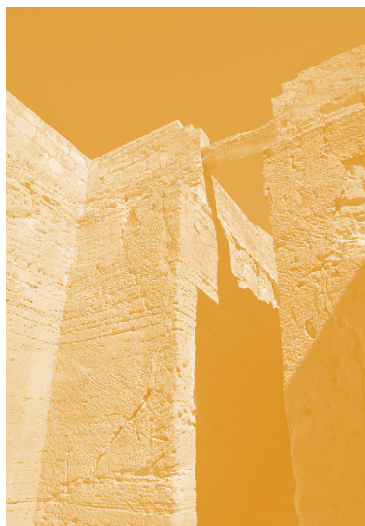


Stone block surplus? Reconstruction of the building process and architectural form of Marina el-Alamein hypogea



Abstract: The monumental rock-cut tombs of the Graeco-Roman necropolis at the site of Marina el-Alamein on the Egyptian Mediterranean coast, today a sightseeing icon following restoration work by the Polish team, have produced significant information about the town, its inhabitants, and burial traditions. Different aspects of the tombs and their content have already been discussed, but without going into the details of the architectural building process. This paper focuses on ancient quarrying and masonry techniques in an effort to reconstruct the process as applied to the large hypogea. An estimate of the volume of stone material sourced during the execution of the underground parts of these tombs was compared with the reconstructed demand for stone ashlar used in the aboveground superstructures. The issue to be examined in this context is whether the tomb hypogea could have produced a surplus of stone building material, thus serving as a quarry for the city itself.

Key words: Egypt, Marina el-Alamein, Graeco-Roman, hypogeum tomb, building technology, architecture

The ancient town in place of modern-day Marina el-Alamein, located about 100 km west of Alexandria and 185 km east of ancient Paraetonium (Marsa Matruh), was discovered in 1986, when work started on the construction of a tourist resort at this Mediterranean coastal site (Daszewski 1991). Archaeological

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excavations uncovered many different structures, establishing the character and chronology of the remains. The settlement, which was established in the 2nd century BC, existed for more than 600 years, ultimately disappearing in the 6th century AD (Daszewski 2011). Despite more than 30 years of fieldwork, the name of the city remains unknown: the harbor of Leucaspis, mentioned in Roman sources, has been considered as a possibility; so has the Byzantine-era episcopal see of Antiphrae. It is probable that the two may have actually been conflated late in the 4th century at the earliest (Twardecki 1992; Czerner 2015).

Investigations of the site have given a good understanding of the town plan made up of three main parts: a harbour,

a residential and public sector, and a cemetery. This paper is focused on the necropolis in the southeastern part of the town. The monumental hypogea cut in bedrock [Fig. 1] could well have supplied building stone for the local community.

Participation in the Polish–Egyptian Conservation project gave the author an opportunity to examine the underground parts of the tombs firsthand searching for evidence that they could have served as quarries of stone building material for the city. Using strategic-game techniques (Kwiatkowska 2017), the author was able to prepare a calculation model which produced measurable results. Two of the most typical hypogeum tombs were chosen for the project, the goal being to carry out the reconstructions.

THE NECROPOLIS

The Marina el-Alamein cemetery, identified at the very beginning of the excavations, was excavated by Wiktor Andrzej Daszewski for close to 20 years (Daszewski 1991; 1992; 1993; 1994; 1995; 1996; 1997; 1998; 1999; 2000; 2001: 47–58; 2003: 51–58; 2011: 435–452; Daszewski et al. 2005: 74–86; 2007: 84–97). More than 30 tombs were unearthed and documented in the course of the archaeological project.¹ They represent a variety of forms, some the best preserved examples of their kind, others unparalleled in Hellenistic and Roman Egypt, engendering extended interest due to the monumentality of their architecture and their ornamentation.

The location on a limestone coastal ridge determined the size and shape of the necropolis, its monumental character and enhanced visibility to the town residents. The ridge is a geological formation stretching west of Alexandria along the coast, punctuated by long depressions (Klemm and Klemm 2001: 641; Medek-sza 2002: 104; for a geological review, see Skoczylas 2002: 1179). The tombs extend 400 m, east to west, across a landstrip about 150 m wide. Situated on a gentle slope, the “houses of the dead” form a succession of tiers that were visible from both the town and the harbor [Fig. 2].

A group of tombs of similar form stood at the center of the site (T1, T1B,

1 A few other tombs discovered by Egyptian archaeologists during the rescue excavations in the late 1980s were neither documented nor published.





Fig. 1. Subterranean part of the hypogeum tomb T6: left (opposite page), view of the inner court and entrance to the burial chamber, above, view of the entrance to the dromos from the inner court (Photos S. Popławski)

T1C, T1D, T1F, T1I, T1J, T1K, T2, T3, T12). These structures consisted of a rock-hewn rectangular pit under a stepped square structure topped with a decorative sarcophagus or a huge pillar or column. Dated mainly to the early 1st century AD (with a few of earlier date, reaching back even to the 2nd century BC) (Daszewski 2011: 438–441), they formed an impressive landmark thanks to their central location and significant height—up to 7 m in the case of individual monuments. The architectural concept behind the most elaborate examples could be described as a complete architectural order presented in a single column or pillar (Czerner 2015). These tombs were crowned with a simplified geometric form of decoration resembling the Nabatean style, which was extremely common at the site (Czerner 2009).

The other tombs were scattered across the necropolis [see Fig. 2]. Among the more elaborate forms two types were dis-

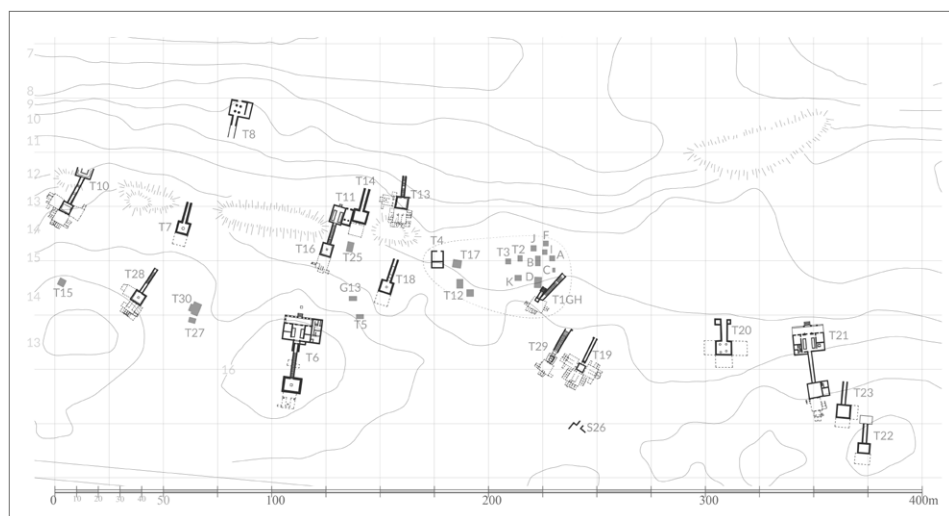


Fig. 2. The necropolis at the site of Marina el-Alamein (Plan S. Popławski, after R. Czerner, K. Majdzik and S. Medeksza)

tinguished: box tombs and hypogea. The box structures (T₁₁, T₁₇, T₂₅, T₂₇, T₃₀) consisted of four or six loculi arranged in two or three rows. The structures were usually oriented N–S and enclosed inside a temenos wall. Their construction was also dated to the early 1st century AD, but the larger examples at least continued to be used into the 4th century AD (Daszewski 2011: 441).

The third category of tombs, the hypogea, were located along the ridge. They were oriented along the slope. These structures are among the largest and probably the earliest at the necropolis. The first hypogea, constructed at the end of the 1st century BC, were in use until the 3rd century AD; they were the most common in the 1st century AD

(Daszewski 2011: 441–452). These tombs consisted of one or more burial chambers located around an open court cut as a shaft in the rock, accessible via a long staircase from the ground surface. A kiosk or larger mausoleum in the form of a pavilion was built aboveground, at the top of the staircase. The orientation of the tomb is adjusted to the sloping surface of the ridge, but the overall layout is with the subterranean burial chamber always at the southern end and the entrance toward the north.

Simple graves were also discovered among these structures. These were pit graves covered with mounds or prisms, grouped in threes and fours, sometimes apparently associated with some of the larger tombs.

THE HYPOGEA

Sixteen burial monuments in the form of rock-cut hypogea (T_{1GH}, T₆, T₇, T₈, T₁₀, T₁₃, T₁₄, T₁₆, T₁₈, T₁₉, T₂₀, T₂₁, T₂₂, T₂₃, T₂₈, T₂₉) have been uncovered to date by the Polish archaeological team. The key features of these tombs are the same, the sole difference being the size and elaboration of the aboveground pavillions.

The underground part consists of an open court with at least one burial chamber having burial niches (loculi) cut in the walls. This court is square in plan, approximately 5.50 m to the side, cut in bedrock to a depth of around 6.00 m. In the earliest tombs (T_{1GH}, T₂₉), it was much smaller, just 1.20 m by 1.20 m, and not so deep. The open court had a wall constructed on the ground surface (which basically corresponds to the rock surface), raised about 1.00 m above the ground.

It ran on a perimeter that was slightly larger than the shaft itself and generally protected the inner courtyard from, among others, sand filling it up. The rule is for the burial chamber, if there is only one, to open off the south side of the court/shaft and be aligned with the long axis of the complex. The chambers are generally slightly bigger than the court; their ceilings are flat, corresponding to the layering of the limestone bedrock, supported in a few instances on rock-cut columns or pillars. Frequently, they are arranged with rock-cut benches and altars, separated from the court in some cases by walls that are fitted with windows and more than one doorway. In the most spectacular example (T₁₀), the rock cut pillars give the impression of a peristyle. Unlike the burial chambers,

the loculi were executed in no apparent order, depending probably more on burial necessity. They were cut in the walls and were approximately 0.40–0.70 m wide, 0.90–1.10 m high and 1.85–2.10 m long.

Access to the hypogeum was down a rock-cut staircase, either vaulted or flat-roofed. The roofing made of stone ashlars limited the width of the staircase to roughly 1.30 m. The entrance to the staircase was

located inside the aboveground structure. In the simpler complexes, it took on the form of a decorated kiosk, while in the largest ones, the mausolea resembled pavilions, composed of a banquet hall with benches (*klinai*) on the two long sides. The most spectacular structures (T6, T21) comprise also secondary rooms (including a rock-cut cistern and a latrine) and facades articulated with porticos.

HYPOTHESIS: MANAGING A SURPLUS OF STONE

The aboveground parts of the tombs were built of stone ashlars and there is every reason to believe that they came from the cutting of the underground chambers. Did this generate a surplus of stone ashlars, especially in the case of the large hypogea, a surplus that one would expect to be removed and used as building material elsewhere in the city? The idea can surely be tested in practice, by reconstructing theoretically the masonry parts of a tomb and calculating material volumes for the purpose of comparison.

However, a theoretical reconstruction must be based on substantive data. In order to test the idea, two hypogeum tombs were chosen for a detailed reconstruction, both well documented and studied, thus

ensuring the feasibility and credibility of the theoretical reconstruction. The tombs were selected on the principle of contrast. Tomb T6 has the largest aboveground part with simultaneously one of the simplest subterranean parts, while T13 consists of an elaborate underground part and a simple kiosk on the surface.

The quickest way to check this hypothesis is to calculate the volume of the underground part and compare it to that of the stone blocks used in the superstructure [Fig. 3]. However, this approach can lead to major mistakes due to the nature of the quarrying and building processes. The author will calculate the volume and show one possible way of how to avoid the said mistakes.

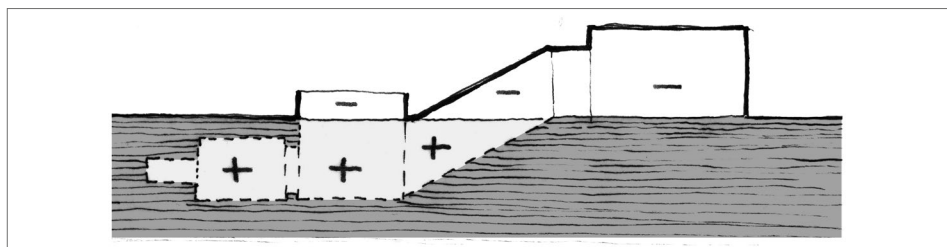


Fig. 3. Schematic illustration of the sourced material equation (Processing S. Popławski)

QUARRYING TECHNIQUES AND THE CONSTRUCTION PROCESS

Quarrying techniques are the single most important factor influencing the amount of stone material that would have been extracted from any given tomb. But in any discussion of stone extraction and dressing techniques the stone itself is the most important element. Limestone was one of the most popular building stones in ancient Egypt (Arnold 1991: 27–36) and regular quarries can be found all along the Mediterranean and in the Nile Valley between Cairo and Esna (Harrell and Storemyr 2013: 19–20). In the case of the local limestone at Marina, it has been described in geological terms as an oolitic limestone: white, fine-grained, horizontally layered, presenting mediocre technical parameters (Skoczylas 2002: 1179). The layered structure results in a greatly varied hardness and resistance to weathering of particular laminae. The average density of the stone is estimated at 2.2 g/cm³, which means that one cubic meter weighs 2200 kg.

The chain of operations in the construction of the Marina el-Alamein tomb should be considered first. One could certainly expect planning and surveying to be the prerequisite steps (Arnold 1991: 7–16; Müller-Wiener 1988: 17–42) and the consistency of layout and orientation of the excavated tombs in the cemetery indicate that this was indeed so. There is no suggestion of a pre-existing quarry operating in this area and the hypogea seem to have been planned and executed individually rather than taking advantage of an independent quarry operation.

The process of cutting the underground parts of these tombs is illustrated by an unfinished tomb excavated at Marina el-Alamein (and more examples of rock-cutting practices can be observed inside the finished tombs). A tomb from Plinthine, a site halfway to Alexandria, also contributes crucial information for understanding the process as a whole.

Structure S26 of the cemetery at Marina el-Alamein, located thanks to an analysis of geophysical readings, turned out to be an unfinished tomb of the hypogea type (Daszewski 2001: 50–51; Herbich, van der Osten-Woldenburg, and Zych 2013: 227). Excavations verified the structure as an open court, which had started to be cut and was abandoned midway [Fig. 4 left]. The north wall of the shaft was 6.15 m long and the cutting had reached a depth from 2.00 m to 2.20 m, leaving an uneven bottom of the triangular shaft with four rough steps in the northeastern corner. The steps were 0.42 m, 0.35 m, 0.30 m and 0.30 m high, starting from the uppermost one. A wide recess in the middle of the north wall, 3.50 m long and 1.60 m wide, could be identified as the beginning of a dromos. The rock surface was cut in the form of two steps, 0.40 m and 0.80 m deep. A few dressed blocks, roughly 0.79 m to 0.30 m to 0.23 m in size, were found loose on the bottom. The structure was filled with sand and could not be dated for lack of any archaeological evidence.

Scaled images of the structure (the feature was backfilled and is no longer accessible) allowed additional observa-

tions to be made. Narrow cuts between the north wall and the triangular steps are less than 5 cm wide. The steps do not follow the alignment of the walls. The bottom level of the incipient dromos does not correspond to the level of either the steps or the bottom of the shaft.

In turn, the hypogeum tomb from Plinthine is part of a Hellenistic and Roman necropolis located on the coastal limestone ridge rising about 20–30 m a.s.l. The site was a major sea and lake (on the inland Mareotis Lake) port roughly halfway between Alexandria and the city at the site of Marina el-Alamein. The geological situation resembles that in Marina and the historical background of the necropolis is similar as well. The hypogeum tomb T3 is dated to the end of the 4th century BC or the beginning of the 3rd century BC. It was multi-phased, and in

many aspects unfinished. Of particular interest is the part described by the researchers as a probable quarry and located between the dromos and open court [Fig. 4 right]. This part may represent an unfinished burial chamber, which was cut most certainly before the 1st century BC when the necropolis ceased to be used. One observes vertical extraction cuts in the walls. The grooves are around 0.15 m wide, the space between them about 0.60–0.80 m. A few steps, around 0.30 m high, were left on the floor surface.

The presented examples combined with knowledge of ancient quarry techniques (Orlandos 1966–1968: 15–69; Müller-Wiener 1988: 43–48; Adam 1994: 21–62; Harrell and Storemyr 2013) will serve here to reconstruct the tomb-cutting and construction processes step by step.

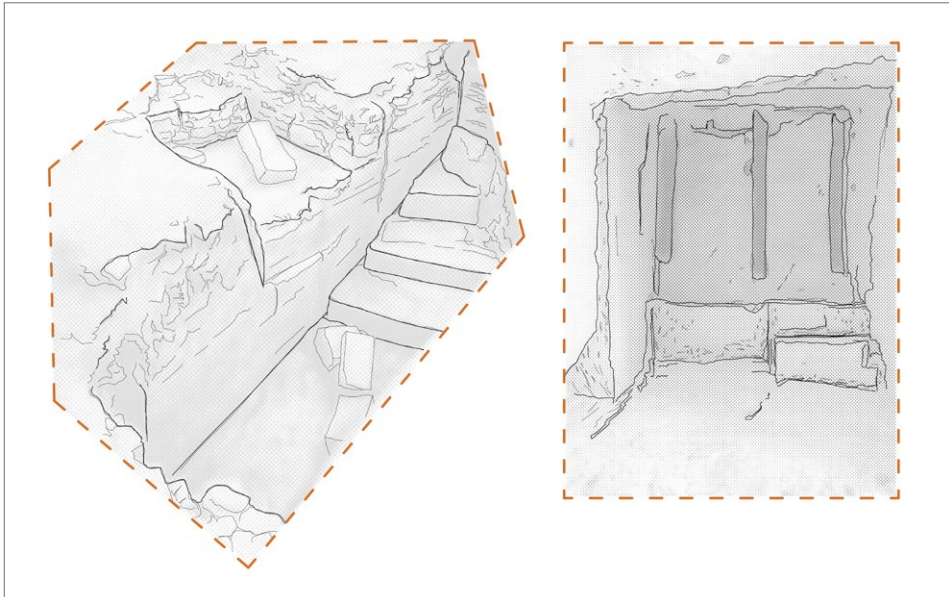


Fig. 4. The quarrying character of unfinished tombs: left, feature S26 in Marina el-Alamein; right, hypogeum T-3 in Plinthine (After Daszewski 2001: Fig. 4 and Boussac et al. 2012: Fig. 6 | drawing S. Popławski)

The first step was to cut an open court and dromos. The work would have proceeded like an open-cut quarry. Workers would start with vertical cuts around the block to be extracted, removing a series of blocks, layer by layer, within the perimeter of the planned court shaft. Blocks from deeper levels could have been brought out through the dromos, which was in all likelihood cut simultaneously. However, the steps preserved at the bottom of the shaft in the unfinished structure S26 indicate that at least in the early stages of the process, the stone material would have been removed directly via the steps without using the dromos. The extracted blocks were already of a required size, hence needed no further splitting. Comparing the height of cut layers and the sizes of blocks used in the construction of town buildings, it was determined that each successive cutting platform was slightly more than 0.30 m high. In his calculations the author assumed a standardized block size: 0.32 to 0.32 m to 0.64 m (Czerner 2015: 8), the width of vertical cuts for extraction measuring 3 cm, and thickness of material lost in the dressing process estimated at 2 cm. Based on these values, the quantity of sourced material was estimated at about 0.65 of the extracted stone volume.

Once the inner court and dromos had been prepared, the next step was to cut the primary burial chamber. A similar procedure was followed in covered quarries. A horizontal slot marking the top of the planned chamber was first removed. When the empty space under the ceiling became high enough for a worker to operate there, the process became similar to that implemented in an open-cut

quarry. Crucial for the reconstruction is the technique for cutting out the space below the ceiling and estimating how much of the stone material was wasted. Based on data from the Plinthine hypogeum, the author has assumed that the uppermost layer of a new chamber would have been roughly 1.00 m high with vertical cuts, 0.12 m wide, around it. Consequently, the quantity of sourced material in this layer under the ceiling could be estimated at about 0.47 of the total extracted stone volume. The lower layers, treated as an open-cut quarry as indicated above, would have had a stone extracting efficiency of 0.65.

The burial niches, which would have been cut next in the burial chamber walls, appear to have been prepared to satisfy specific burial needs. For the most part there seems to have been no planning of the disposition of these loculi. However, in a few tombs (T6, T14, T29) tracing lines were drawn in red to indicate the placement of new loculi (Daszewski 1991: 35–36; 1997: 75–76; 2000: 46; 2003: 53).

The building of the aboveground structure was a separate stage and it is impossible to determine whether it occurred simultaneously, or was later than the quarrying of the subterranean part. The walls were constructed following standard building procedures throughout the cemetery and the town. Standardized stone ashlar formed walls one-block thick with limestone mortar for bonding. Walls were in principle 0.30 m thick with narrower walls measuring 0.20 m. The structures were located no higher than 1.50 m above the bedrock and the foundation walls were probably made out of the stone leftovers.

DESCRIPTION OF THE TOMB ARCHITECTURE AND THE SOURCED MATERIAL EQUATION

Hypogeum T6 was among the first to be discovered and studied, archaeological excavations proceeding simultaneously with basic restoration treatment (Daszewski 1991: 35–37; 1992: 33–35; 1993: 28; 1997: 73–74; 1999: 43–45; 2003: 56–58; Medeksza 2001: 74; 2002: 97–99; Medeksza et al. 2003: 92; 2007: 107). The size of the aboveground pavilion was impressive, especially when contrasted with the single burial chamber with just one niche, which was not even centrally located [see *Fig. 5*]. The total length of the complex was roughly 44 m and the area more than 350 m². The tomb is located at the highest point of the necropolis, on the limestone ridge, around 16 m asl. The archaeological evidence from the excavation of the tomb indicated that it was constructed in the 1st century AD and used in its primary function until the 3rd century AD (although not entirely regularly, I. Zych, personal communication).

The other hypogeum, T13, had two subterranean chambers. The total length of the complex is 24 m. It is one of the structures in a lower tier of tombs, approximately 12.00 m asl, and was dated like T6: construction in the 1st century AD and regular, extensive, ritually varied use until the 3rd century AD. The ritual side of the burial customs observed in this tomb were of particular interest for the excavators (Daszewski 1995: 35; 1997: 76–79; Zych 2010), but for the purpose of the present discussion, the tomb is an example of a simple aboveground mausoleum with an elaborate subterranean part.

DESCRIPTION OF THE ARCHITECTURE

The pavilion of tomb T6 was built on a rectangular plan. The building was 10.80 m deep and 17.60 m wide, the seaward facade encompassing the pseudo-Ionian front portico and the eastern extension added to the original mausoleum. The building, which was perfectly symmetrical in layout, consisted of a central hall with two banquet couches, flanked by a room on either side, entered from the northern portico and exiting centrally by way of the dromos in the southern side, leading down into the subterranean chamber. The eastern extension of the mausoleum was added separately, as indicated by the joining observed also on the foundation walls forming a platform under the whole monument.

A crucial element for the reconstruction of the original appearance of the building is the height of the columns in the portico. The recorded architectural remains were grounds for completing the restoration of the columns to a height of 3.25 m (Medeksza et al. 2007: 107). A wooden roof was suggested over both the central hall and the portico in view of the large spans involved, 3.20 m in the portico and 5.50 m in the banquet hall [*Figs 5, 7 left*]. A similar solution was observed down in the city, in House H10, where impressions of wooden beams were discovered on the top surface of a pseudo-Corinthian capital (Czerner 2009: *Fig. 31*), and in the case of the Palazzo delle Colonne at Ptolemais (Pesce 1950: 25, Pl. VIII.C,F).

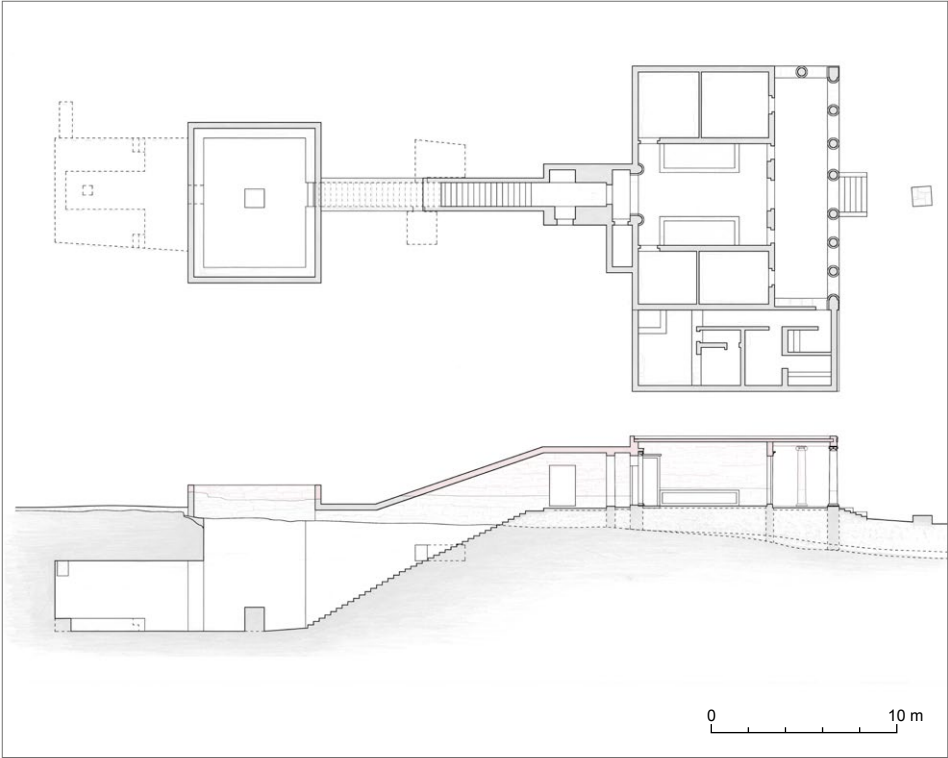


Fig. 5. Tomb T6: architectural reconstruction (After Daszewski 1998: Fig. 8 | drawing S. Popławski)

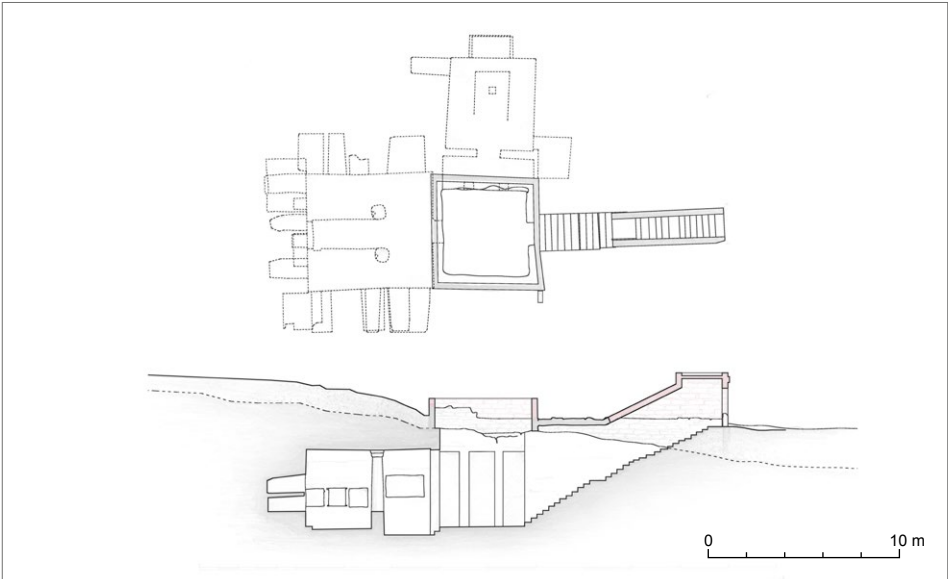


Fig. 6. Tomb T13: architectural reconstruction (After Daszewski 1997: Fig. 3 | drawing S. Popławski)

A monumental flat-roofed staircase led from a small vestibule on the southern side of the mausoleum down into the subterranean part. The staircase was perfectly preserved and undisturbed since the most recent burials dated to the first half of the 2nd century AD at the latest. It was aligned N–S, 17.00 m long and descending 7.00 m to the level of an inner open court, which is 7.00 m wide and 5.50 m long [see *Fig. 1*]. A low wall ran around the shaft mouth on the rock surface. A rock-cut altar (1.30 m high, 1.05 m long, 1.00 m wide) was left standing in the middle of the court and a cistern-well was cut several meters down in the northeastern corner.

A doorway in the south side of the court, located on the axis of symmetry of the tomb, led into a burial chamber. This was 6.00 m wide and 7.25 m long, the height of about 3.80 m matching the height of the narrow entrance, which is just 1.00 m wide. Rock-cut benches line the long sides of the chamber and the back wall, and a rock-cut altar, a simple block shape, stands in the middle. Interestingly, only one loculus was

executed in the southwestern corner, in the topmost tier on the west wall. It has not been explained satisfactorily why the facilities provided by the tomb were not used as intended. Instead, rather irregularly, burials of mummified bodies furnished with so-called painted Fayum portraits, were made in two small chambers cut in the rock and perfectly concealed on either side of the staircase at about the middle of its length. Several broken mummies were stashed in a cache added onto the eastern side of the vestibule at the top of the stairs and a few burials were made also on the floor inside rooms of the eastern extension. These latest burials belong to a period dated to the 2nd–3rd century AD.

The aboveground part of the T13 tomb took on some form of a kiosk [Fig. 7 right]. It has largely been destroyed, but can be reconstructed based on a parallel provided by a partly reconstructed entrance kiosk in the early tomb T1GH. The kiosk is square in plan, slightly wider than the staircase and decorated with corner pilasters, doorframe, and a cornice above a lin-

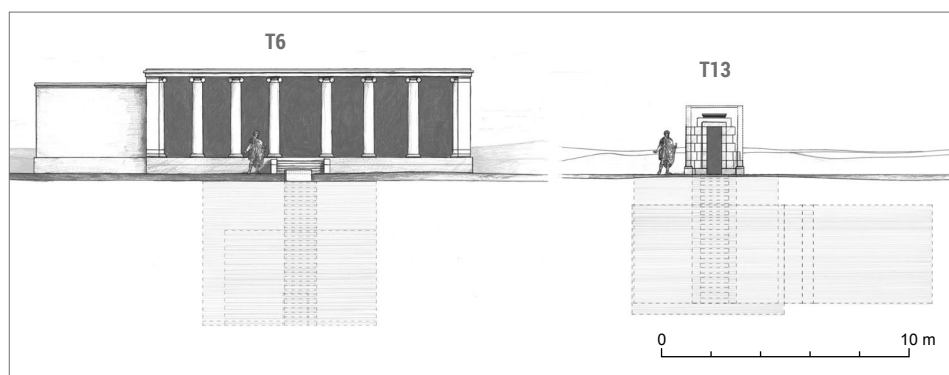


Fig. 7. Comparison of the aboveground and subterranean parts of the tomb (After Medeksza 2005: Fig. 6 | drawing S. Popławski)

tel, restored to a height of about 2.50 m (Medeksza 2005: 114–116). A flat-roofed staircase led down to an inner open court and two burial chambers located west and south of the shaft [Fig. 6]. The staircase, which was 10.00 m long and 1.15 m wide, was covered with monolithic stone slabs almost 2.00 m long. The court, almost perfectly square in

plan measuring 4.40 m to the side, had a low protection wall surrounding the perimeter of the shaft opening on the rock surface. This protective wall was 5.80 m wide and 5.50 m long.

The burial part of the tomb consisted of a large chamber lined up on the N–S axis of symmetry and another chamber off the west wall. The large

Table 1. Volume of sourced stone building material removed from the structure: subterranean parts of the tombs taken into consideration cover dromos, open court, burial chambers and niches in the chambers

Part	T6 – Calculation (m ³)	T6 - Total	T13 – Calculation (m ³)	T13 - Total
Dromos	$1.30 \times (5.80 \times 10.35) / 2$	39.02 m ³	$1.20 \times ((2.40 \times 3.40) / 2 + (2.20 \times 4.20) + (2.30 \times 4.40) / 2) =$	22.06 m ³
Open court	$6.00 \times 5.50 \times 7.00 - 1.30 \times 1.05 \times 1.00$	229.64 m ³	$4.40 \times 4.40 \times 5.15$	99.70 m ³
Burial chamber 1	upper section $1.00 \times 6.00 \times 7.25$	43.50 m ³	upper section $6.00 \times 6.60 \times 1.00 + 1.20 \times 0.60 \times 1.00 - 2 \times 0.70 \times 0.70 \times 1.00$	39.34 m ³
	lower section (with benches) $2.80 \times 6.00 \times 7.25 + 3.80 \times 0.80 \times 1.00 - 0.70 \times (4.85 \times 1.85 + 4.85 \times 1.95 + 2.00 \times 0.60)$	111.10 m ³	lower section $6.00 \times 6.60 \times 3.00 + 1.20 \times 0.30 \times 3.00 - 2 \times 0.70 \times 0.70 \times 3.00 - 2 \times 4.20 \times 1.45 \times 0.45$	111.46 m ³
Burial chamber 2			upper section $4.40 \times 4.80 \times 1.00 + 1.20 \times 0.40 \times 1.00$	21.60 m ³
			lower section $4.40 \times 4.80 \times 2.90 + 1.20 \times 0.40 \times 2.90 - 2 \times 1.40 \times 3.20 \times 0.45 - 0.70 \times 1.80 \times 0.45$	58.04 m ³
Portico			upper section $4.70 \times 1.30 \times 1.00 + 3 \times 1.30 \times 0.36 \times 1.00$	7.52 m ³
			lower section $4.70 \times 1.30 \times 2.90 + 3 \times 1.30 \times 0.35 \times 2.90$	21.68 m ³
Burial niches (loculi)	$0.80 \times 0.70 \times 1.95$	1.09 m ³	$18 \times \sim 1.00 + 4 \times \sim 1.50$	24.00 m ³
		424.35 m³		405.40 m³

chamber was rectangular in plan, 6.00 m wide, 6.60 m long and about 4.00 m high, supported in the center by two pseudo-Doric columns hewn in rock. Altogether 18 burial niches of varied shape were executed in the three sides of the chamber and rock-cut benches were left along the east and west walls. The other chamber had a two-pillar portico (4.70 m wide, 1.30 m deep) and a large door giving entrance to a room that was 4.40 m wide and 4.80 m long, and 3.90 m high. This chamber was also provided with rock-cut benches: wide ones on the northern and southern sides and a narrower one on the western side. Two large loculi, one above

the other, were cut in the main wall opposite the entrance, one high up on the south wall in the corner and the last in a more concealed position just inside the entrance on the north.

Sourced material estimation

The subterranean part of tomb T6 includes a staircase (39.02 m³), an open court (229.64 m³), a burial chamber (154.60 m³) and a loculus (1.09 m³) [Table 1; Fig. 8]. The total volume of material removed when the funerary complex was first arranged (without cutting more loculi) is 424.35 m³. Taking into consideration an estimated efficiency of the process, the volume of extracted stone

Table 2. Volume of stone building material used in construction: aboveground parts of the tombs taken into consideration include mausoleum/kiosk, dromos and perimeter wall

Part	T6 – Calculation (m ³)	T6 -Total	T13 – Calculation (m ³)	T13 -Total
Pavilion / Kiosk	pavilion - phase I podium = 56.93 m ³ floor pavement = 5.61 m ³ outer walls = 51.97 m ³ colonnade = 13.31 m ³ inner walls = 16.13 m ³	143.95 m ³	kiosk $2 \times (2.70 + 1.70) \times (2.50 + 1.50) \times 0.32 + 2.70 \times 2.30 \times 0.32$	13.25 m ³
	pavilion - phase II podium = 9.22 m ³ outer walls = 18.44 m ³ inner walls = 9.98 m ³			
Dromos	dromos roof $17.50 \times 1.80 \times 0.32 + 1.50 \times 4.50 \times 0.32 + 2.50 \times 1.40 \times 0.32$	13.36 m ³	dromos roof $(3.50 + 4.10) \times 0.32 \times 1.90$	4.62 m ³
	dromos walls $0.70 \times 12.30 \times 0.32 + (9.00 \times 3.00) / 2 \times 0.32 + 2 \times (4.50 \times 3.00) \times 0.32 + 3.70 \times 3.00 \times 0.32$	19.27 m ³	dromos walls $2 \times ((7.20 \times 0.64) + (3.90 \times 1.90) / 2) \times 0.32$	5.32 m ³
Perimeter wall	$2.00 \times (2 \times (7.20 + 8.00)) \times 0.32$	19.46 m ³	$2 \times (5.80 + 5.20) \times 2.00 \times 0.32$	14.08 m ³
		233.68 m³		37.27 m³

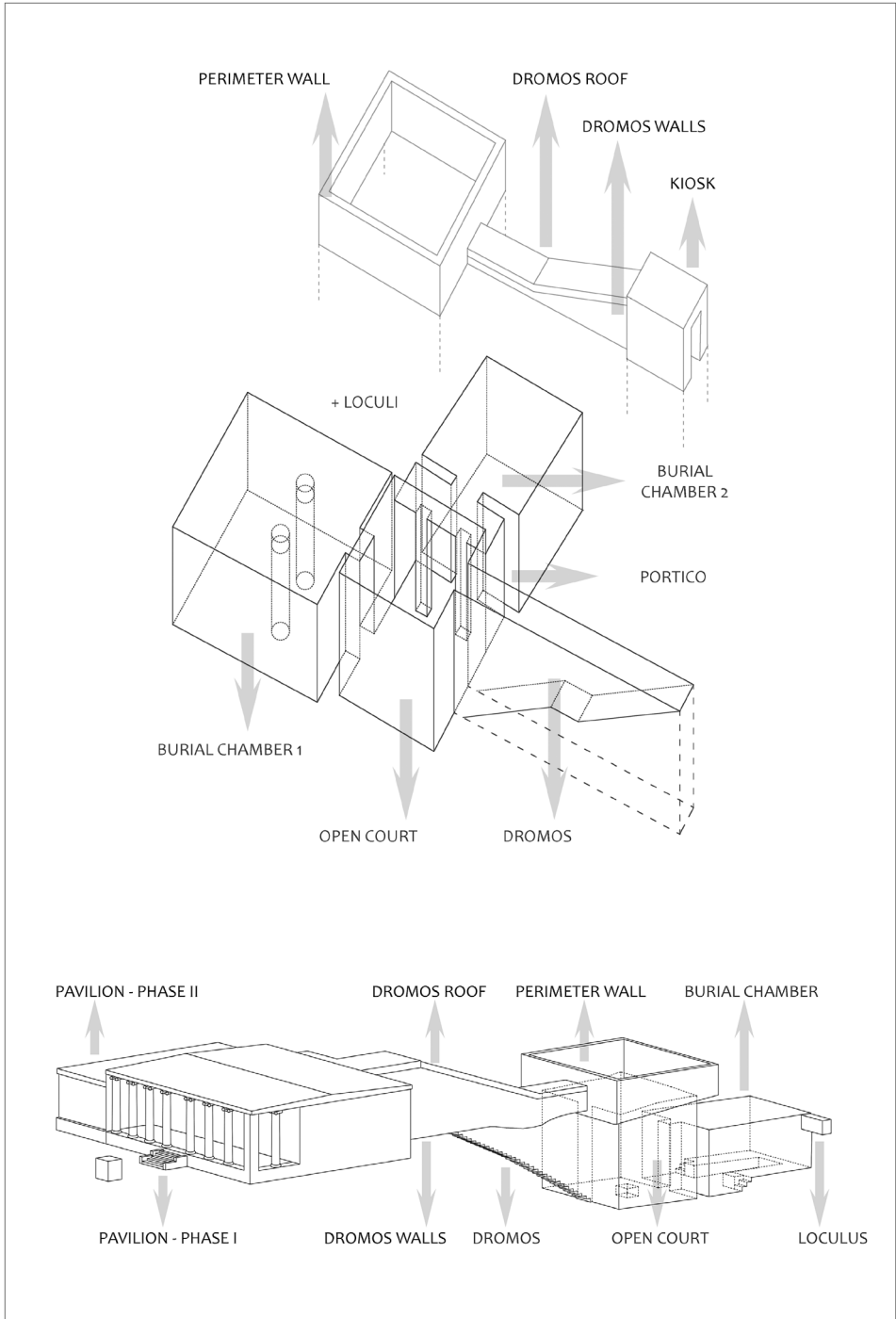


Fig. 8 (and opposite page). Parts of the tombs for which the volume of building material was calculated: above, aboveground part (T6); opposite page, underground part (T13) (Drawing S. Popławski)

blocks is 267.80 m^3 ($0.65 \times 379.76 \text{ m}^3 + 0.47 \times 44.59 \text{ m}^3$). However, the amount of stone used for the construction of the aboveground parts in Phase I amounts to 196.04 m^3 [Table 2; Fig. 8]. The extensions in Phase II required another 37.64 m^3 of stone ashlar. Consequently, an estimated 71.76 m^3 of stone ashlar would have remained after the mausoleum was built and even after the extension was completed, there would have still been some 34.12 m^3 left over.

Looking analogously at tomb T13, the constituent parts of the underground include a staircase (22.06 m^3), an open

court (99.70 m^3), two burial chambers (150.80 m^3 and 79.64 m^3) along with a front portico (29.20 m^3) and 22 loculi (approximately 24.00 m^3) [see Table 1; Fig. 8]. The total volume of removed stone material is 405.40 m^3 . The estimated efficiency of the process indicates that the volume of dressed blocks would have been 246.87 m^3 ($0.65 \times 312.94 \text{ m}^3 + 0.47 \times 92.46 \text{ m}^3$). The construction of the aboveground part required 37.27 m^3 [see Table 2; Fig. 8]. Consequently, in this case, the cutting of the sepulchre produced a surplus of stone ashlar calculated at 209.60 m^3 .

CONCLUSION

A look at the volume of extracted stone and that used in construction of the aboveground parts of two tombs from the early Roman necropolis at Marina el-Alamein demonstrated that a surplus of stone could be generated even when constructing a very elaborate aboveground monument. The estimates are most likely biased because it is impossible to put a number on how much of the stone was lost owing to the poor quality of the bedrock, which could have been cracked or porous in some sections. It is common not to utilize all of the material during a building process.

For the sake of visualising the volume of stone involved, 1.00 m^3 of the stone ashlar is enough to build a wall 0.32 m wide, 3.00 m high and 1.00 m long. In other words, the estimated volume of stone generated from the cutting of tomb T13 (-209.60 m^3) was sufficient to build a wall with these technical param-

eters around a square with sides 50 m long. Therefore, the quantity of stone material sourced from the underground structures known from the site of Marina el-Alamein—about 20 hypogea and at least two huge underground city cisterns, the eastern one $20 \text{ m} \times 19 \text{ m}$ in plan and the western one $50 \text{ m} \times 40 \text{ m}$ (Daszewski 2011: 435)—was substantial and should be taken into consideration in any kind of reconstructions of building investment in the town.

A study of the house building process and the volume of needed stone, which the author is preparing separately based on two houses recently studied in detail (Czerner 2011; Bąkowska-Czerner and Czerner 2019), should demonstrate whether a supplementary quarry would have been necessary at Marina el-Alamein or whether the ashlar sourced from the underground tomb structures were enough to construct the town buildings known so far from the urban site.

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