

THE SURVEY OF AL-WU'AYRA: A CONTRIBUTION TO THE KNOWLEDGE OF THE CRUSADER CASTLES IN JORDAN

by

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In spite of the fame of Petra and the archaeological importance of al-Wu'ayra castle, after a first survey in 1992, we found out that there was an almost total lack of topographical documentation of the whole archaeological site and the surrounding area. Apart from the surveys dating back to the end of the last century and to the first quarter of the twentieth century,¹ up-to-date maps of the whole area could not be found except for the general survey entitled "The Archaeological Map of Petra" drawn to a scale of 1:5000 and carried out by the Royal Jordanian Geographic Society in 1989.²

Because of the considerable morphological complexity of the archaeological site of al-Wu'ayra, making an accurate survey plan turned out to be extremely difficult. The complete lack of previous photogrammetric mapping and of cadastral maps made it practically impossible to foresee especially the operational difficulties of mapping the area.

Nevertheless we accomplished a general plan for the preparation of both general and detailed maps.

The limited amount of time we could spend at the archaeological site³ to gather the data, the shortage of technicians, equipment and funds⁴ compelled us to look for operational ways which would allow us to quickly and cheaply gather metrical data and information which would prove useful to accurately report all the data collected during the survey. At the same time the rough dimensional data of the archaeological site (230 x 350 m) and the more restricted area of the crusader castle (65 x 115 m) where the majority of the more complex structural works and exploratory excavations concentrated, contributed to the individualization of the typologies of the final results and of the most suitable scales of representation.

With regard to the problem of surveying the whole area, we were obliged to use ta-

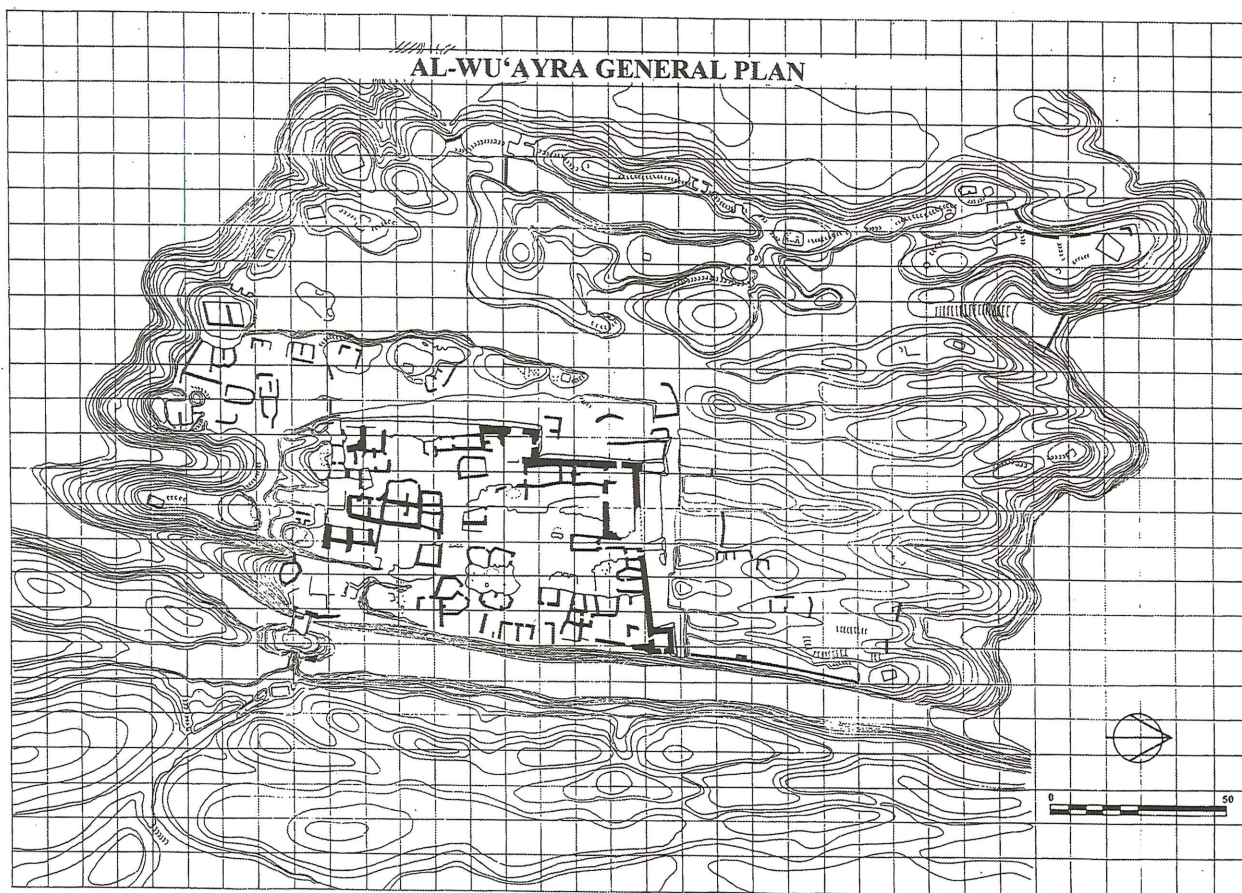
1. For this topic see R. Savignac, Qu'Airah. *RB* 1, Jan. 1903: 114-120; A. Musil, *Arabia Petrea*, Band II, *Edom, Topographischer Reisebericht*, Teil 1-2. Hildesheim / Zurich / New York 1907: 56-73; P. Deschamps, Les entrées des Chateaux des Croisés. Syria 1932: 369-370. For more recent graphic documentation, all of which, however, refers to very small parts of the whole castle area, see R.M. Brown, *A 12th Century A.D. Sequence from Transjordan Crusaders and Ajjubid occupation at El Al-Wu'ayra*. 1987: 267-288; F. Cardini, G. Vannini, M. Papi, R. Berretti and L. Marino, Ricognizione agli impianti fortificati di epoca crociata in Transgiordania, prima relazione. *Castellum* 27/28, 1987: 5-38; G. Vannini, Insediamenti di età crociata in Transgiordania, *LA* 10, 1990: 476-478; L. Marino, O. Dinelli, M. Guerra, G. Labanca, C. Nenci, F. Orlando and R. Sabelli, La fortezza di al-Wu'ayra a Petra: osservazioni sullo stato di conservazione. Pp. 97-102 in L. Marino (ed.), *Siti e monumenti della Giordania, rap-*

porto sullo stato di conservazione. Firenze: Alinea, (1994).

2. Maps on a high scale of the whole of Jordan drawn to a scale of 1 to 250.000, with the location of the archaeological sites have been drawn by J. N. G. C., Directorate of Military survey, with the cooperation of the Department of Antiquities, in 1981; maps to a scale of 1 to 50.000 have been drawn by the Ministry of Economy and the USAID of Jordan, based on the photogrammetric reports carried out in 1961 and on the available data supplied by the Jordan Department of Lands and Surveys, provisional printing of 1992.

3. Groups of archaeologists, architects and geologists participated in the years 1992-94 in this mission funded by the Foreign Office and Ministry of University and Scientific Research (40%) and led by Marco Bini and Guido Vannini.

4. The surveyor team made up of three units operating simultaneously included, apart from the writers, Architect Riccardo Berretti and Caterina Bini.



1. Plan of the al-Wu'ayra castle after the 1993 and 1994 survey season.

cheometric systems employing instruments aimed at drawing the map of the whole archaeological site of al-Wu'ayra to a scale of 1:500.

As to the planimetric and altimetric survey of the keep area where most of the buildings lie and covering about 7500 m², we made use of both tacheometric and direct survey methods supplemented with final data-processing drawn to architectural scales of 1:100 and 1:200. We worked by drawing on the ground geodetic polygonals both as a guide to ensure an accurate and detailed survey and as a main framework for the measurements, and where possible or necessary, by laying out on the ground a regular grid, anchored to a trigonometric datum point, either with a 5 x 5 or a 10 x 10 m mesh.

With regard to the detailed survey of fronts, sections and architectural and ex-

cavation details, to be developed only in sample areas owing to the extent of the area involved in the researches, we had decided to use systems of photogrammetric mapping, supplemented with a direct and tacheometric survey.

The employment of the recently tested new methods, in the field of photogrammetry, carried out by the Department of Applications of Descriptive Geometry of the Faculty of Architecture in Florence, turned out to be very useful for the purpose of the research—both for the quickness of the methods of data collecting and for the simplicity of the technical equipment used for the data collecting. The above-mentioned operational system consists of: taking the pictures with an ordinary non-metric camera, obtaining the co-ordinates of an extremely limited number of points on the surveyed object (reference points) and the

subsequent data processing of the images through the PC program called Photo.⁵ This program has been designed for the mapping on an architectural scale and provides two ways to interpret the data: the first system, called 2D, can transform an image in central projection of a plane surface into a parallel projection (useful for fronts and also for floors and architectural details and two-dimensional decorations); the second system, called 3D, can graphically transform the image into three dimensions and you can get the data in Autocad.

Our operations proceeded as follows:

- 1 - we singled out on the surveyed object the points to be used as reference points, important points or just points highlighted by the laying of special target centres and we also drew up accurate descriptions of them.⁶
- 2 - We took the coordinates of the points through systems of direct measurement (generally for systems of accessible points) or by tacheometric measurement using the forward intersection system;
- 3 - Photos were taken with an ordinary reflex being careful to use only those lenses which do not create distortion effects at the sides of the photogram; even when using a 2D system one image is enough, we believed it necessary, however, to take more than one, where all the reference points are shown, in order to obtain a first-rate image. When using a 3D system we took at least two photos from positions within - and + 45° from the orthogonal axis of the main plane where the object of our sur-

vey was;

- 4 - For a print-out we used a PC equipped with a 80286 processor, a mathematical co-processor and a VGA graphic chart, Autocad programs, an image printer such as Paint and Photostyler, a photogrammetric Photo program, a monochromatic scanner (for the automatic 2D system), a graphic table (for both the manual 2D and the 3D) and a printer or a plotter.

To make the survey of reference points easier when using a 2D system and having to undertake a survey of limited parts of ruins, we built up a pre-established and coordinated reference system, which consisted of the four vertices of a rigid square to be placed on the surface of the surveyed plane when actually taking the photos. We, therefore, built a rather fine (2 cm thick) wooden frame forming a square (the internal length of which was 100 cm), to be applied in various ways (by leaning it, fastening it, propping it up temporarily, or by inserting supports in the holes of the ruined walls) to the surveyed plane which consists of flooring and walled remains, horizontal architectural elements, parts of upright walls (and if that be the case, portions of stratigraphic sections as well) provided that they were of limited dimensions.

The main results of the survey carried out in at al-Wu'ayra and the subsequent graphic print-outs have been collected in several tables and they are the first scientific documentation of some of the most worthy architectural elements best preserved and also of the stratigraphic excavations that we carried out during the projects

5. Compare U. Saccardi, G. Conti, M. Liberatori and M. Magrini, *Fotogrammetria analitica da immagini architettoniche non metriche*. Rimini: Maggioli Editore (1994). Among the contributions prior to the publication of the programme Photo compare U. Saccardi, *Evoluzione di una idea*. In Pp. 371-374 in C. Cudari, (eds) *L'immagine nel rilievo*, Minutes of the study seminar, Lericci 10-11 May I Rome, 20-22 February, University "La Sa-

pienza" in Rome: Department of Representation and Survey, Rome, Gangemi Editore (1992). Similar programmes have recently been developed by other research units in the field of computer science applied to photogrammetry.

6. To use the 2D system you need at least 4 coplanar reference points, for the 3D system you need minimum 6 reference points of which at least 2 non-coplanar ones.

in 1992, 1993 and 1994.⁷

As to the general documentation of the surveyed area, which stretches for about 38.000 m², we also made a general plan, drawn to a scale of 1:500, by means of a topographic survey using tacheometric systems.⁸ It was possible to work on the survey together with the Jordanian National Geodetic Organization and to realize a system with a grid of fixed points, belonging to previously known co-ordinates, deliberately marked on the ground and quite evenly distributed. We then made a certain number of sections with regard to the environment of the whole area in order to evaluate the sudden changes in the altimetrical movement of the vast surveyed area. The automatic elaboration of the data allowed us to carry out a tridimensional digitized model able to visualize, as exactly as possible, the complex morphologic movement of the archaeological site. The documentation of the whole archaeological site, the location of every ruin appearing on the surface and of the rocks bearing conspicuous traces of carving for the construction of little caves, paths provided with steps and levelled areas, or other kinds of constructions bearing witness post life and different phases of use, allowed us to interpret the whole surveyed area. The results of this first synthesis are assembled in two thematic tables on the main evolution phases of the settlement of al-Wu'ayra. The first phase covers the period from the Bronze Age to the Nabataean period, when the whole area was used both as a monumental necropolis and as a sacred area of the settlement of Petra. We discovered parts of paths provided with hewn steps stretching for 365 m, seven big tombs placed in caves,

several places which were probably cult areas, two among which had cisterns and altar bases, and another sixteen areas with groups of holes in the shape of cups, small cisterns and rock carvings in the shape of seats.

The second documented phase dates back to the fortification of the area by the crusaders (1116-1188), and to a later settlement by groups of beduin. We singled out the whole defensive crusader boundary walls which enclosed an area of about 17.330 m², with a perimeter of 1.100 m, which was guarded by watch-towers and guard posts with the keep on the southeastern side and an urbanized area, probably a small village, lying in the southern part of the area.

We then concentrated our work on the area with most of the remains and the settlement traces, which consisted of the keep area of the crusader castle, with the planimetry reports in an architectural scale carried out through integrated survey systems (Fig. 2). A print-out drawn to a scale of 1:200 analyses the keep area, spotting all the remains of the surface masonry walls and the reference points with the relative altimetrical elevations. A further print-out in a scale of 1:100 analyses the same area, divided into four quadrants, and aims at a detailed reading of the surface wall finds and all other factors such as rock carvings, erratic archaeological fragments, areas of debris and collapse, exploratory excavations and other important data. On the same print-out the whole excavated area has been subdivided into topographic units (TU) and the locations of the stratigraphic units of the walls (WSU), visible on the surface, have been pointed out and each identified by a let-

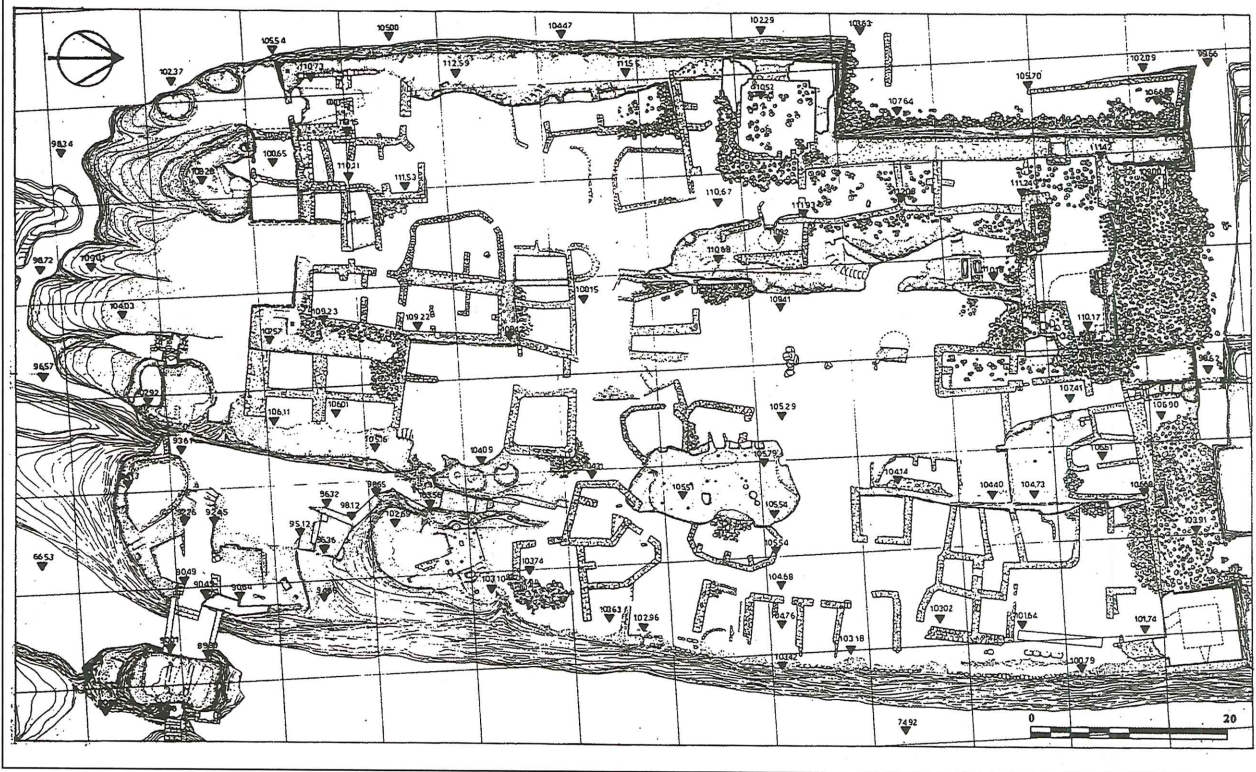
7. They are the stratigraphic excavations carried out in the TU 83, 84, 109, and 119, guided by Guido Vannini and carried out by the archaeologists Mario Frau, Stefano Tuzzato, Cristina Tonghini and Anna Wentkowska.

8. Although we drew up a closed polygonal with more than 500 surveyed points, due to the extreme complexity of the natural formations of the

surveyed area, the carrying out through automatic systems of the print-outs of the isohypses of the ground did not provide adequate results due to the lack of data. We have therefore only drawn print-outs with graphic symbols which provide sufficiently approximate representation of the rock formations with only the graphic highlighting of the altitude of the effectively surveyed points.

AL-WU‘AYRA CASTLE

PLAN OF THE KEEP



2. The keep of al-Wu‘ayra castle.

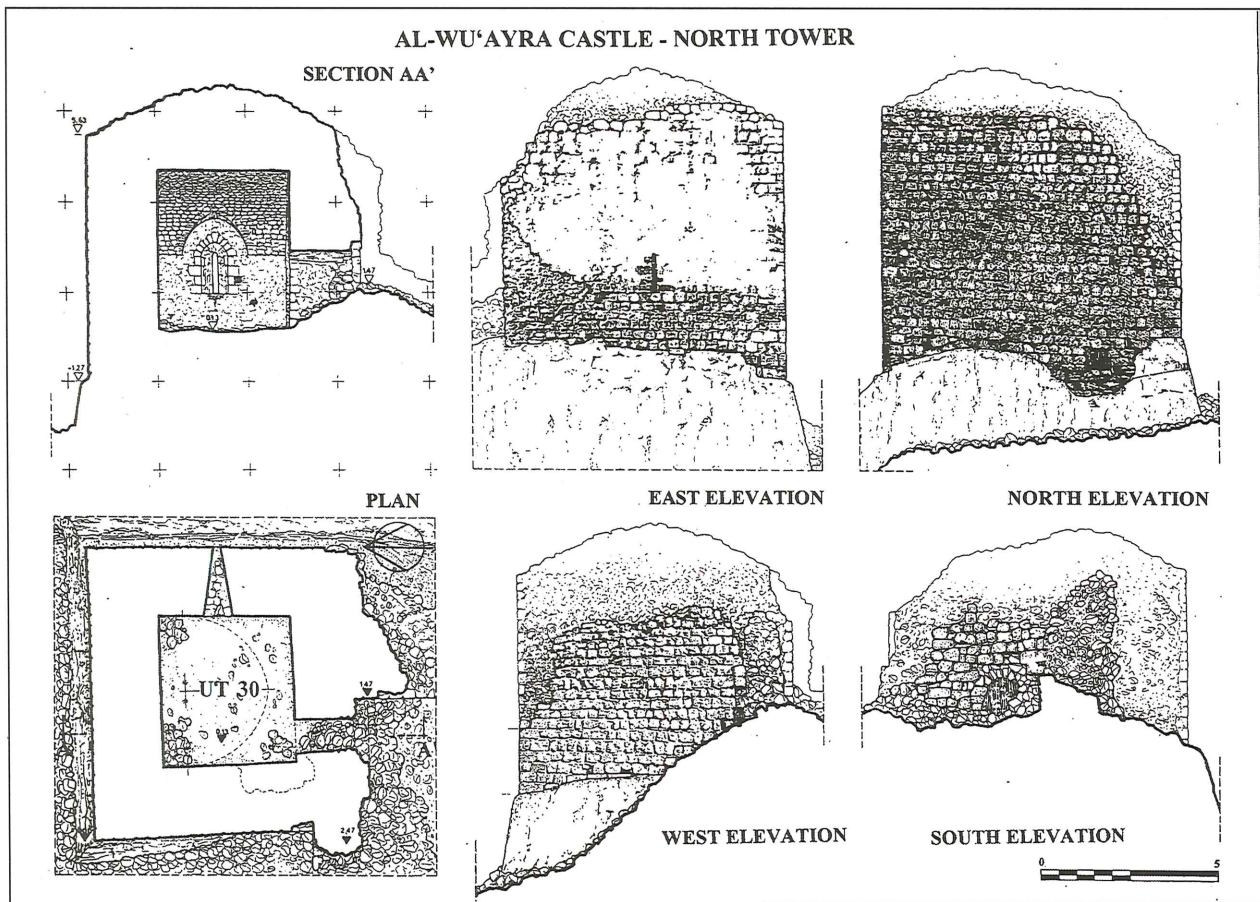
ter and a number. The print-out is completed by 122 surface survey charts describing the topographic units of the considered area and recording the characteristics of each structural element or stratigraphic unit which make them up (i.e. materials, building techniques, stratigraphic connections with the adjoining units).

On the basis of the plan drawn to a scale of 1:200 we drew up a thematic map synthesizing the data acquired through the reading of the essential stratigraphic relations of the elements of each topographic unit. We thus highlighted the main phases of the settlement in the area of the keep, outlining in a more detailed way the structure of the medieval castle, through the singling out of the remaining masonry of the crusader structures and the subsequent transformations due to their reutilization during the later and most recent times.

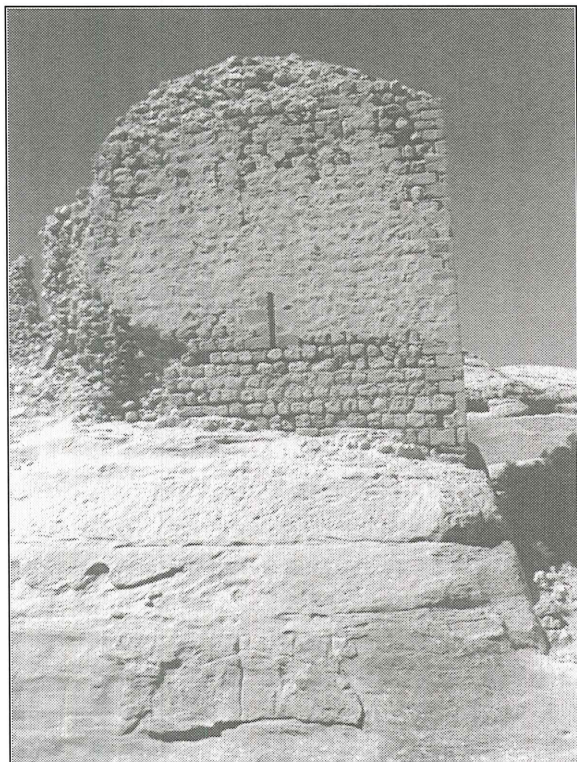
Furthermore we carried out detailed map-

ping of some emerging structures within the area of the keep, especially aimed at testing the integrated surveying techniques and analytic photogrammetric survey. We studied specifically the structure of the angular tower of the external wall on the northern side of the keep and the church with the adjoining cemetery area.

Among the large number of data collecting and photogrammetric reports is included the example of how the northern tower of the al-Wu‘ayra keep was been mapped (Figs. 3 and 4). It is one of the few buildings whose remains reach the height of more than 6m, consisting of the whole ground floor of the tower, which is the angular foundation between the eastern and northern external walls of the keep. The structure has a quadrangular shape with three sides jutting out of the external wall, one of which is inaccessible and directly looks down to the big “wadi”, below the



3. The keep of al-Wu'ayra castle: the north tower.



4. Al-Wu'ayra castle: the north tower.

masonry of the tower, about 35m deep. The measurements provided by the photogrammetric survey of the four fronts of the building allow an accurate reading of the building techniques and of the state of preservation of the monument. As for the western inaccessible front, we carried out the tacheometric operations for the outlining of the points, once they had been located taking "Polaroid" photographs to verify their readability, using the method of forward intersection. Two stations were prepared on the rocks facing the building which had to be surveyed. One of them was made up by a standing point of the geodetic polygonal, the reference point for the whole archaeological area, so as to create a bench mark for the orientation and the positioning of the tower itself.

The work team was composed of: 1) a surveyor who made photos and used the instruments; he carried out the operations of

outlining the eidotype with the monographies of the stations and of the points and wrote down the measurements; 2) by an operator assigned to the stadia (exclusively aiming at the positioning of the survey stations as we only had one tacheometre equipped with a diastimeter which he had to instal alternately on the two stations).

Relative to the northern front we proceeded with the same system (forward intersection); we also experimented, for the first time, with the possibility of applying a system of coordinate reference points made up of a one metre square, made locally for this purpose, directly applied on the front plane which was to be surveyed.

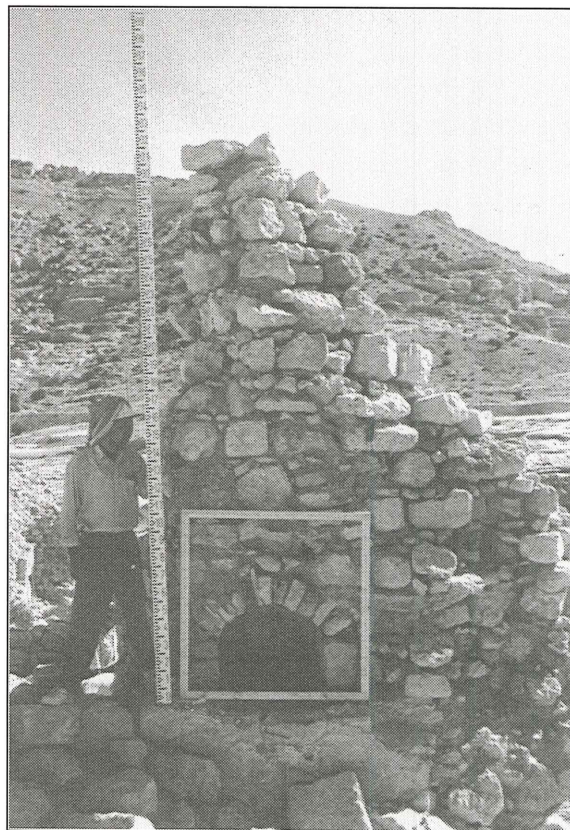
Such a system allowed avoiding operations of calculating the coordinates of the reference points by supplying the points of the reference system with the actual coordinates, shown in centimetres, directly on the photo. We compared these results (the second method can obviously only be used for the survey of directly accessible areas) both with control measurements carried out where they could be easily taken and with the results of the photogrammetric survey carried out using the coordinates of the reference points surveyed with the tacheometric system, thus obtaining acceptable data reports.

The recording of the four sides of the tower (among which there is the eastern front which is totally inaccessible as the masonry lies directly on the top of the rocky cliff of Wādī al-Wu'ayra), carried out directly using scale-reduced photogrammetric images, turned out to be particularly interesting. The building techniques came out clearly: the size of the hewn stones, the wedging of the joints, the building courses, the finishing of the external surfaces in some plastered areas; as well as the detailed report on the condition of the masonry with its numerous gaps, the areas subject to erosion and the disruption in progress described in special thematic charts. The de-

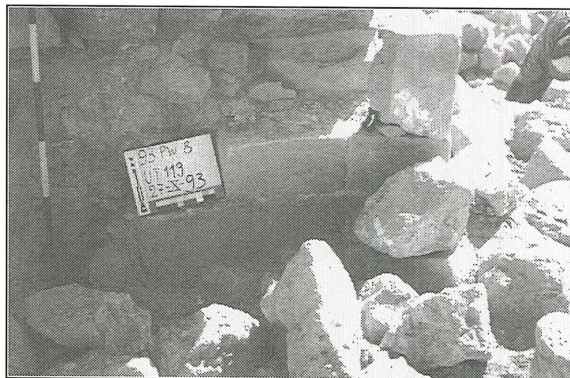
tailed survey has also permitted a formal-typologic reading of the workmanship as well as the precise definition of structural elements and building techniques.

Integrated survey methodologies have also been used in the survey of the ruins of the Crusader church and of the adjoining cemetery area (Figs. 5 and 6).

The use of photogrammetric survey has allowed an exact report of all the preserved parts of the walls and of the masonry which



5. The church of al-Wu'ayra castle: ruins of the apse.

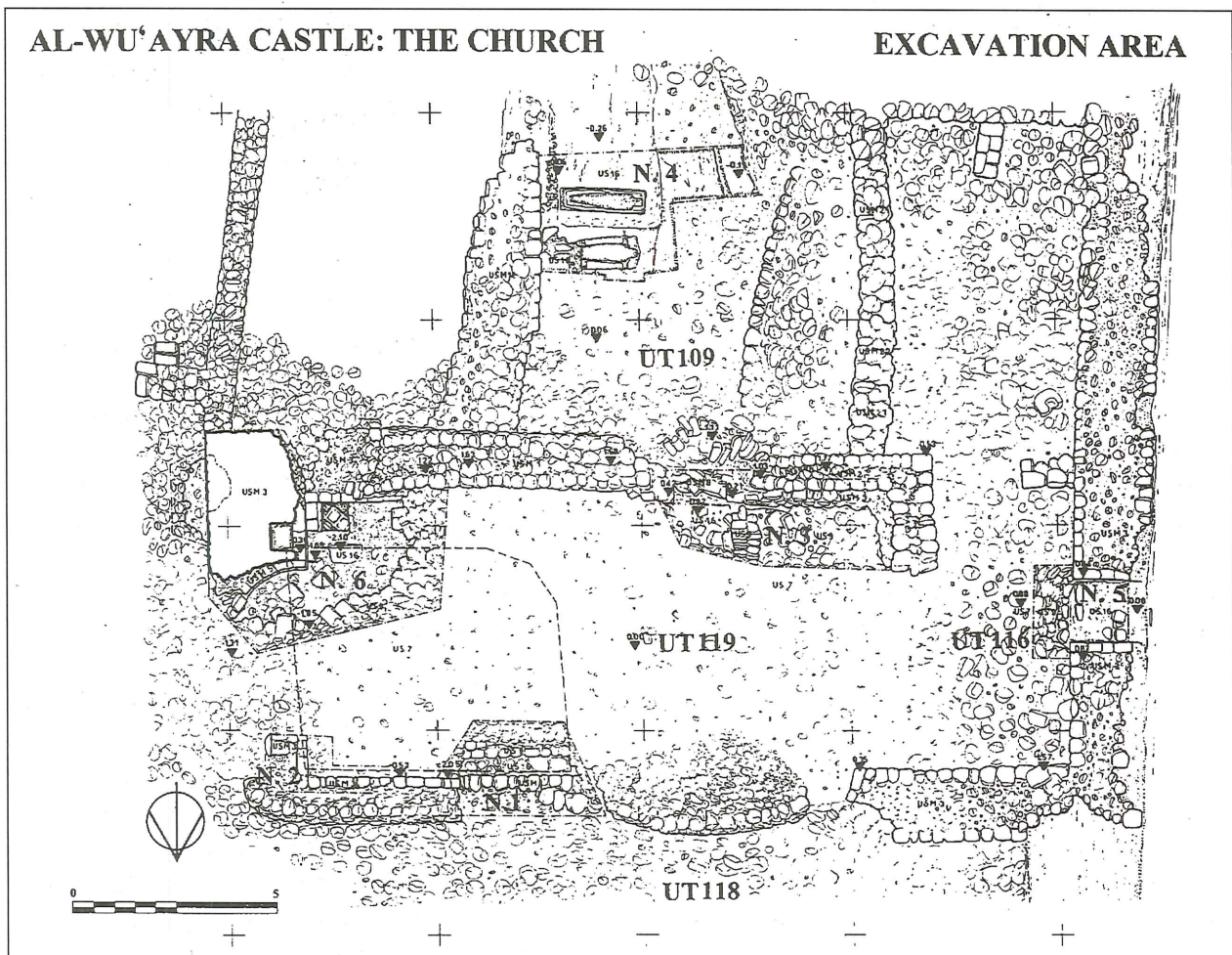


6. The church of al-Wu'ayra castle: part of the Semi-circle of the apse.

emerged during the excavations. Besides, we also experimented a photogrammetric lay-out on some parts of flooring which emerged during the excavation as, for example, the rock-carved floor of the entrance in the west external wall.

The survey in detail allowed the identification of at least two building phases of the present church: the first phase is represented by a basement covered by the apsidal side, which belong to a smaller building; the second phase goes on with the church being excavated at the moment, which was built by enlarging in width the body of the building towards the inside of the boundary wall of the keep.

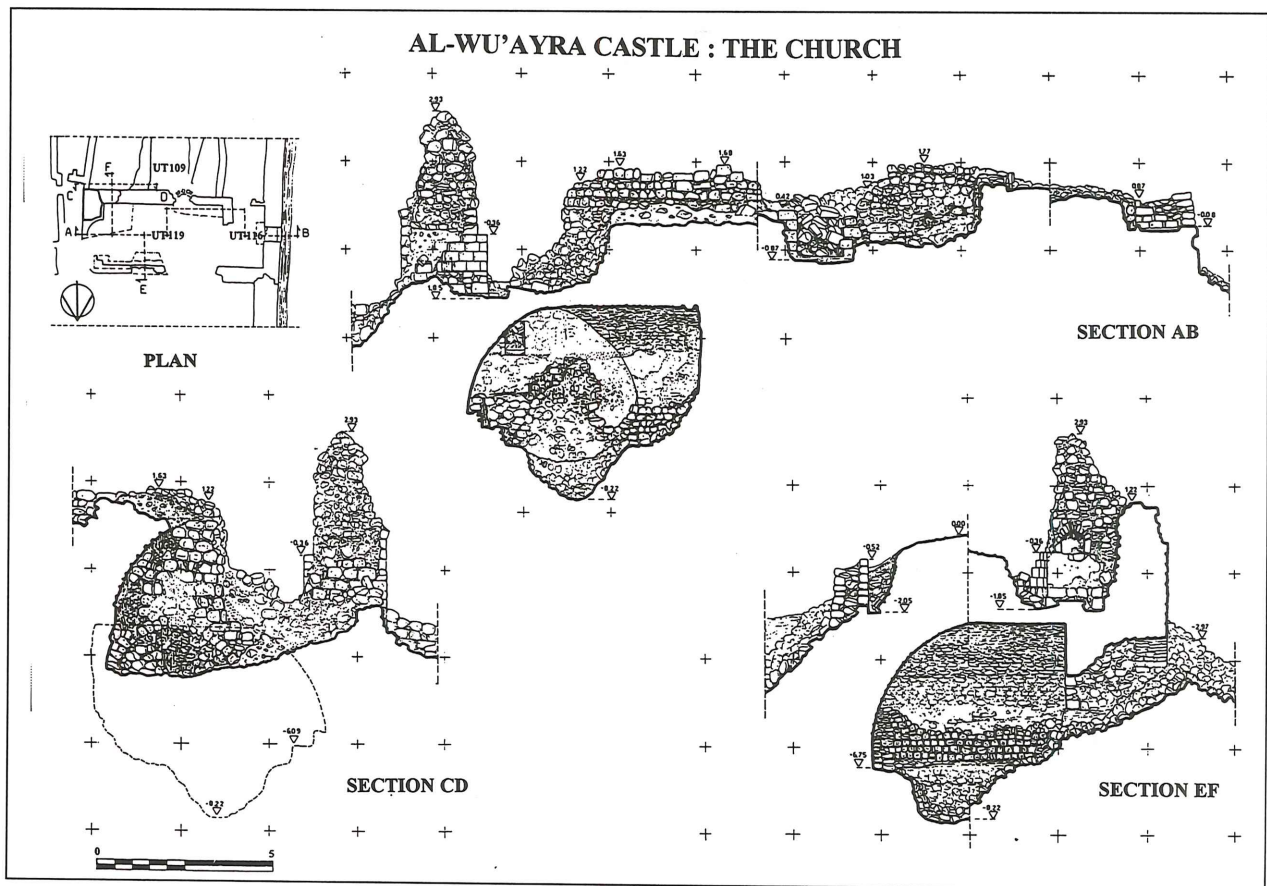
The structure of the church, well outlined during the excavations in 1994, consists of a single aisle, once covered by an ogival barrel vault,⁹ and leading to an apse with two small niches at the sides (Figs. 7 and 8). The aisle is 13.95 m long and 6.97 m wide with a ratio of 1 to 2; there is an entrance on the southern side and another entrance on the western side and at least one window or slit on the northern side. The apse wall is thicker (2.36 m) than the rest of the outside wall (1.77 m) to house the apse structure. During the excavation we collected data concerning both the original flooring of the aisle made of stone slates irregularly shaped, the interior finishings of the walls thickly plastered



7. Plan of the church of al-Wu'ayra castle.

9. The shape of the church vault, nowadays totally lost, is documented together with the apse by the surveys and photos published at the beginning of

the century by Savignac and Musil; compare R. Savignac, *Qu'Airah, op. cit.*; A. Musil, *Arabia Petrea, op.cit.*



8. Cross-sections of the church of al-Wu'ayra castle.

and accurately smoothed with a mortar layer, and the features of the apsis built with large hewn stones accurately carved and put side by side by thin lime joints with a visible finishing.

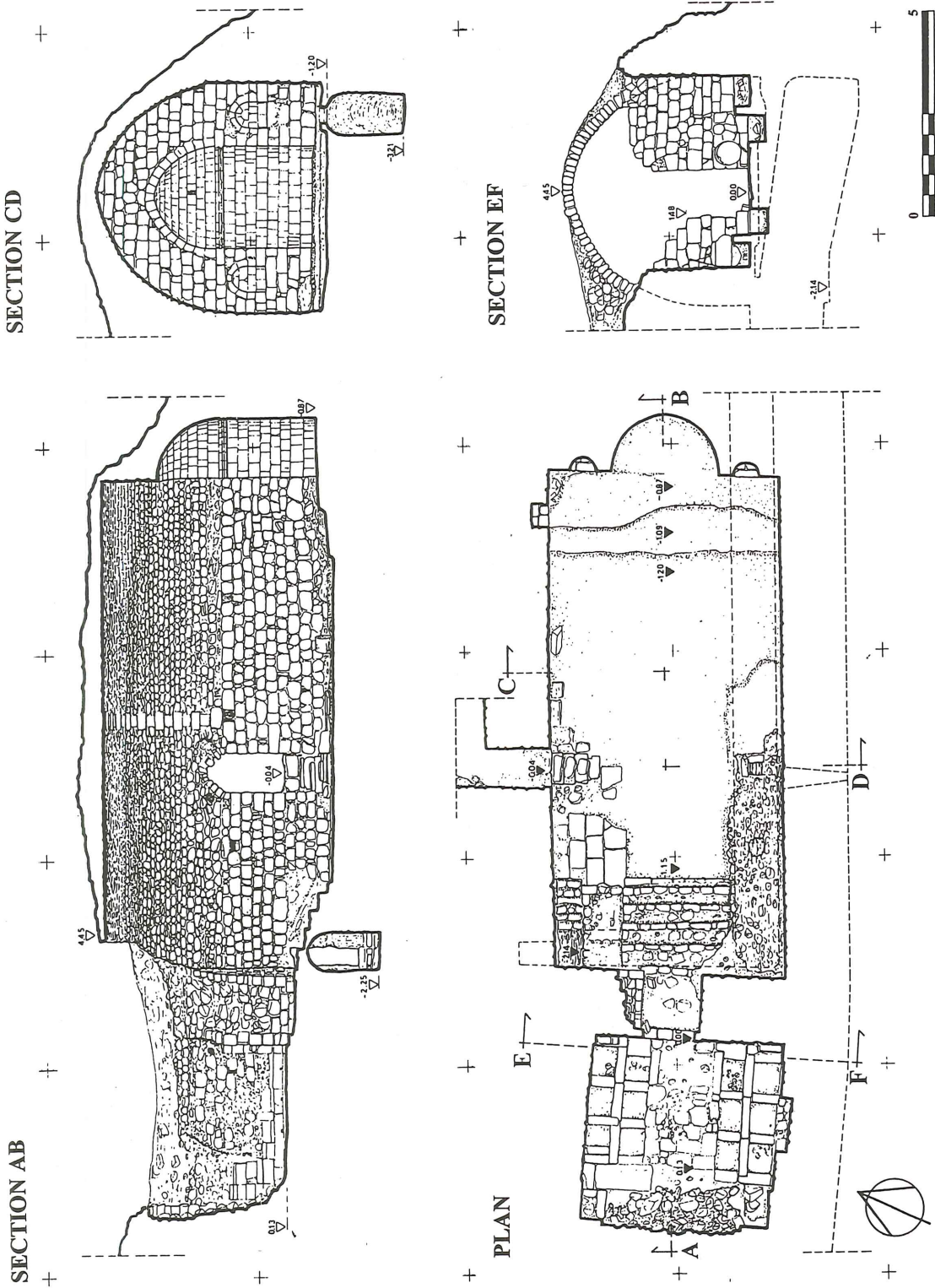
South of the church near the flight of stairs leading to its side entrance, we discovered the cemetery area dating back to the crusader time consisting, at present, of two tombs directly carved into the rock at the bottom shaped to suit the corpse and above it the cavity for the lid.

In an earlier analysis of the structures we could not directly compare with one another, the shape or dimension of the crusader fortifications in Transjordan, because most of them were built in a very short time making the most of the geographic and morphologic features of the area. But as to the architectural study of the period, the analysis and the comparisons between the single buildings or parts of them and between the

building techniques and the technological solutions used to build every single fortified settlement turn out to be particularly relevant.

We surveyed the chapel of the crusader castle in (Figs. 9 and 10) ash-Shawbak in order to make a typological and dimensional comparison with the church in al-Wu'ayra. The former probably dates back to the same period as the church in al-Wu'ayra, having quite similar typological features but being better preserved. It also consists of a single aisle covered by an ogival barrel vault leading to an apse with two small niches at the sides. The aisle has an average width of 5.54 m and a length of 12.15 m; the height of the keystone, which is irregular because of some subsidings and bad restorations, happens to be almost the same as the width of the aisle itself. The two halves of the cylindrical vault which form the roofing, have a radius of approximately 3.25 m owing to

SHOWBAK CASTLE: THE CHURCH



9. Metric survey of the church of ash-Shawbak castle.



10. Ash-Shawbak castle: the apse of the little church.

the sustained deformations. The impost of the vault is at a height of 2.51 m from the average floor level. The width of the apse base is the same. The niches at the sides of the apse have a width of 0.59 m and a key height of 0.78 m and a depth of 0.39 m.

The two churches are the same and, apart from their different dimensions, probably connected with the importance of the settlement and the number of Christian inhabitants of the castle, look like copies of the same model. In fact these buildings do not show any peculiar feature, if compared to the adjoining buildings, but they mingle and form a unity with the castle area. They are located along the boundary wall with connections with the adjoining structures serving, when necessary, as part of the defences of the castle. In both cases we get to the cistern or the main water supply of the fortress through the church. Such a location

may make us believe that the building, besides expressing with this function a link with the ritual of Christian baptism, would serve as a refuge in case the enemy had succeeded in getting into the fortified wall.

The dimensional comparison between the two buildings has highlighted that the interior width of the room under the church of al-Wu'ayra is nearly the same as the one of the church in ash-Shawbak. This fact may suggest that what we considered the earlier building of the church in al-Wu'ayra, could have had the same dimensions and shape of the building in ash-Shawbak and that the church being excavated at the moment refers to a later phase of enlargement with a clearer geometrical structure thus representing a development of the form from previous building.

With regard to the graphic documentation of the exploratory excavations,

we collected all the essential dimensional data of the various stratigraphies, following the excavation and surveying the finds whenever it was necessary.

We drew up maps of the different layers and comprehensive maps of unique individual features to a scale of 1:20. We also made stratigraphic sections of the walls of the excavation and sections and tables of some stratigraphic wall units to a scale of 1:20 and 1:10.

As examples we have shown four print-outs of the exploratory excavation carried out in TU 84 with comprehensive overall maps of the particular features, that is of the surfaces of the stratigraphies which simultaneously appeared during the excavation and which are in geometrical projection with the related sections. In the present phase of the research it has not been possible to draw up either a composite map or a

map of the different periods of the surveyed topographic units. We could not even draw up a reconstruction plan. But we have drawn up the stratigraphic wall sections of the exploratory excavation carried out in the TU 83. Moreover, we carried out some photogrammetric surveys of the stratigraphic sections of TU 119 which were particularly suitable to be surveyed using these methodologies because of the favourable aspects and the peculiarity of the rubble in the strata.

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