CHAPTER 4

The Architecture and Archaeology of the Aqueduct Bridges and Channels

INTRODUCTION

One of the outstanding features of the Thracian aqueduct system is the scale and monumentality of the great aqueduct bridges, surviving mainly from the second phase of the system when it was extended to Vize. The most impressive remains are to be seen at the great bridge at Kurşunlugerme (**K20**) near Gümüşpınar (Fig. 4.1). It is a measure of the magnitude of the project in the late fourth and fifth centuries that it is closely matched by four other great bridges at Ballıgerme (**K18**), Büyükerme (**K29**), Keçigerme (**K30**), and Kumarlıdere (**K31**), together with other major bridges at Talas (**K22**) and elsewhere. In the west of the system ruins of large bridges with three arches, such as the Ayvacık (**K7**) and the Galata Dere (**K8**), first drew the attention of travellers in the mid-nineteenth century, but it was only in the early twentieth century when the drawing of Kurşunlugerme was published by Oreshkov that there was a visual record of the scale and grandeur of the Constantinopolitan bridges.[1] However these bridges remain neglected in all studies of Roman hydraulic achievements, despite the elevation drawings and photographs published by Dirimtekin in 1959. This chapter is concerned with the architecture

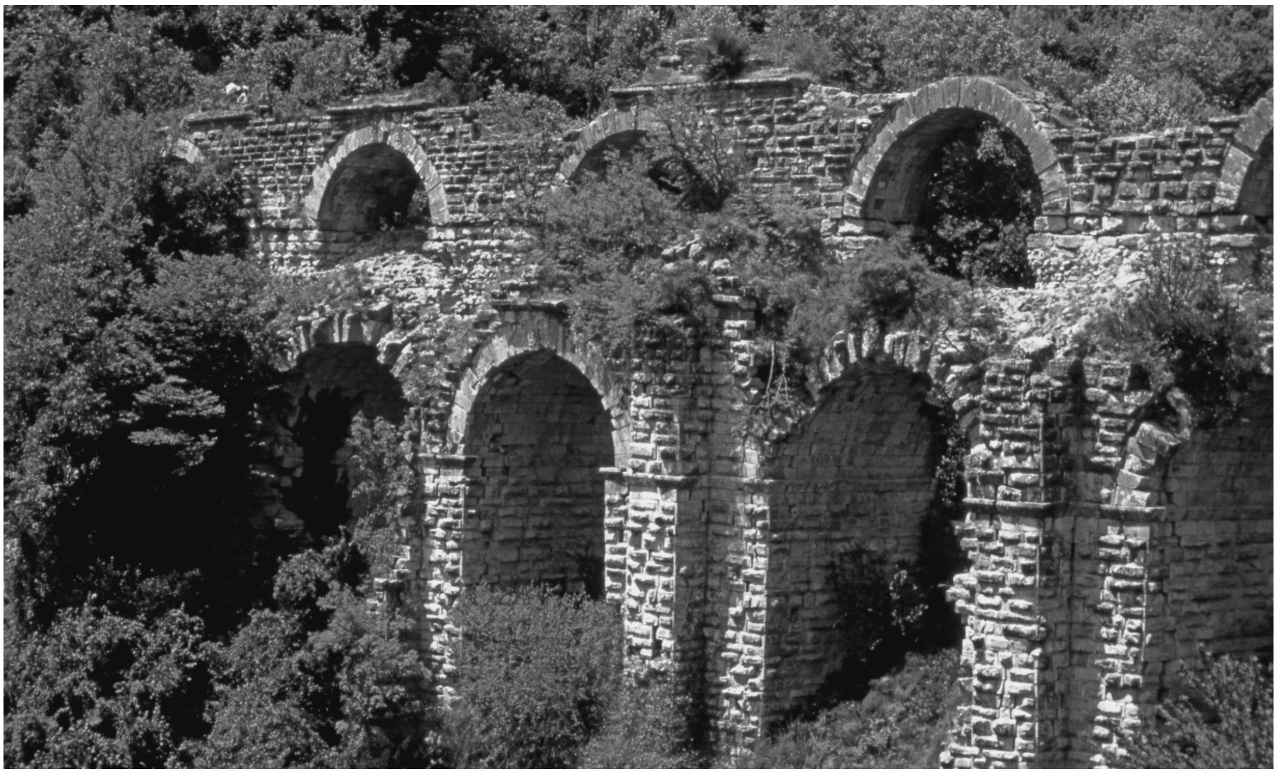


Fig. 4.1 The main bridge at Kurşunlugerme (**K20**) from the north-east.

[1] For travellers' accounts see p. 40 above; see the sketch of Kurşunlugerme by Oreshkov (1915), 88, showing clearly the lower arches and upper two tiers, without any vegetation masking parts of the face. Dirimtekin notes that E. H. Ayverdi, an engineer, also prepared a plan and elevation of this bridge, but he does not note its place of publication.

and archaeology of the water supply system and considers the four great bridges and that at Talas. Almost nothing is known from the literary accounts of the resources required for these construction projects, so only by studying the major structures and the network of channels is it possible to understand the building technology and begin to assess the resources and expenditure required to build and maintain the 'Longest Roman Water Supply System'.

BALLIGERME (**K18**) (Figs 4.2–4.3)

The bridge at Ballıgerme carried the second-phase broad channel across the gorge created where the Karaman River cut across the line of the Stranja ridge. It is one of the most dramatic and severe valleys crossed by the water supply line. At the south end (towards the city) of the bridge the broad channel runs parallel to but below the level of the fourth-century narrow channel from Danamandıra (see Map 5). The bridge is aligned approximately south-east to north-west (Fig. 4.2). It survives to a height of 30 m, but the total height including the 2.60 m-high broad channel can be estimated to have been 37 m above the river bed. The river flowed through a single high arch with a span of 8 m (1), 16 m high and 9 m wide. Above this was an upper tier of four arches, one central (**3**), above the lower main arch, two to the south (**4** and **5**) and one to the north (**2**). Arches **2**, **3** and **4** can be estimated to have had a maximum height of 11 m and width of 9 m. The overall length of the bridge may be estimated at 77 m.[2] The construction of the bridge used large limestone blocks similar to those found at Büyükerme, Kurşunlugerme, Keçigerme, and Kumarlıdere; these are not seen elsewhere on the surviving bridges of either the Danamandıra (Valens) or Vize systems. The specific feature of this construction technique is both the type of stone and the size and dressing of the blocks. The limestone is a very hard, grey-white, metamorphosed rock which in section appears very similar to a coarse marble (Dirimtekin calls it marble). We have not yet discovered the quarries for this stone, although Professor Bono extended his geological enquires over a wide area of eastern Thrace beyond Kırklareli. The size of the blocks is consistent among the five bridges and all provide masons' marks (see Chapter 8) not seen on the other bridges. The height of the ordinary blocks is between 0.37 and 0.42 m, with greater variety in length, between 0.56 and 0.75 m. The blocks are rectangular and are bedded with a hard pink mortar with large brick inclusions, characteristic of early Byzantine work in Constantinople.[3] From fallen blocks and also from the small craters hacked into the face at the joints (to rob out the lead setting of the clamps), it is possible to see that the blocks were also held with iron clamps set in lead; an iron clamp may be seen in a block towards the top of the west face.[4] The blocks were left with quarry-dressed faces and the margins were cut back, but were not as carefully drafted as a rusticated masonry can be. The core of the piers and the arches is of mortared rubble with a hard pink mortar with brick inclusions, similar to the mortar used for bonding the facings.

At the base of the lower arch (1) there is an offset course with a chamfered plinth, located seven courses above the stream bed. At the springing of this arch there is a string-course with a downward-facing chamfer; because of later reconstruction the string-course cannot be seen to run across the face as can be observed at other bridges. In the upper tier, the base of arch (**4**) is marked by a clear string-course, but it is absent from the central arch (**3**) because of rebuilding. The bases of the outer arches (**2** and **5**) are higher and there is no evidence for a string-course; however it is clearly preserved to the north of arch (**2**) and south of arch (**5**). The abutments and original facing are well preserved against the south and north slopes of the valley, including the well-preserved entrance to the broad channel on the south side. For the limited decorative features surviving from the bridge see Chapter 7. It is clear that the bridge underwent two major phases of reconstruction.

2 The bridge was surveyed using a Trimble DR200+ Reflectorless Total Station and we were able to produce a plan and elevation combining measurements taken by the Trimble with rectified photography and field measurements.

3 Ward-Perkins (1958).

4 The use of clamped blocks in Constantinople can be traced back to the fourth century, although because of the conservatism of building techniques it is not possible to recognize any significant chronological changes. An example is known from what is dated to the fourth century at the Bozdoğan Kemeri by Ward Perkins (1958), 65; see the discussion of this type of masonry technique at the Palace of Antiochus and elsewhere by Bardill (1997), 87–8.

FIG. 4.3 The bridge at Ballıgerme (K18) from the north-east.

Phase 2

The work of rebuilding in Phase 2 can be recognized most clearly on the east (downstream) face of the bridge (see Fig. 4.2). The scale of the damage which required repair is most likely to have been caused by an earthquake, although the specific structural evidence of seismic damage is more clearly seen at other bridges, notably Kurşunlugerme (K20) and Keçigerme (K30) (see below). Above the lower arch (1) almost all the facing-stones of Phase 1 appear to have fallen, the exceptions being the quoins, which would probably have had greater lateral support. The archway itself is very clearly deformed, but above it the upper arch (3) collapsed and was rebuilt in Phases 2 and 3. On the upper tier it is clear, however, that in Arch 2 the voussoirs of Phase 1 survived into Phase 3. A major feature of the rebuilding in Phase 2 consisted of two clasping buttresses constructed against the lower arch (see Figs 4.2; 4.4). These projected 3 m downstream and narrowed the archway to approximately 3.5 m (the north face is poorly preserved over the channel and it is not clear if the narrowing extended to the full depth of the passage). The upper arch (3) was also narrowed by the same amount, although here it is clear that the reduction extended across the full width to support the new arch.

The buttresses were constructed of coursed blockwork, that is roughly squared blocks of limestone, clearly from a different source to the Phase 1 blocks and smaller in size (see Figs 4.2 and 4.5). It is not clear how high the buttresses extended, although on the north side the buttress core can be seen to extend 2.5 m above Arch 1. Above this point the face of the south (and possibly also the north) pier was refaced in a similar masonry and the new arch was constructed. Evidence for these repairs is restricted to the central piers and arches of the bridge.

Phase 3

Unlike the rebuilding described for Phase 2, in the following phase the work is located across the whole width of the bridge and is found in the upper arches and on the west side. This phase is characterized by the use of brick arches and brick bonding-course and rubble construction. It is clearly seen on the south side of Arch **2**, where a blocking wall of rubble work and brick bands supports the south side of the Phase 1 voussoirs. In addition to the brick bands, some bricks are set vertically in the rubblework (Figs 4.5; 4.6). The bricks appear similar in size and colour to those re-used in nineteenth-century houses at Karaköy which were taken from the Anastasian Wall nearby. Fragments of a similar construction are seen on both sides of Arch **3**, with a brick arch on the north side. Similar brickwork and core of this phase are seen on the south side of Arch **4** extending on to the west side of the bridge (upstream). As part of this repair it would seem that Arches **3** and possibly **4** were rebuilt as arches, whereas in Arch **2** the primary stone vault was supported by a filling of brick and rubblework.

FIG. 4.4 Buttress on south-east face of the lower arch at Ballıgerme (**K18**).

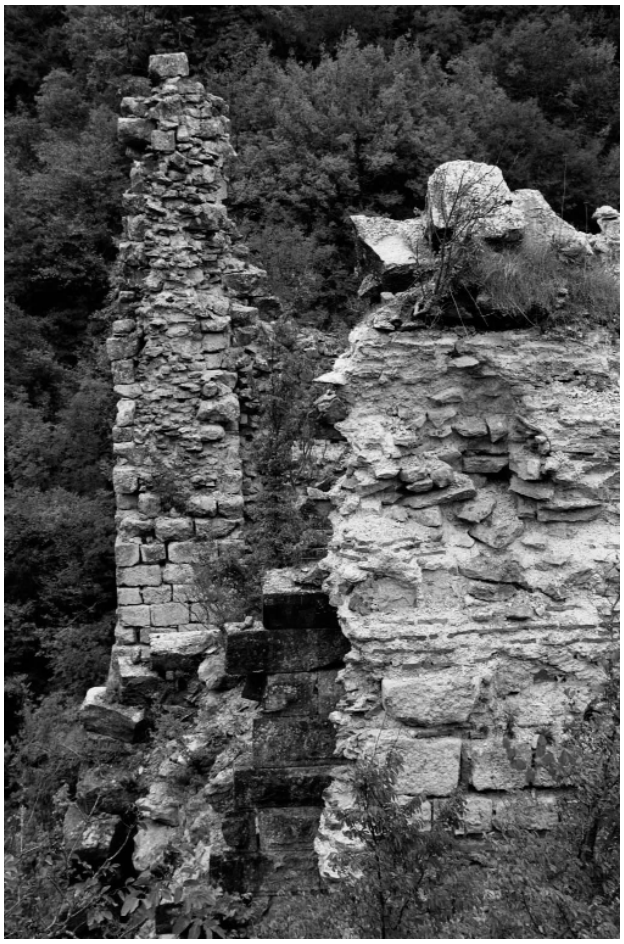


FIG. 4.5 The north pier at Ballıgerme (**K18**), with reconstruction using alternate courses of brick and rubble. To the left is Phase 2 blockwork between Arches **3** and **4**.

FIG. 4.6 East face between Arches **3** and **4** at Ballıgerme (**K18**) showing Phase 2 blockwork.

KURŞUNLUGERME (**K20**) (Fig. 4.7)

FIG. 4.8 Kurşunlugerme bridge (**K20**), bossed blocks beside Arch 2; note how the upper faces of the bosses are cut level to support timber scaffolding.

The setting and the system of channels at Kurşunlugerme are discussed in Chapter 3 and the decorative crosses and other Christian symbols in Chapter 7; this account is concerned with a structural description of the monumental aqueduct bridge which dates to the second main phase of the water supply system.[5] The bridge carries the broad and narrow channels across the valley of the Kurşunlugerme Dere and is the longest known bridge apart from the Bozdoğan Kemeri in the city. Two features mark this bridge out from all the other Thracian bridges: it was built with three tiers and there are buttresses rising to the full height of the lower two tiers. There are three great arches at the base, numbered **18**, **19** and **20** from north to south (right to left on the East Elevation). The stream flows through the north arch (**18**). The middle tier consists of six arches, numbered **12–17** from north to south. The eight buttresses are numbered I–VIII, beginning at the north side of Arch **12** (I–II), and they continued between the arches and beyond Arch **17** to the south. The third tier was narrower and was supported on arches numbered **1–11** from north to south (Fig. 4.7). The overall height of the structure was 35 m (including an estimate of the height of the upper channel) and the length across the upper tier was 149 m.[6] At the valley floor the width of the bridge piers is 11.9 m and the arch is 6 m high. On both faces buttresses 2.13 m wide project 1.19 m; this is the only instance where we see the use of buttresses in either of the main construction phases of the major Thracian bridges, although they were used extensively in the Thracian system from the sixth century and are a common feature of the Ottoman structures from the sixteenth century onwards.[7] The form of the buttresses further distinguishes Kurşunlugerme from all other aqueduct bridges (Byzantine or Ottoman) in Thrace (Fig. 4.9), since, unlike all the other examples, the buttresses at Kurşunlugerme are vertical and do not taper. Instead the structure narrows as it gets higher and both the main face and the buttresses are reduced in width by a series of insets, 1.19 m, 1.09 m, and 0.93 m, respectively, at each of the three tiers.

In details of construction the bridge differs little from the basic form described for Ballıgerme, although in certain areas it is better preserved. Like many of the aqueducts throughout the system it was badly damaged by one or more seismic events, although at Kurşunlugerme the impact appears to have been limited to one side. This is evident from the very significant damage to the upper second and third tiers of the west face (Fig. 4.10), although it can also be recognized in long cracks across the voussoirs of the inside of the arches in the upper tiers, once again focused to the west side. Similar features can be seen at all the major surviving bridges we have studied and they can be understood as a result of damage caused by the lateral P waves of earthquakes with an epicentre located towards the south-east along the North Anatolian Fault.[8] Significantly at Kurşunlugerme these events do not appear to have affected the flow of the water channels across the

[5] The bridge was surveyed using a Trimble DR200+ Reflectorless Total Station and we were able to produce an accurate plan, a detailed elevation of the east façade, and a section through the bridge. For previous studies see Oreshkov (1915); Dirimtekin (1959), see elevation on p. 234–5; Çeçen (1996a).

[6] The length measured from the two lengths of narrow channel across the bridge is 158.79 m.

[7] Buttresses are a feature of the Byzantine phases of the Bozdoğan Kemeri, see Chapter 5, although the date of their usage is not certain.

[8] All the affected sites lie within the quadrant of a circle between west and north, reflecting epicentres located between east and south points of the compass and associated with the North Anatolian fault which lies off the south coast of Thrace.

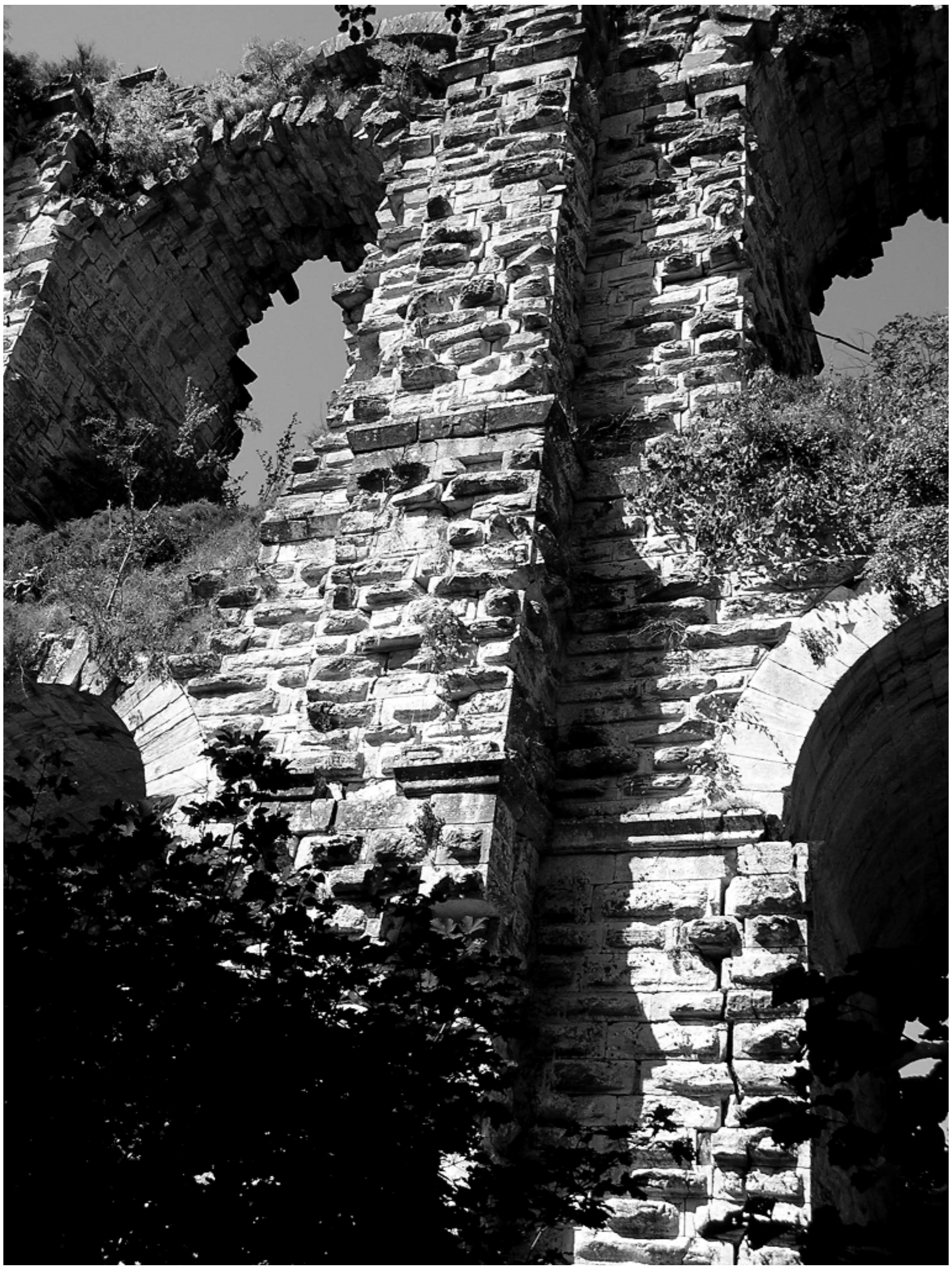


FIG. 4.9 Buttress V, Kurşunlugerme (**K20**); note the changes in the string-course mouldings.

bridge as there is little evidence for restoration or rebuilding.[9]

The block size and building stone are similar to those discussed at Ballıgerme (see Chapter 8 for masons' marks), but in the lowest tier the significant difference is the more elaborate string-course at the level of the impost of the three lower arches with a cyma recta moulding, a feature not seen elsewhere.[10] The lower courses of the main piers are best observed below Arch 18 where the stream flows through. Here there is an offset with a chamfered plinth, and to the east side of Buttress **IV** there are the clear remains of a triangular cutwater to protect the pier from erosion. Near Buttress **VII** there is evidence for an iron clamp inserted to repair a crack in one of the lower facing-stones — an indication of the continued maintenance of the structure, rather than a major programme of rebuilding necessitated by long-term neglect or natural catastrophe.

In the second tier the overall width at the buttresses is 13.84 m, reduced to 11.98 m. The structure is narrowed overall by 0.54 m and the arches are

[9] A few bricks can be found in the debris fallen from the bridge, but unlike Büyükgerme (**K29**) none is seen *in situ*.

[10] See, however, the example of early Byzantine moulding of this type from the Kovukkemer in the Belgrade Forest (Çeçen (1996a), 58).

FIG. 4.10 View of the west face of Kurşunlugerme (**K20**) from the south.

12.92 m high and 7.43 m wide. The same system of continuous chamfered string-courses is seen at the base of the tier, the springing of the arches, and the top of the tier (Fig. 4.7). On the west face a staircase of regular steps survives on the south side of the valley; it is seen to rise from the base of the middle tier (Arch **17**) to the platform at the base of the upper tier (between Arches **10** and **11**). To the north the remains of matching stairs survive below Arch **2**. This feature is not recorded at any other aqueduct so it is unlikely to be simply of utilitarian value.[11]

The upper tier consists of eleven arches; it is 10.83 m high and much narrower, only 4.75 m wide, leaving a platform 3.6 m wide on the west and east sides. The platform on both sides is only preserved beside Arches **10–11** (on the south side of the valley) and **1–3** (on the north side). The upper, third, tier is unique in the system and was required because at this point the narrow and broad channels were still vertically 9.8 m apart (Fig. 4.11). The upper tier can be seen to carry the narrow channel and the east platform of the middle tier carried the broad channel. The system of two channels has already been discussed in Chapter 3; however the importance of Kurşunlugerme for an understanding of the system as a whole requires further consideration. There is clear evidence for the narrow channel at the south end of the bridge. Treasure-hunters have revealed the stone-built face of the channel and its vault, constructed on a ledge cut into the hillside as it turns towards the north-east to cross the bridge. From there it is obscured but there are clear traces of the narrow channel sides above Arch **9** and again at the north end above Arch **1**. It is clear that the narrow channel was carried on a platform at the top of the bridge and that the side walls did not extend across the full width of the upper tier (see Fig. 4.7).[12] The situation of the lower, broad channel is less clear, and our interpretation has altered through the course of the project as there has been further disturbance of

[11] See Chapter 7, 168.

[12] In a manner similar to the Pont du Gard, but unlike the aqueducts of Rome, where the *specus* is enclosed within the body of the bridge; see the comments of Lewis (2001), 178–88.

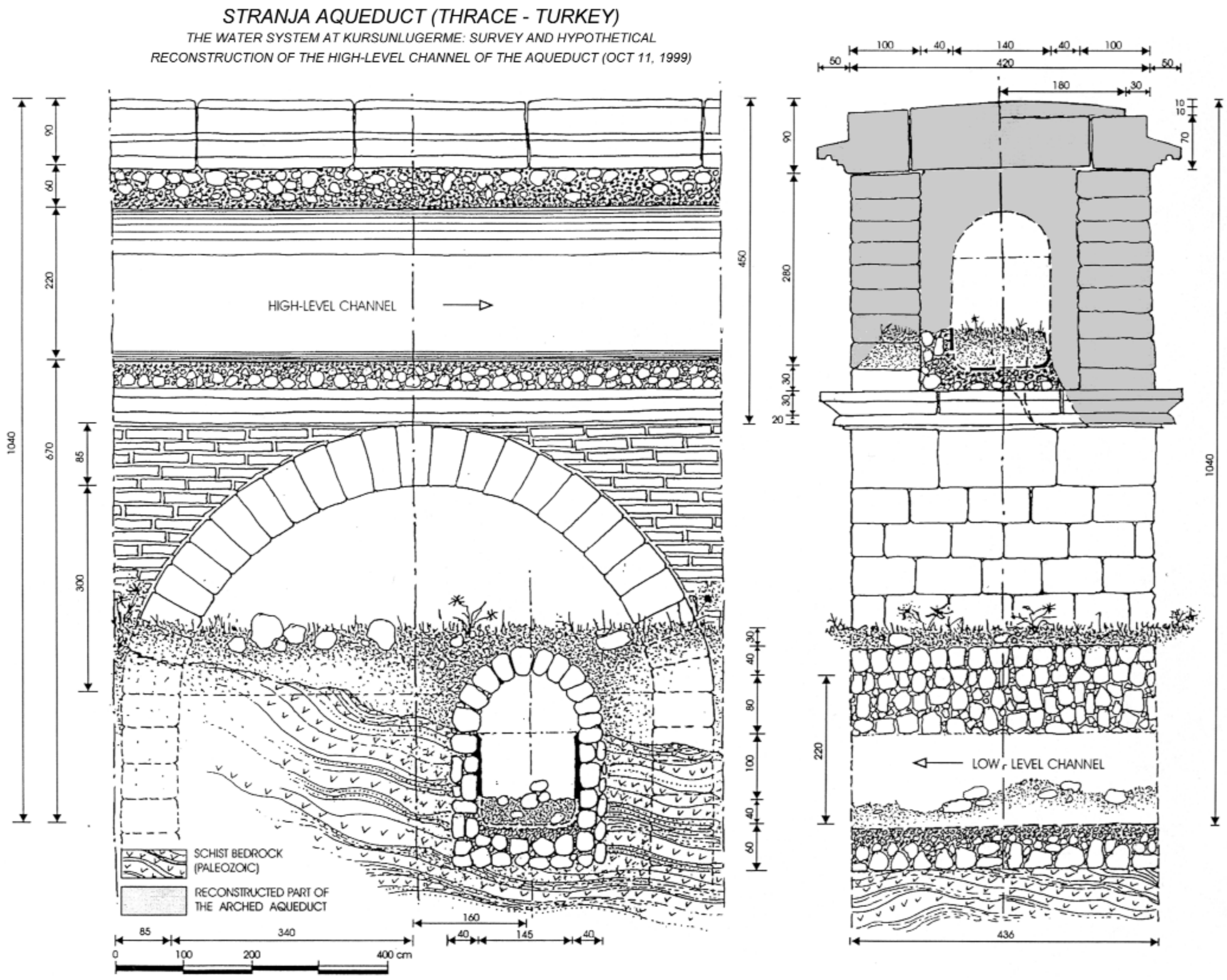


FIG. 4.11 Survey and hypothetical reconstruction of the high-level and low-level channels at Arch 11, Kurşunlugerme (**K20**). (By Paolo Bono)

the structure.[13] From the outset it was always apparent to us that the broad channel passed below Arch 11, approaching the bridge from the west side. Initially, since there was no obvious evidence for a turn across the bridge, we had understood this to indicate that the broad channel continued along the hillside and crossed the now ruined bridge to the east. Our conclusion from these observations was that this was the primary channel for the water supply system.[14]

Subsequently a broad pit dug by treasure-hunters below the east side of Arch 11 during the winter of 2000–1 revealed evidence for the turn of the broad channel along the east side of the bridge, running along the platform at the top of the second tier.[15] As noted before, this platform has largely collapsed, but survives from Arch 3 to the north side of the valley. Opposite Arch 2 further illicit digging had revealed the broad channel edge, located east of the outer edge of the upper tier. Another deep pit located to the north-east of Arch 1 had been largely cut into the natural clay of the hillside and did not show any trace of the broad channel, which must have turned north-west through Arch 1 and can be seen on the hillside about 20 m beyond it. The sequence at Kurşunlugerme provides the key to understanding the chronological sequence and structural relationship of the primary narrow channel from Danamandıra and the later broad channel from Vize, since both can be seen to cross the main surviving bridge and both therefore flowed simultaneously at distinct levels. Less clear is whether the broad channel seen

[13] See above Chapter 3.

[14] See this interpretation in Crow and Ricci (1997) and Bono, Bayliss and Crow (2001).

[15] Fig. 3.40 shows this pit before it had been fully dug out.

on the east side is itself actually a later build. Since the channel approached the bridge from the west and then turned to continue along the north-west side of the valley, it seems surprising that originally the channel was not simply led on the west rather than the east side. It may simply be that, after the major damage apparent to the arches and upper platform on the west face, the channel was then cut below Arches 1 and 11 and into the surviving east platform of the bridge, but this is the type of question that can only be resolved through archaeological excavation. The chronological evidence based on the Christian symbols and acclamations for the construction of the bridge is discussed in Chapter 7.

BÜYÜKGERME (**K29**) (Fig. 4.12)

The length of the aqueduct bridge at Büyükgerme can be estimated at *c.* 135 m, second only to Kurşunlugerme.[16] There are two tiers and the total height of the bridge is estimated at 36 m. There were three arches in the lower tier and above were nine arches equally spaced across the valley. The pier between the lower arches **11** and **12**, and the upper arches **5** and **6** has collapsed and no traces survive apart from the footings. The stream flows below the western arch (**10**). Construction follows the pattern already noted for the great bridges, with large rectangular blocks set in a hard pink mortar. The span of the arches can be estimated at 6 m and the piers are 7.5 m wide. Unlike Kurşunlugerme, the piers are not buttressed and the line of string-courses is discernable on the south façade, although these have mostly been cut back at a later date (Fig. 4.13). The top of the upper tier is poorly preserved and only at Arch **1** at the west

FIG. 4.13 Büyükgerme (**K29**), the south face of the pier between Arches 10 and 11; note how the string-courses and bossed work on the lower facing-blocks have been cut back.

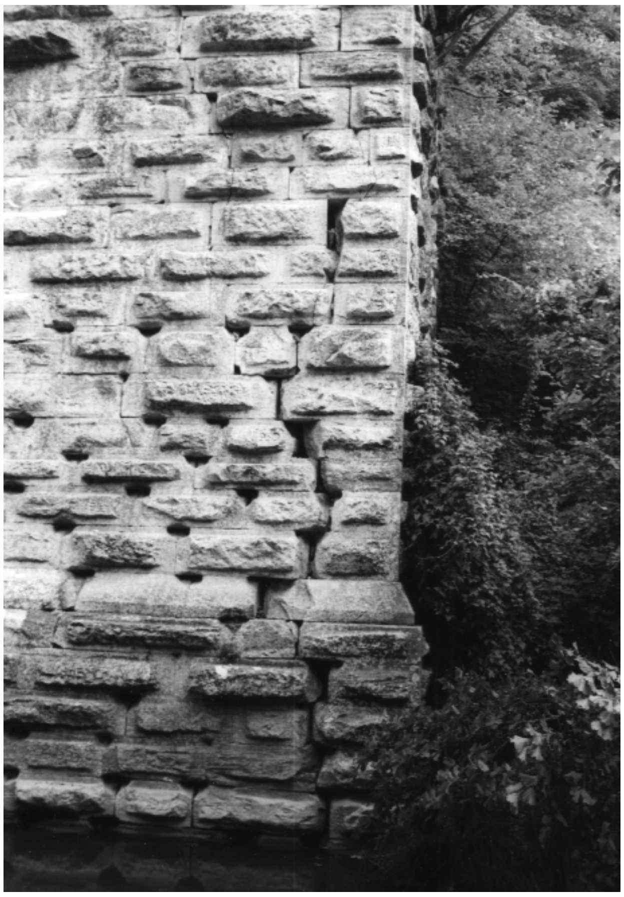


FIG. 4.14 Büyükgerme (**K29**), the face and north corner of the base of the west pier of Arch 10. Note the pitting caused by the extraction of the lead settings for iron clamps and the cracks up the north-east angle.

[16] See the elevation drawing in Dirimtekin (1959), fig. 10, pp. 226–7.

FIG. 4.15 Büyükgerme (**K29**), Arch **4** from the south-east. The Phase 2 narrowing is clearly visible with the springing of a brick vault on the left side.

FIG. 4.16 Büyükgerme (**K29**), the second phase narrowing of the north side of Arch **3**, showing the use of coursed rubble and reused bossed facings.

end of the bridge is the vault of the arch complete. The offset and chamfered course at the base of the piers is visible on the west side of Arch **10** (Fig. 4.14). Limited decoration survives and is discussed in Chapter 7.

Phase 2

The bridge displays some of the clearest evidence for a major intervention at a later period. This can be seen in the extensive refacing of the north side, especially between Arches 1 and 3, and in the narrowing of many of the arches with new vaults (Figs 4.12; 4.15). As noted before, the face of the bridge requiring most extensive repair was located in the north-west quadrant. The earlier facing had clearly fallen, revealing the pink-mortared rubble core of the primary work. This was refaced by irregular blockwork of varying sizes (Fig. 4.16). These blocks are roughly dressed and there was no real concern to square them. This phase of repair survives best in Arches **3** and **4**, where the arch has been narrowed; at the top of the blockwork fill are the bricks for the brick vault within the arch.[17] It is possible that the cutting back of the chamfered string-course in the south façade at the springing of the arches may be associated with this work (see Fig. 4.13). The date of this reconstruction is not clear and will be discussed in the conclusion.

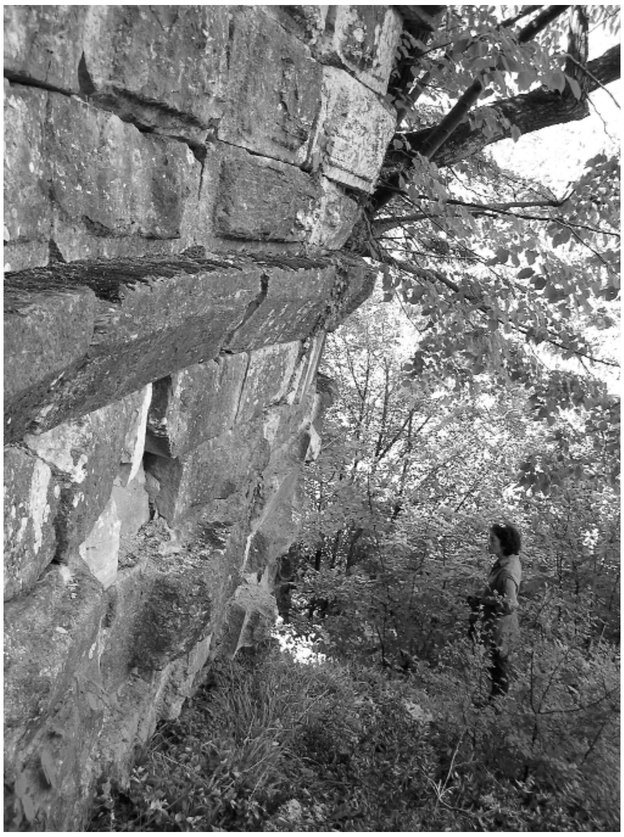
In the narrow valley to the north of Büyükgerme the narrow and broad channels are seen to run closely together, with the former slightly higher (see above, Chapter 3). A broad trench represents the approach of the broad channel towards the west abutment of the bridge. Part of the base of a section of channel is visible above Arch 1 and this is presumably the broad channel. The earlier course of the narrow channel across bridges **K29.1**, **K29.2**, and **K29.3** to the west of Büyükgerme has already been described, but there is still no direct evidence to

[17] This is clearly shown in Dirimtekin (1959), figs 10 and 14, p. 227, who attributes the poor preservation on the north face to wind and rain.

confirm whether the narrow channel was carried across the new bridge after it was completed in the fifth century. Further to the east, the two channels are seen crossing the raised embankment at Karatepe (**K29.4**), where there is evidence for restoration in the sixth century (see Chapter 3).

KEÇİGERME (**K**30)

FIG. 4.17 Keçigerme (**K30**), arches in the upper tier.



This bridge occupies a dramatic setting in a narrow, steep-sided valley comparable only with Ballıgerme.[18] The length can be estimated at 80 m and height at 33 m; there is a single lower arch, with five tall arches in the upper tier (Fig. 4.17). The width of the upper tier measured 6.35 m and the span of the upper and lower arches was 6.4 m. The block size and building stone remains the same as at all three preceding bridges and there are similar basic features, such as chamfered offsets and string-courses. All the upper arches survive to their full height; however we can only be sure that the broad channel crossed this bridge as the narrow channel was observed to continue along to the earlier bridge (but see discussion in Chapter 3). There is no evidence of major restoration, although the north wall of the east abutment has a very severe bulge, possibly the result of major seismic damage (Fig. 4.18). Decorated keystones were noted by Oreshkov and a pair of busts survives on the west side (see Chapter 7).

FIG. 4.18 Keçigerme (**K30**), bulging masonry on the east abutment.

[18] See Oreshkov (1915); Dirimtekin (1959), 225–6; Çeçen (1996a), 176, 181–6 (with numerous photographs).

KUMARLIDERE (K31)

Fig. 4.19 Kumarlıdere (K31) from the east.

This is the final example of the monumental aqueducts proceeding eastwards.[19] It is difficult to estimate the full length of the bridge since there are long embankments leading up to it; these can be seen from an air photograph as a remarkable straight line in dense green forest. Just taking the arched length of the bridge, the distance was recorded at 130 m with a surviving height of 30 m (Fig. 4.19). The lower tier comprises four tall arches and the upper tier eleven, of which only the central four are nearly complete. The span of the arches was measured at 5.3 m and the width of the piers at 8.1 m. Unlike Keçigerme, where upper and lower arches were of equivalent height, here the upper arches are somewhat shorter (Fig. 4.20). Construction and decoration are similar to the examples already discussed. Evidence for repairs was noted in the rebuilding of the east side of the embankment (Chapter 3) and the decoration is discussed in Chapter 7.

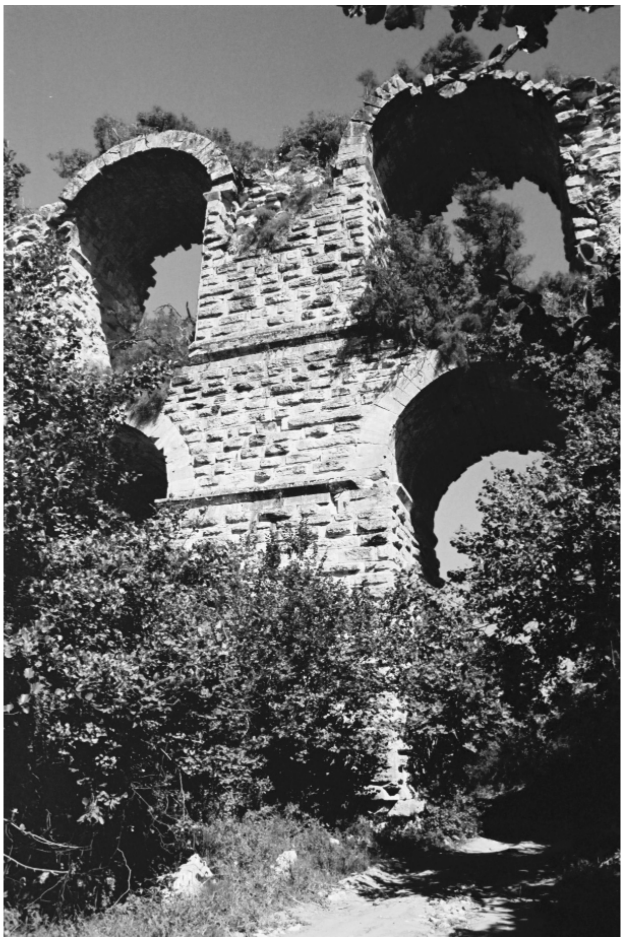


Fig. 4.20 Kumarlıdere (K31), south arches from the west.

[19] See Oreshkov (1915); Dirimtekin (1959), with elevation drawings, fig. 5, pp. 222–3; Çeçen (1996a), 188–97 (with numerous photographs).

TALAS (**K22**) (Fig. 4.21)

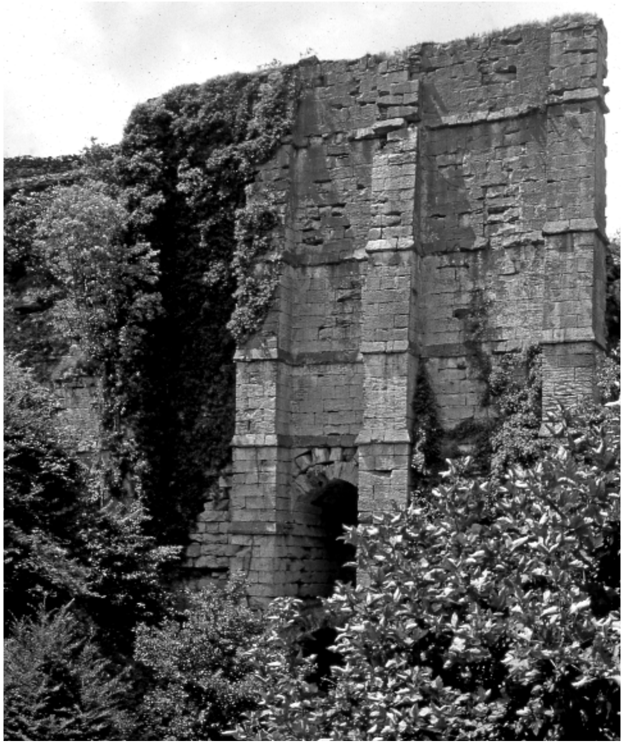


FIG. 4.21 Talas (**K22**), general view from the east (1994).

Talas does not belong to the group of bridges discussed above, since it is not constructed of the hard metamorphosed limestone characteristic of those bridges and it does not display the same features of structural decoration. Instead it is included in this chapter since it is the best and largest example of a reconstructed bridge of Period III.[20] Three major phases of bridges are known in this valley; the first (**K21**) belongs to the early phase of bridges associated with the narrow channel. This was replaced (or supplemented) by a new bridge for the broad channel, a two-tier bridge with a high, single lower arch and three arches above, 60 m in length and about 25 m high. This is the largest surviving new bridge of Period II not constructed in the distinctive monumental masonry style. The building stone is a soft white limestone, which has weathered poorly, although the block size and the style of bossed masonry are comparable to the bridges discussed above (Fig. 4.22). What distinguishes Talas is that in the next phase the bridge was radically rebuilt with new stonework which clad the bridge on both the east and west sides. The new masonry was very different from the construction of either Phase 1 or 2;

FIG. 4.22 Talas (**K22**), view from the north-west of a primary upper arch (right) enclosed within the later masonry (left).

[20] See Oreshkov (1915); Dirimtekin (1959), with elevation drawings, fig. 22; Çeçen (1996a), 168–72, 174–6 (with numerous photographs).

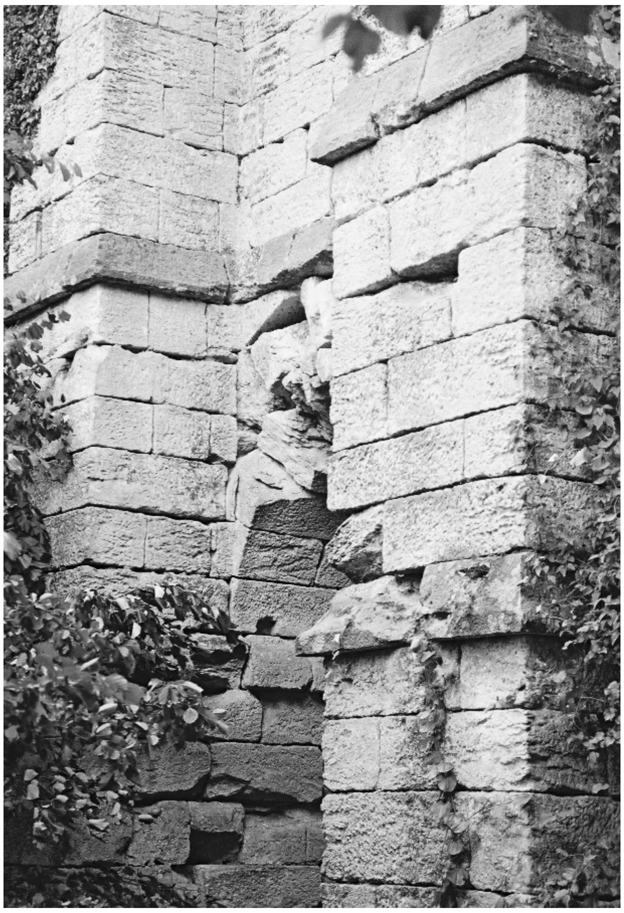


Fig. 4.23 Talas (**K22**), upper central arch in Phase 3, showing chamfered string-course and buttresses.

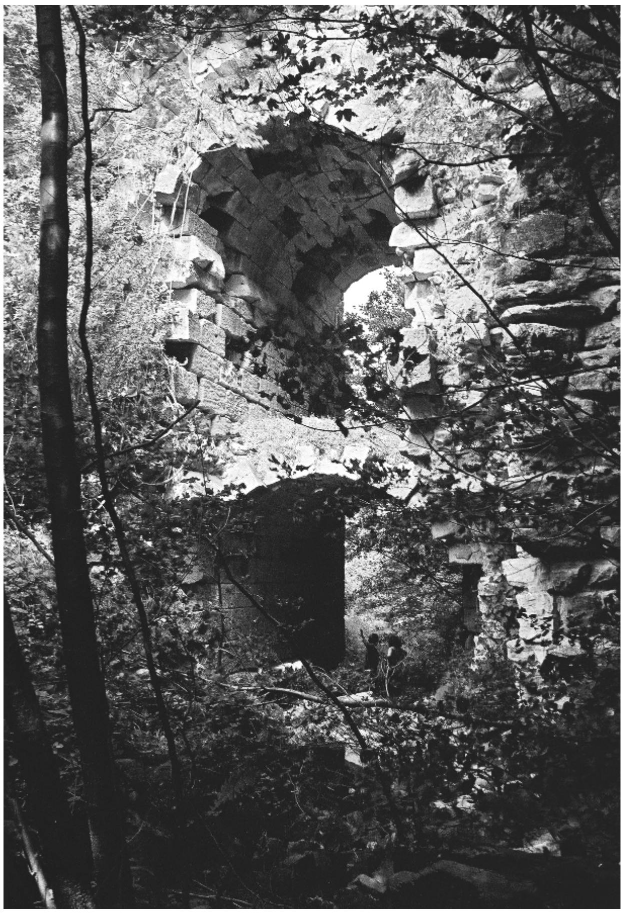


Fig. 4.24 Talas (**K22**), central arch of Phase 3, showing lower arch providing additional lateral support.

the blocks remained squared, though not as precisely as true ashlar, and more significantly they were dressed to a plane face. Drafted margins and quarry-faced dressing are not seen in this phase of building. Another characteristic feature is the use of sloping buttresses and of string-courses and archivolts where the chamfer slopes downwards and outwards (Fig. 4.23), contrary to the conventional forms seen at Kurşunlugerme (**K20**) and elsewhere. At Talas and other sites this work can, however, easily be distinguished from the coarse rubblework which has already been noted from the later phases of Ballıgerme (**K18**) and Büyükgerme (**K29**).

At Talas this rebuilding strengthened the single lower arch by inserting an intermediate arch to provide additional lateral support (Fig. 4.24). The remaining arches of the upper tier were filled and the north face was uniformly clad in a new wall; this created a solid structure, more like the face of a dam than a bridge, articulated vertically by a series of sloping buttresses rising to the full height of the new wall, across which runs a series of distinctive string-courses with an upward chamfer (see Fig. 4.21, 23).

Fig. 4.25 Talas (**K22**), the inner face of the east wall of the water channel, showing small rubblework masonry; the base is largely eroded away. View from the west.

In places, where there has been later collapse, it is clear that the earlier 'rusticated' work was cut back to receive the new plain cladding. The stone used for this new work is a harder limestone, similar to the limestone used for the building of the northern sector of the Anastasian Wall only 6–8 km to the west. This may help to provide a *terminus post quem* for the work at Talas.[21] At the south end of the bridge a high arch survives and there is a clear section of the interior east wall of the water channel crossing this phase of the bridge, with the small block construction seen at Ayvacıkdere (**K7**) and elsewhere (Fig. 4.25). The west side of the bridge has also been faced, but without the buttresses and string-courses of the east wall. Against the buttress east of the lower arch was a section of later repair using rough blockwork (Fig. 4.26), similar to the work described from Phase 2 at Ballıgerme (**K18**) and Büyükgerme (**K20**).

FIG. 4.26 Talas (**K22**), later blockwork on the west face, south of the central arch.

CONCLUSION

The archaeological evidence described in detail in this chapter and in Chapter 3 allows us to construct a relative chronology of the differing types of masonry construction used in the Thracian aqueduct system. These phases can be approximately dated with reference to the historical sources discussed in Chapter 2 and the masons' marks, inscriptions, and carved decorations discussed in Chapters 7 and 8.

I **Primary phase** (fourth century)

The primary bridges are found on the line of the narrow channel from the sources at Danamandıra and Papu. The first phase in the development of the system is to be connected with the earliest historically attested attempt to bring water from Thrace, 1,000 stades from Constantinople, in the reign of the emperor Valens (see Chapter 2). The dimensions of the blocks in the primary bridges can vary significantly. Some are oblong, 0.40 m by 0.25 m, with rough rustication and were noted at the first bridge close to the main road at Hasan Dede Çiftliği. Examples of primary bridges are known from **K19** and **K19.1** and in the valley of the Kurşunlugerme Dere **K20**; however these bridges can be best documented east of the Anastasian Wall and clear examples are known from Nikol Dere (**K20.4**), Maçka Dere (**K20.5**), Talas (**K21**), and in the earlier bridges preceding the construction of the monumental bridges at Büyükgerme (**K29**) – **K29.1** and **K29.2**, Keçigerme (**K30**) – **K30.1**, and Kumarlıdere (**K31**) – **K31.1**. All these bridges present a consistent form of construction; where they can be recorded they were normally 5–5.20 m wide, with abutments and upper piers faced with long, narrow bossed work, topped by a square-section string-course. Above this masonry was either small blockwork or coursed rubblework. Schist was used at Talas (**K21**) for both the lower and upper work where suitable limestones were unavailable. Where the pier had

[21] Crow (2006); Crow (2007a); the Thracian Wall was completed under Anastasius, probably by 504. There were two major repairs under Justinian and it is not inconceivable that the work seen here and elsewhere was completed at the same time as the Wall was being restored.

recently collapsed at Maçka Dere (K20.5) this first phase work is characterized by timber cribwork to strengthen the rubble mortar core. The longest known bridge in this phase was probably the primary bridge at Kurşunlugerme, estimated at 77 m, with a height of 33 m. By comparison the contemporary Bozdoğan Kemeri in Constantinople has a maximum recorded length of 971 m and a maximum height of 40 m.

II **Monumental phase** (end of the fourth or early fifth century)

The monumental character of these bridges has been outlined above; all of the five bridges exhibit identical forms of construction, with monumental facings of a metamorphosed limestone, using quarry-dressed blocks with distinct drafted margins. Some of the projecting faces are dressed so that the upper face has been cut to present a smooth surface for the support of scaffolding on the face. The longest bridge is Kurşunlugerme (K20) (159 m) and significantly this is also the widest, 12 m, supporting two upper tiers with additional buttresses. Kumarlıdere (K31), which is definitely known to have carried both the narrow and broad channels running parallel, is 8.1 m in width, whereas Ballıgerme (K18), Büyükgerme (K29), and Keçigerme (K30) are 7.6 m in width. By comparison the contemporary arcade at Karamanoğlu (K13), constructed for the broad channel alone, was 5.67 m wide. The masons' marks discussed in Chapter 8 indicate the contemporaneity of these bridges. Art historical and epigraphic evidence is discussed in detail in Chapter 7. Unfortunately, the historical sources discussed in Chapter 2 do not allow us to determine a more specific date. In particular, we cannot be certain that the reference to a 'Theodosiac Aqueduct' in a law of 396 refers to the construction of the new channel from Bizye with which this phase of monumental bridge building is linked.

III **Major rebuilding: Talas type** (mid-sixth century)

As has already been noted, a sequence of bridges — (K20.3) Elkaf Dere, (K20.4) Nikol Dere, (K20.6) Ortabel Dere, (K22) Talas, (K23) Leylek Kale, (K25) Cevizlik Kale, and (K29.4) Karatepe — reveals a particular phase of rebuilding attributable to the reign of Justinian. Others in this sequence have not been visited or alternatively were extensively rebuilt in later periods.[22] Another bridge at Luka Dere (K17.1) reveals identical forms of construction, although it is at some distance west and lies in a relatively unexplored part of forest. Identical features do not occur in all examples of this group; however there is sufficient overlap amongst the distinctive indicators — imposts and string-courses, tapering buttresses and plain, quadratic limestone blocks — to be able to associate these structures with the bridge at Elkaf Dere (K20.3) which is dated by the inscription of Flavius Longinus, ex-consul and prefect of the city, who is known to have been involved with works at the Basilica Cistern in the 540s.[23] In this third phase of repairs it is important to recognize not just the uniformity of the programme but the distinctive character of the rebuilding. At two large bridges, Talas (K22) and Leylek Kale (K23), the earlier bridge structure was encased by the new work, creating new much wider structures where the downstream, outer wall was supported by tapering buttresses. The result was the creation of bridges with an overall width comparable only to Kurşunlugerme. At Talas the increased width was 11.2 m and at Leylek Kale 9.2 m; similarly the more modest bridge at Ortabel (K20.6) was increased to 8.6 m, whereas all the primary bridges hardly exceeded 5.5 m. This form of extensive repair can be compared with many of the rebuilt Republican bridges in the Roman Campania, which were similarly encased with buttressed walls under Hadrian and later emperors.[24] The sixth-century rebuilding may also be attested at Kale Dere, on the line from Pınarca, where the construction of the high south pier of the second bridge closely matches the masonry at Talas and elsewhere.

IV **Major repairs** (eighth century?)

The comprehensive programme of repairs seen in Period III is different from the extensive but more piecemeal repairs represented in Period IV. These can best be documented at two of the major bridges:

[22] Not yet visited include K20.7 and K24; others extensively rebuilt or ruined include K20.5 Maçka Dere.

[23] See Chapter 2.

[24] Ashby (1935), among many examples see Ponte Taulella on the Anio Vetus, fig. 3; Ponte Lupo on the Aqua Marcia, fig. 11, 117–21.

FIG. 4.27 Büyükgerme general view.

Ballıgerme (**K18**) and Büyükgerme (**K29**). At both bridges one elevation underwent extensive repairs with roughly-squared blocks laid in courses; at the former bridge there were also unusual clasping buttresses at the corner of the lower arch. Some of the stone is reused, but others blocks may be reworked; similar stone repairs are found at a number of other bridges: Gümüşpınar Dere (**K19**), (**K19.1**), Ceviz Dere (**K20.1**), Maçka Dere (**K20.5**), and Talas (**K22**) on the main line, as well as the second bridge at Kale Dere on the Pınarca branch.[25] At Talas (**K22**) the rough blockwork of Period IV is clearly later than the distinctive rebuilding programme seen in Period III, but at both Ballıgerme (**K18**) and Büyükgerme (**K29**) the extent of the later work reveals a major programme of rebuilding distinct from Period III. At Büyükgerme there is also evidence surviving for activity on the south elevation where the main string-course at the level of the lower arches has been cut back, possibly in advance of additional facings (Fig. 4.27). Brick vaults are seen springing in Arch 4 and since there is no evidence for later repairs, as at Ballıgerme, it is presumed that they belong to the same phase as the coursed blockwork. The date of this repair will be discussed below.

V **Repairs** (middle Byzantine)

Evidence for the use of brick survives from a number of bridges as fallen bricks, rather than brickwork *in situ*. However, apart from the example discussed above from Büyükgerme (**K29**), there is clear evidence for the more extensive use of brick and rubble from Ballıgerme (**K18**). This is seen in the repair to the south end of the west face, constructed with alternating rubblework and brick bonding courses. Similar brickwork is seen at the filling of Arch **2** at the north end of the bridge. A specific feature of this work is the use of vertical bricks in cloisonné style, a feature normally associated with middle and later Byzantine construction.[26]

[25] Chapter 3, Section 4.3.

[26] See the discussion of examples from the walls of Constantinople and Nicaea in Foss and Winfield (1986), *passim*. The majority of dated examples are from the twelfth century or later. At Ballıgerme it is worth noting that the cloisonné construction is more limited than the ostentatious examples from the city walls.

Discussion

Ballıgerme provides a key to the succession of rebuilding styles, from the coursed blockwork cladding to alternate brickwork and rubble repairs. The question is how far is it possible to refine the dating of these two final phases to try and establish how far these repairs can be associated with historically-attested restoration and repairs to the aqueducts. At Talas it is possible to show that the blockwork repairs of Period IV are later than the Period III structure datable to the sixth century, thus providing a *terminus post quem* for the Period IV masonry. The coursed blockwork set in a hard mortar of this latter work can be broadly paralleled in works on the Theodosian Land Walls and at Nicaea in the mid-eighth century.[27] The next phase (V) at Ballıgerme, of alternate brick and rubble bands with some evidence of cloisonné, is unlikely to be earlier than the eleventh century and this in turn provides a *terminus ante quem* for Period IV work. It is possible, therefore, to recognize in the Period IV work at two major bridges and elsewhere the major restoration reported by Theophanes in 766. This work drew in Anatolian stonemasons, Thracian brick-makers, and other workers from across Constantine V's empire.[28]

As has already been observed, the last main phase (Phase V) at Ballıgerme (**K18**) provides evidence for the latest significant repairs to any of the major Thracian bridges outside of the city. Following the restoration by Constantine V there is no historically attested work to the Thracian system until the beginning of the eleventh century, when Skylitzes' *History* records the renovation of the aqueduct of Valens by Basil II (*c.* 1020) and a decade or so later work undertaken by Romanos III, who added channels outside the city and *kastelloi* within.[29] In addition an inscription of Basil II and his brother Constantine VIII, found in the vicinity of Karacaköy (in the lower part of the valley of the Karaman Dere), records that:

Time threatened a wondrous piece of work,
Not only time, but (also) a multitude of barbarians.
But routing the barbarians
The wondrous emperor Basil restored (it) again
Along with Constantine his young brother.
Basil the Goth, who was appointed *archegetes* for the year
Together with Elpidios Brachames, the *taxiarchos*, assisted him.

This metrical inscription refers only to the 'wondrous work' and has been understood to refer to repairs to either the Thracian (Anastasian) Long Walls or the aqueduct system.[30] It is unlikely to be associated with the Long Walls, since these no longer functioned after the seventh century.[31] In her discussion of the Byzantine inscriptions from Thrace, Asdracha considered that this text was originally located at another important military construction or the nearby aqueducts, although since no military structures of the middle Byzantine period are known in the forests close to Karacaköy, the former explanation seems unlikely. The closest sites are the Byzantine fortresses at Binkılıç or at Derkon, east of Terkos Lake.[32] Involvement of senior Byzantine officers in the building work may not be significant, since, as Ivison notes, there is good evidence for the involvement of the military in the construction of other types of building, such as state-sponsored churches, and Thrace was always a military zone between the Byzantines and the Bulgars with a significant military presence.[33] Asdracha suggests dating the inscription to 1001–2.[34]

The inscription cannot be associated directly with work at Ballıgerme, but it does provide the context for such renovations in the eleventh or early twelfth centuries, as well as indicating the increasing problems that the system faced. Furthermore the very nature of the restoration in Phase V, involving additional support for the earlier masonry arch,

27 See the caution expressed by Foss and Winfield (1986), 115–16, concerning the differences between the construction of the walls of Leo III and Constantine V from Nicaea ((1986), 100), where the walls were constructed in 'a uniform style of carefully arranged marble blocks set invariably in mortar', and work by the same emperors on the Land Walls at Constantinople ((1986), 53–4).

28 See Chapter 2, pp. 19–20; to Phase IV may also be added the rebuild of the lower bridge at Nicol Dere in schist (**K20.4**).

29 See Chapter 2, 21; Appendix 1.

30 Schuchhardt (1901), 113–14, argues for the Anastasian Wall; while Seure (1912), 567–8, fig. 14, preferred the aqueducts. For more recent discussions, see Crow and Ricci (1997), 256 and Asdracha (1991), 306.

31 Crow (2006).

32 Ivison (2000), 10, associates the inscription with fortifications (wrongly stating that it was found at Derkon).

33 Ivison (2000), 10; for military activity in the area, see the Life of St Mary the Younger of Bizye, and the inscriptions from Silivri and Çorlu, Mango and Ševčenko (1972); Asdracha (1991); and Ivision (2000).

34 Asdracha (1991), 309.

illustrates precisely the problem identified by Manuel I in the 1170s. Choniates reports that at time of drought, 'He noted that the old arcades which conveyed water to Byzantium were long since collapsed, and that it would be a difficult task to reconstruct them, one requiring much time'.[35] From this time on, the long distance system with its great bridges which had provided Constantinople with water for seven centuries was abandoned and the Byzantine and later Ottoman city was to rely on closer sources.

THE CHANNELS

A significant feature of the last phase (V) of restoration at Ballıgerme (**K18**) is that it carried the broad channel from the west, a valuable indicator of its continuing significance until the twelfth century. The channels provide less direct evidence for programmes of repair and restoration, although the historical sources more often talk of work to the channel (*holkos*) than to the bridges themselves. Both the broad and the narrow channels were covered throughout their lengths. The normal option was to construct the water channel against the side of a hill so that the line proceeded, often with great sinuosity, around the hills in order to maintain a gentle gradient towards the city. It was built in the standard 'cut and cover' technique well known from Roman aqueducts around the Empire.[36] There is no instance where the channel is not buried, apart from bridges and raised substructures, unlike the partly exposed channel of the Aqua Claudia outside Rome.[37] On the west approach to the bridge at Kurşunlugerme the stone-vaulted narrow channel has been exposed by treasure-hunters and it can clearly be seen to have been constructed as a free-standing structure within a trench cut into the hillside, which was later covered over.[38] In some cases it was necessary to construct the channel within a shallow trench and a section through the construction layers is visible in the roadside east of Pınarca.[39] There is no comparable surviving exposure of the broad channel, although at the quarry at Babadar Dere (**G17.2**) the channel can be seen constructed within a rock cutting 3.5 m wide.[40]

The roof of the channels varied,[41] although it is not clear how far this can be seen to reflect differing phases of construction. For the broad channel the wide vault was a fairly shallow curve and the main differences are seen in the type of stones used for the construction of the vault, small squared or rubble. Greater variety is seen in the vaults of the narrow channels, some of which are pedimented, whereas others have a steeper or shallower segmental arch, with varying types of stone employed. The clearest evidence for differing phases of construction is apparent in one of the supplementary channels on the north side of the Kurşunlugerme valley. At a point where the channel came to a turn across the hillside there had been a collapse which was later repaired. The width of the channel remained constant in both phases, but the primary channel had a pedimented roof, while the later repair had a shallow curve.[42] At all periods the construction was of mortared rubble; in some instances the sides of the channels were faced with small, squared blocks of limestone and this form of construction survives on a number of bridges, notably at Ayvacık Dere (**K7**) and Talas (**K22**).[43] It is also seen in channels at **G17.1** near Aydınlar, in the west approach to Ballıgerme[44] and elsewhere. The normal form of facing was narrow pieces of limestone or metamorphic rubble set in a hard mortar with crushed brick. A consequence of groundwater leaching through the roofs and walls was that lime from the mortar created small stalactites and limescale on the walls; this is more commonly apparent in the large channels (see Figs 3.18, 3.28, 3.50).

Although the walls of the channels mostly survive as roughly-finished rubblework, in a number of places there was clear evidence for surviving waterproof plaster on the walls and on the channel floors.

35 See Chapter 1, 21; Appendix 1.
36 Hodge (1992).
37 Van Deman (1934), 229, textcut 29.
38 See Chapter 3, 59.
39 See Chapter 3, Fig. 3.36.
40 See Chapter 3, Fig. 3.21.
41 See the differing cross-sections recorded by Dirimtekin (1959), figs 2 and 9, 240.
42 See Chapter 3, Fig. 3.37.
43 At both places the work belongs to Phase III or later, see Chapter 2.
44 See Chapter 3, Figs 3.28 and 3.32.

On the west abutment of the bridge at Ayvacık (**K7**) part of the plastered base was well preserved and showed at least two main phases, with a well-defined curve at the junction with the side wall of the channel. Partial sections of the bases of the channels are also well preserved from the narrow, upper channel at Kurşunlugerme (**K20**) and at Büyükgerme (**K29**), where part of the broad channel can be seen — all indicate phases of restoration. At Gelin Dere (**K6**) there is a very clear section of the tunnel as the channel leaves the east side of the bridge, which has been bulldozed recently to make a village track. The sides and base of the channel are clearly preserved, with 15 mm of water-proof plaster over which was between 70 and 90 mm of sinter. On the channel side the sinter was up to 40 mm thick in four clearly-defined layers, each with a varying number of finer bands. Deep sinter was, however, only found in the minority of channels, possibly indicating that the greatest deposits were closer to the spring sources where there was the maximum precipitation.[45] Plastered walls survive in a number of instances, at least up to 1 m in height. In a number of cases it was possible to identify the level of regular maximum water flow from the precipitation of calcium carbonate. At Karamanoğlu (**K13**) the lime encrustation was at a height of 1.00 m in a broad channel, 1.60 m wide, providing some indication of the maximum delivery of the channel during the winter and spring months. The same height is also known from the broad channel west of Ballıgerme (**K18**).[46]

TUNNELS

Evidence for a tunnel is most clearly demonstrated at Karamanoğlu, where the broad channel is led across low ground on an arcade and where there is clear evidence for a shaft in the hillside beyond. Elsewhere the evidence is largely surmised where high ground intervenes in the known course of the channels, although shaft openings are reported west of Binkılıç indicating the line of the Safaalan tunnel.

[45] Gelin Dere is close to the springs at Ergene; another massive deposit of sinter is in the overflow channel from the main collection pool at Pınarca, see Chapter 3, 78.

[46] For Karamanoğlu see Chapter 3, 47; for Ballıgerme see Chapter 3, 51.