ILION (ÇANAKKALE EZİNE) SU YOLLARI

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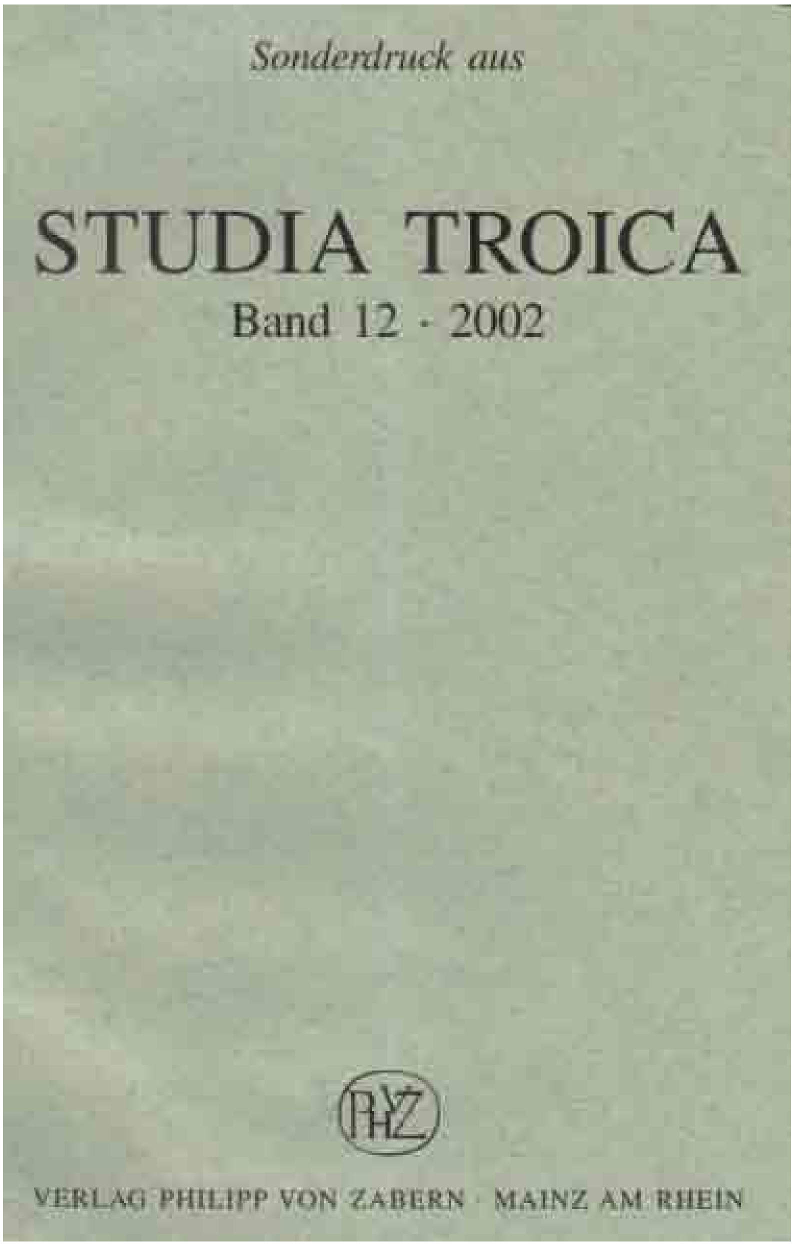

William Aylward ile Cura Aquarum ın Ephesos 2004 birlikte olduk. Orada sunulan bu değerli çalışmanın çıktısı kendisi tarafından verilmiştir.

THE AQUEDUCT OF ROMAN ILION AND THE BRIDGE ACROSS THE KEMERDERE VALLEY IN THE TROAD

William Aylward, Gebhard Bieg and Rüstem Aslan

Abstract

In Roman times an aqueduct brought water to Ilion from a source in the mountainous interior of the Troad. This article describes the physical remains of the water system and proposes a course for the aqueduct between 20 and 30 km long. The best known segments of the aqueduct include a large masonry bridge across the Kemerdere valley and part of an underground masonry conduit near the village of Tevfikiye.

The aqueduct had an initial segment of terracotta pipelines which later carried water into a subterranean channel. The link between the these two systems has not been located, but the engineers may have put it at a transitional point in the topography between mountains and plateau, which is today marked by the village of Gökçali. Neither the source of water in the mountains nor the point at which the aqueduct entered the city has been found, but the loss in height over the entire length of the water system can be estimated at 400 m.

The bridge across the Kemerdere valley is the largest of several bridges on the aqueduct. It is also among the largest aqueduct bridges in Turkey, with a span of 16 m and a water channel elevated 27.5 m above the valley. Evidence for accurate dating is sparse, although the bridge's construction materials and technique point to the Julio-Claudian or Hadrianic period. The keystone was decorated with a bust which has weathered beyond recognition. The bust may have depicted Apollo Thymbraeus, who supposedly had a nearby sanctuary that was tied to the legendary fall of Troy as the setting for Apollo's gift of prophecy to Cassandra and Achilles' abduction and murder of Troilus.

Zusammenfassung

In römischer Zeit wurde durch einen Aquädukt Wasser aus dem bergigen Hinterland der Troas nach Ilion geführt. Dieser Artikel beschreibt die physischen Überreste dieses Wassersystems und rekonstruiert den Verlauf des Aquädukts, der zwischen 20 und 30 km lang war. Die am besten bekannten Teile des Aquädukts bestehen aus einer Aquäduktbrücke über das Kemerdere Tal und einem unterirdischen gemauerten Tunnel nahe des Ortes Tevfikiye.

Der Aquädukt bestand im Oberlauf aus Terrakottaröhren, die später in einen unterirdischen Tunnel mündeten. Dieser Verbindung der zwei Systeme konnte bislang nicht genau lokalisiert werden, aber die römischen Ingenieure könnten sie am Übergang von den Hügeln zum Plateau errichtet haben, der heute durch das Dorf Gökçali markiert wird. Weder der Anfang des Aquädukts, noch sein Eintritt in die Stadt konnte bislang bestimmt werden, doch betrug die Höhendifferenz über die gesamte Länge des Systems etwa 400 m.

Die Brücke über das Kemerdere Tal ist die größte unter den bekannten Brücken des Aquädukts. Sie zählt mit einer Spannweite von 16 m und einer Höhe des Wasserkanals von 27.5 m Höhe über dem Tal zu den größten bekannten Aquäduktbrücken der Türkei. Hinweise für eine genaue Datierung sind nur spärlich vorhanden, jedoch sprechen die genutzten Baumaterialien und die Bautechnik für julisch-claudische oder hadrianische Entstehung. Der Scheitelstein des Bogens ist mit einer Büste geschmückt, die weitgehend zerstört ist. Diese Darstellung könnte ein Bildnis des Apollo Thymbraios sein, der wahr-

scheinlich ein Heiligtum in der Nähe besaß, das durch Apollons Prophezeiung an Kassandra sowie den Hinterhalt und die Tötung des Troilos duch Achilleus mit dem Fall von Troia in Verbindung gebracht werden kann.

Introduction

Roman Ilion's only known aqueduct had its source in the Ida Mountains, about 20 km east of the city. Prior to the current campaign to Troia, the only known vestige of the aqueduct was a monumental bridge over the Kemer ("Arch") river in the Kemerdere valley, about 11 km east of Ilion (Figures 1, 4). Survey and excavation conducted since 1994 confirm that Ilion was supplied by an external water source in Roman times.[1] This evidence consists of terracotta pipelines, an underground channel with a masonry cover, and several smaller bridges that helped to carry the conduit across uneven terrain from source to terminus. Discovery and study of this evidence was achieved by surveys along the aqueduct's path in 1994 and 1995, the excavation of part of the underground conduit just outside Ilion's eastern fortification wall in 1998, a measurement survey of the Kemerdere bridge in 1999, and a GPS survey of the aqueduct's terracotta pipelines and smaller bridges in 2001.[2] This article is the first detailed account of Ilion's aqueduct, and the first to consider its specific course. Because many parts of the aqueduct remain elusive, a comprehensive study is not possible. But there is sufficient evidence for a partial reconstruction the aqueduct's course and hydraulic characteristics, and for informed discussion of its building materials and technique, engineering works, and date. The authors hope that continuing research on the water supply of Ilion will at some point merit a comprehensive publication of the aqueduct and the verification or correction of estimates and conclusions drawn here.

Previous Research

Ilion's aqueduct and monumental bridge across the Kemerdere valley have been consistently overlooked in studies on Roman bridges and aqueducts which deal with sites outside Italy.[3] Travelers to the Troad have called attention to the Kemerdere bridge since the early nineteenth century, and in March of 1801 Philip Hunt seems to have been the first modern traveler to document it.[4] In 1819 the botanist Philip Barker Webb saw the bridge and placed it on his map of the Troad, and his colleague Fox-Strangways drew the first known illustration of the bridge (Figure 2).[5] William M. Leake visited the Troad in 1800, and in 1824 he suggested for the first time that the aqueduct on the bridge may have supplied Classical Ilion.[6] In 1839 Thomas A. B. Spratt and Peter W. Forchhammer took detailed measurements of the bridge and they marked its location and correct orientation on the first measured map of the Troad.[7] Heinrich Schliemann mentioned the role of the bridge in Roman Ilion's water supply, but he did not explore the aqueduct.[8]

Prior to the current campaigns to Troia, Wilhelm Dörpfeld, John M. Cook, and Aşkidil Akarca were the only twentieth-century scholars to mention Ilion's aqueduct.[9] Dörpfeld photographed the Kemerdere bridge and published a general description of its construction and role in Ilion's water supply (Figure 3).[10] Cook published photos of the bridge and provided a summary of published observations on the aqueduct, along with his own observations on the water supply.[11] Akarca published a photo of one of the smaller bridges, as well as two elevations of the Kemerdere bridge's northwest face: a schematic drawing showing the principal dimensions, and a stone by stone sketch.[12] Summary observations on the aqueduct and its connection to Ilion have been made regularly in publications of the Troia Project.[13]

The course of the aqueduct

The course of the aqueduct can be reconstructed from the positions of nine bridges documented

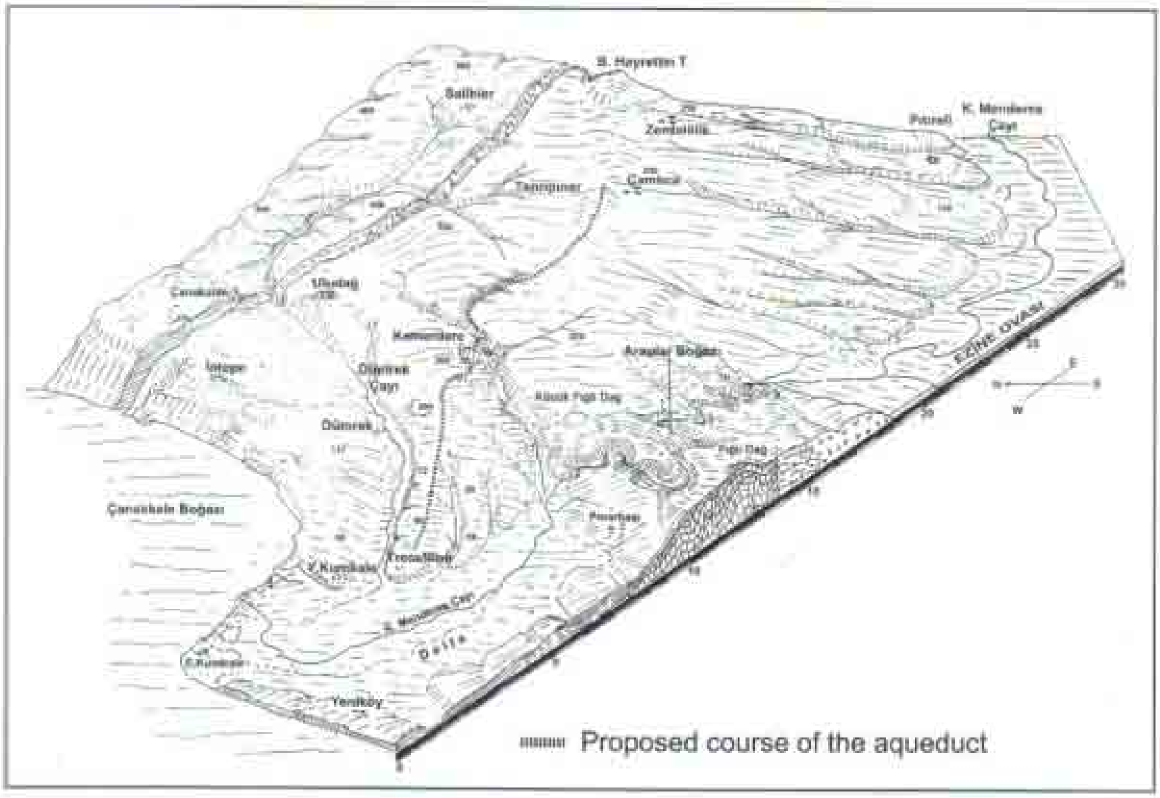

Fig. 1 Proposed course of the aqueduct. Map by Gebhard Bieg, after Bilgin 1969, pl. 29.

between 1994 and 2001 and the discovery and excavation of a section of underground conduit in the village of Tevfikiye in 1998. The comments of early travelers such as Judeich and Cook are also useful. The most elusive question is the source of the aqueduct, but it probably began somewhere on the watershed west of Hayrettin Tepe, and to the north of the villages Zerdalli and Çamlica (Figure 1). This part of the Troad is mountainous land below the summit of Kayali Dağ to the northeast, and between the drainage basins of the Scamander river to the south and the Kemer river to the northwest. From its source the aqueduct followed a course to the northwest, down into the drainage basin of the Kemer river (the Kemerdere valley), where it crossed the narrow river gorge on a tall masonry bridge. The aqueduct then proceeded west along the northern slopes of the Kemerdere valley. At the village of Çivler it turned to the northwest and meandered through hill country above the northeast bank of the Scamander. There it crossed a tributary of the Scamander, the Polisin Dere, and made its way down to the village of Gökçali, below Kara Tepe. Gökçali stands near the head of a narrow limestone plateau that separates the drainage basins of the Dümrek (the ancient Simois) and Scamander. This plateau slopes down from east to west, and Ilion was located on its western tip, elevated above the Trojan Plain with a panoramic view of the coast from Tenedos to the Dardanelles.

Discussion of the course of the aqueduct will be divided into the following segments: source; the aqueduct southeast of the Kemerdere valley; the large bridge over the Kemer river; the aqueduct northeast of the Kemerdere valley; terminus. These segments are then followed by discussion of the aqueduct's gradient and some historical conclusions.

Fig. 2 Illustration of the northwest face of the bridge by Fox-Strangways. After Barker Webb 1822. View to south.

Source

The location of the water source for the aqueduct remains unknown, although most of the evidence points to a source somewhere between Çamlıca, Hayrettin Tepe, and Salihler (Figure 1). Akarca put the source at Suçıktı, but acknowledged possible additional sources at Tanripinar, Çakır Büyet, and Çamurca.[14] Cook reported that villagers provided conflicting information for the water source – some put it at Hayrettin Tepe, others at Çamlıca or Çakır Büyet, and still others at Tanrıpınar, a spring to the south of Salihler.[15] Judeich found a section of wall near Çamlıca and identified it as part of a Roman aqueduct.[16] A source further east, closer to Hayrettin Tepe, is suggested by the natural springs in that area, especially at the head of the drainage basin of the Ilıca Dere, which opens to the south toward the middle Scamander. On the basis of this area's reddish soil and the testimony of Pausanias (10.12.3–4), Cook identified the site of Dam Kale as ancient Marpessos, and the Ilıca Dere as the Aidoneus, which was said to have bubbled up from underground in the manner of the spring at the head of the valley.[17]

The source probably lay somewhere on the mountainous plateau between Hayrettin Tepe, Çamlıca, and Tanrıpınar, and at about 440 masl. A source further to the east is unlikely because the terrain there descends either into the valley of the Ilıca Dere to the southeast or into the Kemerdere and Dümrek valleys to the north and northeast, respectively. The aqueduct may have had a single source of water, but this would not have been a requirement, and the evidence for multiple sources in this area shows that water could have been collected from a number of locations. At some point, sources would have been combined into a water system along a common path, but this would not have been necessary until the aqueduct reached the first known bridge along its course,

Fig. 3 Photograph of the southwest face of the bridge in Wilhelm Dörpfeld's photo archive (Dörpfeld Photo Archive, German Archaeological Institute, Athens, No. 171).

about four km northwest of Çamlica, in a gulch called the Suçıktı Deresi (Figure 4).[18]

The Course of the Aqueduct Southeast of the Kemerdere Valley

The first signs of the actual path of the aqueduct exist high on the southeast side of the Kemerdere valley. Here the engineers built small masonry bridges to carry the aqueduct over gulches that carry seasonal runoff into the Kemer river. Bridges have been discovered in three of these gulches – the Suçıktı Deresi, the İncirlidere, and the Yörükyurdu Deresi – and it is possible that others await identification closer to the water source (Figure 4). These bridges had single-ribbed arches, with travertine voussoirs supporting haunches of flat unworked stones bonded with thick mortar joints. Bridges on the Suçıktı Deresi and the Yörükyurdu Deresi only required a single arch to span the narrow gulches, but the bridge across the İncirlidere, now almost completely destroyed, had up to four successive arches in order to span the somewhat wider ravine. There are no signs of a masonry conduit on or around any of these bridges, and it appears as if they had been built to carry pipelines.[19]

The bridges are all about 1.80 m wide. The arch of the bridge on the Suçikti Deresi has a 3 m span, and the top of the keystone stands about 3.50 m above the bed of the gulch (Figures 5, 6). The original length of the bridge was probably about 5 m. The voussoirs are roughly worked, and the arch springs from outcroppings of bedrock. A thick mass of calcium carbonate is adhered to the intrados, and this was apparently caused by leaks in the pipeline.[20] The original length of the bridge

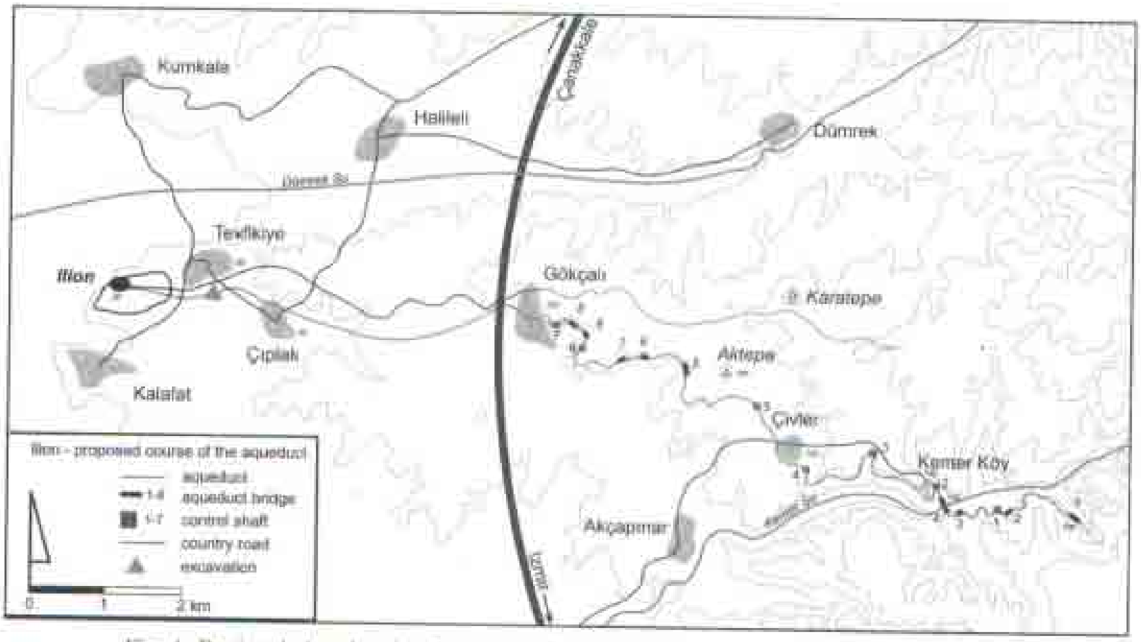

Fig. 4 Regional plan showing the proposed course of the aqueduct. Map by Gebhard Bieg.

Fig. 5 Small bridge on the Suçıktı Deresi. View to southwest. Dia Troia 45968.

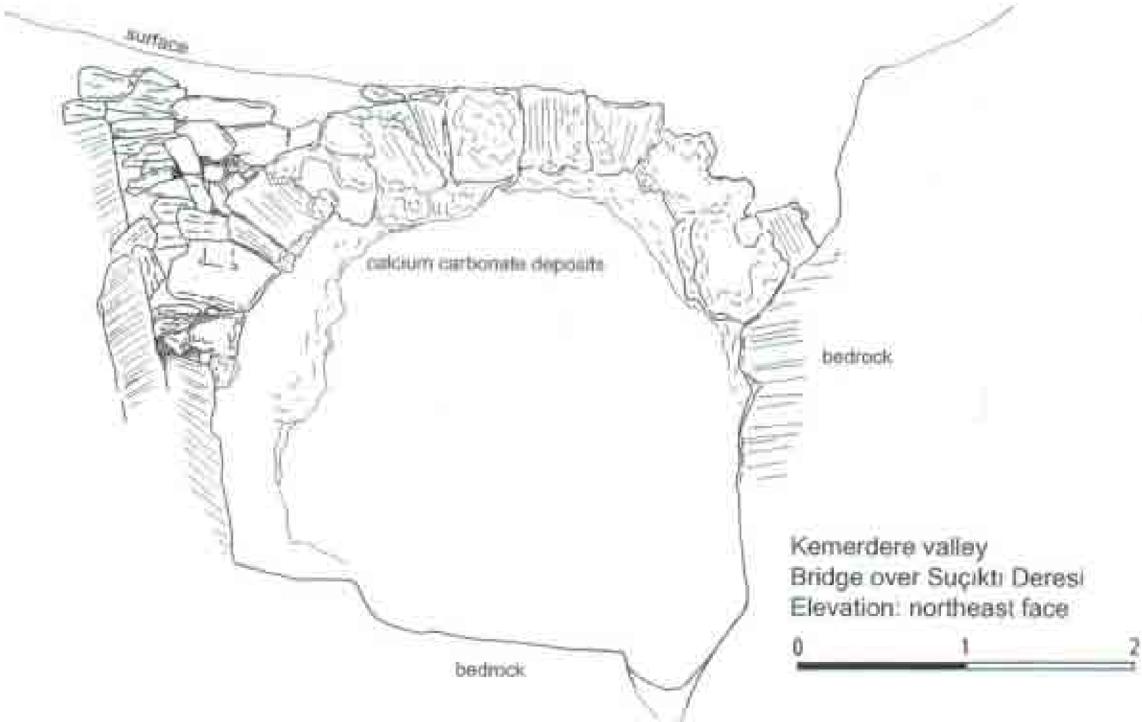

Fig. 6 Elevation of the small bridge on the Suçıktı Deresi, northeast face. Illustration by Rüstem Aslan and Sinan Kılıç.

on the İncirlidere was about 15 m and it was built in the same materials and technique as the other bridges (Figures 7, 8). The central part of the bridge has completely washed away. The arch on the northeast bank, which is now almost completely buried, has a crude brick liner applied to the intrados, perhaps intended to strengthen the bridge against what was apparently once a formidable tributary of the Kemer river. The bridge on the Yörükyurdu Deresi has neater voussoirs, and the keystone is 0.57 m high and 0.27 m wide at the extrados (Figures 9, 10). The bridge is about 7 m long and 3 m tall, and the span of the arch measures 2.90 m. Heavy calcium carbonate deposits are visible on the intrados and on almost the entire northwest face of the bridge, probably also the result of a leaky pipeline.

The only evidence for the actual water conduit are segments of parallel terracotta pipelines, broken and exposed on the side of the road that runs along the southeast side of the Kemerdere valley (Figures 11, 12). The pipes lie about 0.10 m apart, one slightly lower than the other. Both pipelines have an interior diameter of 0.16–0.18 m and walls between .02 and 0.03 m thick. Sinter deposits on the interior are found mainly on the bottom and sides, and this suggests an open system of gravity flow in these segments of the aqueduct.[21] Broken sections of the parallel pipelines have been found in two locations – near the cutting for a modern gas-line between the Suçıktı Deresi and the Incirlidere, and about 120 m east of the Yörükyurdu Deresi. In both locations the pipes were *in situ*, founded on bedrock and buried up to a meter in fill. Cuffs were oriented to the east and flanges to the west, and the pipelines had a gentle slope down to the west.

The pipelines near the Yörükyurdu Deresi were at an elevation up to 20 m above the Yörükyurdu Deresi and the large bridge across the Kemerdere valley. If the water in these pipes was ever carried across these bridges, then it would have had to have been brought down to the level of the bridges in rather dramatic measure, in which case a cascade or a circuitous course of

Fig. 7 Small bridge on the İncirlidere. View to southeast. Dia Troia 45973.

piping may have been employed to reduce the gradient.[22] The double pipeline could indicate multiple sources of water or a single source with discharge in excess of a single pipeline's capacity.[23] What is clear is that the engineers designed the system to collect water in pipes on the southeast side of the Kemerdere valley and direct it to a single crossing point. Pipes would have allowed the engineers the greatest flexibility in laying the water lines across the uneven terrain.[24] The substantial loss of height between the source and the Kemerdere valley would have guaranteed flow and drastically reduced any need for cleaning. Rather than maintaining a gradient, the chief concern of the engineers for this segment of the aqueduct was probably containing and/or relieving hydrostatic pressure.[25] It is conceivable that header tanks were installed at regular intervals for

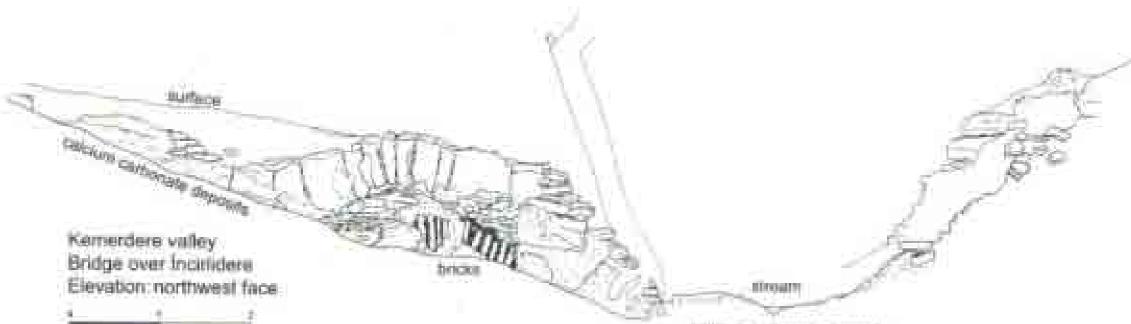

Fig. 8 Elevation of the small bridge on the İncirlidere, northwest face. Illustration by Rüstem Aslan and Sinan Kılıç.

Fig. 9 Small bridge on the Yörükyurdu Deresi. View to southeast. Dia Troia 45971.

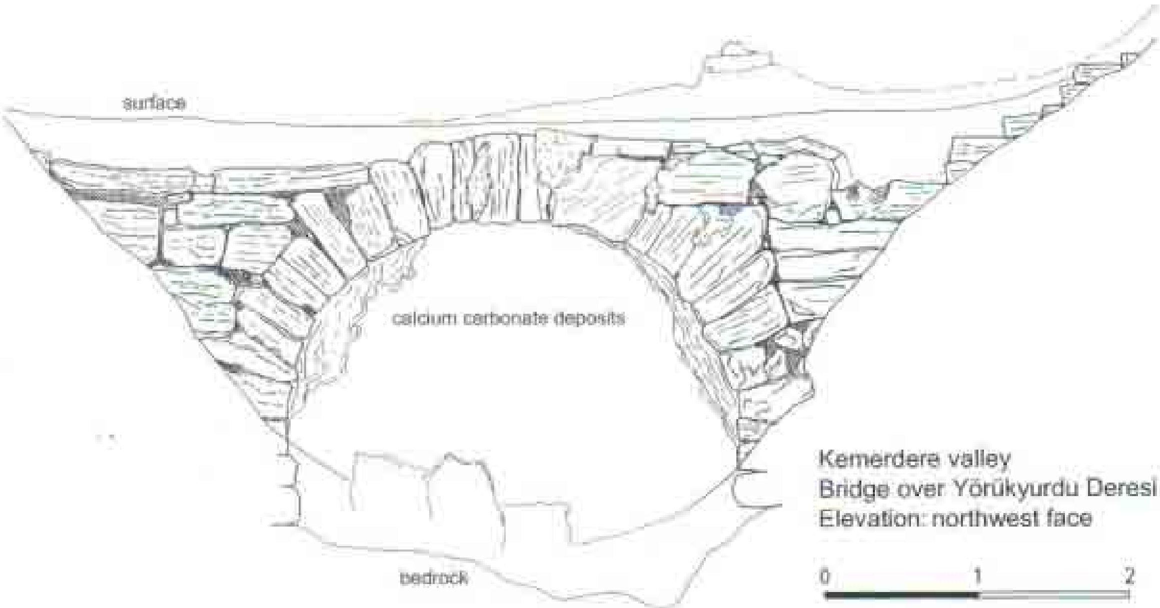

Fig. 10 Elevation of the small bridge on the Yörükyurdu Deresi, northwest face. Illustration by Rüstem Aslan and Sinan Kılıç.

Fig. 11 Terracotta pipelines on the southeast side of the Kemerdere valley near the Yörükyurdu Deresi. Dia Troia 45958.

Fig. 12 Detail of the side-by-side terracotta pipelines. Dia Troia 45964.

Fig. 13 The large bridge across the Kemerdere valley. View to the southeast. Dia Troia 28091.

this purpose, although none have been found.[26] The small bridges across the gulches and ravines would have also reduced hydrostatic pressure by elevating the pipelines and reducing the head (the distance of a closed pipeline below the water's natural surface level). Still, measures taken by the engineers to reduce hydrostatic pressure were apparently not enough to prevent leaking where the pipelines crossed the bridges.

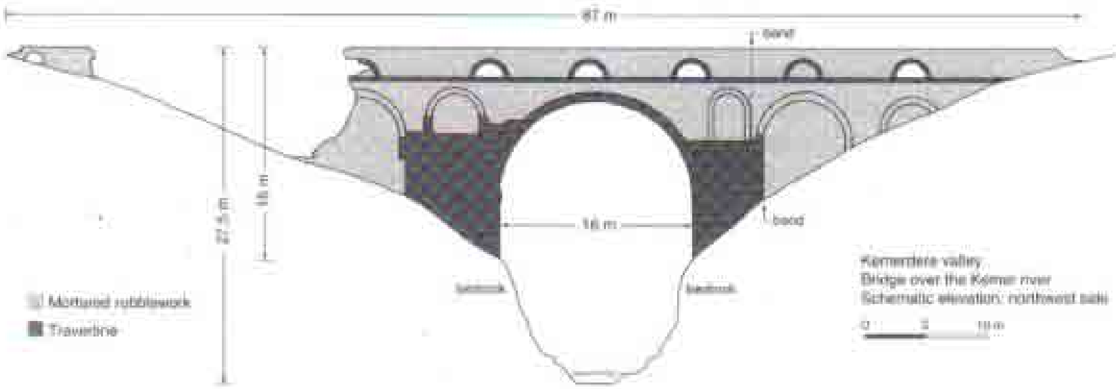

Fig. 14 Schematic elevation of the bridge showing principal dimensions and materials. After Akarca 1978, fig. 12. Illustration by William Aylward.

The Bridge across the Kemerdere Valley

The most impressive section of the aqueduct crosses the tall two-tier bridge that spans the Kemerdere valley just below the village of Kemer Köy ("arch-town"), about 11 km east of Ilion (Figures 1, 13–17). In size, the Kemerdere bridge ranks among the larger aqueduct bridges of the Roman world (Figure 14).[27] The abutments are 1.40 m thick, and the bridge widens to about 1.60 m at both ends.[28] The maximum span of the principal arch is about 16 m.[29] A twenty-meter segment of the bridge on the northwest bank has collapsed to the northeast. The total preserved length of the bridge is about 87 m. From the base of the abutments to the preserved top of the water channel the bridge measures about 16 m, and the top of the structure lies about 27.50 m above the riverbed.[30]The length of the Kemerdere bridge is unremarkable compared to aqueduct bridges in the Roman world, such as those at Nîmes and Cherchel, Algeria.[31] The structure of the Kemerdere bridge is far shorter than the height of the Pont de l'Oued Bellah at Cherchel and the aqueduct bridge at Tarragona (each 26 m) not to mention the Pont de l'Oued Ilelouine at Cherchel (35.38 m) and the Pont du Gard (over 40 m).[32] In terms of the elevation at which the water channel crosses the valley, however, the Kemerdere bridge is noteworthy, and seems to rank only behind the aqueduct bridge at Pondel near Aosta (over 60 m), the Pont du Gard (48.77 m), the Pont de l'Oued Ilelouine at Cherchel (35.38 m).[33] The bridge also ranks high in the category of maximum span of the principal arch. The 16 m span of the arch on the Kemerdere bridge is smaller than the spans of the arches in the two lower tiers of the Pont du Gard (24.52 m and 19.2 m) and the span of the Trajanic bridge at Antioch on-the-Orontes (22 m), but wider than the span of the Ponte San Pietro on the Aqua Marcia at Rome (15.5 m).[34]

The design and construction of the bridge shows careful attention to engineering and economy of materials.[35] It was built precisely where a narrow basaltic lava formation appears prominently in the landscape, oriented across the Kemerdere valley from northeast to southwest.[36] The engineers chose this site for good reasons. The basaltic lava formation's density and resistance to river erosion had made this the narrowest point in the Kemerdere valley, and outcroppings of the formation were conveniently located on opposite banks of the river. The engineers placed the abutments for the bridge, measuring 1.40 m thick, inside notches cut into these outcroppings, well out of reach of flood waters.[37] The basaltic formation also seems to have provided building material for the small-stone facing in the superstructure of the bridge.[38] All of these factors suggest that the construction site was chosen by engineers who were familiar with the complexity of building aqueduct bridges in remote locations.

The abutments are made of dry-laid ashlars of a dense, shelly travertine, and they both rise past the impost and into the lower part of the spandrel (Figures 15, 16).[39] The masonry is not isodomic, and courses show considerable variation in height, with the occasional instance of tall blocks used alongside stacked short blocks. Despite this variation, the engineers brought the abutments up to uniform height at the level of the impost course. Larger blocks – some over 0.50 m high and 1.50 m long – were used for the lower courses, where there is occasional cross-bonding through the thickness of the abutments. Edges on some of the larger blocks were beveled for easier laying, and some of the corner blocks have drafted margins. There are some signs of putlog holes, projecting bosses, and cuttings for scaffolding on the abutments, but not enough to reconstruct the falsework and centering that must have been used for construction and maintenance.

The northeast abutment is about 2 m wider than the abutment on the southwest bank. To determine the width for each abutment the engineers may have used the point at which the impost course in each abutment intersected the river bank (Figure 14). The southwest side of the gorge is steeper, and this made for an abutment only about 6 m wide, whereas the northeast abutment, on a somewhat gentler slope, is about 8 m wide. The engineers appear to have designed a narrower abutment for the bank with the steeper slope, where resistance to the weight of the bridge would have been diametrically opposed to the

Fig. 15 Detail of the northwest abutment, northeast face.

Fig. 16 Detail of the southeast abutment, southwest face, and bend in the bridge. View to southeast. Dia Troia 42480.

thrust of the arch. Conversely, the wider abutment on the gentler slope may have been designed to compensate for the weaker resistance of the slope to the thrust of the arch.

The cost of quarrying and transporting the travertine into the remote Kemerdere valley may have been prohibitive, and the engineers appear to have economized on non-local materials where the design allowed. For tall masonry structures Roman engineers often designed abutments thicker than the superstructure in order to increase lateral stability, but on the Kemerdere bridge the abutments are the same thickness as the superstructure (1.40 m).[40] In addition to its use in the abutments, the dense travertine is only used in the voussoirs of the bridge's principal arch, as well as in a few voussoirs of the relieving arches and the projecting string course between the bridge's upper and lower tier (Figure 14).

The single masonry arch that spans the river is the same thickness as the abutments. This is a true arch with a single rib of travertine voussoirs, and it has the appearance of a full 180° arc. There are twenty five voussoirs of varying width on each side of the keystone, and they were joined without mortar. Most are wedge-shaped, and some have drafted margins. Neither the intrados nor the extrados was trimmed to an even finish. The masons paid greater attention to the profile of the extrados on the lower haunches of the arch, except on the northeast face of the southeast abutment, where they keyed the extrados into the masonry of the abutment.[41] The relief bust on the keystone is discussed below.

With few exceptions the engineers used mortared rubblework behind the abutments and in the superstructure. Most of the rubble facing is composed of flat unworked stones laid in fairly

Fig. 17 The southwest face of the bridge. View to the north. Dia Troia 45982.

regular courses, and it was probably quarried from the basaltic lava formation near the bridge. The core is composed of thick beds of lime mortar with a heavy aggregate of unworked rubble, like that used for the facing a few sections of terracotta pipe, and a small amount of tile. There is moderate correspondence between the courses of aggregate in the core and the courses of the facing.[42]

In the lower tier of the bridge, the engineers laid the mortared rubblework in sections around relieving arches, three behind the southeast abutment, and at least three behind the northwest abutment (Figures 14, 17). Large relieving arches spring from the edge of the travertine abutments, and these are each flanked by smaller relieving arches on top of the abutments and higher up the slopes of the valley. The crowns of all these relieving arches more or less correspond in height to the crown of the principal arch across the river. The relieving arches are made from voussoirs arranged in overlapping ribs, each about four blocks deep, and they are built through the full thickness of the bridge. The voussoirs of the relieving arches were made of the same material as the mortared rubblework facing, with flat unworked stones arranged in a radial pattern between mortar joints. A small number of voussoirs in these arches, especially on the northwest end of the bridge, were made of wedge-shaped travertine blocks, perhaps from material left-over from the construction of the abutments.[43]

The double tier design of the bridge allowed the engineers to attain the desired height for the water channel and fortify the bridge against buckling and tilting brought on by earthquakes and high winds, both known in the Troad.[44] A projecting string course of limestone blocks separates the lower and upper tier. The upper tier is the same thickness as the lower one, and it was made of the same mortared rubblework. A six-meter section of it is preserved on the northwest bank, now isolated from the rest of the bridge by the collapse. Seven small arches are preserved in this tier. If these had been spaced evenly across the bridge in the original design, then at least eight can be restored. Five of these are now open arches, originally built with travertine voussoirs in double or triple-ribbed arches. Now most of the voussoirs have fallen away, leaving only the impression of the extrados in the remaining mortared rubblework. These open arches would have lightened the load of the upper tier on the arch below, and they would have also alleviated wind pressure against the bridge. The arches in the upper tier that were placed above the largest of the relieving arches in the lower tier are closed, and it is difficult to determine if these were filled during construction as centring or at a later point as repairs.[45]

The engineers also built an obtuse bend into the bridge on its southeast side, through the full height of both tiers and the open water channel (Figure 18). The bridge begins to cross the valley in a northwesterly direction, and then, about 25 m into the valley, at the very southeast end of the southeast abutment, the bridge turns between 10° and 20° to the west.[46] The bend would have had benefits for the stability of the bridge and the flow of water across the elevated conduit. The engineers may have used the bend to keep the bridge founded on top of the hard basaltic formation in the bedrock, or to add to the longitudinal stability of the ca. 85 m-long bridge by inhibiting lateral oscillation from wind pressures against the tall and narrow masonry structure.[47] A bend was not included at the opposite end of the bridge, where a twenty-meter section of continuous mortared rubblework has collapsed.

There is no evidence for the transition of the aqueduct between the open channel on the bridge and the water conduits on either side. The segment of the aqueduct between the source and the Kemerdere bridge had the steepest average slope on the entire water system (about 2%), and the engineers may have designed the bend in the bridge to retard the velocity of water as it entered the open water channel. The channel walls were built of mortared rubblework to a thickness of about 0.40–0.45 m, and they are preserved to a height of about 0.60–0.65 m.[48] The surviving fifty-meter segment of the open water channel narrows from 0.67 m to 0.58 m, and if it had continued to nar-

Fig 18 The open water channel on the deck of the bridge. View to south. Dia Troia 42463.

Fig. 19 Terracotta pipes on the southeast bank of the Kemerdere valley, about 2 m to the southwest of the bridge, at the level of the string course between the upper and lower tiers. Dia Troia 45986.

Fig. 20 Detail of the decorated keystone. Dia Troia 45983.

row at this rate, it would have been only 0.52 m wide by the time it reached the end of the bridge. In addition to the estimated .08% slope across the bridge (see below), the bend and the narrowing would have worked in concert to encourage uniformity of flow between water conduits on either end of the bridge – the bend would have inhibited velocity at the beginning of the bridge and the narrowing would have increased velocity at the end of it.[49]

The channel was uncovered. It did not appear to have a deposit of calcium carbonate, but it was wide enough to accommodate side-by-side terracotta pipelines. Two sections of terracotta pipeline were discovered on the southeast bank of the river, immediately below the southwest face of the bridge, not *in situ*, and apparently where they had tumbled out of the channel (Figure 19). One of the pipes preserves a uniform sinter deposit around the interior, and this is consitent with calcium carbonate deposits on the small bridges as evidence for greater hydrostatic pressure in the pipes where they crossed bridges on the water system.

The Decorated Keystone

The southwest face of the keystone was decorated with a carved bust in relief (Figure 20). An accurate identification of the bust is undermined by its poor state of preservation, but clues can be gleaned from early eyewitness accounts of the bridge, the location of the bridge, and the iconography of comparable keystones. Even in the absence of a precise identification, a brief synthesis of the evidence brings the significance of the bridge into sharper focus.

We know of only four published comments on the bust. Barker Webb, the first to mention it, suggested that it was a portrait of a Roman emperor.[50] Dörpfeld also called it a Roman emperor, adding that it was perhaps a member of the Julian family who led the water supply into Ilion.[51] Cook also called it Julio-Claudian, and Akarca concurred.[52]

The top half of the head has now eroded away, but it appears to have been about twice life-size. A close look at Dörpfeld's photo of the bridge shows that in his day the shape of the head was still recognizable, but most if not all detail had worn away. Barker Webb saw the bridge almost a century before Dörpfeld and was able to say that the figure appeared to have a laurel crown.[53] The only other visible features of the bust are a clean-shaven face and the clear delineation of the chin and neck.[54]

Ironically, the identification of the bust as a portrait of a Roman emperor can be ruled out on the basis of Barker Webb's own testimony to the laurel crown. On Roman public monuments laurel crowns appear in ritual context, such as triumph or *supplicatio*,[55] or in group portraits in a context of dynastic commemoration,[56] but they rarely appear as fixed ornamentation on individual imperial portraits.[57] Furthermore, a commemorative portrait of a Roman emperor on the Kemerdere bridge would have been out of place among references to emperors on aqueducts and bridges, for which inscriptions were the favored medium.[58] Finally, rather than commemorate benefactors, decorated keystones normally displayed themes related to the function or physical setting of the monument they adorned. For example, Medusa protomes were used as apotropaics on the keystones of the Mausoleum of the Julii at Glanum, and on the keystone (overlapping the architrave) of the arch of Augustus at Rimini.[59] Pendant images of Hermes and Hercules, standard for an athletic context, adorned the keystones of arches in the cavea of the stadium at Aphrodisias, and at Tymbriada in Pisidia, a bearded personification of the Eurymedon river was carved on the keystone of a foot bridge near the god's sanctuary.[60]

Rather than a Roman emperor, the above points of iconography, context, and function point to a personification or deity for the bust on the Kemerdere bridge. The Kemer river was known to the Ilians as the Thymbrius, and the example of the epiphany of the Eurymedon on the bridge at Tymbriada suggests that the Kemerdere bridge might have been adorned with a personification of

Fig. 21 The water channel in Tevfikiye. Neg. Troia 98/21-2.

the Thymbrius river.[61] Unfortunately, this identification for the Kemerdere bust is undermined by the absence of a long wavy beard, which was part of the standard iconography for anthropomorphic representations of river gods in Greek and Roman art.[62] Moreover, Barker Webb's description of the Kemerdere bust as laureled is at odds with the standard headgear of river gods: lotus, reeds, wheat, fruit, horns and/or ears of a bull, diadem.[63] Had Thymbrius been the intended representation, the sculptor certainly would have added a beard as the most clearly perceptible iconographic marker for a river god. The position of the bust, suspended high above the Kemerdere valley, would have augmented the need for clarity.

It is conceivable that the bust depicted Apollo. The laurel crown and clean-shaven face are consistent with the god's iconography in Greek and Roman art,[64] and the aqueduct bridge was located in the domain of Apollo Thymbraeus, whose epithet was derived from the ancient toponyms Thymbra and Thymbrius.[65] A portrait of Apollo Thymbraeus on the Kemerdere bridge would have made sense to Ilians because of the god's special importance in Trojan legend.[66] Thymbraean Apollo helped to build the walls of Troia, and he was a patron of Trojan youth. Helenus and Cassandra received the gift of prophecy at Apollo's sanctuary, and Troilus was ambushed and murdered by Achilles while training his horses there. A bust of Apollo Thymbraeus on the aqueduct bridge would have also been an appropriate apotropaic for the protection of Ilion's water supply.[67]

The Course of the Aqueduct Northwest of the Kemerdere Valley

This segment of the aqueduct is not as well known, but five additional masonry bridges have been found between the villages of Çivler and Gökçalı. These show that the aqueduct crossed the small valley of the Polisin Dere and contoured around Aktepe before moving toward the village Gökçalı, which is at the head of a narrow limestone plateau that separates the drainage basins of the Simois (Dümrek) and Scamander (Figures 1, 4).[68] The bridges here are similar in size, materials, and construction to those described above, and they also appear to have carried terracotta pipelines. This is supported by the discovery of fragments of terracotta pipes with sinter deposits on the northwest slope of the Kemerdere valley, which suggest that, once across the bridge, water was also carried in pipes.[69]

The aqueduct then followed the slope of the plateau down to the west, through the village of Tevfikiye and into Ilion. At some point the aqueduct was converted from a system of terracotta pipelines into an underground channel with a masonry cover, part of which was discovered during construction for a schoolhouse in the village of Tevfikiye in 1998 (Figures 21, 22).[70] The exact location of the conversion is unknown, but the engineers may have decided to put it somewhere near Gökçalı, where the transition from hills to plateau may have called for new type of conduit.[71]

This section of the conduit had been built about one meter below the ancient surface, and a trickle of cool water continued to seep from the sediment that filled the *specus* to a height of 1.30 m.[72] The conduit measured 1.92 m from the intrados of the vaulted cover to the channel floor. The engineers dug a trench approximately 1 m wide, and then into the floor of this trench, they dug another trench about 1.5 m deep. The water was carried in the lower trench, which, at least at this point on the aqueduct, did not have masonry walls and was only coated with thin and patchy hydraulic mortar, pink and brown in color and on average 0.01 m thick. The mortar is in a better state of preservation on the south wall, where it was applied as high as the top of the channel. It is possible that the coating of hydraulic mortar deteriorated because of the rather high water velocity presumed for this segment of the aqueduct, which had an average gradient of 12 m per km.[73] There is no significant accumulation of sinter. The lower channel was 1.45 m high, 0.60 m wide just below the vaulted cover, and 0.45–0.50 m wide at the base.[74] The vaulted cover rested on the shelf above the lower channel, and it had roughly shaped voussoirs secured in a radial pattern by a generous application of lime mortar with a coarse sand and pebble aggregate. The absence of masonry walls for the channel is unusual. The engineers would have cut costs by only partially lining an earthen trench with hydraulic mortar, but a conduit of this type would have been prone to leaking, and friction along the uneven and unfinished floor and walls would have reduced overall efficiency.[75]

The lower trench had been cut though several layers of natural fill, and in 1998 ground water was visibly percolating out of a thick saturated layer of sandy sediment, especially where buoyancy was inhibited by a dense layer of brown impermeable clay above (Figure 22). If the ancient builders noticed this apparently karstic phenomenon during aqueduct construction, they do not seem to have tried to tap the ground water or divert it into the conduit.[76]

Terminus

At some point the aqueduct would have entered the city walls. Ilion was fortified with a limestone fortification wall in the third quarter of the third century B.C., but the eastern stretch of this wall is almost completely destroyed, and there is no sign of a *castellum* in this area.[77] Dörpfeld's reconstruction of the fortifications includes a round structure five meters in diameter at the eastern city wall.[78] It is located on a rise in the topography, about 10 m higher than the city's agora and 15 m higher than much of the Lower City on the plateau to the south of the akropolis. This location would have been ideal for a terminal *castellum*.[79] Dörpfeld's reconstruction also shows a wall running from the round structure into the city toward the akropolis and in the general direction of the Lower City bath discovered in 1932.[80] It is conceivable that this was a *substructio* or some other component of Ilion's water distribution system.[81]

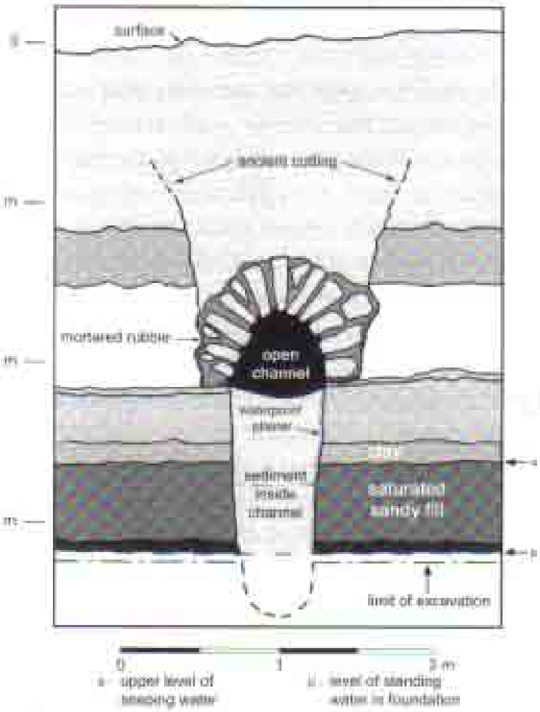

Fig. 22 Cross section of the water channel in Tevfikiye. Illustration by William Aylward.

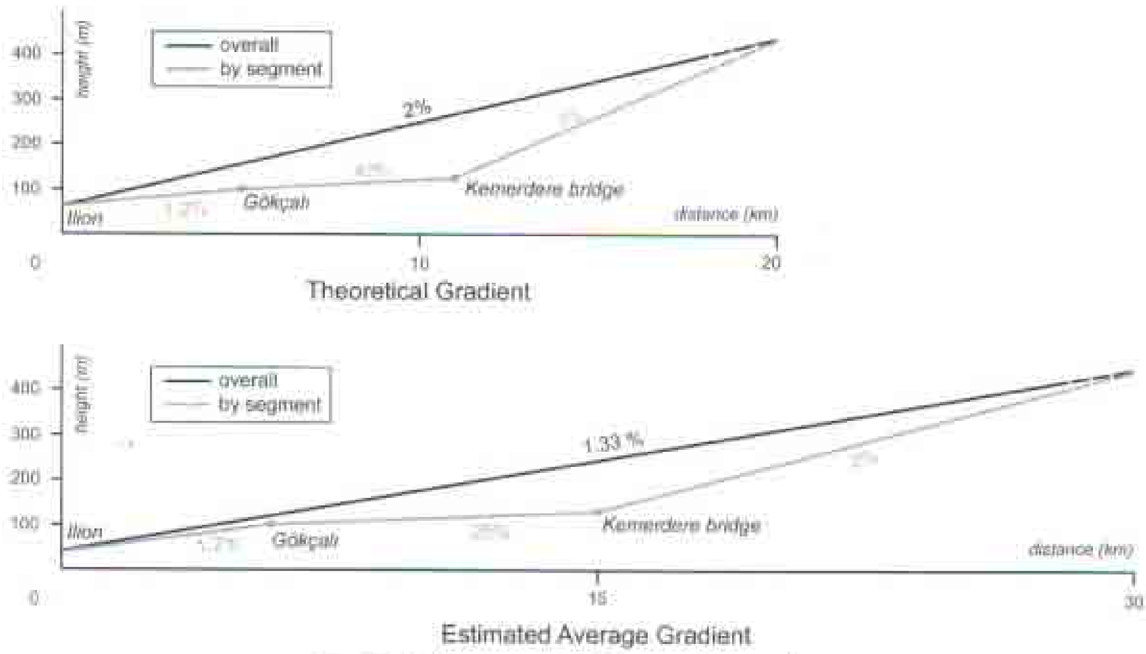

Fig. 23 Schematic graph of the aqueduct gradient.

Gradient

While the course of the aqueduct proposed here is somewhat speculative and limited by the aqueduct's often poor state of preservation, the evidence at hand does allow for an estimate of theoretical and average gradients, both overall and by segment (Figure 23).[82] A source on the mountainous plateau near Hayrettin Tepe would have been roughly 9 to 10 km southeast of the large bridge across the Kemerdere valley. The direct distance from the same bridge to Ilion is about 11 km.[83] The total direct distance from source to terminus was therefore at least 20–21 km. The nine known bridges that carried the aqueduct are all more or less aligned between the area of the presumed source near Hayrettin Tepe and Ilion, and no major detours are perceptible in the course of the aqueduct. The orientation of the bridges, however, shows that the actual course of the aqueduct followed a meandering path across terrain with sinuous contours. The actual length of the aqueduct must have been substantially longer given the twists and turns required to maintain an adequate gradient across the uneven terrain.[84] A safe estimate for the total length of the aqueduct is probably 25–30 km.[85]

On the mountain plateau to the southeast of the Kemerdere valley, Hayrettin Tepe, Çamlıca, and Tanrıpınar have an elevation of 452, 404, and 465 masl, respectively, and an average elevation of 440 masl.[86] From this elevation the conduit would have had a total loss in height of 400 m before it reached Ilion's city wall (40 masl). On the basis of 20 km for the minimum direct distance between source and terminus, one can calculate a theoretical gradient of 20 m per km (2.0%) for the aqueduct. An actual conduit length of 25 km would have had an average slope of 16 m per km (1.6%), and a conduit 30 km in length would have had an average slope of 13.3 m per km (1.33%).[87] A loss in height between 13.3 and 16 m to the km would have exceeded the usual gradient for Roman aqueducts, but it would have been comparable to the overall slope of the Aqua Julia and the aqueduct at Segovia.[88]

The real gradient would not have been uniform, and the terrain suggests that rather substantial changes in slope probably occurred over the entire length of the conduit. The descent from the area of the presumed source near Hayrettin Tepe to the bridge across the Kemerdere valley would have had the steepest gradient.[89] The loss of height in this interval probably amounted to at least 300 m over a direct distance of about 10 km, and this works out to just over 30 m per km, or a hypothetical gradient of about 3%. A real distance of 15 km would have made for an average slope of 2% between the source and the bridge.

The slope on the bridge across the Kemerdere valley was gentler. The floor of the bridge's upper tier is only preserved to a length of 50 m. A 0.40 m drop in elevation along the direction of water flow was recorded by Rüstem Aslan in 1995, and this means a loss in height of 8 m per km, or a .08% slope. This is steeper than the gradient on most aqueduct bridges, but only slightly steeper than the gradient on the Ponte S. Gregorio on the Anio Vetus at Rome.[90]

The section of the aqueduct between the Kemerdere bridge and Gökçalı had the gentlest gradient. The direct distance between the bridge and Gökçalı is about 6 km, but this was exceptionally hilly terrain, and the aqueduct's detours to cross the Polisin Dere and meander around Aktepe suggest that the real length of this segment was probably about 10 km. The bridge is only about 25 m higher than Gökçalı, so the real gradient for this segment of the aqueduct works out to a loss of height of about 2.5 m per km, or a .25% average slope.

The final leg of the aqueduct from Gökçalı to Ilion measures 5 km as the crow flies, and in this case the conduit would have had little reason to diverge from a course more or less due west along the narrow spur of land that separated the Scamander from the Simois. The eastern fortification wall of Ilion was about 60 m lower than Gökçalı, and this means that this segment of the aqueduct had a loss in height of about 12 m per km, or a 1.2% average slope.

The bridge across the Kemerdere valley appears to have punctuated the transition from the steep drop out of the mountains to the more moderate descent toward Ilion. A conduit with two very different profiles was common for aqueducts that carried water down from mountains and then across plains.[91] The aqueduct's estimated average slope across the proposed 10–15 km of conduit between the source and the bridge across the Kemerdere valley is between 2% and 3%. Once the aqueduct landed on the northwest side of the Kemerdere valley its gradient appears to have flattened to an average slope of about .56% (= a loss of height of 5.6 m per km) over the estimated 15 km of real conduit distance between the bridge and Ilion.

In this model, the shallowest possible gradient for any section of the conduit is steep in relation to known gradients of Roman aqueducts. The engineers of such a precipitous conduit would have almost certainly included settling basins, drop shafts, or cascades to dampen velocity, and tanks to relieve static pressure, especially along the piped section of the aqueduct between the source and the Kemerdere bridge, but evidence for any of these devices has yet to turn up.[92] Several stones and artificial stone formations in the vicinity of the bridges may have been used as control points for laying out the gradient (Figure 4).

Estimation of the daily output of the aqueduct is not feasible.[93] The aqueduct was composed of terracotta pipelines and gravity-flow channels at various locations along its course, and the transition between these is not completely understood. In addition, accurate figures for a wetted area and wetted perimeter of the conduit are difficult to estimate on the basis of a extremely short section of conduit with irregular construction and patchy hydraulic mortar. Finally, flow along the aqueduct must have been subjected to a fair amount of variation due to seasonal change and presumed methods of design for retarding velocity and countering hydrostatic pressure across the unusually steep average gradient.

Historical Conclusions

Ilion's arterial water supply was a supplement to local springs, ground water wells, and rainwater cisterns, which appear to have been important for the city in both the Greek and Roman periods.[94] At some point the local water supply was augmented with an aqueduct. The construction and design of the Kemerdere bridge suggest that this happened in the early imperial period, and evidence from the city of Ilion and comparable aqueducts allow for a provisional date as early as the Julio-Claudian era for the introduction of the water supply to Ilion.[95]

The combination of mortared rubble and dry-laid ashlar masonry in the Kemerdere bridge is consistent with Roman architectural practice in the East in the Julio-Claudian period.[96] The Kemerdere bridge is also similar in appearance and materials to other aqueduct bridges of Julio-Claudian date, such as the Augustan-period bridge of C. Sextilius Pollio at Ephesus (4–14 A.D.), which has piers in ashlar masonry supporting mortared rubble, as well as the Caligulan bridge at Antioch on-the-Orontes and the Augustan bridge at Tarragona, Spain, both of which had an open water channel.[97] Conversely, the bridge is remarkably different from the Stroggylo bridge on the Hadrianic aqueduct at Corinth, which had piers of *opus caementicium* with ashlar facing including spolia, and alternating bands of brick and rubble facing in the upper level.[98]

Clues for dating the aqueduct can also be gleaned from the earliest buildings at Ilion which would not have made sense for the city without an arterial water supply. These include a bath in the lower city and a bath and nymphaeum in the agora. The lower city bath is of no help as it was only partially excavated in 1932 and the results only mentioned by C.W. Blegen.[99] Construction deposits from the nymphaeum belong to the Antonine period. From the agora baths, *opus reticulatum* facing, *tegulae mammatae* from the heating system, and mosaic pavements combining tesserae and pebbles all point to a date near the end of the first century B.C. or beginning of the first century A.D., and the facing and tiles are particularly suggestive of late-Republican and early-Imperial building methods of Roman Italy.[100] In general it is not unreasonable to associate the construction of a bath with the establishment of an arterial water supply. Baths have a functional relationship with aqueducts in Roman architecture and urban planning, and the construction or renovation of an aqueduct in a Roman city was, in most cases, linked to the construction or renovation of a public bath.[101]

Aqueducts at Ephesus and Antioch on-the-Orontes show that cities in the Roman East were embellished with aqueducts as early as the Julio-Claudian period. Urban renewal at Ilion at this time is consistent with the city's special connection to the Julio-Claudian family on the basis of the Aeneas legend.[102] Augustus visited in 20 B.C. and Julio-Claudians can now be linked to construction on the akropolis, and in the large theater (Theater A), the lower city, and the west sanctuary at Ilion.[103]

Despite the evidence for a Julio-Claudian date, there is nothing about the aqueduct or its bridges that would preclude construction at a later period. Moreover, many large cities in the East managed without aqueducts until the time of Trajan and Hadrian, who both enriched cities with external water supplies.[104] Of special interest is Alexandria Troas, where citizens had neither aqueduct nor proper baths until the benefaction of Herodes Atticus in 135 A.D.[105] A date for Ilion's aqueduct prior to this is consistent with the relative importance of each city, both regionally and in the eyes of Rome.[106]

Bridges were sometimes added to aqueducts in order to shorten the route, but there is no reason to believe that the Kemerdere bridge did not belong to the original period of aqueduct construction. There is no sign of an abandoned loop around the valley, and the moderate slope of the bridge indicates that the engineers planned for it in the original design, as did the engineers of the Eifel aqueduct at Köln.[107] The smaller bridges can be understood as contemporary with the large bridge on the basis of similarities in materials and technique. The brick liner used to repair the bridge on the İncirlidere, in combination with the absence of brick anywhere else on the aqueduct, provides additional evidence for the original construction of the aqueduct prior to the established use of brick in Asia Minor in the early part of the second century A.D.[108]

Questions of cost, patronage, and use are unresolved.[109] The price of Ilion's aqueduct may lie between figures given for aqueducts at Nicomedia and Alexandria Troas in the first half of the second century A.D. – under 1 million *drachmae* for the former, which involved two separate and unfinished projects, and 7 million for the latter.[110] There is no clear indication of the patron. Possibilities include a private benefactor, as at Ephesus and Alexandria Troas, the imperial family, as at Antioch on-the-Orontes, Corinth and Nicomedia, or an institution of Ilion itself, especially the Sanctuary of Athena Ilias, which was an established bank and money-lender.[111] Principles of aqueduct construction were highly specialized, and the limited number of engineers with the appropriate training seem to have come from the West.[112] Evidence for architectural traditions of Roman Italy in the city's agora baths allow for the possibility that an engineer trained in the West was involved in the design and construction of Ilion's aqueduct and its bridges.

The aqueduct's period of use is difficult to gauge. There are only slight accumulations of sinter along the free-flowing sections of masonry conduit on the Kemerdere bridge and at the Tevfikiye schoolhouse. Thicker deposits can be observed on the smaller masonry bridges and on the insides of terracotta pipes, but none of this points to a clear pattern or duration of use. The absence of significant sinter deposits would appear to suggest a short life for the primary use period of the aqueduct, although this could also indicate low levels of calcium carbonate in the ancient water supply.[113] The conduit discovered near Ilion in 1998 apparently continued to carry water until sediment choked off the supply, and this suggests a gradual demise of the aqueduct due to lack of maintenance rather than an abrupt or disastrous end.

Notes

1 The authors thank Prof. Dr. Manfred Korfmann, Director of the Troia Project, and Prof. Dr. Brian Rose, Head of Greek and Roman Excavations at Troia, for permission to research and publish this material. The authors are also grateful for the observations of Professors Carole Newlands, Ernst Pernicka, Dr. Christian Wolkersdorfer, Ralf Becks, M.A., and Sinan Kılıç M.A., and the assistance of Dr. James Compton Tucker and John Wallrodt M.A. All diapositives provided by Gebhard Bieg, if not otherwise stated.

2 Work in each season involved various combinations of the authors. Sinan Kılıç participated in the 1994 and 1995 surveys. Dr. Mikhail Treister and Reyhan Körpe participated in the excavation of the underground conduit in 1998.

3 E.g., Wikander 2000; Hodge 1992; Galliazzo 1994; Gazzola 1963; O'Connor (1993, 2) who claims to have set out to "make reference to all bridges for which information has been found."

4 In Walpole's memoirs (1818, 106–107): "We found an ancient aqueduct, crossing the river, at a considerable height above its bed. Though much injured by time, it is still so striking an object as to give the name of the 'aqueduct river' to the stream that runs beneath it. The principal arch is about thirty-five feet in diameter, and is yet entire … The rocky bed in which the river here runs, its bold abrupt banks thus united by a lofty arched aqueduct, and crowned with wood, form a striking scene, which I regretted my want of power to sketch." Cf. Allen 1999, 46, 277 note 70; Cook 1973, 115 note 2; Napier 1840, 293.

5 Barker Webb (1793–1854) gives a brief description of the bridge in his topographical study of the Troad, which appeared in Italian (1821), German (1822), and French (1844), but never the English in which it was composed: cf. Cook 1973, 116; Leaf 1923, ix. Barker Webb's map of the Troad is the first to show the location of the bridge, but at the wrong orientation – southwest to northeast instead of southeast to northwest. The illustration by Fox-Strangways did not appear in all editions.

6 Leake (1824, 289): "the aqueduct probably conveyed water from Mount Ida to New Ilium." He may have only known of the bridge from descriptions of it by Hunt and Barker Webb.

7 Allen 1999, 72–73, 75, 290 note 1; Cook 1973, 32, 48–51. Wilhelm Dörpfeld's emended copy of this map is in the holdings of the University of Cincinnati's Burnam Classics Library. Other versions of this map appear in Maclaren 1863 (map by Graves and Spratt dated 1840) and Forchhammer 1884 (map by T. Spratt and P.W. Forchhammer dated 1850). Other early maps with the bridge: Heinrich Kiepert 1877; Walter Leaf 1923.

8 Schliemann 1884, 225; 1881, 77, 110, 610; 1875, 239.

9 See also Blegen et al. 1950, pl. 43, and the unpublished photographs from the Blegen campaigns in the Troia archive at the University of Cincinnati: vol. 11, pages 25–32.

10 Dörpfeld 1902, 241–242 and Beilage 32 for a closer view of the bridge.

11 Cook 1973, 115–116, 282.

12 Akarca 1978, 42–45, figs. 12, 35–40. Akarca's elevation of the large bridge (fig. 12) omits the relief bust on the keystone and indicates too few voussoirs for the principal arch. The collapsed northwest end of the bridge suffered further destruction between the time of Dörpfeld and Akarca, and has since eroded even more: compare Figures 3 and 14.

13 E.g., Kayan 2000, 143–144; Rose 1999, 61; Aslan 1995, 110.

14 Akarca 1978, 33–34.

15 Cook 1973, 282. Schliemann (1881, 610) believed that the water came from the "upper part" of the Kemer River.

16 Cited by Cook (1973, 282), who supported this identification, but did not see the wall himself.

17 Cook 1973, 281–282.

18 Kayan (2000, 143), without citing specific evidence, suggests a confluence of smaller water lines closer to the large bridge across the Kemerdere valley. For aqueducts with multiple sources, see, e.g., Hodge 2000a, 21–28; 1992, 119, 168, 267; Kessener 2000, 108.

19 Bridges on the Hadrianic aqueduct at Corinth carried a formal *specus* and measure between 2.5 and 4 m wide: Lolos 1997, 285–289 and fig. 4.

20 Hodge 1992, 302. There are no stalactites, as on the aqueduct bridge at Perge: Hodge 2000b, 59 fig. 9.

21 Hodge 1992, 232–233.

22 Hodge 1992, 178.

23 For multiple pipelines in aqueducts, see Hodge 1992, 42, 115.

24 Hodge 1992, 113–115.

25 Vitruvius *De Architectura* 8.6.9. See Hodge's discussion of pipes and pressure: 1992, 45, 147, 151, 156, 232–238.

26 Vitruvius *De Architectura* 8.6.7. There are signs of a possible header tank high on the southeast side of the Suçıktı Deresi, but further investigation is required. In 2001 the entire northwest bank above the bridge had been razed by mechanized plowing.

27 Aqueduct bridges should be distinguished from continuous arcades, viaducts, siphons and pressure towers, and all of these from road bridges, because of significant differences in function and design requirements: Lolos 285 and note 29; Wilson 1996, 8; Hodge 1992, 129–131, 424 note 9; Matthews 1970, 12–14.

28 This is much narrower than the Pont du Gard, where the lower piers are 4.5 m wide, but it is comparable to the thickness of the aqueduct bridge at Tarragona, which is 1.86 m wide above the buttressed piers: O'Connor 1993, 154, 156.

29 Based on measurements by Akarca 1978, fig. 12. Hunt gives a span of 35 ft (Walpole 1818, 106–107), but the 55 ft-measurement by Spratt and Forchhammer is more accurate: Forchhammer 1842, 39; 1884, 19; cf. Cook 1973, 115–116.

30 In 1999 we measured a height of 26.42 m from the top of the water channel above the keystone down to the bedrock on the north bank, but about two meters southeast of this point the riverbed is almost 1 m deeper. It is therefore reasonable to calculate just un-

der 27.50 m for the preserved height of the bridge above the river bed, and this is consistent with with Spratt and Forchhammer's 1839 measurement of 92 ft (roughly 27.5 m) "über dem Bett des Flusses" (Forchhammer 1842, 39; 1884, 19).

31 Pont du Gard: 275 m. Pont de l'Oued Bellah: 288 m: Hodge 1992, 132 fig. 82, 141 fig. 97, 144, 424 note 9.

32 Hodge 1992, 129, 134 fig. 85, 137 fig. 91, 141 figs. 97–98, 144, 189; O'Connor 1993, 154, 156.

33 Pondel: Döring 2000, 113 fig. 5. A bridge on the Aspendus aqueduct was originally 20 m. high: Kessener 2000, 109 fig. 10, 110.

34 Hodge 1992, 131; Ashby 1935, 116. O'Connor (1993, 151, 154) gives 24.4 m for the widest span of the Pont du Gard, and 16 m for the original span of the Ponte San Pietro. According to Dio Cassius (68.130.1–6), the stone piers in Trajan's bridge across the Danube stood 170 ft apart, but these were spanned with wooden arches; cf. O'Connor 1993, 142–145. See O'Connor 1993, 161 for an unconfirmed height of 60 m for a bridge at "Antioch." Including other categories of Roman bridges, the Severan road bridge at Kâhta in Cappadocia has the greatest maximum span of any Roman bridge in Turkey (34.20 m), and this is second only to the span of the Pont St Martin in northern Italy (35.64 m). Kâhta: Galliazzo 1994, cat. 824; O'Connor 1993; 127–129. Pont St Martin: Galliazzo 1994, cat. 427; O'Connor 1993, 89–90. The ruined road bridge over the Caicus River at Pergamon had three central spans of about 19 m each: Galliazzo 1994, cat. 861.

35 For Roman bridge engineering, see, e.g., Hodge 2000c, 70–77; 1992, 129–147; O'Connor 1993, 163–186.

36 Kayan 2000, 143 and fig. 4; Rapp – Gifford 1982, fig. 1.

37 The Kemer river remains a substantial tributary of the Scamander, especially in winter and spring: Kayan 2000, 143; Cook 1973, 115; Schliemann 1881, 78. The authors noted flood debris at least two m above the riverbed in the immediate vicinity of the bridge.

38 The material is identical, although no quarry sites have been identified. This was common for bridges, especially in remote areas: Hodge 1992, 129–130.

39 The material may have been brought from around Ilion: cf. Birkle – Satır 1994, 149.

40 Hodge 1992, 143–144.

41 Cook 1973, pl. 10.

42 Cf. Ward Perkins 1981, 273, and fig. 173.

43 Some of these are visible in the collapsed section of the bridge on the northwest bank, bonded with lime mortar 0.01–0.02 m thick, and of the following average size: 0.10–0.13 m W (intrados); 0.13–0.16 m W (extrados); 0.58–0.68 m H. Travertine left over from the construction of the abutments also appears to have been put to use at the base of a relieving arch on the northeast face of the bridge.

44 Hodge 1992, 131, 142–145. Earthquakes: Rapp – Gifford 1982, 43–58; Cook 1973, 394. Winds: The Meltemi, or Etesians, off the Dardanelles in the summer months are particularly fierce (The Black Sea Pilot 1969, 57–58, 71; 1990, 29).

45 The latter seems unlikely, given the need for resistance to wind pressure.

46 The sideways thrust at the bend was not great, and buttressing was not required; other examples are normally 45° or greater: Kessener 2000, 110; Hodge 1992, 118, 421 note 55; Matthews 1970, 10.

47 Hodge 1992, 143–144; above note 44.

48 The channel is now filled with about 0.30 m of sediment. There are no signs of a covered *specus*. The aqueduct bridge at Tarragona had an open channel 0.70 m wide and 1 m deep: Hodge 1992, 137 fig. 91; O'Connor 1993, 156.

49 Hodge 1992, 118–119, 219–232, 420–421 notes 53, 54, 55. Sinter would have also slowed velocity, but no significant deposit of calcium carbonate incrustation was noted along the channel.

50 Barker Webb 1821, 49: "Quattro miglia all'incirca superiormente di esso è attraversato da un bell'aquidotto, il cui arco di mezzo molto più largo degli altri che rimangono, salta attraverso il fiume ad una grande altezza sopra il suo letto, e sulla parte nord-ovest di esso veggonsi i resti di un busto in alto rilievo che sembra coronato di alloro, il quale sporge in fuori scolpito sulla pietra che forma la chiave dell'arco e che probabilmente rappresentava qualche imperatore romano." See above note 5.

51 Dörpfeld 1902, 242.

52 Cook 1973, 116, pl. 10–11; Akarca 1978, 34. Cook implies that Dörpfeld, not Barker Webb, was the first to comment on the bust.

53 Barker Webb 1821, 49: "... un busto in alto rilievo che sembra coronato di alloro ..." Barker Webb 1822, 69 ("Lorbeer"); Barker Webb 1844, 48 ("couronné de laurier"). See above note 5. Barker Webb's profession in botany might have assisted his identification of the crown. Leaf (1923, ix) praised his work in the Troad for its "scientific accuracy and faithful description."

54 This is consistent with Cook's statement that the neck remained in sharp focus: Cook 1973, 116.

55 Ryberg 1955, 47, esp. note 46.

56 E.g., Rose 1997a, cat. 80, pl. 191 (Metroon at Olympia), cat. 105, pl. 207 (Sebasteion at Aphrodisias); D. Kleiner 1992, 403–404, figs. 368, 369 (tetrarchs in the Vatican Library); Bol 1984, Taf. 15, 19, 22, 23 (Nymphaeum of Herodes Atticus at Olympia).

57 Only a few individual portraits survive with permanent laurel wreaths: E.g., Rumscheid 2000, cat. 74, 80, 81; Fittschen – Zanker 1983, 55 (Nr. 52 Replik

25) Beilage 38c–d (Hadrian), 59–61 (Nr. 55) pl. 61–62 (Antinous); Inan – Rosenbaum 1966, 71 no. 35 (Hadrian?), 76 no. 44 (Antonine emperor?); Budde 1965, 105 (Trajan?; cf. D. Kleiner 1992, 209, 212; Inan – Rosenbaum 1966, 208 no. 186). The *Blätterkranz* worn by the Augustus in the Capitoline Museum may not be laurel: Eck – Fittschen – Naumann 1986, 50–51; Fittschen – Zanker 1983, 9, 10 note 13 (no. 8). Sometimes laurel may have been added to portraits as temporary decoration: D. Kleiner 1992, 243.

58 Aicher 1995, 166–168. E.g., Rome: the Porta Tiburtina for repairs to the Aqua Tepula, Marcia, and Julia by Augustus (5/4 B.C.), and repairs to the Marcia by Titus (79 A.D.) and Caracalla (212/213 A.D.) (*CIL* 6.1244–1246); the Porta Praenestina (Maggiore) for construction of the Aqua Claudia and Anio Novus by Claudius (52 A.D.), and repairs by Vespasian (71 A.D.) and Titus (81 A.D.) (*CIL* 6.1256–8); the Anio Novus (Frontinus *De Aquaeductibus* 2.93). Outside Rome: Aezani (Levick 1988, 6 no. 10); Aspendus (Kessener 2000, 105, 110); Athens (*CIL* 3.549); Mérida (Pfanner 1990, 90 and pl. 7b); Pondel near Aosta (Döring 2000, 113 fig. 5, 114–115); Sarmizegetusa (Boatwright 2000, 32); Segovia (Wilson 1996, 14); Sicily, the Aquae Corneliae (Wilson 1990, 100–101). For road bridges, see Trajan's bridge over the Tagus River near Alcántara in Spain (*CIL* 2.759, 760, 761; Galliazzo 1994, cat. 754), but cf. F. Kleiner 1991, 182–192. Busts of Hadrian and Sabina were used in combination with an inscription on a granary at Myra and perhaps at Patara, too: Boatwright 2000, 123.

59 Glanum: Salviat 1989, 50. Rimini: Blake 1947, 204. A bust of a soldier on the Fréjus aqueduct (not on the keystone) could indicate military involvement in construction: cf. Wilson 1996, 19 note 103.

60 Aphrodisias: Welch 1998, 551, fig. 7. Tymbriada: Galliazzo 1994, cat. 842; Kaya – Mitchell 1985, 48, fig. 12, pl. 3a. Other examples, many unidentified: Turkey: Tyche on the so-called Temple of Hadrian at Ephesus; door in the Odeion in the Upper Agora at Pergamon; city gate at Tlos (Wurster 1976, 32 fig. 6); bull's head protomes(?) on a bridge at Aezani (Galliazzo 1994, cat. 837). Italy: Saepinum (Zanker 2000, 32 and fig. 8), and Blake (1947, 199, 201–202, 204, 207–208, 210) for city gates at Falerii Novi, Fano, Paestum, Pola, Pompeii, Susa, Volterra, the Ponte dell'Abadia at Vulci, and the bull's head protome on the keystone of the Porta Tiburtina. Portugal: gate at Pax Iulia (Alarcao 1990, pl. 1f). For reliefs of Hercules used to decorate aqueducts, see Salowey 1994, 93–94. For Roma and the Genius Populi Romani on consoles linking archivolt and architrave on Roman commemorative arches, see F. Kleiner 1985, 83; D. Kleiner 1992, 446.

61 Thymbrius river: Strabo 13.1.35; cf. Cook 1973, 117–18; Leaf 1923, 179–180; Schliemann 1881, 77–80; Smith 1857, 1194; Hobhouse 1813, 753.

62 Familiar examples are the Nile and Tiber from the temple of Isis at Rome and the canopus at Hadrian's Villa, as well as personifications of the Danube on columns of Trajan and Marcus Aurelius. Others are too many to list here. In general, Klementa 1993, 203–205; Gais 1978, 355–370; Isler 1970, 93–113; Simon 1981, 8, 14 note 96; Toynbee 1934, 30–33; Weiss 1988, 139–148; Vollkommer 1994, 787–790. There are some exceptions: E.g., Dierichs 1999, fig. 5 (Maeander?); Fedak 1999, 51 (river in Pannonia?); Coleman 1988, 121 fig. 3 (Volturnus?); Pollitt 1986, 55 and fig. 1 (Orontes); Kaya-Mitchell 1985, 49–51, pls. 4, 5 (Eurymedon); Gais 1978, 357, 360, fig. 5 (Gelas); Isler 1970, no. 273, pl. 21 (Achelous); cf. F. Kleiner 1985, 83, pl. 17.1–2.

63 Klementa 1993, 56, 148, 215–216; Gais 1978, 355–370; Simon 1981, 14 note 99. E.g., Von Gerkan – Krischen 1928, 124, fig. 121 (Maeander with wheat, fruit, and bunches of grapes); Speier 1972, no. 440; Toynbee 1934, 30–33 (Nile with lotus, reeds, wheat, and/or flowers); Speier 1972, no. 2306; Calza – Nash 1959, 9; Le Gall 1953 vol. 2, 5, 25, pl. 1, 8 (Tiber with marine vegetation). Kaya-Mitchell 1985, 49 (Eurymedon with bull horn and diadem). Literary references: E.g., Homer *Iliad* 21.237 (Scamander); Virgil *Aeneid* 8.34 (Tiber), 10.205 (Mincius); *Georgics* 4.371–372 (Eridanus); Ovid *Metamorphoses* 8.882–883, 9.3, 99–100 (Achelous); Pausanias 10.33.5 (Kephisus at Lilaea in Phocis).

64 Birge 1994, 13; Flashar 1992, 142, 194–195, 204; Pollitt 1986, 174, fig. 182; Simon 1981, pl. 5.2; Simon 1984.

65 Homer *Iliad* 10.430; Strabo 13.1.35; Mynors 1990, 301; Parke 1985, 178.

66 Gantz 1993, 221, 597–603, 648 with sources; Parke 1985, 178, 253 note 16, with sources. Cf. Roccos 1998, 267; Salowey 1994, 93; Pettersson 1992, 48–51, 69, 71–72.

67 Apollo is connected to bodies of water in myth (e.g., Daphne) and art (e.g., Apollo with Hercules and a personification of the Port of Ostia on the Arch of Trajan at Beneventum), cf. Hesiod *Theogony* 347 and Caldwell 1987, 49. A spring was closely connected to the oracular function of cults of Apollo at Chryse, Claros, Didyma, and Sura (Lycia): Parke 1985, 23–26, 177, 197, 210–213, 219–223; Fontenrose 1988, 79–80, 83–84. The toponym Tanrıpınar, one of the water sources proposed by Cook (1973, 116, 282), means "god's spring."

68 Strabo (13.1.34) called this a "great neck" of land that separated the plain of the Simois from that of the Scamander; cf. Cook 1973, 112.

69 Cook (1973, 115–116, 282) mentions a terracotta pipeline on the slopes below the village of Kemer Köy; cf. Akarca 1978, 35.

70 Rose 1999, 61, and fig. 23; compare Kek 1997, 61, and fig. 1 for cross sections of Roman aqueduct channels; Grewe 1998.

71 A short section of terracotta pipe found to the east of Çıplak could indicate a transition closer to Ilion: Pustovoytov 1999, 355–356.

72 Local authorities allowed 48 hours for investigation, and it was only possible to document a one-meter length of the conduit, although it clearly continued to the east. A continuation to the west was not found. No diagnostic material was recovered from the channel. The base of the channel was measured but not observed, as it was obscured by muddy water.

73 Cf. Lolos 1997, 295.

74 This is taller and narrower than other masonry conduits, such as the Pont du Gard and the aqueduct at Brevenne (Hodge 1992, 97, figs. 48, 49e).

75 Lolos 1997, 295; Hodge 1992, 219–224.

76 Karst: Crouch 1993, 63–82, esp. 64, 75, and, e.g., 207 for comparison with Akragas.

77 City walls: Rose 1997c, 93–96.

78 Dörpfeld 1902, Taf. 2. A fortification tower can't be ruled out, but there are no other towers known on the fortification circuit.

79 For *castella*, see Vitruvius *De Architectura* 8.6.1; De Kleijn 2001, 32–38; Jansen 2000, 111–125; Taylor 2000, 26–30, 35–37, 49–51; Hodge 1992, 174, 280; Evans 1994, 6–8.

80 See below note 99. Remains of the wall, now buried, run parallel to the south side of the Tevfikiye village cemetery.

81 Hodge 1992, 128–129, fig. 80.

82 For aqueduct gradients, see Hodge 2000b, 49–57; 1992, 178–184, 216–219, 347–348, 441 note 13; Lewis 2000, 347–348; Wilson 1996, 8–9; Matthews 1970, 9–11; Ashby 1935, 37–39.

83 Kayan's (2000, 143) estimate of about ten km for this distance is too short.

84 Cf. Hodge 1992, 117, 178–180.

85 The eleven conduits that supplied Rome were an average 45 km long, and Pergamon's aqueducts were 42 and 50 km long: Garbrecht 2001; Hodge 1992, 347–348; Wilson 1996, 5–6 note 10.

86 Elevations from Cook 1973, 273 (Area Map C).

87 These figures are based on computations of total height loss divided by total distance; cf. Hodge 1992, 218.

88 Hodge 1992, 218, 347. Average overall gradients were between 1.5 m and 3 m per km. Aqua Julia: 16.4 m per km. Segovia: 12.4 m per km.

89 In 2001, GPS data with a +/- 10 m margin of error indicated an elevation of 125 masl for points taken on top of the bridge, and this is consistent with the position of the bridge below the village of Kemer Köy, which has a known elevation of 150 masl.

90 Hodge (1992, 145–146) calls the 7.66 m per km slope of the Ponte S. Gregorio "orthodox."

91 Hodge 1992, 218.

92 Chanson 2000, 47–72; Hodge 1992, 160–161, 178, 217, 233–238.

93 In general: De Kleijn 2001, 47–60; Taylor 2000, 33–39; Lolos 1997, 295–296; Hodge 1992, 224–227, 345–355; Matthews 1970, 14–15.

94 Wells and cisterns: Tekkök et al. 2001; Aylward 1999, 166, 169, 172; Rose 1998, 102; Hayes 1995, 185–196; Jablonka 1995, 49, 57; Dörpfeld 1902, 241. Springs: Rose 2000, 61–65; 1999, 55–61.

95 For problems in dating aqueducts, especially local determinants on materials and design, see, e.g., Wilson 1996, 12–19; Blake 1947, 215, 341.

96 The absence of brick is also significant. Hodge 1992, 130, 424 note 13; O'Connor 1993, 89–90; Ward-Perkins 1981, 273–275; Wilber 1938, 53–54 and note 9. Akarca (1978, 34–35) saw the combination of materials as evidence for two phases of construction, the first of entirely ashlar masonry and the second with a large repair of mortared rubble and the addition of the bend on the southeast side. Problems with this scenario include the complete absence of collapsed or re-used travertine ashlars from a presumed original design, as well as the unlikely collapse of almost the entire superstructure without the voussoirs or keystone. A combination of ashlar masonry and mortared rubble in a structure is not an indicator of separate phases of construction, e.g., Yegül 2000, 140–143; Lolos 1997, 287 note 32.

97 Ephesus: Ward-Perkins 1981, fig. 175; Heberdey 1923, 263–265; Wilberg 1923, 256–262; for the water system, see Ortloff – Crouch 2001; 852–856. Antioch: Wilber 1938, 53 and fig. 3. Tarragona: above note 48. Also compare Augustan road bridges at Narni and Aosta (Pont St Martin), which has keyed masonry on the extrados: Galliazzo 1994, cat. 427; O'Connor 1993, 89–90 and fig. 53. Blake 1947, 213–214, 218, 341. All of these examples have masonry courses of various height in the abutments. The bridge's relieving arches and decorated keystone are also comfortable in this period. Relieving arches: Tabularium and Forum Iulium: Blake 1947, 152, 224. Decorated keystones: Blake 1947, 225; above note 60.

98 Lolos 1997, 287–288. The bridge may be post-Hadrianic; cf. Wilson (1996, 14) for the two-phase Los Milagros arcade.

99 Blegen 1950, 9; 1932, 446.

100 Evidence for dating is discussed in Aylward 2000, 75, 77, 159–161, to which add Wilson 1996, 18–19; Yegül 1992, 363–365.

101 Boatwright 2000, 109–111 (Tables 6.1 and 6.2); Manderscheid 2000, 176–177; Mitchell – Waelkens 1998, 198; Lolos 1997, 300; Wilson 1996, 16–18; Aicher 1995, 27–28; 1993, 351; Hodge 1992, 5–6, 128, 264–268; Robinson 1992, 99; Bruun 1991, 73;

Camp 1991, 109; Wilber 1938, 52; see esp. Alexandria Troas for a combination of aqueduct, nymphaeum and bath in 134/35 A.D.: Koldewey 1884; Öztaner 1999.

[102] E.g., Torelli 1999, 165–183; Lindner 1994, 25–102; Gruen 1992, 6–51, esp. 12–31; Rose, *forthcoming*; Rose 1997b, 103–105; Sage 2000, 213–214; cf. Strabo 13.1.27.

[103] Rose *forthcoming*; 1998, 90; 1994, 76–80; 1993, 100–104; 1992, 46; 1991, 71. Visit of Augustus: Halfmann 1986, 158; *IGR* IV 203.

[104] Boatwright 2000, 108, 109, 112, 167–168; Lolos 1997, 292–294; Camp 1991, 109–110; Sherwin-White 613–615. Cf. Reynolds 2000, 17, 20; Wilson 1996, 18.

[105] Philostratus *Lives of the Sophists* 548–549. Boatwright 2000, 116–118; Riel 1997, T125.

[106] Alexandria Troas was a Roman colony that was granted the *Ius Italicum* under Augustus: Riel 1999, 20–21. Ilion had been head of the Troad *koinon* from the end of the fourth century B.C., and tax free since 188 B.C.: Cohen 1995, 153–154; Rose 1992, 45–46; Magie 1950, 66, 869–871.

[107] Hodge 1992, 118, 145–146, 193, 217; Wilson 1996, 15. A bridge built to cut off a loop would have required a steep gradient to link disparate levels of the original conduit that had contoured around the valley; cf. Frontinus *De Aquaeductibus* 1.18; Wilson 1990, 100–101.

[108] Ward-Perkins 1981, 277.

[109] In general, Wilson 1996, 14, 18; Hodge 1992, 113, 117, 389 note 5.

[110] Riel 1997, T125; Kek 1995, 225; Sherwin-White 1966, 614. For cost in general, see Wilson 1996, 6, 16–19; Hodge 1992, 5–6, 389 note 5; Aicher 1993, 351; Kek 1997, 254–264.

[111] Sanctuary of Athena Ilias: Magie 1950, 239, 869, 1119–1120.

[112] Pliny *Letters* 10.37.3; cf. Lolos 1997, 292; Wilson 1996, 18–19; Sherwin-White 1966, 613–615; Wilber 1938, 52.

[113] Hodge 1992, 227–231, 415 note 14. For dating period of use by sinter, see Kessener 2000, 110 fig. 11, 111; Wilson 1996, 15–16.

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