

The late antique quarry of al-Jumayil: preliminary observations

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Abstract On-going research at the site of al-Jumayil (Jordan) has allowed for the identification and documentation of an extensive limestone quarry, which served as an extraction source of building material for the settlement dwellings and other fabric being excavated. The quarry contains important evidence of technological know-how, especially extraction methods and preparation such as splitting, drilling, levering, chiseling and dressing. In particular, unfinished blocks and roof slabs that had been worked but not extracted are still *in situ* and match those identified in the church fabric and in other buildings of the site. The quarry was subsequently turned to a water cistern, a change of use that offers a prime example of resource optimization and pragmatism.

Keywords quarries, extraction techniques, al-Jumayil, Late Antiquity, Arabia

Introduction

In *De Aedificiis*, which documents the building activity of the Byzantine emperor Justinian in the 6th century, Procopius of Caesarea recounts a miraculous event that took place prior to the building of the *Nea Ekklesia* in Jerusalem; he states that: “God revealed a natural supply of stone perfectly suited to this purpose in the nearby hills, one which had either lain there in concealment previously, or was created at that moment. Either explanation is credible to those who trace the cause of it to God” (Proc. aed. 5, 6, 19–20)¹. Indeed, provision of adequate quantities of building material was necessary to supply the increasing demand of imperial, lay, and ecclesiastic founders across the Empire and particularly in the Levant². Procopius’s annotations in *De Aedificiis* reflect a process of economic development of the region during the time of

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- 1 Procopius also describes the stone quarrying: “So they cut out blocks of unusual size from the hills which rise to the sky in the region before the city, and after dressing them carefully they brought them to the site in the following manner. They built waggons to match the size of the stones, placed a single block on each of them, and had each waggon with its stone drawn by forty oxen which had been selected by the emperor for their strength” (Proc. aed. 5, 6, 11–13 [English translation by Dewing 1914]). See also Dell’Osso 2018, 295–297.
 - 2 An outstanding number of building projects is attested in Greek inscriptions, especially in the countryside in the second half of the 6th century: Di Segni 1999, 162; Hamarneh 2022, 88.

Justinian, and its continuation is supported by epigraphic, textual, and archaeological evidence, testifying to an intensification of building activity from the second half of the 6th century to the 8th century³.

Admittedly, the provision of building material was part of a complex planning system: sites capable of supplying the needed quantities of stone had to be identified in the environs in order to reduce transport costs from the extraction areas to the building locations. Due to the scarcity of timber, mortared stone masonry was the foundation of most construction techniques in the South Levant in Late Antiquity⁴, as buildings still standing at several sites testify. Geologically speaking, it is worth noting that the regional landscape is characterized by layered, raised old marine deposits or by low magmatic ones, each with different levels of hardness⁵. As such, the most common and wide spread type of quarries in the region is open cast, often sought out in the immediate vicinity of urban and rural centers to facilitate stone extraction, loading, and transport⁶. Following stone extraction, quarries found a secondary use as locations for wine or olive presses, and more commonly as open cisterns when provided with an efficient system of channels, basins and openings that guaranteed rain and run-off water harvesting. Such measures not only reveal a pragmatic approach, but also suggest striking territorial and resource management planning⁷.

Tracing the archaeological evidence of the on-going FWF-funded research project “Rethinking Periphery in Late Antique Arabia”⁸, the survey of the rural settlement of al-Jumayil and its surrounding areas provided a unique opportunity to document an extensive stone quarry that supplied building material for the double church (currently under excavation) and was later transformed into a cistern.

The site of al-Jumayil

The village of al-Jumayil is located on the southern limit of the former Byzantine diocese of Madaba, a few kilometers southwest of the World Heritage site of Umm er-Rasas (fig. 1). The rural settlement displays well-preserved buildings and traces of intensive ancient agriculture, in addition to burials, caves, cisterns and quarries on the external edges of the settlement. The densely inhabited landscape develops according to the geological features of the site: a central hill with a relatively steep rocky slope

3 Di Segni 2017, 297.

4 Such buildings were proved to be solid and earthquake-resistant as several structures are still standing.

5 Rock hardness determined which types of stones were used in which building parts: limestone from layered deposits appears as roof-slabs and arch stone, while harder sedimentary rocks such as chert were implemented in walls.

6 See the documented cases in the area of Jerash: Abu-Jaber et al. 2009, 67–75; Hamarneh – Abu-Jaber 2012.

7 See examples in: Arce 2014, 387.

8 This research project is funded by a grant from the Austrian Science Fund (FWF), project number P 35326.

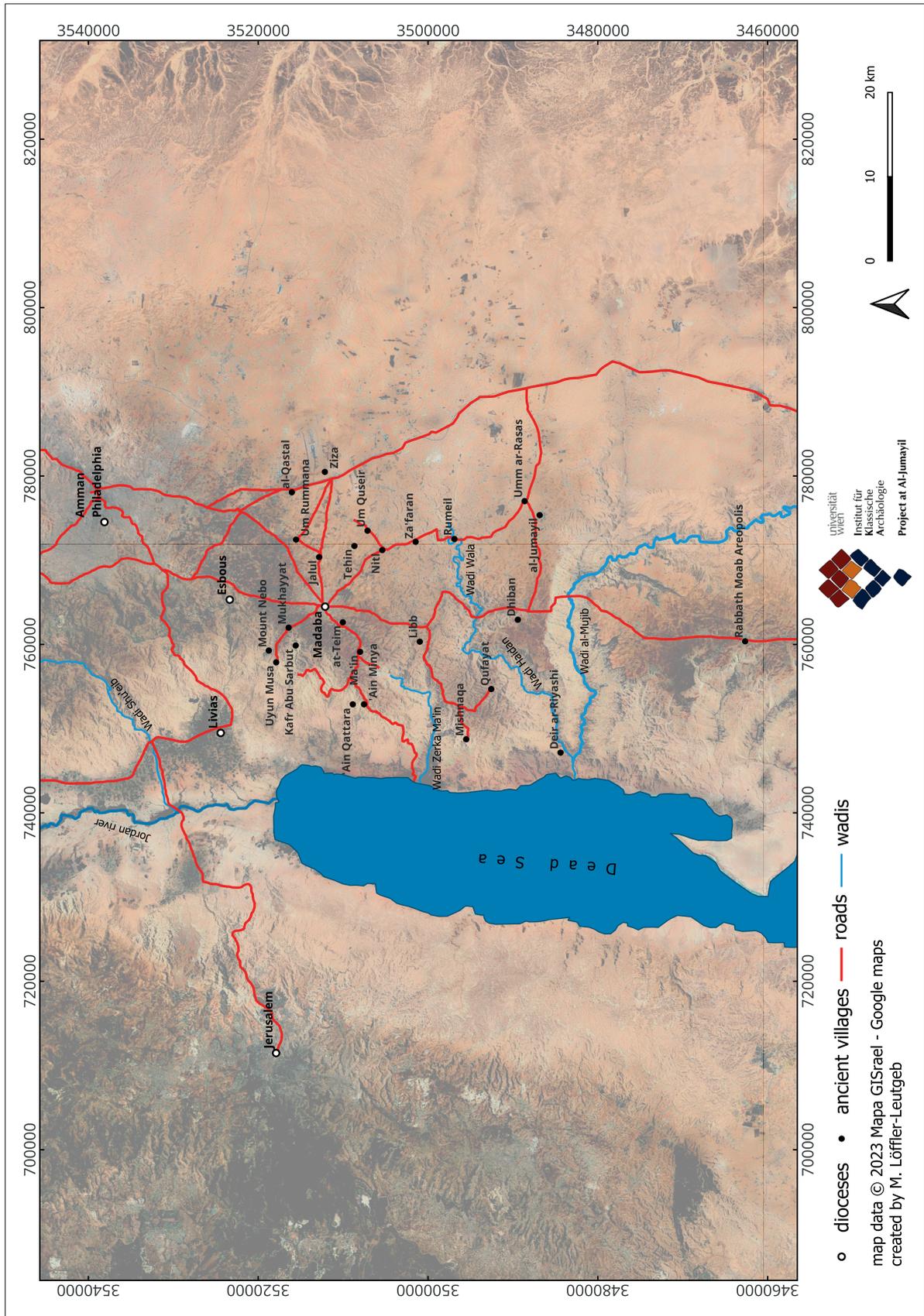


Fig. 1 Map of the Diocese of Madaba (M. Löffler-Leutgeb)

descends towards the two wadis that delimit the site to the North and South. Thus, dwellings are erected on the western, northern and southern sides of the central hill, whereas the lowest part of the slope, not suitable for construction, was used for underground cisterns hewn directly in the bedrock to allow rain and run-off water to be collected.

The standing structures visible on the surface are mostly built from spolia and appear to be of a considerably later date (end of the 17th to early-mid 19th century), while the walls, collapsed arches and roofs appear to relate to earlier phases of the settlement, most probably the Late Antique and Medieval periods, as can be evinced from the collected surface pottery. The excavation works have focused on two adjacent churches constructed on the lower western edge of the settlement and delimited by a wide rectangular enclosure. These two single-nave churches each end with an apse of differing size on their eastern side; several rooms appear to be built against the north wall of one of the churches⁹. The 2021–2023 seasons aimed at close examinations of the North church, which was completely covered by collapsed arches and thick layers of debris¹⁰. The stratigraphic excavation uncovered the exceptionally conserved walls, vault corbels, fallen roof slabs, and the support system of the hemispherical dome above the presbyterium *in situ* – allowing the categorization of the building among the all-stone structures, a well-documented technique widespread in Syria and in the Hauran, but less common in the diocese of Madaba¹¹. The church, like the majority of dwellings on the site, was built using the local limestone, of which the fossiliferous type was preferred for vaulting and roofs¹².

The church itself incorporates several *spolia*, which possibly came from unidentified earlier buildings. Its internal walls were plastered, and the floor was covered with mosaics. The research methodology focused on cleaning and delimiting the external walls and proceeded with three main tasks: stratigraphic excavation, survey, and digital documentation of all notable features of the site (buildings, architecture, water resources, agricultural features etc.), in addition to identifying the sources of building material within the perimeter of the site itself and in nearby areas¹³.

9 Savignac was the first to identify one of the two churches on his visit to the site around 1932; he was followed by Piccirillo who saw the same building (Savignac 1936, 242; Piccirillo 1989, 260–261).

10 The results of the past two campaigns are published in: Hamarneh et al., in press.

11 There are some exceptions such as the two-church complex at Nitl, some buildings at Umm er-Rasas, and several underground cisterns still have their slab roof in place.

12 Fossiliferous white, grey and reddish limestone is a sedimentary rock. See Abu-Jaber 2012.

13 As at the site of the church of al-Mushabbak in Syria with a quarry site next to the south-west of the church. See Zakkour 2007, 66–67.

The quarry

The quarry (locus Co21) stands on the rocky northwestern edge of the site (fig. 2). It features multiple layers of continuous activity over an as yet undefined period of time; the diversity of layers is formed by a complex system of negative interfaces. However, a correlation of the unfinished blocks *in situ* and the lithotype of those used in the fabric of the church may offer evidence for quarrying linked to specific building activity in the late 6th century.

Significant evidence of stone extraction techniques, together with tool marks, chiseling, dressing and extraction planning can be seen in all parts of the quarry (fig. 3a and 3b). Further, there are numerous traces of the process of extraction (using drilling, wedging and levering techniques). The blocks show a regular or standardized size (using the Roman foot as a basic dimensional unit of measurement) and bear the traces of recesses carved to insert the wedges used to split them. Large blocks were arranged following the same orientation (N-S or NE-SW), probably according to the limestone quality and date of quarrying (fig. 4). The cessation of quarrying activity can be evidenced by a wall of unextracted blocks on the north side, which appear to be the last planning activity before the subsequent conversion of the area for water storage.

The quarry offers valuable comparative material in regard to the technological features and the extensive landscape of production of the Diocese of Madaba, especially around the site of Umm er-Rasas, which still awaits systematic study and documentation¹⁴. Upon accurate analysis, several specific elements such as forms of production technology and logistics, as well as indications of the social context of the stoneworkers and quarry owners, about whom we know so little, can be evinced. Quarry ownership is no insignificant matter in this context, as private owners could work the quarry themselves, hire others to do it for them (*locatio operis*), or lease the right to work the quarry to someone else (*locatio rei*)¹⁵. Such consignments are hypothetically suggested in the case of Aphrodisias in Asia Minor, and entail the owner (as the lessor) contractually empowering a contractor (as the lessee) to extract material from the quarry¹⁶. The cost for such a lease could be a fee, a share of the output, or a set amount of extracted raw materials. Stone extraction and quarrying certainly could secure a steady income, while in the specific case of the open cast quarry identified at al-Jumayil, the extraction was limited to a volume of circa 321–350 m³, making it evident that it was a coordinated supply for a specific building¹⁷. However, other vertical open cast quarries,

14 The visible quarries in the area of the Stylite tower at Umm er-Rasas were documented by Marino – Piccirillo 1991; Bujard 2016, 111–115; a study of quarries and quarryscape in Jordan was carried out by Abu-Jaber and others. See Abu-Jaber et al. 2009.

15 Russel 2013, 46.

16 Ward-Perkins 1971, 137–138; Reynolds 1996, 122.

17 Similar instances of quarries adjacent to building sites can be seen around the buildings in the eastern wadis of Umm er-Rasas under study. Hypothetically speaking, the quarries at both the sites of al-Jumayil and Umm er-Rasas must have been under common management during the Byzantine period.

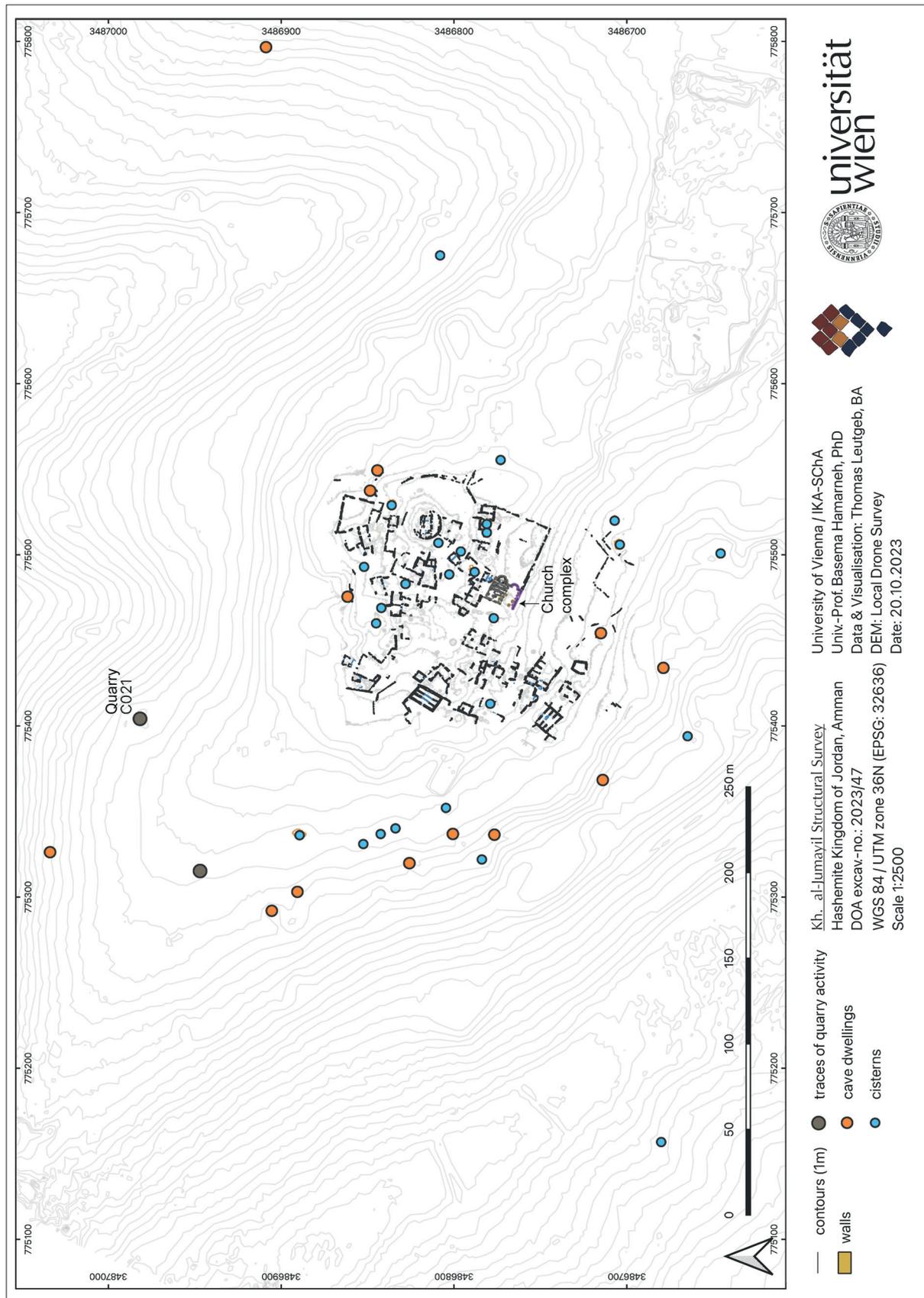


Fig. 2 Contour Map of the site of al-Jumayil showing the churches and the quarry area (T. Leutgeb)

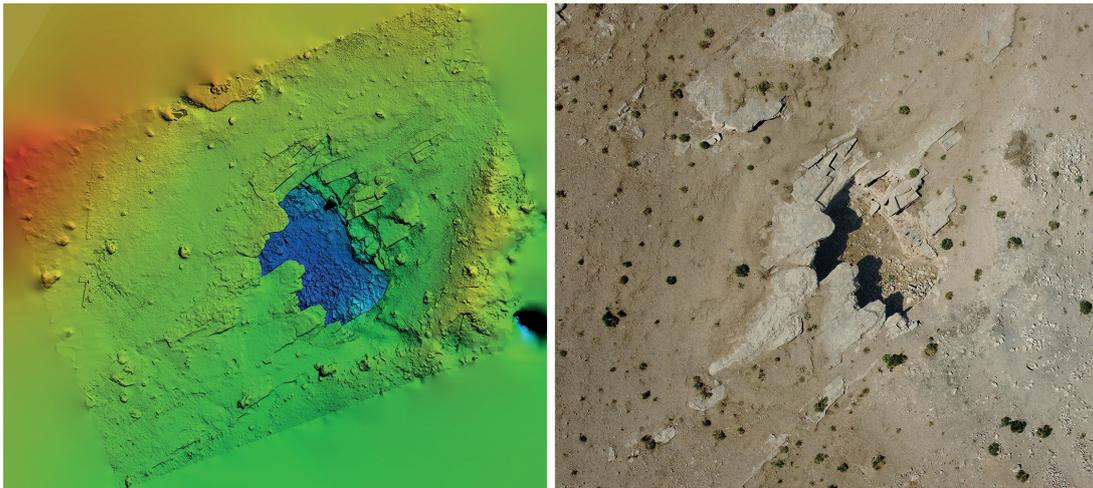


Fig. 3 a. b Aerial view of the quarry and Digital Elevation Model (DEM) of the quarry (T. Leutgeb)



Fig. 4 Quarry contrast image (T. Leutgeb)

characterized by fine, linear worked steps within the bedrock, can be seen throughout the landscape surrounding the settlement¹⁸, thereby indicating that a management system of one or several owners existed.

Secondary use

The subsequent utilization of the quarry as a cistern relates to the general water management system and planning implemented at the site as a whole, as 31 cisterns have so far been identified and documented in the settlement through Lidar scanning¹⁹. The quarry of al-Jumayil was covered with a thick layer of rough grey and white plaster still *in situ* at several areas of the structure, and several deep channels running towards the opening of Co21 were hewn into the bedrock²⁰. In addition, the opening of an underground channel is located in the southwestern area of the structure which ensured that all seasonal rainfalls could be channeled and stored in the facility.

According to Butler, a large Roman quarry at Umm el-Jimal shows evident signs of regularization into a rectangular-shaped cistern with dimensions of ca 40 × 30 m in plan and an average depth of 6 m, giving an exposed quarry area of 1,200 m² and the extracted volume of 7,200 m³ (with each cubic meter corresponding to 1,000 liters of water)²¹. Such a pragmatic approach is an excellent example of how the need for resources was met in settlements²².

In other cases, some quarries were transformed into winepresses especially when they were located next to vineyards; treading floors and vats were excavated directly in the bedrock, and some vats were coated by additional plaster layers. The landscape around such installations exhibits a division into small plots of land that can be interpreted as areas for the cultivation of such commodities, especially by monastic communities. Some fields were covered with crushed limestone debris resulting from the quarrying process, which was considered ideal for the cultivation of grapes and olives owing the alkalinity of the limestone and this kind of soil's drainage²³. Such is the case in the area around the Stylite tower and the small complex in the eastern wadi, both on the northern limits of Umm er-Rasas. There, the wine press was carved into the rock; it also included an irregularly shaped chamber at the center of which is an indentation

18 Comparisons for vertical quarrying can be found in Dayyah 2001, and also at several undocumented and unpublished areas of Umm er-Rasas.

19 Analogous *modi operandi* have been identified in several Roman and Nabataean sites across the Levant.

20 Gharayyib – Ronza 2007.

21 The quarry is hewn in bedrock in the proximity of the Roman fort. See figure in: Butler 1913, 159. Arce (2014, 395) mentions other similar cases at the following forts and castra: Zizia-Jiza (volume 82,080 m³); Quweira (volume 3,040 m³); Qasr Bshir (15,840 m³); Deir el Quinn (trapezoidal): 50 × 52 × 38 × 42 m (6 m in height); Humeima: 30 × 20 m (3,000 m³); two were identified at Qastal: 3,960 m³ and 9,200 m³; and the last two at Qatrana 69.4 × 69.4 m; and Dayaniyya: 46 × 29 m.

22 Coli et al. 2007, 63–64.

23 Arce 2014, 396.

holding the vertical axis of a screw press²⁴. To the side of this crusher are two small basins which formerly belonged to the grape storage rooms and made it possible to gather the *mustum*. The crusher itself is in turn connected by a narrow channel to a tank intended for collecting the juice from crushing and pressing. Similar rock-hewn presses have also been discovered next to the monastery of al-Kanisah in Wadi Afrit²⁵, at Mount Nebo²⁶, and a smaller one at al-Jumayil²⁷.

Geological aspects

The documentation and interpretation of the quarries at al-Jumayil has been conducted so far from an archaeological perspective, since geological research on the site is on-progress. According to the Geological Map of Jordan, al-Jumayil is part of the Belqa Group²⁸ dominated by sedimentary rocks of the Late Cretaceous Period (Coniacian-Maastrichtian stages). The rock formations of the site are visible in cisterns, caves and quarries; they contain chalk, marl, bituminous limestone, phosphorite, silicified limestone and chert. Three of these components – chalk, marl and limestone – belong to the class of sedimentary rocks and the carbonate subdivision, whereas phosphorite and chert belong to the subgroup of chemical and biochemical rocks (fig. 5).



Fig. 5 Rock stratigraphy of the north-western corner of the quarry (Photo M. Löffler-Leutgeb)

24 Bujard 2016, 113.

25 Piccirillo – Alliata 1998, 208–209.

26 The winepress was identified on the North-Western slope of the Monastery: Saller 1941, table 161.

27 The wine press was excavated in 2021: Hamarneh et al., in press.

28 Bloxam – Heldal 2008; Jreiat 2013.

The top layer of the quarry is comprised of a soft limestone deposit, showing clastic, with variable grain sizes, and a significant proportion of fossil inclusions²⁹, reminiscent of coquina or fossiliferous limestones. The colour of the rock is a light beige to sand tone, and the surface is heavily weathered by exposure, due to the porous structure with its high percentage of inclusions³⁰. This type of stone can be seen in most of the buildings at the site of al-Jumayil. In the excavated church complex it was employed as masonry stone for the walls, pillars, arch stones, roof slabs, and for the reliquary pit found in the South church as well as being originally used in the floor of the sanctuary or bema. The quarry's northwestern internal face shows deposits of light beige marl and a layer of chert, which were also used as building material in walls throughout the site and within the church structure.

Stone extraction and extraction planning

The two main quarrying principles used on site at al-Jumayil are channelling/carving and levering/splitting (fig. 6a and fig. 6b). Levering describes a method in which already existing open fractures within the rock deposit are expanded through the insertion of tools³¹, whereas channelling is used for detaching the blocks. Channels with an average width of 4–6 cm were carved in the rock, to “cut out” the needed block or section, possibly using pickaxes; the same process was applied at the upper levels of the quarry



Fig. 6 a. b Two types of unfinished blocks with signs of channelling and levering (Photos M. Löffler-Leutgeb)

29 Bloxam – Haldal 2008.

30 Abu-Jaber 2012.

31 Sometimes fire was used to fracture the bedrock.

face to extract longer roof slabs. In some cases, both methods have been used in combination. The resulting blocks were smoothed after extraction to create a regular form.

Tool marks

Different traces of tool marks can be seen in the quarry. There are, for example, straight parallel lines on the edges defining a carved channel that can be attributed to the use of a chisel (fig. 6a–b), whereas the rounded marks on the inside of a channel may result from the use of a stone hammer. Similar signs of a stone hammer or pounders can be seen on the surface where a stone block has been extracted (fig. 7a), while traces of a chisel can be found in the extraction channel on the corner edges. Wedge marks, created by chisels along a section of rock that was intended to be extracted are also identifiable (fig. 7b). The wedge holes are about 8 to 10 cm long, 5 cm wide and max. 6 cm deep. Surprisingly, pick marks have not been identified in the quarry itself, but they were found instead on the limestone blocks used for the arches, which even feature several different styles of pick marks. This suggests that, once extracted, the stones were reworked and adapted by stone workers before being employed in the building.

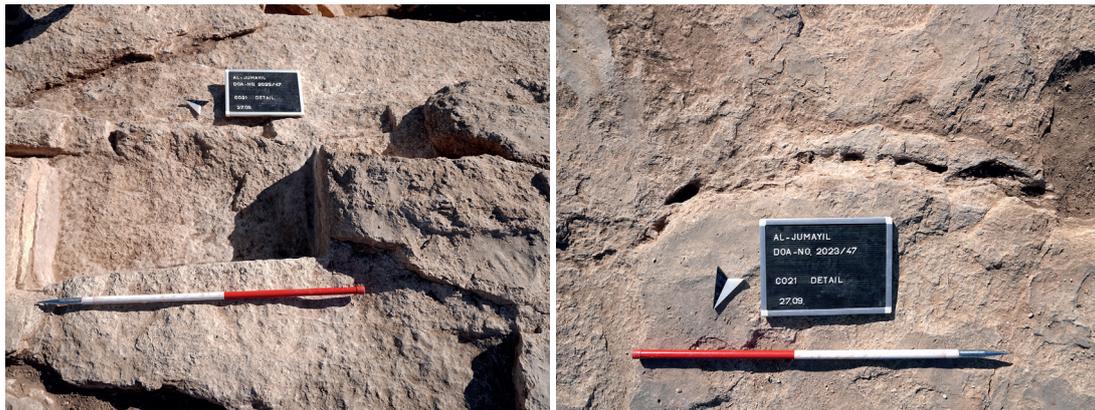


Fig. 7 a. b Unfinished blocks (fractures and channelling – left; traces of chisel marks and a wedge line – right) (Photos M. Löffler-Leutgeb)

Unfinished blocks and rock waste

Some evident traces of incomplete work have been found at the al-Jumayil quarry site (fig. 5) and in other quarries documented at the neighboring town of Umm er-Rasas. There are some unfinished, partly finished and finished stones as well as small fragments of rock displaying tool marks lining the lower internal edges of the al-Jumayil quarry, but this area requires additional investigation due to the subsequent plastering and reuse of the spot as a cistern. It is worthy of mention that no debris of stonework were detected, however it cannot be excluded that this by-product was transformed

into chips, rubble and cubes of various sizes, which were recycled in various ways, the cubes for example were mixed with mortar and used to plaster the church walls and the roof. The excavation of the stratum of the collapsed roof and walls yielded more than 12,000 of such cubes, some in use and mixed with mortar (fig. 8). It cannot be ruled out that smaller remnants were crushed to produce hydraulic mortar to coat the cisterns.



Fig. 8 Large *tesserae* mixed with mortar (Photo M. Löffler-Leutgeb)

Stone dressing, fitting on site and logistics

Indications of further work steps immediately following the stone extraction from the quarry are hard to detect and identify, though it is clear that stones were transported to the building locations for further processing and use³². The internal southeastern vertical surface of the quarry preserves evidence of dressing and fitting conducted *in situ*. Four to five courses of limestone were cut into blocks: the stone size ranges from large rectangular stones (82.1 × 34.9 cm), to medium-sized stones (from 73.9 × 32.4 cm

³² Bloxam – Heldal 2008.

to 56.4 × 29.5 cm), and even small sizes (36.1 × 30.4 cm). However, their extraction was not finalized, and the wall was instead covered with a thick layer of rough, white and grey chalk mortar and used as a cistern. Big chunks of this hydraulic mortar can still be found *in situ* along the wall and on its edges (fig. 5).

Although the quarry is within walking distance from the building site, the size and weight of the blocks, especially the roof slabs, the uneven terrain, and the lack of a road system in the settlement would suggest transport using animals such as donkeys or camels³³. The latter appear in the context of transporting building materials on mosaics and in the frescoes of Qusayr Amra dated to the Umayyad period.

Conclusion

The open cast quarry of al-Jumayil is a salient feature of the late antique settlement's landscape; its study and analysis offer valuable insights into the planning strategies for exploiting the territory and the way local resources were used efficiently to save time, effort and cost. Not only were quarries sought in the immediate environs thus allowing the territorial spread of the settlements to be identified, but they also made use of a rocky landscape which was not suitable for agricultural purposes. As soon as the mere stone extraction operations were concluded, the quarries were subsequently repurposed as open-air cisterns, implying a remarkable level of administrative organization and drive to optimize resources.

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33 Camels can comfortably carry a load of 150 kg and a maximum of 450 kg: Arce 2014, 401.

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