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ABSTRACT

Failed Roman Imperialism. An Unfinished Roman Aqueduct at Artaxata in Armenia

Achim Lichtenberger – Mkrtich Zardaryan – Torben Schreiber

During the 2019 excavation campaign of the Armenian-German Artaxata Project, a previously magnetically detected anomaly was investigated. The excavation revealed a monumental line of *opus caementicium* foundations. These foundations relate to an unfinished aqueduct bridge that was built between A.D. 114–117 by the Roman army in the course of Artaxata becoming the capital of a Roman province of Armenia. Since Roman presence in Armenia was only short-lived, the aqueduct was never completed and abandoned after the Romans left the country. In the paper we discuss the archaeological evidence of the aqueduct, the historical context and project the aqueduct line to possible water sources. Furthermore, the geochemistry of the mortar is analyzed to characterize the mortar receipt which is Roman. The newly discovered aqueduct attests to failed Roman imperialism in Armenia.

KEYWORDS

Artaxata, Armenia, settlement archaeology, Roman imperialism, water supply, magnetic prospection

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Failed Roman Imperialism

An Unfinished Roman Aqueduct at Artaxata in Armenia

with contributions by Arnaud Coutelas and Barbora Weissova

Introduction

1 The ancient city of Artashat-Artaxata is situated in the central part of the Ararat Valley, on the left bank of the Arax River and some 10 km to the East of the present-day city of Artashat[1]. The site occupies the 15 hills of the Khor Virap heights and the adjoining plain to the East and to the South (Fig. 1). On one of the hills (given the number VI by the Artashat expedition) the famous medieval monastery of Khor Virap is situated. According to previous field investigations, the Hellenistic and Roman-period city was a megacity covering at least 700 ha and together with its suburbs and necropolises about 3,000 ha.

2 The settlement history of the Artaxata heights goes back to the 5th–4th millennia B.C. Furthermore, the remains of a large settlement from the late 2nd and early 1st millennia B.C. as well as rich archaeological evidence of the Urartian city were discovered here[2].

3 Artaxata, the capital of the Artaxiad and Arsacid dynasties of Classical Armenia, was founded by king Artashes-Artaxias I in the late 180s B.C. and functioned as the main centre of the Armenian state up to the mid-5th century A.D. The historical sources report that Hannibal was involved in the foundation of the city[3]. Artaxata was the capital of the Armenian kingdom, and only during short periods in the 1st and 2nd centuries A.D. can direct Roman influence be traced in the urban material culture. In A.D. 114–116/117, the Roman emperor Trajan tried to establish a Roman province of Armenia, but although he tried hard, it was a short-lived episode in the history of the city. Artaxata remained the capital of the Arsacid dynasty of Armenia. The Sasanian king Shapur II in A.D. 369 conquered Artaxata and some of the population were deported to Iran[4].

1 The authors would like to thank the Armenian Academy of Science and the Deutsche Forschungsgemeinschaft for funding the project. A great thank you also goes to all team members of the 2019 excavation campaign. Furthermore, we would like to thank the owners of the fields Gevorg Sheroyan and Vardan Aghamalyan for enabling us to undertake archaeological fieldwork on their property. On the archaeology of Artaxata cf. Khachatryan 1981; Arakelyan 1982; Invernizzi 1998.

2 Zardaryan 2018, 105–145.

3 Strab. 14, 6, 32; Plut. Lucullus 31–32. Cf. Traina 1999/2000, 63 f.

4 Faustus Byz. 4, 55.

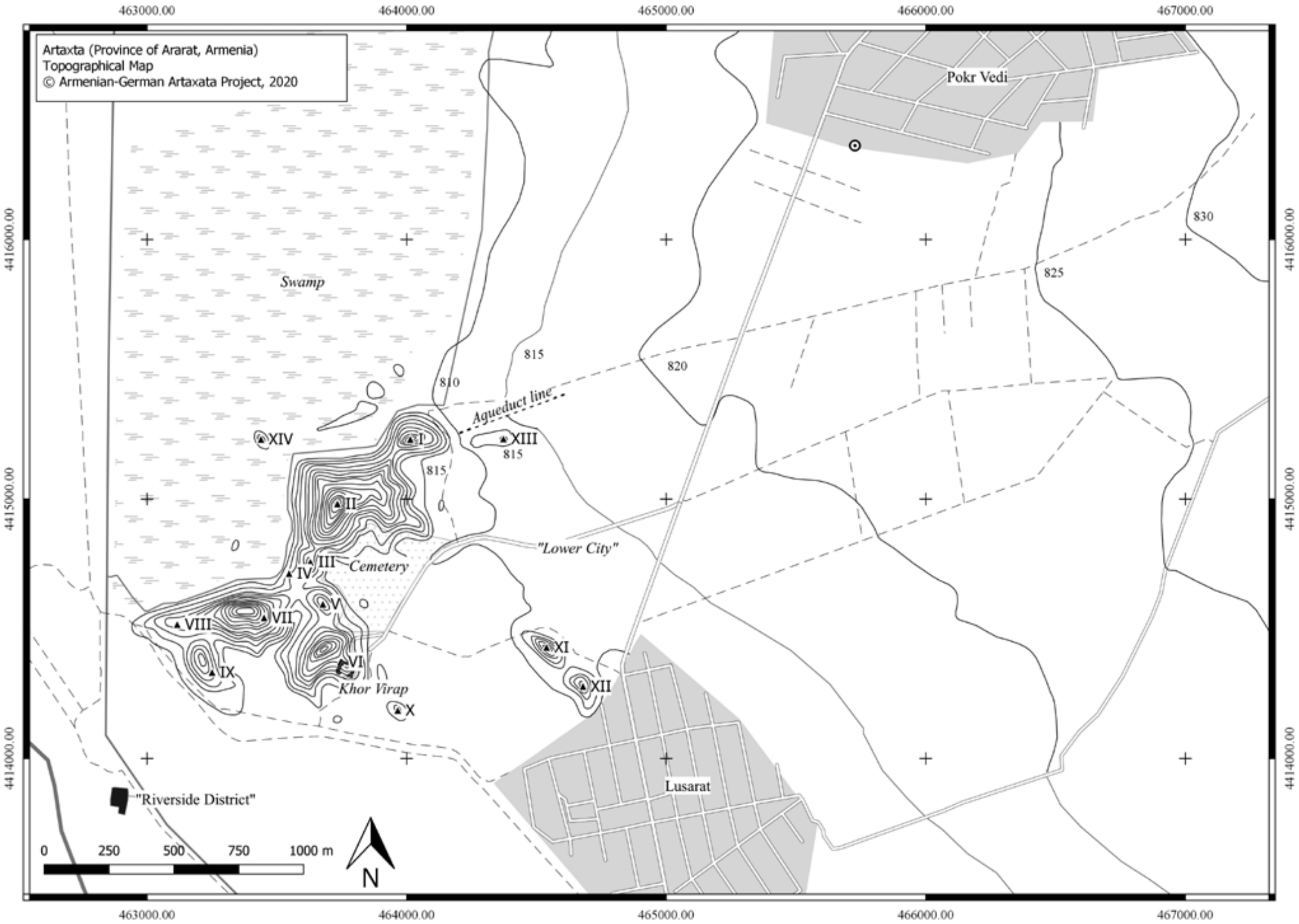

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Fig. 1: Map of Artaxata and vicinity (scale 1 : 30 000)

4 During the systematic excavations of Artaxata since 1970 by the Institute of Archaeology and Ethnography of the Armenian Academy of Sciences, the Hills I, IV and VII were excavated[5]. In addition, some areas of Hills II, V, VIII, the so-called north-eastern necropolis, as well as an area on the left bank of the Arax River (»Riverside District«) were explored[6]. In the framework of these investigations a number of discoveries were made, among them an almost 10 km fortification wall surrounding the hills. Within the settlement, blocks of dwellings and public buildings, workshops, baths and water supplies relating to the urban infrastructure were revealed. Notable finds are a marble statue of Aphrodite, terracotta figurines, an almost 9 m long Latin inscription dedicated to the Roman emperor Trajan (Fig. 2; AE 1968, 510), mosaics, murals, coins and clay seal impressions from different areas of the classical world[7].

Fig. 2: Pokr Vedi inscription (AE 1968, 510)

5 The archaeological discoveries illustrate industrial and building activities as well as the religious and aesthetic preferences of its population and demonstrate the

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5 Khachatryan 1981; Arakelyan 1982.

6 Khachatryan 2005; Zardaryan 2016 (2020).

7 On the results of the excavations of Artashat and some of its archaeological finds see: Zardaryan 1977a; Zardaryan 1977b; Khachatryan 1981; Arakelyan 1982; Tonikian 1992; Tonikyan 1992; Zardarian – Akopian 1994; Tonikyan 1996; Khachatrian 1998; Zardaryan 1999; Zardaryan 2000; Khachatryan – Neverov 2008; Zardaryan 2018; Zardaryan 2016 (2020); Schreiber 2021, 277–310.

3

Fig. 3: Artaxata, results of the magnetic prospection in 2018

far-reaching economic and cultural connections of the city, which embraced an area from Central Asia to Western Europe and from North Africa to the Crimea. The finds unearthed by the excavations of the city are of great importance for our understanding of the history and culture of ancient Armenia as well as the Classical Near East.

6 In addition to the excavations of the Institute of Archaeology and Ethnography, ancient Artaxata has also been explored since 2016 in the framework of joint international projects. In 2016–2018 the Armenian-Polish »Pokr Vedi Project«[8] focused on a detailed survey of the north-eastern suburbs of the city where Trajan's inscription was found.

7 The aim of the new Armenian-German Artaxata Project of the Institute of Archaeology and Ethnography of the Armenian Academy of Sciences and the Institute for Classical Archaeology and Christian Archaeology of Münster University, which was initiated in 2018, is the investigation of the »Lower city« of Artaxata. The main object of research, Hill XIII, is located in the plain about 100 m to the east of Hill I, on the north-eastern edge of the Khor Virap heights. The 2018 campaign conducted an extensive geomagnetic survey of Hill XIII and adjacent areas to the north and south of it (Fig. 3)[9]. Due to the building materials used (mud bricks) and the soil conditions, the magnetic survey yielded excellent results. Furthermore, a test trench on the north slope of the hill was excavated in 2018[10]. On the basis of the magnetic survey, several areas

8 The project was initiated in 2016–2018 by the Institute of Archaeology and Ethnography, National Academy of Sciences, Republic of Armenia and the Institute of Archaeology of the University of Warsaw, co-directors – M. H. Zardaryan, Karasiewicz-Szczipiyorski and O. Kubrak.

9 Lichtenberger et al. 2019.

10 Lichtenberger – Zardaryan in press.

4

Fig. 4: Artaxata, results of the magnetic prospection in 2018 and trenches of 2019

on Hill XIII and to the north of it were identified and excavated in 2019. On Hill XIII well-planned domestic architecture from the 2nd century B.C. to the 1st century A.D. was excavated, which is not, however, the subject of this paper[11]. North of Hill XIII a row of geomagnetic anomalies (Fig. 4) was investigated and partly excavated which provided us with important evidence for the construction of an aqueduct probably related to the attempt by the Roman emperor Trajan to establish the Roman province of Armenia.

Context and Establishment of a Roman Province in Armenia

8 During the late-Hellenistic and early Roman periods, Armenia was a country within the spheres of interest of two empires, Rome and Parthia[12]. Both antagonistic powers tried to establish indirect rule over the Armenian kingdom and interfere with the appointment of kings. In 69 B.C., the Roman commander Lucullus came to Armenia and won a victory over the Armenian king Tigran II but was later defeated on his march to Artaxata[13].

9 The culmination of the Roman-Armenian conflict was the military campaign initiated by Nero in A.D. 58–59, which resulted in the capture and destruction of Ar-

11 On the preliminary results of the 2019 campaign, see Lichtenberger et al. 2020, 184–227 and Lichtenberger et al. 2021, 245–276.

12 Chaumont 1976; Chahin 2001.

13 Plut. Lucullus 32.

taxata, the capital of Armenia, by Corbulo and the installation of the pro-Roman ruler Tigran VI on the Armenian throne[14]. However, this Roman success was rather short-lived and served to strengthen the Armenian-Parthian alliance against Rome. The treaty of Rhandeia in A.D. 63 put an end to these rather aggressive endeavours of Rome: the defeat of the legions of Caesennius Paetus by the Armenian-Parthian forces compelled Nero to sign a peace treaty, to accept the Parthian prince Tiridat as king of Armenia, and to satisfy merely by his ostentatious coronation in Rome. With Tiridat I a new Armenian royal dynasty, the Arsacids, was established. Rome paid significant amounts of money to the king of Armenia and sent architects and craftsmen to reconstruct Artaxata. There is also a tradition that Artaxata was renamed Neronias[15]. The city and the kingdom however remained independent.

10 During the reign of the Flavians the status quo of Armenian-Roman relations, established as a result of the treaty of Rhandeia, was generally maintained. However, in spring of the year 114 the peace, which had lasted almost 50 years, was broken. Using the ›un-coordinated‹ enthronement of king Partamasir (A.D. 113) as an excuse, the Roman legions, headed by the emperor Trajan invaded Armenia[16]. This resulted in the displacement and murder of Partamasir, the capture of Artaxata and the annexation of the country as province Armenia Major. The creation of the new province was marked by issuing a series of triumphal coins in Rome[17]. A Roman military camp is also said to have been erected at Artaxata. Its location is not yet known, but several Latin inscriptions found in the vicinity of Pokr Vedi stem from this period. These include the tombstone of a soldier of the I Italic legion (C. Val. Cre[scent])[18], the monumental inscription dedicated to Trajan, naming the Legio IIII Scythica[19], and numerous samples of locally produced bricks and roofing tiles but with stamps of the said legion[20]. Furthermore, some samples of Roman weapons and ammunition (*caliga militaris* in particular)[21] have to be mentioned.

11 Most impressive is the monumental inscription of the Legio IIII Scythica (Fig. 2). It is not known from what kind of building it originates. It has been suggested that it belonged to a monument commemorating a victory such as a triumphal arch[22] but other structures built by the Roman legion, such as a bridge, are also possible candidates. Recent archaeological work in the vicinity of the findspot of the inscription indicates that a river flowed through this area, probably the ancient course of the Metsamor River, and this lends plausibility to the suggestion of a bridge[23]. In any case it is clear that the legion was very active, and Trajan strove hard to establish a Roman province. He appointed Lucius Catilius Severus as equestrian propraetor of the new province, thereby underlining the seriousness of his efforts[24].

12 Michael Speidel pointed to the fact that the Legio IIII Scythica carried an unusual honorific title, namely *operosa felix* (»hard-working, fortunate«) and that it indeed worked on a number of construction projects[25]. Legions are quite often dispatched to large infrastructure projects such as roads, bridges, city walls and aqueducts[26]. This

14 Tac. Ann. 14, 23, 1; Cass. Dio 62, 19–20. Cf. Goldsworthy 2003, 297–327.
15 Cass. Dio 58, 6.
16 Cass. Dio 68, 20.
17 Woytek 2010, 478 f. no. 590v-2.4 pl. 118.
18 Arakelyan 1967; Arakelyan 1971.
19 AE 1968, 510; Arakelyan 1971.
20 Khachatryan 2006.
21 Zardaryan 2016 (2020), fig. 12/3.
22 Mitford 2018, II 553.
23 This work was done in the framework of the Armenian-Polish project (see above note 8) and is yet unpublished.
24 IL Afr 43; CIL X 8291.
25 AE 2001, 1956. See for that Speidel 1998; Speidel 2001.
26 MacMullen 1959.

might relate also to the structure that was embellished by the Pokr Vedi inscription, and the legionary engineering relates to the establishment of the provincial capital.

13 After the establishment of the Provincia Armenia, Trajan headed south and victoriously marched through Adiabene, central and southern Mesopotamia and, having conquered Babylon, Seleucia on the Tigris and Ctesiphon, made his way to the shore of the Persian Gulf. Along with Armenia, two other Eastern provinces were thereby created – »Adiabene« and »Mesopotamia«[27]. However, Roman domination was brief: anti-Roman insurrections had flared up in all the conquered kingdoms by the end of the year 116, which the Empire was unable to suppress. After Trajan's death, Hadrian abandoned the province[28] and the legion left Artaxata, bringing the legion's work to an abrupt end.

14 Hadrian (A.D. 117–138) and later Antoninus Pius (A.D. 138–161) pursued a more balanced Eastern policy with regard to Armenia, where the head of an anti-Roman rebellion Valarsh I (A.D. 117–140) came to power. Tension between Armenia and Rome escalated once more in A.D. 163, again impacting Artaxata, under the rule of emperors Marcus Aurelius and Lucius Verus. This resulted in a short spell of Roman occupation, though these events are outside the chronological framework of this paper.

15 From the point of view of Roman presence in Artaxata the »Riverside District«[29] is particularly noteworthy. The planning concept of this section of the city, the external design of its buildings (the ruins of the Ionic order temple, the regia, the bathing complex etc.) and their interiors (mosaics, murals, cornices), the water supply system, building techniques – all these are evidence of the direct influence and adaptation of Roman architectural and construction traditions. Taking into account the chronology of the earliest layers of the district (the second half of the 1st century A.D.), we may conclude that its foundations were laid in the time of Tiridat I. Notable constructions and subsequent destructions can be traced to the beginning and to the second half of the 2nd century A.D. Therefore, we can assume that during the period of Roman presence in Artaxata, under the rule of Trajan and Marcus Aurelius/Lucius Verus, the headquarters of the Roman administration had been located here, which then became the target of anti-Roman insurrection[30].

From Geomagnetics to Excavation: Archaeological Evidence of a Roman Aqueduct in Artaxata

16 Excavations in 2019 in the framework of the Armenian-German Artaxata project, on the lowland section of the site (»The Lower City«) to the east of the main group of Khor Virap heights, revealed a Roman construction which is unique for Armenia (Fig. 5 and 6).

17 To the north and north-west of Hill XIII, at a distance of 30 to 40 m from the north-western slope, a clearly visible line of magnetic anomalies was observed during the geophysical survey of 2018 (Fig. 4)[31]. This line is formed by a row of single spots with high negative amplitude at almost regular intervals of between 3 and 4 m. This line can be traced over a length of approximately 150 m in the geophysical survey image. The amplitudes and the ordered structure indicated that it is a man-made structure. It runs east-north-east

27 Marciak 2017, 366–379.

28 Historia Augusta, Hadr. 5, 2–5.

29 Khachatryan 2013; Zardaryan 2016 (2020).

30 Zardaryan 2016 (2020), 305–310.

31 The geomagnetic prospection was carried out by the Berlin-based company Eastern Atlas from September 18th to 23rd 2018 and covered approx. 11.2 hectares. For the methodology, technical application and the overall results see Lichtenberger et al. 2019.

to west-south-west straight towards Hill I. Shortly before reaching the slope, the signal becomes weaker and gets lost, suggesting that the structure lies deeper below the earth's surface here. The line is accompanied by further anomalies, which were interpreted as ditch fillings. The terrain, which is covered with melon, corn and grape fields – and was therefore not accessible everywhere – descends from 814.5 m a.s.l. at the easternmost point of the dot line to approximately 813 m a.s.l. at the westernmost point and thus by around 1.5 m (Fig. 7). In a satellite image available on Google Earth from the 5th of July 2010, cropmarks can be determined which suggest that the structure continues to a length of at least 400 m (Fig. 8).

18 The regular layout of the anomaly indicated that it could relate to an ancient aqueduct – especially if one considers that the line is heading straight to Hill I and thus to the Upper City of Artaxata[32]. In order to verify this assumption, three trenches were dug following the line of the structure during the excavation campaign of 2019 (Fig. 9).

5

Fig. 5: Artaxata, trench No. 3 (ART19-Tr-03) seen from Northeast

Trench No. 3

19 The first trench (ART19-Tr-03, Fig. 4. 5. 6) was laid out in the eastern melon field, at the outermost edge of the area covered by the geophysical survey. In an area of 5 m × 4 m, the line was cut in such a way that two ›pillars‹ could potentially be uncovered. At a depth of only 20 to 30 cm, the surface of one of the structures responsible for the strong anomalies in the survey image was exposed: a massive block of *opus caementicium* (ART19-Tr-303). The uncovered upper side of the rectangular block measures 1.85 m × 2.2 m. After levelling the area, another block appeared at a distance of 1.8 m from the eastern edge of the first block. This second block (ART19-Tr-307) measures 2.1 m in width and could be uncovered at a length of 0.86 m before it runs into the north-eastern profile. It can be assumed that block 307 has the same dimensions as block 303, so that the distance from the centre of one block to the next in this part of

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Fig. 6: Artaxata, trench No. 3 (ART19-Tr-03) seen from Southwest

32 On the construction of aqueducts in the Roman world cf. Grewe 1985.

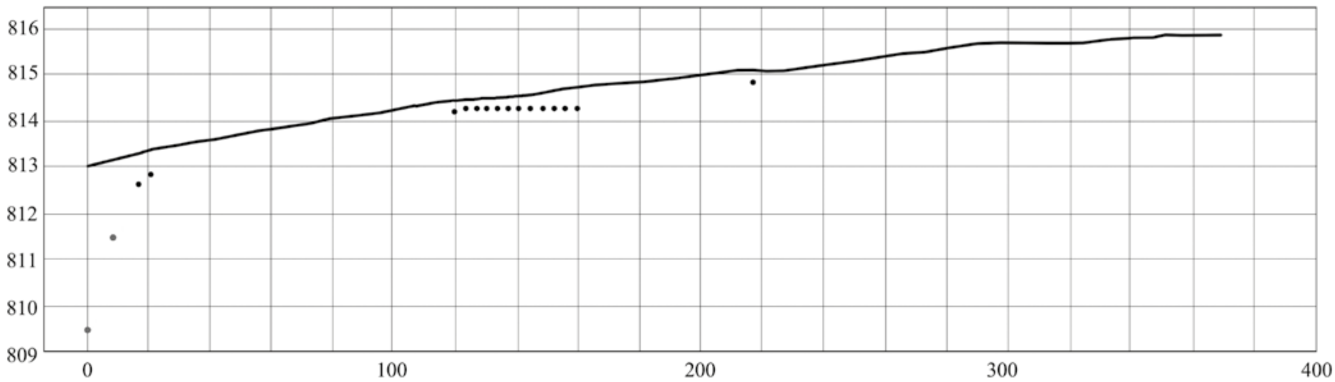

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Fig. 7: Artaxata, level of landscape and height of aqueduct pillars (0 m = western most pillar, documented by drilling)

Fig. 8: Artaxata, results of the magnetic prospection in Artaxata 2018 and reconstructed aqueduct line

the investigated structure can be given as 3.6 m. The elevation of the even horizontal surface is 814.32 m a.s.l. for block 307 and 814.29 m a.s.l. for block 303. The heights therefore do not differ significantly.

20 The anomalies accompanying the white dot line, which were interpreted as ›ditch fillings‹ in the magnetograms, turned out to be a solid stone and clay packing (ART19-Tr-304). This feature occupies the entire area of the south-eastern third of the trench (5 m × 1.17 m) and extends into the south-western, south-eastern and north-eastern profiles. The exact dimensions of this structure to the south-east could not be conclusively determined during the 2019 excavation campaign. After evaluating the geophysical images, however, a total width of this strip of about 2 to 2.2 m can be assumed. This feature is probably of more recent origin.

21 After the described structures had been uncovered, further deepening took place between the blocks 303 and 307, mainly to determine the depth of the blocks. A

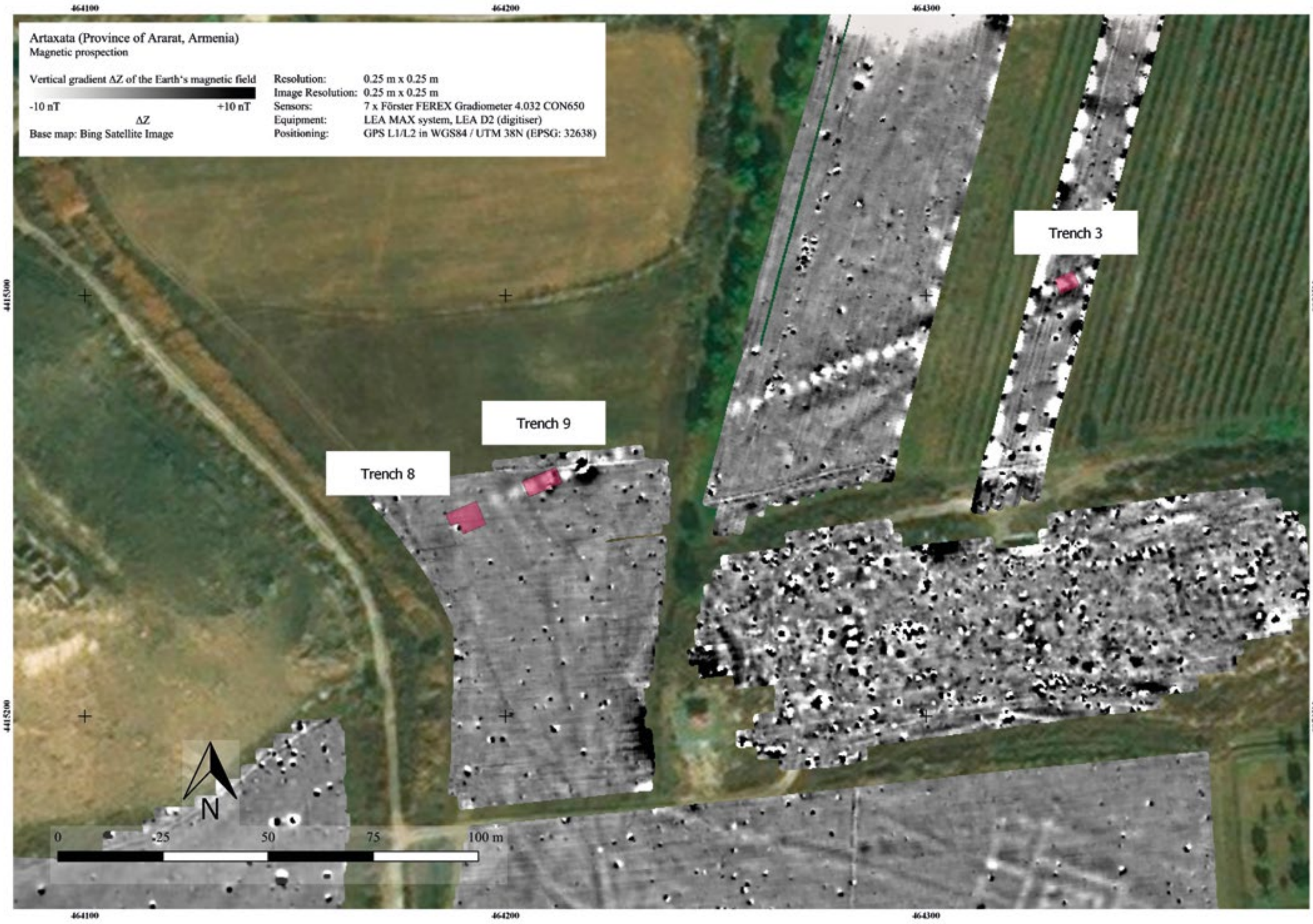

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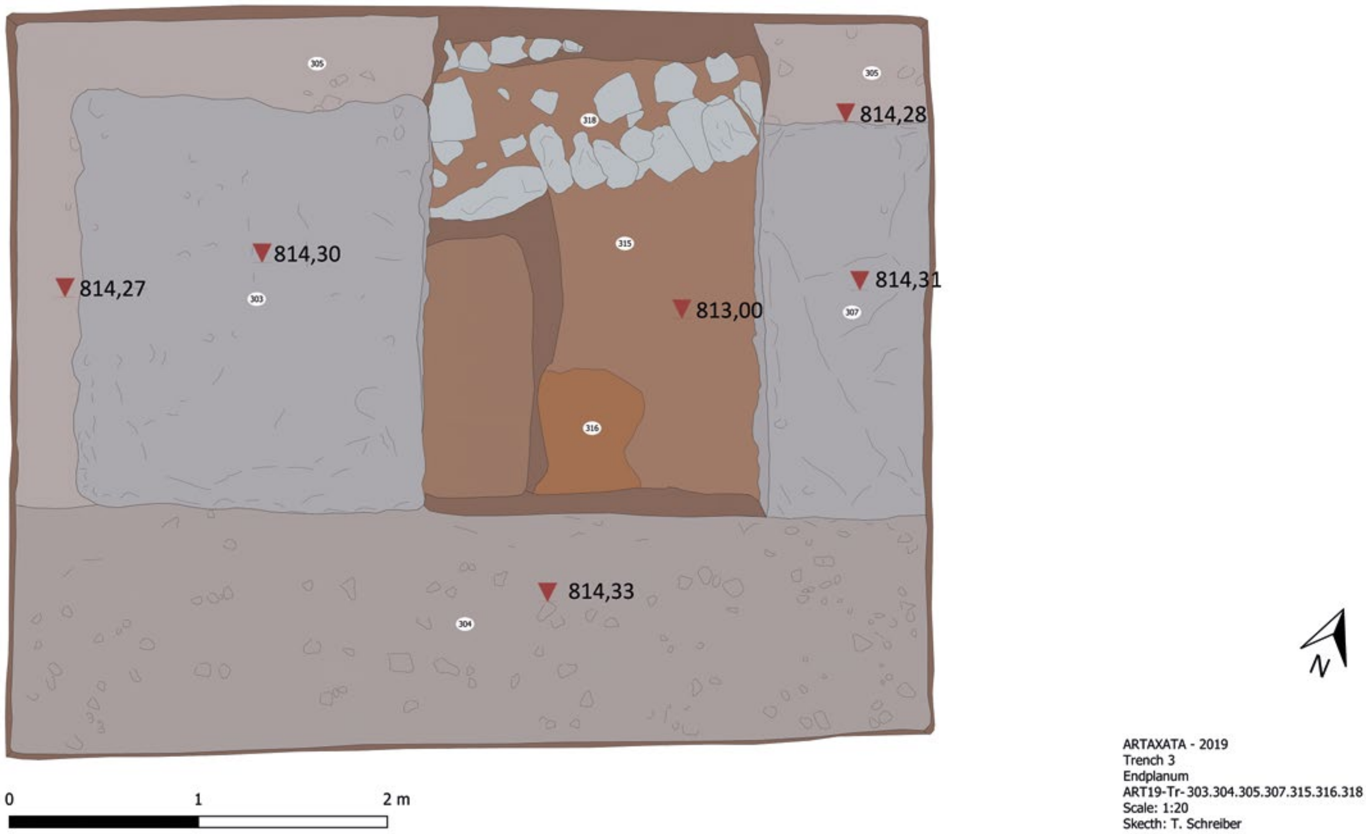
Fig. 9: Artaxata, results of the magnetic prospection in Artaxata 2018 and position of trenches Nos. 3, 8 and 9 (ART19-Tr-03. 08. 09)

wall-like structure (ART19-Tr-318, Fig. 5. 6. 10. 11. 12. 13) appeared 0.6 to 0.75 m below the upper edge of the blocks. This structure deviates significantly from the orientation of the blocks and is aligned more in a southwest-northeast direction. Due to the depth of 0.95 to 1.35 m below the field surface and the strong anomaly of the *opus caementicium* blocks, this structure was not captured in the geomagnetic measurements. This wall-like structure consists of unworked stones, which differ significantly in size. The length of this row of stones is 1.85 m, the width about 0.95 m, whereby it cannot be said with certainty that the northern row of smaller and the southern row of much larger stones actually belong to only one structure, especially since the space between them was only filled with earth. It can be assumed that the wall-like structure was cut by block 303 when it was erected, or that parts of the structure were removed in the course of the construction work in the area now occupied by the block. In the northeast, the ›wall‹ was only slightly affected during the construction of block 307.

22 The southern profile (Fig. 14) shows very clearly a sequence of several layers: layer 304 – the already mentioned solid stone and clay packing – is only 10 cm thick at most and of particular hardness. It has a large number of small stone inclusions – which divides it from layer 305 in the north – and is reminiscent of a recent road or paved patio which might accompany the line of *opus caementicium* blocks still visible until recent times. The following layer ART19-Tr-309, which is almost half a meter thick, is also very solid. ART19-Tr-311, ART19-Tr-312 and ART19-Tr-313, on the other hand, are much less firm and have a much higher sand content. Towards the deeper layer ART19-Tr-314, the clay content of the earth increases significantly, which makes this layer appear much more compact.



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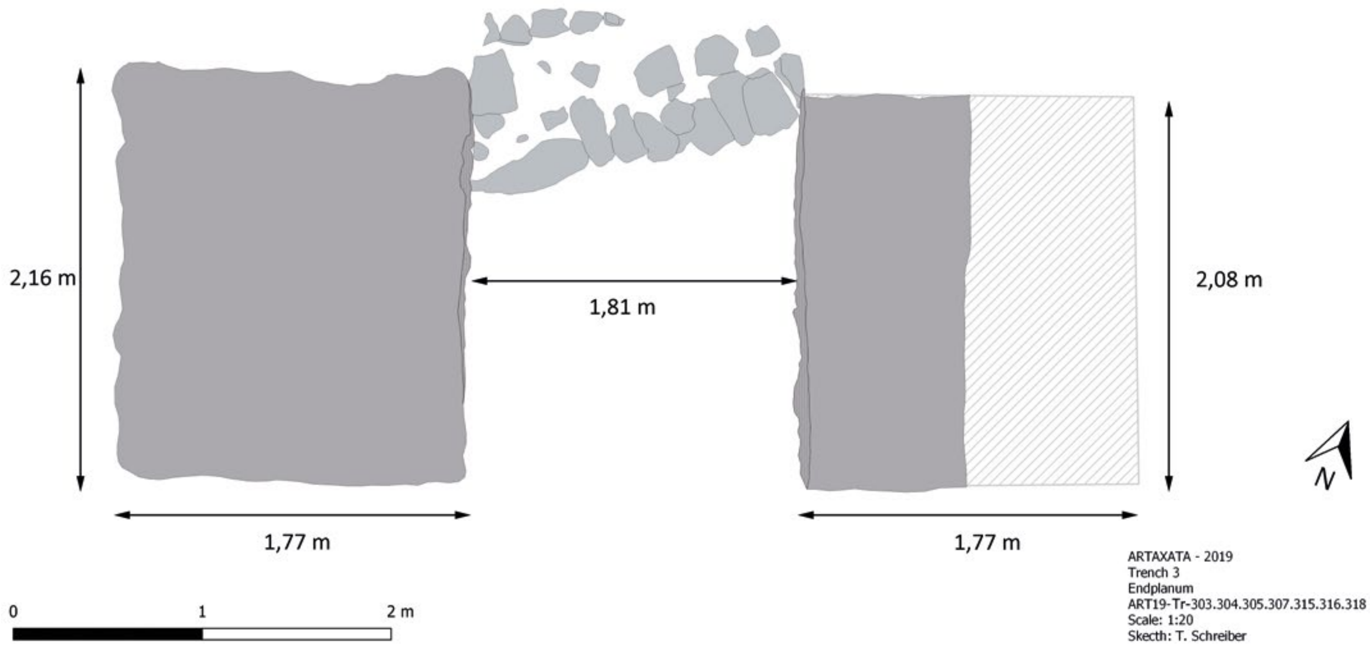

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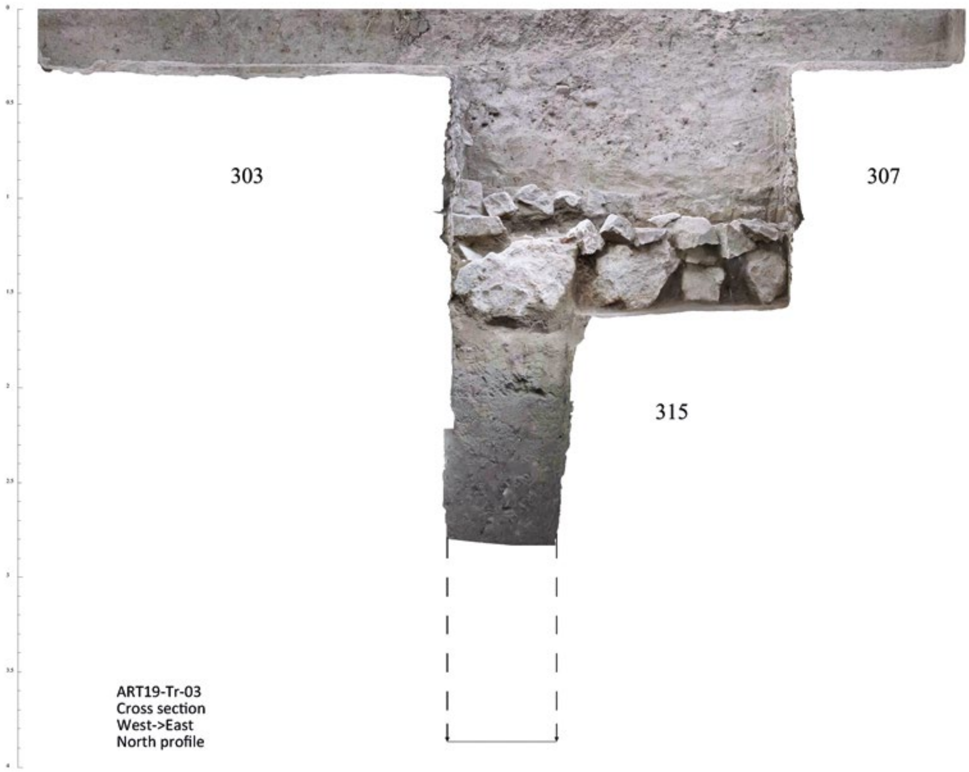
Fig. 10: Artaxata, drawing of trench No. 3 (ART19-Tr-03)

Fig. 11: Artaxata, drawing of aqueduct pillars and wall in trench No. 3 (ART19-Tr-03)

23 To further explore the depth of block 303, a strip of 1.5 m × 0.7 m east of 303 and south of 318 was deepened to reach the lower end of the block. Even after 3.6 m this was not reached and work in this area of trench No. 3 had to be stopped due to incoming groundwater. The exact depth of the structure thus could not be determined.

24 The north-eastern side of the block shows a rather smooth surface (Fig. 15) in the upper part down to a depth of about 1 m. Above the ›wall‹ 318 the surface of the block is much rougher. From a depth of approximately 1 m the surface structure chang-



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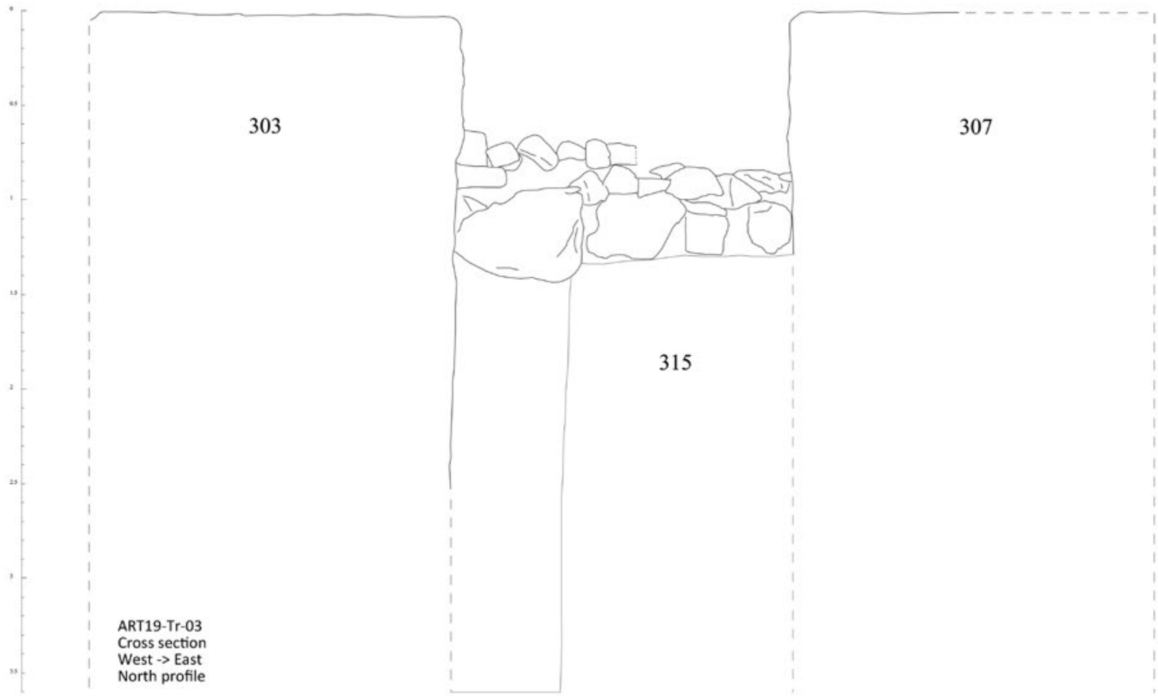

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es, and different layers can be seen. Horizontal lines with a thickness of up to 0.1 m can be observed, which must be related to the construction process. These traces can be interpreted as the layered filling of the *opus caementicium* which was necessary to allow the building material to dry sufficiently. The surface of the south-west side of block 307 shows these traces even more clearly (Fig. 16). Here the surface in the upper part is also much less smooth than in block 303. These differences can probably be attributed to

Fig. 12: Artaxata, orthographic cross section of trench No. 3 (ART19-Tr-03)

Fig. 13: Artaxata, drawing of orthographic cross section of trench No. 3 (ART19-Tr-03)

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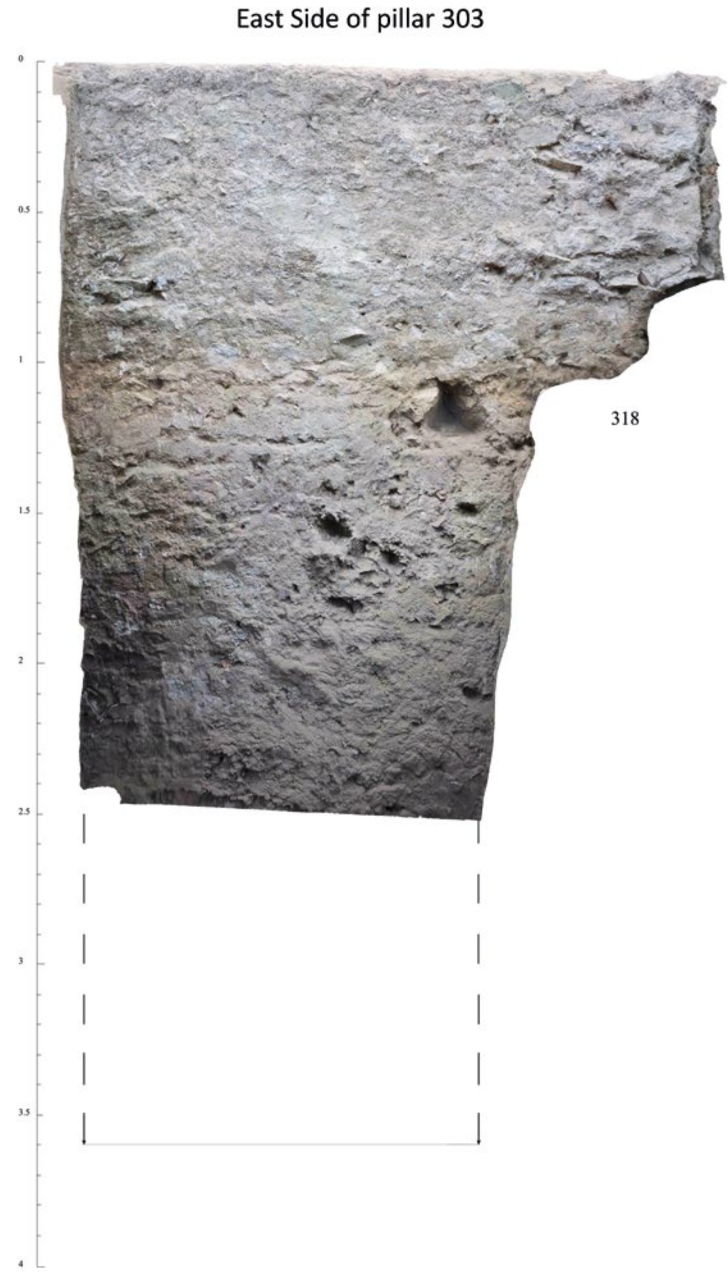

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Fig. 14: Artaxata, orthophoto of the southern profile of trench No. 3 (ART19-Tr-03)

Fig. 15: Artaxata, orthophoto of the east side of pillar ART19-Tr-303

Fig. 16: Artaxata, orthophoto of the west side of pillar ART19-Tr-307

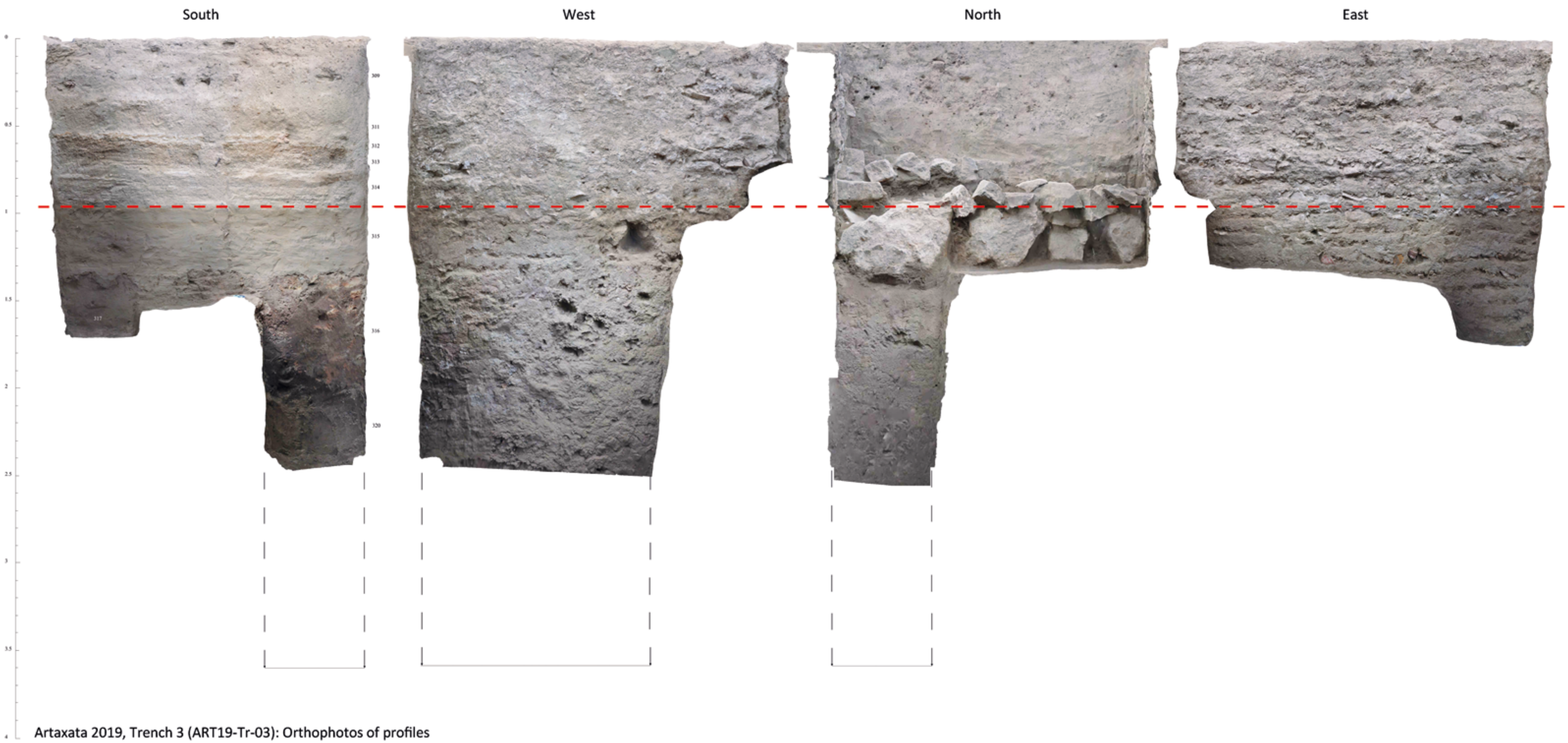


Fig. 17: Artaxata, orthophotos of the profiles of trench No. 3 (ART19-Tr-03)

the fact that the north-eastern side of block 303 was exposed to the elements, while the south-western side of block 307 was protected, so that traces of the construction process are more discernible here. However, this would also mean that the northern part of the surface of block 303 above the ›wall‹ 318, which appears coarser overall, was covered by a structure no longer preserved and was not exposed to the weather.

25 A more detailed study of the south-eastern profile of the section (Fig. 14) reveals clear traces suggesting that the *opus caementicium* blocks protruded about 1 m from the ground over a longer period and were visible on the surface. The upper layers 309, 311, 312, 313 and 314 are alluvial deposits. The exact time at which they have accumulated is still being investigated[33], but it is to be expected that these layers were formed in flood events. The level that can be described as the building horizon for the structures investigated by us must therefore be found below these accumulations of flood events (Fig. 17).

26 Below these layers lies the very homogeneous layer ART19-Tr-315, which has a clay-like consistency. After about 40 cm two further features come to light. A wavy line, which relates to a strong earthquake, runs through 315 towards the west[34]. There, feature ART19-Tr-316 emerges, which consists of partially burnt bricks or brick fragments that covered an ash pit (ART19-Tr-320). The wavy line passes over this ash pit and the brick cover. Below the wavy line the feature of the clay-like earth continues to the east, labelled here as ART19-Tr-317. The pit was dug into the clay layer 315/317 before the construction of block 303. The assumption that this pit is not directly related to the construction of pillar 303 was proven by a ^{14}C-dated charcoal sample from layer 316. The sample dates back to the 8th to 5th century B.C. and thus well before the assumed erection of the pillars[35]. This date is confirmed by Iron Age-Urartian pottery that was found in the pit. Whether the pit 316/320 has any connection with the construction of wall 318 remains open, although their chronological correlation is highly probable.

27 The lower end of the ›wall‹ 318 in the north of the trench lies on the same level as the wavy line in the south, but it is not attested below the wall. It is assumed that the construction pit for the blocks was dug into layer 315/317 and that the construction horizon lies above this feature. This also explains why the pouring lines of the *opus caementicium* are still visible in block 303 at the height of layer 315 and why they are ›washed out‹ above. The upper part of the blocks must have been visible for a long period.

28 The date of the *opus caementicium* pillars cannot be established by stratified finds, since layer 315, which was the construction layer, was empty of datable pottery. We therefore took a sample for optically stimulated luminescence (OSL) dating from layer 315. The analysis was done at the University of St. Andrews/Scotland, and the best estimate on the age of the accumulation is that it was deposited after 1.76 ± 0.20 ka (A.D. 260 ± 200). This implies that a date roughly between A.D. 60 and 460 can be assumed for the construction of the *opus caementicium* pillars.

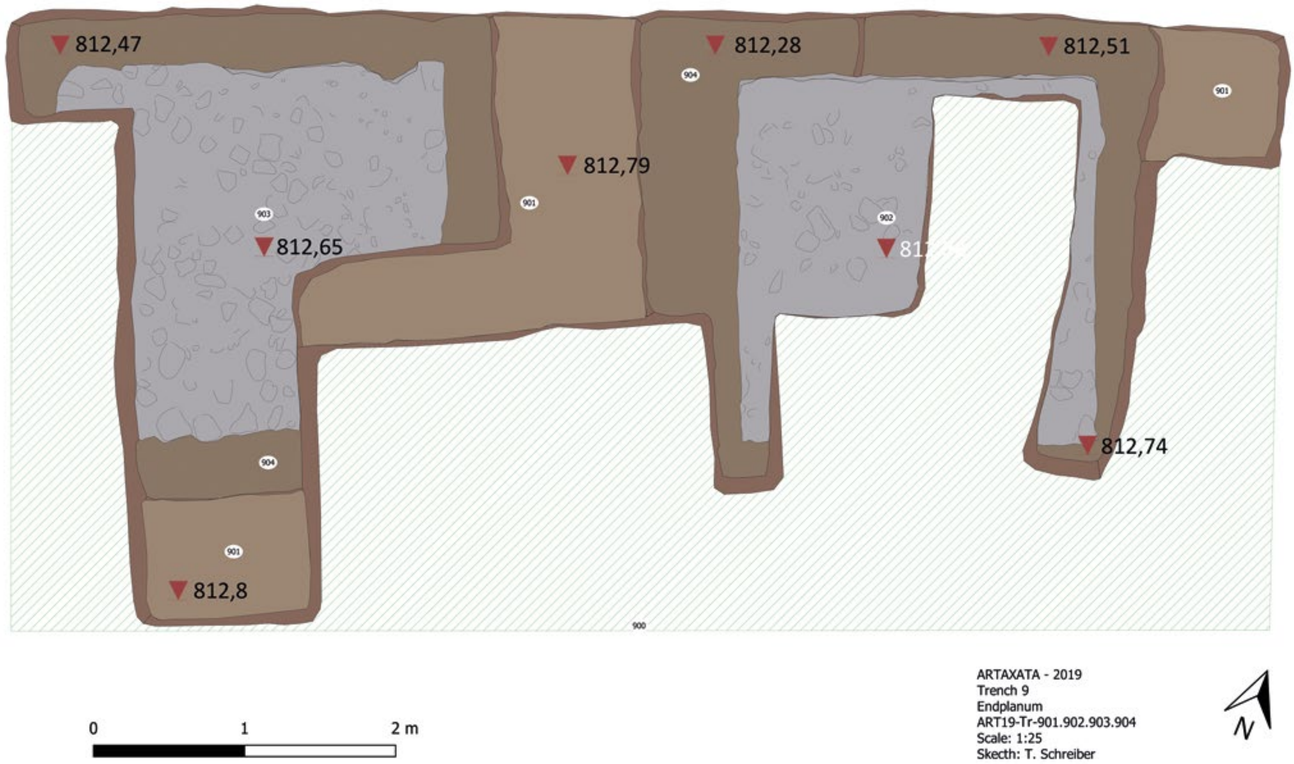
Trenches Nos. 8 and 9

29 Considering the two *opus caementicium* blocks from trench No. 3, it was clear that the long line of anomalies in the geophysical image actually constituted one structure and the only possible interpretation is that of aqueduct pillars. After the completion

33 Optically stimulated luminescence (OSL) analysis of four samples was conducted by Tim Kinnaird from the School of Earth & Environmental Sciences at the University of St. Andrews/Scotland. Cf. Avagyan et al. 2018.

34 This archaeologically registered earthquake will be a topic of a forthcoming study in collaboration with the Geodynamics specialists of the Institute of Geology of the National Academy of Armenia, Yerevan. Cf. Avagyan et al. 2018.

35 Sample no. 43801 (ART19-Tr-316), Curt-Engelhorn-Zentrum Archäometrie gGmbH, ^{14}C age 2431 ± 23 BP, δ^{13}C (AMS) -29.2, calibration curve IntCal13, 1σ B.C. 697–415, 2σ B.C. 745–407 (95,4 %).



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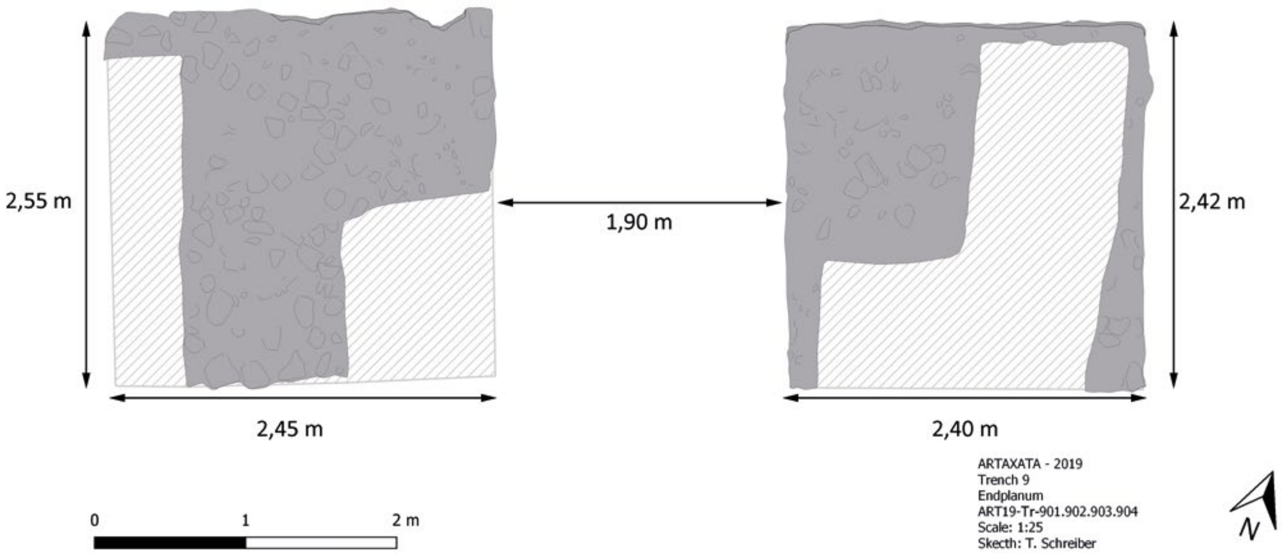

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of the earthworks in trench No. 3, an attempt was made to reach the south-western end of the ›pillar line‹ and potentially adjoining structures by the layout of trench No. 8 in a grass field (Fig. 9). In this area covering approximately 42 sqm, however, no archaeological features were detected in a depth of up to 1.5 m. Later drilling at this location was able to prove a structure at a depth of 3.4 m below the modern surface[36].

30 Another trench (ART19-Tr-09) 12 m further to the northeast was laid out, because here the anomalies in the magnetogram are shown more clearly. Here the surface of two further *opus caementicium* blocks (ART19-Tr-902.903) were uncovered at a depth of 0.45 and 0.58 m, respectively (Fig. 18 and 19). Around the two blocks, the

Fig. 18: Artaxata, drawing of trench No. 9 (ART19-Tr-09)

Fig. 19: Artaxata, drawing of aqueduct pillars in trench No. 9 (ART19-Tr-09)

36 This drilling was done by Nikolaas Noorda, Groningen, in March 2020.

earth was deepened by 0.2 to 0.6 m to expose the outer edges. Apart from the two blocks, no archaeological features were detected in the area of trench No. 9.

31 Block 902 in the eastern part of the trench has a regular layout of 2,45 m × 2,45 m. Block 903 follows at a distance of 1.96 m from the south-western edge of 902. It measures 2.52 m × 2.52 m and is therefore square as well but slightly larger than 902. The distance between the centres of the blocks is 4.5 m and therefore 0.9 m more than between 307 and 303.The elevation of the surface is 812.63 m a.s.l. for block 902 and 812.87 m a.s.l. for block 903. Thus, a height difference of 0.24 m can be determined. This corresponds to the observation that the height of the block surfaces decreases from east to west (Fig. 7). The difference in height from block 307 to block 903 is 1.42 m over a distance of approximately 139 m measured centre to centre. This value is slightly lower than the decrease of the present-day terrain by about 1.5 m from the area of trench No. 3 to the area of trenches No. 8 and No. 9.

32 The blocks in trenches No. 9 and No. 3 differ not only in shape, size and height, but also in texture. It is noticeable that the blocks 902 and 903 are much rougher on the upper surface and have inclusions of more and even bigger stones than blocks 303 and 307. However, modern disturbances and damage to the aqueduct pillars must be expected in this area, resulting in a lower height of the pillars.

33 South of the pillars 902 and 903 no archaeological features were found. This corresponds roughly to the magnetogram (Fig. 3 and 4), which in this area does not show the anomaly accompanying pillars 303 and 307 – in the case of the two north-eastern pillars the compact stone packing 304[37].

34 The varying distance between the pillars in this area and the much larger circumference of these may indicate the approaching end or change of direction of the structure. The clear difference in height compared to the pillars in trench No. 3 can possibly be explained by the fact that not even the pillars uncovered in trench No. 9 were completely cast and finished here. According to the magnetic survey the pillars following in a south-western direction – proven by the later drilling – may have been left standing in an even earlier stage and the signal therefore appears so thin.

35 In any case, the construction work at none of the sites investigated progressed beyond the foundation stage. Nowhere were elements of above-ground construction detected, so it is safe to say that the aqueduct remained unfinished. The features in trench No. 9 indicate that in the south-western part not even the foundation blocks were completed.

Searching for Further Pillars

36 Parallel to the excavation work in trench No. 9, small sondages were carried out along the projection (a white dotted line in the magnetic image) to search for the pillars in between. A total of eleven further pillars were found (Fig. 20). Starting from block 303, nine pillars were recorded to the southwest.

37 Due to an inaccessible corn field in the southwest, no immediately adjacent pillar could be investigated, so that the search was continued southwest of the field. Here, however, two factors came together which made it impossible to detect further pillars on the basis of the sondages, as the results in trench No. 9 made clear: somewhere on the line between the last pillar before the corn field and trench No. 9, the distance between the pillars changes and they are significantly deeper, at a depth of about 0.5 m below the surface.

38 Starting from block 307, the neighbouring pillar – the last one visible in the magnetogram to the north-east – was detected. Three blocks spaced 3.6 m apart – from

37 A strong anomaly south of pillar 902 was interpreted by the geophysicists as a modern disturbance and was apparently not affected by the archaeological earthworks.

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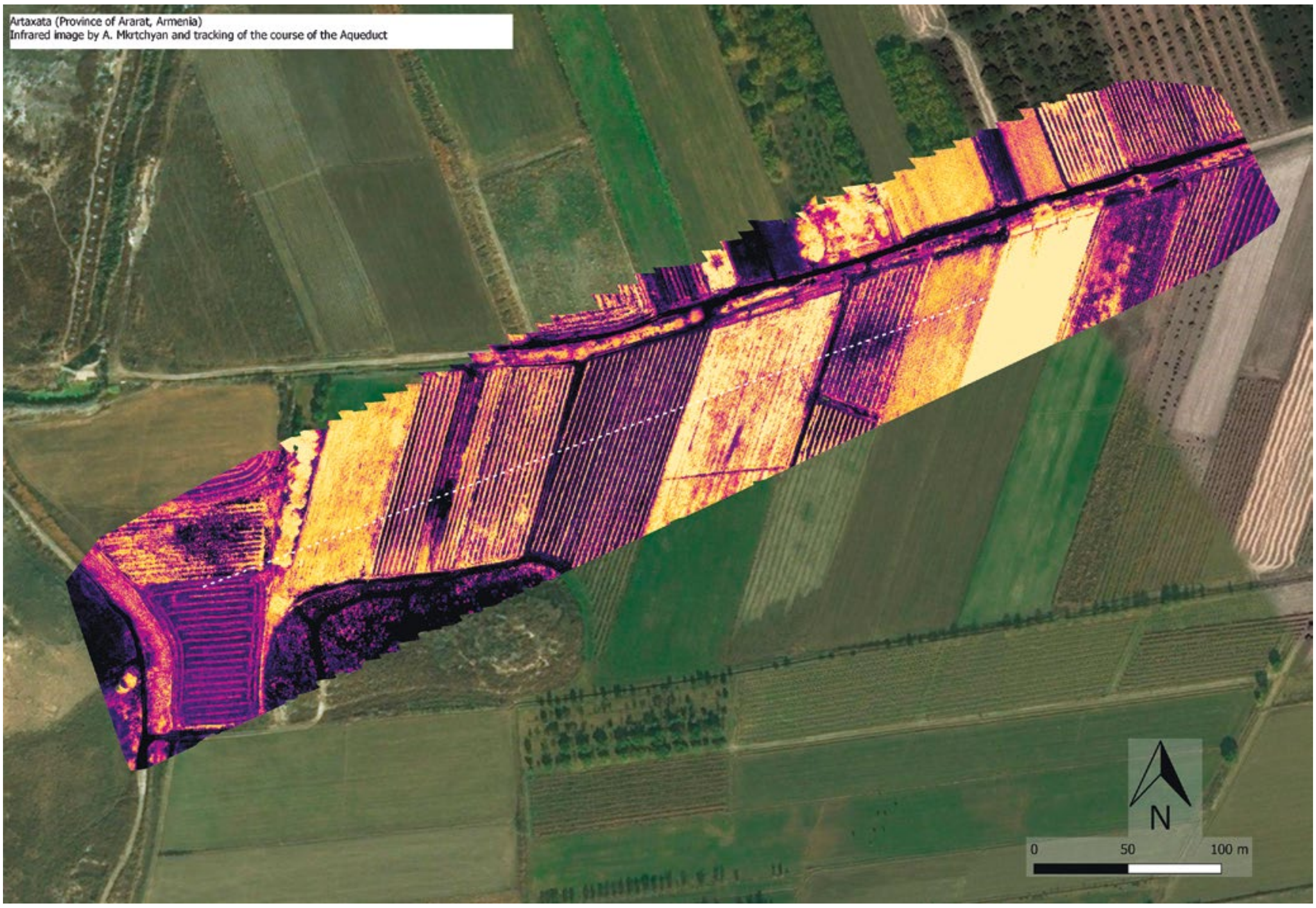

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Fig. 20: Artaxata, results of the magnetic prospection in Artaxata 2018 and position of excavated pillars and suspected pillars

Fig. 21: Artaxata, infrared image of the area N-NE of Hill XIII from 2019

centre to centre – were discovered in this area. Accordingly, at a field boundary 61.2 m north-east of block 307, a further sondage was carried out that revealed another pillar. Thus, a continuous row of pillars at regular intervals can be assumed here. If this is the case, another approximately 15 pillars must be assumed in between. The attempt to uncover another pillar at a distance of 75.6 m north-east of the last found pillar was unsuccessful, but all in all the pillars have now been traced (by means of an archaeological investigation) over a total length of approximately 200 m, measured from block 903 in the south-west to the last one detected by a sondage in the north-east (Fig. 20, red crosses).

39 Adding another 200 m of aqueduct course that are visible in the distinct soil and vegetation patterns of the Google Earth image to the east (Fig. 8), the aqueduct can be traced for about 400 m overall. In order to further investigate the course to the east infrared spectral drone imagery was applied[38]. This allowed us to reveal an additional 60 m of the aqueduct in the eastern direction (Fig. 21). In total, the aqueduct can now be traced for at least 460 m: approximately 200 m by archaeological sondages, 200 m by Google Earth, and 60 m by infrared photography.

The Roman Aqueduct at Artaxata

40 The explored structure consisting of massive blocks of *opus caementicium* set at regular intervals must be interpreted as the remains of pillars of an arched Roman aqueduct (or aqueduct bridge)[39]. There is no alternative interpretation for this kind of construction. Since only the *opus caementicium* foundations were found and no remains of a collapsed suprastructure were evident, it is obvious that this aqueduct was never finished and construction stopped at the foundation stage. Clearly the aqueduct never brought water into the city[40]. The aqueduct bridge typically is the last section of an aqueduct bringing water into a city lying in the plain[41]. Remarkable in the case of the Artaxata aqueduct is the ratio between the dimension of the pillars and the intervals. In Artaxata, the intervals are smaller than the length of the piers. Usually aqueducts use a maximum span of arches for a good value construction[42], but in cases when such arcades are erected in seismic areas (such as the Ararat valley) ›pycnostyle‹ constructions were implemented to guarantee stability and robust arches. Such ›pycnostyle‹ pillars were e. g. used for the 1st century A.D. aqueduct in Tyre and became more common in late antiquity[43]. Also, the wet underground in Artaxata might be an explanation not only for the very deep foundations of the piers but also for the narrow intervals. Therefore, the short intervals between the piers attest to a good knowledge of the engineers about the local situation and conditions of the construction.

38 The drone photography of the territory covering appr. 100 ha and further analyses of the images were done by Arshaluis Mkrtchyan, Institute for Archaeology and Ethnology of the National Academy of Science of Armenia.

39 On Roman aqueducts see, e. g., Grewe 1985; Hodge 1992; Kek 1996; Döring 2016.

40 It can be discussed whether the aqueduct linked into an older water supply system of Artaxata. The likely termination point of the aqueduct coincides with an area from which several linear features seen as anomalies in the magnetogram embark south (Lichtenberger et al. 2019, 83). We tentatively interpreted these features as possible streets, but of course water pipes are also possible interpretations. This needs to be explored through excavations in the coming years.

41 Cf. e. g. Hodge 1992, 161. 170.

42 Pace 1983, 47; Aicher 1995, 14.

43 Kahwagi-Janho 2016, 146–149. Cf. e. g. the late antique aqueducts to Constantinople (Crow et al. 2008, 93–99 and Crow in press). One also needs to mention that in some cases aqueducts later were strengthened by broadening the piers or closing the intervals such as in the case of the Samosata aqueduct (Fig. 23). On such repairs see also Pace 1983, 50; Hodge 1992, 168.

Dating the Artaxata Aqueduct

41 The dating of the construction of the aqueduct according to the OSL can be narrowed down to a period between A.D. 60 and 460. The construction material, *opus caementicium*, was typical of the Roman construction method and therefore it can be assumed that Roman workmen were involved[44]. The cement was a lime and sand mortar of fine Roman quality, containing among other things volcanic sand (on the analysis of the *opus caementicium* see the appendix A by Arnaud Coutelas). The detailed analysis of the geochemical characterization is published to create a baseline for further plaster and mortar studies in the region which are still lacking. In particular the characterization of the ›Romanness‹ of the receipt is crucial to underline the Roman involvement in the construction.

42 In the period A.D. 60–460 two historical scenarios are likely:

– The first scenario is soon after A.D. 66 when, following the Roman destruction of Artaxata under emperor Nero (A.D. 59), the Romans paid reparations to king Tiridat I, and Tiridat used the money to employ Roman workshops to rebuild the city[45].

– The second scenario is between A.D. 114–117, when emperor Trajan had conquered Armenia and established a province with the capital of Artaxata. It was during this period that a Roman legion was based at Artaxata and the Roman administration forcefully tried to establish the infrastructure of the new Roman province. Particularly from this period different types of lime mortar (including *opus caementicium*) were commonly used in the architecture of Artaxata[46].

43 Although the archaeological dating evidence is not conclusive, we are inclined to favour the second scenario, namely a dating of the aqueduct construction to the time of the unsuccessful attempt to establish a Roman province of Armenia under Trajan. This scenario best explains why the construction was unfinished: there would be no explanation – apart from mismanagement which of course cannot be ruled out – for stopping the work under Tiridat I after A.D. 66. However, the expulsion of the Romans in A.D. 117 would be a plausible explanation for the sudden halt in construction. Assigning the construction of the aqueduct to the time of Trajan would also be consistent with the sheer size of the project. Building an aqueduct was a mega project that in the Roman period was often done by the army. The presence of the Legio IIII Scythica, the *operosa felix*, at Artaxata would perfectly fit to such a construction that was meant to serve the capital of the new province. Therefore, it is most likely that the construction of the aqueduct can be dated to A.D. 114–117.

Roman Aqueducts in the East and the Roman Army

44 The unfinished aqueduct in Artaxata is the hitherto easternmost evidence of a Roman aqueduct constructed on arches. Arched sections of water pipes were usually either used to bridge valleys or constructed at the end of an aqueduct when the water pipe was already close to its destination and a maximum of pressure was needed for further distribution[47]. Such arched aqueducts which are cost-intensive ventures and require a technological knowledge of *opus caementicium* construction are typically found in Roman contexts. Because of the technological knowledge and the labour-intensive work, the Roman army was often involved in such constructions.

45 Evidence for this is found in Palestine, where the high-level arched aqueduct of Caesarea Maritima (Fig. 22) was constructed by Roman army units as attested by a

44 On *opus caementicium* cf. Lamprecht 1996 (p. 89–108 on the use in aqueduct constructions).

45 Cass. Dio. 63, 6, 6.

46 Khachatryan 2013; Zardaryan 2016 (2020).

47 Cf. Grewe 1985, 53.

22

Fig. 22: High level aqueduct of Caesarea Maritima

23

Fig. 23: Aqueduct bridge at Samosata

total of ten Latin inscriptions[48]. Another monumental arched aqueduct was erected in Tyre in Phoenicia in the 1st century A.D., but it is not known who was responsible for its construction[49]. The aqueducts of Antioch on the Orontes likewise were built with the advent of the Romans and possibly with imperial involvement[50]. The same is true for the early imperial arched aqueduct of Apameia[51]. We have no information about the builders of the large aqueducts in Commagene, namely in Samosata (Fig. 23) and Cyrrhus, but it can be assumed that they too were built with Roman involvement[52].

48 Lehmann – Holum 1999, 71–79 nos. 45–54; CIIP II, 1200–1209. For the aqueduct see most recently Gendelman – ʻAd 2019, 26–32.

49 Kahwagi-Janho 2016, 109–178.

50 Wilber 1938; Leblanc – Poccardi 2004.

51 Balty 1987, 16–21; Vanesse 2011, 191.

52 Dörner – Naumann 1939, 54–61 (Samosata). The arched aqueduct in Cyrrhus (north of the city and on the eastern bank of the river Afrin) is yet unpublished (personal communication M. Blömer, Münster). Regarding a possible arched aqueduct in Doliche, cf. Todt – Vest 2014, 11 f.

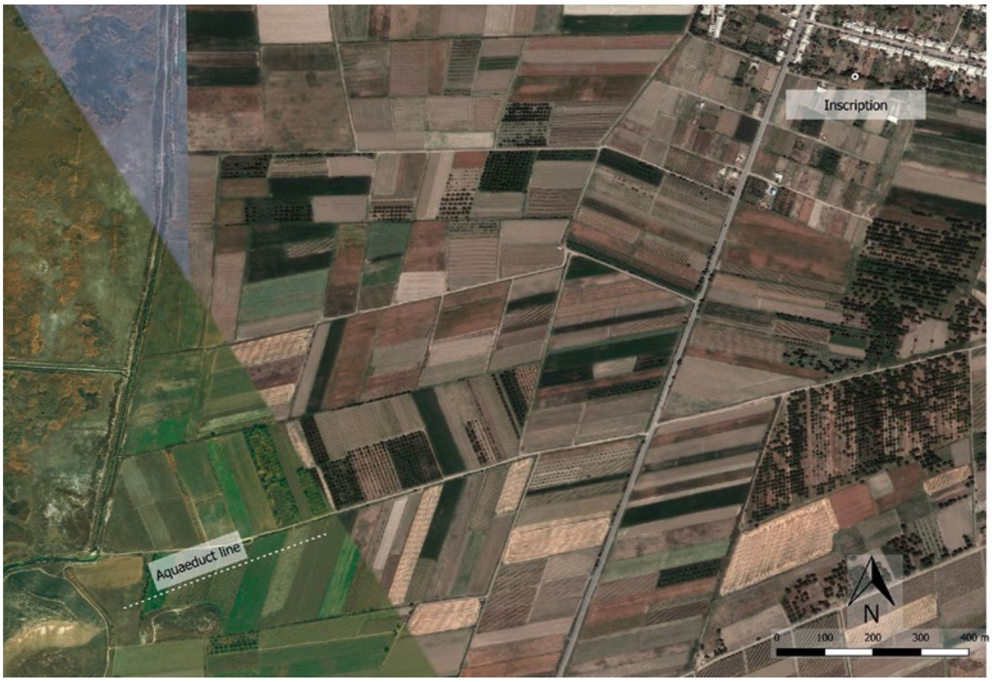

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Fig. 24: Artaxata, findspot of the Inscription from Pokr Vedi in relation to the aqueduct line

At Jerusalem, Roman army units were for sure involved in the construction and repair of the high-level aqueduct as attested by a series of inscriptions found in the vicinity of Jerusalem[53]. The aqueduct of Eleutheropolis in southern Judaea was likewise constructed by Roman soldiers; an inscription on a rock-cut section attests to this[54]. Di Segni, who studied the Palestinian evidence and collected epigraphic testimonies of Roman army aqueduct constructions even goes a step further and suggests that all the larger aqueducts in the region need to be explained by the presence of the Roman military and in fact were constructed by Roman military units[55]. This is supported by the evidence for other aqueducts in the Western provinces, where the Roman army was responsible for aqueduct construction[56].

46 Therefore, it is likely that the aqueduct of Artaxata was also planned and built by the Roman army and it ties into a series of such structures further West, stretching from Commagene to Northern Syria and into the Southern Levant.

47 Despite sophisticated discussions about ›Romanisation‹ in recent scholarship, which resulted in a complete dismissal of the term[57], the aqueduct of Artaxata can indeed be regarded as a marker of Roman presence and Roman influence. It is directly connected to the attempt of the Romans as an invading power to establish Roman rule in this part of the world and, therefore, the term Romanisation seems appropriate. Although it is not possible to directly relate the monumental Pokr Vedi inscription of the Legion IIII Scythica to the construction of the aqueduct, it nevertheless attests to the engagement of the hard-working legion in an area in line with the orientation of the aqueduct. The inscription was found approximately 1.45 km northeast of the easternmost tracked part of the aqueduct and ca. 500 m north of the reconstructed line (Fig. 24). If the inscription related to a bridge as suggested above, this bridge would have been also the likely location of an aqueduct crossing a river.

53 Di Segni 2002, 40–47.

54 Di Segni 2002, 51 f.

55 Di Segni 2002, 52 with note 90.

56 MacMullen 1959, 214–218; Di Segni 2002, 55. See also CIL III 762 (Odessus).

57 Gutsfeld et al. 2019.

48 We have no firm evidence how long the aqueduct was originally meant to be and from where it was supposed to bring water into the city. However, approximately 30 km to the east of the city, the springs of the Vedi river are an excellent option for bringing water into Artaxata (see the appendix B by Barbora Weissova). They are strong and the distance to the city, the new capital of the Roman province, is not too far, comparable to the 32 km length of the Samosata aqueduct[58].

49 The unfinished aqueduct of Artaxata is proof of a failed Roman Imperialism in Armenia and an impressive testimony to the Roman attempt to establish a Roman province. If finished, the monumental arches and the abundance of running water would have turned Artaxata into a Roman city. It would have been the easternmost Roman arched aqueduct in the ancient world. This was not meant to happen, and after the Roman legion was driven out of Armenia in A.D. 117, Artaxata continued to prosper as the capital of the Arsacid royal dynasty.

Appendix A: Lime Mortar from an Aqueduct Pillar at Artaxata

50 In recent years there has been a renewed interest in the study of archaeological lime mortars[59]. One of the lessons learned from this work is that there are many analytical techniques that can be used for the characterization of mortars. All of them have their advantages as well as their disadvantages. Some are destructive. Others reveal only partial information.

51 Petrography can compensate for this[60]. The importance of the inspection of the materials through the transmission optical microscope is evident[61]. It is an indispensable component to any study of lime mortar, as it enables one to obtain a real image of the structure of the material, its porosity and the presence of lime lumps, etc.[62].

52 Petroarchaeological studies consider ancient lime mortars as the products of know-how and integrate both archaeological data and the results of optical petrographic analyses of the materials. A first synthesis was presented at the end of the 2000s[63]. Numerous studies have since followed, making it possible to render not only an operating chain of the lime mortar but, more generally, a ›technical chain‹ identifying the parameters and relationships that influence the final composition of the material or the rendering[64].

53 It is these analytical insights that motivated the petroarchaeological study of a sample of the construction mortar from one of the pillars of the Artaxata aqueduct. The objective was to establish what the composition of the material was, and to compare this composition with those types known to the Roman world, in order to understand whether there was a specific choice of recipes for the construction of this building. No such investigation has yet been undertaken in Artaxata.

Fig. 25: Artaxata, sample ART19-Tr-212, pillar surface

25

58 Dörner – Naumann 1939, 60.

59 The city of Pompeii, in particular, provides many examples. See Castriota et al. 2008, 299; Miriello et al. 2010; Piovesan et al. 2011; De Luca et al. 2014.

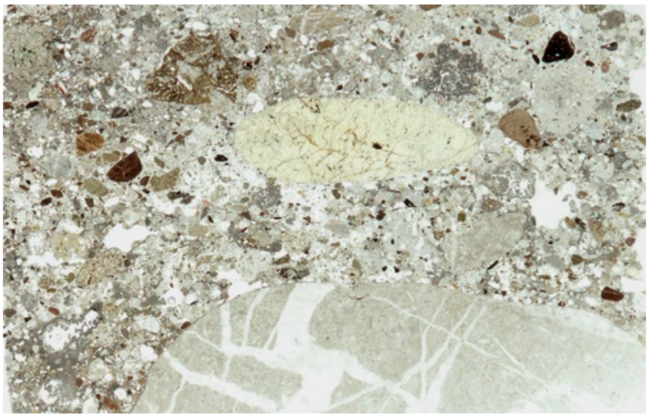
60 Palazzo-Bertholon 1998; Büttner 2003; Coutelas 2003.

61 Elsen 2006.

62 Pavía – Caro 2008.

63 Coutelas et al. 2009.

64 Coutelas 2011.



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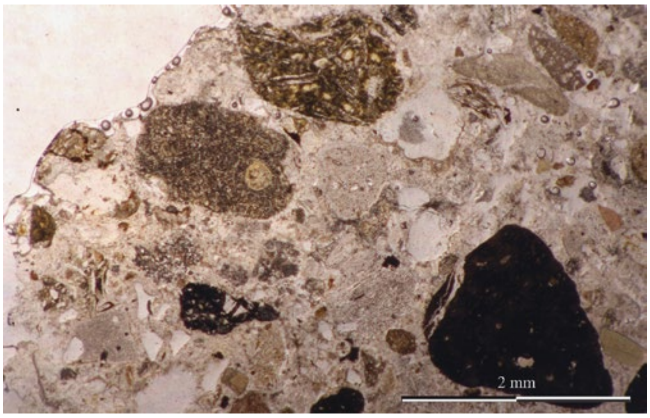

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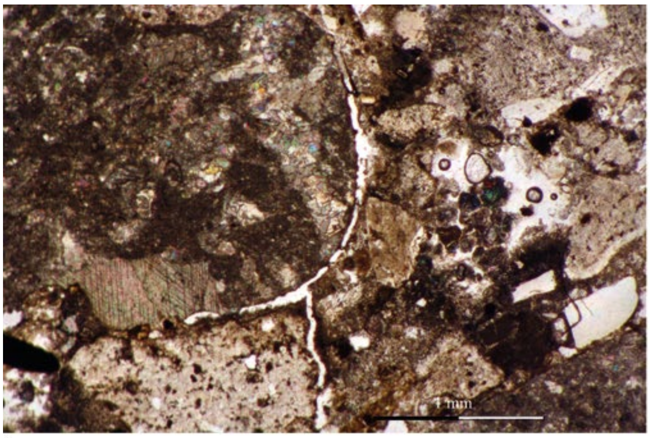

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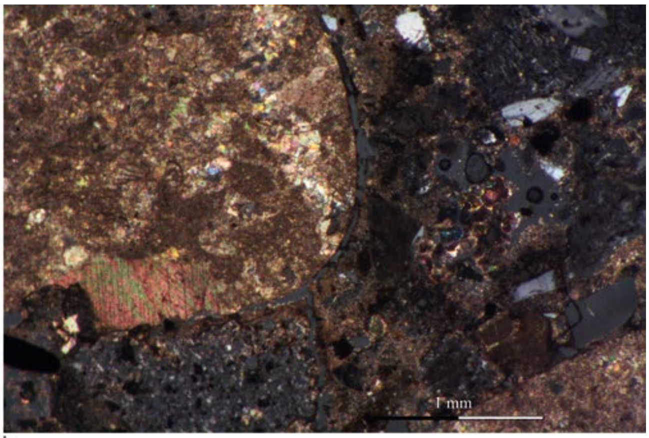

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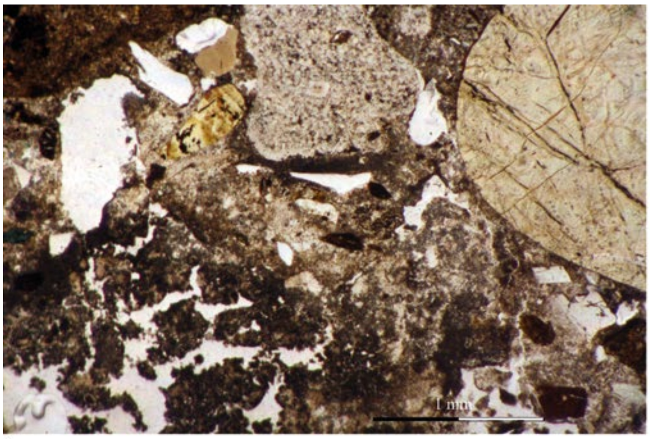

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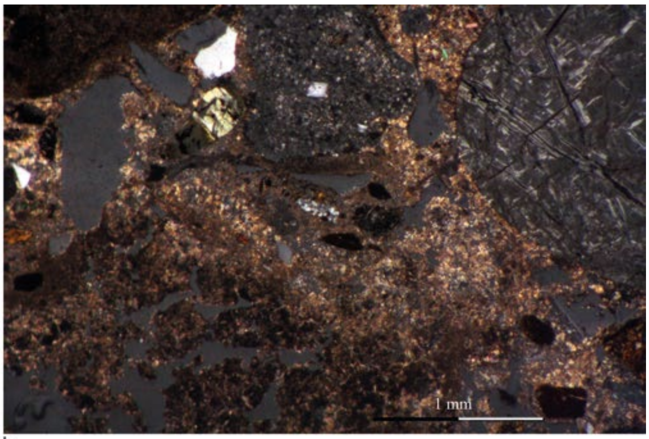

b

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Composition of the Mortar

54 The selected mortar sample is ARTA-19-212. It was taken from the surface of one of the pillars in trench No. 3, block 307 (Fig. 10). The fragment measures about 6 cm × 10 cm, is 5 cm thick with a fairly smooth surface (due to the formation of a concretion film?) and a reverse side with centimetric rock chips from the block of the pillar (Fig. 25).

55 In macroscopy, to the naked eye, the mortar is chalky in texture, compact and of good quality. It is light beige-grey in colour, with frequent millimetre-sized lime

Fig. 26: Artaxata, thin section of ART19-Tr-212 mortar. The image measures 2.40 cm × 3.60 cm

Fig. 27: Artaxata, microphotography of the ART19-Tr-212 thin section in natural light. One can see the basalt grains in the middle of the light beige lime matrix

Fig. 28: Artaxata, microphotographs of the ART19-Tr-212 thin section in plane polarized light (left) and in crossed polarized light (right), showing, in particular, in the upper left half a limestone grain with large calcite crystals

Fig. 29: Artaxata, microphotographs of the ART19-Tr-212 thin section in plane polarized light (left) and in crossed polarized light (right). The major part of the image corresponds to the matrix of the mortar, covered with many voids and with a heterogeneous aspect, more or less clear in natural light and more or less birefringent in crossed polarized light. Some of the less bright areas correspond to ranges of hydraulic compounds

lumps of flattened shape. Some small flattened voids can be seen. The aggregate corresponds to mainly siliceous sand, from colourless to dark grey. The grains are matt, blunt, fine to coarse. There are a few small black grains and rare yellow to light ochre millimetre sherds of pottery.

56 The sample was prepared as a thin section, with induration, and then thinning to a thickness of 30 µm (Fig. 26). Under microscopy, a lime to aggregate ratio of 1 : 3 to 1 : 4 was determined. Three-quarters of the aggregate are made of silica sand: volcanic sand mainly (basalt; Fig. 27), quartz, feldspars/plagioclases, biotite and staurotide(?). The grains are between 100 and 500 µm in diameter or they are millimetric. They are blunt. The remaining one-quarter consists of limestone grains: fragments of biomicrite with crystallizations of sparry calcite in the voids (Fig. 28).

A ›Semi-Hydraulic‹ Matrix

57 The mortar matrix is heterogeneous in appearance (Fig. 29). Some areas are characteristic of recrystallized aerial or slaked lime, while others show losses of birefringence characteristic of the formation of so-called ›hydraulic‹ compounds, calcium aluminosilicates with variable ratios, as can be observed in present-day cements. These compounds notably allow the mortar to set more quickly and have better water resistance.

58 Scanning electron microscope observations carried out at the ERM laboratory (Poitiers, France), supplemented by elementary chemical analyses[65], made it possible to specify the chemical nature of the phases present. The chemical compositions are mainly silico-calcic (Fig. 30) with the notable presence of aluminium, magnesium, sulphur and iron.

59 These compounds may be present in a lime mortar if the lime used is hydraulic lime, or if »pozzolanic reactions« have occurred between slaked lime and aggregate[66]. It is known from Michel Frizot's bibliographical research as well as his work on a large number of mortars from Roman Gaul[67], that the limes used by ancient builders were slaked lime, often very pure. This is in line with the prescriptions given in the few ancient texts that have come down to us, especially those of Vitruvius, who recommends the calcination of the hardest and whitest possible stones[68].

60 The term »pozzolanic reactions« comes from the word »pozzolana«, volcanic ash from Pozzuoli (in the Bay of Naples) that Vitruvius recommended for making mortars for immersed masonry. This ash is characterized by the presence of a vitreous phase rich in silica and alumina, soluble in very basic conditions and therefore potentially reactive in contact with the calcium hydroxide of slaked lime[69].

	Cl	MgO	Na_2O	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	FeO	SO_3	Total
ART19-Tr-212 binder, area of 90 × 68 µm (c)	0,39	1,59	0,46	6,46	29,09	0,72	55,24	0,10	0,00	1,49	4,47	100,00
ART19-Tr-212 binder, area of 90 × 68 µm (b)	0,20	1,31	0,39	5,87	27,08	0,52	59,23	0,08	0,00	0,99	4,34	100,00
ART19-Tr-212 binder, area of 90 × 68 µm (a)	0,33	1,26	0,43	5,10	22,17	0,50	64,91	0,00	0,09	1,06	4,15	100,00
ART19-Tr-212 layer on aggregate	0,03	1,21	0,07	2,43	7,05	0,25	87,04	0,02	0,05	1,03	0,80	100,00

30

Fig. 30: Artaxata, chemical compositions of zone surfaces of the binder. They are expressed as oxides normalized to 100 percent

65 The microscope used is a JEOL JSM IT500 LV (Low Vacuum) type microscope equipped with an Everhart-Thornley type secondary electron detector. The analysis system is the QUANTAX system from *BRUKER AXS Microanalysis* equipped with a Peltier-cooled detector Silicon drift XFLASH X-ray fluorescence (E.D.S.).

66 Coutelas et al. 2004.

67 Frizot 1975.

68 Vitr. 2, 5.

69 Coutelas et al. 2004.

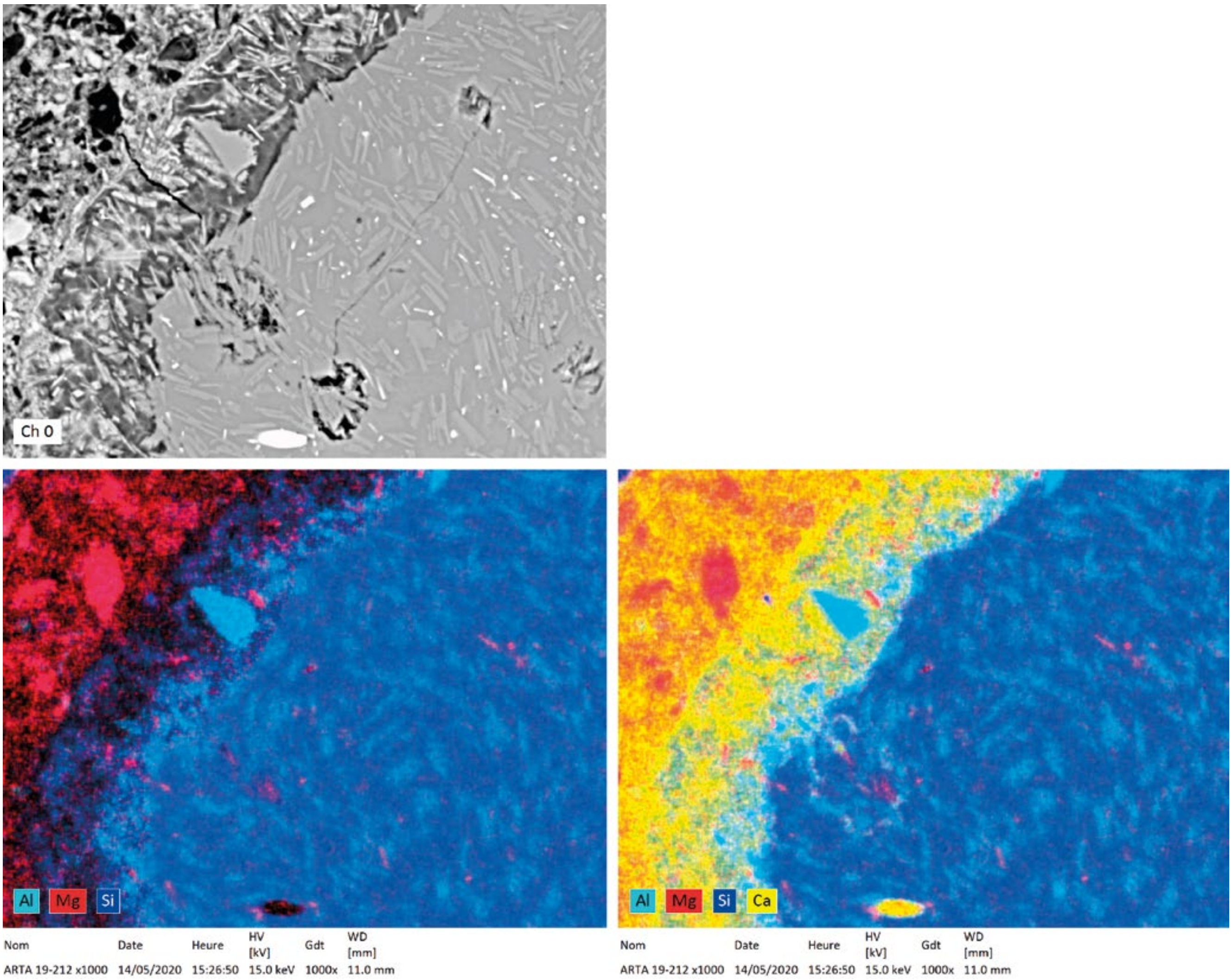

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Fig. 31: Artaxata, reaction fringe developed on a microlithic structure of a grain (basaltic lava fragment). Combination of elementary distribution maps of aluminium, magnesium, silicon and calcium over the area

61 The aggregate of the ART19-Tr-212 mortar consists mainly of volcanic sand. It is not volcanic ash and therefore not pozzolana, but the chemical composition is close to that of pozzolana, and it is, moreover, a material with a particularly sensitive glassy phase. It is thus this volcanic sand that induced the formation of hydraulic compounds within the matrix, following pozzolanic reactions with lime. Scanning electron microscope analyses revealed the existence of reaction fringes where basaltic glass was ›consumed‹ and replaced by calcium silicate minerals (Fig. 31).

Discussion

62 The ART19-Tr-212 mortar is a high-quality mortar. The making was not perfect, since there are frequent lumps of lime, but this is undoubtedly due to the large volumes of material required when erecting a monumental structure such as an aqueduct.

63 The recipe used is common for the Roman world, with one part of slaked lime to every three to four parts of natural sand. This sand is largely made up of volcanic sand. It is questionable whether this was a deliberate choice in order to obtain a better-quality material, with hydraulic properties, or whether it was just coincidence due to the abundant presence of this sand in the local geological environment. This question is all the more relevant since this building could be related to a hydraulic function.

32

Fig. 32: Artaxata, sample of sand from the Arax River (from modern context)

64 The presence of mortar containing hydraulic compounds however does not mean that the structure was related to the presence of water[70]. Especially since ›real‹ hydraulic mortars, those made for water-related structures, were made from specific recipes (use of pozzolana, sherds of pottery) and used mainly for rendering (plaster, concrete floors). In this case, it is a masonry mortar. The aggregate contains very few sherds of pottery, which appear to be impurities. The sand is volcanic, but it is not strictly speaking ash. What is more, this sand is certainly of local origin, present in large quantities. The geology of the Armenian Highlands is indeed characterized by many volcanic phenomena. Comparison with a modern sand sample from the nearby Arax River in particular shows strong similarities (Fig. 32): the same composition of minerals and rocks and the same granulometry. Only the gravel of metamorphic rocks is not present in the mortar. The choice of the masons was therefore not for a specific aggregate, but for an easily available aggregate.

A. C.

Appendix B: Modelling a Feasible Course of the Artaxata's Aqueduct Using Path Analysis

65 The present work examines feasible routes of an aqueduct bringing fresh water to the city of Artaxata and bridging the valley between the expected water sources and the city. The study was initiated by the detection of remains of the aqueduct during a geomagnetic prospection, which revealed a line of rectangular foundations running in west/southwest – east/northeast direction, starting northeast of the city. The foundations are at a regular distance of 1.8 m apart and the total length of the detected line is 460 m. Several of the foundation blocks were confirmed by the archaeological excavation in 2019 (for details see above).

66 One more point to be considered when modelling the course of the aqueduct is an old riverbed of the River Metsamor, discovered in the same area where the Pokr Vedi inscription (Fig. 2)[71] was found, and situated a mere 1500 m northeast from the remains of the aqueduct. It is highly probable that there was a bridge crossing here which suggests that the aqueduct led through this point as well.

67 Based on the information from locals, which was further confirmed during the prospections in 2019 and 2020, two places situated east and northeast of the city respectively are possible sources of fresh water supply (Fig. 33). The closer source (no. 1) is located on the River Vedi, some 25 km east of the city as the crow flies. The second source has two feasible springs (nos. 2 and 3) which are located southeast of the village Garni, some 29 and 30 km northeast of Artaxata. No. 3 lies directly on the River Azat and no. 2 on its tributary. Both springs flow into the River Azat.

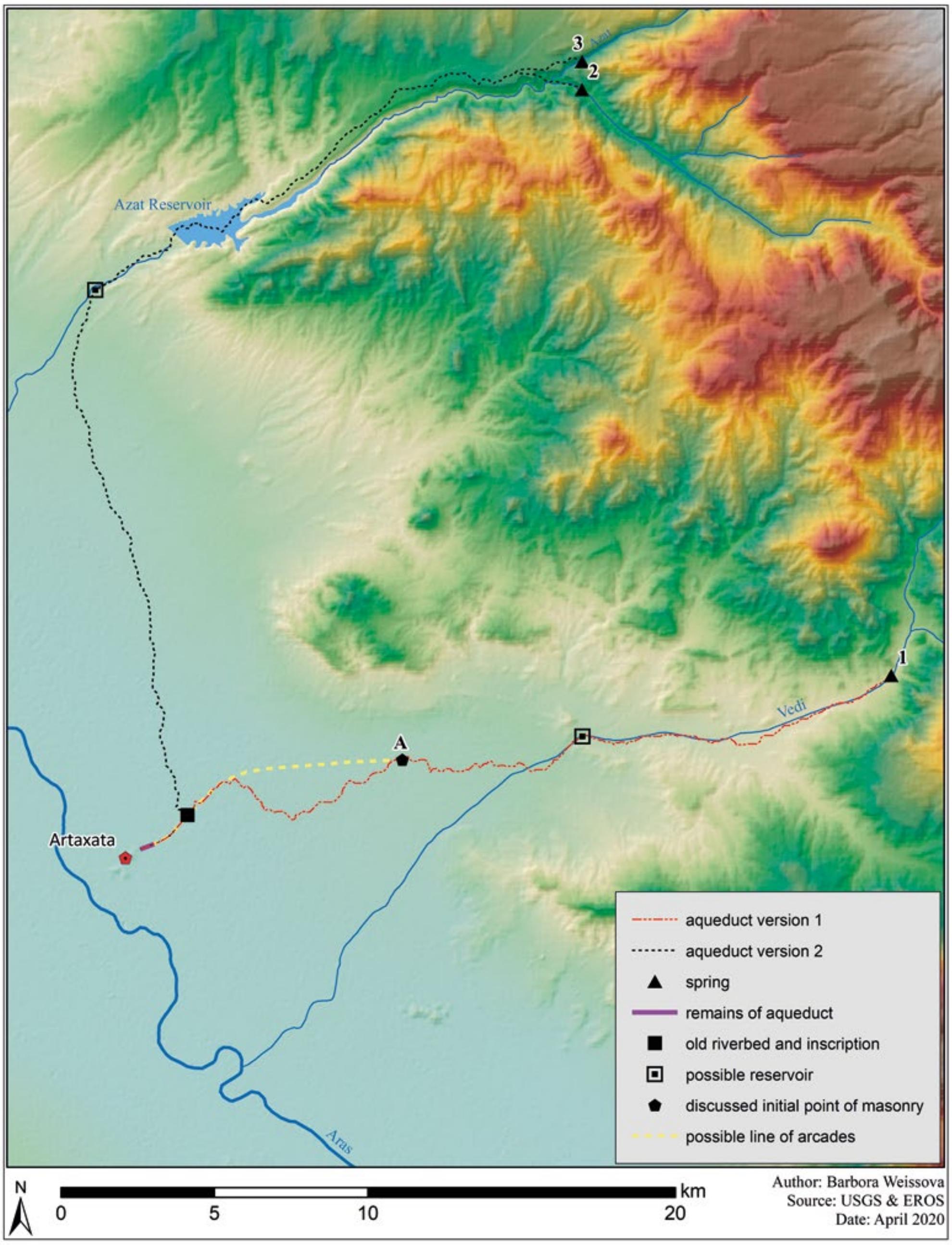
Methodological Approach

68 Considering the fact that a typical Roman aqueduct was a surface channel, closely following the contours of the land[72], I suggest approaching the computation of its

70 Coutelas 2019.

71 On the inscription, see Tonikian 1992, 166 f. fig. B.

72 Hodge 1992, 93.



33

Fig. 33: Artaxata, map of the hinterland of Artaxata depicting the discussed features of the path analysis

feasible route using path analysis[73]. Path analyses have hitherto been widely applied in archaeology to calculate probable routes of roads[74]. On the example from Artaxata, the study suggests a way how to use path analysis to compute likely routes of aqueducts.

69 The basic source for the present analysis is the digital elevation model produced based on void-filled SRTM with the precision of 30 m[75]. Aspect and slope values derived from the elevation model need to be reclassified[76] in order to create a friction

73 The present study uses ESRI ArcMap 10.7. The licence was provided by the Institute of Archaeological Studies of Ruhr University Bochum.

74 White 2015, 407–414.

75 The elevation model is based on two void-filled 1 Arc-Second Global SRTM (Shuttle Radar Topography Mission) images (SRTM1N39E044V3, SRTM1N40E044V3) mosaiced together and projected (WGS84 UTM Zone 38N). The acquisition date of both is the 11th of February 2000. Publisher: U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Centre; source URL: https://earthexplorer.usgs.gov/ (28.11.2019).

76 On the basic principles of reclassification, see Wheatley – Gillings 2002, 84. 85. 87–89.

surface. The friction surface is used for calculating a cumulative cost raster and, finally, the path analysis between the spring and the end of the aqueduct, in this case represented by the city Artaxata.

70 In particular, the aspect values showing the cardinal directions of the slope are converted into hundreds[77] in order to enable clear orientation in the values when combined with the slope. The reclassification of the slope is more complex and required a number of trials in order to find the suitable way. The main thinking behind the process is that ancient aqueducts relied on gravity to transport water, but the smaller the degree of the slope, unless it is too near to zero, the better. The usual gradient is around 1.5 and 3 m per km[78] which implies even in case the total length of the aqueduct extends[79]. Therefore, the first trial considered only slope values < 1 degree as the feasible range, excluding all the others as impassable.

71 After combining the reclassified aspect and slope, the essential step was to ascribe new values to the resulting cost raster, considering the favourable aspects as more plausible. At this step, it is inevitable to divide the calculations, weighting cells for springs in the east and in the northeast in a different way. The aspects favourable for both locations include southwest, west and northwest. In addition, for the springs in the northwest, the cells facing south were also classified as beneficial.

72 The categorical reclassification of the slope allowing only for one degree as a maximum gradient did not allow for the calculation of the cost distance, let alone the feasible path. It appeared that there is no possible way to reach Artaxata from any of the springs and avoid all the slopes which exceed one degree. Therefore, it was necessary to consider steeper slopes and reclassify them as plausible in order to find the feasible course of the aqueduct. Adding in this way degree by degree when reclassifying the raster, the first possible reconstruction appeared when considering slopes including 10 degrees in the case of Vedi (spring no. 1) and not less than 20 degrees in the case of Azat (springs nos. 1 and 2). The results of the path analyses are plotted on Fig. 33 as versions 1 (Vedi) and 2 (Azat).

73 The last analytical step was to determine where the aqueduct needed to leave the ground in order to maintain the water level necessary to supply the city situated on several hills of diverse heights. Since no distribution tank or castellum aquae[80] has been detected so far, we can only guess which parts of the city were indeed supplied with running water. Using the contours extracted from the elevation model, two possible scenarios are presented for the aqueduct.

Results

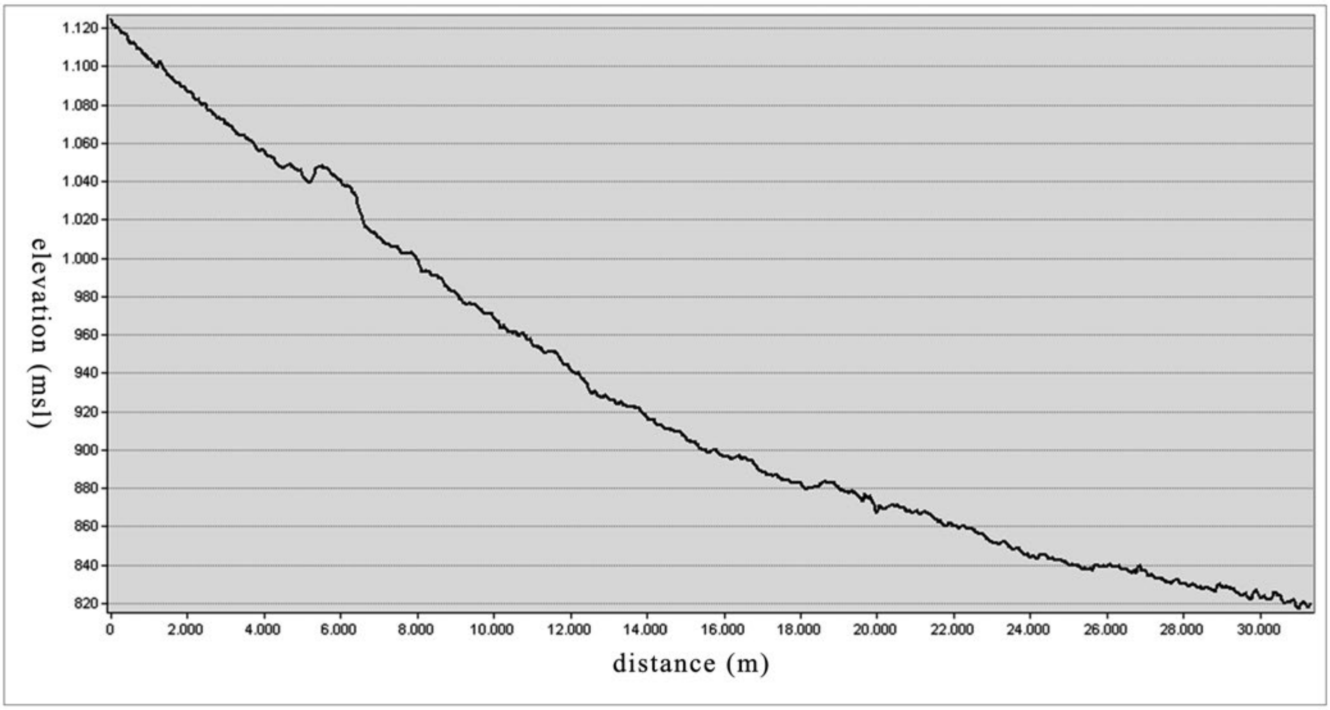
74 Version 1 bringing water from the spring recorded at the River Vedi (no. 1) is 31.3 km long and it descends some 306 meters (from 1125 msl to 819 msl). The elevation difference and the length of the line imply an average drop in elevation of 9.8 m per 1 km or 9.8 m per mille respectively. A closer look at the elevation profile of the aqueduct (Fig. 34) divides the inclination of the slope into three distinctive sections. Within the first 12 km the gradient equals 15 m per mille; between 12 and 18 km it is 10 m per mille; and in the last section 5 m per mille. One anomaly was recorded at 5.4 km from the spring, where the elevation descends abruptly some 10 m and reverts within the next 800 m. It is hard to determine the reason for this anomaly without a targeted prospection, since the satellite image does not show any obstacles in the direct line,

77 The reclassified values are as follows, with cardinal directions represented in brackets: 100 (N), 200 (NE), 300 (E), 400 (SE), 500 (S), 600 (SW), 700 (W), 800 (NW), 900 (N).

78 Hodge 1992, 216–219.

79 In general, Döring 2016, 82. In particular, see the course of the Hadrianic aqueduct in Corinth (Lolos 2018, 99), and Roman aqueducts in Mytilene (Kourtzellis et al. 2018, 111) or in Cadiz (Marrero et al. 2016, 99–101).

80 Döring 2016, 105–107.



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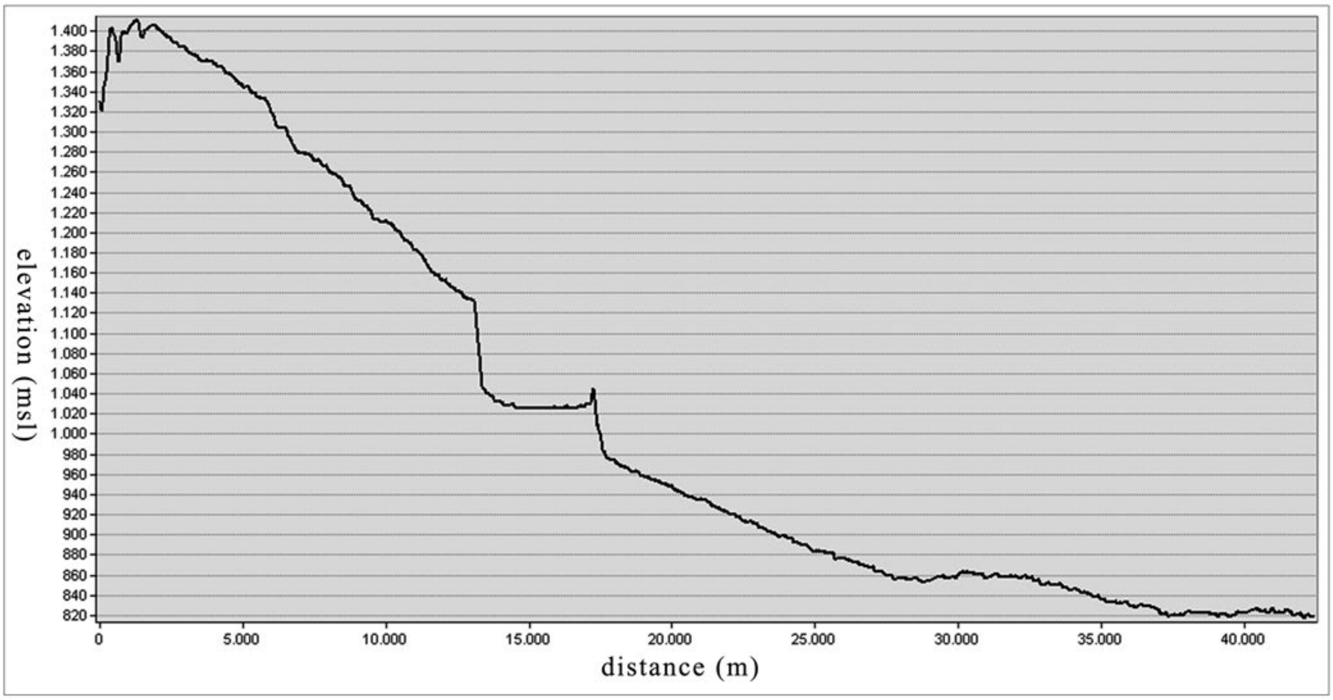

35

suggesting that the anomaly might be caused by an error in the elevation model. A possible reservoir was recorded by local archaeologists just at the 10th km, shortly before the river and the aqueduct enter the plain. Examining the course of the calculated line from the spring to the city, the first 12 km follow the valley of the River Vedi, reaching as far as the Ararat plain. The river then turns to the southwest, but the probable course of the aqueduct continues in a roughly western direction. It is only in the last 4 km that it turns southwest, closely following the detected remains of the aqueduct. As the River Vedi has changed its course numerous times, this description is merely an observation

Fig. 34: Artaxata, elevation profile of aqueduct version 1 connecting spring no. 1 and Artaxata

Fig. 35: Artaxata, elevation profile of aqueduct version 2 connecting spring no. 3 and Artaxata

of the actual situation, which is not necessarily consistent with the original context of the aqueduct and the river.

75 Version 2 considers two springs situated at the River Azat just southeast of the village Garni. Since both the length and the profile of the aqueduct are the same, whether calculated from spring no. 2 or no. 3, the following text describes only one of the calculations, from spring no. 3. The elevation difference between the spring (1330 msl) and the westernmost pillar of the aqueduct in Artaxata (819 msl) is 511 m. The length of the calculated aqueduct is 42.4 km, which results in an average drop in elevation 12.1 per mille. The elevation profile of its route (Fig. 35) appears rather unfavourable due to several facts. The first 2 km have some abrupt climbs and drops, with differences in elevation reaching 80 m. The following 11 km descend no less than 25 m per mille, followed by an anomaly caused by the reservoir built in the last century. The first drop of 100 m in elevation is not self-evident but based on satellite images it might be connected with construction activities carried out in the area when building the reservoir. The water level is represented as a perfectly elevated surface of 2 km in length, followed by the sharp drop in elevation of about 80 m caused by the dam wall. Given that the reservoir is a recent development and the aqueduct here would have followed the Azar River, the average drop in elevation would be no less than 36 m per mille. The next 12 km descend 10 m per mille. This section also revealed a potential ancient water reservoir, situated 3 km from the dam. The last section, by contrast, had to overcome a gradient of about 25 m. Looking at the modelled line of the aqueduct from the spring towards the city, it follows the valley of the River Azar as far as the Ararat plain. Then it turns southwards, aiming for the city. It meets the old tributary of the River Arax from the north/northwest and at that point turns sharp southwest to follow the remains of the aqueduct.

76 Comparing the lengths and average drops in elevation, it is more likely that version 1 represents the course of the aqueduct that supplied Artaxata with fresh water. Even though the inclination of the modelled aqueduct is not an ideal one, it does not constitute a unique case in Roman architecture[81]. To keep the aqueduct functioning, complex techniques of Roman hydraulic engineering such as cascades[82] had to be used in order to slow down the flow in the first two- thirds. The last one-third had to leave the ground at some point, depending on which height the water level had to maintain or, in other words, which parts of the city the aqueduct supplied.

77 Based on the SRTM, the top of the citadel is 875 msl. If the aqueduct supplied the whole city including the citadel, the masonry had to start somewhere around point A (Fig. 33). The direct dashed line shows the possible course of the arcades, as the elevated aqueduct did not necessarily have to follow the terrain. The length of the arcades is about 9.5 km, and its height reaches not less than 56 m at the foot of the city. It shortens the total length of the aqueduct to 29 km.

Conclusion

78 The study uses path analysis to calculate the most feasible route of the aqueduct between three springs and Artaxata, determining in this way the spring that was most probably used to supply the city with fresh water.

79 Spring no. 1 is situated some 25 km east of the city. The path analysis revealed a 31.3 km long aqueduct with an average drop in elevation 9.8 m per mille. The elevation profile of the aqueduct shows an almost uniform curve, with the gradient oscillating between 5 and 15 m per mille.

81 Compare with the lengths and elevation differences listed by Adam 2001, 241–243. Especially noteworthy is the aqueduct in Lyon-Craponne, which reaches an average inclination of 16.8 per mille.

82 As, for instance, in the case of the aqueduct over the *Brévenne*, aqueduct of *Cherchel* or the *Aqua Marcia* mentioned by Adam 2001, 242. For an overview of technical elements used for building Roman aqueducts, see Hodge 1992, 160 f.; Aicher 1995, 7–22; Kek 1996, 79–124.

80 Springs nos. 2 and 3 are located about 30 km northeast of Artaxata and showed similar results when connected with the city by the path analysis. The analysis produced a 42.4 km long aqueduct, with an average drop in elevation 12.1 per mille. The elevation profile shows several abrupt inclines and drops of up to 25 m per mille and 20 m per mille, respectively.

81 Comparing the lengths and elevation profiles, version no. 1 conclusively proves to be more probable. However, the first two-thirds of the tilt, starting from the spring, would have required measures to slow down the flow. Some sections of the last one-third, depending on which parts of the city were to be supplied, had to be kept at an appropriate height. This implies that the remains of the arcades detected during the geomagnetic prospection do not represent the entire length of the aqueduct. If the aqueduct supplied the whole city, including the citadel, the arches would have had to be 9.5 km long, with a height of up to 56 m. Since such an enormous height is improbable, we have to assume that the aqueduct was made only to supply the lower parts of the city.

B. W.

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