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CONSTRUCTION OF ANCIENT HOUSES IN MARINA EL-ALAMEIN. ANALYSIS OF THE DEMAND FOR BUILDING STONE

Abstract: Although structures within the ancient settlement in Marina el-Alamein were built almost exclusively of local limestone, no remains of ancient quarries have been found. The author calculates the cubature of stone used in the construction of the houses, based on the knowledge of the applied building solutions. The resulting data make it possible to address the question of the city managing the works without its own quarry, sourcing limestone from subterranean structures alone.
Keywords: Graeco-Roman Egypt; Marina el-Alamein; construction techniques; residential architecture; quarry

The initial discovery of ancient ruins on the Egyptian coast of the Mediterranean Sea by W.A. Daszewski led to further archaeological investigations and conservation work, currently spanning a nearly thirty-year period. Thanks to these projects the archaeological site in Marina el-Alamein represents one of the most significant testimonies to the Graeco-Roman settlement in northern Egypt. The site's uniqueness is emphasised by the complexity of the city's remains, which feature residential buildings, public facilities, a vast necropolis, as well as the port infrastructure. All of the uncovered structures were built using local oolitic limestone (Skoczylas 2002, 1179; Mrozek-Wysocka 2006), undoubtedly quarried in close proximity to the settlement. Yet the location of the ancient quarry remains appears to have eluded scientists. Furthermore, the search outside the site area is no longer possible due to land degradation resulting from modern extraction (Daszewski 2008, 422–423; Skoczylas 2002, 1178–1179).

The following deliberations aim to answer the question, whether the subterranean structures carved in the bedrock could have provided enough material to play an instrumental role in the construction works. This article is a continuation of a project launched earlier on, which incidentally resulted in the publication of estimates of the volume of material sourced from underground tomb construction (Popławski 2020). The current aim is to recreate the construction process of a residential building. Collation of data on the surplus stone obtained in the process of carving the tomb with the expected stone demand during house construction, will allow us to answer the above question. This analysis may provide a valuable springboard for debate on the location of ancient quarries.

Marina el-Alamein

The city existed from the 2nd century BC to the 6th century AD. It was founded in a coastal lagoon of the Mediterranean Sea, 96 km west of Alexandria [Pl. 1: 1]. Its layout is not regular, although the streets run mostly east to west and north to south. There are three distinguishable main functional zones (Medeksza 1999b, 120–121) amongst the structures examined so far [Pl. 1: 2].

Located to the north of the site are remains of port infrastructure. Residential quarters dating back mostly to the 1st century AD and following the layout of earlier buildings were discovered in the centre, along with a city square and baths. The south and southwest of the city is occupied by necropolises. The monuments investigated in this area belong to the oldest architectural remains. They were erected between the 2nd century BC and the 1st century AD. The youngest identified structure is a Christian basilica dating to the 4th–5th century AD and located in the southeastern outskirts of the settlement.

Residential Architecture

Most of the ruins uncovered so far are remains of houses in the form of vast foundations with paved courtyards. The spatial layout of the residential quarters predominantly follows the irregular road network and may be a result of terrain constraints [Pl. 2: 1]. Their functional design was typically inspired by the plan of Greek houses of the *oikos* type (Bąkowska-Czerner and

Czerner 2019, 74; Medeksza 1999b, 122). The main public rooms and courtyard were set on the same polygonal axis. The inner courtyards are mostly asymmetrical, enclosed by either an incomplete peristyle, or one or two porticos. The later houses often imitate Roman designs, while the earlier tend to emulate the Greek ones. Discovered among the remains of the structures was a significant number of architectural ornaments in a highly simplified form typical of an area under Alexandrian influence (Czerner 2009).

Construction Methods

The buildings were constructed using local limestone. The walls were built of regular blocks of standardised dimensions or rubble masonry. In both instances, the faces of walls were plastered with lime, which served to lend greater visual harmony to the architecture. Irrespective of form or size, all houses followed roughly the same building solutions. For the purpose of further analyses, these are introduced below in the description of the structural elements.

In general, similar construction solutions were widely used on the northern coast of Egypt, most likely due to the easily available local limestone. Houses erected the same way as in Marina el-Alamein might be found in Taposiris Magna and Plinthine (Boussac 2007, 445–479; 2015, 187–217), Marea (Kościuk 2012, 29–38; Babraj, Drzymuchowska and Willburger 2014, 45–62; Derda, Gwiazda and Pawlikowska-Gwiazda 2020, 531–550), and Alexandria (Rodziewicz 1984; Majcherek 2007, 201–212). Moreover, almost no remnants of dried or fired brick have been discovered in the context of residential architecture at these sites.

Foundations

The appearance of the foundations was determined during conservation works conducted in the northeastern corner of house H1. The remains discovered while reconstructing the walls allow a detailed description of the laying method (Medeksza *et al.* 2008, 105–108).

A construction of rubble masonry bound with clay mortar was laid in a narrow foundation trench. A gap of approximately 0.15 m between the wall under construction and the trench wall was filled with clay, although it is safe to assume that mudbricks had been used originally. The surface of the wall was coated with a layer of clay about 0.05 m thick. On top of this underpinning, transverse courses of limestone blocks were stacked as far as the base of the wall, which was masoned with 0.30 m wide blocks laid lengthways.

The transverse layer of limestone blocks was not present in the houses whose walls were constructed with rubble masonry. It is most likely that the walls were constructed directly on top of the rubble foundation secured with a layer of clay.

Walls

Single-skin walls of regularly shaped stone blocks were built using lime mortar, which probably served not only as a wall bonding agent, but also allowed shifting and adjustment of additional stones. The standard block dimension used in the city is approximately 0.31 × 0.31 × 0.60 m, roughly corresponding with the Roman foot measurements. Limestone slabs laid on their narrow side, which was only a dozen or so centimetres thick, were equally often used for the construction of partition walls. The faces of the raised wall were plastered with lime.

The rubble masonry wall construction technique could be observed during archaeological and conservation works carried out in house H9 (Medeksza 2001b, 5; 1999b, 133–134). Masonry facing blocks were arranged practically without the use of a binding agent, whereas the core-forming rubble backfill was liberally primed with a fairly thin clay mortar. The mortar would close gaps in the backfill and bind it together. Additional finish, plaster or polychrome, was applied only after the wall had been erected to its full height, and following the completion of the ceiling. The first layer of lime plaster contained thick rubble fractions and sank quite deep into the gaps between facing masonry, further binding the outer layers.

Sun-dried brick walls were masoned with clay mortar. Due to the influence of severe atmospheric agents they mostly did not survive to the present day or were destroyed shortly after their discovery. The outer surfaces of these types of walls were plastered with lime.

In all instances described above, the faces of walls would commonly be given additional finish. The one to three layers of plaster applied subsequently contained gradually finer grains of sand. Typically with the addition of gypsum powder, the last layer was smoothed out and acted as a base for murals.

Floors

The floors were built with approximately rectangular limestone slabs in a range of sizes. Their thickness slightly varied, averaging 0.12 m. The floor slabs were laid directly on compacted sand. No additional layers of crushed stone or hard core acting as a substrate were noted.

Roofs and ceilings

No preserved roofs or ceilings, nor any collapsed fragments of these structural elements, have been found among the ruins of the residential buildings within the site area. Based on the lack of ceramic roof tiles in the uncovered ruins, it is thought (Bąkowska-Czerner and Czerner 2019, 78; Medeksza 1999b, 124) that the roofs in Marina were built in the form of flat terraces rather than pitched roofs known from Greek culture. Traditional forms employed in residential structures in this region allow the use of both flat as well as pitched roofs, or – by covering public rooms with a pitched roof, while all others with a flat one – even a combination of the two.

The only clue which offers a plausible hypothesis in respect of the roof's appearance is imprints of palm trunk beams impressed in lime mortar in the collapse of Hellenistic baths (Czerner *et al.* 2016, 173). They suggest the use of ceilings or flat roofs, at least in public buildings, and confirm that the ancient citizens of Marina were capable of creating such structures. Further clues can be obtained by analysing the width of rooms, and based on known analogies.

Ceilings and flat roofs were a popular roofing method used in residential buildings in Ptolemaic and Roman Egypt. Examples of such solutions are found in Fayum (Boak and Peterson 1931, 26–27; Bresciani 2001, 65–70; Jouguet 1901, 389; Rubensohn 1905, 1–2), Dakhla Oasis (Bowen 2015, 231; Hope and Whitehouse 2006, 313–316), The Nile Valley (Kawanishi 2018, 6) or the Mediterranean coast (Derda *et al.* 2020, 558–560; Majcherek 2018, 40; 2011, 45; Rodziewicz 1984, 116). According to scientists, their construction was based on the use of irregularly shaped tree branches or palm tree trunks as ceiling beams. Placed on top of them were thatch bunches or palm-leaf ribs tied with hemp or palm fibre ropes, used as laths (the elements transverse to the beams). On this palm frame, leaf mats would be placed. The outer layer was most commonly made in the form of clay or, less often, lime daub. There are known examples of whole floors of sun-dried bricks or thin flagstones laid on daub (Jouguet 1901, 389; Rodziewicz 1984, 116; Derda *et al.* 2020, 558–560). Furthermore, the roof finish would remain a matter of choice. It was also possible to either leave the structure exposed or cover it with plaster.

However, it is worth noting that it is unlikely that all rooms in the houses discovered in Marina were roofed with the use of palm trunk beams, which are characterised by low load-bearing capacity. The extensive span of the main rooms indicates that they would have required intermediate supports, traces of which have not been found. Their measurements are as follows: H1 = 7.00 m (Medeksza *et al.* 2006, 101–104; Czerner 2011), H2 = 7.40 m (Medeksza *et al.* 2007, 86–88), H9 = 6.50 m, 7.35 m (Bąkowska-Czerner and Czerner 2019; Medeksza 1999a, 53–57), H9a = 6.30 m (Medeksza 1999a, 53–57), H10 = 6.65 m (Medeksza 2000, 48–51; Czerner and Bąkowska-Czerner 2020, 311–335). This may also suggest the use of imported timber with more suitable mechanical properties for the roofing process.

Stonework

As well as its application for the construction of walls and flooring, masonry was also used in the carving of architectural decoration in colonnaded porticos and an ornamental niche. Thresholds, reveals, and often door lintels were made of limestone. Dimension stones were utilised in the construction of subterranean structures, cellars and cisterns. Additionally, stone blocks also served as both steps and supporting structures in stairwells.

Demand for limestone

Many of the over fifteen structures identified as residential buildings (Bąkowska-Czerner and Czerner 2021) underwent thorough documentation and conservation. The double objective of the works carried out on the uncovered ruins was preservation as well as preparation for their *in situ* exposition and future tourist traffic demands. For our calculations, two houses previously subjected to a detailed architectural study will be used as examples. The structures are significantly different. House H1 bears characteristics of a regular plan and was built with limestone blocks. House H9, with its architectural layout determined by the available space, was built with rubble masonry.

House H1

House H1 [Pl. 2: 2] lies in the northern part of the site, in closest proximity to the port facilities out of all identified residential buildings. The uncovered remains predominantly date back to the occupational phase in the 3rd–4th century CE. The building is among the largest and most regular residential structures in the area, and occupies the area measuring approximately

22.23–22.33 (E–W) × 27.00–27.95 m (N–S). Located in the centre of the house is a spacious courtyard (10.40 × 12.80 m). The most important rooms were planned on the main axis of the building, which is also their axis of symmetry. Many of the other rooms surrounding the courtyard are of unusual shape, making their function difficult to determine and allowing for only partial reconstruction of the functioning of the house.

The remains of house H1 were discovered in 1986 (Daszewski 1990a, 17–18; 1990b, 110). The initial works encompassed documentation (Bentkowski 1991; Medeksza 2005, 108–109), identification of two occupational phases and theoretical reconstruction of the hypothetical appearance of the structures (Łużyniecka 1998, 28–35). The exploration and conservation of the remains then continued (Medeksza *et al.* 2012, 82–84; 2006, 101–104, 112–114), subsequently resulting in the publication of of a report on current research as well as the reconstruction of the two-storey decoration of the peristyle courtyard portico (Czerner 2011).

The estimation of the height of the building's both storeys (Czerner 2011, 139–140) was possible on the basis of the discovered remnants of architectural decoration. In accordance with the standard proportions of the pseudo-Corinthian order, the bottom columns measured 3.60 m, while the first-storey columns were 2.44 m. In total, the height of the portico was 6.645 m.

Having established the layout and height of the structures, we can now proceed to the calculation of the volume of stone used in the construction process [Table 1]. The calculations were made using the dimensions of the building that are known. Because only a few individual fragments of decoration survive from the first storey today, the following assumptions were made. The existence of a storey was assumed in the entire outline of the building with the exception of the inner courtyard and the main room, subsequent to its hypothetical elevated height. In the upper floor, it was further estimated that there had been stone floors, while the roofs had been finished with clay daub. In addition, it was finally concluded that stone walls would have been masoned to the full height of the house, although it is possible that the upper floors had been made of mudbrick or other typically lighter materials.

House H9

House H9 [Pl. 3] is located at the southeastern edge of the residential quarters. Its layout bears the closest resemblance to the Greek design. It features a vestibule, a courtyard and a representative room set on

Table 1. House H-1: calculations of used stone cubature, S. Popławski

Part	Calculation	Ashlars	Rubble masonry
Foundation	length × width × height (ashlars) 196.40 × 0.60 × 0.30 (rubble masonry) 196.40 × 0.80 × 1.00	35.35 m^3 –	– 157.12 m^3
Walls	surface × height 81.26 m^2 × 7.35	597.26 m^3	–
Paving	surface × thickness 498.30 m^2 × 0.12	59.80 m^3	–
Roofs/ ceilings	surface × thickness 362.90 m^2 × 0.045	16.33 m^3	–
Architectural decoration	volume of stone before carving 8 × (3.60 × 0.45 × 0.45 + 2.44 × 0.30 × 0.30) + 2 × (3.60 × 0.70 × 0.70 + 2.44 × 0.47 × 0.47) + 28.15 × 0.145 × 0.40	13.83 m^3	–
Subterranean structures	2 × (length × (width + height + arc length) × thickness) 2 × (7.70 × (2.60 + 0.65 + 2.60 × π/2) × 0.30)	33.88 m^3	–
	Σ	**756.45** m^3	**157.12** m^3

the same polygonal axis. Despite the district's irregular road plan, the house itself was built in keeping with the E–W direction and occupies an area of approximately 32.40–35.27 m long (E-W) and 18.85–22.72 m wide (N–S).

House H9 was one of the first structures identified, explored and subjected to conservation at the site. The works carried out at the site shortly after its discovery in 1987 initially focused on the creation of the conservation project (Fidecka 1991; Radzik 1991). They then continued further until the anastylosis of individual elements of the structures in the years 1995–1998 (Medeksza 1996, 44–52; 1997, 83–87; 1998, 73–76; 1999a, 53–55).

The research, carried out simultaneously with the conservation work, culminated in the publication of a complete study of the building remains (Medeksza 1999b; Bąkowska-Czerner and Czerner 2019).

Taking into account the preserved fragments of decoration, it is possible to recreate the height of individual structural elements. The most important room, *oikos*, is decorated with an *aedicula* located on the axis of the entrance. Its surviving fragments had undergone an anastylosis and were later restored onto the wall in 1999–2000 (Medeksza 2001a, 66–68). The height of the top of the niche was estimated at a minimum of 3.50 m, and bearing in mind the necessary space above the ornament, we know that the interior was even higher. The entrance to the vestibule leading to *oikos* was flanked by pillars, whose height was estimated at a minimum 3.75 m based on proportions specific to their architectural order. Accordingly, the height of the columns of the portico can be estimated at 3.06 m.

The information we have gathered about the layout and height of the buildings is sufficient to calculate the volume of stone used for their construction [Table 2]. In estimating the demand, it was assumed that the two main rooms (*oikos* and *andron*) and the vestibule were raised in relation to the others. In addition, the assumption was made that the second floor had existed only to a largely limited extent in the southeastern corner of the house, whereas the remaining surface of the flat roof had formed open terraces.

Table 2. House H-9: calculations of used stone cubature, S. Popławski

Part	**Calculation**	**Ashlars**	**Rubble masonry**
Foundation	length × width × height 186.85 × 0,8 × 1.00	–	149.48 m^3
Walls	surface × height (rubble masonry) 132.33 m^2 × 4.10 + 71.10 m^2 × 2.60 (ashlars) 5.08 m^2 × 4.10	– 20.82 m^3	727.41 m^3 –

Paving	surface × thickness 364.70 m² × 0.12	43.76 m³	–
Roofs/ ceilings	surface × thickness 85.30 × 0.045	3.84 m³	–
Architectural decoration	volume of stone before carving 2.07 m² × 3.45 + 16.0 × 0.145 × 0.40	8.07 m³	–
Subterranean structures	2 × (length × (width + height + arc length) × thickness) 2 × (3.90 × (1.40 + 0.90 + 1.40 × π/2) × 0.30) + 8.60 × (2.20 + 0.80 + 2.20 × π/2) × 0.30	27.17 m³	–
	∑	**103.66** m³	**876.89** m³

Calculation results

With the above assumptions, the estimated cubature of the material used in the construction of house H1 is 756.45 m^3 of limestone blocks and 157.12 m^3 of rubble masonry. For house H9, the values are 103.66 m^3 and 876.89 m^3 respectively. Considering these calculations, we can further conclude that the highest demand was generated by the construction of walls and their foundations. The other elements of the building proved to be insignificant in the overall calculations.

Conclusions

The obtained results are several times higher than the volume of limestone blocks obtainable in the process of carving of the subterranean tombs in the area of the site (Popławski 2020). In the case of the latter, the figures were closer to approximately 71.76 m^3 for a tomb with a smaller underground part and 209.60 m^3 for monuments with more extensive tomb chambers.

The surplus of limestone blocks from the construction of a single tomb was quite substantial even in comparison with the demand for the material during the construction of the houses. Nevertheless, it was not possible to complete a fully-fledged residential building relying exclusively on material obtained in this way. Thus, the search should continue for ancient quarries or bigger subterranean structures which would have provided enough building material. City cisterns are certainly a likely candidate and therefore, the possibility of utilising them as quarries should be evaluated in a separate analysis.

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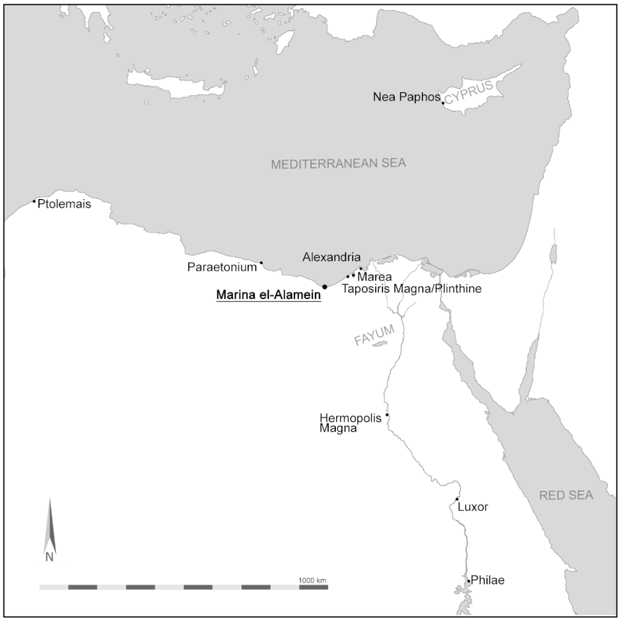

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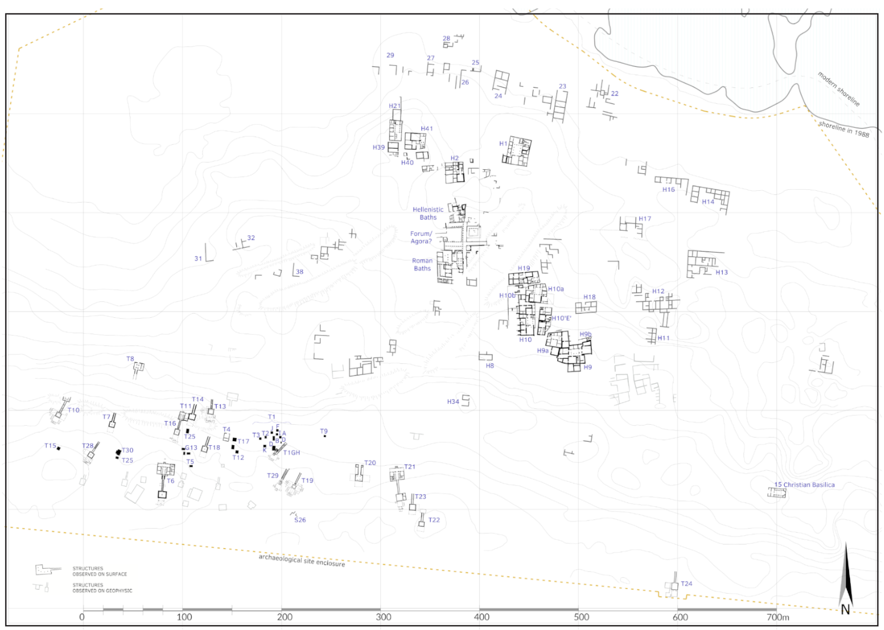
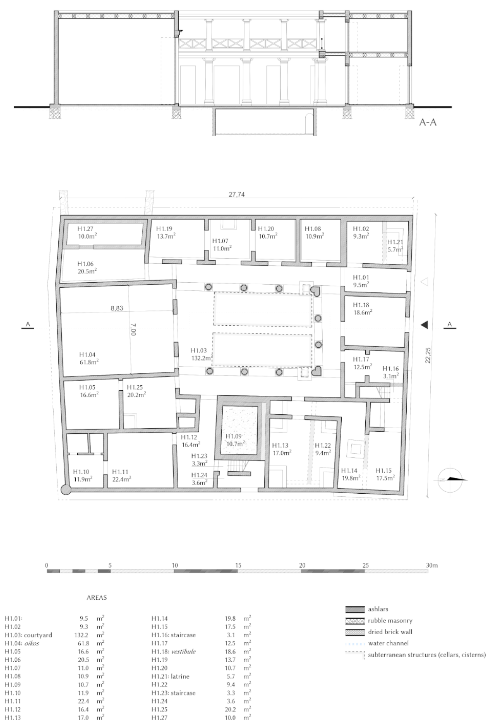


2

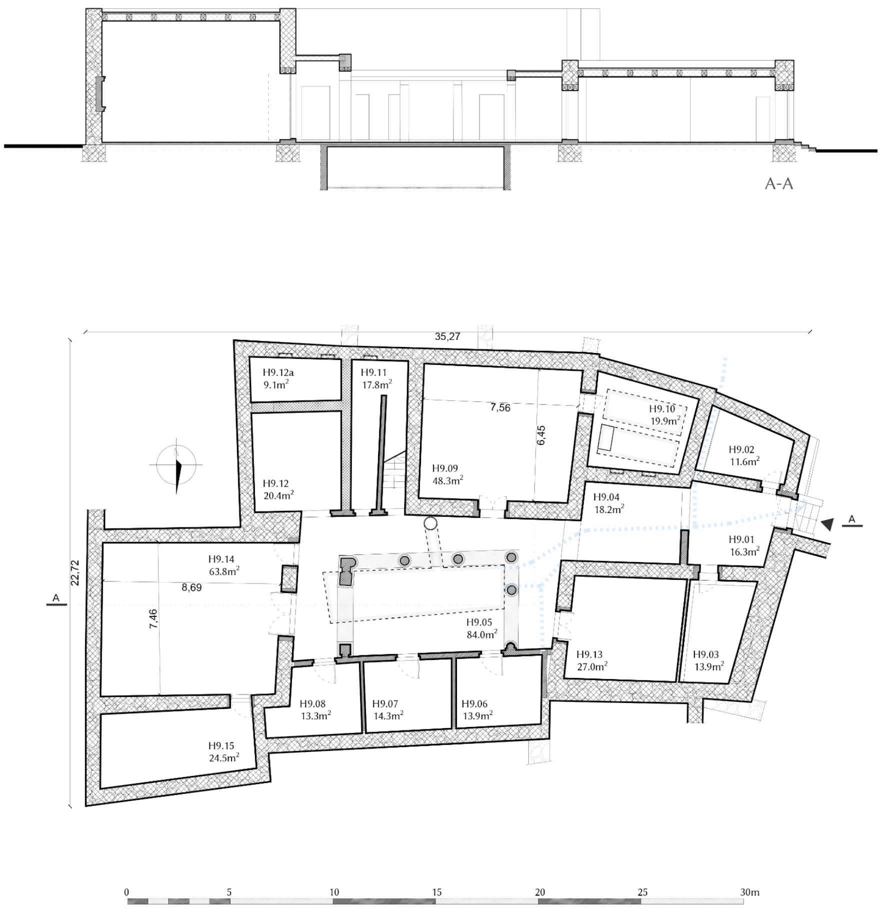
Pl. 1: 1 – Map of Egypt with the sites mentioned in the text, S. Popławski
Pl. 1: 2 – Plan of the Marina el-Alamein site, S. Popławski (after K. Majdzik, M. Krawczyk-Szczerbińska and R. Czerner)

1



2

Pl. 2: 1 – Ancient houses in Marina el-Alamein. Photo by the author
Pl. 2: 2 – House H-1, S. Popławski (after R. Czerner and M. Krawczyk-Szczerbińska)



AREAS

H9.01: *vestibule*	16.3m^2
H9.02: latrine	11.6m^2
H9.03: storage room	13.9m^2
H9.04:	18.2m^2
H9.05: courtyard	84.0m^2
H9.06	13.9m^2
H9.07	14.3m^2
H9.08	13.3m^2
H9.09: *andron*/*triclinium*	48.3m^2
H9.10: kitchen	19.9m^2
H9.11: staircase	17.8m^2
H9.12	20.4m^2
H9.12a	9.1 m^2
H9.13: living room	27.0m^2
H9.14: *oikos*	63.8m^2
H9.15	24.5m^2
SUM:	416.30m^2

ashlars
rubble masonry
dried brick wall
water channel
subterranean structures (cellars, cisterns)

Pl. 3 – House H-9, S. Popławski (after S. Medeksza)