ISPARTA YALVAÇ
SU YOLLARI

PISIDIAN ANTIOCH

THE SITE AND ITS MONUMENTS

by
Stephen Mitchell
and
Marc Waelkens

with contributions by
Jean Burdy, Maurice Byrne, Jean Öztürk
and Mehmet Taşlıalan

Duckworth
with
The Classical Press of Wales

M.Bildirici with Paulette & Jean Burdy in Israel in 2001

Chapter 6

THE AQUEDUCT, NYMPHAEUM AND BATH HOUSE

G. Weber studied the aqueduct of Antioch as part of his series of articles on the ancient aqueducts of Anatolia. He followed its course for 1200 metres and described the nineteen piers and the arches which remained in his day. On the site he recognised the existence of a stone pressure pipe and indicated that it belonged to a siphon. This was supported by a long wall which crossed the saddle and entered the north part of the site close to a rectangular building which was levelled to its foundations. Twelve specimens of the stone blocks of this pipeline were found reused in Yalvaç itself. He dated the whole system to the hellenistic period with repairs in Roman times.[1] The members of the Michigan team investigated the upper reaches of the aqueduct, including the system of tunnels and bridges in the middle section of its course which Weber had not seen, and made a series of drawings and photographs to which we have had access. However, none of their observations was published.

The following account of the remains,[2] based on a survey carried out by J. Burdy and M. Taşlıalan in 1995, follows the course of the aqueduct from the city to the springs (*Fig.* 32). The final point where it entered the city was necessarily a tank (*castellum*) which was either contiguous with the nymphaeum or combined with it. The aqueduct reached the level of this tank by means of a stone pressure pipeline (siphon) 800 m long, as Weber had already identified, and this section was preceded by the arches which have always attracted attention because of their conspicuous position on the hill ridge leading south towards the city. Upstream, beyond the arches, the course of the channel joins a recently widened dirt road which leads to the mountains along the same crest. The side walls or the floor of the channel sometimes appear in the road surface or in the embankment beside it. The road then runs uphill and the remains of the aqueduct are lost for about 500 m before it appears again at a lower level at a beautiful one-arched bridge, constructed from massive blocks. Beyond this the course of the aqueduct is lost again on a spur of the hill. Two short tunnels are reported locally to have carried the water through this spur but these were not located. To the north-east there is a further underground channel on the right side of the Suçikan Dere. Two stretches of this, one above and one below the important remains of two bridges at the junction of two valleys, are in perfect condition and accessible through manholes and at points where the vault has collapsed. The last identifiable point of the aqueduct is a manhole situated 4 km in a direct line and 6 km overland from the nymphaeum.

The source of the water is almost certainly the springs, which are now tapped

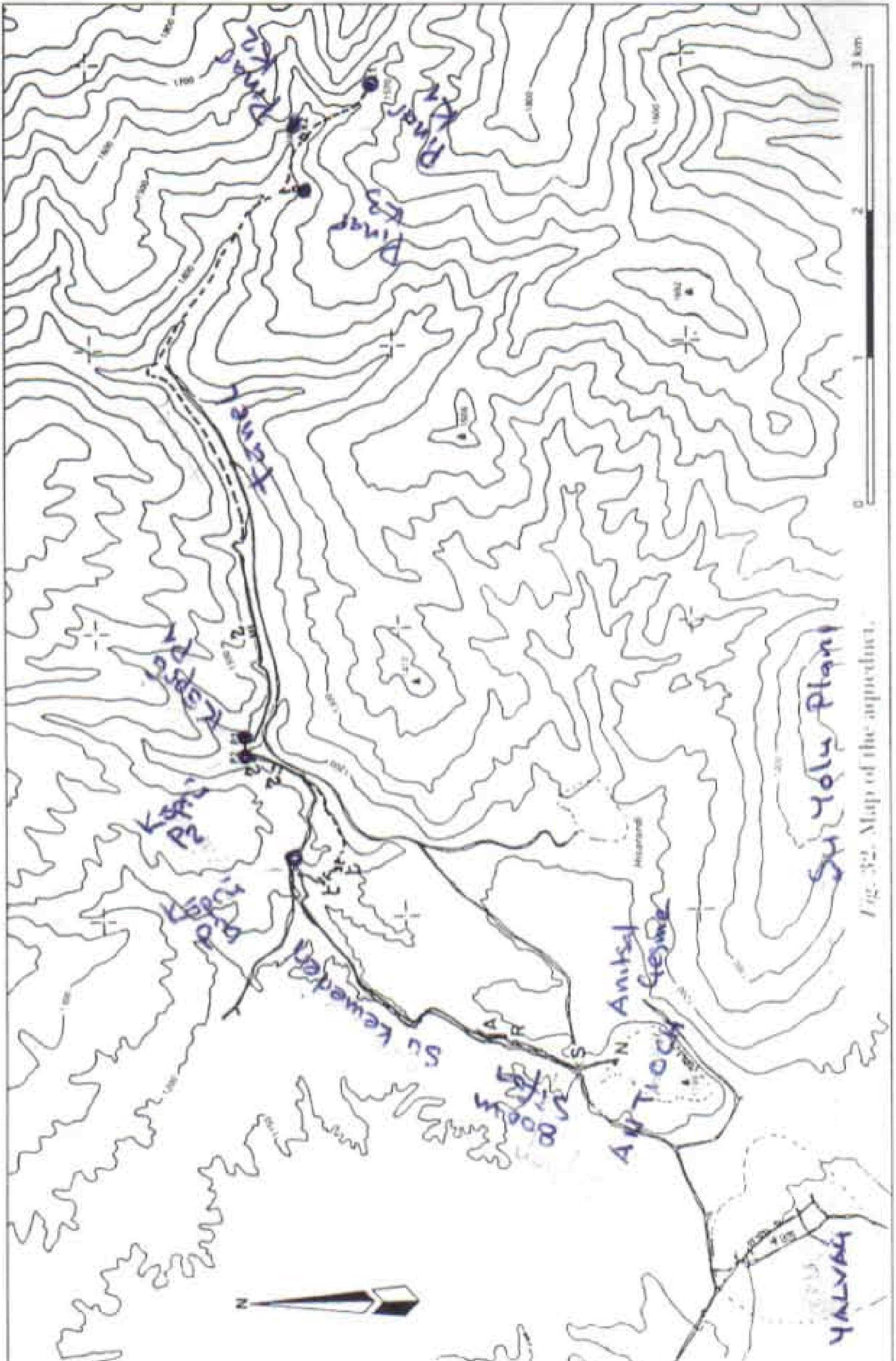


Fig. 32. Map of the aqueduct.

by two recent water supply pipelines leading to Yalvaç, the first laid down in 1952, the second its replacement of thirty years later. These springs are about 4 km upstream and on the left-hand side of the Suçikan Dere, at 1440, 1465 and 1570 m above sea level (PLATE 116). Thus the whole length of the aqueduct, measured from the intermediate spring which was probably the main source, was 10 km, with an approximate drop in level between the source and the city of 287 m. In one of his popular descriptions for the *Michigan Alumnus* F.W. Kelsey reported that the source of Antioch's water was a copious and ice-cold spring which lay in the hills eight miles from the city. The water was brought to the city by underground tunnels, where this was practicable. Robinson's general report on the 1924 season also observes that the water came from a natural spring six or seven miles away to the north of the city, whence it could be distributed in terracotta or lead underground pipes.[3]

PLATE 116.
The Suçikan Dere
(Kelsey archive 7. 1479).

The underground channel

The channel was surveyed in three areas (see *Fig.* 32). The first section could be entered by a manhole (R2) 1 km above bridge P1 and followed for 40 m upstream and 66 m downstream. The second section is accessible by two holes in the vault below bridge P2, allowing progress within the tunnel for 15 m from the first and 20 m from the second point of entry. The third section could be traced intermittently for about 800 m snaking beside or along the line of the earth road on the ridge until it reached the arches. The visible remains here include the side walls levelled down to the roadway, with their brick cement lining and quarter-round shape in the bottom corners, the floor of the conduit, which is sometimes excellently preserved, and at two spots the bare foundation.

Fig. 33 illustrates the construction details of the channel, which was built, as was usual, in a filled trench. The masonry is of rough small stones, comprising schist in the mountains and limestone on the hill ridge near the arches, bonded together by lime cement of uneven quality (PLATE 117). In the conduit itself it is beige, of good quality and often in excellent condition; elsewhere in the foundation courses it is blue-grey in colour. There was some variation in the thickness of the foundation, between 30 and 60 cm, and of the side wall, between 50 and 75 cm. Various different construction techniques were adopted for the floor of the channel. One was observed in a 50 m section where the ridge falls away and the conduit makes two sharp turns during a steep descent. Here the floor was made of large rectangular *tegulae*, laid flat and end-to-end, each measuring 62 x 45 cm. Their edges which are 5 cm thick and 4 cm high were bedded in quarter-round of cement which sealed the joint between the side walls of the channel and the floor. Woodbridge made a drawing of a section, which shows a V-shaped channel 40 cm deep, made from stone or terracotta tiling, not cut directly into the rock. Above this there was a vaulted tunnel made of rubble and mortar, 1.30 m high and about 80 cm wide. Another section is located immediately before

PLATE 117.
Aqueduct tunnel, construction details (Kelsey archive 7. 1481).

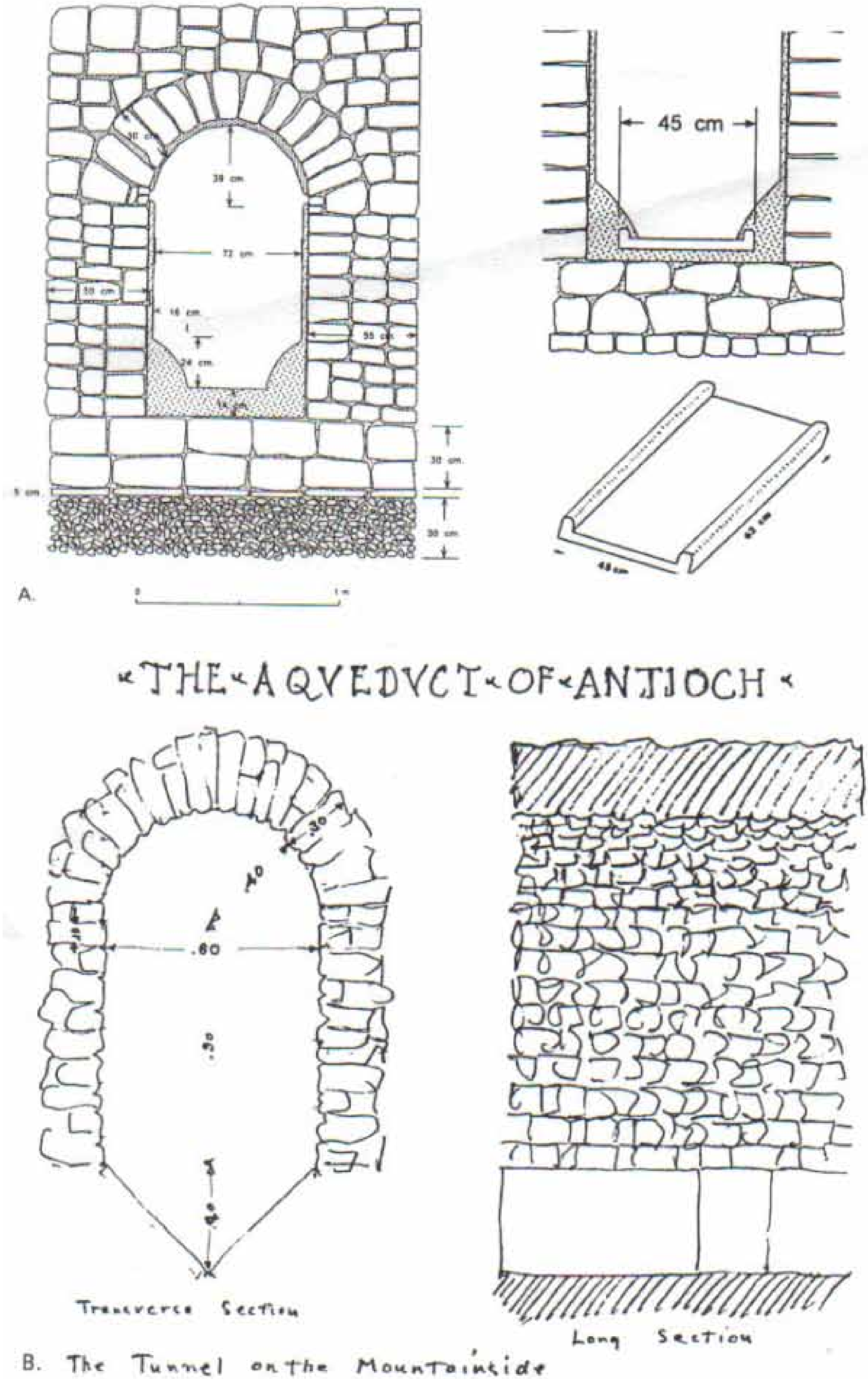


Fig. 33. Aqueduct tunnel sections (A. Burdy; B. Woodbridge).

the arches, probably at the point where the channel emerged from underground. Here the foundation was 1.6 m thick and much stronger, and a row of rectangular slabs, measuring 1.4–2 m long, 1.1–1.4 m wide and 15–25 cm thick can be seen. These belonged to a flat roof which originally covered this part of the channel, contrasting with the vaulted roof of the underground section.

Below bridge P2 the channel had been converted into a burial place at an undetermined date and yielded two human skulls, some bones and fragments of pottery.

The manholes

For maintenance, cleaning and repairs manholes provided access through the vault to the channel. Six were located, belonging to three groups. Manholes R1–3 are spaced at regular intervals of 45 m from one another about 1 km above bridge P1. R4 is about 50 m below bridge P2. R5–6 are 42 m apart about 200 m below R4. All of them are similar in shape and construction. They are square in section and the same width as the channel (76–8 cm) constructed from cement with no broken tile. They were covered with large square limestone slabs. In four cases these lids are completely buried and may only be seen from the inside of the tunnel. Manhole R2, was covered by a single slab, 1.67 long, 1.14 wide and 16 cm thick, which has shifted slightly and lies at an angle across the opening. R6 was covered by two slabs laid side by side, one of which, now broken, lies in the downstream corner of the manhole. The other, measuring 1 m by 97 cm by 12 cm, has slid 15 m downhill from its original location. The height of the manholes from the top of the side wall of the channel to the bottom of the covering slab varies between 65 cm for R4 to 1.3 m for R3 and probably for R2.

The facing stones of the walls of the manholes, usually measuring 20–30 cm across and 10–15 cm thick, were roughly squared. Where the front and rear walls meet the vault of the tunnel they were supported on arches constructed from rough arch stones 30 cm high. Footholes were cut into the opposite side walls of the shafts to ease access.

The bridges

The aqueduct system includes three bridges. The first two, P1 and P2, are located 100 m apart at the end of two valleys, the Küçükkemer Dere ('stream of the small arches') and the Kemer Dere ('stream of the arch'). The third bridge P3 is situated two kilometres downstream in the valley of the Killet Dere.

Bridge P1 has three arches and is nearly 30 m long, between 4 and 5 m high, and 2.05 m wide (PLATE 118). In its present state it is almost completely buried by silt and the stream today flows under the upstream arch, which is the only one still intact (PLATE 119). It spans 4.6 m and is constructed from 17 monolithic voussoirs, measuring 2.05 m (the width of the bridge), 80 cm (rib thickness), 35–40 cm at the intrados and 45–55 cm at the extrados. The downstream arch appears to have been its symmetrical counterpart, while the central arch was much wider, spanning 7 m. The intrados of the main arch is only 50 cm above

PLATE 118. Aqueduct. Bridge P1 (Kelsey archive 7. 1354).

PLATE 119. Aqueduct. Bridge P1, upstream arch.

the modern ground surface and the highest voussoirs of the downstream arch are only partially visible. The first pier ends with a moulded cornice of type C3 (see below p. 192). It is 2.65 m long and separated from the upstream abutment by a passage 1.4 m wide, the upper part of which has disappeared.

Bridge P2 is the largest but most damaged of the three (PLATE 120). It is about 50 m long (42 m between the abutments), 2.1 m wide at the top and 11 m above the stream bed at its heighest point. It had five arches and the present stream passes under the uppermost of these. A number of large embossed blocks scattered around seem to be *in situ*, thus indicating the approximate position of the upstream abutment and the 2.35 m square first pier, which were separated from each other by a passage 1.5 m wide (PLATE 121). The second and third piers are indicated by incomplete foundation remains; the fourth has disappeared entirely; but the fifth is intact. It stands 2.2 m square and between 2 and 3 m high

Plate 120. Aqueduct. Bridge P2, general view from the north (Kelsey archive 7. 1356).

on a steep slope. It is capped by a cornice of type C3 which supports a recessed arch made from 17 voussoirs and spanning 4.6 m (Plate 122).

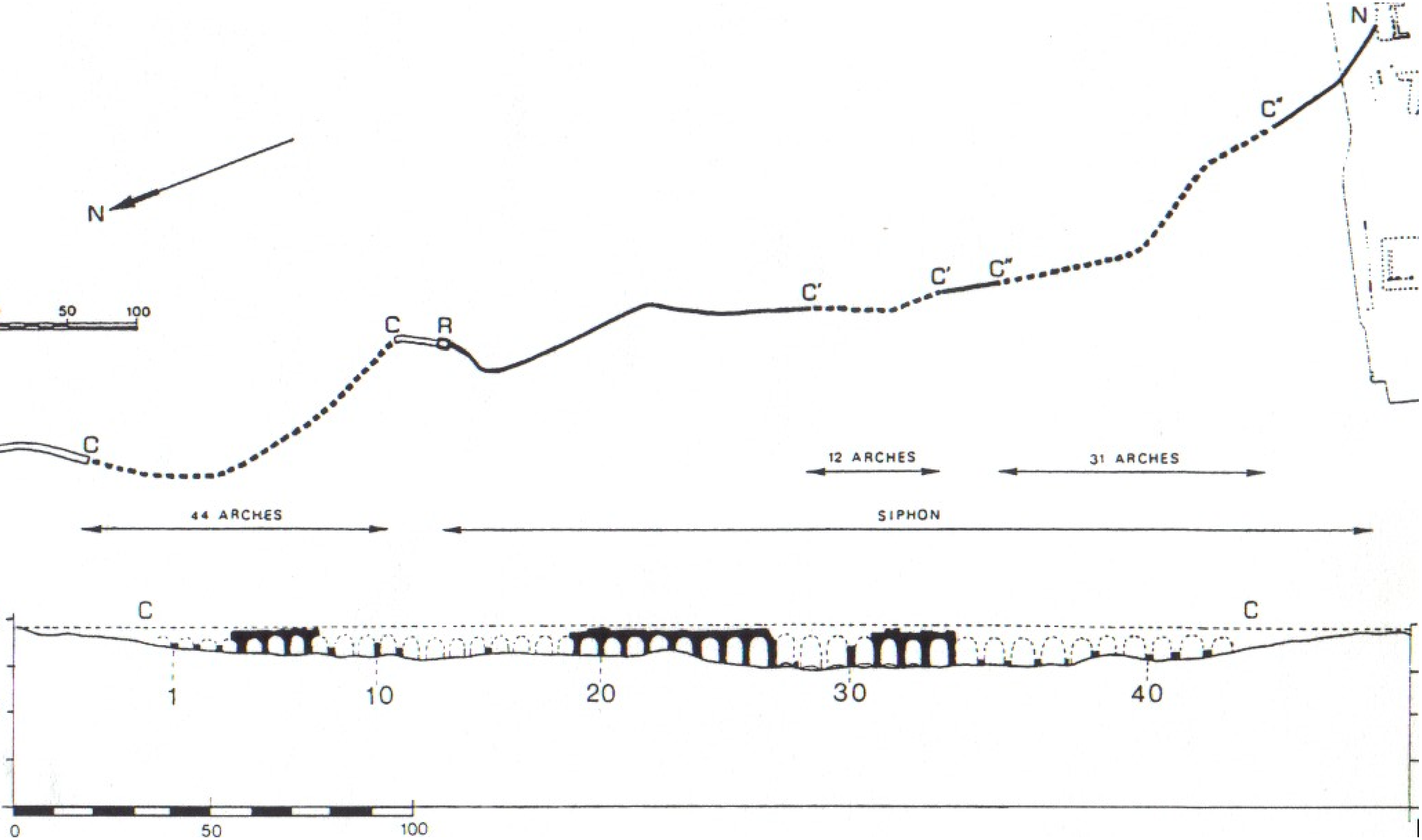
Bridge P3 is the smallest and best preserved of the three, 15 m long, 2.1 m wide and 5 m high. There is only a single arch with a span of 2.9 m constructed from 11 monolithic voussoirs. The spring stones of the arch are recessed 20 cm behind the abutments which have no cornice. Two square flood passages 60 cm wide are symmetrically placed in the abutments above the level of the spring stones and 1.5 m from the edge of the arch (Plate 123).

Plate 121. Aqueduct. Bridge P2, abutment and first pier from the north (Kelsey archive 7. 1357).

PLATE 122. Aqueduct. Bridge P2, fifth pier and arch from the north (Kelsey archive 7. 1358).

PLATE 123. Aqueduct, bridge P3.

The architecture and construction technique of the bridges are similar to that of the arches. Their positions were chosen with care at the narrowest points of the three valleys. P2 and P3 were partially supported on rock outcrops which helped to protect them from undermining by flood water. The narrow passageways between bridges P1 and P2 and their abutments served the same purpose as the passages for flood water through bridge P3.


N
C'
C'
C''
C'
C
R
C
50
100
12 ARCHES
31 ARCHES
44 ARCHES
SIPHON
C
C
1
10
20
30
40
0
50
100

The arches (*Fig.* 34a)

The long row of arches on the hill crest which runs towards the city is the most spectacular part of the aqueduct and the most impressive standing ruin of the entire site (PLATE 124). Arundell had seen 21 piers, reduced to 19 by the time of Weber's visit, in three groups of 9, 9 and 5 respectively. Today 19 complete piers can still be made out in three groups (PLATE 125).

The total length of the arched section of the aqueduct between the two end abutments, which are still clearly visible, is 280 m. Two blocks of the downstream abutment of the arches are still *in situ*. Then a discontinuous line of masonry of small stones at ground level, 40 m in length, leads to a high point where the siphon probably began. Although the remains of the arcaded section are discontinuous, they allow us to assume that there were originally 43 piers and 44 arches, to be numbered p1–43 and a1–44 respectively, counting from upstream. Fourteen arches still exist in three groups: a5–a7, a20–a27, and a32–a34. Piers p4–p7, p19–p27, and p31–p34 remain intact, as do p10 and p30 in isolation, giving a total of 19. Seven other piers, p1, p3, p8, p35, p40, p41 and p43 still have at least one full course of stones, and enough remains of p2, p28, p42 and p43 for measurements to be taken. Only minor remains are left of p12, p15, p16, p29, and p36–p38, and nothing at all of p9, p13, p14, p18 and p39.

A careful examination shows that the arches conform to one of two dimensions. The average span of a1–a22 was 4 m, and of a23–a44 4.6 m. All of them rest on square piers, 2.15 m wide. Four elements, however, contribute to hide this uniformity. Firstly, the springs of the arches are recessed on the cornices which top the piers. These recesses are irregular and often asymmetrical, but average about 20 cm, making the interval between the piers some 40 cm shorter than the arch spans. Secondly, the line of the arches is not straight but takes two turns to the left, near p13–p14 and then near p20–p23 (see PLATE 124). The change of direction is more obvious in the latter case, where the rough trapezoidal rather than square sections of the piers mark the bend. So p20 has a left side of 2 and a right side of 2.5 m, and p23 has a left side of 2.25 and a right side of 2.40 m, the longer sides marking the outside of the curve. Thirdly, the tolerance in the module of construction is rather large, between 5 and 10 cm. Fourthly, the aqueduct has suffered considerable damage from earth movements, due to the weakness of its foundations in the rather soft soil, compounded by the effect of earthquakes. A great many large blocks have moved, some seriously, and a few piers are actually dislocated (e.g. p34). Some of these have been roughly rebuilt (p31, p32), while others have collapsed into a chaos of blocks (p28, p29) or have more or less disappeared altogether.

The arches are the same width as the bridges, 2.1 m, and their voussoirs are made from one or two blocks extending across the full width (PLATE 126). The extrados is at a constant level, but the height of the arches varies between 4 and 7.5 m according to the irregularity of the ground surface. The piers vary in height between 2 and nearly 5 m. The height of the arches may also vary by up to 1 m between the left and right sides of the aqueduct, to counteract the natural

PLATE 124. Aqueduct. Arches a20–a27 (Ballance).

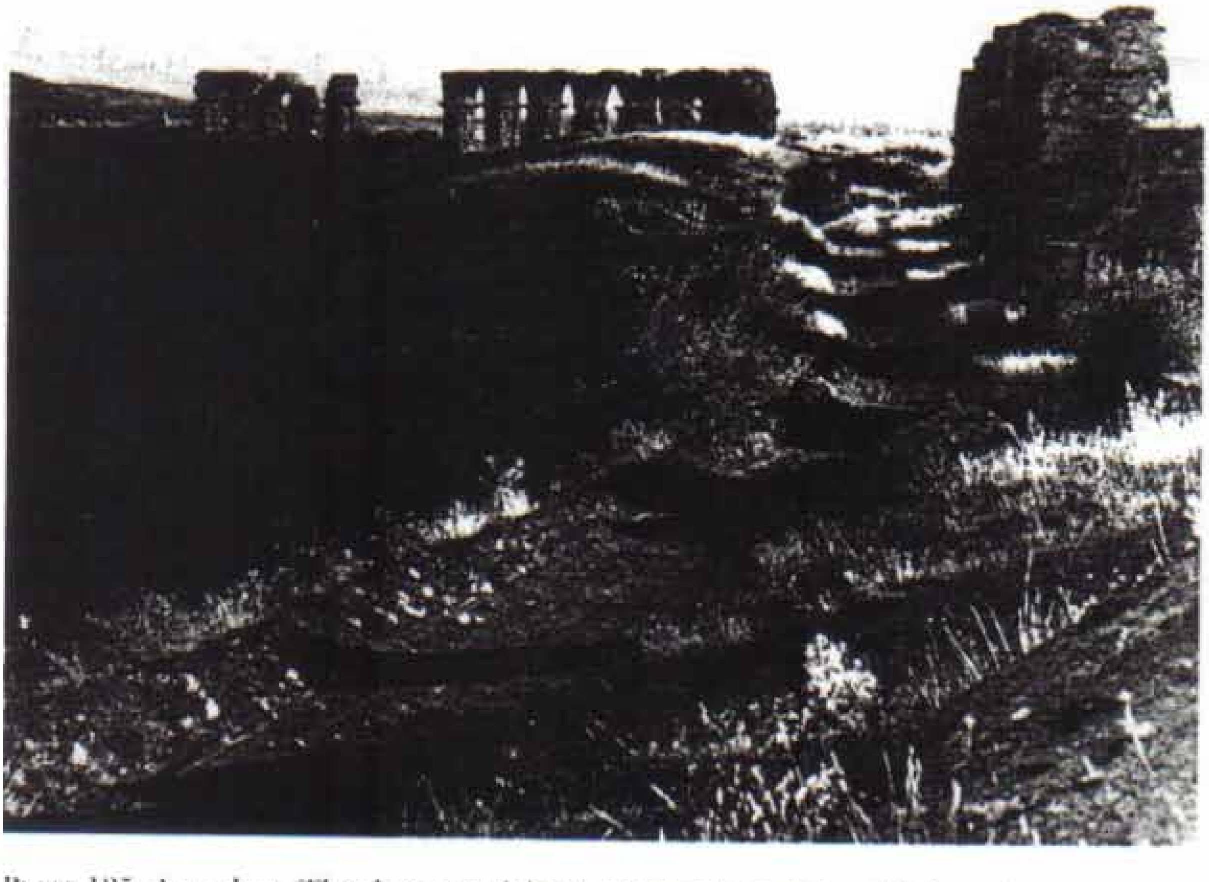


PLATE 125. Aqueduct. The three surviving sections of the arches (Ballance).

PLATE 126.
Aqueduct. Piers and voussoirs (Ballance).

slope of the terrain or because of the embankments of the road which crosses the line of the arches at the point where piers p17 and p18 used to be. The 4 m arches, a5–a7 and a20–a21, are made from 11 voussoirs, and so probably were all those up to a21. Arches a23–a27 and a32–a34 have 15 voussoirs, as presumably did all the spans from a23 to a44. Arch a22, however, has 13 voussoirs, and it was here that the change of span from 4 to 4.6 m should have occurred. In fact measurement shows that the increased span first occurs at a23.

The highest piers p27–p35 are supported along their whole width (2.4 m) by foundation arches, which are now visible only at ground level or have been completely buried. Although none of the springs of these hidden arches is now visible, cornices of type C3 were clearly noticeable.

The siphon (*Fig.* 34b)

The whole length of the siphon is 800 m, comprising a downhill section of 560 and an uphill section of 240 m (PLATE 127). It consisted of two series of arches at different levels, the first with twelve and the second, forming the *venter* of the bridge, with about 30 spans. Of these 13 have been identified in the downward and 1 in the upward slope.

The likely position of the header tank of the siphon is marked by two cut stones of unusual shape, one resembling a lintel block with a raised soffit, the other a thick rectangular slab, 1.9 x 0.9 m with a strong raised rim, which looks like a basin. Three sections of the siphon have to be distinguished. In the first section, 190 m long from R to C', the hill crest turns slightly to the right and loses 10 m in elevation over a 40 m stretch. A bend to the left restores the original direction and it runs almost horizontally for 100 m before a gradual ascent to an intermediate level 2 m higher. Many massive blocks scattered along this line imply that the structure was built in a gently descending slope so as to avoid any

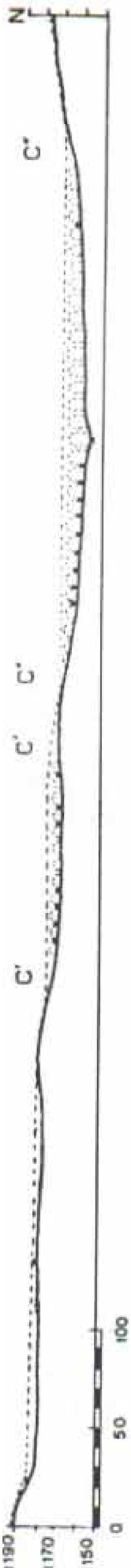


Fig. 34b. Aqueduct siphon. Elevation (Burdy).

rise along the length of the aqueduct before the siphon began to ascend to the city. Intermediate height changes would be hydraulically dangerous for a pressure pipeline.

The second section, nearly twice as long as the first, began at the end of the descent. It consists of an almost continuous line of fallen blocks which appear to have been placed side by side at a later date between the bases of piers. The latter are either preserved only in their lowest courses or have disappeared completely. At the beginning from C' to C'' there is a sequence of four square piers, measuring 2.4 m wide and 8 m apart from axis to axis, set on courses of larger foundations. The following 50 m stretch would have comprised six piers, of which parts of three survive, and seven arches. Beyond the last of these piers, which is preserved up to its second course, the line of the siphon is marked by an intermittent scattering of stones which were probably part of a continuous foundation. From this point, C''', some blocks remain from an abutment which led to a new series of arches. In the first 40 m the remains of four piers can be tentatively identified. Then there were nine piers in succession which today form the longest continuous series from the siphon. Apart from the last two, which are trapezoidal, as the line turns to the left, these are all 2.4 m square.

Where the siphon reaches the lowest part of the saddle it cuts the line of the modern track which uses this easy passage from one valley to another (see PLATE 127). The point is 560 m from and 33 m below the head of the siphon. The ascent up the city side of the saddle can be easily followed after a break of about 20 m in which all remains have disappeared. This section began with rough stone masonry bound with mortar, soon followed by a line of blocks set in one or two sill courses. The foundations are 2.4 m wide and 150 m long with a turn to the left in the direction of the nymphaeum. This appears to have been a continuous wall, but some of the blocks have their embossed faces turned towards the interior of the construction or on their top surface, implying that they are part of the reconstruction of an earlier building The appearance of a section of cornice and *in situ* foundations of original piers is evidence that the continuous walling was preceded by a system of piers and arches. Over the final 100 m the aqueduct may be followed in the form of a raised bank leading to the nymphaeum, but nothing is visible at the city end of the receiving tank which abutted its rear wall.

PLATE 127. Aqueduct. The siphon from the city wall (Ballance).

The actual head of the siphon would have reached 33 m if there had been no construction above ground level. The actual height remains hypothetical. It would have been 25 m or even as little as 20 m if the arches had been respectively 8 or 13 m high. The present state of the ground level shows a difference of 13 m between the two ends of the siphon. In fact the end at the nymphaeum was surely raised above ground level, to give sufficient height for the water to be widely distributed within the city. For the moment we shall presume a height of 3 m, reducing the loss of head along the siphon's entire length to 10 m.

As usual in the Roman East, the pipeline was made of stone. Nine stone pipe blocks were found, including four near the lowest point of the siphon itself.[4] The other finds included two in a small valley 50 m below the ridge and about 400 m above the beginning of the siphon, one in the *Tiberia platea* within the city, and two others in the houses of modern Yalvaç. These displaced examples had probably all been reused in secondary contexts. The pipe blocks are roughly square at the end (75 to 80 cm) and 40 to 60 cm long (except for one example at 1.10 m). A cylindrical hole 23 to 25 cm in diameter runs through the block lengthways.[5] At one end there is a lip, 6–7 cm thick and projecting 6 cm, at the other a socket 5–6 cm deep, with a radial recess of 7–8 cm which allowed the insertion of the adjacent block. One of the blocks had a third hole 24 cm in diameter perpendicular to the axis of the channel, a feature that is also found in other examples (PLATE 128).

PLATE 128.
Section of stone pipeline, incorporating a junction, in Yalvaç.

The architecture (*Fig.* 35)

The aqueduct was built in *opus quadratum* of blue-grey limestone, which had probably been obtained from the hillside quarries facing the acropolis on the left bank of the Suçikan Dere (the Anthius). Most of the blocks measure 1.1–1.2 m in length and 0.8–1.1 m wide, but some of them are over 2 m. Their height which determines that of the courses is more variable: about 20% are 40–50 cm, 20% 60 cm, 30 % 70–80 cm, and 30% around 90 cm. A few reach a height of 1.05 m. *Fig.* 35 shows one pier in the plan of the sill course, with the essential structure made up from four massive corner blocks, each weighing from 2 to 3.5 tonnes. Smaller, well squared stones complete the facings and the interstices between the blocks are filled with a solid core of rough rubble.

All the blocks were laid without mortar and have surfaces cut smooth for between 6 and 12 cm, with central bosses which protrude up to 15 cm. The blocks with face-to-face joints were locked together with dovetail clamps, identifiable from the cuttings which may still be seen. However, the dislocation of the joints and the facing stones indicates the movements which they have undergone.

The voussoirs of the bridges were made from single slabs, while both single and double stones occur in the arches. They were generally 2.1 m long, 40 cm side at the intrados and 60 at the extrados, and between 60 and 80 cm deep according to the radius of the span. The voussoirs of the braces of the highest arches, being 2.4 m long, often weighed more than 3 tonnes and were among the largest and heaviest blocks used in the entire construction. The outer ends of the voussoirs were also embossed.

The foundations could only be closely examined at the right hand side of pier p22. They were rather poorly constructed of rough stones set in mortar, only 30 cm thick. However, elsewhere the first course of large squared masonry is a little larger than the course above and so makes the stone work more stable. In these cases the blocks have a raised edge about 5–8 cm high and 15 to 30 cm wide

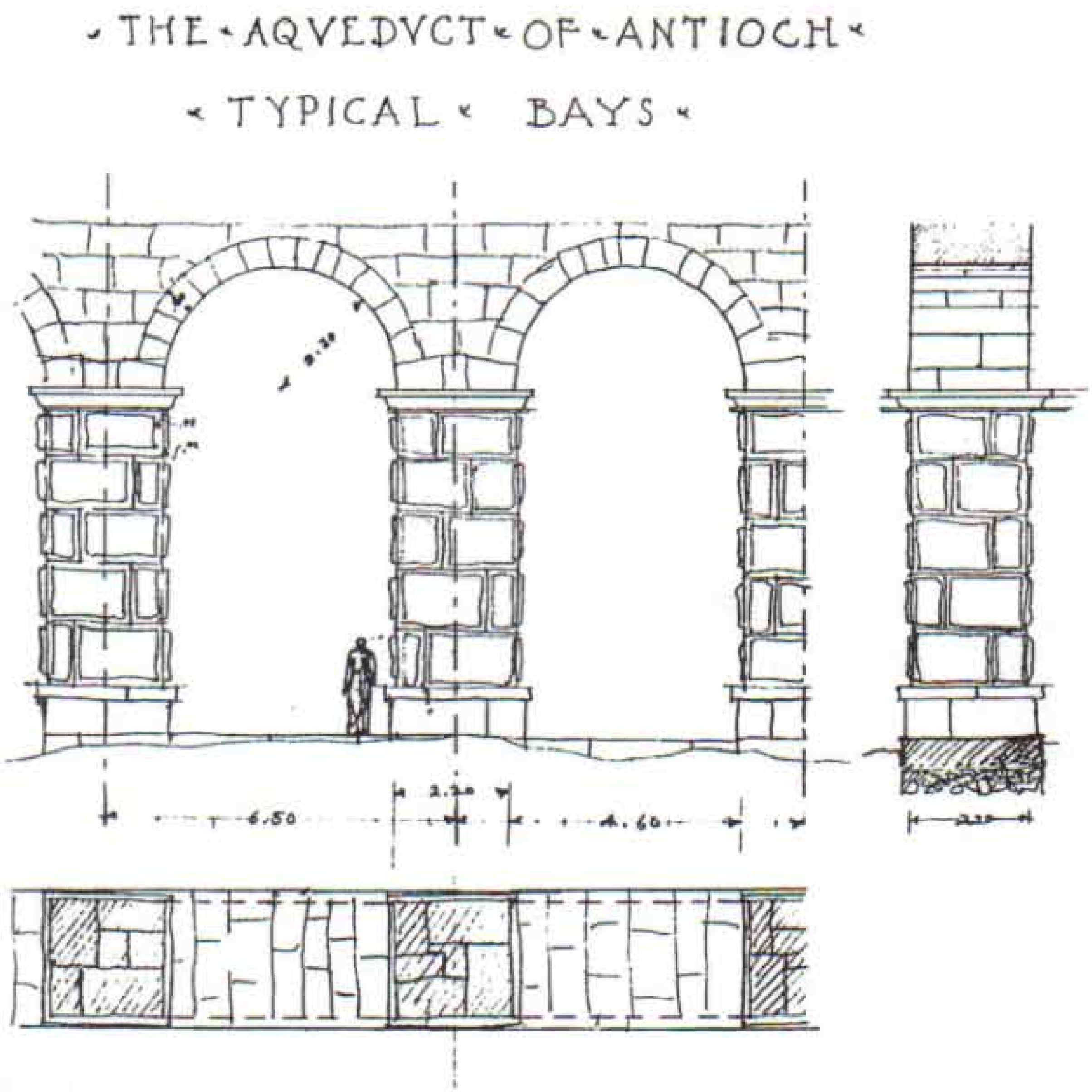


Fig. 35. Aqueduct masonry (Woodbridge).

a foundation. The same profile was also noted on the second course of piers p20 to p29 and on the last visible pier of the upper part of the siphon (*Fig.* 35).

The piers are all crowned by cornices, which can be classified into three types according to their mouldings, C1, C2 and C3 (*Fig.* 36). They are distributed as follows: C1 piers p1, p5–p7 (Plate 129); C2 piers p21–p28, p30, p33, p34 (Plate 130); C3 piers p4, p10, p19, p20, p40, p43, the braces of p27–p29. This moulding was also noticed among scattered blocks which have rolled downhill from the ridge, near the end of the siphon and on the bridges P1 and P2. No moulding at all was carved on the roughly finished piers p31 and p32.

Did the building of the aqueduct, of the channel and of the structure that carried them correspond to a single unit of structure, a module? The problem may be tackled by comparing a few dimensions with the length of the Roman foot (29.6, say 30 cm). The inner width of the channel is 75 cm, that is 2½ feet, and the height of the side wall is 90 cm, 3 feet. The arch spans are 4 and 4.6 m, 13 and 15 feet, and their width, 2.1 m, is 7 feet (with braces of 2.4 m, 8 feet). The

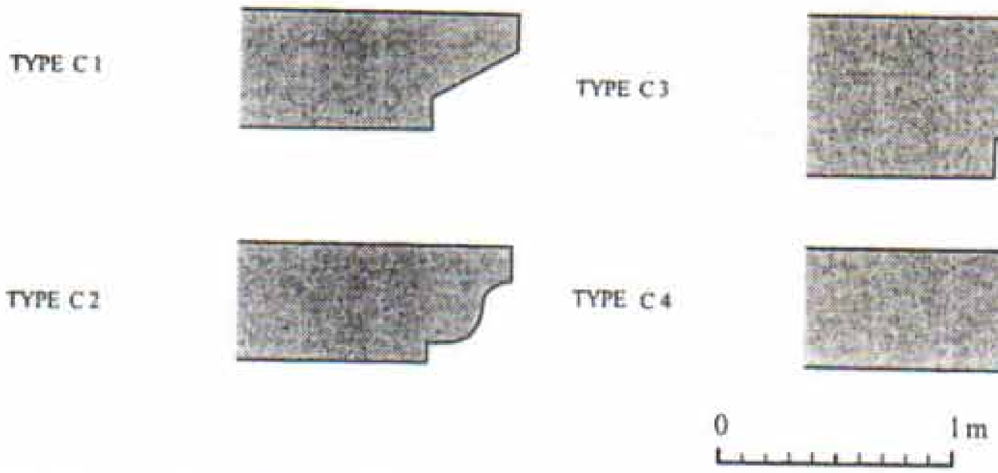


Fig. 36. Aqueduct pier mouldings (Burdy).

PLATE 129.
Aqueduct. Piers p5 and p6 with cornice type C1 (Ballance).

PLATE 130.
Aqueduct. Piers p24 and p25, with cornice type C2 (Ballance).

dimensions of the massive blocks and the thickness of the sill course are often 60 and 90 cm, 2 and 3 feet. Although these figures suggest that the standard Roman foot was widely employed as the main module, there are also many examples of measurements taken along the aqueduct which bear no simple relation to a 30 cm unit.

Profile and slope of the channel (*Fig.* 37)

A comparison of the course with the profile shows clearly the general conception of the aqueduct and its remarkable adaptation to the terrain both upstream in the wild topography of the mountains and downstream where the arches cross the lower part of the ridge and where the siphon crosses the saddle at the dip below the city site (Figs. 18 and 34a; PLATE 127). The descent of the whole aqueduct from its assumed source at 1465 m to the end tank at the nymphaeum at 1178 m was 287 m over a distance of 11 km, producing an average gradient of 26:1000. This average includes wide variations of slope, for instance over the first 4 km from the springs down to the first surviving remains,[6] and at the end siphon, and in the steep stretch where *tegulae* were used in the channel floor. Although this section is partially destroyed, it appears to have descended 15 m in a stretch of 200 m, a gradient of 75:1000, an exceptionally steep slope which allows us to infer that the descent was controlled by some sort of cascade.

The gradient of the channel including this steep intermediate tiled section was about 6:1000. However we can estimate that the average gradient for the sections on either side of the first two bridges, then at ground level along the ridge road, and finally along the line of arches was about 2:1000, a very satisfactory figure for a controlled flow of water.

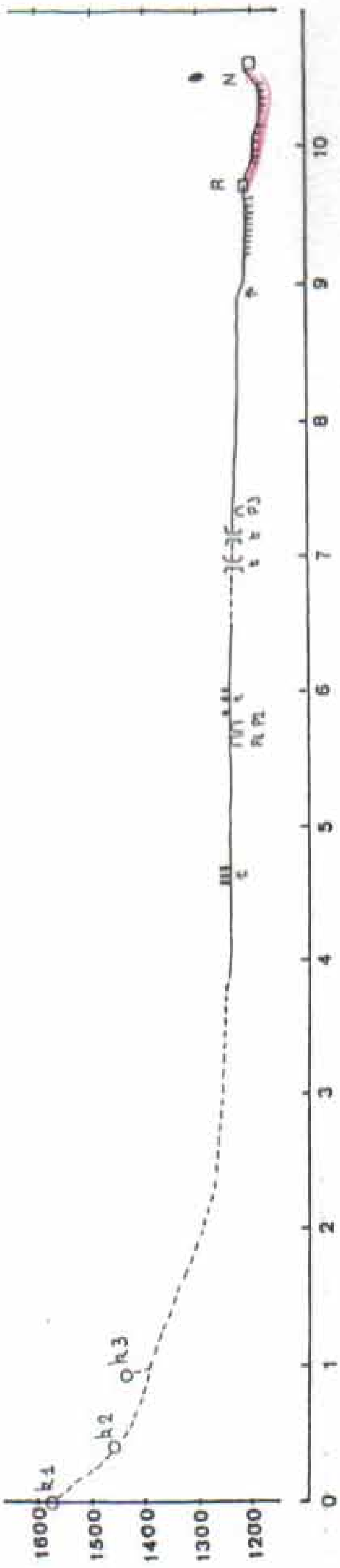


Fig. 37. Aqueduct gradient. Schematic elevation (Burdy).

Water output

This value can be used to calculate the potential output of the channel. It is important to make a distinction between the aqueduct's potential output, extrapolated from its technical characteristics, and the real discharge which was dependent on the outflow of the springs. The potential output may be calculated both for the channel and for the siphon. The potential output of the channel is conditioned by the area of the cross-section, the condition of its floor and side walls, and by its gradient. If we assume that the cement was in good condition with a degree of roughness midway between a very smooth surface and a slightly encrusted grainy surface, and reckon with a gradient of 2:1000, the cross section illustrated in *Fig.* 33 and a water depth of 40 cm, a little more than half the channel's width, by applying Bazin's formula we can calculate that the average velocity of the flow will have been about 0.8 m per second and the resulting discharge 200 litres per second or 17000 m^3 per day.

The output of the siphon is more difficult to estimate. Applying the Manning formula to a stone pipeline 24 cm in diameter, 800 m long and with a roughness of 60, one obtains a velocity of 1 m per second and an output of 4000 m^3 per day. The formulae of Bazin and Darcy would give an output of 2–3000 m^3 per day. The comparison of these results is not surprising, although at first sight the channel looks to have been too large in comparison with the pressure pipe. The latter will have placed an upper limit on the system's capacity.

What could the outflow of the springs have been when the aqueduct was in use? We can only use the modern data for the facilities built in 1952 and 1982 which provided 3–4000 m^3 per day, closely corresponding with the calculations for the siphon. The effective output of the aqueduct can accordingly be estimated at 3000 m^3 per day.

The date of the aqueduct

There is neither epigraphical nor other direct evidence to date the aqueduct. The only two inscriptions from Antioch which have a bearing on the water supply date from late antiquity and have no bearing on the original construction (see appendix 1 no. 11). We must refer to the buildings and the historical development of the city, take its conception, structure and workmanship into account, and compare it with similar systems elsewhere in Anatolia.

The aqueduct ended at a tank which formed part of the nymphaeum and also probably supplied water to the large bath house which is situated about 200 m to the west of this. These two monuments are to be dated to the first century AD, and provide a terminus post quem for the system leading to them. The aqueduct could provide water to two-thirds of the city which underwent enormous development in the Augustan perod. This urban context suggests that the aqueduct should be dated to the early first century AD.

Two aspects of the conception and structure are typically Roman: first, the section and dimensions of the channel, built from rough stone and mortar, with its vault interrupted at regular intervals by manholes; second, the bridges and arches, completely built from massively cut and well fitted blocks with embossed faces, without mortar except in the core of small rough rubble.[7] This type of *opus quadratum* is very common in Asia Minor and the bridges virtually replicate the design of those known at Side, Phaselis, Alabanda or Aspendus. These are probably to be dated in the first century AD, although in all cases, as at Antioch, conclusive evidence is not to hand. Stenton and Coulton in their study of the aqueduct at Oenoanda made an inventory of thirty cities where siphons made from stone pipe blocks were in use, almost two-thirds of them in Asia Minor. Their analysis led to the conclusion, with some reservations, that all these aqueducts are to be dated to the Roman period, and the Antioch aqueduct is certainly no exception to this.[8]

On the other hand the rebuilding of some of the piers, and the replacement of some of the arcade with stretches of continuous walling, points to a renovation of the aqueduct at a later period, perhaps the fourth century, when the city was revived as the capital of the province of Pisidia.

The nymphaeum (*Fig.* 38)

We made only a cursory examination of the buildings associated with the distribution of water within Antioch. We were able to make a ground plan of the foundations of the nymphaeum, which received water directly from the aqueduct at the north end of the city, but no decorative ornament or inscription survives from the building, and it is accordingly very hard to date accurately. The bath house with its adjoining exercise area lay at the north-west corner of the site, only about 150 m from the head of the aqueduct which provided its water supply. Indeed some traces of canalisation were visible between it and the nymphaeum. It has always been clear that many of the vaulted chambers of the bath house, which shows signs of at least two construction periods, survive intact. In recent years much of the building has been cleared of overlying soil by the efforts of Yalvaç Museum and the layout of the rooms and construction details are now much clearer than they were at the time of our survey. However, since our own work on the building was cursory, and the recent excavations have not been fully published, a lengthy discussion would be inappropriate here.

Our measurements show that the foundations of the nymphaeum which received the water were around nine metres lower at around 1178 m above sea level than the water channel on the opposite ridge. No doubt, therefore, the nymphaeum's superstructure and the wall of the reservoir behind it approached this height. If water could be distributed from a point eight metres higher than this it could have been directed anywhere in the western part of the city, to the buildings along the *cardo maximus*, and reached the level of the *Tiberia platea*, but not to the imperial sanctuary or the eastern part of the city.

The two early visitors to Antioch who paid most attention to the aqueduct, Hamilton and Weber, also commented on the nymphaeum. Hamilton had observed the remains of a high tower, which he took to be a water reservoir, and Weber produced a plan of a rectangular building, 32 x 13 m, constructed out of fine rectangular blocks with reinforcement at each of the corners, but reduced to a single course of stone at ground level.[9]

The foundations of the nymphaeum comprise a rear wall 27.2 m long and 3.9 m thick with wings at either end projecting 10.7–10.8 m, each 3.20 m thick (*Fig.* 38; PLATE 131). They are constructed from rectangular grey limestone blocks up to 3 m long. Most of the larger blocks have a single centrally placed rectangular dowel hole (*c.* 14 x 4.5 x 8.5 cm) and there are butterfly-shaped clamp holes joining three of them at the south-west corner. The stones have been cut smooth at the top and at the sides to receive the adjoining courses. The interior of the structure was partly made from ashlar blocks, which must have taken the main weight of the structure above, and partly of rubble embedded in limestone mortar. The arrangement of the ashlar blocks illustrates the simple design of the building. It was U-shaped. The rear wall, which also acted as the front wall for a water reservoir, was 2.2 m thick, while the walls at the sides were less massive at 1.6 m, since they did not have to withstand the pressure of so large a volume of water. The water basin along the front was around 1.10 m wide and apparently divided into three sections, each measuring about 5.50 m, the length also of the two side basins.

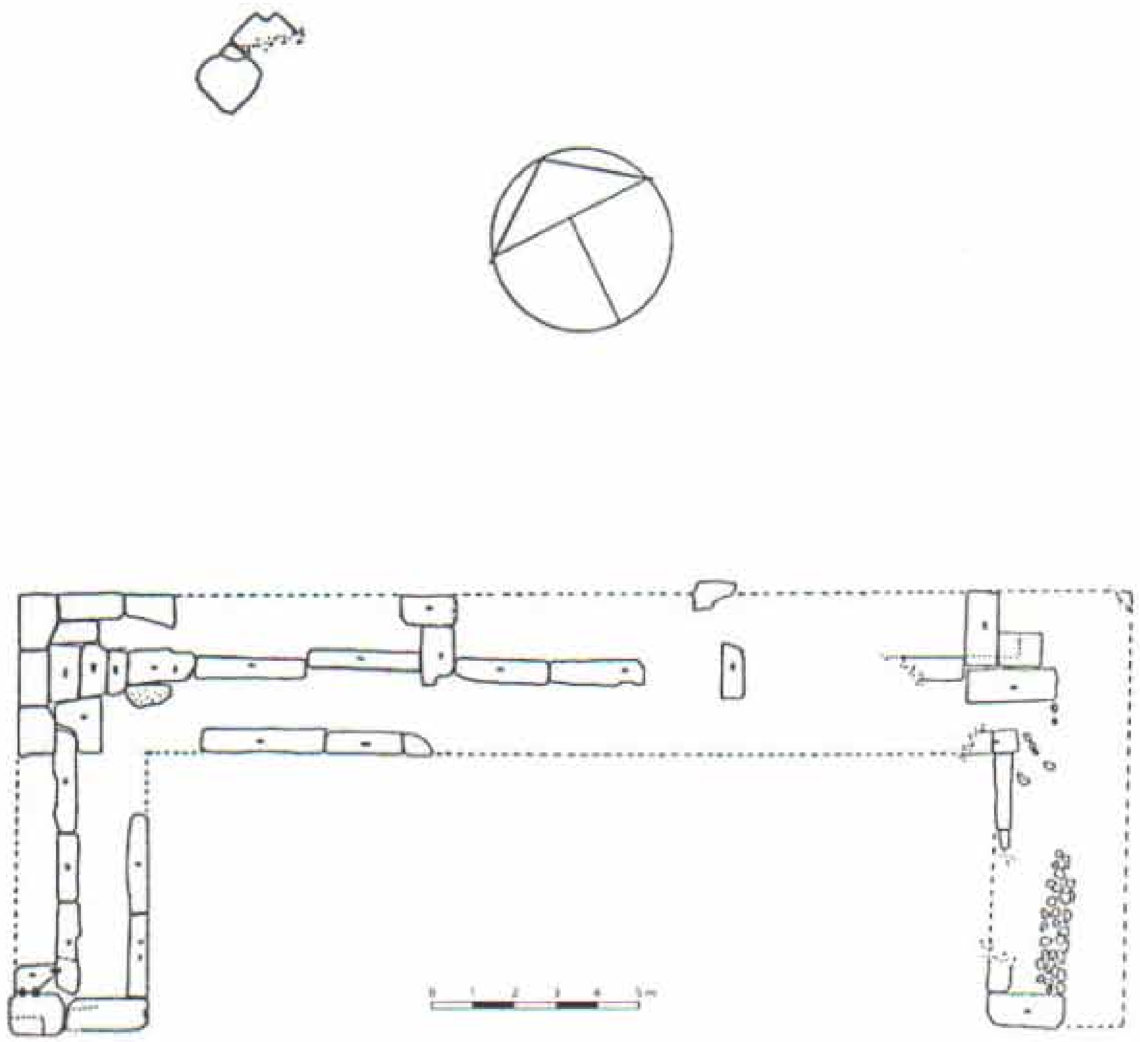


Fig. 38. Nymphaeum. Ground plan.

Such U-shaped fountain houses became immensely popular in imperial Asia Minor, but the origin of the design lies in the hellenistic period. Geographically there is a close parallel at hand in the fountain house recently excavated and now being restored at Sagalassus, which was probably built in the first century BC and restored in the mid-first century AD.[10] In southern Asia Minor the tradition of this type of building may be followed in the monument erected at Side in front of the theatre for Vespasian in AD 71, with projecting wings on either side of a recessed central aedicula. This was converted into a fountain house at a later date, although this may not have been its original purpose.[11] Roughly contemporary with this, but on a much larger scale, is the nymphaeum built by the father of the emperor Trajan at Miletus.[12] The nymphaeum of Pollio at Ephesus belongs to the same period.[13] Again, the design reappears locally at Sagalassus in the Hadrianic nymphaeum building which was erected there close to the main city bath house.[14]

Even without any trace of the architectural decoration and statuary that surely once adorned the building, the aesthetic function of the nymphaeum is transparent from its location. On the one hand it masked from view an ugly, functional building, the water reservoir that stood at the head of the aqueduct, just as the Hadrianic nymphaeum at Sagalassus concealed the plain front wall of the odeum there.[15] On the other hand, also as at Sagalassus, it stood at the head of one of the major streets, an emphatic punctuation mark in the articulation of the city's public buildings. It can, therefore be seen as a text-book illustration of a principle of Roman town planning, the use of elaborate decorative structures to focus attention amid the long vistas of a regular street pattern.[16]

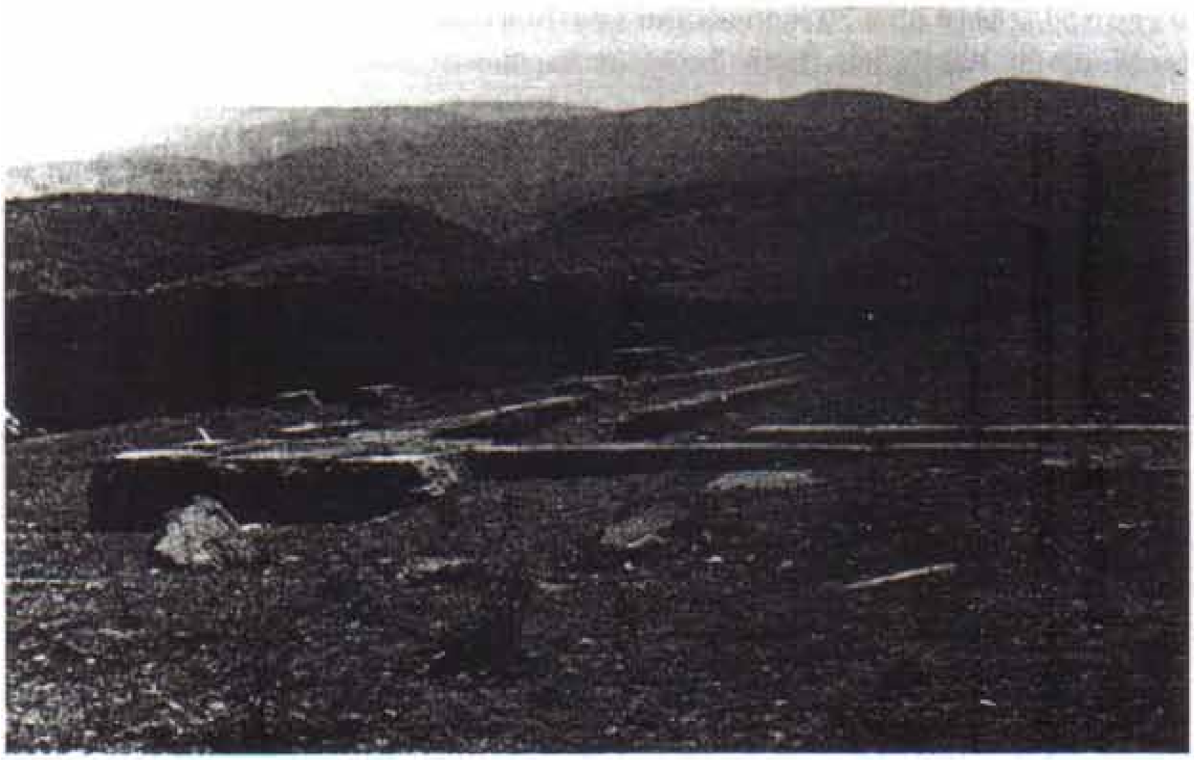


PLATE 131. Nymphaeum, west side (Ballance).

Dating the nymphaeum at Antioch is a matter of guesswork. It would be unexpected for the prime position at the end of the *cardo maximus* to be left without an imposing terminus building for long after it was constructed. Furthermore, it is clear that in terms of function the nymphaeum must be closely associated with the aqueduct, and therefore also with the bath house. The arguments given above for an early first-century date for the aqueduct are reinforced by the considerations which affect the date of the nymphaeum. A date in the first half of the first century AD seems most likely.

The bath house

The final building to be discussed in this section is the bath house in the north-west corner of the city. This is what Arundell in 1834 described as 'two magnificent arches, a souterrain running far beneath the hill, and supporting the platform of a superb temple'. In 1981 J. Ward-Perkins was a little more accurate in referring to 'a large vaulted platform of mortared rubble masonry faced with ashlar, which served as the basis for a later building'.[17] Astonishingly, none of the travellers or archaeologists who visited Antioch in the century and a half between these two dates, not even Weber who marked it as a temple on his plan, identified this structure as the bath building that it is. That is enough to justify including this short section here, although detailed comment on the basis of the survey observations made in 1982/3 would be wholly superfluous following the excavation begun by Mehmet Taşlıalan, which has now cleared seven large underground chambers at the western end (PLATE 132).[18] These excavations confirm above all the huge scale of the building, which was already apparent from measurements we could make before excavation began. The bath house measured at least 55 x 70 metres, and was thus comparable in scale to the largest buildings in Pisidia, the bath house at Sagalassus, which was 80 m east–west

PLATE 132. Bath house from the south-west after partial excavation (Taşlıalan).

including a covered exercise area and 55 m north–south, and the Severan bath building at Termessus.[19] Taşlalan remarks that the construction technique of the outer walls, made from immaculate ashlar masonry, is reminiscent of the work found in the Augustan sanctuary buildings.[20] The date of the building, however, remains to be established.

Adjoining the bath house on the east was a rectangular colonnaded area, measuring about 38 x 29 m, which was surely a palaestra. The entire gymnasium complex therefore extended nearly 120 m from west to east, almost half way to the nymphaeum. Foundations, as well as stone pipe blocks found in this area, may belong to the canalisation system which brought water from the aqueduct head to the bath house.

Notes

[1] *JdI* 19 (1904) 96–101.

[2] See also J. Burdy and M. Taşlalan, 'L'aqueduc d'Antioche de Pisidie', *Anatolia Antiqua* 5 (1997) 133–66, for a French version of the account provided here.

[3] Kelsey, *The Michigan Alumnus* 31. 18 (1925) 404; Robinson, *AJA* 28 (1924) 440.

[4] For a collection of the evidence from Asia Minor, see E.C. Stenton and J.J. Coulton, 'Oinoanda: the Water Supply and Aqueduct', *AS* 36 (1986) 15–59.

[5] The dimensions are comparable to those noted at other sites, for example at Laodicea and at Patara.

[6] Here it has to be assumed that the profile followed the terrain closely. It is possible that devices such as fall shafts or short steep sections (like the one with *tegulae* just before the arches) were built along the first 2 km and designed to reduce the height, thus allowing the construction of a channel with a gentler slope.

[7] Cf G. Weber, *JdI* 19 (1904) 97. Weber rightly disputed Hamilton, *Discoveries* I, 472, who thought that the irregularities in the construction of the piers should be attributed to rough repairs at a later period. Woodbridge showed the type of cornice illustrated by Weber on his specimen drawing of one of the arch bays.

[8] Ramsay, *Cities of Saint Paul*, 250, speaks of 'work of the best period'. J.B. Ward-Perkins, *Roman Imperial Architecture* (The Pelican History of Art, 1981) 280, of 'the fine Augustan aqueduct, built throughout of squared stone'. Such an early date for the aqueduct has very significant implications for the date of the bath house, which it supplied. Currently the earliest dated bath building in Roman Asia Minor is the bath built by Vergilius Capito at Miletus in AD 43; see Mitchell, *Anatolia* I, 216.

[9] Hamilton, *Discoveries* I, 473; Weber, *JdI* 1904, 99 Fig. 7.

[10] M. Waelkens, *AS* 41 (1991) 197–203; *Sagalassos* I, 44; II, 43–86 (excavation report); III, 47–53.

[11] A.M. Mansel, *Die Ruinen von Side*, 70–75; Ward-Perkins, *Roman Imperial Architecture* (1981) 300 Fig. 194.

[12] J. Hülsen, *Milet* I. 5 (1919); Ward-Perkins, *Roman Imperial Architecture*, 298–9 with Fig. 192. F. Glaser, 'Brunnen und Nymphäen', in *Die Wasserversorgung antiker Städte* II (1987) 105–31, with bibliography. For the dating see Strocka, *Markttor*, 22 n. 26 and 64.

[13] E. Fossel, and G. Langmann, *JÖAI* 50 (1972–5) 301–11.

[14] M. Waelkens, *AS* 39 (1989) 73–4; *VII Araş.*, 124–6 with figs. 14–19; and in E. Schwertheim (ed.) *Forschungen in Pisidien*, Asia Minor Studien 6 (1992) 53–4.

[15] Waelkens, *AS* 39 (1989) 69 Fig. 3 and 73–4.