AZRAQ ‘AYN SAWDA RESERVOIR PROJECT (2014-2016) TOPOGRAPHICAL PLAN, INVENTORY OF THE CARVED BLOCKS AND ASSESSMENT OF THE STATE OF PRESERVATION OF THE ARCHITECTURAL REMAINS

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Al Azraq Oasis occupies a large area in the Eastern Desert of Jordan. It is located at the centre of the Al Azraq basin and is bordered to the north by the basalt flow of the southern Hawrān. Human occupation in this area is attested from the Lower Palaeolithic period (Late and Final Acheulian, *ca.* 250,000 years BP) onwards, and was present due to the abundant water resources associated with a high-water table (Rollefson *et al.* 2001; Richter *et al.* 2007, 2010; Maher *et al.* 2011; Cordova *et al.* 2008, 2013). The Al Azraq Oasis actually consists of a paleo-lake, now a seasonally inundated saline mudflat (**Fig. 1**). ‘Ayn As Sawdā’ is one of the several natural springs which feed the oasis. It is located inside a reservoir-enclosure, which is one of the main archaeological remains in the Al Azraq area (**Fig. 2**)[1]. Its location in a marsh is particularly interesting as it involves construction techniques specific to a wet environment. This site is well known in art history due to the discovery of several basalt blocks carved in bas-relief.

Faced by uncertainties concerning both the function and the dating of the structure, the Department of Antiquities of Jordan (DoAJ) and the French Institute for the Near East (Institut français du Proche-Orient, Ifpo), entrusted Lorraine Abu Azizeh with a new archaeological project dealing with research in architecture and archaeology as well as with conservation issues. A preliminary architectural analysis was made in 2013 (Vibert-Guigue and Abu Azizeh 2013), followed by two field seasons of the new Azraq ‘Ayn Sawda Reservoir Project, consisting of architectural and archaeological studies in 2014 and 2015 (Abu Azizeh *et al.* 2014, 2015) and a study season in 2016 (Abu Azizeh *et al.* 2016)[2]. This paper will present the structures related to the reservoir-enclosure of ‘Ayn As Sawdā’ and some of the initial results of the Azraq ‘Ayn Sawda Reservoir Project, namely the topographical plan of the site, the study and inventory of the carved blocks and an assessment of the current state of preservation[3].

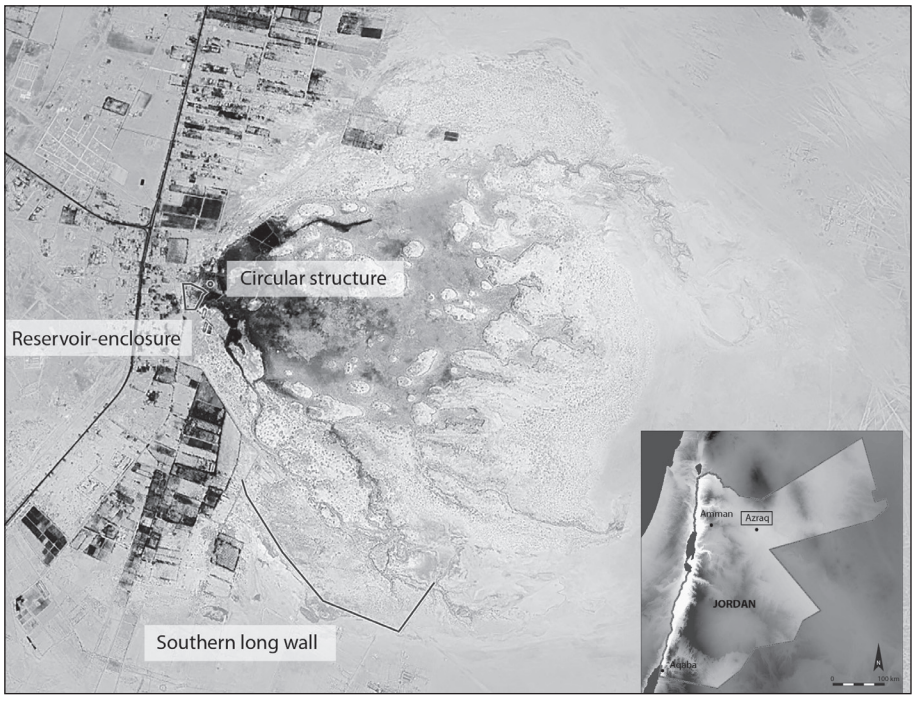
Previous Research

The site of ‘Ayn As Sawdā’ was first described by Alois Musil in 1927 (Musil 1927: 340-342) and then by Lionel W.B. Rees in 1929 (Rees 1929: 89-92), who erroneously named it “*Ain el Asad*” (**Fig. 3**). Their plans and illustrations contain many interesting elements; however, they lack precision and are somewhat rudimentary in nature. Moreover, the accompanying descriptions often contradict the architectural plan and require a cautious reading. Rees undertook excavations at the site, unearthing circular structures close to the northwestern corner of the reservoir enclosure that he interpreted as wells. He also dated the “reservoir” to the Byzantine period, interpreting its function as being for the storing

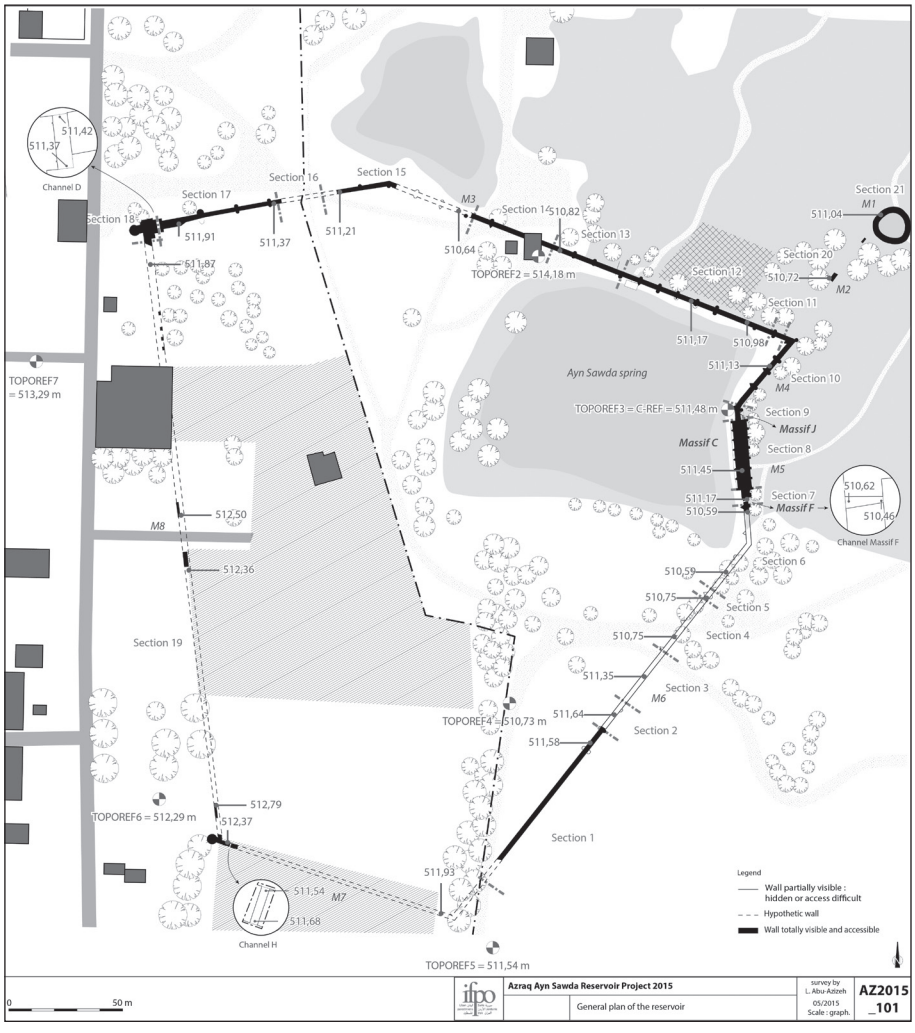
1. Nowadays, the archaeological site is partly in the Al Azraq Wetland Reserve, which is managed by the Royal Society for the Conservation of Nature (RSCN). It is also part of the Azraq Ash SHīshān Heritage Area, supported by the DoAJ.

2. The team included two architects; Lorraine Abu Azizeh and Aurélien Stavy, and two archaeologists; Julie Bonnéric and Barbara Couturaud.

3. The archaeological excavations program and its results will be presented elsewhere, see Abu Azizeh *et al.* forthcoming.



1. *Location of the architectural remains of 'Ayn As Sawdā', Al Azraq, Jordan (AASRP 2020, after Bing Map).*



2. *Plan of the reservoir-enclosure showing elevations, sections of the wall and location of the topographic references implemented in 2015 (AASRP 2015).*

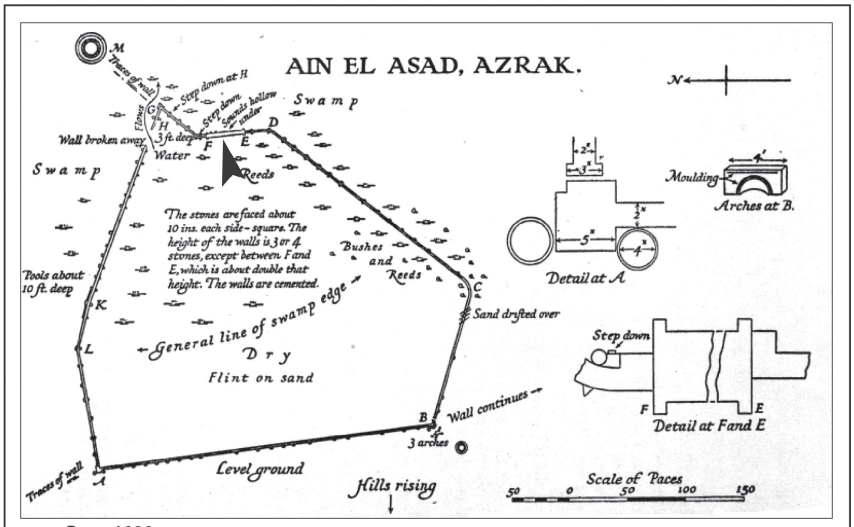
of fresh water. Interestingly, his plan indicates traces of wall going north and south from the western wall of the reservoir-enclosure that are no longer visible on the surface and are partly covered by modern dwellings. His plan also shows a small circular structure next to the southwestern angle of the "reservoir"; this structure may still exist but has not been identified on the surface, though it should be noted that it is located outside the reserve, among modern constructions. Fifty years after Rees, in a management plan for the Al Azraq Wetland Reserve, Peter J. Conder suggested that the wall of the reservoir-enclosure was intended to separate the fresh water of the 'Ayn As Sawdā' spring from the saline waters of the paleo-lake (Conder 1979: 13). He also associated the site with the Roman period and dated it around 300 AD. In 1982, David Kennedy proposed a new description of the "reservoir", based on aerial photographs and the plan established by Rees (Kennedy *et al.* 1982: 96-106). He was also the first clearly to describe and locate a long wall extending north from the reservoir-enclosure, probably corresponding to the traces of walls mentioned by Rees, which is no longer visible nowadays (**Fig. 3**).

In the early 1980s, because of excessive groundwater pumping for agricultural activities and urban water supply, the 'Ayn As Sawdā' spring started to dry out. In 1983, preoccupied by the drastically low level of the water in the reserve, the DoA sent Ghazi Bisheh to undertake rescue excavation works on the site of 'Ayn As Sawdā' (Bisheh 1986: 12-14). The first restoration of the enclosure wall was also initiated at that time. On that occasion, basalt blocks with mortise and tenon joints were discovered due to the lowering of the water level. Some of these blocks were decorated. They were concentrated inside the reservoir-enclosure, along a reinforcing buttress on its eastern wall, referred to here as Massif C. The refined ornamentation of the blocks suggested to Bisheh that Massif C corresponded to some sort of recreation platform. Fifteen years later, in 1997, an archaeological project, directed by Richard Watson and Wesley Burnett, resumed the study of the site (Watson and Burnett 2001). Three soundings were made during a single excavation season, leading to the discovery of a channel crossing the northern enclosure wall. The site was described in further detail and Musil's plans were corrected (**Fig. 3**). The function of the structure was interpreted as a reservoir that was supplied by the 'Ayn As Sawdā' spring, and intended to collect winter rainwater from outside through the channel. Contrary to most of their predecessors, they dated the site to the Umayyad period and attributed its construction to the caliphate of Al-Walid II (743-744). They believed that the "reservoir" could have been part of a larger but unfinished complex, perhaps intended to become a hunting reserve.

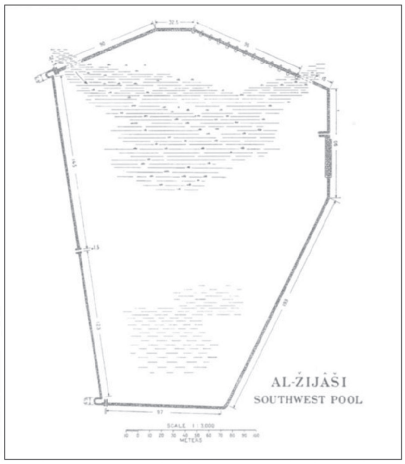
More recently, in 2004, Claude Vibert-Guigue undertook the study of the carved basalt blocks (Vibert-Guigue 2004, 2006, 2007, 2008, 2009, 2010 and 2013). He also published a plan, based on previous publications, but showing new elements, such as the visitors' track (**Fig. 3**). Five field seasons were conducted, entailing surface cleaning below the western face of Massif C and leading to the discovery of 71 additional blocks, like the first ensemble found in 1983 by the DoA, more than half of them adorned with bas-reliefs. An iconographical analysis led him to date their production to the Umayyad period and to suggest a strong Sassanid influence. Vibert-Guigue also proposed that some of the blocks might have formed a circular medallion organized around the largest block found (Vibert-Guigue 2010). Denis Genequand has also dated the site to the Umayyad period in his study of aristocratic settlements in the Near East under the Umayyad dynasty (Genequand 2012).

In 2013, due to the need to conduct further research at both an archaeological and an architectural level, and following the request of the DoA, the Ifpo implemented a new project in 2014, the Azraq 'Ayn Sawda Reservoir Project. The project lasted three years and was organized around four research axes: topography and architectural analysis of the site and the remains, inventory and morphological study of the carved blocks, assessment of the state of preservation of the architectural remains and archaeological excavations[4].

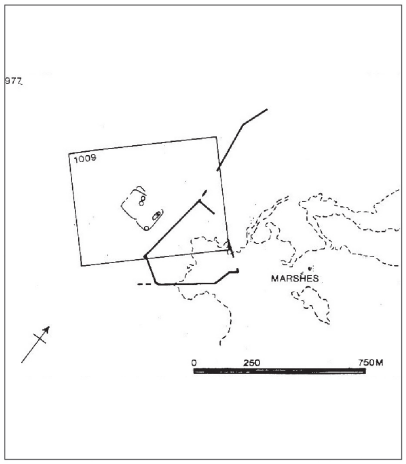
4. Only the first three axes are presented here. The archaeological excavations will be published separately; see Abu Azizeh *et al.* forthcoming.



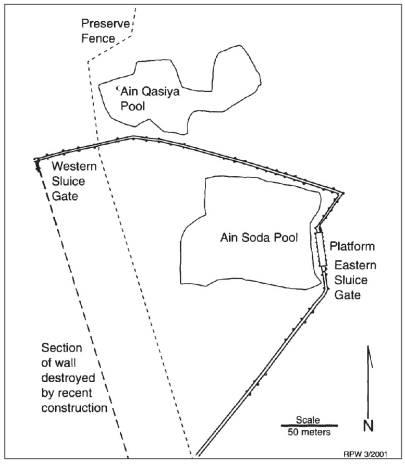
Rees, 1929



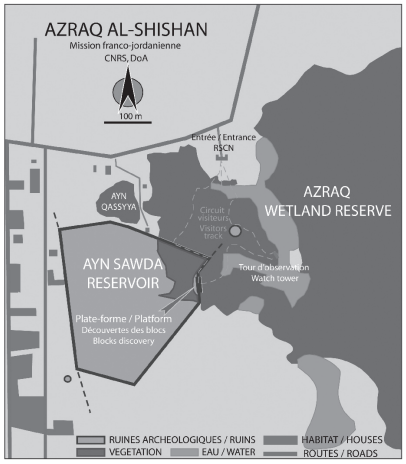
Musil, 1927



Kennedy & *al.*, 1982



Watson and Burnett, 2001



Vibert-Guigue, 2008

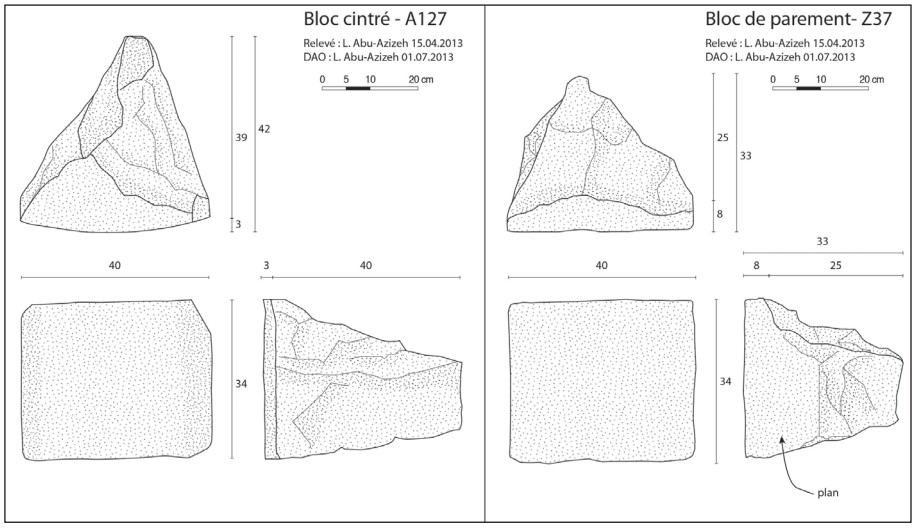
3. Previous plans of the reservoir-enclosure (after Musil 1927, Rees 1929, Kennedy et al. 1982, Watson Burnett 2001 and Vibert-Guigue 2008).

Architectural Description and Topographical Plan

The site comprises three main structures: the reservoir-enclosure, a circular structure north-east of the reservoir-enclosure, and a long wall located more than 1km south of the reservoir-enclosure (see **Fig. 1**). All three share similarities from an architectural point of view, even though neither their contemporaneity nor their connection has been clearly established.

The reservoir-enclosure is the most important structure on the site (see **Figs. 1, 2**). The inner and outer faces of the wall are made of basalt blocks in diamond tip shape (**Fig. 4**). The width of the wall varies from 1.70m to 2.15m. The height of the preserved masonry varies from a barely visible line in the ground on the worst preserved sections, to four stone courses above the natural soil, as on Massif C and its surroundings (**Fig. 5**). The original height of the wall is difficult to reconstruct, but it probably would not have exceeded four to five courses. The height of the courses is regular, as they measure between 28cm and 40cm. The width of the basalt blocks varies from 15cm to 70cm, while their depth varies from 35cm to 70cm. The internal filling of the wall consists of medium to large basalt rubble stones in mortar (**Fig. 6**). In some areas where the wall was heavily damaged, it was possible to see that the internal fill was clearly made up of several layers corresponding to the stone courses and separated by a thin layer of hard, compact mortar; it can be assumed this was the case for the entire wall, but it has not been possible to verify it. The top surface of the wall is currently composed of the facing blocks of the highest existing course and the internal fill between the two wall faces (**Figs. 6, 7a, 7b** and **8**); no evidence of a wall covering system was found.

Formerly known as the "platform" (Bisheh 1986; Watson and Burnett 2001; Vibert-Guigue 2004), the long Massif C on the eastern wall M5 measures 30.5×6.10m (**Fig. 9**). There is an adjoining, smaller massif at each end of Massif C. Massif J, on the north end of Massif C, measures 4×1.5m and borders the outer face of wall M5 (**Figs. 9, 10a**); its main function has yet to be identified. Massif F, located south of the long Massif C, measures 3.4×1.6m and presents the same building technique as Massif C (**Figs. 9, 10b**). Partially collapsed, it clearly shows that it is not linked with the main wall of the reservoir-enclosure.



4. Drawings of two diamond tip-shape basalt blocks used in the architecture of 'Ayn As Sawdā' (AASRP 2015).

5. Massif C: a) general overview from the north; b) triangular buttresses on the inner side; c) foundation bench on the inner face (AASRP 2014).

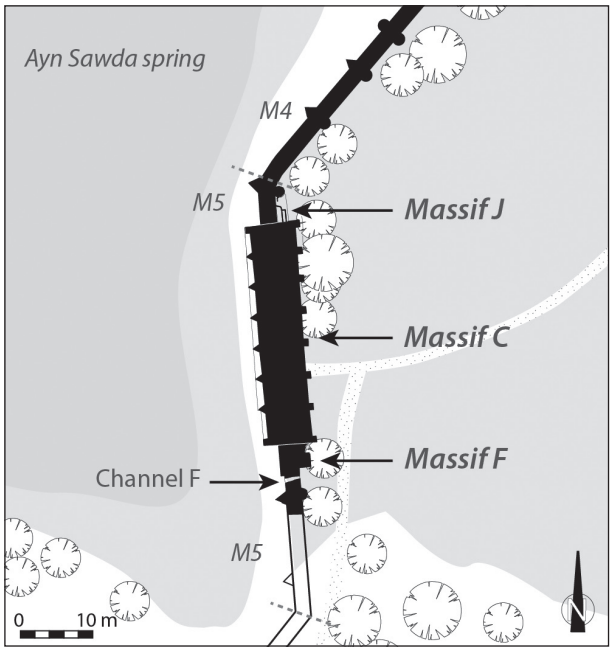
There are 55 buttresses distributed along the wall of the reservoir-enclosure, clearly bonded with it (**Figs. 7, 11**): 41 are semicircular in plan (diam. 1.18m to 1.75m) and are distributed along the northern and eastern walls M3, M4, M5 and M6 (**Figs. 7a, 2**); the 13 others are triangular (width 95cm to 2.25m) and are systematically positioned on the inner face, along the northern and eastern walls M3, M4 and M5 (**Figs. 7b, 2**). Two additional buttresses were unearthed during the excavations, located on the western ends of the southern and northern walls M7 and M3 (**Figs. 8, 2**); these are roughly indicated on Musil's plan (see **Fig. 3**). They are different in terms of shape, since they are larger than the others, and completely circular (diam. 4.82m and 4.50m). On the outer face of Massif C, 8 rectangular buttresses were built (approx. width 68cm, approx. depth 95cm) (**Fig. 9**); on its inner face, there is a rectangular one at the southern and the northern ends (approx. width 66cm, approx. depth 82cm to 94cm) (see **Figs. 5c, 7c**), and 6 triangular ones in between (approx. width 1.15m), built on a foundation bench made of long basalt headers block (see **Fig. 5b**).

6. Example on the wall of the reservoir-enclosure showing the internal fill linked with the one of the buttresses (AASRP 2015).

7. The three types of buttresses: a) semicircular; b) triangular; c) rectangular (AASRP 2014).

8. Circular buttresses: a) in the north-western corner of the reservoir-enclosure; b) in the south-western corner of the reservoir-enclosure (AASRP 2014).

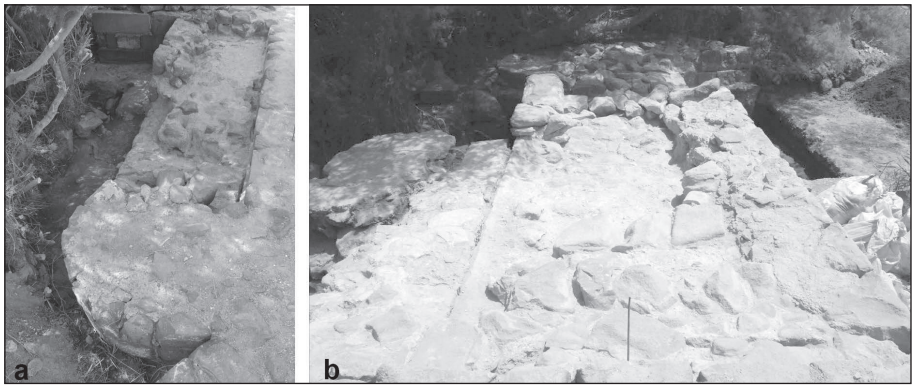
Although the study of the masonry was occasionally obstructed by restoration works carried out by the DoA and the RSCN on Massif C, the eastern wall M4 and the eastern part of the northern wall M3, the architectural analysis has proved the homogeneity of the ensemble, which most probably indicates a single construction phase. Indeed, the wall face is systematically and regularly interrupted by the buttresses and the internal fill of the wall is clearly linked with one of the buttresses (see



9. Plan of Massif C (AASRP 2015).

Figs. 6, 7), contrary to previous observations (Watson and Burnett 2001: 76). Furthermore, most of the buttresses still visible have facing blocks penetrating into the masonry of the main wall, proving, here again, their connection. These observations, combined with the typical Umayyad shape of the buttresses (Genequand 2012) allows the wall to be dated *a priori* to this same period.

Approximately 50m northeast of the northeastern angle of the reservoir-enclosure is a circular structure, covering an area of 105m^2 (see **Figs. 2, 12**). The structure seems linked to the reservoir-enclosure by a possible wall, from which some stones have been excavated. Its wall (length 50m, approx. width 2.40m) is similar to the reservoir-enclosure, both the inner and outer faces being made with basalt blocks cut in a diamond tip shape, and the fill consists



10. Small massifs next to Massif C: a) Massif J view to the south; b) Massif F view to the south (AASRP 2014).

11. Two examples from Massif C showing the link between the wall and the buttresses: facing blocks penetrating into the main wall's masonry (AASRP 2015).

12. Circular structure north-east of the reservoir-enclosure: a) mortar partly covering the steps; b) inner steps (AASRP 2014).

of small basalt rubble stones and mortar. The three courses that define the wall's elevation are built in a step-like way on both faces, each step being around 15 to 20cm wide. The height of the courses varies from 20 to 30cm. The lower course is made of large, roughly squared blocks, unevenly flat on the superior facing; the middle course is made of a series of large, cut rectangular blocks; lastly, the upper course is composed of small, cut rectangular blocks. It seems that the structure has been subjected to many modern restorations, especially on the upper course where one additional course was set on the inner face, made of small cut basalt blocks. It should be noted that the structure is unevenly covered by a white mortar (**Fig. 12a**).

Lastly, situated to the south of the reservoir-enclosure, a long wall should be mentioned, previously described by Kennedy (Kennedy *et al.* 1982: 96-106). During the fieldwork of the Azraq 'Ayn Sawda Reservoir Project, the 1.6km remains of this wall were surveyed (see **Figs. 1, 13**). It runs roughly southeast, bordering the marshes, and three changes of direction have been identified before reaching a corner that marks a clear shift in orientation towards the northeast and the core of the wetland. The architecture and the building techniques are similar to those of the reservoir-enclosure. The width of the wall varies from 1.20 to 1.50m. There are also buttresses along both faces; most of them are no longer visible and only 8 circular ones were identified (diam. 1.05m to 1.43m).

Until 2014, only five basic plans of the 'Ayn As Sawdā' structures were available, made by Musil in 1927, Rees in 1929, Kennedy in 1982, Watson and Burnett in 2001, and Vibert-Guigue in 2008 (see **Fig. 3**). None of these plans was based on topographical surveys of either the area or the structures, and thus remained inaccurate. Therefore, a first topographical plan of the site was created and integrated in a geodetic system. The overall survey of all visible structures –*i.e.* the reservoir-enclosure, the northern circular structure and the southwestern long wall– was completed by hand, in the field (see **Fig. 2**). Seven topographic reference points were placed along the reservoir-enclosure wall. Their position was then verified, in order to guarantee the accuracy of their placement, which varied from 1cm to a maximum of 3cm, a gap considered as very acceptable since the scale of the site is of several hectares and the distance between the total station and the farthest points surveyed was approximately 500 metres.

The establishment of the general plan of the site offered the opportunity to work on the elevations of the different structures (see **Fig. 2**). The accurate study of the levels of the reservoir-enclosure revealed a variation in the elevation of the top of the wall of about 2 metres (510.75m on the northern wall M3 to 512.79m close to the southwestern corner).

A certain regularity (511.48m to 511.58m) is visible along the eastern walls M4, M5 and M6, whereas a clear difference appears on the western part, both on the northern wall M3 where only one course is preserved (511.91m), and on the entire western wall M8 (512.50m).

The topographic survey also showed an important gap between the altitudes of the

13. The long wall located south of the reservoir-enclosure and its different states of preservation: a) with the facing preserved; b) with the facing damaged causing collapse of internal fill; c) badly preserved (AASRP 2016).

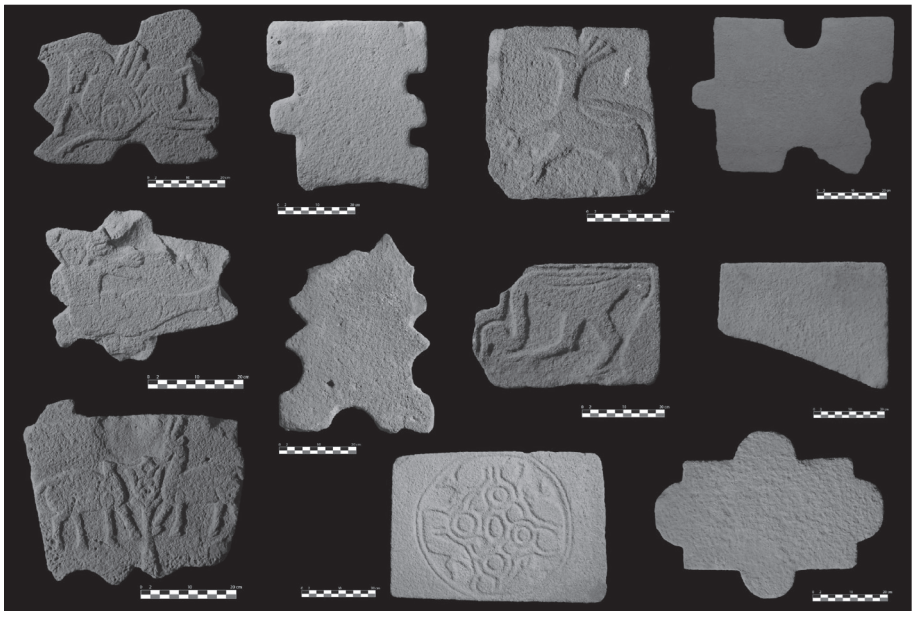
northwestern channel (sector D, max. elev. 511.42m), the southwestern channel (sector H, max. elev. 511.68m) and the eastern channel (sector F, max. elev. 510.50m). The question of elevation is crucial here, especially when related to structures containing water, and this comparison shows a difference of 1.18m between the channels located in the southwestern corner, which is the highest, and the one situated on the eastern wall, which is the lowest.

It should also be noted that the base of the foundation of the northern wall M3, through which the northwestern channel is pierced, is at the same elevation as the top of Massif C (511.42m and 511.45m). This difference shows that the structure is not a large water reservoir with an entry channel located in the northwest and an evacuation channel in the east as previously proposed (Watson and Burnett 2001), since it is evident that the first one could not have been lower than the second one. This suggests that the structure was more of an enclosure wall, at least its western part (wall M8) (Abu Azizeh *et al.* forthcoming).

The Carved Basalt Blocks

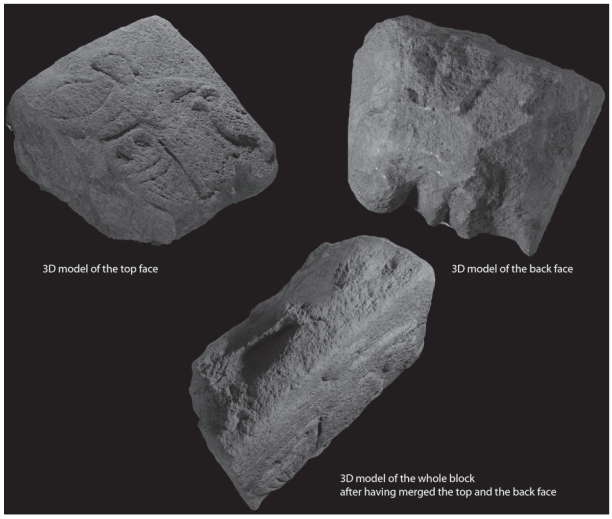
The carved basalt blocks discovered between 1981 and 2013 in the reservoir-enclosure of 'Ayn As Sawdā' form an exceptional archaeological collection, which, until now, has no known iconographic parallel (**Fig. 14**) (Abu Azizeh 2015). The corpus consists of 106 blocks: in 2016, 92 blocks were exhibited in the archaeological depot of Qal'at Al Azraq, 10 were presented in the Museum of Jordanian Heritage at Yarmouk University in Irbid and 4 of them have disappeared since their discovery. Ninety-five blocks have a carved upper face (52 bas-reliefs, 7 high-reliefs) with figurative representations that assimilate the ensemble to the Umayyad period (Bisheh 1986: 13-14; Vibert-Guigue 2006: 327). Reliefs depict animals (fishes, game animals, wild animals, eagles, dogs, *etc.*), ornamentation with plants (trees, pomegranates in a vase, *etc.*), mythological creatures (winged horses, sea horses, *senmurv*, mermaids, *etc.*), human beings (women, men) and geometrical shapes (interlacing, sun, *etc.*). Differences of colour between blocks were noticed, varying from black to a rusty colour due to being in water for a long time.

The common point of almost all the blocks is the presence of mortise and tenon joints on one or several of their faces. This system is composed of two elements: one presents a male extremity and the other a female extremity, which is mainly used in carpentry and joinery (Aurenche 1977: 118, 166). Blocks are of different shapes, *i.e.* rectangular, square, circular, trapezoid or irregular, and the mortises and tenons are either rectangular, triangular or circular (**Fig. 14**). Only the upper face is cut precisely and flat (**Fig. 15**). The lateral faces and the back face are roughly and approximately

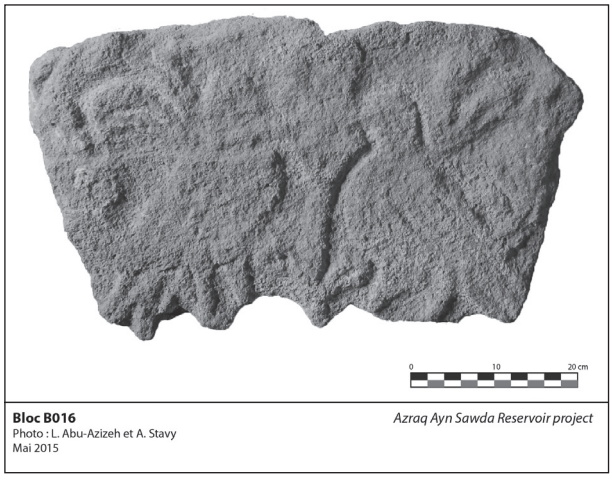


14. Some of the decorated basalt blocks found in the reservoir-enclosure (AASRP 2015).

flat –they do not present the same profile as the architectural blocks that compose the walls of the reservoir-enclosure– *i.e.* cut with a diamond tip shape. The thickness of the blocks varies from one to another, up to 36cm. The state of preservation of the blocks is relatively good: only two blocks are broken and fragmentarily preserved, but breaks were noted on 77 blocks. The upper face is sometimes very damaged, making the reading of the relief difficult, as on block B016 for instance (**Fig. 16**).



15. Multiple views of carved basalt block bearing a relief (AASRP 2015).

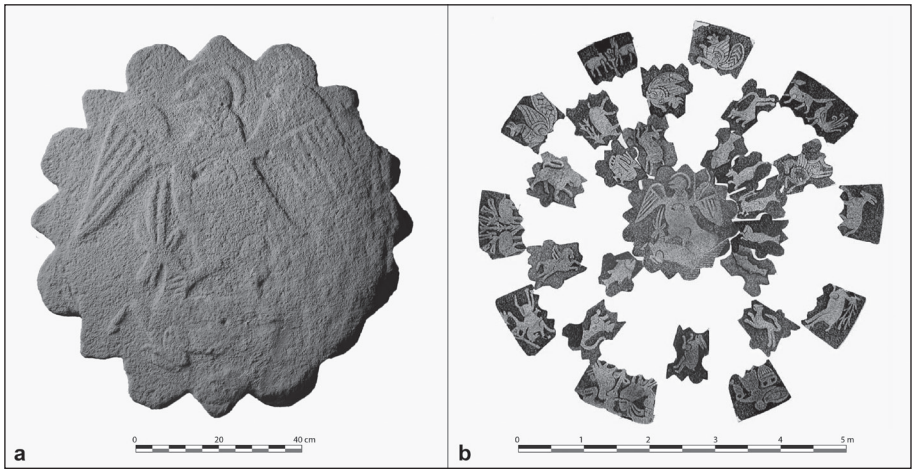


16. Block B016 showing a relief depicting two birds and a tree (AASRP 2015).

The function of these blocks is difficult to understand. Vibert-Guigue has proposed that part of the blocks belongs to a specific set that he describes as a circular medallion (Vibert-Guigue 2010) (**Fig. 17b**). This medallion, half of the blocks of which would be missing, would be organized in three circular registers around the central block B093 (**Fig. 17a**); its total diameter would then be 3.10m. This hypothetical reconstruction has never been tested with the real blocks as their manipulation is very complicated due to their weight and size.

One of the aims of the Azraq 'Ayn Sawda Reservoir Project was not only to document the blocks, but also to use new techniques that allow new approaches to their study in order to better understand their function. A database was set up, integrating the list of the blocks, the new graphic documentation and the details observed on site (description of the assemblies, surfaces, measurements, *etc.*). This exhaustive catalogue has since been used by the DoA of Al Azraq as a control tool for the collection.

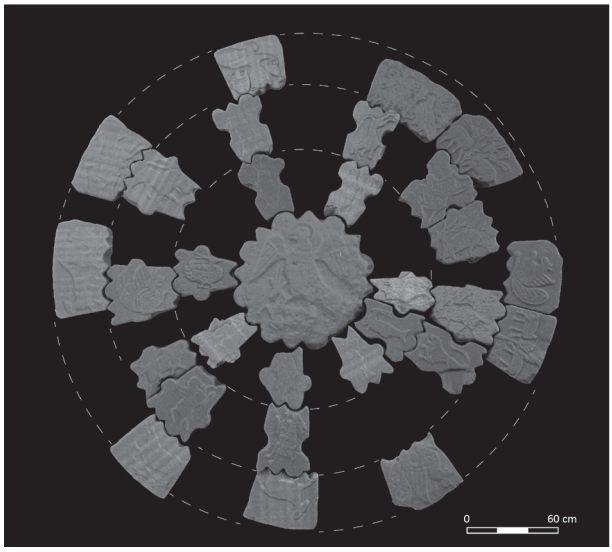
The new documentation of the blocks bearing a relief also allowed 3D scaled models to be generated thanks to photogrammetry. The 3D models are easily manipulable in 3D display software and constitute a unique documentation which allows the whole corpus of blocks to be worked on virtually. In this context, a collaboration was set up between the Ifpo and



17. Circular ensemble of adorned basalt blocks: a) central basalt block B093 (AASRP 2015); b) reconstruction of the medallion suggested by Claude Vibert-Guigue (Vibert-Guigue 2010).

an engineering school in France, the CESI in Ecully, in order to make 3D prints of the 59 blocks bearing a relief decoration (**Fig. 18**). The blocks were printed at scale of 1:5. The weight of every element varies between a few dozen grams and approximately 200g, allowing their handling in order to test not only the organization of the blocks between each other but also to better define the integration of the blocks in the general architecture and the reservoir-enclosure. More particularly, the 3D prints of the blocks allowed previous hypotheses to be tested, in particular the reconstruction of a circular medallion by Vibert-Guigue. If certain fittings of tenons and mortises seemed to work in 2D, the tests with the 3D printed blocks showed the incompatibility of these combinations (see **Fig. 17b**) and seems to refute the hypothesis of a circular medallion placed on a vertical wall. The work is still in progress but the printed blocks clearly are an exceptional study tool to propose new hypotheses based on the previous results, with blocks fitting into each other to create three levels encircling a central medallion, even though some of the rectangular blocks do not take part in the composition (see **Fig. 18**).

Finally, the archaeological excavations around Massif C did not lead to the discovery of new carved blocks; no architectural or stratigraphical link could thus be established beyond doubt between the reservoir-enclosure and the ornamental blocks. However, the precise study of the blocks during the documentation phase revealed the presence of mortar remains on the back face of 20 blocks. This indication, as well as the variable thickness from one block to the other led to the idea that they might be elements belonging to a pavement. The irregular shape of the back face of almost all the corpus works in favour of this hypothesis (Abu Azizeh *et al.* forthcoming).



18. New proposal for the combination of the basalt blocks based on 3D printed blocks (AASRP 2015).

Assessment of the State of Preservation

The architectural and archaeological analysis carried out over the three years of the Azraq 'Ayn Sawda Reservoir Project also entailed an assessment of the condition of the remains in order to draw up a plan for their preservation. Although located in a protected environment, the vestiges face several threats. Indeed, the state of preservation of the wall varies greatly, depending on its location either inside or outside the Wetland Reserve (**Fig. 19**). Outside the reserve, traces of the wall of the reservoir-enclosure are still visible and are located on non-fenced private property. Since these areas are accessible, the visible masonry is at serious risk of looting and destruction. The long wall located south of the reservoir-enclosure also faces major threats (see **Fig. 13b**). Some of the structures inside the reserve, such as the northern wall M3, the eastern walls M4 and M6, and Massif C, form part of the tourist track and therefore also face serious threats. These are the impacts from visitors and water buffalo inside the reserve, the recent aridity of the soils on an architecture made to be in a wet environment, and abundant vegetation. The combination of these three phenomena accentuates the visible damage to the masonry. Despite several restorations led by the DoA in the 1980s and the day-to-day attention from the RSCN, the general state of the reservoir-enclosure continues to deteriorate, putting the structure as well as the visitors at risk.

One of the objectives of the Azraq 'Ayn Sawda Reservoir Project was to establish an inventory of all the visible features of the reservoir-enclosure, therefore combining an architectural description of the construction, a description of the pathologies of the masonry and a complete photographic documentation.

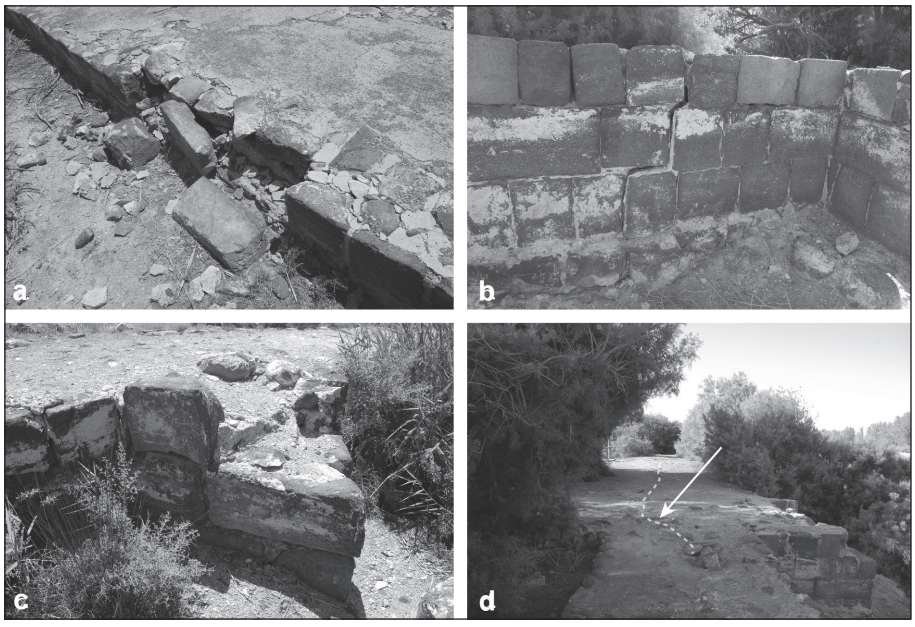
19. Views of different states of preservation of the architectural remains of the reservoir-enclosure: a) in section 1, the wall is located inside the Wetland Reserve, recognizable because of the topography of the terrain, but no longer visible; b) in section 2 (zone I), the wall is located inside the reserve but out of the tourist track and has not been restored; c) in section 11 (zone II), the wall is located inside the reserve, on the tourist track, and has undergone some modern restorations; d) in section 19 (zone III), the wall is located outside the reserve, on non-fenced properties (AASRP 2015).

Such an assessment of its condition constitutes a necessary base for establishing a protection and restoration plan for the reservoir-enclosure that is able to define the priorities and urgency. To carry out this assessment, a specific methodology was used: the wall was divided into 21 sections, each one identifiable by an important change in terms of visibility or of construction (see **Fig. 2**). A description sheet was created and systematically filled for each of the 21 defined sections of the wall. The sheet contains graphics as well as descriptive elements concerning general data, for instance length of the section, width of the wall, presence or absence of buttresses, but also more specific data related to the architecture, such as the number and height of the visible courses, the presence of mortar or coating, details of building technique, *etc.* Finally, it mentions the pathologies detected and their probable causes. On every sheet, a distinction is made between data related to the interior and the exterior of the reservoir-enclosure.

Of the total of 21 defined sections, 19 belong to the reservoir-enclosure itself. Section 20 deals with features located between the northeastern corner of the reservoir-enclosure and the circular structure to the north (sector E) and section 21 corresponds to the circular structure (sector A). Sections 1, 3, 14, 16 and 19 are areas where the wall is no longer visible (**Fig. 19a**). The other sections refer to the zones where the architecture is visible, either partially or entirely; for instance, in some sections, such as sections 2 and 17, only one course is visible, while sections 8 and 9 presents at least four courses. Although it is clear that the wall is in a poor state of preservation, it is nevertheless possible to distinguish three main zones.

Zone I includes all sections from 2 to 7, section 13 and section 15. This zone is relatively well protected given that it is located inside the reserve and away from the zone accessible by tourists (**Fig. 19b**). Here, the wall is still in its original state as it has had little or no modifications and has not undergone any restoration. Only the dense vegetation is present and covers some of it, especially sections 4 and 6. In terms of protection, maintenance and control of the vegetation is definitely required and the systematic backfilling of the wall's base will insure that the foundation is covered and better protected.

Zone II comprises sections 8 to 12 and section 21. It is part of the mandatory path followed by tourists visiting the reserve (**Fig. 19c**). Access to the wall itself starts from the western end of section 12 facing the observation platform, and the exit is located on Massif C, in section 8, on a wooden bridge leading the tourists to a



20. Damage on the wall of the reservoir-enclosure located inside the reserve, on the tourist track (zone II): a) lifting of facing blocks; b) transverse cracking in the wall; c) falling of blocks; d) longitudinal crack on Massif C (AASRP 2015).

second viewpoint. This zone is heavily restored and underwent significant modifications; consequently, it has lost its main original features, especially on the upper courses, which were systematically rebuilt. In general, multiple problems can be seen on the wall that are due to the restoration, the impacts of the visitors and the animals of the reserve, but also due to the aridity of the soil. Many of the facing blocks have collapsed, the connections between the wall and the buttresses are at risk, and large fractures can be seen on Massif C for instance (**Figs. 20b, 20d**). The recent mortar needs to be purged *i.e.* the modern mortar needs to be removed and the face of the wall reconstructed. Secondly, it is important to consider moving the visitor's path or maybe protecting the wall with a wooden footbridge.[5] It is also necessary to consider the problems related to the aridity of the soils, which is especially the case in sections 8 and 9, on the inner face of the reservoir-enclosure. Indeed, the excavations near Massif C (soundings C2 to C5) revealed the presence of peat and clay in the lower levels, proof of significant water stagnation and of an unfavourable soil for construction. A geotechnical study is necessary to understand better the stability limits of the soils.

Finally, Zone III, comprising sections 17, 18 and 19, is located outside the Wetland Reserve on private non-fenced properties (see **Figs. 19d, 21**). In this zone the wall is clearly at risk, and the threats are greater than those inside the reserve, especially since this area is subjected to looters digging holes into the wall, around it and even below it. Even when these diggings do not cause direct destruction, they nevertheless weaken the archaeological remains, especially when they are not backfilled. It needs to be enclosed urgently to limit looting and the deposition of garbage from the neighbouring areas. In section 19, excavations should be planned as it will allow to verify the presence of a fourth canal, previously drawn on Musil's plan (Musil 1927; see **Fig. 3**).

The condition assessment also provided a basis on which further maintenance could be suggested, specifically by identifying zones in which urgent operations were crucial. Based on this, work was initiated in 2015 with maintenance in two zones where action seemed urgent: in sections 15 and 5.

In sector G (section 15), some preventive protection was begun. In fact, a previous sounding had uncovered the entire first course of the wall, as well as the top of the foundation, but it had never been backfilled, putting the basalt course in danger. Therefore, in 2015, it was decided, after documentation, to backfill the entire zone with earth up to half the height of the preserved course. Following the same method, a systematic backfilling of every sounding opened in 2014 and 2015 was conducted.

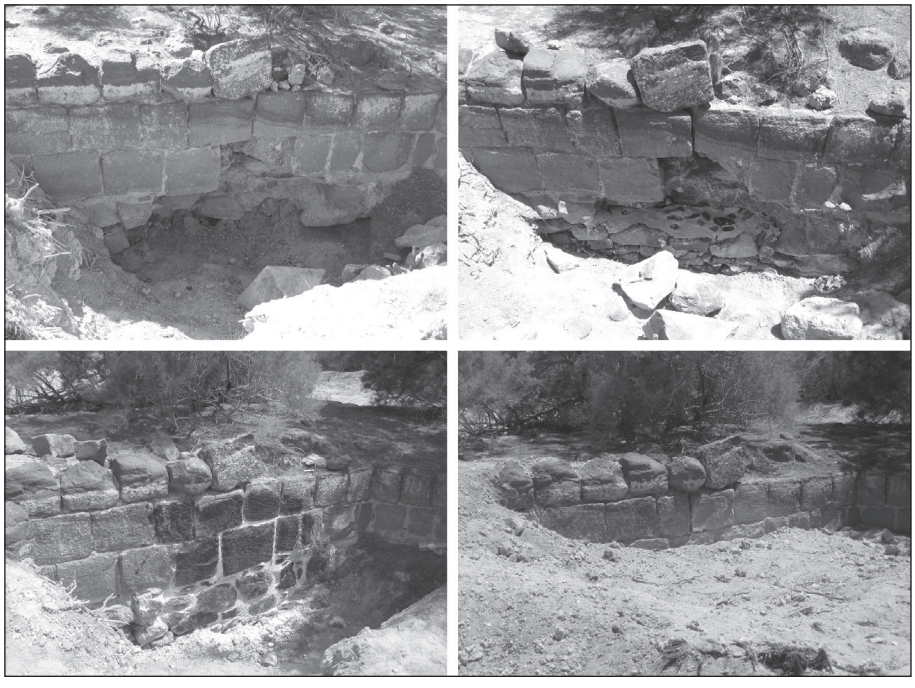
The second intervention was made south

5. These recommendations were issued in 2016.

of Massif C (section 5), where there again, a sounding had been made by previous projects, aiming to study the wall's foundation. The sounding was located inside the enclosure, on the western facing of the wall. The wall presented three levels of cut basalt courses and a foundation of approximately 70cm deep. It was in a very poor state of preservation: the foundation had completely collapsed and one block from the lower course of the facing stones had fallen down. The aim of the restoration was to secure the wall and the area in general. Therefore, the operations were carried out in two steps: restoration of the wall, then backfilling of the sounding (**Fig. 22**).

These interventions were very urgent. Zones that need restoration are numerous; portions of the eastern wall M4 and the northern wall M3, which form part of the visitor's path in particular, will need attention. Another project should focus on the composition of ancient mortars, in order to make the modern mortars as similar as possible to the original ones. The assessment made here is only one step towards

21. Examples of the current state of preservation of the wall of the reservoir-enclosure outside the reserve (AASRP 2015).



22. Different stages of the restoration and backfilling of the wall of the reservoir-enclosure in section 5 (zone I), inside the reserve but away from the tourist track (AASRP 2015).

the preservation and revitalization of this landmark of history and natural ecosystem that is the reservoir-enclosure of Al Azraq.

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