish red inside. Roman period.

**e) Roof tile fragment**

18 Fragment of terracotta roof tile, found by the southern row of arcades in the courtyard.

**f) Late Roman/Byzantine to Umayyad(?)**

19 (E/6): rim of jar. Fabric very hard, light red with broad ash grey core; very pale brown thick wash. Late Roman–Byzantine.

20 (N/3): rim of jar. Fabric with “sandwich” section (pale orange to very pale brown); thin very pale brown wash on surface. Late Roman–Byzantine.

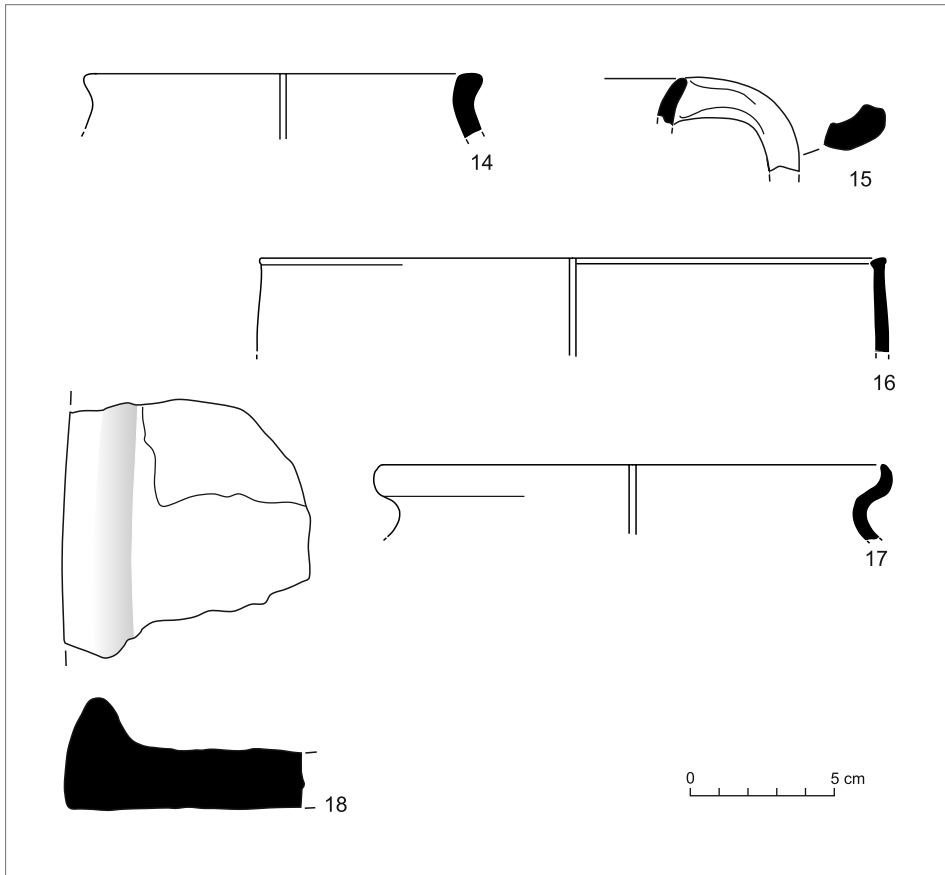


Fig. 21. Cooking vessels of Roman and Byzantine date (14–17); fragment of Roman roof tile (18) (PCMA UW Khirbat as-Sar Project/drawing and digitizing M. Burdajewicz)

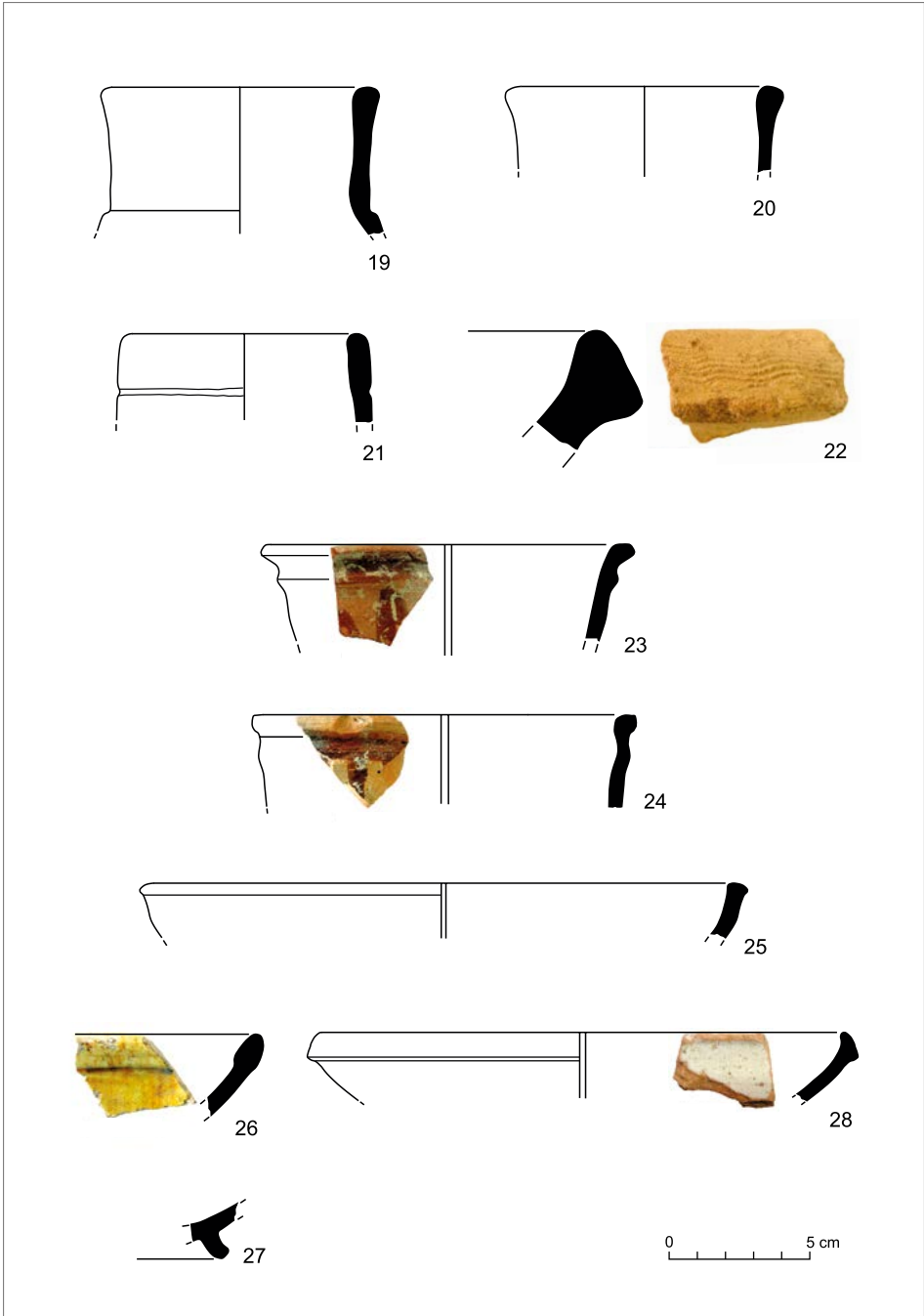


Fig. 22. Late Roman/Byzantine to Umayyad(?) (19–22); Umayyad (into Abbasid?) painted pottery (23–25); medieval glazed pottery (26–28) (PCMA UW Khirbat as-Sar Project/drawing and digitizing M. Burdajewicz)



21 (N/5): rim of jar. Fabric pale pink, dense, minute dark grey grits(?); whitish wash on exterior. Late Roman-Byzantine.

22 (N/2): rim of basin. Fabric dense, pinkish beige, rare small white eruptions; surface very pale brown outside, pale brown inside. Byzantine or Umayyad.

**g) Umayyad (into Abbasid?) painted pottery**

23 (N/1): rim of amphora or big jug. Fabric hard, pink, dark red ornaments against a pink surface.

24 (E/7): rim of amphora or big jug. Fabric as that of N/1 (No. 23); dark red ornaments against a light brown surface.

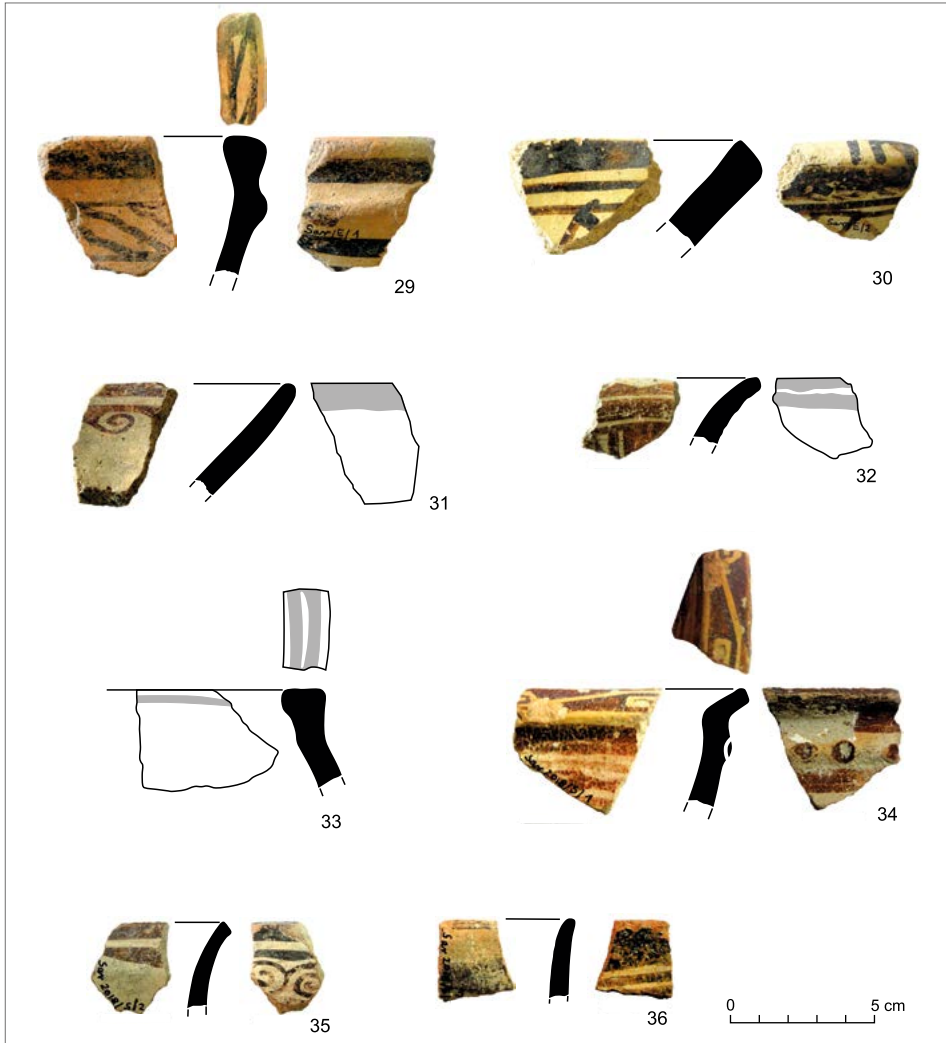


Fig. 23. Painted pottery (Mamluk) (29–36) (PCMA UW Khirbat as-Sar Project/drawing and digitizing M. Burdajewicz)

25 (SE/3): rim of bowl/dish(?). Fabric as that of N/1 (No. 23); pinkish white wash and a band of pale red paint outside.

### **h) Medieval glazed pottery**

26 (E/5): rim of bowl or plate. Fabric pale red, yellow glaze.

27 (S/4): base of bowl. Fabric hard orange-red with voids and some black grits; on the interior traces of dark green glaze against a milky white wash.

28 (S/5): rim of dish. Fabric hard pink, occasional small white grits; white wash on interior and rim; no remains of glaze preserved.

### **i) Painted pottery (Mamluk)**

29 (E/1): rim of deep bowl. Fabric very pale brown, porous; surface pink inside, very pale brown outside, ornament painted in dark brown; lightly burnished.

30 (E/2): rim of dish. Fabric very pale brown, porous; ornament in dark brown paint against a very pale brown surface, lightly burnished.

31 (E/3): rim of bowl. Fabric as that of E/2 (No. 30), with ornament in dark reddish brown, burnished.

32 (E/4): rim of bowl. Fabric as that of E/2 (No. 30), with ornament in orange-brown, burnished.

33 (SE/1): rim of crater(?). Fabric slightly porous, with "sandwich" section (grey inside, pink outside), some white and black grits; surface dark pink, burnished inside and on rim; black band painted on rim.

34 (S/1): rim of deep bowl. Fabric very pale brown, rather porous; surface very pale brown, ornament in dark red-brown and a row of circlets impressed outside; lightly burnished inside and on rim (Mamluk or perhaps Abbasid?).

35 (S/2): rim of bowl. Fabric as that of S/1 (No. 34); surface "white", very dark brown ornaments; burnished.

36 (S/3): rim of bowl. Fabric light red, gritty; surface pink to pale brown, lightly burnished; ornaments in very dark brown paint. [JM]

**APPENDIX 2**

**PRELIMINARY RESULTS OF THE GEOPHYSICAL SURVEY**

The geophysical survey at Khirbat as-Sar, undertaken on 10–28 March 2018, concentrated on procuring data for a study of the site layout and the location of remains of stone architecture where they were not visible on the ground surface. The results will be instrumental in planning future excavations.

The resistivity method employed in this case has as its general assumption the observation of changes of the electrical field, generated in the ground, by a system of electrodes (Herbich 2011). In archaeological research, the method is useful for non-invasive location of features characterized by electrical resistance different from that of the surrounding ground [Fig. 24]; it is used in the investigation of sites where buildings and other architectural remains are expected (Schmidt et al. 2015: 68). Features visible on the ground surface implicate the possibility of more features being revealed underground. The conditions at the site

make other geophysical methods, widely used in archaeological research (like GPR or magnetometry), practically impossible to apply owing to the extensive stone debris lying on the surface. Indeed, the accumulation of stone debris was such in some places (mainly the southeastern corner), that even this method could not be applied.

**METHOD**

The measurements were taken with an Elmes ADA-05 R resistivity meter. The survey was carried out in profiling mode, using a twin-probe array with traversing probes AM=1.0 m apart, and remote probes BN=6.0 m apart. This probe configuration allowed changes of apparent resistivity to be observed to a depth of approximately 1.50 m, but without the possibility of differentiating the depth of particular structures recorded within a prospected layer. Measurements were collected in 20 m by 20 m grids, at one-

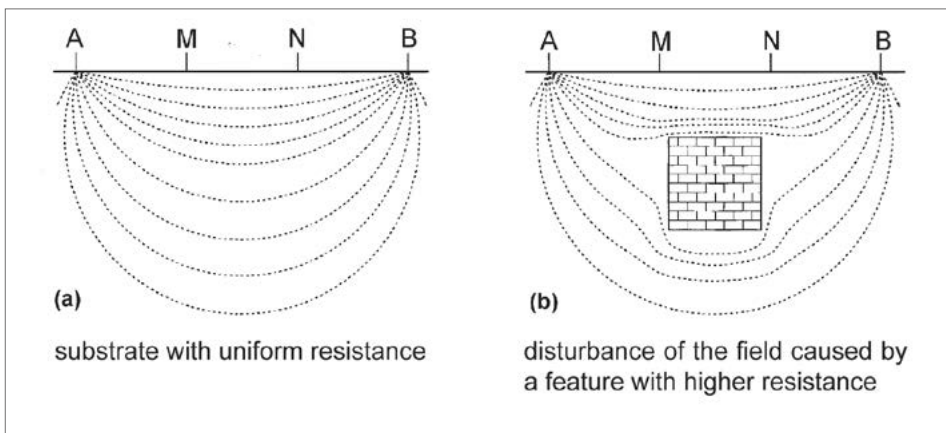


Fig. 24. Model of the distribution of the electric field in the ground (After Herbich 2011: Fig. 1)

meter intervals, along lines (traverses) one meter apart. The survey results are presented as maps of changes in ground resistivity values. The data were processed and analyzed with Surfer 8.0 software, producing gray-tone maps. The geophysical maps were first integrated with other data categories (satellite imagery, results of topographical survey) using a GIS environment and then interpreted.

**RESULTS**

The area surveyed, approximately 0.86 ha, comprised the surroundings of the temple compound (“qasr”) and was extended to available areas south and east of the “qasr”. The survey was divided into three separate areas, marked A, B and C, each covered with a grid network to facilitate the identification of anomalies (with let-

ters in rows and digits in columns, e.g., A1, C3 etc.) [Figs 25–26].

Area A [Fig. 26:a] is located in the southwestern part of the site. The resistivity map of this area shows numerous distinct linear high-resistivity anomalies, running parallel and perpendicular to one another. A clear and detailed image of rectangular anomalies, visible in B2 and C2, corresponds to the remains of walls on the surface and to structures concealed under the debris. The eastern edge of B2 and the northeastern corner of C4 could not be surveyed due to the large amount of debris and the surface relief. A large, rectangular anomaly (approximately 19 m by 15 m), aligned roughly southeast–northwest and recorded in B1 and the western part of B2, may reflect a large structure, partly visible on the



Fig. 25. Location of surveyed areas (PCMA UW Khirbat as-Sar Project/processing R. Ryndziewicz, satellite imaging Google Earth)

surface as a network of ridges. A linear anomaly in C1 and two parallel linear anomalies in C2 may be connected with this structure; it probably reflects a mas-

sive wall. The anomalies recorded in C3 and C4 reflect the remains of walls visible on the surface, complemented by data on structures underground. A low resistivity area visible in squares A3, A4, B3 and B4 is connected with a small mound devoid of stones rising above the surface. In square B4, the survey recorded a large linear anomaly, probably reflecting a large wall that was not to be seen on the ground.

Area B [Fig. 26:b] is located in the northeastern part of the site, east of the “qasr” and the two rows of arches. The area comprised a slope falling to the northeast and a small hill located on the eastern edge of the site. The resistivity map of this area shows numerous structures invisible on the surface. A linear anomaly in C1 is located along the same line as the southern row of arcades and probably reflects a structure connected with this row. The resistivity response in the northwestern part of area B, located on the higher part of the slope, reflects regular rectangular structures, although the image of this part is interrupted by an overabundance of stone debris. The anomalies recorded in the central part of the area (B2 and B3) have no equivalent on the surface and reflect regular structures, which can be interpreted as wall remains. A high-resistance area in the southern part of C3 corresponds to the remains of walls and stone debris on the surface.

Area C [Fig. 26:c] is located in the northwestern part of the site and adjoins the north and west walls of the “qasr”. The resistivity map of this area shows numerous structures aligned with the “qasr”. The anomalies registered in A3 may represent

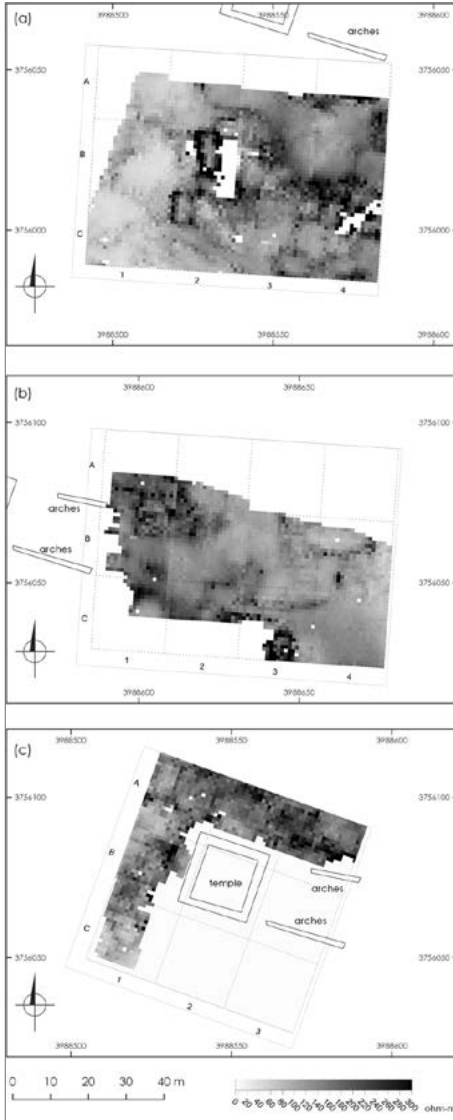


Fig. 26. Resistivity maps of the site. Grayscale plot – 0–300 ohm-m: a – Area A; b – Area B; c – Area C. Coordinate system: WGS84/Pseudo Mercator (PCMA UW Khirbat as-Sar Project/processing R. Ryndziejewicz)

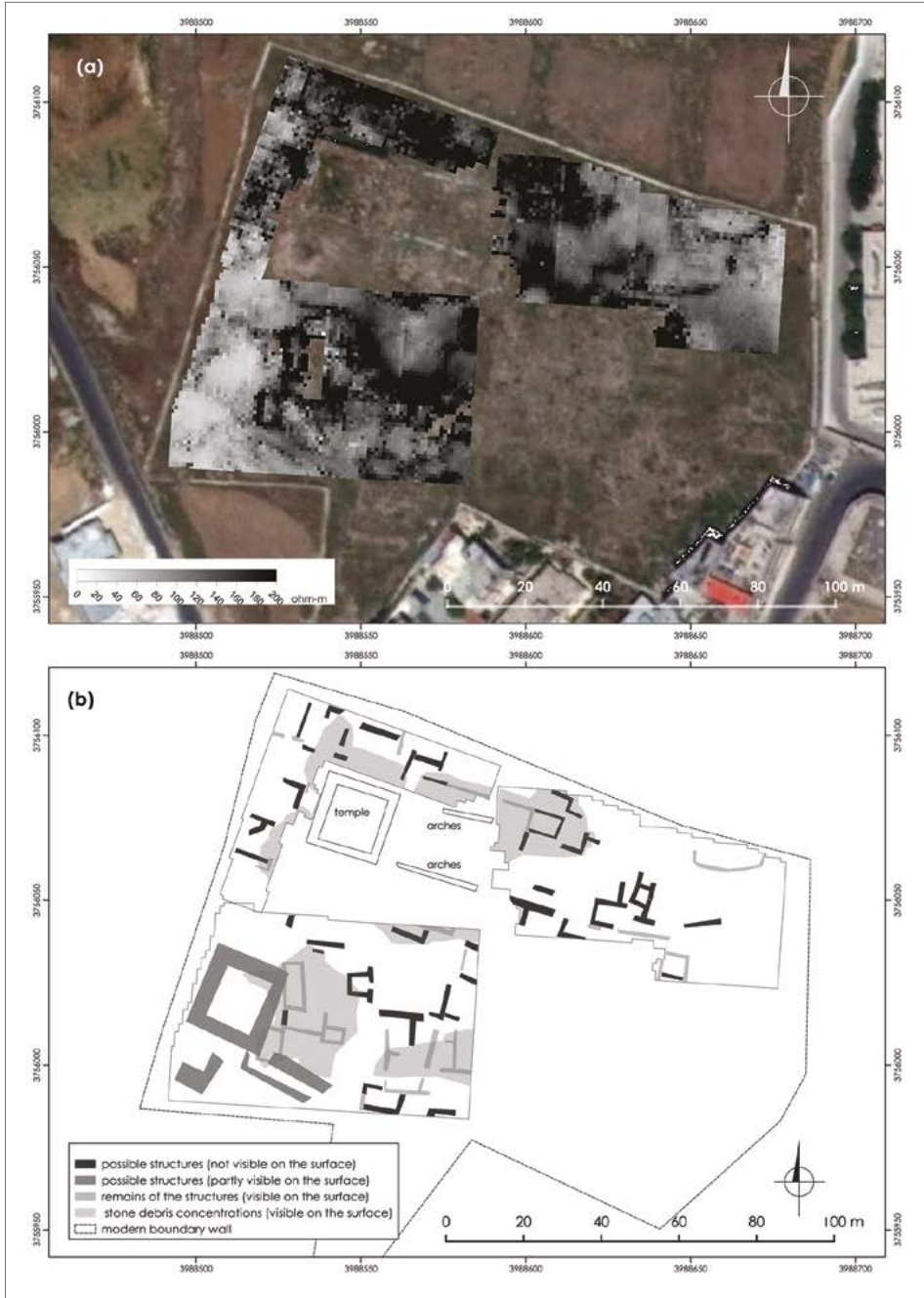


Fig. 27. Resistivity map of the site superimposed on a satellite map. Grayscale plot – 0–200 ohm-m; below, archaeological interpretation of the result. Coordinate system: WGS84/Pseudo Mercator (PCMA UW Khirbat as-Sar Project/processing R. Ryndziewicz, satellite imaging Google Earth)

a structure parallel to the northern row of arcades. Some anomalies recorded in A<sub>1</sub>–C<sub>1</sub> could reflect the remains of walls.

### CONCLUSIONS

The result of the geophysical survey [Fig. 27:a] provided data on the overall layout of the site, complementing observations of the remains on the surface with images of numerous structures concealed underground. Numerous high-resistance linear anomalies can be interpreted as a reflection of building remains. Structures surrounding the temple compound follow the same alignment as the temple. South of the temple, the walls have a more “random” orientation; they may

be associated with a different phase of site occupation. A large regular anomaly recorded in the southwestern part of the site may be interpreted as the remains of an unknown big structure or part of an enclosure wall. This interpretation [Fig. 27:b] is based both on the shape and values amplitude of the anomalies and a comparison with structures still to be seen on the surface. Integration of geophysical data with a detailed mapping of structures preserved aboveground has yielded a comprehensive site plan [see above, Fig. 2]. The archaeological interpretation of the results should be verified by testing to determine the kind of structure and its alignment. [RR]

### APPENDIX 3

## PETROGRAPHIC ANALYSIS OF THREE SAMPLES OF PAINTED PLASTER

Several fragments of painted plaster were found on the surface during a survey conducted at the site of Khirbat as-Sar (Sara). The fragments were scattered over an area of about 4 m<sup>2</sup>. Three samples were collected for preliminary petrographic examination (KHS 001, KHS 002, KHS 003) [Fig. 28].

All samples consist of a single layer of plaster; no remains of preparatory mortar have been noted. The plasters appear to have been spread evenly, as they measure 7–9 mm. The samples are compact and hard. The sections of samples KHS 001 and KHS 002 show very fine, densely packed aggregates which can hardly be discerned with the naked eye [see Fig. 28]. Sporadic larger mineral inclusions and

small pores appear throughout the section. Sample KHS 001 is covered with opaque dark red paint, whereas sample KHS 002 is painted black. In both cases, the paint is applied evenly and thickly, its surface is matt, but smooth. The paint is in good condition, shows no powdering.

Sample KHS 003 is slightly different. Its section contains gray, beige, and dark brown stone-like grains the size of which ranges from a fraction of a millimeter to 3 mm [see Fig. 28]. The plaster surface is not as smooth as in the two former cases. The fragment of a red design painted against white background seems abraded, although the remains of the paint suggest that it was once thickly applied.

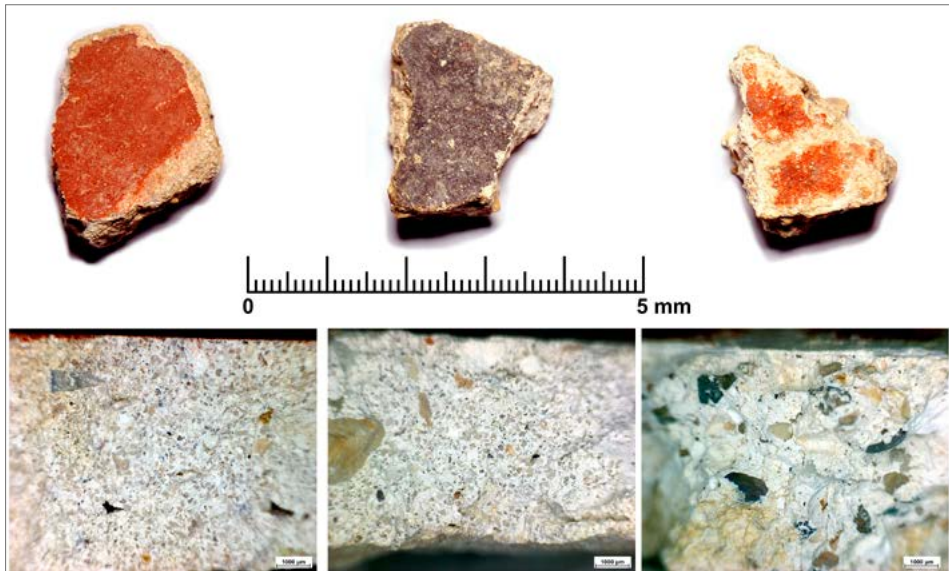


Fig. 28. Three fragments of plaster and corresponding photographs of their sections taken under a portable digital microscope (TPL 1,3MPix 1x-40x/200x) connected to a laptop computer. From left to right: sample KHS 001, KHS 002, KHS 003 (Photos J. Burdajewicz)



Examination of petrographic thin sections revealed that calcium carbonate acts as a binder of all three samples (61.5% by volume in sample KHS 001, 58% in sample KHS 002, and 63% in sample KHS 003)

[Fig. 29].<sup>2</sup> The micrite matrix is heterogeneous, showing distinctive clusters of micrite and aggregates of sparite, possibly from incomplete calcination of the limestone rock in lime kiln. The matrix

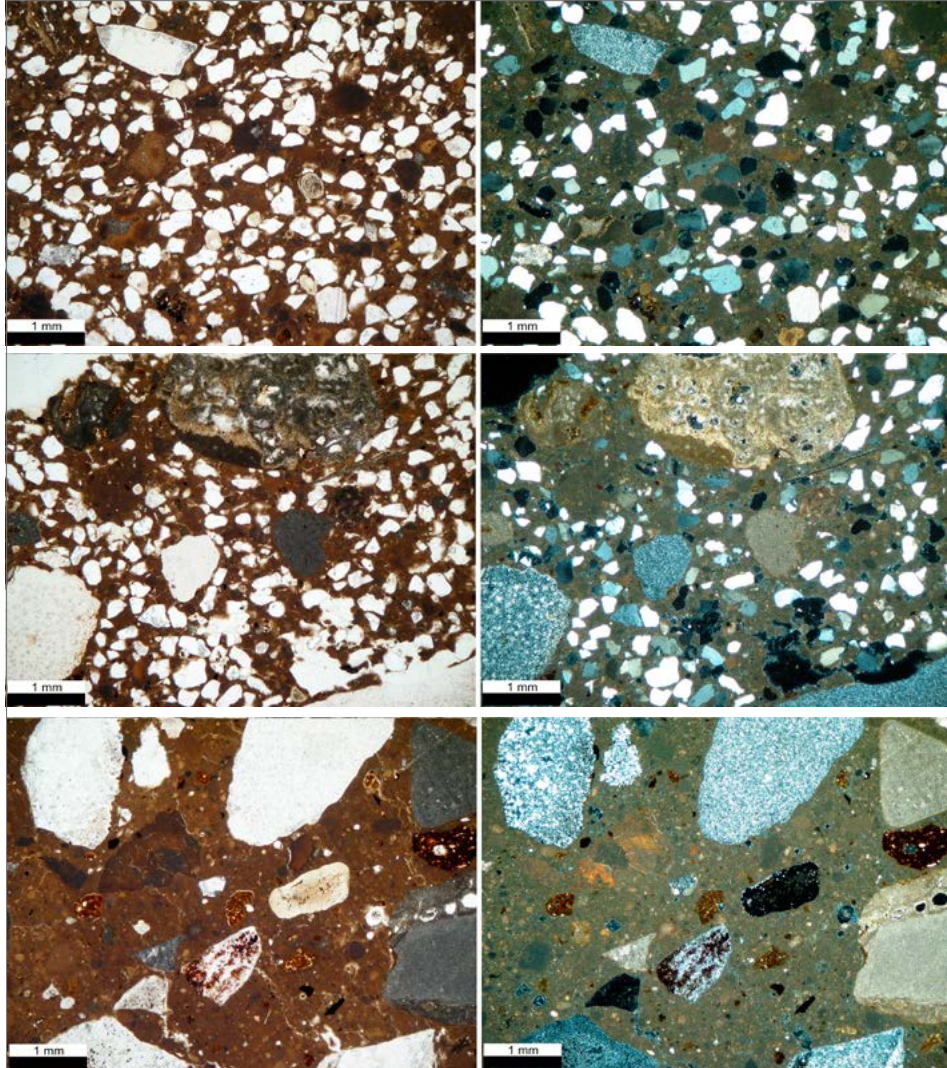


Fig. 29. Microphotographs of samples, from top, KHS 001, KHS 002 and KHS 003, viewed under one polarizer (left) and two crossed polarizes (right) (Photos W. Bartz)

2 The analyses were handled by Laboratorium Konserwacji Sylwia Svorová Pawelkovicz. Examination and interpretation of petrographic thin sections was carried out by Dr. Wojciech Bartz (Institute of Geological Sciences, University of Wrocław).

of samples KHS 001 and KHS 002 has some microcracks.

There is a noticeable difference in composition of fillers used in plasters represented by samples KHS 001 and KHS 002 on the one hand, and sample KHS 003 on the other. The principal kind of filler in the former pair of samples is quartz (29.5% in KHS 001 and 22.5% in KHS 002). The grain size of quartz is very uniform as it fits within the 0.4–0.5 mm range [see *Fig. 29* top and center]. Most of the grains are monocrystalline; polycrystalline specimens consisting of two or three crystals are seldom seen. The grains are almost spherical, rarely slightly elongated; they are generally subrounded and rounded, rarely angular and subangular.

The second type of filler which occurs in samples KHS 001 and KHS 002 are rock fragments (7.5% for KHS 001 and 18.5% for KHS 002). They are represented by silica rocks (chalcedony) or microcrystalline gypsum rock, micro-sparite or oosparite limestone, as well as orange-brown claystone. The grain size is not uniform as it ranges from 0.5 mm (most typical for the claystone particles) up to 1.5 mm (observed in the case of limestone). The particles, except for the claystone which has rounded grains, tend to be angular and subangular. Occasionally, small fragments of foraminifera may be seen. The samples contain also some accessory amount of fine charcoal particles (up to 0.2 mm) in the form of needles, which may have come from the combustion processes in the lime kiln. The very similar composition of samples KHS 001 and KHS 002 suggests that they are contemporaneous and come from one structure.

Sample KHS 003 differs from the first two samples described primarily because it lacks quartz [see *Fig. 29* bottom]. The only type of filler used in this render are rock fragments (36%). They comprise the same types of rocks as in the case of the two former samples: there are fragments of silica rocks (chalcedony) or gypsum rock, micro-sparite limestone with ooids, as well as numerous orange-brown particles of what appears to be claystone. As already noted during the macroscopic examination, the sizes of these aggregates vary. The largest are the fragments of silica or gypsum rock (1–2 mm), followed by limestone fragments (approx. 1 mm), and claystone particles (approx. 0.5 mm). The latter aggregate has rounded grains, whereas the former two tend to be angular.

## Discussion

While to draw conclusions on the basis of a preliminary analysis of three samples of plaster is far-fetched, a few observations are forthcoming that could be of interest for an interpretation of the survey results as they may be indicative of the period of execution of the plasters.

Firstly, all samples are characterized by a relatively high participation of filler (roughly 40%), a feature characteristic of Roman-period renders. Vitruvius recommends even three parts of sand to one part of lime in case of quarried sand, and two parts of sand to one part of lime in case of riverbed or beach sand (Vitr. II.5.1). However, these proportions could be applied only in the case of a high-quality slaked lime and archaeometric studies tend to demonstrate that the participation of fillers was usually somewhat lower. The preparatory mortars and painted

plasters from the Roman sanctuary at Chhîm (Lebanon) contained 40–60% of fillers (Burdajewicz forthcoming), while samples of mortars and painted plasters from various Roman structures in Caesarea Maritima (Hippodrome, Vault 8 of the warehouse, Roman villa) were closer to Vitruvius' guidelines as they showed filler content between 50% and 75% (Linn 1996: 36–48).<sup>3</sup>

These results stand in contrast with mortars and plasters from late antiquity which tend to have very little filler. Plasters from the early Christian basilica at Chhîm contained 27–32% of fillers (Burdajewicz forthcoming); samples of mortars and painted plasters from various late antique structures in Caesarea Maritima (bath-house, Vault 9 and 11 of the warehouse, area KK) contained very little or no aggregates (Linn 1996: 49–54); similarly, plasters from an early Christian church at Hippos-Sussita showed no evidence of mineral filler except for one sample, which contained 10% of mineral aggregates (Michniewicz and Michalska-Nawrocka 2005: 83, 91).

Secondly, the presence of two types of aggregates (quartz and rock fragments) in samples KHS 001 and KHS 002 suggests that the craftsmen preparing them probably followed some pre-established guidelines, since the type of aggregates, alongside their amount, influences the properties of the render (Pavía and Toomey 2008; Scannell, Lawrence, and Walker 2014; Stefanidou, Papayianni, and Pachtá 2012). Alternatively, it is also pos-

sible that quartz was not easily available in the area and craftsmen preparing the render represented by KHS 001 and KHS 002 saved it by adding some rock fragments. The lack of quartz in sample KHS 003 could support the idea that quartz was not readily available. Nevertheless, further investigations on the source of the mineral aggregates are necessary for such determinations.

The third observation concerns the fraction of quartz which fits within a 0.4–0.5 mm range. Such a uniform grain size may suggest that this aggregate was sifted. This, again, suggests careful preparation of the material, a characteristic feature of many Roman-period mortars and plasters, which accounts for their high quality and durability. For example, the uniformity of grain sizes is one of the factors that decreases the porosity of a mortar and increases its strength (Gutman et al. 2016: 305–307; Stefanidou 2016). If the aggregates are uniform in grain size, they will mix well with the binder, will be well-packed in the mortar and will increase its strength. Meanwhile, aggregates of varying sizes will not be as evenly distributed and tightly arranged inside the mortar, which, as a result, will be more porous and prone to mechanical damage. Despite some addition of rock fragments of varying size, samples KHS 001 and KHS 002 appear to be very firm and compact.

Lastly, the good condition of the paint layer preserved on samples KHS 001 and KHS 002 is suggestive of fresco painting,

3 Most archaeometric studies of Roman and late antique wall painting from the Roman provinces of *Syria*, *Palaestina*, and *Arabia* focus unfortunately on the qualitative composition of the renders and omit the question of the binder–aggregate ratio, hence there is little comparative material.

the most common painting technique in the Roman period.<sup>4</sup> This technique produces wall paintings characterized by durability and permanence of colors because the pigments become sealed under a surface veil of calcium carbonate.

As noted above, sample KHS 003 has a somewhat simpler composition than the other two samples as it lacks quartz. Furthermore, the paint layer preserved on this sample is abraded and appears of overall poorer quality than the paint on KHS 001 and KHS 002. Nevertheless, these differences do not necessarily indicate a different time of execution. They could be explained by the expertise of

another team of craftsmen or a different (and likely, less prominent) function of the building in which the painting was executed.

To sum up, the three investigated fragments betray characteristics of a Roman-period workshop. Furthermore, the level of the workmanship appears decent, especially in the case of samples KHS 001 and KHS 002. Should further fragments of wall paintings be recovered, especially if they are found in connection to a particular building, it would be worthwhile to extend the technical investigations to a greater number of samples and include an analysis of the paint layers. [JB]

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4 In the *fresco* technique, dry pigments are mixed with water and applied to damp (fresh) lime-based plaster. Calcium carbonate, which forms from calcium hydroxide ( $\text{Ca}(\text{OH})_2$ ) from the plaster during the carbonation process, fixes the pigments to the support and renders the paint layers permanent and insoluble.

## References

### Abbreviations

- Vitr. Vitruvius, *The ten books on architecture*, transl. by M.H. Morgan. New York: Dover Publications, 1914
- Burdajewicz, J. (forthcoming). Same site, different times: comparison of technique of execution of wall paintings from a Roman temple and an Early Christian basilica in Chhim, Lebanon. In P. Tomassini (ed.), *La peinture murale antique : méthodes et apports d'une approche technique. Actes de la journée d'étude organisée par le Centre d'Etude des Mondes Antiques et le Centro Studi Pittura Romana Ostiense, Louvain-la-Neuve, 21 avril 2017*
- Butler, H.C. (1919). *Syria: Publications of the Princeton University archaeological expeditions to Syria in 1904–5 and 1909. Division II: Architecture, Section A: Southern Syria*. Leiden: E.J. Brill
- Conder, C.R. (1889). *The survey of eastern Palestine*. London: Committee of the Palestine Exploration Fund
- Gatier, P.-L. (2006). Zénon de Caunos à Beth-Phogôr (P. Lond. VII 1930). *Topoi*, 14(1), 287–289
- Glueck, N. (1939). *Explorations in Eastern Palestine III* [=Annual of the American Schools of Oriental Research 18–19]. New Haven, CT: American Schools of Oriental Research
- Gutman, M., Zupanek, B., Kikelj, M.L., and Kramar, S. (2016). Wall paintings from the Roman Emona (Ljubljana, Slovenia): characterization of mortar layers and pigments. *Archaeometry*, 58(2), 297–314
- Herbich, T. (2011). Metoda elektrooporowa w badaniach archeologicznych [Electrical resistivity method in archaeological research]. In J. Jasiewicz (ed.), *Metody geoinformacyjne w badaniach archeologicznych: VI Sympozjum Archeologii Środowiskowej, Poznań – Ostrów Lednicki, 19–21 maja 2011 r.* (pp. 37–41). Poznań: Bogucki Wydawnictwo Naukowe [in Polish]
- Ji, Chang-ho C. (2000). *The survey in the regions of Iraq al-Amir and the Wadi al-Kafrayn, 2000*. Unpubl. report submitted to the Department of Antiquities of Jordan
- Linn, R. (1996). *Scientific investigation of the Roman and early Byzantine wall paintings of Caesarea, Israel* (unpubl. MA thesis). University of London
- Merrill, S. (1881). *East of the Jordan: A record of travel and observation in the countries of Moab, Gilead and Bashan*. New York: Charles Scribner's Sons
- Michniewicz, J. and Michalska-Nawrocka, D. (2005). Petrography of the plasters from Hippos. In A. Segal, J. Młynarczyk, M. Burdajewicz, M. Schuler, and M. Eisenberg, *Hippos-Sussita: Sixth season of excavations (July 2005)* (pp. 82–91). Haifa: Zinman Institute of Archaeology, University of Haifa
- Pavía, S. and Toomey, B. (2008). Influence of the aggregate quality on the physical properties of natural feebly-hydraulic lime mortars. *Materials and Structures*, 41(3), 559–569

- Scannell, S., Lawrence, M., and Walker, P. (2014). Impact of aggregate type on air lime mortar properties. *Energy Procedia*, 62, 81–90
- Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C.F., Sarris, A., and Fassbinder, J. (2015). *EAC guidelines for the use of geophysics in archaeology: Questions to ask and points to consider*. Namur: Europae Archaeologia Consilium
- Stefanidou, M. (2016). Crushed and river-origin sands used as aggregates in repair mortars. *Geosciences*, 6(2), 23. <https://doi.org/10.3390/geosciences6020023>
- Stefanidou, M., Papayianni, I., and Pacht, V. (2012). Evaluation of inclusions in mortars of different historical periods from Greek monuments. *Archaeometry*, 54(4), 737–751