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The Umayyad Bath Complex at Ḥammām as-Sarāḥ: Analysis and Interpretation

Abstract

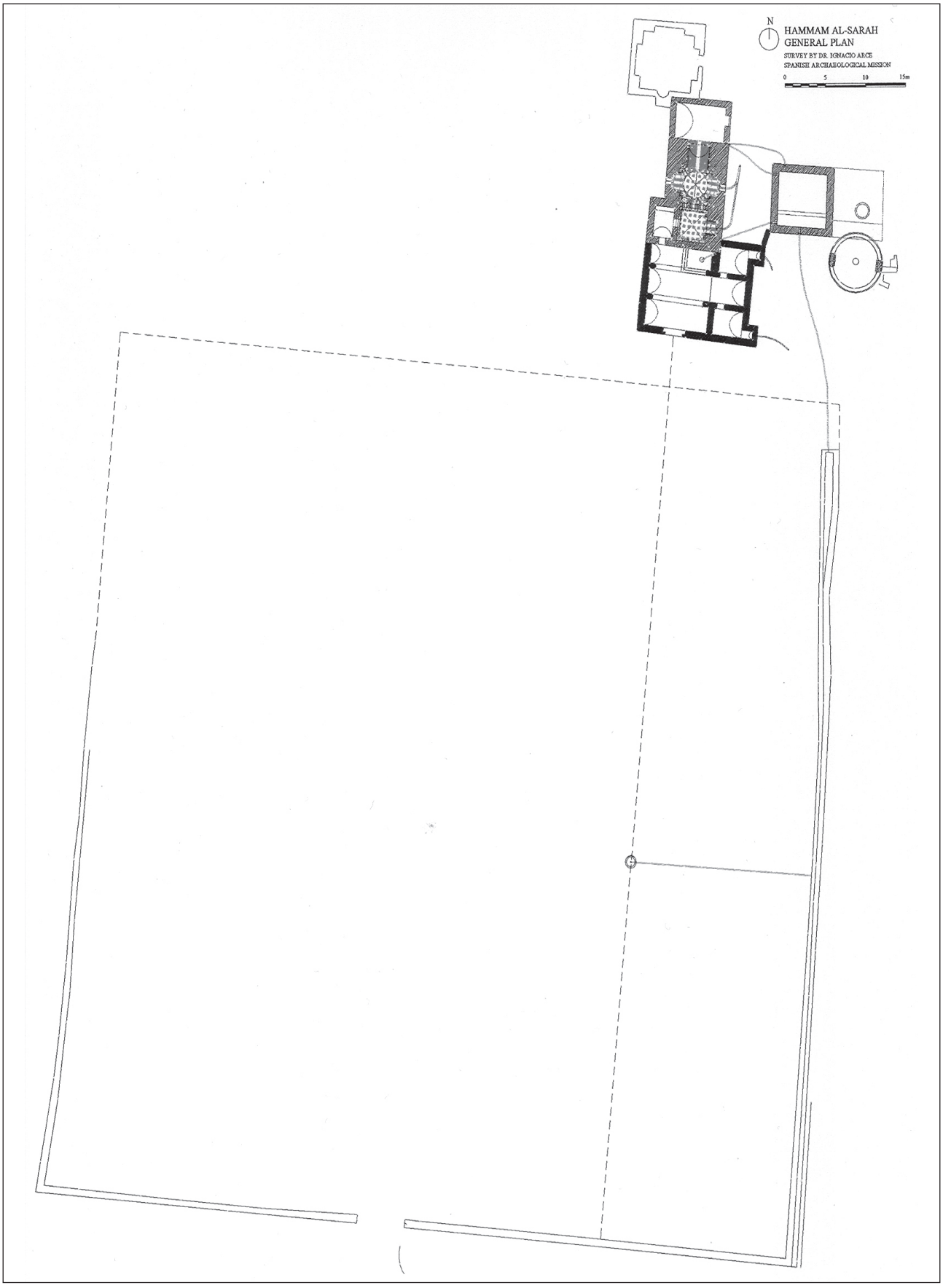
The aim of this paper is to present and review the Umayyad complex and bath-house of Ḥammām as-Sarāḥ, which has recently been excavated and restored under the direction of the author[1].

1.1 Location and General Description of the Complex[2]

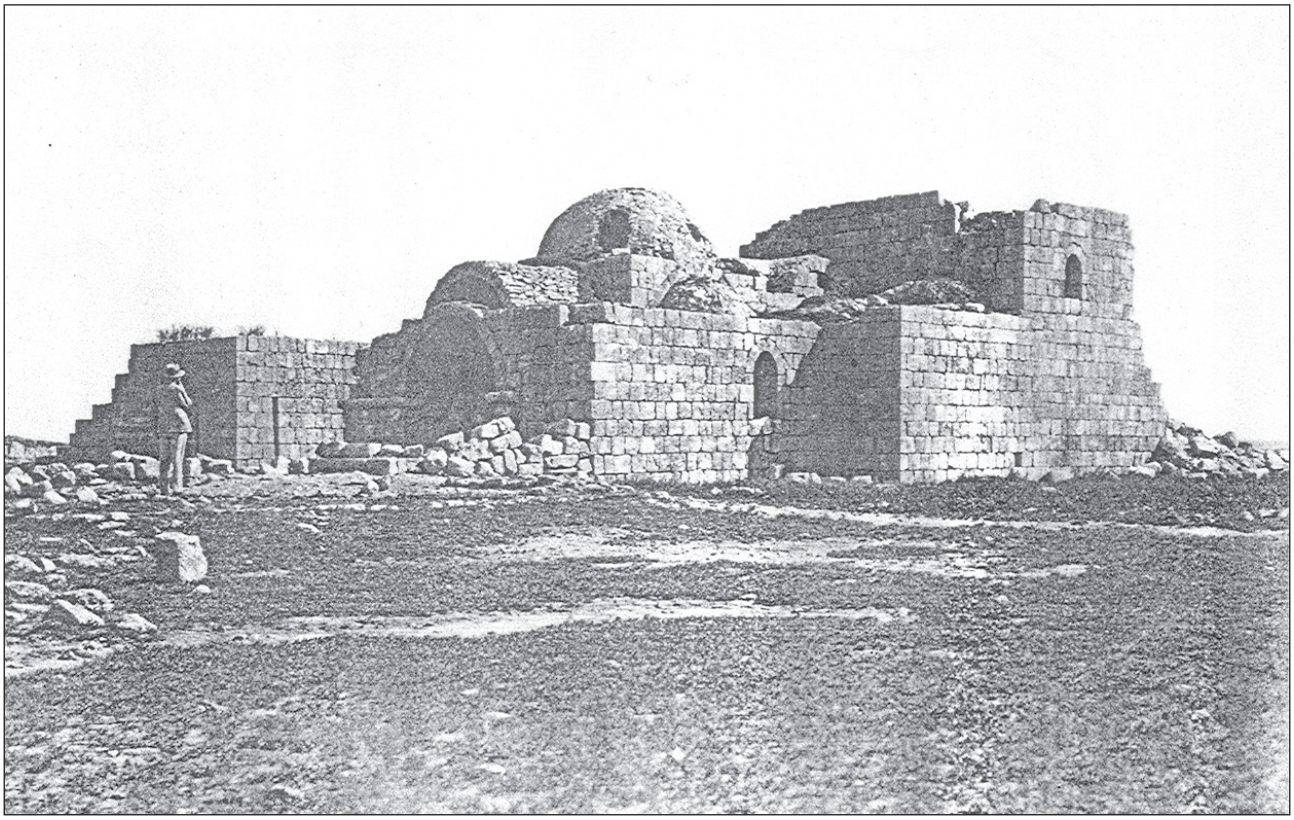
Hammam as-Sarah is located 56 km north-east of Amman and is related to the Umayyad palatial complex of Qaṣr al-Ḥallābāt, located three and a half kilometers to the west. It is composed of several elements: the bath-house itself with the adjoining audience hall, the hydraulic infrastructure and the walled garden (FIG. 1). a mosque was attached to the service rooms of the bath-house at its northernmost end at a later date, while some houses - so far undocumented - lay close to the asphalt road further to the north. The date of these additions is still being debated (owing to a lack of material evidence), although the mosque is clearly post-Umayyad.

The building was first discovered by Butler in 1905 and later described, photographed and surveyed by Creswell in 1926[3]. It was well-preserved until 1950s (FIG. 2), but it has been seriously damaged since then owing to massive looting that almost completely destroyed the building (FIG. 3). Excavation and restoration undertaken by the Department of Antiquities in 1974-5 prevented its complete ruin, although some of the elements were not successfully restored (owing to a lack of proper technical supervision [see Bisheh 1990: 225]), obscuring and altering in some points the proportions and structure of the building, especially with regard to the rebuilt *tepidarium* vaults (FIG. 7) and *caldarium* dome (FIG. 4). a thorough intervention of the building and complex has been carried out, at the request of the Department of Antiquities, as part of the excavation and restoration project at the Ḥallābāt complex directed by the author. The aims are to dismantle the emergency reconstructions built in 1974 (that encased the original remains within a newly built stone facing, constructed using a hard cement-based mortar) and to attempt to consolidate the structure, regaining both the original proportions and a mechanical balance between the original remains and the newly rebuilt elements to guarantee their structural equilibrium. Accordingly, a softer lime-based mortar is being used. It should allow the old and new sections of the building to behave as a whole, preventing differential movements and thereby guaranteeing its preservation. The analysis and de-restoration process carried out has provided an in-depth view of the complex

1. The excavation and restoration of these structures (and of the nearby *qasr* and mosque at Ḥallābāt) has been funded by the Spanish Agency for International Cooperation under the direction of the author. The Spanish Ministry of Culture (IPCE) provides further funds for ongoing complementary research activities. The length of this paper does not permit the more recent restoration works carried out on the building and the complex under the direction of Dr Arce to be presented; these will be the subject of a future paper.
2. See Creswell 1979: 498-502 and Bisheh1989.
3. The pictures from the Creswell archive at the Ashmolean Museum in Oxford have been a valuable source of information, as have those from the Documentation Centre of the Department of Antiquities of Jordan and those provided by Dr Bisheh from his excavations. I would like to take this opportunity to thank Drs Teresa Fitzherbert and Catrina Hamarneh, curators of these respective archives, as well as DoA Directors General Dr Ghazi Bisheh, the late Dr Fawwaz Khreyshah, Dr Ziad al-Saad and Dr Monther Jamhawi for their kind assistance and collaboration.



1. Ḥammām as-Sarāḥ. General plan of the complex, with the bath-house, the hydraulic complex and the enclosed garden.



2. Ḥammām as-Sarāḥ. View of the building in the 1950's. Chicago University.

3. Ḥammām as-Sarāḥ. View of the building in 1974 before the DoA intervention. DoA Archive.

4. Ḥammām as-Sarāḥ. Internal view of the building after the restoration. Note the reconstruction of the dome, and the northern arm of the tepidarium's cross vault, erroneously elongated in the 1974 restoration till the southern arch of the dome's pendentives. This area was originally occupied by the "venturi suction chamber", opened to the sky.

that allows a better understanding of how was it built and used. Ultimately, this will permit us to carry out a proper restoration of the remains that survive[4].

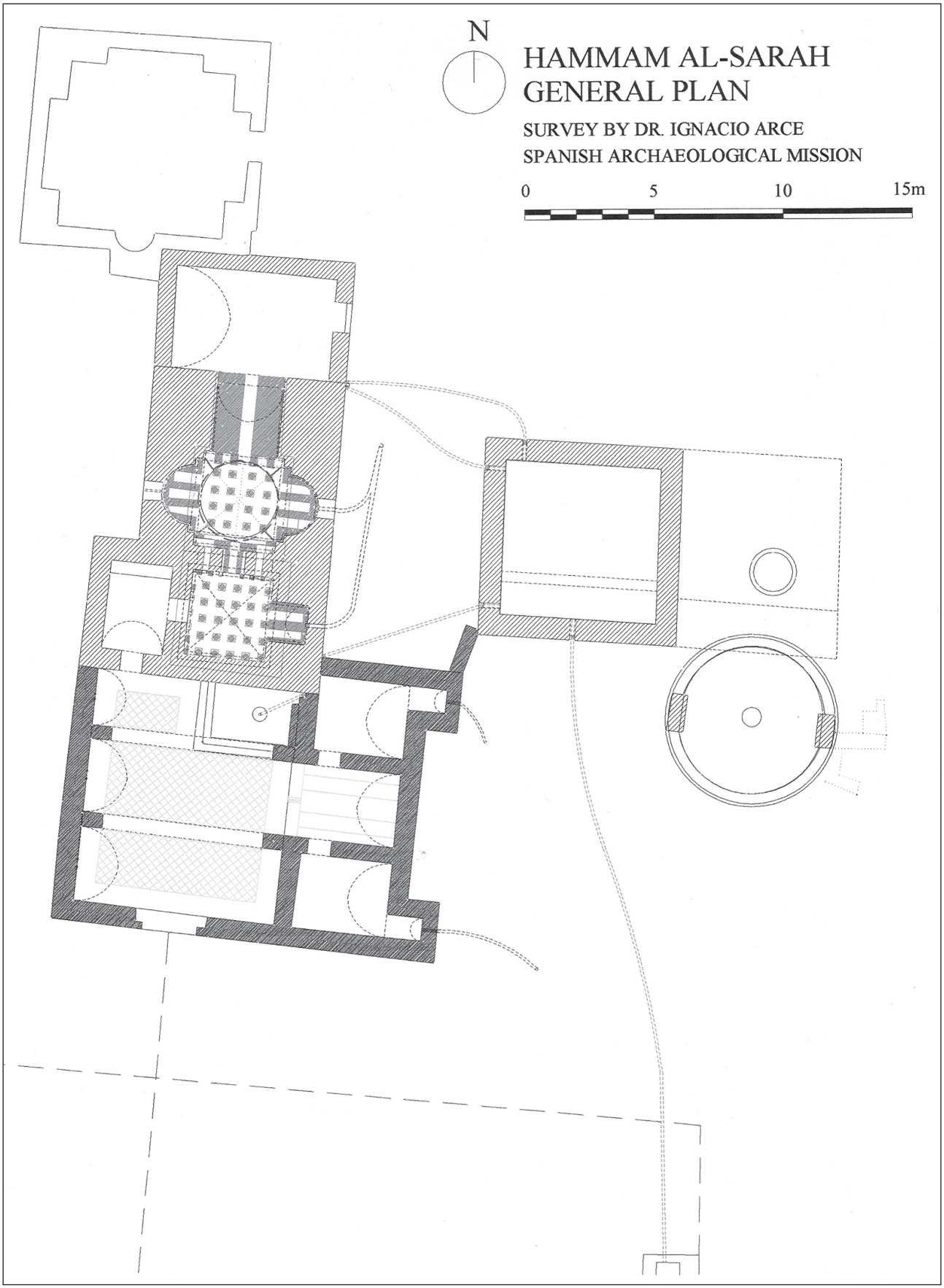
1.2 The Bath-House Building.

As pointed out by previous researchers, the structure of the bath-house at Ḥammām as-Sarāḥ is strikingly similar to that of Quṣayr 'Amra in plan[5], although the building technique of our structure, with its well-dressed and squared medium-sized stone masonry, is of better quality of that of 'Amra[6] (constructed of coursed unsquared stones and massive chips in the jointing), and the overall size of its rooms is larger. Other significant technical differences between the two structures will be the subject of further analyses. The two main sections of the building are the so-called audience hall[7] (actually a structure that also includes an alcove and the restrooms) and the bathing rooms proper, placed in a compact angular arrangement (FIG. 5). Material evidence supports the hypothesis that these two sections of the bath-house were built one after the other. The differences in building technique between the respective sections not only demonstrate this, but also indicate a lapse of time between both building phases[8].

1.2.1 The Audience Hall[9]

The so-called audience hall consists of a main rectangular room (7.82 × 9.1 m in plan), covered by three barrel vaults resting on two east - west diaphragm arches and the northern and southern walls of the room[10], plus an alcove with flanking resting rooms provided with latrines. The diaphragm arches (6.3 m in span and slightly pointed) spring from two low piers topped with quarter-round brackets (which are the only standing remains). Surprisingly, neither the piers nor the arches were bonded to the perimeter walls, but instead abutted them suggesting that they were probably constructed immediately

4. This is an ongoing project, the results and conclusions of which will be reviewed when the intervention is finished. I express my gratitude and recognition to my assistants, Mr Mohammad Nasser and Mr Ghassan Ramahi, and to the whole team for their commitment and support.
5. The recently identified Umayyad bath-house at al-Qastal, of which just part of the plan has been exposed, seems to share some similarities with al-Sarah and 'Amra in the arrangement of some rooms, especially the apsed alcove flanked by two lateral rooms that opened on to the hall (Bisheh 2000).
6. Ironically, this better standard of construction has led to its destruction by looters seeking to reuse its squared blocks.
7. This space recalls the so-called thermal basilicas that were built in some Late Antique bath houses, e.g. Sepphoris and Andarin. They served to facilitate passage, giving access on the one hand to the rest rooms and on the other to the bath itself.
8. The section with the bathing rooms was built first, with the hall and rest rooms being added later (see below).
9. Bisheh (1989: 225) designates this room an "audience hall", on the basis of its hypothetical use. To avoid confusion we use this term as well.
10. For a detailed discussion about the building techniques, see Arce 2003a, 2006 and 2007a.



5. Ḥammām as-Sarāḥ. Detailed plan of the building, the hydraulic system, and the late mosque.

after the perimeter wall of the room itself[11]. The central and southern vaults are very similar, spanning 2.88 and 2.85 m respectively, while the northernmost vault spans a distance of just 2.2 m. a quarter-round moulding runs over the crown of the diaphragm arches and all around the perimeter walls, marking the impost line of the vaults (very similar to the nearby mosque at Qaṣr al-Ḥallābāt). Above it, two courses of well-dressed limestone *voussoires* can be seen in Creswell's photos (#EA_CA_5401). We do not know for sure if the three barrel vaults were built with squared masonry up to their crowns (similar to those from the central alcove and the lateral rooms), or if their upper sections were completed with thin limestone slabs in brickwork fashion (as in the bathing rooms), or even using lightweight concrete made of lime mortar and volcanic tuff (as in the contemporary nearby barrel vaults at Ḥallābāt mosque). The technical and constructional similarities between al-Sarah and Ḥallābāt mosque, with identical springing of the three barrel vaults (*i.e.* resting on parallel diaphragm arches), lead us to consider the latter solution as the most likely, as it is the lightest and consequently the most stable, but this is by no means certain. The room was lit by three arched windows in the upper section of the western wall, under the crown of these three barrel vaults.

In the eastern corner of the room there was a small, sunken fountain-pool (Ar. *fisqiya*), measuring 2.9 × 2.05 m in plan with two lines of steps surrounding its southern and western sides[12], that was originally lined and paved with marble slabs. It has a central cylindrical pier consisting of two superimposed split drums with a hollow core that fed the fountain by means of a clay pipe coming from the elevated water tank (another pipe located in the south-west corner drained the pool outwards). Bisheh reports traces of four lead-filled holes on the upper drum, indicating that a basin was probably placed on top of it. The traces of marble statues found in the pool itself (Bisheh1990: 227 and pl. 63a-d) might have been part of this decorative fountain[13]. On the northern wall just above the pool, traces of a (now illegible) inscription in red paint can still be seen. The fact that it would have been covered by the marble panelling of the pool (as holes in the wall to host supporting cramps demonstrate) makes it an odd feature, perhaps best explained by the hypothesis that the building was constructed in two stages (see below).

On its eastern wall, between the two diaphragm arches, a vaulted alcove (2.85 m wide and 4.25 m deep) opens to the main hall through an arch. As at Quṣayr ʻAmra, this recess would have been the focal point for the audiences that may have taken place in this room. Its vault was built with finely dressed stone masonry, springing from a moulded cornice This alcove is flanked by two rest rooms, also vaulted (2.9 m wide by 3.5 m long) that are entered through doors with stilted relieving arches[14] (now disappeared, but visible in Creswell photographs #EA_CA_663 and 5401). Both were illuminated by three narrow rectangular windows, two in the lateral walls and one in the rear wall. At the back of these lateral rooms, in the outer corners, there are two rectangular recesses (0.9 m wide by 1.4 m deep) projecting beyond the eastern façade. These were also covered by small barrel vaults and were used as latrines. The barrel vaults of the alcove, rest rooms and latrines were built with well-dressed voussoires, as can be also seen in the historical images from the Creswell Archive (photographs #EA_CA_5401 and 5402).

11. This can still be seen today at level of the piers, but in earlier pictures from the Creswell archive (photo #EA_CA_663) it can be seen how it also occurs in the upper section of the arches.
12. The wall flanking the eastern side of the pool was built of thin pieces of roughly hewn limestone (similar technique to that of the vaults and dome of the bathing rooms), thereby doubling the masonry wall of the room. The northern wall (built of ashlars) was the location of the red painted inscription, later obscured by the marble covering this section of the wall.
13. This fountain pool could have functioned as a cold plunge-pool, typically placed in the *frigidarium* of the traditional Roman baths.
14. A similar relieving arch is found at Qaṣr al-Ḥallābāt (pre-Umayyad phase) and its Umayyad mosque, as well as in the Umayyad structures at Amman, Harrane and Qastal. I propose a Yemeni origin for this distinctive architectural element (alien to the Syrian tradition before the second half of the 6th century AD).

Although one would have expected to find the entrance to this main hall in the western wall, *i.e.* in front of the alcove (as at Quṣayr ‘Amra), somewhat unexpectedly the door is in the center of the southern side. This unusual arrangement, which forces the visitor to turn sharp right to face the alcove, finds a logical explanation when the complex as a whole is taken into account, *viz*. the location of the door is determined by the arrangement of the walled garden and its fountain, axially aligned with the door. In contrast to Quṣayr ‘Amra, where the internal alcove (the so-called ‘throne alcove’)[15] determined the location of the door, at Ḥammām as-Sarāḥ the external garden influenced the position of the entrance.

The jambs of this door were decorated with an unusual style of alternating concave and convex fluted mouldings, similar to those found at Ḥallābāt mosque[16] and on the porch of the bath of Khirbat al Mafjar. At Ḥammām as-Sarāḥ the decorative patterns reached a level of complexity not seen in the previous cases. The lintel was a superb re-used Roman element decorated with a *tabula ansata* and two knotted wreaths (found broken and now restored).

Linings and Pavements

The pavement of the main hall consisted of a frame of marble slabs defined by the bands between each pair of opposed piers as well as by the perimeter of the room and the edges of the pool, while the rectangular sections in between were paved with square stone tiles (24 × 24 cm) placed diagonally. This created a chessboard pattern of alternating white and pinkish colors, corresponding to the two different kinds of limestone used. We can elicit this scheme from the imprints left in the mortar bedding and from some remains still found *in situ*. At the south end of the western wall, near the corner, a drain pierced the wall at the floor level. Access to the alcove or ‘throne hall’ is defined by a step with a stone threshold (51 cm wide). Two square depressions in its ends - beside the lateral walls - indicate that two pilasters flanked the entrance[17], while a central channel (*misrab*) drained its floor towards the main room. The rest of the alcove would have been also paved with marble slabs, as five longitudinal bands can be identified in the mortar bedding. The lateral rooms had mosaic floors with a pattern of diagonally placed squares (some traces still survive in the northern one). The latrines’ floors were 20 cm higher than the mosaic ones of the lateral rooms and were paved with marble slabs with a central hole. Bisheh (1990: 228) reports that run-off from the lateral rooms was channelled into the latrines through pipes (7 cm diameter) running under the recesses, so as to use waste water from the lateral rooms for flushing. Unfortunately they have now all gone.

Stucco Mouldings

The scarcity of stucco found during the excavations carried out by the Department of Antiquities (Bisheh 1989: pl. 61-62), and the facts that most of the walls were built of finely dressed stone-masonry and were decorated with carved mouldings, indicate that this decoration was used mainly to frame doors and windows (some of the fragments retrieved correspond to arched elements). Traces of stucco framings for glass *civas* and recently discovered fragments of flat, coloured glass suggest that the windows were glazed in order to facilitate control of the temperature of the rooms.

1.2.2 The Bath-House Rooms

The rooms corresponding to the bath-house

15. This name is derived from the depiction on its back wall of the Caliph seated on a throne and under a *fastigium* (see Almagro et al.1975). Accordingly, it was assumed that this was the place where a throne (if any) to preside the audiences offered in this hall would have been placed.
16. The restoration of the Ḥallābāt mosque (also directed by the author) has confirmed the close relationship between these three structures in terms of building techniques, spatial conception and individual decorative motifs. This suggests that the same architect may have been responsible for the three buildings (or, more precisely, the later additions and transformations made in these structures).
17. These could correspond to a screen to seclude the alcove, or might even have been an alternative location for the marble statues found amongst the rubble in the nearby pool.

proper are grouped in an angular setting, consisting of two heated rooms (*caldaria*) and their respective *hypocausta* aligned with the *preafurnium* (furnace; Ar. *furun*), while a room without *hypocaustum* is placed laterally in relation to the second heated room in a compact block. These three rooms have been usually interpreted according to the traditional basic scheme of *'caldarium',* '*tepidariu*m' and '*frigidarium'*, with some discrepancies relating to the last[18]. The fact that the cold water tub[19] disappeared from this last room and benches were added to it indicates a change of use. This latter room might have been used as a changing and waiting room before the warm rooms, in order to get the body used to the hot temperatures (it would have been warmed indirectly by heat coming from the latter)[20]. The *caldaria* (*caldarium* and *tepidarium*) might respectively be described in functional terms as a *sudatorium* and *destrictarium*.

The disappearance of a '*frigidarium*' as traditionally understood, plus the location of the cold-water bathtub (transformed into a decorative fountain) in the main hall[21], recalls the Late Antique baths of Syria, demonstrating their influence on the transformations that led to the mediaeval *hammam*. Furthermore, this change would be consistent with the hypothesis proposed by G. Charpentier (1995: 231-3) that technical changes were developed in the Levant from Late Antiquity onwards, *viz*. the introduction of a mixed wet / dry heating system. This would have combined the traditional 'dry heat' generated by the Roman *hypocausta* with 'wet heat' created by injecting steam. This steam would have been generated in a basin above the furnace and been introduced into the *caldarium* / *sudatorium* through an opening in the top of the wall that separates it from the nearby furnace (as can still be seen at Quṣayr 'Amra). This would thus have been the first step in the development of the true mediaeval *hammam,* which was conceived as a bath with wet heat. This technical sophistication accords well with other technical innovations at Ḥammām as-Sarāḥ. For example, the semi-circular bathtub recesses in the *caldarium* and the rectangular example in the *tepidarium* do not project outwards (as at Quṣayr 'Amra)[22], but instead consist of a compact block of masonry, on top of which the vaults and dome were raised. This innovation would have prevented heat loss and made the building more thermally efficient.

This new functional distribution matches also better with the Arabic medieval terminology used for baths' spaces in the standard medieval *hammam*[23]: *Maslah* (a sort of *apodyterium* with access to the latrines and to the proper bath rooms –that we could assimilate to the "audience hall"); *Bayt awwal* or *Wastani barrani* (an unheated room next to the warm ones, used as a cloakroom in wintertime); *Wastani Juwwani* (a warm room devoted to rubbing and depilation; and *Juwwani* or *Hararah* (the hot room close to the furnace and fitted with bathtubs).

The Transition Room / Apodyterium[24]

As mentioned, this small room (2.40 × 3.48m

18. Bisheh, according to their apparent use, designates them "*caldarium*", "*tepidarium*" and "*apodyterium*" (Bisheh 1989: 228-9).
19. The bath tub is replaced by a pond, with added decorative value, and incorporated into the *apodyterium* itself, which could in turn have functioned as an audience hall justifying this decoration.
20. According to the temperature shift we could describe this room as a type of '*tepidarium*', while if we only take into account its use as a changing room we should follow Bisheh and call it '*apodyterium*'. In order to avoid confusion, we will use the term 'transitional' or 'changing room'.
21. Equivalent to Late Antique thermal basilicas, which also incorporate cold water tubs.
22. We assume that Quṣayr 'Amra is earlier than Sarrah, being a sort of intermediate prototype following Late Antique models. Sarrah, being slightly later in date, would represent a further improvement of some of these innovations.
23. This detail was pointed by Oleg Grabar when analyzing the function of the different rooms in the Bath-house at Qasr Al-Hayr al-Sharqi (see Grabar et al. 1978).
24. As we have seen, we could consider it the antecedent of the medieval *Bayt awwal* or *Wastani barrani.*

in plan) would have been used as a changing (cloak), tempering and waiting room, thus an *apodyterium*, and not as a proper *frigidarium,* because the cold water pool or bathtub that should have existed here has disappeared.

It was covered by a barrel vault with its axis along the main length of the room (*i.e.* north-south). The first springing courses in both sides of the vault are of finely dressed stone, while the rest of the vault is built with thin roughly cut wedge-shaped limestone pieces, set likewise a brickwork vault. The springing line is not marked by any cornice moldure. This section of the vault was internally plastered. Traces of mural paintings can still be seen on this plaster. It is not clear if the walls, of fine limestone coursed masonry, were plastered and painted as well, although it is probable. Externally, the vault was plastered as well with an impervious lime mortar with crushed bricks/pottery that provided it with a characteristic pink color. The room is entered from the northwestern corner of the audience hall from a door 88cm wide and 1.66m high. Against the north wall was built a bench 80cm wide and 40 cm high. It is possible that a small window would have been opened at the top of this end wall just under the crown of the vault to illuminate the room (other option would be some *oculi* piercing the vault –although does not seem the case as they do not exist in the *tepidarium*)[25]. Water was drained out through a hole in the West wall. a door (80cm wide and 1.66m high) opened in the East wall gives access to the *tepidarium/ destrictarium.*

The Tepidarium / Destrictarium

It is an almost square room (3.31 × 3.14m in plan)[26] covered by a cross vault (following the standard vaulting scheme of bathhouses in the Umayyad period). It has a recess in its eastern wall (1.55m. wide by 1.48 m. deep)[27] covered by a barrel vault, that hosted a bathtub (a drain at the floor level of the back wall connected to a an outdoor channel running northward was used to empty it).

This warm room, hypothetically used as *unctuarium/destrictarium* (for anointing and rubbing)[28] was entered from the Transition room through a door in its E wall, creating thus an angular circulation scheme. This "bent" scheme is apparently intended to prevent the formation of air streams that would disturb the different temperatures that should be achieved in each room of the bath. This circulation scheme is continued with the aligned access between the *tepidarium/ destrictarium* and the *caldarium/ sudatorium* facilitating the circulation of hot air from the furnace. Its floor (*suspensurae*) was resting in its central section on a grid of 5×5*pilae* made of cylindrical bricks (28-29 cm in diameter and 5/6cm thick)[29] built on a square brick (29×29×5cm side)[30] intended as a base. On top of them two additional square bricks were placed. These supports are arranged in lines, being also connected in their upper sections. The spaces between these supports are spanned by two *pedal*-size bricks leaning against each other, defining a kind of series of parallel linear arcades of angular arches, being after covered by the *suspensurae* bricks (probably of bigger dimensions)[31].

25. At Quṣayr 'Amra the vaults of the audience hall, the lateral rooms flanking the throne alcove, and the *tepidarium* are pierced with *oculi* made with clay pipes.
26. With the wall linings that conceal the hot-air wall chambers the dimensions would be 2.95 × 3.08m
27. Taking into account the wall linings they would become 1.36 × 1.5m respectively.
28. Thus could be seen as the antecedent of the medieval *Wastani Juwwani*.
29. Some of them present in their face an "L" (a gamma letter?) finger-incised in the clay before firing.
30. Some present diagonal lines (double and single ones) incised also with the fingers. Other bricks bear symbols resembling a "t" and a "b" combined in the same piece.
31. A fragment of a brick of 42.5cm long and 6.5cm thick (it is not possible to verify its original width) is still preserved in the remains of the floor (*suspensurae)* of the *caldarium*. If they would have been square they would be slightly smaller than the standard Roman *sesquipedales* 44.4cm square (1 ½ of a 29.6cm foot). We could thus consider them *sesquipedales* of a foot of 28cm.

In the northern and western perimeter of the room (corresponding to the areas of access and major circulation), the *suspensurae* was resting on rectangular pilasters of brick built against the wall which were connected in its crown with brick-made arches. The dimensions of the bricks used in these pilasters vary between 17×17×5cm and18×18×5.5cm[32]. In the northern section were placed aligned with the opening connecting the hypocausts of the *caldarium* and the *tepidarium* to allow the circulation of warm air without obstacles. The recess for the bathtub was heated as well by means of two channels built with bricks in its floor and the heated walls. a small channel connects the SE corner of the *caldarium* with the N. wall of the recess of the *tepidarium*. It was apparently intended to drive hot water into this warm bathtub (although it could have also supplied extra hot air to the heated wall chamber of the recess).

The walls were also heated by means of a hot-air chamber created between the final wall-lining and the masonry wall itself, up to a height of 2.45m above the floor level. At this height the walls are offset, overhanging approximately 12-13cm so as to create that hot air chamber. In some areas it seems that hollow clay *tubuli* (box flues) may have been used, but none of them remain *in situ* except a sample in the *caldarium*. In other sections of the walls, it seems that these chambers might have created using smaller hollow clay elements, or by the final marble slabs (maybe in combination with *tegulae mammatae*) due to the presence of the holes where the metal cramps to hold them would have been fixed. This last hypothesis is based also in the absence on the walls of the characteristic traces of shoot that usually leaves the imprint pattern of these *tubuli*.

In the overhanging section of the walls were built several grooves to host the cylindrical clay pipes that acted as chimneys for the hot air circulating in these wall chambers coming from the *hypocaustum*. The three built-in channels than can be seen in the upper section of the southern wall have widths that vary between 13 and 15cms. Inside these, ceramic pipes 10cm in diameter were placed, fixed with mortar that was finally flushed with the surface of the wall itself. There were another two of these flues in the northern wall, flanking the door towards the caldarium, which we have identified after the research conducted. These ones end at the upper edge of the chamber open to the sky that we will describe below.

This northern wall, including the door lintel and all the area above it, had almost completely disappeared due to the stone looting (FIGS. 4, 7a). Nonetheless, in the upper section of this wall that separates the *tepidarium* and the *caldarium* still could be seen evidences that permit to elicit the existence of a singular chamber open to the sky (FIG.7b) created inside the thickness of this wall. This hypothesis was confirmed by the plans and section drawn by Lh. Vincent[33] in 1926 and the pictures published by Creswell (_ 1979 figs. 553 and554). This unusual chamber had been completely obscured with the awkward reconstruction of the north section of the cross vault, projecting it until the arch of the *caldarium* pendentives, linking both structures (FIGS. 4, 7a). The two aforementioned flues which are the final exit for the fumes and hot air circulating in the *hypocaustum* and in the wall chambers, ended at the upper edge of this open chamber. The only explanation for this chamber open to the sky and the related flues, is that it was intended to force the circulation of the hot air by means of the "*venturi*" effect[34] created by the wind blowing on it: The vacuum created by the wind in that chamber generates also a depression at the mouth of the flues, suctioning the air and

32. Their sides show the imprint of mould, thus they would be square bricks of 18×18×5.5 or 17.5×17.5×5cms made on purpose (*i.e.* slightly smaller than the standard Roman *bessales* (19.7cm square). Nonetheless, some of them might have belonged to bigger bricks, being cut to fit those dimensions: In the area between the *tepidarium* and the *caldarium* can still be seen bricks of 16×22×5cm –although these seem to have been cut from bigger ones.

33. In the "AB" section drawn by Vincent, this chamber is clearly drawn, although no explanation of its function is given (see Creswell 1979: fig554).

34. Atomizers that disperse perfume or spray paint (airbrushes) and steam siphons, that use the kinetic energy from the flow of air or the steam pressure, respectively, to create a partial vacuum, work on the same principle.

fumes inside it, forcing thus the circulation of air and smoke in the whole system[35] (See FIG.7b).

Thus, the location of this device at the end of the hot air circuit would help to guarantee and regulate the circulation of air, that otherwise would make the whole system inoperative. Without this system to force the hot air and smoke circulation, the areas far away from the furnace would not be heated at all, preventing the whole system from functioning properly.

The cross vault that covers the main space of the *tepidarium* was also built, as in the case of the barrel vault of the *apodyterium*/ transition room, with thin wedges of roughly-hewn limestone (FIG.6). Just the vault springers are built with four courses of well dressed stone each, which help to define the geometric shape of the rest of the vault (with slightly pointed arches in section). It is clear that the plaster with its mural paintings (remains of which can still be seen on it) were running all over both sections of the vault and the upper sections of the walls as well. This painted rendering would have stopped at the height where the marble slabs lining the lower section of the walls ended, which corresponds to the heated section of the walls[36]. The original north and south sections of the cross vault were still standing while the eastern and western ones collapsed and were awkwardly restored in 1974[37].

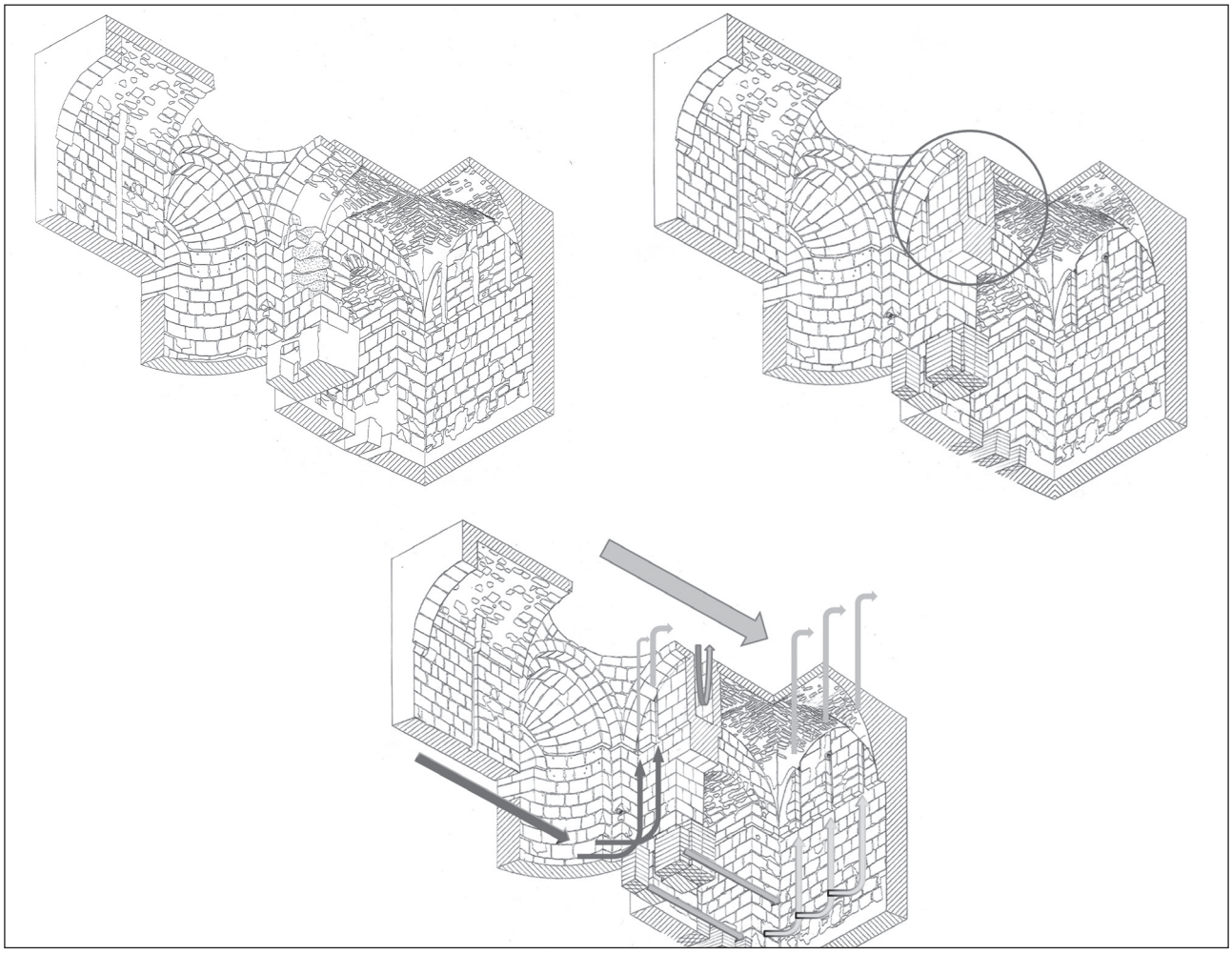
The barrel vault above the recess had disappeared also due to the looting, being rebuilt in 1974 with a wrong depressed profile and using solely crudely hewn limestone blocks. Its actual

6. Ḥammām as-Sarāḥ. Internal view of the building before the restoration. Note the remains of the lateral semi-domed recesses, the pendentives, and the *tepidarium*'s cross vault in the background. DoA Archive.

35. The flues opened at the upper edge of the chamber to get benefit from the vacuum generated in it. Otherwise, if they would have ended/opened at its lower/bottom area, they would have collected rainwater or even worse: they would have prevented the hot air and smoke from exiting the flues due to the pressure of the wind entering the chamber, neutralizing the desired effect.

36. A stucco or marble cornice might have marked the horizontal limit between the marble and the upper plastered and painted areas.

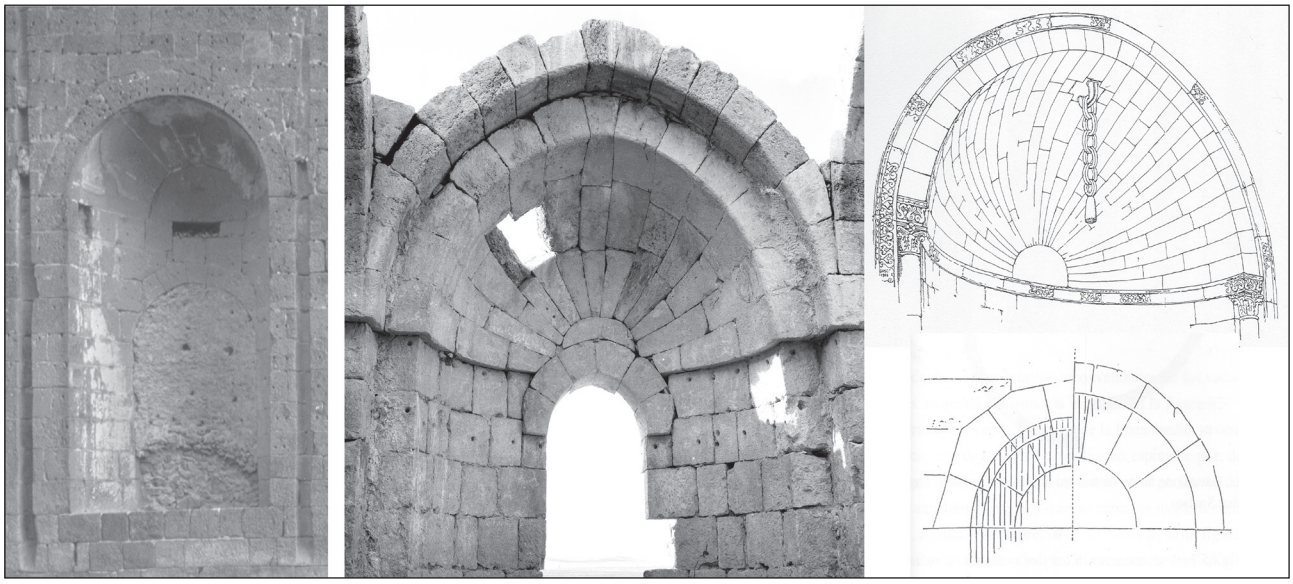
37. As mentioned, in this restoration, the northern section of the vault was projected connecting it with the southern arch of the pendentives of the caldarium dome, obscuring the original arrangement of the structures in between them.



7. Ḥammām as-Sarāḥ. Axonometric sections.
   a) Condition after the 1975 restoration: Notice the erroneous reconstruction of the northern arm of the *tepidarium*'s cross vault, elongated up to the caldarium pendentive.
   b) Present condition after de-restoration of the 1975 intervention and new restoration: Note the chamber open to the sky between the *tepidarium* and the *caldarium*. It was used to force the circulation of the smoke and hot air in the system, thanks to the suction created in the vertical flues coming from the *hipocaustum* that open at the top end of the chamber, due to the *"venturi"* effect (depression) created by the wind blowing above this chamber.

shape and the building technique used originally can only be elicited from the few remains *in situ* and the pictures available: Two complete courses[38] of finely dressed voussoires from the northern springer of the vault (and the first one from the southern one) are still *in situ*. In the upper face of the western wall of the *tepidarium*, the stones that were leaning against the extrados of this vault still stand, offering the exact profile of its extrados (slightly pointed –with a distance between arch centres equal to1/10 of the vault span), and demonstrating that the face of the vault (the frontal arch opening to the *tepidarium*) was built solely with finely dressed voussoires. In Creswell's photo (#EA_CA_5402), it can be seen that the inner and back sections of this vault were nonetheless, built with hewn thin slabs of limestone in a brickwork fashion (similar to the barrel vault of the neighbouring *apodyterium* or transition/changing room –which also has well dressed voussoires in the springing courses). Finally, we have the parallel sample of the barrel vault over the furnace area, built with the same technique, the external edge of which

38. These courses run from the front till the back of the vault, overhanging the precedent courses to allow the creation of a heated wall chamber (like in the rest of the *tepidarium*). The existence of this heated wall chamber in the recess is confirmed as this offset of the upper courses occur also at the back of the recess and the width of this offset is constant (12-15cm) in all the walls.



8. Semi-domes with fan-like joints radiating from the back. a) Shabha (Philippopolis) Roman Baths; b) Ḥammām as-Sarāḥ (DoA Archive); c) Khirbat al Mafjar (from Hamilton 1959); d and e) Ledja and Jerash (from Choisy 1883).

is also faced with a well dressed masonry arch (see Creswell's photo # EA_CA_558). We can conclude thus, that this solution was also the original one for this vault.

The Caldarium / Sudatorium

A door (also 80cm wide) in the centre of the northern wall of the *tepidarium* gives access to the *caldarium,* a room originally covered by an *umbrella* dome on pendentives, and flanked by two lateral semi-circular recesses pierced with arched windows and covered by semi-domes.

The plan is quite complex and presents some dimensional irregularities[39] giving as a result an irregular setting for the dome: Actually the room has a cruciform plan with an apparent square base setting of 3.7 by 3.7m, corresponding to the maximum length of its two arms. The problem is that the southern arm (the one towards the *tepidarium*) is longer (deeper) than the other three ones (49cm deep, instead of the average 29cm of the other three). This gives as a result that the dome base defined by the respective four arches spanning over these shallow "arms", is not a proper square, as expected, but a rectangle (2.78 × 2.98m) oriented north-southwards. This fact is partly disguised by the overhanging upper sections of the walls (that coincide also with the springing lines of arches and vaults), which are offset outwards (like in the *tepidarium*) to allow the creation of hot air chambers in the walls of the room[40]. As a result, the width of the northern and southern arms (and the corresponding span of the overhanging arches that cover them -3.18m and 2.98m respectively) is less than those of the eastern and western ones (2.90m for the arm width and 2.78m for the span of the overhanging arches respectively).

The pendentives' arches are slightly pointed, with a distance between centres of one tenth of the actual span. The semicircular recesses' walls present the same offset solution for the hot-air chambers. Accordingly, although their diameter at the base is 2.35m, the arches above them have a span of 2.23m at the springing line. The related semi-domes have also a slightly pointed section, but their most remarkable characteristic is the disposition of their voussoires with radial joints stemming out from the back of their base (FIGS.7, 8). This solution can be also seen at the central niche of the audience hall of the bath of

39. These irregularities are probably due to some dimensional confusion during the process of its laying-out, or some deliberate alterations to guarantee its stability (see below).

40. This offset is not even uniform, and varies between the 10cm in the central areas and the 6cm in the semicircular recesses.

Khirbat al-Mafjar (showing another close link between these two Umayyad monuments[41]). At Sarrah the joints radiate from a saddle-like block placed atop the windows which rise above the springer line of the semi-domes. The arches above these windows are also quite odd, because are built with six voussoires, not having thus a keystone although they have a clear pointed profile[42], something unusual in the Umayyad architecture.

On these pendentives it was built an *"umbrella"* dome, *i.e.*, a dome with a polylobed circular base and a ribbed vault divided into individual webs, each of which had a baseline curved segmentally in plan and also curved in elevation as can be seen in Creswell photos. This dome collapsed in the 1960's due to the looting. Apparently, there were nineteen or twenty projecting ribs built with thin slabs of roughly cut stone. According to Creswell description, quoted by Bisheh -_1990:229; "un-hewn shale" was used in its construction, although in the pictures the thin slabs seem to be of the same kind of those made of limestone used in the vaults from the *tepidarium* and the furnace area. The dome was pierced at its base with some circular windows. It was resting without any structural cornice ring on the pendentives, which were built of coursed and well dressed limestone and placed between the four perimeter arches above described. The shape of the dome helped to disguise its irregularity determined by that of its base. The thrust generated by the dome was compensated and driven down by the two lateral semi-domes, by the mentioned deeper arch from its southern side (that would thus find a mechanical explanation for its apparently abnormal extra depth), and by the barrel vault spanning over the furnace in its northern side.

The floor (*suspensurae*) was supported over the *hypocaustum* by a grid of four by four *pilae* made of cylindrical bricks identical to those from the *tepidarium*, supporting also rows of triangular arches achieved by couple of bricks leaning against each other. In the perimeter of the room, the floor was resting on rectangular pilasters of brick (with bricks 17.5-18cm square and 5.5-6cm thick and others 22×18×6cm) built against the wall and connected by proper semicircular arches. The lateral semi-circular recesses (intended to host hot-water bathtubs, as the drains at the base of the walls would demonstrate) were heated by means of three channels built with bricks running under them. The *caldarium* walls were also heated with the hot air circulating inside the box flues (*tubuli*) placed between the marble lining and the offset walls behind them. The shallower depth available in these semicircular recesses poses a problem about the way the hot-air chamber was created here. This could have achieved by using specially designed *tubuli* shallower than the standard, or more probably cylindrical pipes (like those used in the upper flues chimneys)[43]. Some box flues (*tubuli*) were found in the main central space, showing that at least part of this area would have been lined with these box flues. The lowermost ones presumably sat half on the bricks beneath the floor with their other half open to the *hypocaust*. They would have been mortared in rows to the stone wall and the other face coated in plaster and lined with marble to form the inner surface of the room. The only box flue found *in situ* is placed in the northwest corner. It is 25cm high × 14cm long × 12cm wide × 0.7cm thick. Irregular, oblong vents were cut into the short sides connecting them and allowing also the lateral circulation of hot air inside them.

41. This solution was already developed as early as the 2nd C AD as a way of solving the mechanical problems when trying to built a semi-dome on a semi-circular niche with the "standard" concentric conical courses, which forces the plan of the niche to be ultra-semicircular to prevent the collapse of the keystone of the semi-dome. Samples can be seen at Jerash, Ledjah and Shahba. See also Choisy 1883: Figs 80 and 84 and Arce 2005.
42. Their dimensions are 75cm wide and 87cm high (till the springing line of the arch) and 1.29m (till its crown).
43. This shallow dimension of the available space and the lack of traces of shoot on the walls with the characteristic pattern that shows the location of the box flues, lead us to consider even alternative hypothesis like in the case of the *tepidarium*: The interspace could have been created by the marble slabs of the lining (maybe with the help of *tegulae mammatae*), although this hypothesis presents technical difficulties. Actually, the holes for the cramps used to fix the marble slabs, and remains of the cramps themselves are still clearly seen on the masonry of the recesses.

The external faces were not scored. The hot air entered these chambers from the *hypocaustum* and was driven out by means of four vertical ducts built with cylindrical clay pipes (10cm external diam.) placed at the four corners of the room, stemming out from the wall offset corners. Those from the northern corners had their exit ends at the base of the prismatic drum on which rests the dome (defined by the four arches from the pendentives), while those from the southern corners had their exit ends on top of that drum, beside the "venturi effect" suction chamber open to the sky, above described, that existed between the *caldarium* and the *tepidarium*.

Similarly to what we suppose happened at Quṣayr ʻAmra, vapour was most probably introduced into the caldarium from the neighbouring furnace area through an opening in the wall that divided both spaces[44], providing extra wet heat to the dry one provided by the *hypocaustum*.

The Praefurnium and the Service Area

The northern section of the *caldarium* appears nowadays opened to an elongated vaulted space (3.12m long by 2.58m wide, covered with a slightly pointed barrel vault rebuilt in 1974, placed north-southwards). At its northern end there was located the mouth of the furnace (*praefurnium*) that heated the air in the *hypocaustum*. The lower walls defining the duct of the *praefurnium* leading the hot air towards the *hypocaustum* were built with basalt stones (reused elements, some of them brought certainly from Qaṣr al-Ḥallābāt – retrieved from pre-Umayyad structures). a wall must have existed separating the furnace area from the *caldarium*. Due to the great length of this space, it is possible that the dividing wall between furnace and *caldarium* would be placed so as to create a recess with a bathtub in the northern side of the *caldarium*[45] , meanwhile at the other side of the wall a water tank would have existed, placed over the furnace to heat the water used in these bathtubs and to produce vapour that would be introduced in the *caldarium* (that accordingly might be interpreted as a *sudatorium* with a mixed hot/humid heating system).

To facilitate the operation of the furnace, two big flues were built within the lateral walls of this vaulted chamber (plus a hole opened at the apex of the vault that can be seen in Vincent´s section). The furnace was operated from the service area room (6.20 by 3.95m), which apparently was originally covered by a barrel vault (see Vincent's plans in Creswell 1979). Here fuel was stored and the responsible for heating the bath (*fornaciarius*) might have had his lodge as well. a door in its eastern wall opened to the area where the hydraulic infrastructures were located (suggesting that the person in charge of operating the furnace, might have also been the one in charge of their maintenance and control as well)

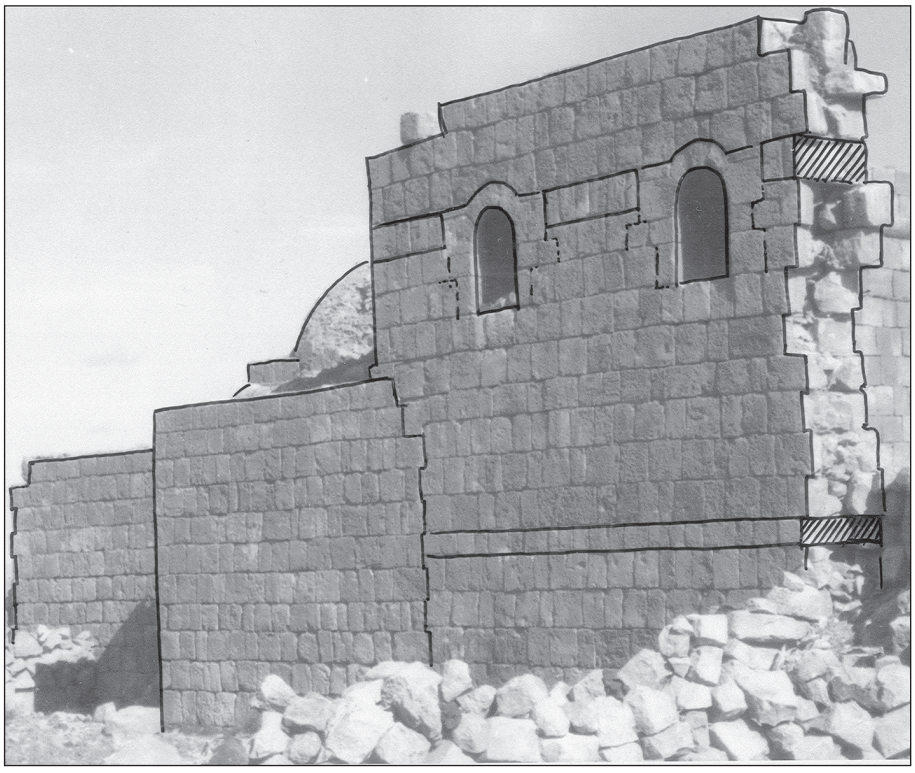
1.2.3 Phases of Construction of the Building

Several irregularities noticed in the building have led to put forward the hypothesis of a construction in two stages of the two main sections of the building, the proper bathing rooms block and the so-called audience hall block: Firstly, the irregularities in plan (see FIG.5) and in section of the northernmost aisle of the audience hall and its vault (narrower than the other two); Secondly, the lack of continuity that can be ascertained in the masonry work of the eastern and western façades in the transitional zones between both sections of the building (the technique changes and the horizontal joints of the courses are not aligned).

The discontinuity of the courses in the NW façade that can be clearly seen in the historical pictures (from Chicago University and Creswell Archive), corresponds to the vertical joint-line between the transition/changing room and the audience hall (FIG.9). It can be proven (following the principles of architectural stratigraphy, and according to the masonry

44. Accordingly it could be seen as the antecedent of the *Juwwani* or *Hararah in* medieval *hammams* (see above, Charpentier 1995 and Grabar 1978).

45. This would explain the continuity of the offspring of its vault (2.48m of span), and the possible existence of heated wall chambers here.



9. Ḥammām as-Sarāḥ. Construction phases: Detail of the joint between the *frigidarium* (to the left) and the audience hall (to the right) abutting on the former. Note the distinctive change of building technique in both stages (Cropped photo from DoA Archives).

building practices)[46], that the section of the audience hall abuts against and over the section of the bathing-rooms block and consequently, the latter had to be built before than the audience hall. On top of this, an indentation of alternated projecting blocks was left in the southwest and southeast corners of the bathing-rooms block, to facilitate the connection of both sections of the building when it would have been completed.

Closer examination of these historical photographs and the analysis of the remaining walls and the building plan, demonstrate without doubt that, although the building would have been planned as a whole, the audience hall was built later than the block with the bathing-rooms (FIG.5). This is particularly evident when we realize from these historical pictures that this construction in two stages involved also a change in the building techniques used. In the first stage, the walls were built with traditional *emplecton* masonry (*i.e.*: two faces of well squared masonry in regular courses[47] with an core of lime-mortar and rubble) without any key element (headers) connecting both external faces. In the second stage, corresponding to the audience hall, a different technique is found: Each six/eight courses of double-faced standard masonry blocks (stretchers) is found a course composed entirely of elongated blocks placed across the wall from face to face (headers) tying them. The first row can be seen at mid height, while the other one is eight courses above the first one, at the level corresponding to the springing line of the window arches (FIG.9). The first building technique is very common in the region during the Classical and Umayyad periods (the mosque at Ḥallābāt is built with it), while the second one is found in the basalt architecture from the Ḥawran and at Qaṣr al-Ḥallābāt (used in the pre-Umayyad building phase corresponding to the 2nd half of the 6th C. AD). The technique found at the Qaṣr, which served as a model for the Umayyad builders of the latest stage at Ḥammām as-Sarāḥ, is

46. Due to the change of masonry work and the indented joint itself between them.

47. The average height of the courses is 35cm with maximum of 42cm. Internally, the height of the overhanging projecting courses is of just 24cm in height, being laid horizontally, penetrating the core of the wall to guarantee the construction on top of them without compromising the stability of the wall. The height of the courses in the second stage does not vary apparently much from those of the first one.

slightly different, as the courses of headers are built with basalt stones to take advantage of the mechanical properties of this kind of stone, ideal to stand the flexion and tensile efforts borne by these elements[48].

The change of techniques is also noticeable in the construction of their respective vaults: Those from the bathing rooms are built most of them, with roughly hewn stones, similar in dimensions and shape to bricks, while those from the audience hall were apparently built most of them with well dressed voussoires.

This construction in two stages would explain some other oddities identified in the structure: Firstly, the inscription in red paint found on the southern wall (that was covered by the marble panelling of this area close to the fountain basin)[49]; Secondly the somehow awkward connection between both sections of the building that gives as a result that the span of the vault of the audience hall over the northernmost bay (the closest to the bathing-rooms) is narrower than the other ones; Thirdly the presence just in this section of the building of the fluted concave-convex carved moldures from the main door (which recall those from the second phase of the Ḥallābāt Mosque). These two building stages could be thus related to the two steps also ascertained in the construction of the nearby and coeval Mosque at Qaṣr al-Ḥallābāt, which will be the object of a detailed analysis in a forthcoming publication.

1.3 The Hydraulic System

To the East of the building are the remains of the hydraulic infrastructure: the well, the water wheel (*saqiyya*) and the elevated water tank. They have been heavily looted, being left just the circular base of the lane of the water wheel (for the animal that revolves around a central base to raise the water by means of a gear and a system of pitchers), the shaft of the well (1.5m of diameter built with carefully dressed limestone and at least 14m deep)[50] and the base of the raised water tank. This elevated water tank served to provide the water raised by the *saqiyya* with enough pressure to arrive by means of the pipe siphons to the bathtubs, the heating tank in the *praefurnium* area (as well as to the fountains). The tank was square in plan (side: 7.67 m externally and 6.03m internally) its floor was raised 1.7m from the land level and its walls were approximately 1.4m high[51] (internally) and 80cm thick. This gives a capacity for the tank of fifty cubic meters of water. It was internally plastered with an impervious lime plaster mixed with crushed bricks. Four exit holes with related grooves were built in the walls of the tank to host the clay pipes (10cm in diameter and 38cm long –of which 3cm correspond to the narrower neck used as socket for interconnection) that drove the water to the bath-house, the fountains and the garden: Two in its western side, and another two in the northern and southern sides. The two channels coming from the northwestern corner of the tank drove water to the heater tank[52], the one from its SW corner fed the fountain in the audience hall while the one coming from its southern side fed the secondary deposit for the fountain and to water the garden. In the plan drawn by Vincent (Creswell 1979: fig. 553) can be seen a fragment of a wall dividing internally the water tank (it is located east-westwards 4.33m to the South of the northernmost wall), that was clearly intended to provide water to both areas separately (being devoted the bigger

48. See Arce 2007a and 2007b.

49. The painted inscription was found above the pool, on a section of the wall that was covered by marble slabs fixed to the walls by means of cramps fixed on holes (still visible spotting the inscription). Why to paint an inscription in an area that was intended to be covered? It just would make sense if we consider that the audience hall was built later than the bath-rooms and accordingly, the inscription would have been seen till the moment the construction of the section of the audience hall took place. Another hypothesis put forward, is that the inscription would have been done after the building was looted and the marble lining removed, but the epigraphic evidence (the calligraphy used) would not support this hypothesis. Attempts to read it have been done by Z. Zayadine and F. Imbert, but they have not been published.

50. Ghazi reports a depth in 1974 of 16m (_1989: fig.1).

51. We have extrapolated this dimension from the existing historic pictures.

52. A series of projecting stones in the eastern façade of the bath-house close to the furnace area, and thought to have been indentations to link an enclosure wall never built, happened to be the support against which the twin pipes run up from the floor to feed the heater tank.

one to the bath itself). Special mention deserve the clay pipes used at the base of the vertical drains of the tank: They have a closed end (the one corresponding to the socket-neck, which is no present –for which it has a length of just 35cm), and a lateral opening near the base to connect the following horizontal tract of the clay pipe duct. The area to the west of the tank and surrounding the mouth of the well might have been covered by an arcaded structure (similar to that from ‘Amra) to host the gear and the related mechanism to drive the water raised by the *saqiyya* to the water tank. An elongated drinking trough for animals has been uncovered in our excavations. It is located to the north of the water tank and the *saqiyya*, and was fed not from the water deposit but from the *saqiyya* itself.

1.4 The Walled Garden

Traces of the foundations of an oblong wall precinct (apparently it might be square in plan) can still be seen surrounding the complex (FIGS.1, 11). It is not clear if this perimeter wall just defined a square enclosure of 90 by 90m approx, or if it included a bigger extension of land. The first stretch is located 23.5m to the south of the water tank, and runs southwards for 90m approximately. It turns then westwards, running for another 93m, although in the middle it disappears for a while, marking perhaps the place where a door or a sluice for entering the water driven by the *wadi* during the rainy season would have been placed. It turns again northwards, running for another 61.5m (although it seems that it might have continued further northwards outside the current walled precinct of the archaeological site). At the northern end of the eastern stretch of the garden wall, the two parallel sections that compose the wall come apart, creating a sort of narrow and elongated wedge (triangular in plan as a transversal stretch of wall closes its northern tip). This structure would be a secondary tank to provide the needed pressure to keep the water feeding the garden and its fountain. The fourth line of clay pipes that stem out from the main elevated water tank, which drives the water up to this secondary tank, is still intact *in situ*. This section of clay pipes coming from the tank ends at this precise point with a “blind end” piece identical to that of the base of the tank ducts. It has the lateral opening pointing upwards indicating that the water was driven up to this oblong tank by means of a vertical stretch of pipes now disappeared.

Traces of a fountain stone basin and its feeding clay pipe have been identified in the central-eastern area of the walled precinct as part of the same scheme (FIG.10). The fountain was actually located in axis with the main door of the audience hall, 58.5m southwards from it, and 22.4 m away from the eastern wall of

10. Ḥammām as-Sarāḥ. Fountain basin from the walled garden. Note the clay-pipe channel beside it, still *in situ*.

11. Ḥammām as-Sarāḥ. Aerial view of the complex after the restoration with the walled garden and its fountain, the hydraulic system and the bath-house itself (Photo courtesy of APAAME).

the precinct. The fountain basin was carved in a monolithic piece of limestone (with an external diameter of 1.38m and a wall 67cm high, and an internal diameter of 1.06m and an internal depth of 40cm). It was found broken in pieces, some of them missing[53]. At the center of its base it is pierced with a hole of 12.5cm in diameter to host the clay pipe that fed it. Almost all the clay-pipe tract that drove water to the fountain is still *in situ*: it runs 22.4m eastwards until the eastern garden wall. It is clear that another line of water clay pipes must have connected this section with the tract bringing the water from the secondary elongated tank.

It is thus possible that the entire perimeter wall worked as an aqueduct, being used not only to feed the fountain but to irrigate the garden or cultivated area enclosed by this perimeter wall. On the basis of the location of the site, on the bed of a *wadi* (from its subterranean water-table the water is obtained and raised by means of the *saqiyya*), an hypothesis regarding the functioning of this garden could be put forward: Apparently in wintertime, during the rainy season, the water driven by the *wadi* Rukban (that runs northwards just to the West of the garden, still flooding regularly the area) would have been retained by the perimeter wall (acting as a dam) and allowing thus water to soak the soil of the garden, meanwhile, during the dry season, the *saqiyya* would have been operated to irrigate the garden and not just to provide water to the bath.

The low wall present at Quṣayr ‘Amra[54] (wedge-shaped in plan) was intended as a cutwater to divert the winter flash-floods, protecting thus the building that is in the middle of the *wadi* bed. At Ḥammām as-Sarāḥ the intention behind the setting seems to collect the fertile silts brought by the seasonal floods, to enrich a cultivated orchard or garden and to irrigate it. At al-Sarah there is just one *saqiyya* to serve the garden and the baths (despite its bigger size), while at Quṣayr ‘Amra there are two of them. This would indicate a more effective and efficient system for water harvesting and management in the case of al-Sarah. Still is not clear if the cultivated precinct was devoted just to the pleasure of the senses or if it might have had even a commercial scope as a part of the agricultural estate in nearby Ḥallābāt.

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53. The remaining pieces have been now restored.

54. Nonetheless traces of a perimeter wall and the presence of a second *saqiyya* indicates the presence of a sort of garden there as well.

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