

Article

# Reconstructing the Ancient Route Network in Pergamon's Surroundings

Bernhard Ludwig <sup>1,2</sup> 

<sup>1</sup> Istanbul Department, Deutsches Archäologisches Institut (DAI), İnönü Caddesi 10, 34437 Istanbul, Turkey; bernhard.ludwig@dainst.de or bernhard.ludwig@fu-berlin.de; Tel.: +90-212-3937600

<sup>2</sup> Department of Earth Sciences, Institute of Geographical Sciences, Freie Universität Berlin, Malteserstr, 74-100, 12249 Berlin, Germany

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**Abstract:** The surrounding landscape of ancient Pergamon is characterized by several mountain ranges, the Bakırçay Valley and River and the Aegean coastline. The accessibility of this region was vital for the city since it provided food and resources as well as trade, communication and military movements, all facilitated by a well-developed route network. Despite the importance of roads for the development and prosperity of the city, the ancient route network is still widely unexplored and archeological evidence of roads is extremely rare. This study therefore aims to reconstruct the ancient route network in the surroundings of Pergamon by combining historical and archeological sources with modern computer-aided least-cost path analyses, while also considering changes in the landscape that have occurred since antiquity. Based on these detailed results, conclusions may be drawn about the characteristics and functional diversity of the routes. Although the investigation of the route network in the surroundings of Pergamon cannot be considered complete, the results of this study already offer a valuable basis for further research, analyses, modeling and field work.

**Keywords:** ancient roads; ancient route network; Bakırçay Valley; GIS; itineraries; landscape archeology; least-cost path analysis; milestones; Pergamon; Western Asia Minor

## 1. Introduction

The ancient city of Pergamon (modern Bergama) is located about 25 km inland on a steep hill in the lower Bakırçay Valley (Kaikos Valley). Although it was one of the most important urban centers in Asia Minor, the city had no direct access to the sea. It is generally assumed that this situation placed the city at an economic disadvantage compared to coastal cities such as Ephesus and Smyrna.

To counterbalance this supposed disadvantage, the coastal settlement of Elaia, which had existed since archaic times, was developed into the harbor city of Pergamon under Attalid rule [1,2]. In addition to the most important harbor of Elaia, that sheltered the Pergamenian fleet, other harbors such as Pitane (modern Çandarlı) or Kane (modern Bademli), provided supra-regional trade, transport and communication. The fertile Bakırçay plain was an essential agricultural basis for the food supply of the city. Extra-urban sanctuaries, such as Kapıkaya or Mamurt Kale, situated in the Kozak Mountains (Pindasos) and the Yund Dağı Mountains (Aspordenon), respectively, played a significant role in the religious life of ancient Pergamon. Beyond this religious aspect, the mountains provided fundamental resources such as firewood, timber, granite, and marble.

The substantial importance of a route network for Pergamon and its surroundings should therefore already be clear, as it enabled the exchange of people, goods, ideas and information.

Despite the long history of research at this site, the traces of ancient roads in the vicinity of Pergamon are still unknown or only published in fragmentary form (cf. [3–5]). Archeological evidence of roads in this region is also extremely rare. This study therefore aims to narrow this lack of knowledge

and open up new perspectives for future research and targeted field surveys in the surrounding landscape of this major urban center.

## 2. Study Area

The study area extends from the headwaters of the Bakırçay River to the east of the Gölcük Mountains (957 m a.s.l.) to the Kara Dağı Mountains (Kane Peninsula; 754 m a.s.l.) on the Aegean coast (Figure 1). On its approximately 130 km long course from the springs to the estuary, the Bakırçay River runs through the eponymous valley, which is delimited by the Kozak and Madra Dağı Mountains (Pindasos, 1243 m a.s.l.) in the north and by the Yund Dağı Mountains (Aspordenon, 782 m a.s.l.) in the south.

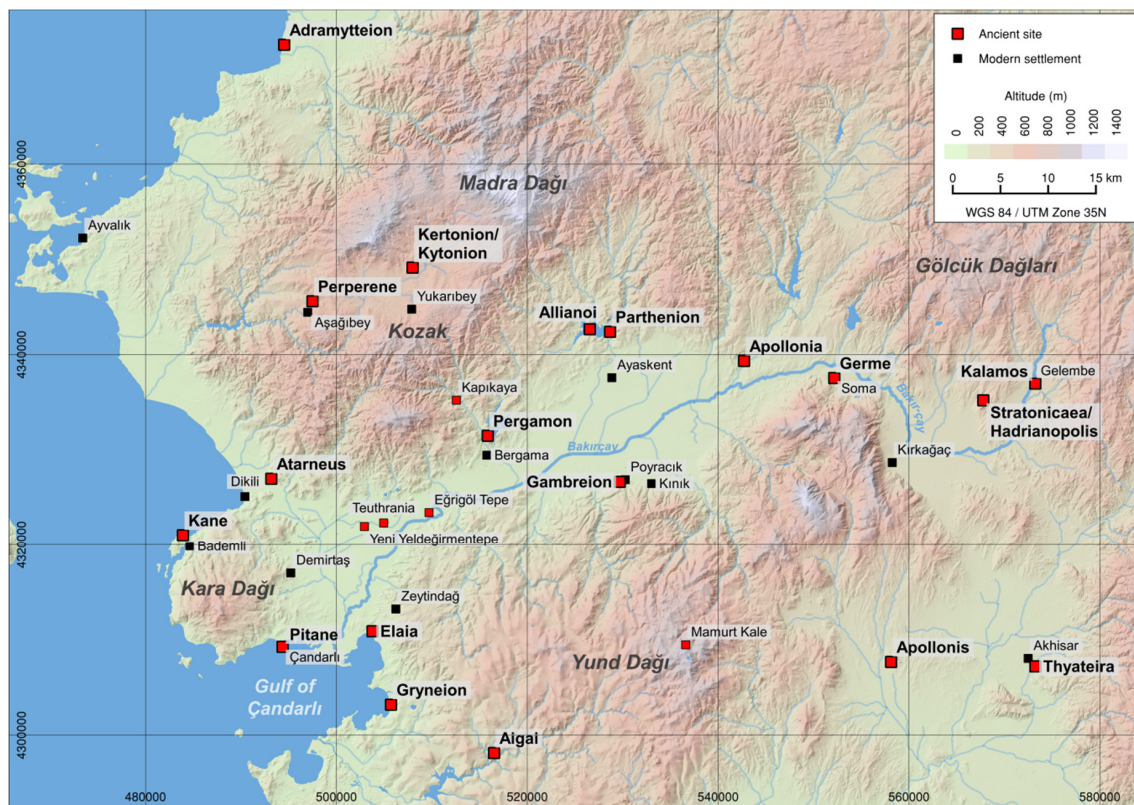


Figure 1. Study area with ancient sites.

The Bakırçay Valley can be divided into three regions. The upper Bakırçay Valley stretches from Kalamos (modern Gelembe) to Kırkağaç and is separated by a ridge of hills south of Stratonicea/Hadrianopolis into smaller eastern and larger western sections. Further on its course, the Bakırçay River runs through the narrow middle Bakırçay Valley, stretching approximately 20 km. Germe (modern Soma) is located in the center of this subregion. From ancient Apollonia, the valley extends for about 50 km to the Gulf of Çandarlı where the Bakırçay River flows into the Aegean Sea. The coastline north of the estuary is characterized by a steep coast with striking cliffs and a multitude of smaller peninsulas and bays and is dominated by the 750 m high Kara Dağı Mountains, the highest mountains of the Kane Peninsula. The lower Bakırçay Valley is divided into an eastern basin with a maximum width of about 15 km and a narrower western basin. The center of the lower Bakırçay Valley is marked by the city hill of Pergamon (Figures 1 and 2).



**Figure 2.** Western lower Bakırçay Valley. View from Kalarga Tepe (Teuthrania) to the east. Background: the city hill of Pergamon, the Kozak Mountains (left) and the Yund Dağı Mountains (right).

On its way from the headwaters north of Kalamos to its estuary in the Gulf of Çandarlı, the main river is fed by numerous tributaries from the neighboring mountains. The city hill of Pergamon, for example, is surrounded by two tributaries of the Bakırçay River. The Kestel Creek (Ketios), which today is dammed to create a reservoir, passes the ancient city hill on its east side, whereas the Bergama Creek (Selinos) flows along its west side.

The entire plain of the lower Bakırçay Valley was significantly affected by fluvial erosion and deposits of the river [6]. In the area around the Yeni Yeldeğirmen-tepe, approximately 3.5 m of sediment have been deposited since the Bronze Age [7] (pp. 183–188). In the area 1.5 km east of Kalarga Tepe (Teuthrania) (Figure 2), geo-archeological research was able to prove that the terrain was 1.7–2.0 m lower in antiquity than today [6]. Near Atarneus and the Geyikli Valley, the sedimentation in the past 1950 years is at least 6 m [8,9]. After the Bakırçay River was regulated and dammed up in the last century, the landscape changes caused by the river are now only minimal. Larger changes result from the intensive agricultural use of the plain in recent years.

In the western lower Bakırçay Valley, the river has almost remained in its same course and flows into the sea between Elaia and Pitane. Wilhelm Dörpfeld (cf. [10] (pp. 395–399), [11] (pp. 273–276)) hypothesized that the estuary of the Bakırçay River was located near Atarneus in antiquity and that the alluvial fan of the Geyikli Deresi or Asarboğaz Çayı blocked this estuary. This created a depression that was already marshy in ancient times and that flooded at certain times of the year until the 19th century ([12] (p. 8), [13] (pp. 7–9)). The swamp area is reported to have reached all the way to Kalarga Tepe (Teuthrania) [13] (p. 9). Other researchers (cf. [14,15]) contradicted this hypothesis at an early stage, and recent geo-archeological research [9], [8] was finally able to disprove it. Today the area has largely been drained by means of channels.

### 3. Objectives

This study aims to reconstruct the ancient route network in the region of Pergamon by combining historical and archeological sources with modern computer-aided least-cost path analyses, while considering the above-mentioned changes in the landscape. Subsequently, conclusions may be drawn about the characteristics and functional diversity of the routes.

Dating is one of the greatest challenges in the study of ancient roads. Some routes can have a very long usage history, which can hardly be defined precisely. This study, however, aims to focus on routes of the Hellenistic and Roman Imperial Period.

### 4. Methods

To reconstruct the ancient route network, various historical sources and archeological records were first compiled and evaluated. Using this information, an initial outline of the route network can

be developed. Probable traces of the routes, however, remain either vague or unknown and for many connections there are no indications at all in the historical sources.

These gaps were then filled by the calculation of least-cost paths. The reconstructed routes were also based on contemporary paths and trails in the landscape that consider the local topography.

By combining all available sources with modern computer-aided analysis, a comprehensive overview of the ancient route network in the surroundings of Pergamon was obtained.

#### 4.1. Archeological Data

##### 4.1.1. Archeological Remains of Ancient Roads

Only well-documented archeological records of road infrastructure provide a reliable basis for study. The sole proven remains in the area around Pergamon were found during field surveys on the Kane Peninsula ([16] (pp. 184–185), [17] (p. 151)). From Kane up into the Kara Dağı Mountains, a paved road leads to the tower houses of Asarlık Tepe and Söğütlü Kale ([18] (pp. 211–213); [19] (p.119)).

Furthermore, short road segments were documented during field surveys on the periphery of Elaia [20]. A road paved with pebbles leads from the north-western gate of Elaia through the necropolis to the Bozyer Tepe. A second road also runs from this city gate northeast to the ancient main road towards Pergamon.

##### 4.1.2. Archeological Remains of Ancient Bridges

When building roads, streams, rivers or swamps must be crossed. Where fords are no longer sufficient, bridges are required to pass these obstacles, and are therefore integral parts of roads networks. In total, 17 at-least-partially ancient bridges can be identified in Pergamon's vicinity (Figure 3).

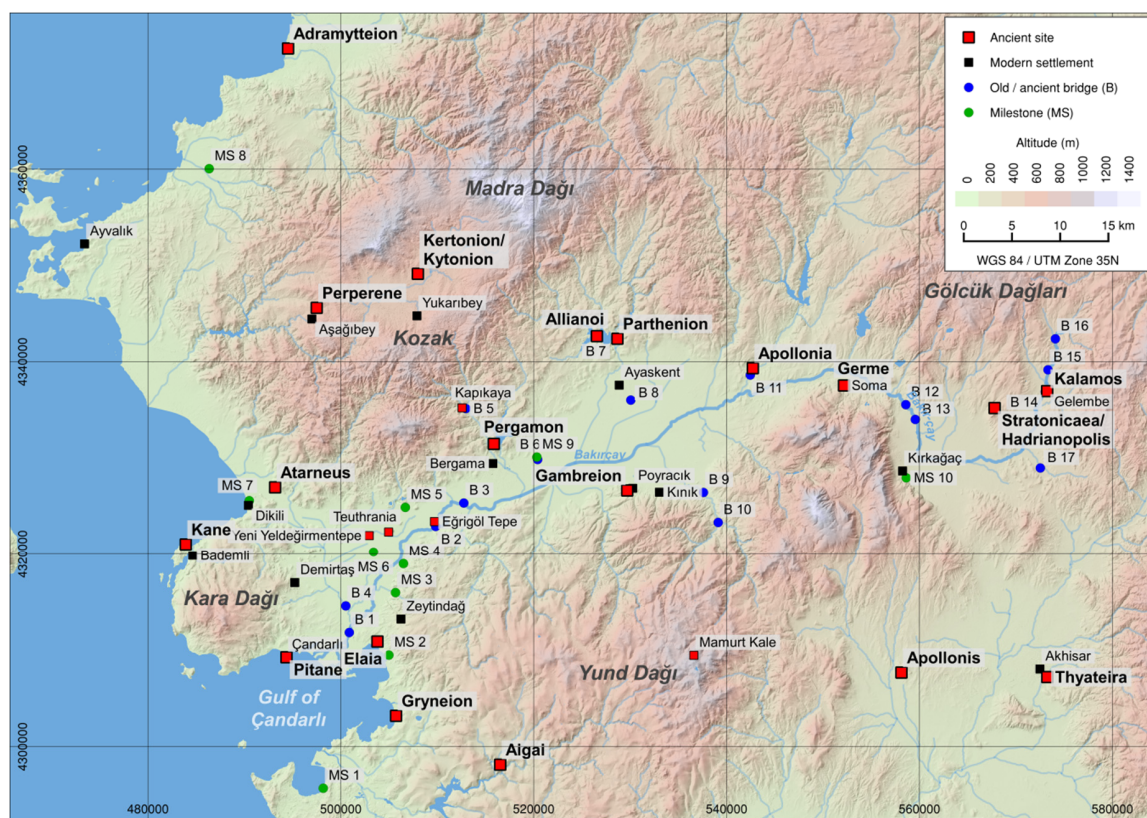


Figure 3. Study area with the location of bridges and milestones mentioned in the text.

The remains of a Roman bridge (bridge 1) (cf. [5] (p. 553), [12] (pp. 30–31), [19] (p. 114 with supplementary sheet 1), [20], [21] (p. 96), [22] (p. 197)) are located between Elaia and Pitane. The bridge crossed the Bakırçay River in a southeast-northwest orientation and had three *opus caementitium* piers with ashlar placed in front of them.

Another ancient bridge (bridge 2), which probably also dates from the Roman Imperial Period, crossed the Bakırçay River south of Eğrigöl Tepe (cf. [12] (p. 30), [18] (p. 215), [21] (p. 78), [23]). Today, only the remains of the bridge heads exist. The bridge was erroneously called Izmir Köprü by C. Schuchhardt [19] (pp. 116–117), but the actual Izmir Köprü (modern Vakıf Köprü; bridge 3) crossed the river 3.5 km northeast of Eğrigöl Tepe oriented southwest-northeast. From this bridge, an approximately 2 km long and straight road led to Pergamon, which Walter von Diest [12] (pp. 29–30) dated to the Roman Imperial Period, like the bridge itself, because of its substructure and straight course.

In addition to the three bridges crossing the Bakırçay River, there is another bridge (bridge 4) over the Asarboğaz Çayı in the western lower Bakırçay Valley [24] (pp. 124–125). The two-arched Hacismail Köprüsü (Figure 4) lies 5.7 km southeast of Demirtaş in an east-west orientation across the river. This bridge has been renovated and repaired several times in the past, but it is assumed that the substructure goes back to an ancient predecessor.



**Figure 4.** Hacismail Köprüsü (bridge 4) in the western lower Bakırçay Valley.

At the sanctuary of Kapıkaya in the Kozak Mountains, the Bergama Creek (Selinos) was crossable using a Roman bridge (bridge 5) made of *opus caementitium* [12] (p. 9).

A total of 4.5 km east of Pergamon, parallel to the modern highway, the Ottoman Koyun Köprü (bridge 6) runs east-west over an abandoned meander of the Bakırçay River [5] (pp. 538–539), [12] (p. 15), [19] (p. 109).

At Parthenion, a Roman bridge (bridge 7) led to the baths of Allianoi [12] (p. 13), [19] (pp. 131–132). The bridge lies in a reservoir today.

Furthermore, W. von Diest [12] (p. 15) describes a Byzantine bridge (bridge 8), which crosses the Bakırçay River on the route between Gambreion (modern Poyracık) and Parthenion. This could be Hanum Köprü, which is marked on several maps [25]. W. von Diest [12] (p. 15) also mentions two presumably ancient bridges (bridge 9, 10) over the Karadere Creek southeast of Kınık.

At Apollonia, at the transition between the middle and lower Bakırçay Valley, a medieval bridge with 15 pillars (bridge 11) crossed the river [5] (p. 538), [12] (p. 16), [19] (p. 109), [26] (p. 406).

Two bridges, Kılıç Köprü (bridge 12) and Ördek Köprü (bridge 13) [12] (p. 18), crossed the Bakırçay River north of Kırkağaç and are dated to the post-Byzantine era by Klaus Rheidt [27] (p. 233).

Important ancient bridges are located in the upper Bakırçay Valley near Kalamos (modern Gelembé), at the presumed intersection of the ancient roads from Pergamon to Thyateira (modern

Akhisar) and from Hadrianoutherai (modern Balıkesir) to Thyateira. K. Rheidt [27] (p. 233) compares the bridge at the western end of Kalamos (bridge 14) with other bridges of the Roman Imperial Period.

Two other ancient bridges (bridge 15, 16) are described by W. von Diest [12] (p. 20) north of Kalamos along the ancient road to Hadrianoutherai.

Bridge 17 is located on the route from Kalamos to Thyateira, about 2 km southeast of Karakurt, parallel to the modern road [27] (p. 232).

#### 4.2. Additional Sources and Data

One of the most important bodies of evidence in the study of ancient roads and paths are itineraries, such as the *Itinerarium Antonini*, which is a register of roads and waystations from the 3rd century CE. It contains more than 2000 locations along with distances from station to station. The linear recording of space by means of route plans provided knowledge of connections between individual places and was of great importance for travelers in antiquity, even if the distance figures handed down should be questioned critically today (cf. Miller [28] critically Kubitschek [29] or Löhberg [30] critically Rathmann [31]). There is one route in the *Itinerarium Antonini* leading through the study area and across Pergamon [32] (Table 1).

**Table 1.** Route through the study area mentioned in the *Itinerarium Antonini*.

Place	Dist. <sup>1</sup>	Place	Dist.	Place	Dist.	Place
Adramitio <sup>2</sup>	53	Pergamo <sup>3</sup>	25	Germe	33	Thyatira <sup>4</sup>

<sup>1</sup> Distance figure in miles. <sup>2</sup> Adramytteion. <sup>3</sup> Pergamon. <sup>4</sup> Thyateira.

Compared to the *Itinerarium Antonini*, the *Tabula Peutingeriana* ([28,33,34]) is a cartographic representation of the road network in antiquity (Figure 5). The map, whose origin and authors are unknown, was first published in the 16th century by Markus Welser, a distant relative of Konrad Peutinger after whom the map is named [35] (pp. 338–339). It is assumed that the original map dates back to Roman times [34] (p. 149), although recently hypotheses have been formulated that it has Hellenistic origins [35]. A total of five routes relevant to this study can be identified on the *Tabula Peutingeriana* (Table 2, Figure 5). During the process of copying over the centuries, changes and errors appeared on the map [36]. Especially the distance figures can be mis-copied easily and should be questioned critically.



**Figure 5.** Section of segment IX of the *Tabula Peutingeriana* (after K. Miller [37]).

**Table 2.** Routes mapped in the *Tabula Peutingeriana*.

Place	Dist. <sup>1</sup>	Place	Dist.	Place	Dist.	Place	Dist.	Place
[?]tto <sup>2</sup>	none	Pergamo <sup>3</sup>	25	Gerame <sup>4</sup>	33	Tyatira <sup>5</sup>		
[?]tto <sup>2</sup>	15	Corifanio	5	Elatia	15	Attalia	10	Ela <sup>6</sup>
Cyzico <sup>7</sup>	none	Phemenio	30	Argesis <sup>8</sup>	35	Pergamo <sup>3</sup>		
Hadrianuteba <sup>9</sup>	8	Pergamo <sup>3</sup>						
Ela <sup>6</sup>	16	Pergamo <sup>3</sup>						

<sup>1</sup> Distance figure in miles. <sup>2</sup> Adramitio (Adramytteion). <sup>3</sup> Pergamon. <sup>4</sup> Germe. <sup>5</sup> Thyateira. <sup>6</sup> Elaia. <sup>7</sup> Cyzicus. <sup>8</sup> Ergasteria. <sup>9</sup> Hadrianoutherai.

Further information on stations or distances in the study area are provided by ancient milestones, which were summarized by David French [38] (Table 3, Figure 3).

**Table 3.** Milestones found in the surroundings of Pergamon.

No.	Description <sup>1</sup>	Reference
MS 1	Aliağa	[38] (p. 62)
MS 2	Kazıkbağları 1-6	[38] (pp. 62–67)
MS 3	Dereiçi (former Tekkedere)	[38] (p. 67)
MS 4	Kurfallı 1-2	[38] (pp. 67–69)
MS 5	Ovacık (former Kalarga)	[38] (p. 69)
MS 6	Aşağı Kırıklar	[38] (pp. 69–71)
MS 7	Dikili	[38] (p. 71)
MS 8	Armutova 1-2	[38] (pp. 71–72)
MS 9	Bergama, Paşaoğlu Çiftlik	[38] (pp. 102–103)
MS 10	Kırkağaç 1-2	[38] (pp. 181–182)

<sup>1</sup> Description after D. French [38].

Important information on roads and paths in the Pergamene region is also provided by literary sources from antiquity (e.g., Aelius Aristides, Galen, Strabo), most recently compiled by Murat Tozan [5].

A special inscription that offers specific information about the streets in Pergamon is the astynomoi inscription. Among other things, the width of the lanes of the country roads (leophoroi) within the urban territory is regulated by law: “Among the roads that run through the countryside, the main suburban roads (leophoroi) shall not be less than 20 cubits in width, the other streets not less than eight cubits, unless some use pathways as access to one another through the [different] areas.” [39] (pp. 27–28).

In addition, early travel reports [40] from the 19th and 20th centuries provide important information on the location and course of ancient roads, but also on the design and preservation status of roads and bridges. The reports and maps of the first researchers in Pergamon ([12,21,41]) are worth mentioning. A first systematic collection of the archeological records in the vicinity of Pergamon was summarized by Carl Schuchhardt [19] and published in combination with a map by Otto Berlet [25].

Atlases such as the Barrington Atlas of the Greek and Roman World [42] or the Historical Atlas of the Ancient World [43] also offer a good overview, but due to their scale, they only show very idealized road courses.

#### 4.3. Least-Cost Path Analysis

Where the available archeological and historical data on ancient roads and their courses are insufficient, modern computer-aided analyses can be of assistance. Least-cost path analyses offered the possibility to identify the most probable routes between two locations, making assumptions about modes of traffic and ease of travel. The calculated least-cost paths can differ in their course, depending on which of the two locations is the starting point or destination. Least-cost path analyses and their theoretical and methodological approaches have been carried out and discussed in numerous archeological studies in recent years (e.g., [44–50], among many others).

The calculation of the least-cost path is based predominantly on topographic data (digital elevation model DEM) and the positions of a starting point and a destination, which in this study were archeological sites. Other environmental data that influence movement through the landscape can be included. Slope, vegetation, hydrological data, soil types or visibility are often combined as “costs” to an accumulated cost raster. These data are then used to calculate the “least-cost” path between the two sites. The calculated path, however, does not represent an actual route, since numerous factors such as territorial claims, seasonal restrictions, different types of transport (e.g., on foot, on horseback, in a boat) and different modes of travel (e.g., different numbers or types of traveler) [51] (p. 5) can only be considered to a limited extent in the calculation. The weighting of these cost factors is also complicated.

Although the least-cost paths in this study were calculated only on the basis of slope data, the results provide important insights into the infrastructure and spatial organization of the ancient landscape in terms of trade, transport, security and connectivity of different sites ([52] (p. 115), [53] (pp. 236–237)).

#### 4.3.1. Topographic Data

The analysis of potential ancient route courses is highly dependent on topographic data, i.e., digital elevation models, even if they usually cannot accurately represent the ancient terrain. It is generally assumed that the higher the resolution of the digital elevation model is, the more reliable and accurate the results are.

The model used in this study is a digital elevation model from the TanDEM-X satellite mission provided by the German Aerospace Center and the European Space Agency (ESA) with a resolution of 12 × 12 m per pixel and a vertical accuracy of 2 to 4 m, depending on the slope [54].

#### 4.3.2. Software and Calculations

The least-cost paths were calculated in the R software [55], using the *leastcostpath* package [56], which uses classes and functions of the *gdistance* package [57]. Two cost surfaces were first calculated on the basis of the above mentioned TanDEM-X. The slope cost surface is based on Tobler’s hiking equation [58], (cf. [56]) and the traversal across slope cost surface is based on Bell and Lock [59] (cf. [56]). Both cost surfaces were weighted equally and combined into a cumulative cost raster. The resulting least-cost paths are calculated using the Dijkstra algorithm [60].

### 5. Reconstruction of the Route Network in the Surroundings of Pergamon

It can be assumed that Pergamon, as one of the ancient metropolises of Asia Minor, was a central hub within the route network of the region. Routes in the Pergamon region are reconstructed here by combining all previously mentioned sources and are supported by least-cost path analyses.

Whenever routes, paths, or roads are mentioned in the following section, speak to their design and functional characteristics are not concretely defined. The connections can range from simple trails to elaborately constructed roads. This study also assumes a usage history of the routes at least in the Hellenistic and Roman Imperial Periods. Whether individual routes already existed in earlier times and how long their usage history extended beyond this period cannot be clarified in this context.

In the following section, routes are named alphabetically with capital letters (A). Individual sections are numbered with the corresponding letter and a number (A1). Alternative routes are provided with an additional number (A1.1).

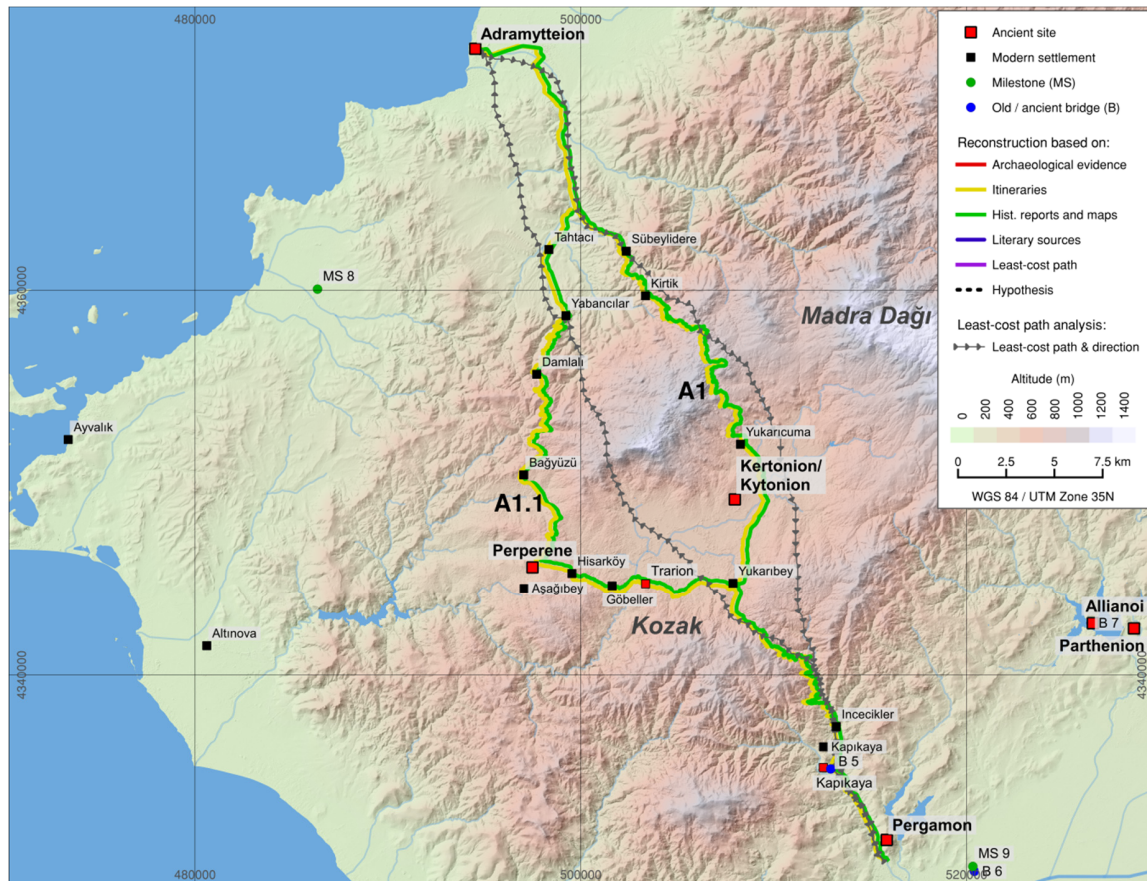
#### 5.1. Route A Adramytteion – Thyateira

The route from Adramytteion (modern Edremit) to Thyateira (modern Akhisar) is already described in the *Itinerarium Antonini* (Table 1) and in the *Tabula Peutingeriana* (Table 2, Figure 5). Three sections of this route are analyzed here.



### 5.1.1. Route A1 Adramytteion – Pergamon (via Kytonion)

Pergamon could be reached using various routes through the Madra Dağı Mountains or the Kozak Mountains from the north. A well-documented route led from Adramytteion to Pergamon (Figure 6), which was already recorded at the end of the 3rd century CE in the *Itinerarium Antonini* in the context of a route from Lampsakos to Laodikeia. In the *Tabula Peutingeriana*, this route is also mentioned, but without any distance figure.



**Figure 6.** Calculated least-cost paths and reconstructed routes between Adramytteion and Pergamon.

From Adramytteion, the route left the coast and led southwards into the Madra Dağı Mountains to the plateau of the Kozak Mountains, passing Kytonion ([12] (p. 10), [61] (pp. 13–14)). Kytonion ([19] (p. 124), [61] (pp. 13–14)) thus formed an intermediate station on the Kozak plateau halfway between Adramytteion and Pergamon. From Yukarıbey, the route continued southeast and reached the Bergama Creek (Selinos) 2.2 km north of the sanctuary of Kapıkaya. In this section, rock cuttings from the ancient road and ancient pavement were still identifiable at the beginning of the 20th century [12] (p. 9). The road, whose ancient pavement was still visible even in recent times [12] (p. 9), led over a bridge (bridge 5) of *opus caementitium* at Kapıkaya [12] (p. 9) along the creek to Pergamon.

In the *Itinerarium Antonini*, the distance from Adramytteion to Pergamon is given as 53 miles (78.53 km; 1 mile = 1.48 km) (Table 1). The length of the reconstructed route is 71.17 km, taking the ascents into account. The difference of 7.36 km may be the result of a copyist's error in the itinerary. It is more likely, however, that inaccuracies in both the distance figure in the *Itinerarium Antonini* and the reconstructed route lead to this difference. It is also possible that the distance figure refers to route A1.1 via Perperene (75.98 km) described below.

In 19th and 20th century maps, this route is marked as a way through the mountains (cf. [12,25,41]).

The least-cost path analysis, which was calculated from Adramytteion to Pergamon, strongly supports the probability of this route. The least-cost path shows the proposed route in an idealized form and differs only in the area of the Kozak plateau from the reconstructed route.

#### Route A1.1 Adramytteion – Pergamon (via Perperene)

The calculated least-cost path from Pergamon to Adramytteion runs west of the northern Kozak ridges (Figure 6). Ernst Fabricius [61] also assumed an ancient route via Perperene, one of the most important settlements in the Kozak Mountains (cf. [62] (pp. 296–309) with additional literature). Together with Richard Bohn [61] (p. 2), he considered Perperene as well as Kytonion to be important fortresses securing the roads from Adramytteion to Pergamon.

From Pergamon, the road followed the previously described course along the Bergama Creek (Selinos) to Yukarıbey. Here it branched off to the west and led along Trarion via the modern villages of Göbeller and Hisarköy to Perperene. North of Perperene, the road is said to have crossed the mountain ridge near the village of Bağyüzü [61] (p. 2), [62] (p. 305).

In the *Itinerarium Antonini*, the distance from Adramytteion to Pergamon is given as 53 miles (78.53 km). With a difference of 2.55 km, this distance figure almost corresponds to the length of this reconstructed route (75.98 km).

There is no archeological evidence so far for a second parallel route connecting the western Kozak Mountains and Perperene with Pergamon [62] (pp. 304–305). However, such a route can certainly be assumed, especially since the area around Perperene contained numerous resources such as wood [3] (p. 19), granite, marble ([19] (pp. 148–151), [62] (pp. 303–304), [63]), and ores (Strabo 13.1.51 [64], [19] (p. 148)) that could be brought to Pergamon via these routes.

#### 5.1.2. Route A2 Pergamon – Germe (via Apollonia)

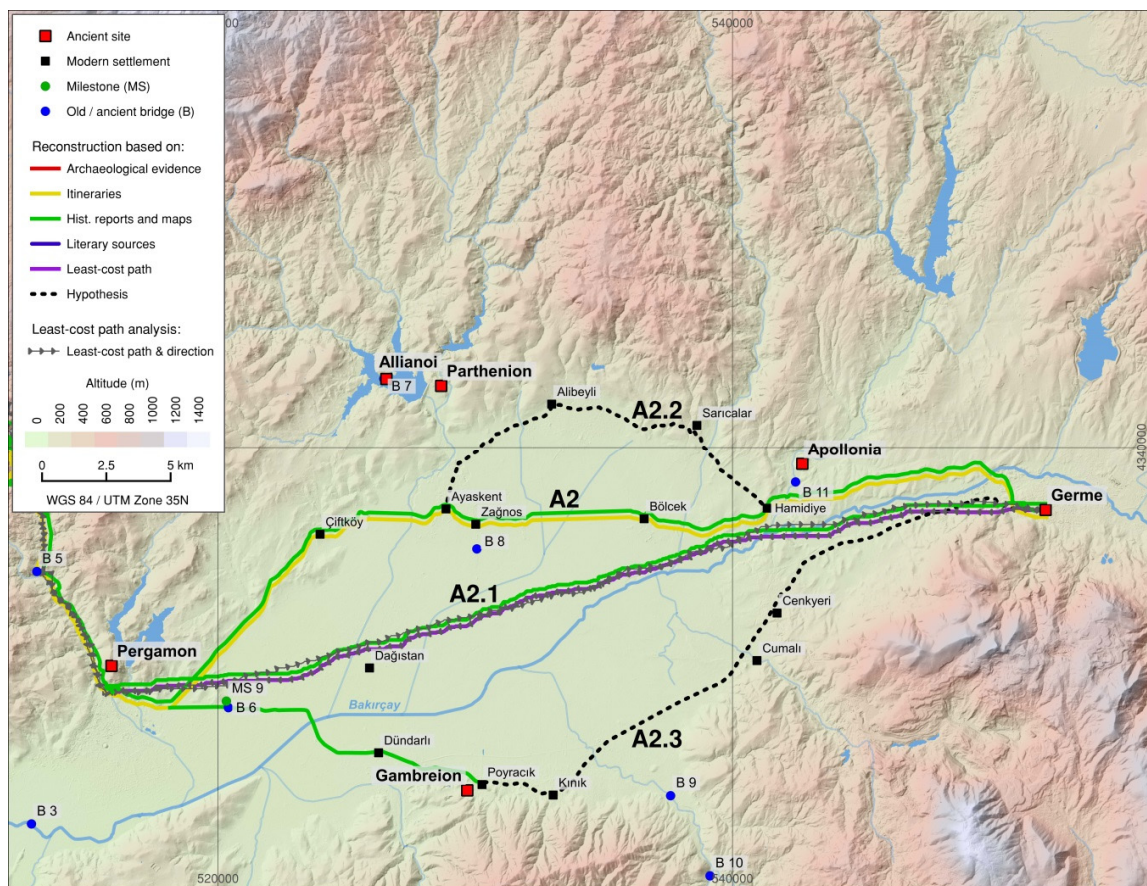
The main route mentioned in the itineraries continued from Pergamon through the eastern lower Bakırçay valley passing Apollonia to Germe (Figure 7). In the *Itinerarium Antonini* (Table 1) and on the *Tabula Peutingeriana* (Table 2, Figure 5) this route is indicated as 25 miles (37.04 km).

The exact course of the route is difficult to reconstruct. Geo-archeological studies [6,8,9], have shown that the landscape of the lower Bakırçay Valley has changed considerably up to the present day and that the river has repeatedly shifted its bed in the past. The riverbed of the Bakırçay River and its tributaries has also been partially relocated, straightened, or canalized (see study area), and these activities have caused the disappearance of old paths or evidence of monuments such as ancient bridges.

Old maps [65] (plan II), [25] show a route from the foot of the city hill of Pergamon leading east and crossing the Kestel Creek (Ketios) after about 650 m, next to the modern bridges. From this point on, there are several possibilities for the course of the ancient route through the eastern lower Bakırçay Valley, which can only be reconstructed on the basis of the distance figures from the itineraries and historical maps. The most probable course leads via the modern villages of Çiftköy, Ayaskent, and Zağnos. In ancient times, the roads from west to east (A2 Pergamon–Germe) and north to south (H Parthenion–Gambreion) likely also crossed in this area. Via Kadıköy and Bölcek, the route probably continued through the valley to Hamidiye, which lies 2 km southwest of ancient Apollonia. From Hamidiye, the route finally led to Germe, crossing the river there.

The calculated least-cost paths are not very meaningful due to the aforementioned dynamic geomorphology of the plain and the anthropogenic impacts on the landscape in the eastern lower Bakırçay Valley.

The reconstructed route from Pergamon to Germe is 41.75 km long in total and thus 4.71 km longer than indicated in the *Itinerarium Antonini* and on the *Tabula Peutingeriana*. Considering the inaccurate localization of Germe and the potential inaccuracies of the itineraries, this difference is tolerable.



**Figure 7.** Calculated least-cost paths and reconstructed routes between Pergamon and Germe.

#### Route A2.1 Pergamon – Germe (through the Plain)

The distance of 25 miles (37.04 km) mentioned in the itineraries correlates with the calculated least-cost path between Pergamon and Germe (40.85 km). According to these data, the route must have gone almost straight along and south of the former riverbed through the eastern lower Bakırçay Valley (Figure 7). This hypothesis is only supported by the map of Heinrich Kiepert [41], on which such a route can be seen. The route crosses the Bakırçay River north of the modern village of Dağistan and leads south along the old river through the valley to Soma (Germe).

#### Route A2.2 Pergamon – Germe (Along the Northern Edge of the Eastern Lower Bakırçay Valley)

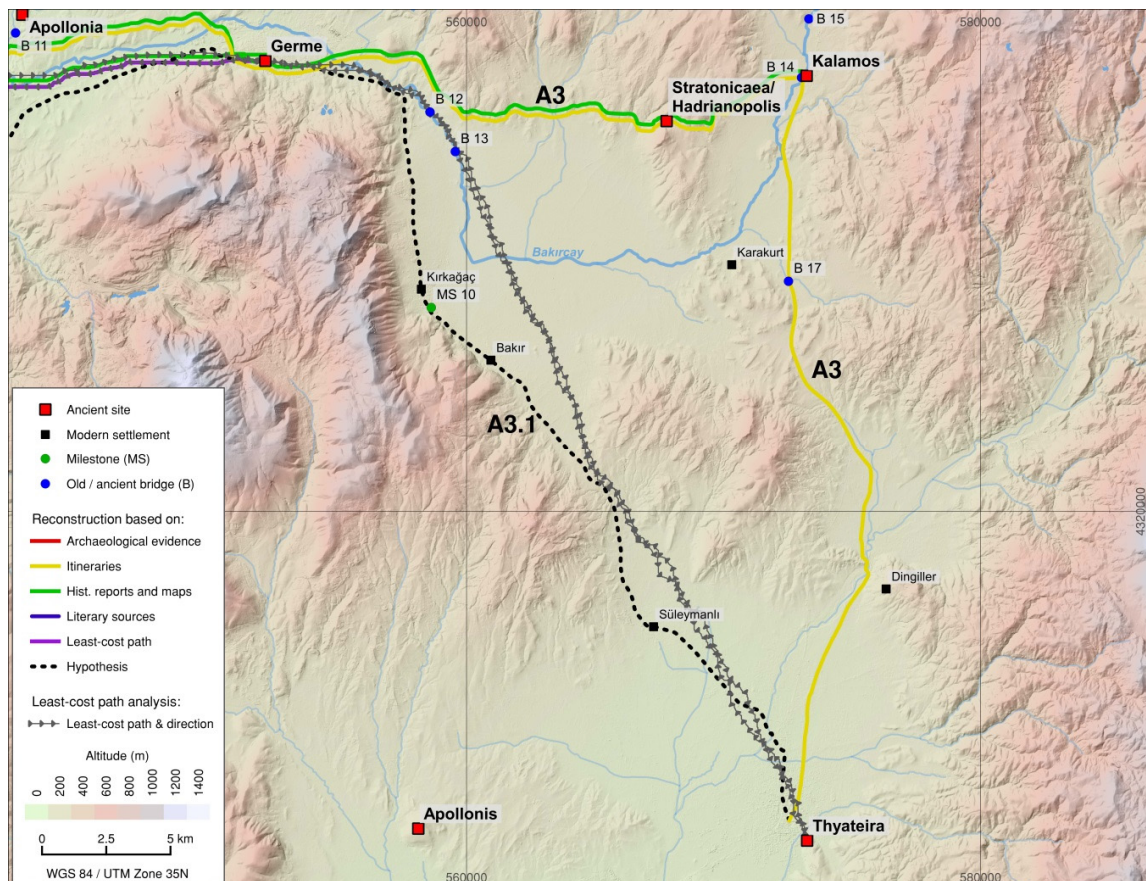
Alternatively, this route may have led from Ayaskent further north towards Parthenion and then along the slopes of the Madra Dağı Mountains through the villages of Alibeyli and Sarıcalar on to Hamidiye (Figure 7). This is a route that offered a good alternative during the seasonal floods of the rivers in the plain and therefore may have been used at least temporarily.

#### Route A2.3 Pergamon – Germe (Along the Southern Edge of the Eastern Lower Bakırçay Valley)

Another possibility is a route from Pergamon along the southern edge of the valley via ancient Gambreion to Germe (Figure 7). From Pergamon, the route leads east, as described above, and continues in a straight line further east over the Koyun Köprü bridge (bridge 6). It then leaves the modern highway and leads via the village Dündarlı to Gambreion. This section between Pergamon and Gambreion had existed in antiquity, evidenced by a route leading southeast through the Yund Dağı Mountains to Apollonis (see route G1). The route east of Gambreion may have been a back road or a seasonal alternative route passing Cumalı and leading to Germe.

### 5.1.3. Route A3 Germe – Thyateira (via Stratoniceae/Hadrianopolis and Kalamos)

From Germe, the route mentioned in the itineraries continued to Thyateira (Figure 8). For this section, the itineraries indicate a distance of 33 miles (48.90 km). Based on this distance, a route via Stratoniceae/Hadrianopolis and Kalamos, as reconstructed by K. Rheidt [27] (pp. 232–234), is most likely. Kalamos existed at least since the Roman Imperial Period, proven by a large building ([21] (p. 65), [27] (pp. 233–234)) and a bridge (bridge 14). The place was probably an important traffic junction [21] (p. 65) where the road from Pergamon met the north-south connection from Hadrianoutherai to Thyateira (route F).



**Figure 8.** Calculated least-cost paths and reconstructed routes between Germe and Thyateira.

From Kalamos, the route led south over a bridge (bridge 17) [27] (p. 232), roughly following the course of the modern road and finally reaching Thyateira. Thus, the distance of the reconstructed route from Germe to Thyateira is 55.36 km. It is 6.46 km longer than indicated in the *Itinerarium Antonini*, a difference that can be neglected in the light of various uncertainties.

### Route A3.1 Germe – Thyateira (via Kirkağaç)

In contrast, the calculated least-cost path runs from Germe via Kirkağaç to Thyateira (Figure 8). Two milestones (MS 10) [38] (pp. 181–182) from the 3rd–4th century CE, which were found at Kirkağaç, could be related to such a route. A route following this least-cost path was recently reconstructed by M. Tozan [5] (pp. 541–547), who mentions a fortress on Dedetepe that could have controlled this road. This route from Germe to Thyateira comes to a distance of just 40.40 km and is even shorter than the route via Kalamos described above. K. Rheidt [27] (pp. 232–233), however, lists unfavorable landscape characteristics such as marshy headwaters or steep and unsafe slopes for this area. Together with the

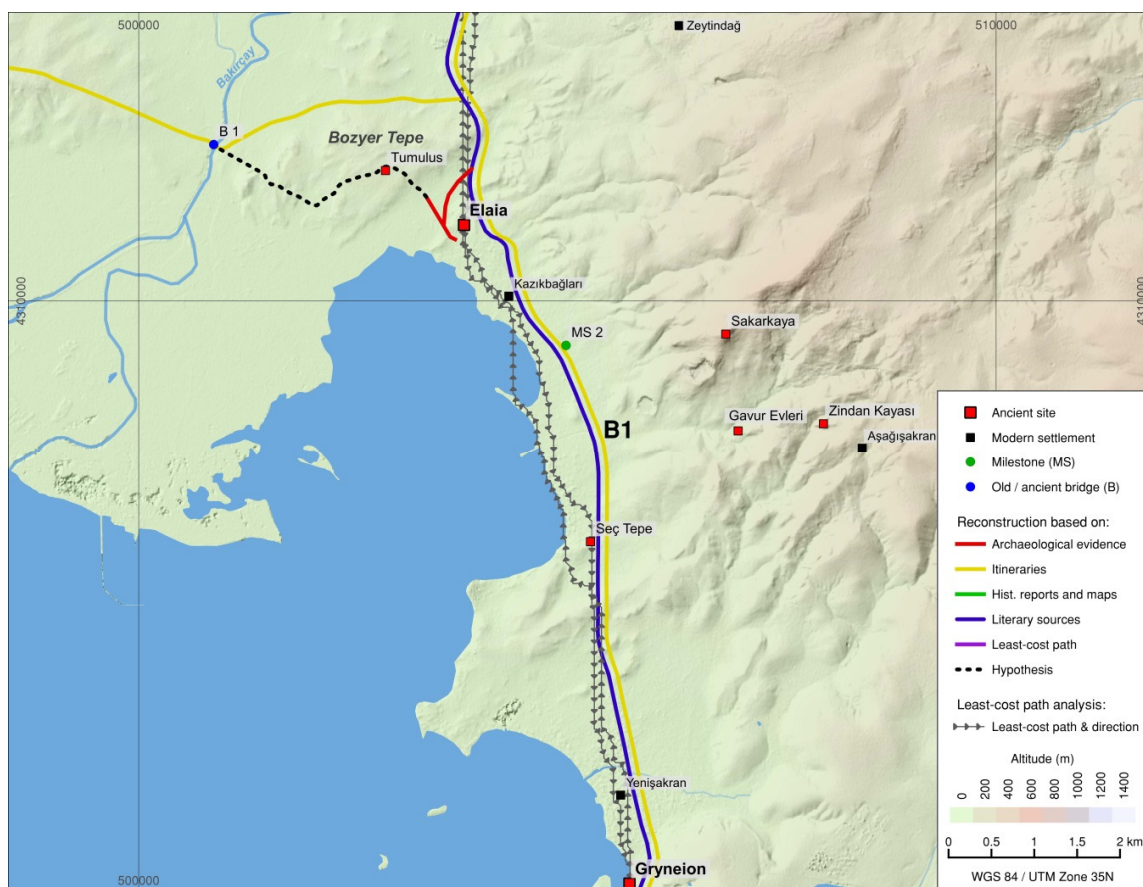
significant deviations in distance from the itineraries, this route seems unlikely to have been a common historic route.

## 5.2. Route B (Ephesus –) Gryneion – Pergamon (via Elaia)

The route from Ephesus to Pergamon was probably already important under Attalid rule and was built or extended as a Roman road during the establishment of the province of Asia Minor under Manlius Aquilius [66] (pp. 34–35). Several milestones [38] (pp. 62–69) from the 1st–4th century CE found in the area of Zeytindağ, Elaia (MS 2), Tekkedere (MS 3), and Kurfalı (MS 4) give evidence for the connection between Pergamon and Ephesus, which is also depicted in the *Tabula Peutingeriana* (Table 2, Figure 5) and are subsequently discussed only in its last section from Gryneion via Elaia to Pergamon.

### 5.2.1. Route B1 Gryneion – Elaia and around Elaia

The coastal route roughly followed the course of today's highway. Coming from the south, it first passed the tumulus on Seç Tepe and the fortress on Sakarkaya at some distance (Figure 9). The ancient route then passed east of Elaia, circumnavigating its city walls. Its course is probably also the same as today's highway (Figure 10). From the eastern city gate, the route ran through the north-eastern necropolis and past the Bozyer Tepe into the Bakırçay Valley [20]. Under the rule of Vespasian, repairs were carried out in the area of this road section, as evidenced by an inscription [66] (p. 35). North of the Bozyer Tepe, a route then branched off to the west and led to a Roman bridge (bridge 1) over the Bakırçay River.



**Figure 9.** Calculated least-cost paths and reconstructed route between Gryneion and Elaia.



**Figure 10.** Foreground: Harbor basin of Elaia. Background: Highway leading past Elaia into the western lower Bakırçay Valley and to Bergama (Pergamon) similar to the ancient route B.

From the north-western city gate of Elaia, a road paved with pebbles led through the north-western necropolis of Elaia to the southern slopes of the Bozyer Tepe [20]. Due to the higher sea level in antiquity [67] it can be assumed that the road ran through the necropolis [68] (pp. 185–188), passing the tumulus on the Bozyer Tepe [69] (pp. 202–208), and continued to the bridge (bridge 1) over the Bakırçay River.

Another road, identified by geophysical measurements, also led from the north-western city gate to the north-east, where it joined the main road to Pergamon [20].

### 5.2.2. Route B2 Elaia – Pergamon (via Bridge 3)

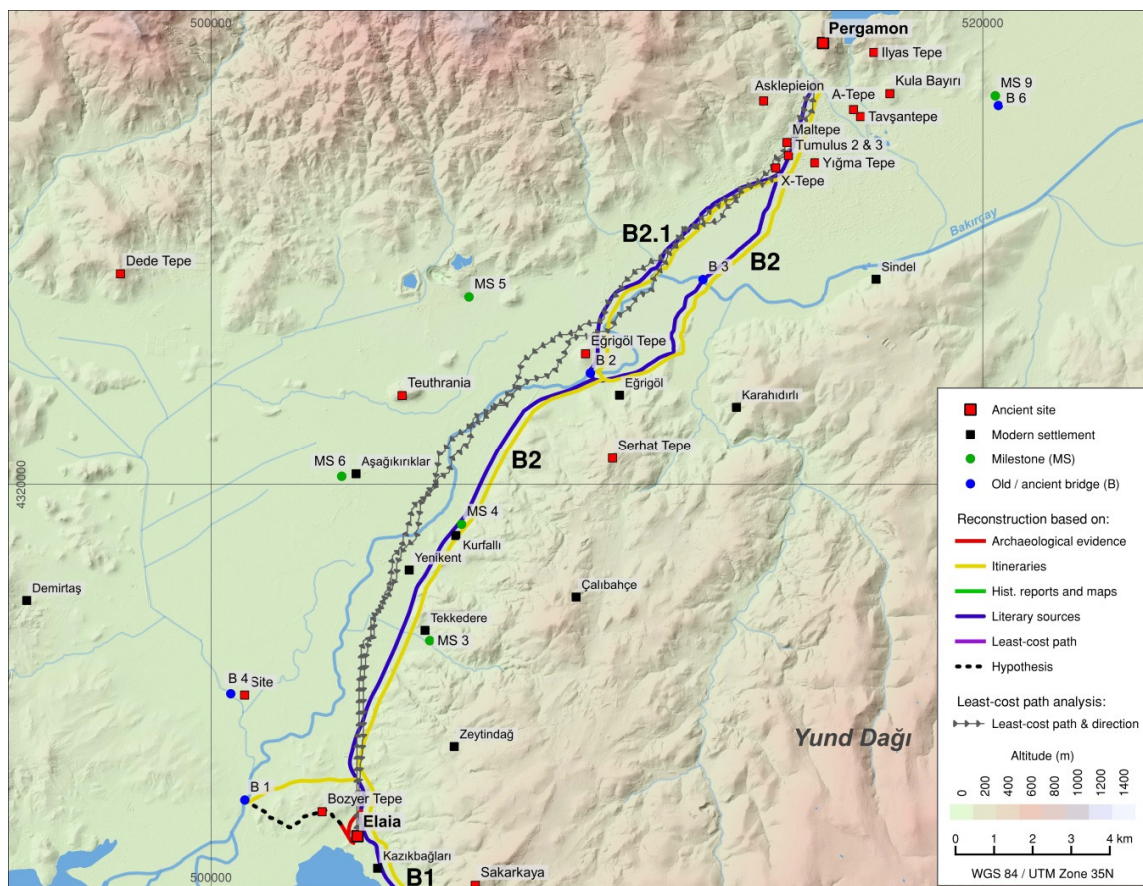
North of Elaia, the ancient route ran along the southern edge of the Bakırçay valley (Figure 11), like the highway does today, and was flanked by graves and tumuli. Road construction work north of Elaia revealed two stone cist tombs from the Hellenistic Period [70] and an ancient tumulus near Kurfalı, shown on O. Berlet’s map [25].

South of Eğrigöl Tepe, an ancient bridge (bridge 2) crossed the river. From this location on, there are two possibilities for the continuation of the route to Pergamon. The route may have continued further east and crossed the river at bridge 3, running straight on until it turned north about 1 km southwest of the present outskirts of Bergama and reached the foot of the ancient city hill. Just before the ancient city, the route passed numerous tumuli, such as X-Tepe, Yiğma Tepe, Tumuli 3 and 2 and Maltepe.

The entire city façade of Pergamon, with its large buildings such as the Trajaneum, the Temple of Athena, or the Great Altar, was oriented towards this route. This created an enormous long-distance effect for travelers moving along the road long before they reached city (cf. [71–73]).

In the *Tabula Peutingeriana* (Table 2, Figure 5), the distance from Elaia to Pergamon is given as 16 miles (23.71 km). The route reconstructed here has a length of 24.64 km and correlates almost exactly to the recorded distance. The difference of 930 m may be the result of rounding errors or the result of measuring from the city gate and not from the city center in antiquity.

The route between Elaia and Pergamon can be assumed to be reliable in its course and was one of the most important traffic connections for Pergamon. Only the section between the Eğrigöl Tepe and Pergamon still allows space for discussion due to the current state of research.



**Figure 11.** Calculated least-cost paths and reconstructed routes between Elaia and Pergamon.

#### Route B2.1 Elaia – Pergamon (via Bridge 2)

An alternative route from Eğrigöl Tepe to Pergamon ran further north. Starting at the ancient bridge 2 south of Eğrigöl Tepe and passing the hill to the east, it reached Pergamon after 24.63 km (Figure 11). Both routes had the same distance and could have been used at the same time. If one of the routes has been temporarily impassable, for example due to seasonal flooding of the Bakırçay River ([6,8,9]), the important connection to Elaia would still have been ensured via the parallel route.

The calculated least-cost paths between Elaia and Pergamon correspond almost exactly to the reconstructed route.

#### 5.3. Route C Adramytteion – Elaia

The *Tabula Peutingeriana* (Table 2, Figure 5) shows a road connection from Adramytteion along the coast and the eastern slopes of the Kara Dağı Mountains to Elaia, where it meets the previously described road from Ephesus to Pergamon (route B). Andreas Külzer [4] (p. 194) last reconstructed a course along the coast, passing Atarneus and leading along the northern edge of the Bakırçay Valley to Pergamon (Figures 12 and 13). Such a route, in the form of a well-developed road from Atarneus to Pergamon (route L), of supra-regional importance, has not yet been proven.

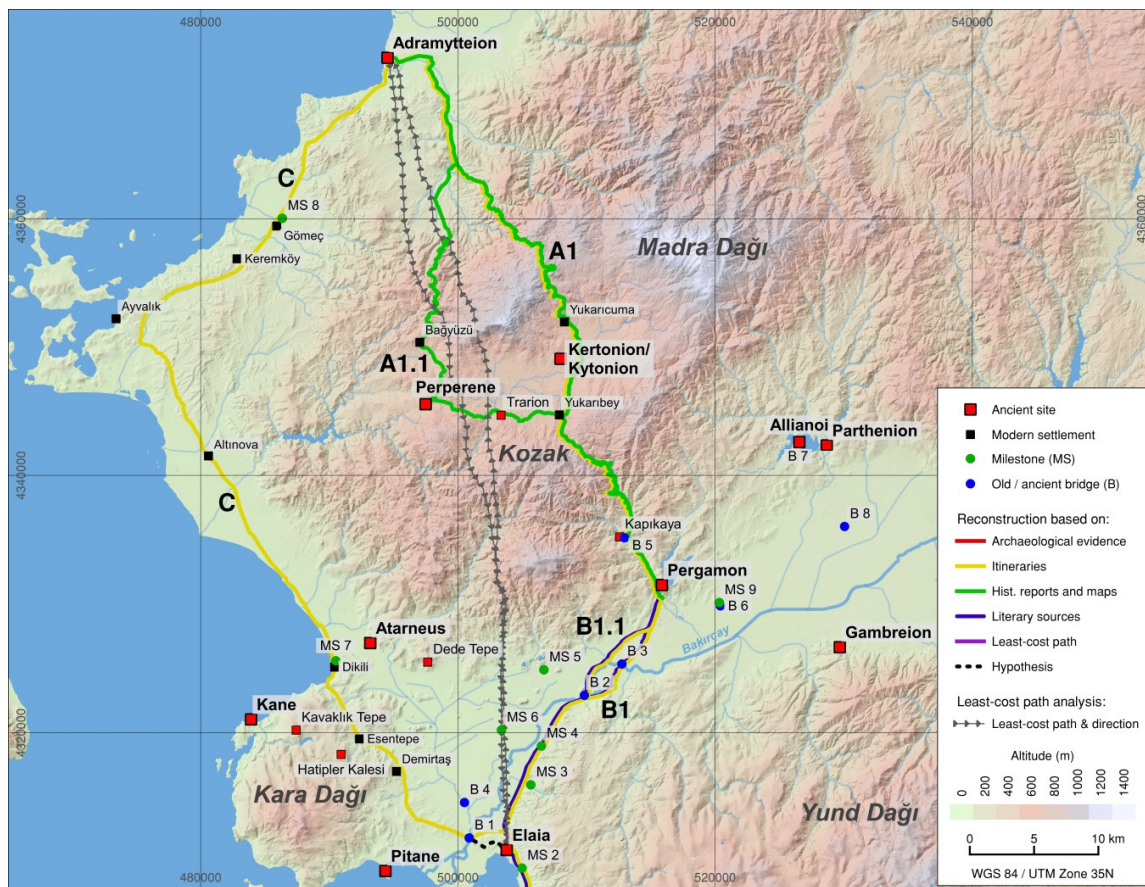


Figure 12. Calculated least-cost paths and reconstructed route between Adramytteion and Elaia.



Figure 13. Atarneus. Left: Coastline west of Atarneus and northern outskirts of modern Dikili. Right: Narrow passage into the western lower Bakırçay Valley between Kozak and Kara Dağı Mountains.

A milestone (MS 7) was found in the 19th century during the construction of the new road from Dikili to Bergama (Pergamon), but its original location is ambiguous [74] (p. 9–10) and therefore does not provide much information for the reconstruction of the routes.

The least-cost paths between Adramytteion and Elaia do not run along the coast, but through the Kozak Mountains passing Perperene (Figure 12). Although at first glance this seems a rather unlikely route, the length of the least-cost paths (67.6 km) correlates surprisingly well with the distance of 45 miles (66.68 km) mentioned in the *Tabula Peutingeriana*. Nevertheless, it is most likely that the route from Adramytteion to Atarneus ran along the coast. Due to the topographical situation of the Kara



Dağı Mountains and the swampy depression south-east of Atarneus, the route probably led along the present villages of Esentepe and Demirtaş to Elaia, as the modern road does.

This reconstructed route has a length of 82.30 km, which corresponds to 55 miles. On the *Tabula Peutingeriana* the route from Adramytteion to Elaia is indicated as 45 miles (Table 2, Figure 5). It is most likely, that 10 miles were lost due to a copying error on the section “[?]tto (Adramytteion)–15 miles–Corifanio–5 miles–Elatia–15 miles–Attalia–10 miles–Ela (Elaia)”.

#### 5.4. Route D (Cyzicus –) Ergasteria – Pergamon

In the *Tabula Peutingeriana* (Table 2, Figure 5) another road is shown that led directly from Cyzicus at the Sea of Marmara to Pergamon and was analyzed only between Ergasteria and Pergamon.

##### 5.4.1. Route D1 Ergasteria – Pergamon (via Parthenion and Allianoi through the Bakırçay Valley)

The distance between Ergasteria, which is located near today’s Balya, and Pergamon, as given in the *Tabula Peutingeriana*, is 35 miles (51.86 km) [4] (p. 197). The actual distance between Ergasteria and Pergamon, however, is much greater. The least-cost paths calculated between the two places instead have a length of about 90 km (Figure 14). They are almost twice as long as those shown in the *Tabula Peutingeriana* and correspond to the distance of 440 stadia (about 81 km) mentioned by Galen (Gal. 12.230 [75]). Apart from these distances, there are no other indications of an ancient route available. The route can nevertheless be located in the area of the least-cost paths with high probability. It may have led via today’s Ivrindi to Allianoi and Parthenion and continued through the Bakırçay Valley on the previously reconstructed route between Pergamon and Germe (route A2).

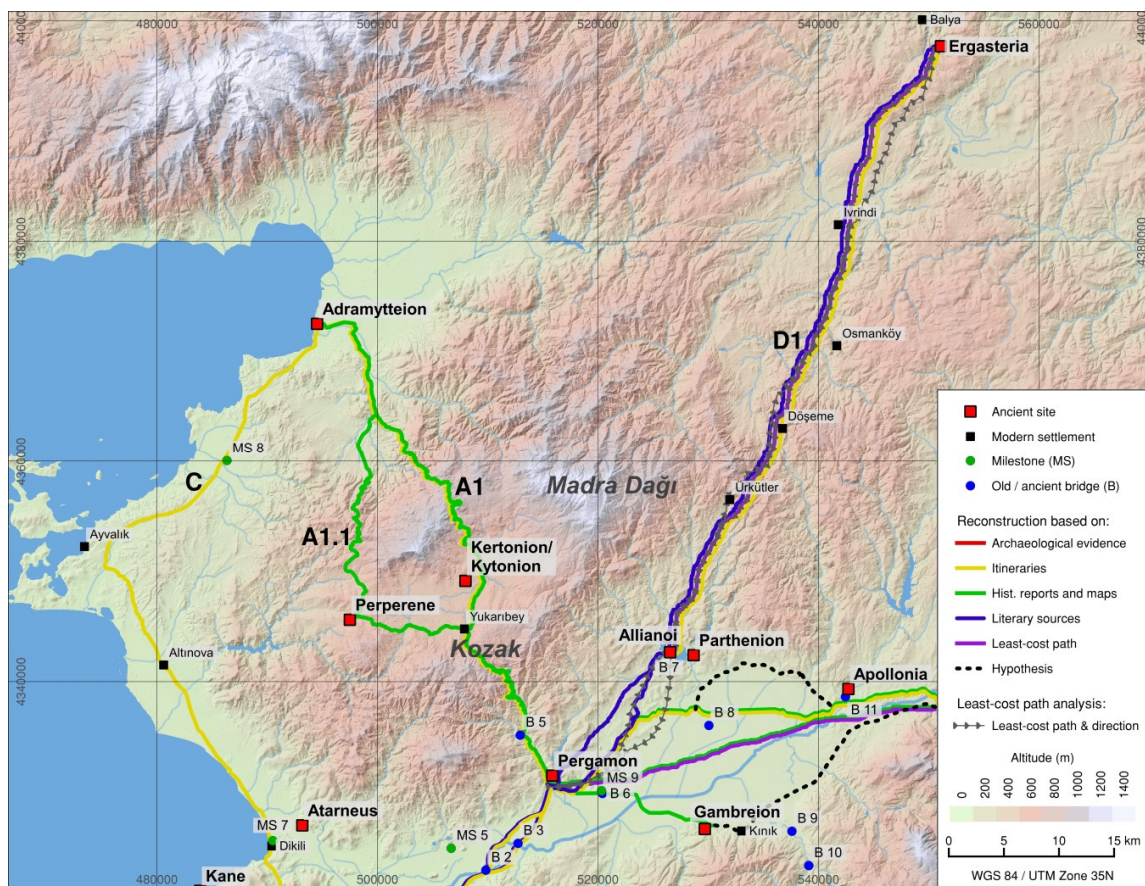
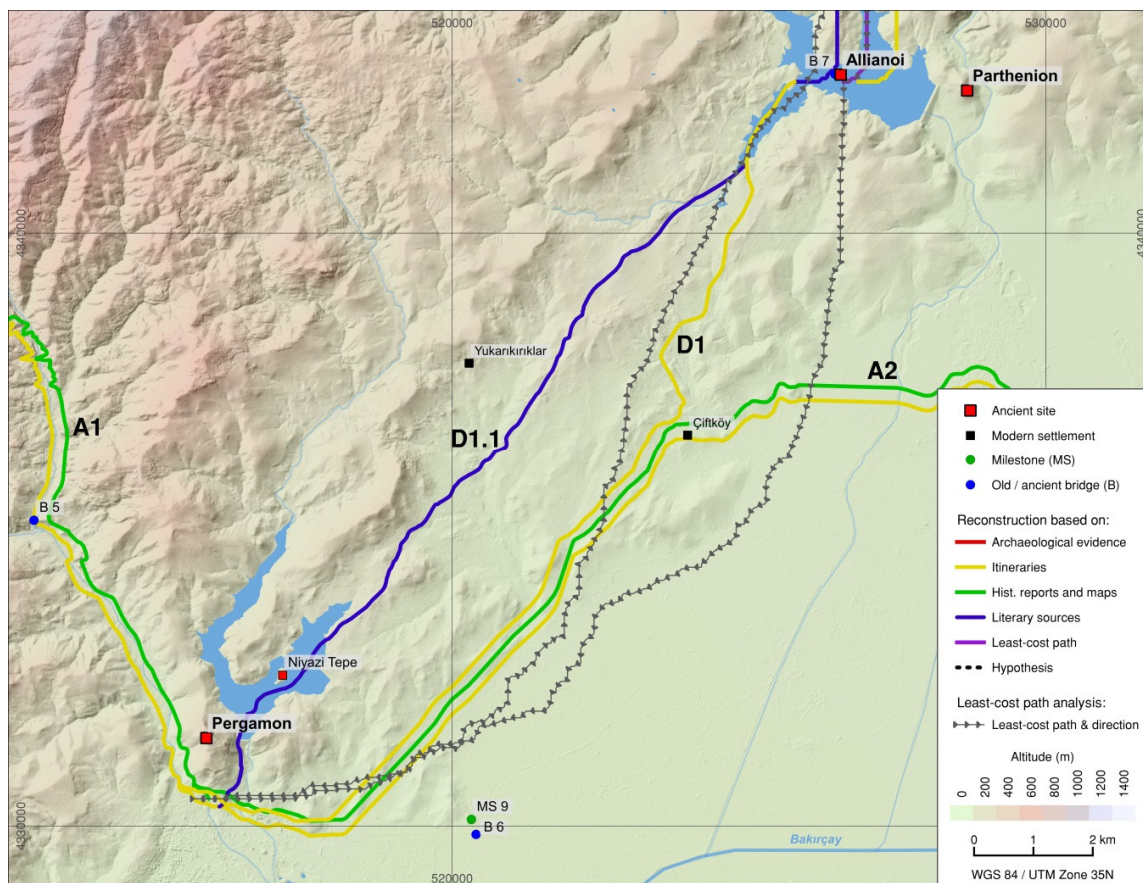


Figure 14. Calculated least-cost paths and reconstructed routes between Ergasteria and Pergamon.

### Route D1.1 Ergasteria – Pergamon (via Parthenion and Allianoi through the Kestel Creek Valley)

For the section between Allianoi and Pergamon, Galen (Gal. 6.424 [75]) gives a distance of 100 stadia (18.6 km) and thus allows for conclusions about said course (Figure 15). The sections of the least-cost paths between Allianoi and Pergamon and the reconstructed route from Allianoi through the Bakırçay Valley have distances of about 20 km and correspond to the round number of 100 stadia of Galen. An alternative route with about 18 km, which would also correspond to Galen’s specifications, can have led through the Kestel Creek Valley (Ketios Valley) and along the Niyazitepe, where a Roman grave monument is located [76]. Both routes, the one through the Bakırçay Valley and the one through the Kestel Creek Valley, are therefore likely to have existed.

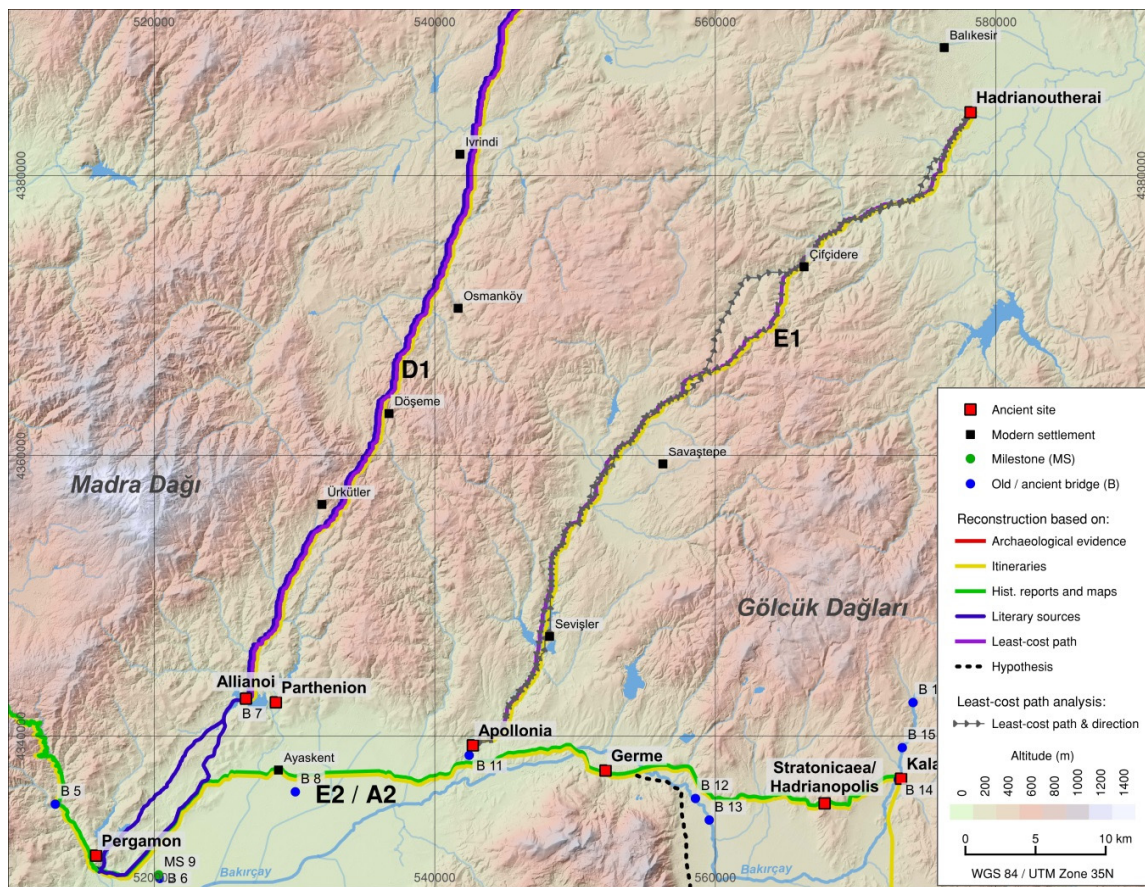


**Figure 15.** Sections between Allianoi, Parthenion, and Pergamon of the calculated least-cost paths and reconstructed routes between Ergasteria and Pergamon.

### 5.5. Route E Hadrianoutherai – Pergamon

#### 5.5.1. Route E1 Hadrianoutherai – Apollonia

A road from Hadrianoutherai (modern Balıkesir) to Pergamon with a distance of 8 miles (11.85 km) is shown in the *Tabula Peutingeriana* (cf. [5,42,77], Table 2, Figure 5). The distance figure must be incorrect, since the reconstructed route gives a length of about 100 km. This may be the result of a copyist’s error. The distance figure LIII (78.44 km) may have been mis-copied to VIII (11.85 km) during one of the copying stages of the *Tabula Peutingeriana*. Even assuming such an error, the reconstructed route would still be about 20 km longer than shown on the map. Due to the lack of evidence, only the least-cost path analysis can be used to reconstruct the route between the two locations. However, the ancient road will most likely be found in the area of the calculated paths (Figure 16).



**Figure 16.** Calculated least-cost paths and reconstructed route between Hadrianoutherai and Apollonia.

### 5.5.2. Route E2 Apollonia – Pergamon (=A2)

In Apollonia, the road coming from Hadrianoutherai met the east-west connection between Pergamon and Germe, which was already described as route A2 (Figures 7 and 16).

### 5.6. Route F Hadrianoutherai – Thyateira

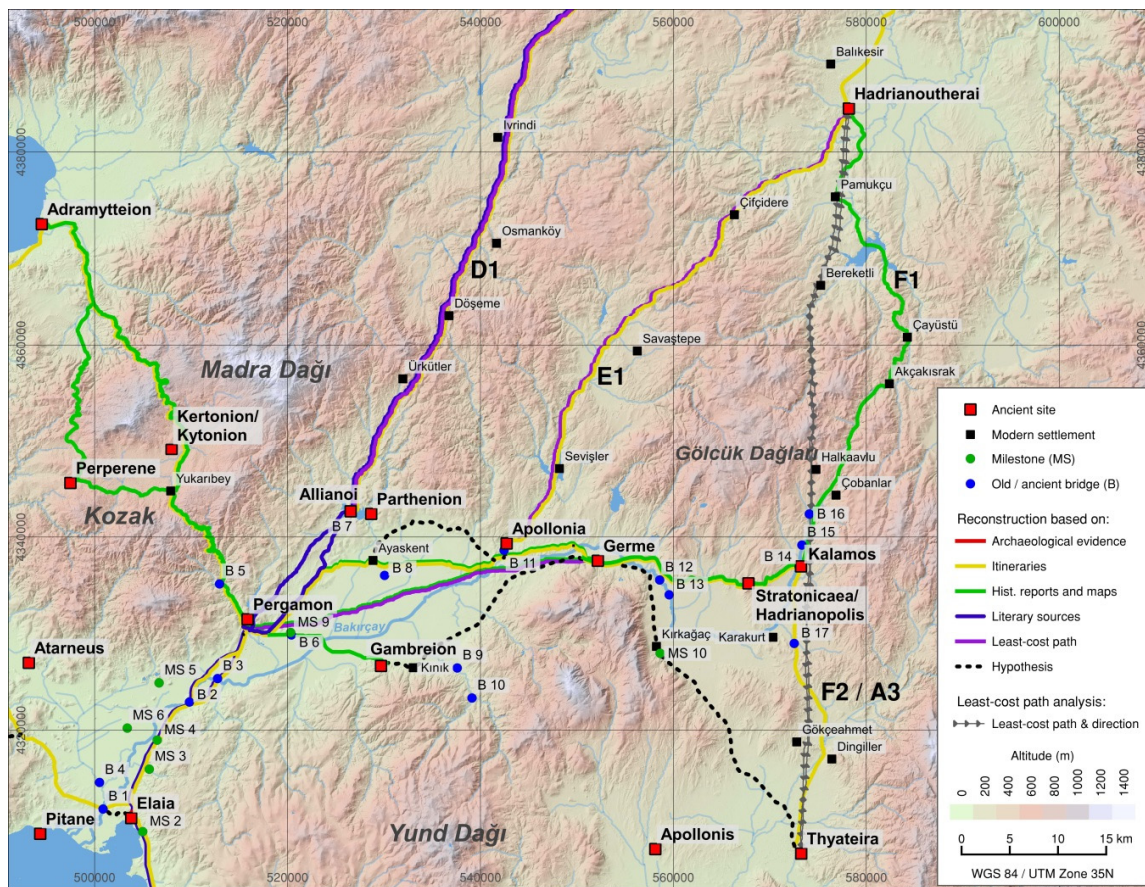
#### 5.6.1. Route F1 Hadrianoutherai – Kalamos

From Hadrianoutherai, another road led to Thyateira (Akhisar) via Kalamos (Gelembe) (Figure 17). The route is not mentioned in any of the itineraries and probably gained importance only in Byzantine times [27] (p. 231).

The least-cost path runs from Hadrianoutherai slightly southwest and straight on through the mountains to Thyateira, passing Kalamos on the way. The reconstructed route, on the other hand, runs in an arc along the river valleys further east. It can be reconstructed from various sources ([5] (p. 542), [12] (p. 20), [27] (p. 232)) and remains of bridges (bridge 15 and 16) in the area.

#### 5.6.2. Route F2 Kalamos – Thyateira (=A3)

The route between Kalamos (Gelembe) and Thyateira (Akhisar) corresponds to route A3, which was described above (Figures 8 and 17).



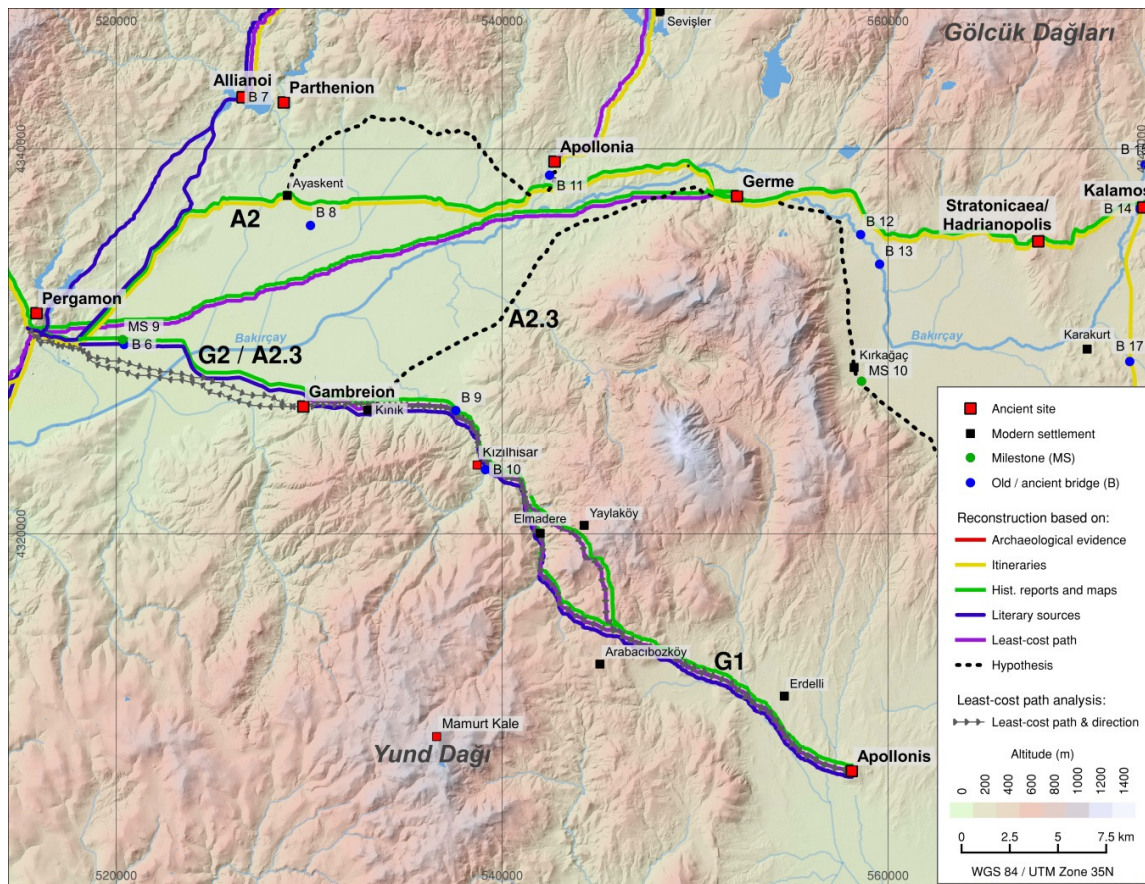
**Figure 17.** Calculated least-cost paths and reconstructed route between Hadrianoutherai and Thyateira via Kalamos.

### 5.7. Route G (Sardis –) Apollonis – Pergamon

#### 5.7.1. Route G1 Apollonis – Gambreion

From Apollonis, a road led through the Yund Dağı Mountains into the eastern lower Bakırçay Valley and to Pergamon (Figure 18). Strabo (Strabo 13.4.4 [64]) mentions a distance between Apollonis and Pergamon of 300 stadia (55.8 km), which indicates a course through the mountains and not through the Bakırçay Valley. W. von Diest ([12] (p. 25), [19] (pp. 105–106)) describes a road with ancient pavement and a width of 5 m leading from Apollonis into the mountains and probably to Gambreion. K. Rheidt [27] (pp. 231–232) considers this route as a gateway for Turkish tribes from the Yund Dağı Mountains into the lower Bakırçay Valley in Byzantine times and mentions a fortress at Kızılhisar ([12] (p. 15), [19] (pp. 130–131)).

The least-cost path from Apollonis to Gambreion runs through the river valleys via Elmadere. In the opposite direction, the path runs slightly further east via today's Yaylaköy, similar to the route reconstructed by M. Tozan [5] (p. 563) and shown by O. Berlet [25]. On the northern side of the Yund Dağı Mountains, the least-cost paths run through the valley of the Karadere Creek, past the aforementioned fortress at Kızılhisar into the lower Bakırçay Valley and to Gambreion. The calculated least-cost paths between Apollonis and Gambreion can be assumed as the probable route.



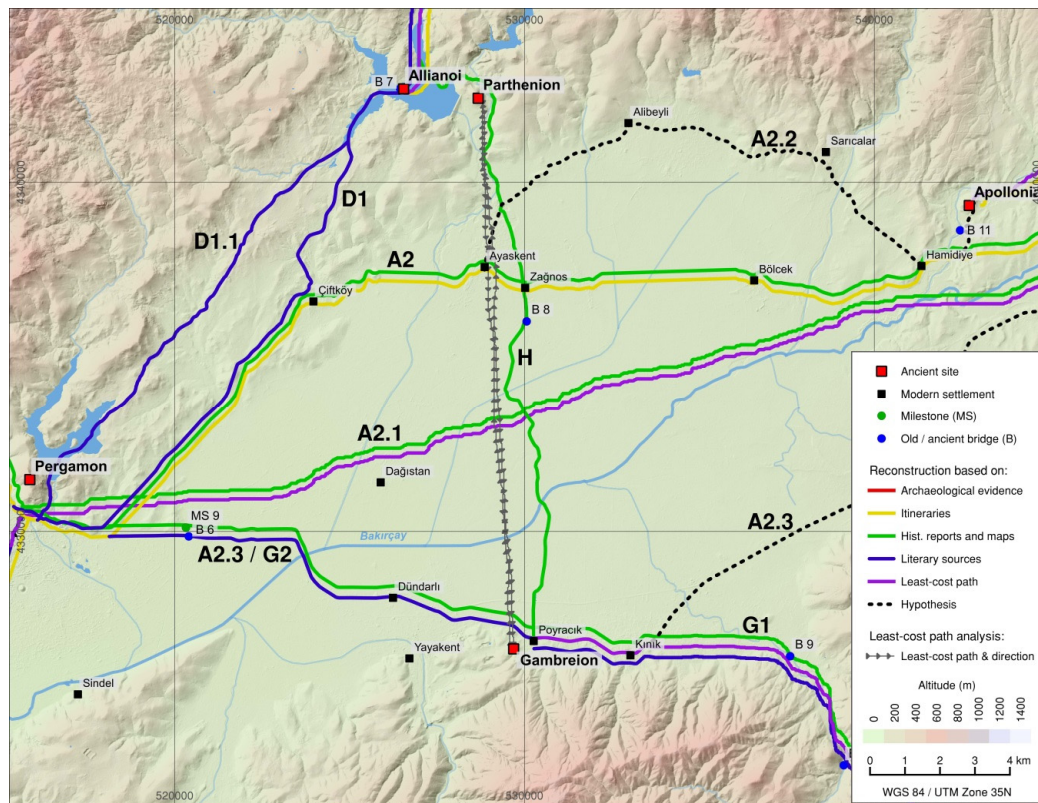
**Figure 18.** Calculated least-cost paths and reconstructed routes between Apollonis and Pergamon via Gambreion.

### 5.7.2. Route G2 Gambreion – Pergamon

Although Gambreion was located halfway between Pergamon and Germe, near present-day Poyracik and Kınık, it probably played a minor role as a stopover between those places, since the main route (route A2) ran north of the Bakırçay River [19] (p. 130) in antiquity (Figure 7). As the first larger settlement north of the Yund Dağı Mountains, Gambreion was instead an important stopover for travelers coming from Apollonis (Figure 18). From Gambreion, the route continued northwest where it crossed the Bakırçay River and further on another tributary (see also route A2.3) in the area of the Ottoman Koyun Köprü (bridge 6). Next to the bridge, a milestone (MS 9) [24] (pp. 102–103) dating back to the 4th century CE and with Pergamon as the starting point (*caput viae*), was discovered in the 19th century. From the bridge, the route ran to the west, where it met the route coming from Parthenion, Germe and Apollonia (route A2).

### 5.8. Route H Parthenion – Gambreion

It can be assumed that Gambreion and Parthenion, as the largest settlements in the eastern lower Bakırçay valley, were also connected by a route (Figure 19). Several bridges and fords are known in this area from the 19th century, over which the route through the plain may have passed [12] (p. 15). Also worth mentioning is a Byzantine bridge (bridge 8) south of Zağnos, which possibly originates from an ancient predecessor. The calculated least-cost path leads east of the bridge via Ayaskent. Although the result of the least-cost analysis must be interpreted with great caution due to the landscape changes and the repeated shifting of the river bed (see study area), the ancient route was probably within the range of the least-cost path, the bridge and the reconstructed route.



**Figure 19.** Calculated least-cost paths and reconstructed route between Parthenion and Gambreion.

### 5.9. Route I Magnesia – Pergamon

From ancient Magnesia (modern Manisa), located in the Hermos plain, a route led through the Yund Dağı Mountains to Pergamon ([12] (p. 25), [21] (pp. 74–75)) (Figure 20). It was recently reconstructed by M. Tozan [5] (p. 554) via the modern villages of Demirci, Recepli, and Örtülü. The route passed the highest peaks of the Yund Dağı Mountains and the sanctuary in Mamurt Kale, one of the most important extra-urban sanctuaries of Pergamon. The site had direct lines of sight to Pergamon [78] and a road connection to the city hill can also be assumed from the extension of the sanctuary under Philetairos [79].

The calculated least-cost paths run further west and offer another option for the way through the Yund Dağı Mountains.

### 5.10. Route J Aigai – Pergamon

#### 5.10.1. Route J1 Aigai – Pergamon

The largest ancient settlement in the Yund Dağı Mountains was Aigai (Figure 21), which must have had a road connection to Pergamon. The main route between the two cities probably followed an old road [12] (p. 27) from Aigai via Ismailli and along a ridge to Maruflar. The route continued northwest down into the valley of Değirmendere and followed the creek until reaching the road from Elaia to Pergamon (route B2). Then 1 km southwest of Karahıdırlı, the route passed a Hellenistic fortress or watchtower [80], which was located on a hill above the valley and served as a checkpoint at the entrance to the Bakırçay Valley. In addition, there was another fortress with the same function in the valley dating back to the Roman Imperial Period ([12] (p. 28), [19] (p. 117)). Both sites underline the importance of this route.

The calculated least-cost paths connect Aigai and Pergamon almost directly and give no further hints for the reconstruction of the ancient route.

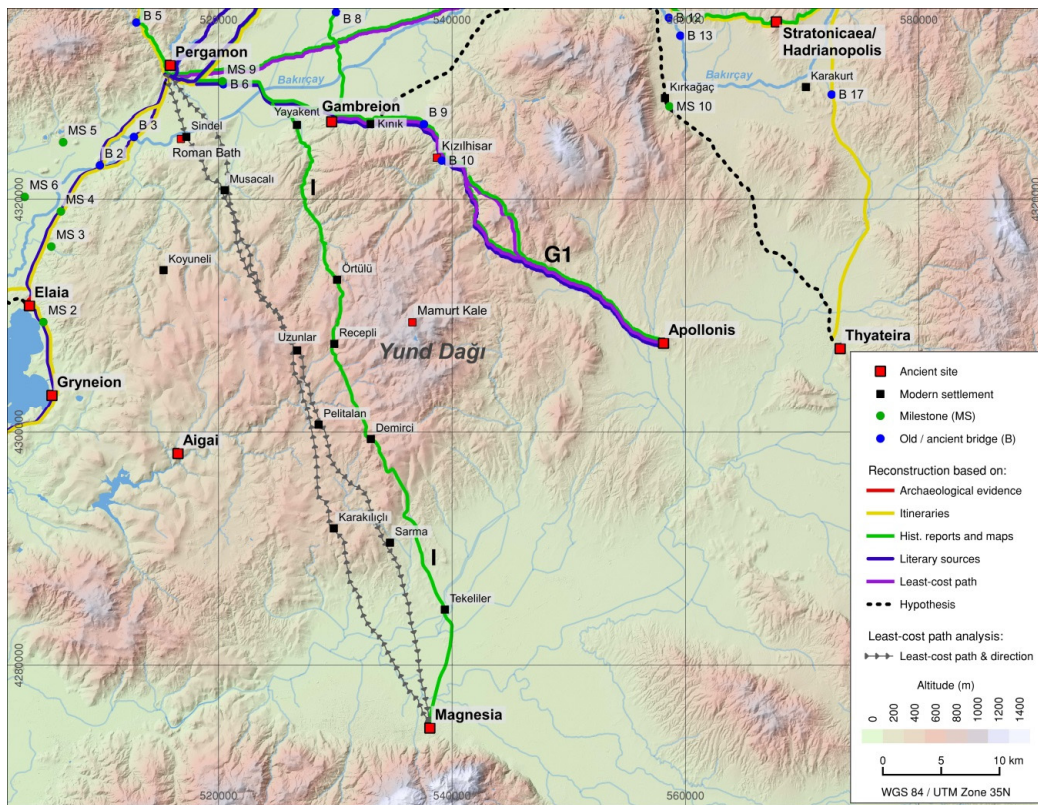


Figure 20. Calculated least-cost paths and reconstructed route between Magnesia and Pergamon.

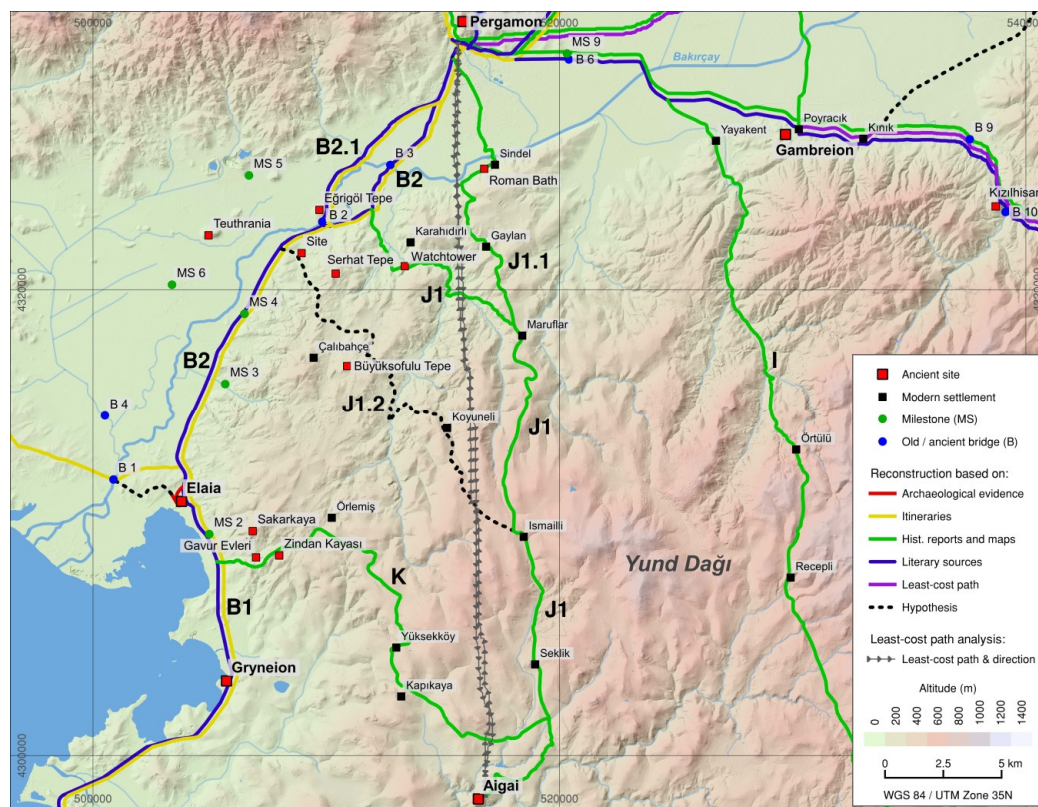


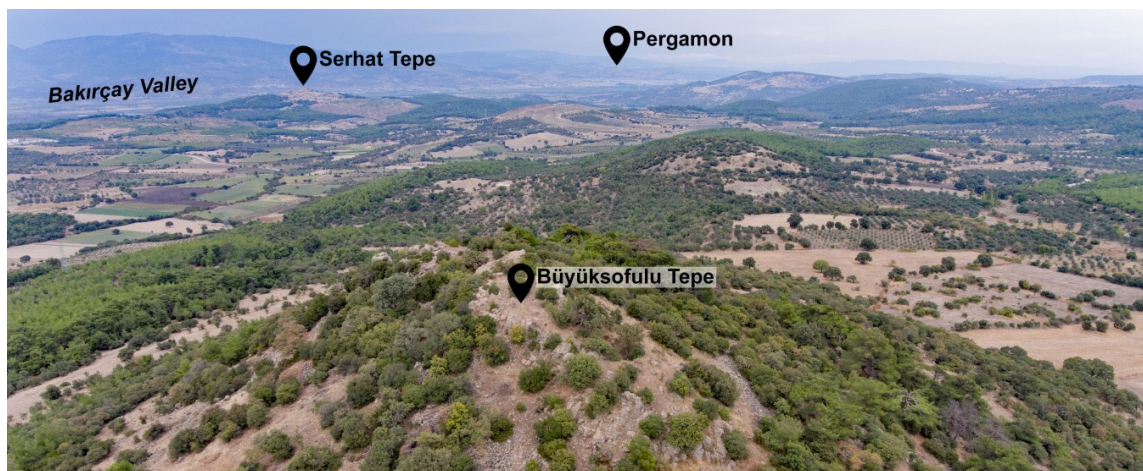
Figure 21. Calculated least-cost paths and reconstructed routes between Aigai and Pergamon and between Aigai and the ancient coastal route.

### Route J1.1 Aigai – Pergamon (Eastern Route)

From Maruflar, another route went further east via Gaylan and Sindel to Pergamon [12] (p. 27) (Figure 21). Just outside of Sindel, remains of a thermal bath ([19] (pp. 129–130), [80] (p. 168)) dating back to the Roman Imperial Period can be found right next to the modern road to Bergama. Such a route was recently reconstructed by M. Tozan [5] as well.

### Route J1.2 Aigai – Pergamon (Western Route)

Another route from Aigai to Pergamon branched off to the west at Ismaili and continued to Koyuneli, where a fortress controlled the route in Byzantine times ([27] (supplementary sheet 6), [5] (p. 554) (Figure 21)). K. Rheidt [27] and M. Tozan [5] reconstruct this route from Koyuneli further on to Karahıdırlı. As an alternative route to the two previously described, a course through the basin northeast of Çalibağçe is more conceivable. This route would have instead passed the Hellenistic watchtowers on Büyüksöfulu Tepe [24] (pp. 117–118) and on Serhat Tepe ([18] (pp. 213–214), [81] (pp. 121–123)), which were intensively built to control the region and the route (Figure 22). Further on its course, the road would have passed a large Roman villa [23] before it joined the road from Elaia and Pergamon (route B).



**Figure 22.** View from the fortress on Büyüksöfulu Tepe to the north. Route J1.2 ran from east (right) to west (left) into the Bakırçay valley passing between Büyüksöfulu Tepe and Serhat Tepe.

### 5.11. Route K Aigai – Coastal Road (Elaia)

From Aigai, another road led through the mountains via the village of Kapıkaya to Elaia (Figure 21), for which the pavement is supposedly still preserved in some places today [12] (p. 27). At the foothills of the Yund Dağı Mountains, the route passed the Hellenistic fortresses on Sakarkaya [22] ((p. 201), [82] (pp. 171–173)) and Gavur Evleri ([19], (pp. 114–115), [22] (pp. 200–201)) as well as Zindan Kayası ([22] (p. 201), [83] (pp. 222–225)), which may have been used as a fortress in the Hellenistic Period.

### 5.12. Route L Atarneus – Pergamon

#### 5.12.1. Route L1 Atarneus – Pergamon

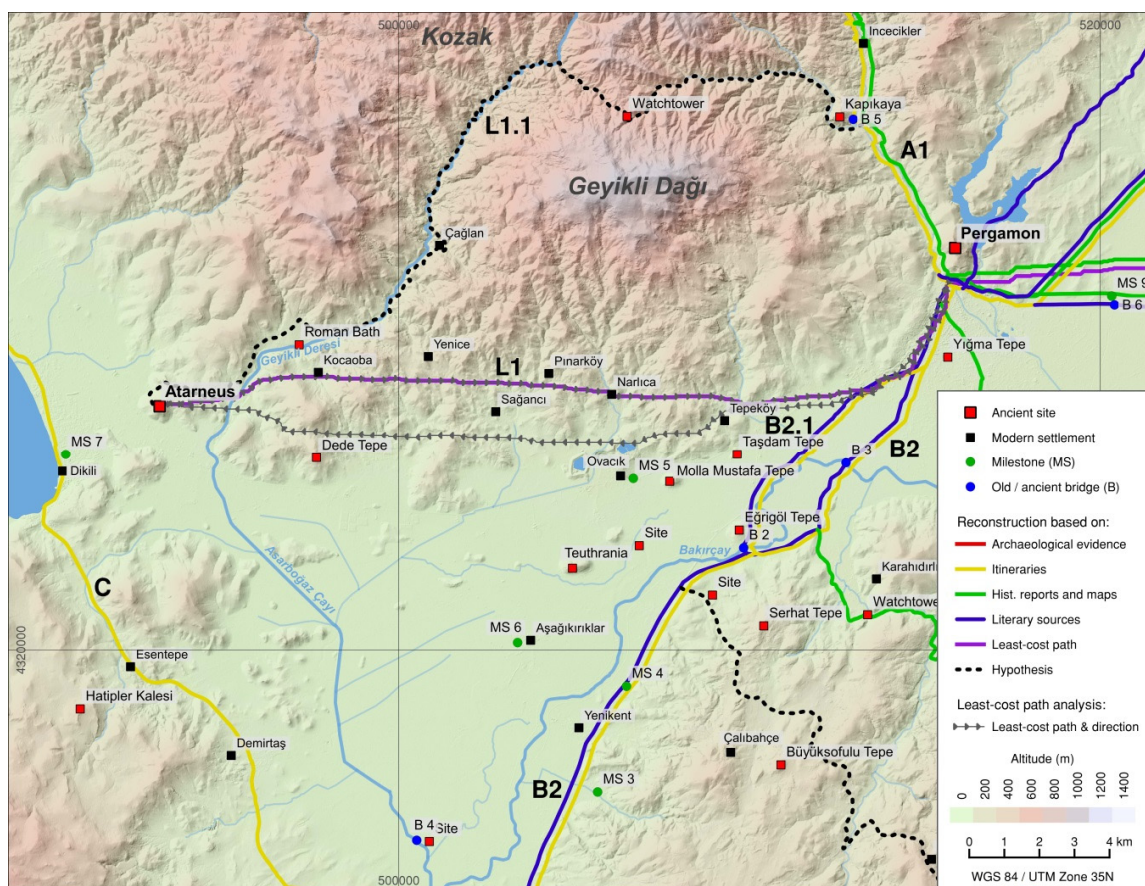
In antiquity, the route from Atarneus or modern Dikili to Pergamon did not play a key role because the important harbors of Elaia and Pitane were located south of the Kara Dağı Mountains in the Gulf of Çandarlı. Moreover, Atarneus was already flourishing in Hellenistic Period and lost importance with the rise of Pergamon [84].

In many historical maps, the connection between Atarneus or modern Dikili and Pergamon is shown as the best developed road in the region and is therefore considered as a continuously important



connection since antiquity. In fact, this road was only constructed by Carl Humann in the second half of the 19th century [12] (p. 9). At this time, Dikili became increasingly important as the nearest harbor to Bergama. But even a milestone (MS 5) [38] (p. 69) discovered at Ovacık does not give any indication of an ancient road or its course.

Another specific aspect of this route is the condition of the landscape between the foothills of the Kozak and Kara Dağı Mountains. Southeast of Atarneus, there was a swampy area, which partly extended all the way to Kalarga Tepe (Teuthrania) (see study area). C. Humann had to build elaborate bridge constructions to cross this swamp, but due to their need of intensive maintenance, they collapsed after a few years [12] (p. 9). It is therefore unlikely that a well-developed road already existed in antiquity. It is instead more probable that a route between Atarneus and Pergamon existed along the slopes of the Kozak Mountains and the Geyikli Dağı, similar to the calculated least-cost paths (Figure 23). The most probable course follows the calculated least-cost path from Atarneus to Pergamon, which passes the present villages in the foothills of the Kozak Mountains and the Geyikli Dağı. In addition, there have been no settlements between Dikili, Ovacık and Aşağıkırklar that needed to be made accessible by roads at least until the 19th century ([25,41]).



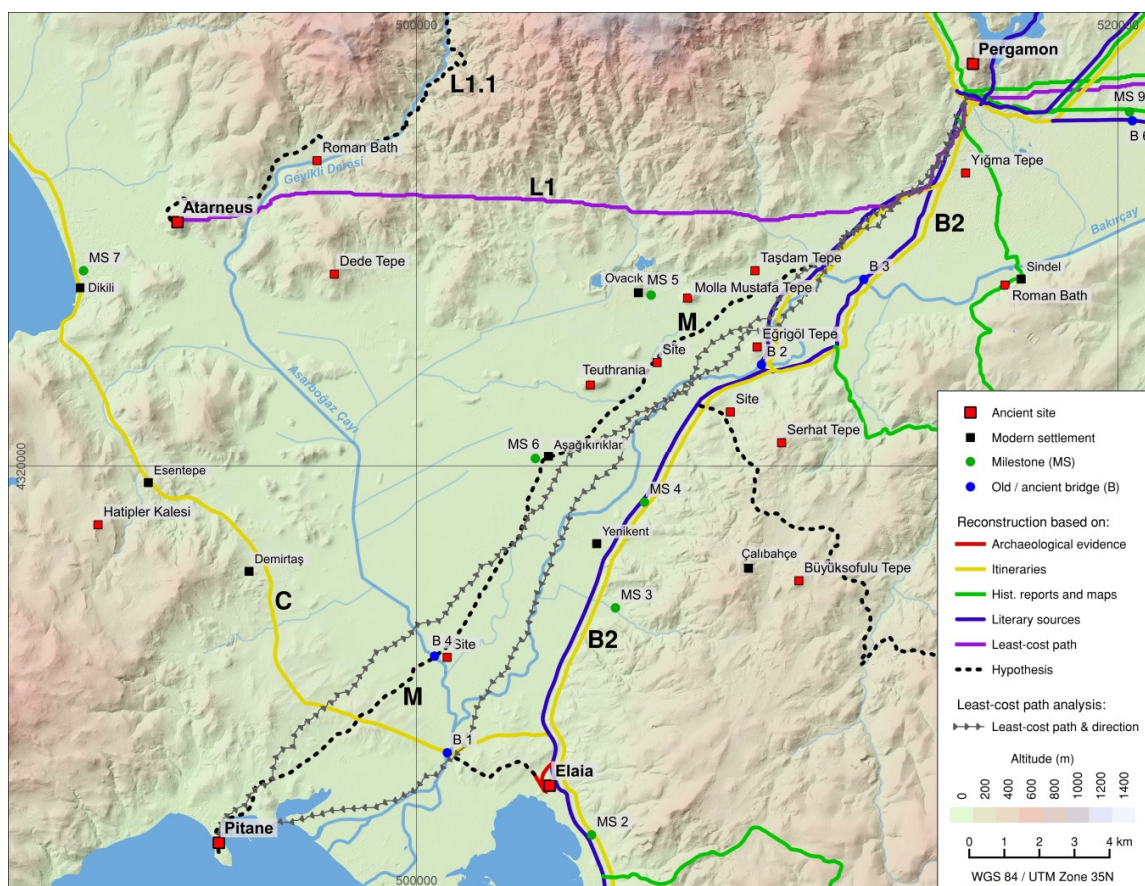
**Figure 23.** Calculated least-cost paths and reconstructed routes between Atarneus and Pergamon.

#### Route L1.1 Atarneus – Pergamon (through the Kozak Mountains)

An alternative route from Atarneus to Pergamon may have led through the Kozak Mountains north of the Geyikli Dağı (Figure 23). The route ran through the Geyikli Dere, passing a Roman thermal bath and reaching the pass that led to the K m r Dere. On the narrow ridge, a probably Byzantine watchtower controlled the pass between the two valleys ([19] (p. 128), [24] (p. 123)). Leaving the watchtower behind, the route continued via Kapıkaya to Pergamon.

### 5.13. Route M Pitane – Pergamon

Pitane played an important role for Pergamon's connection to supra-regional maritime trade networks, at least since the Roman Imperial Period [85]. Due to its peninsular position, the city could only be reached by land from the north (Figure 24). It can be assumed that a route north of the Bakırçay River through the plain already existed in antiquity. Although the landscape of the plain has changed since antiquity (see study area), several archeological sites can be considered as evidence for such a route, such as bridge 4 over the Asarboğaz Çayı. Sections east and west of the bridge are paved with spolia today [24] (pp. 124–125). A site next to the bridge dating back to the Roman Imperial Period [24] (p. 125) underlines the continuity of this river crossing. Moving onwards, the route runs south of Teuthrania where it meets the ancient main road leading down the southern slope of the prominent hill. A milestone (MS 6) [38] (pp. 69–71) found nearby at Aşağıkırıklar with Pergamon as starting point (*caput viae*) provides further evidence of a road in this area. East of Teuthrania, the road passed a necropolis [23] that is located on the southern slopes of the Sultantepe. A few hundred meters further east, between the old arms of a river on a slightly elevated hilltop [6], a large building complex from the Hellenistic or Roman Imperial Period is located ([18] (pp. 216–217), [23]). Further on, the route passes the Taşdam Tepe, where the entrances of a tumulus [86] and a rock chamber grave [86] (p. 242) are oriented southeast towards the route. Via the route mentioned in section B2.1, the road from Pitane finally led to Pergamon.

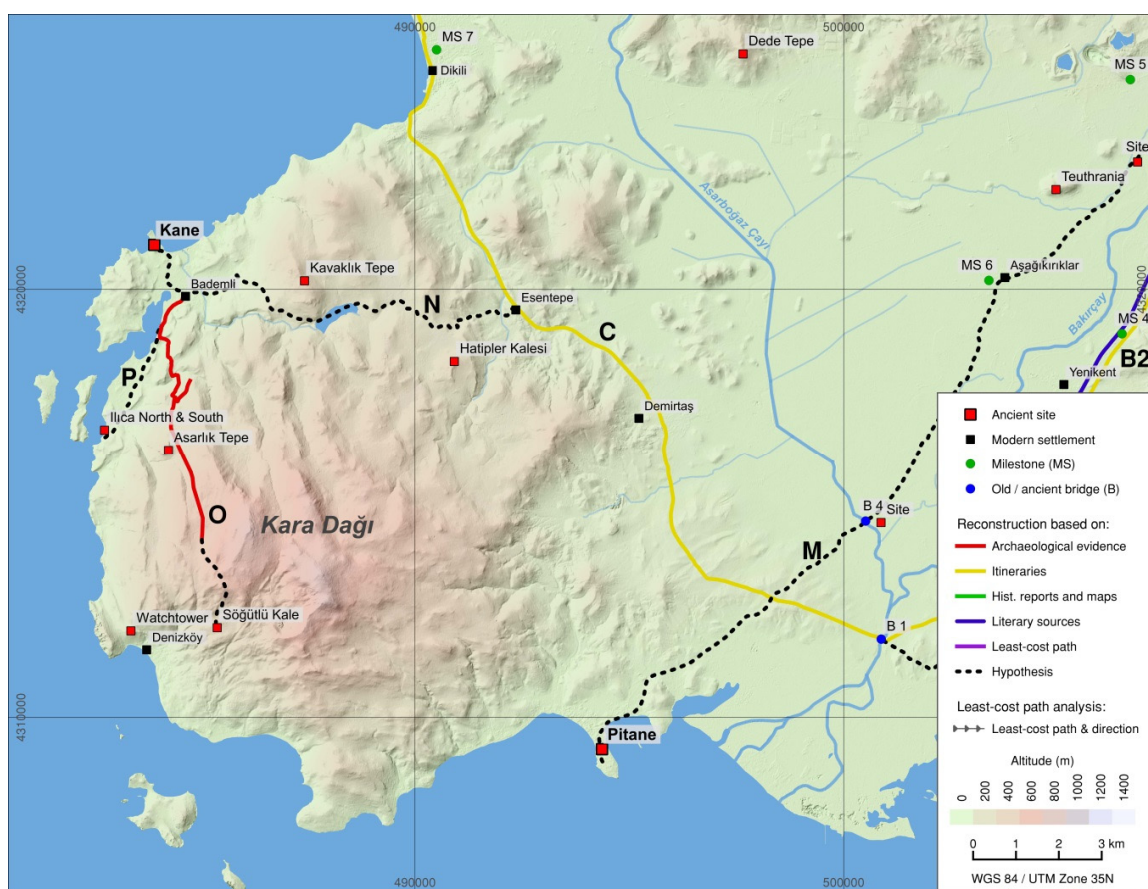


**Figure 24.** Calculated least-cost paths and reconstructed route between Pitane and Pergamon.

The calculated least-cost path from Pergamon to Pitane runs near the already identified and discussed road between Pergamon and Elaia. The last section between bridge 1 and Pitane runs through an area that was below sea level in antiquity [67]. The calculated least-cost path from Pitane to Pergamon corresponds approximately to the reconstructed route.

#### 5.14. Route N Kane – Coastal Road (C Adramytteion – Elaia)

An ancient road between Kane and Atarneus is not very likely. The shoreline is extremely steep in this area and the construction of a road would have required much effort and resources. For a relatively small harbor city like Kane, waterborne transport was much more efficient than the construction of coastal roads. However, the harbor was by no means cut off from the road network of the region. A connection from Kane through the Kara Dağı Mountains, passing the fortress on the Kavaklık Tepe ([18] (pp. 212–213), [19] (p. 119)) and the settlement of Hatiplar Kalesi ([81] (pp. 119–121), [87] (pp. 181–182), [88] (pp. 154–158)) and leading to the ancient coastal road (route C) can be assumed (Figure 25). The fortress on Kavaklık Tepe would have therefore served as an important observation point for the security of the route and the largest known settlement in the northern Kara Dağı Mountains, Hatiplar Kalesi, and would have been well connected to both the harbor in Kane and the Bakırçay Valley.



**Figure 25.** Reconstructed routes between Kane and the ancient coastal road and from Kane to the Kara Dağı Mountains.

#### 5.15. Route O Kane – Kara Dağı Mountains

The only remains of an ancient extra-urban road that have been discovered so far are located in the northern Kara Dağı Mountains (Figure 25). The road led up into the Kara Dağı Mountains and connected Kane with the farmsteads of Asarlık Tepe ([18] (p. 212), [19] (p. 119)) and Söğütlü Kalesi ([18] (pp. 211–212), [19] (p. 119)). The southern part of the road consists of andesite field stones over a length of 1.1 km and has a width of between 1 m and 2.5 m. A second lane has been identified on the northern part of the road, and 1.5 km south of Bademli another paved road branches off to the north-east.

Whether the road from Söğütlü Kalesi continues to the watchtower at Denizköy [17] (pp. 161–164) or even to Pitane, as reconstructed by Tozan [5], is uncertain, since the terrain in this part of the peninsula is very rugged. The road instead served as a connection between the fertile plateaus and the farmsteads of the Kara Dağı Mountains and the harbor of Kane.

#### 5.16. Route P Kane – Ilica North and Ilica South

Thermal baths (Ilica North and Ilica South) dating back to the Roman Imperial Period ([16] (pp. 178–179), [17] (pp. 164–167), [89] (pp. 146–150)) can be found along the shore south of Kane (Figure 25). It can be assumed that they had moorings for transporting people and goods to the nearby larger harbors of Kane, Pitane or Elaia. An additional 4.5 km long land route to Kane also cannot be excluded. The terrain along the coast is relatively flat and such a route not only may have connected the thermal baths but also the bays and landing sites ([16] (pp. 177–178)) near the Arginusae Islands with Kane.

#### 5.17. Route Q Perperene – Coastal Road (Near Ayvalık)

From Perperene in the Kozak Mountains, at least two other routes led to the ancient coastal road (route C). One connection was recently reconstructed by M. Tozan [5] (p. 563) along today's Bergama-Ayvalık road to the coast (Figure 26).

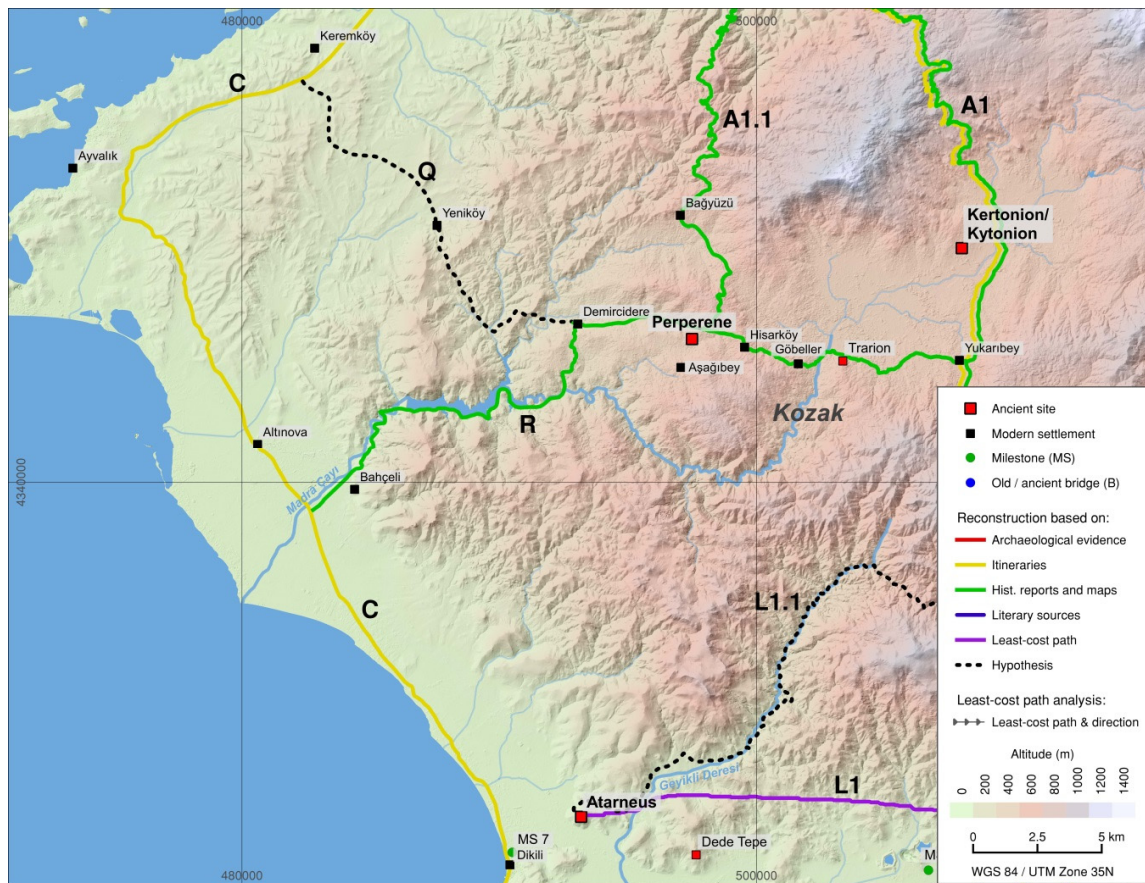


Figure 26. Reconstructed routes between Perperene and the ancient coastal road.

#### 5.18. Route R Perperene – Coastal Road (Near Altınova)

Another route probably ran to the coast near modern Altınova (Figure 26). It was recently reconstructed by K. Rheidt [27] (supplementary sheet 6) along with a Byzantine fortress near Bahçeli. It is mentioned by W. von Diest [12] (p. 12) as a “summer path”, as it led through the riverbed of the Madra River at numerous places.

5.19. Route S Kozak Mountains and Kestel Creek Valley – Pergamon

Another route must have led from the Kozak Mountains through the Kestel Creek Valley (Ketios Valley) to Pergamon (Figure 27). Due to the modern reservoir north of the city hill, any remains of a route are likely lost in this area. A watchtower on the Çoban Tepe [19] (pp. 128–129) next to the river is strong evidence for the existence of route through the valley, however. From this place the valley could be observed and controlled very well. Another site is located 5 km north-east of Çoban Tepe near Avunduruk. It offered an outstanding view of the Kestel Creek Valley up to Pergamon and into the Kozak Mountains, serving as an observation post as well (Figure 28).

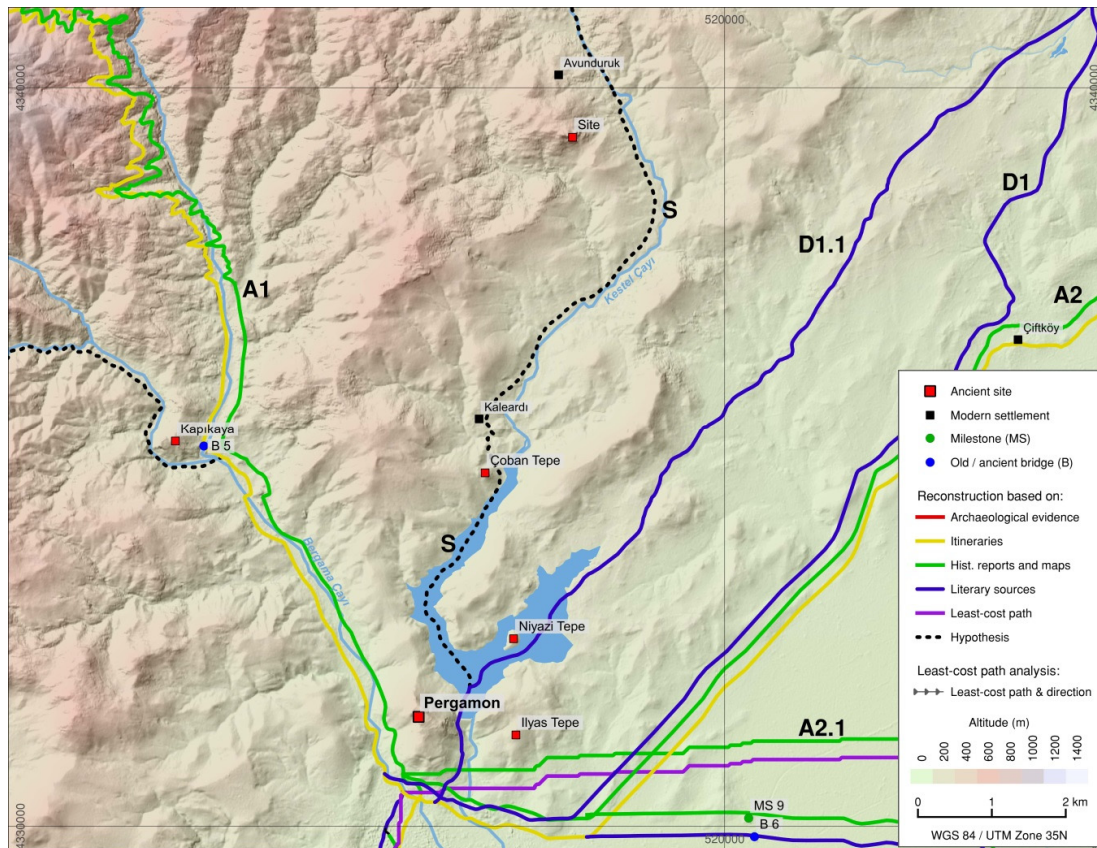


Figure 27. Reconstructed route from Pergamon through the Kestel Creek Valley into the Kozak Mountains.



Figure 28. View from the site near Avunduruk to the south.

## 6. Discussion

The routes reconstructed in this study connect the city of Pergamon with its surrounding mountain ranges, the Bakırçay Valley and the Aegean coastline. The compilation of all routes provides a general overview of the route network for the first time (Figure 29, Table 4), which can now be discussed in different contexts. Even though this route network does not claim to be complete, since, for example, smaller secondary routes and some supra-regional connections to settlements at a greater distance from Pergamon could not be considered, important aspects can be derived from this network.

### 6.1. Route Network as Element of Socio-Economic Processes

A city like Pergamon was dependent on the food supply from its rural surroundings. The extent to which the Pergamon Micro-Region was able to supply the city or whether additional imports were necessary is the subject of current discussions [90,91]. It can be assumed, however, that the lower Bakırçay Valley and the adjacent slopes and valleys, whose fertility was already praised by Strabo (Strabo 13.4.2 [64]), ensured a large part of the food supply. They were made accessible by the east-west connections through the lower Bakırçay Valley. The route to Elaia (route B2, B2.1) or the routes to Pitane (route M) and Atarneus (route L) connected the western lower Bakırçay Valley with its scattered agricultural and rural settlements, which existed during the Hellenistic Period and probably continued during the Roman Imperial Period [90] (pp. 155–159). The same can be assumed for the eastern lower Bakırçay Valley with the routes to Parthenion and Allianoi (route D1, D1.1), Apollonia (route A2, A2.1, A2.2, E2) and Gambreion (route G2).

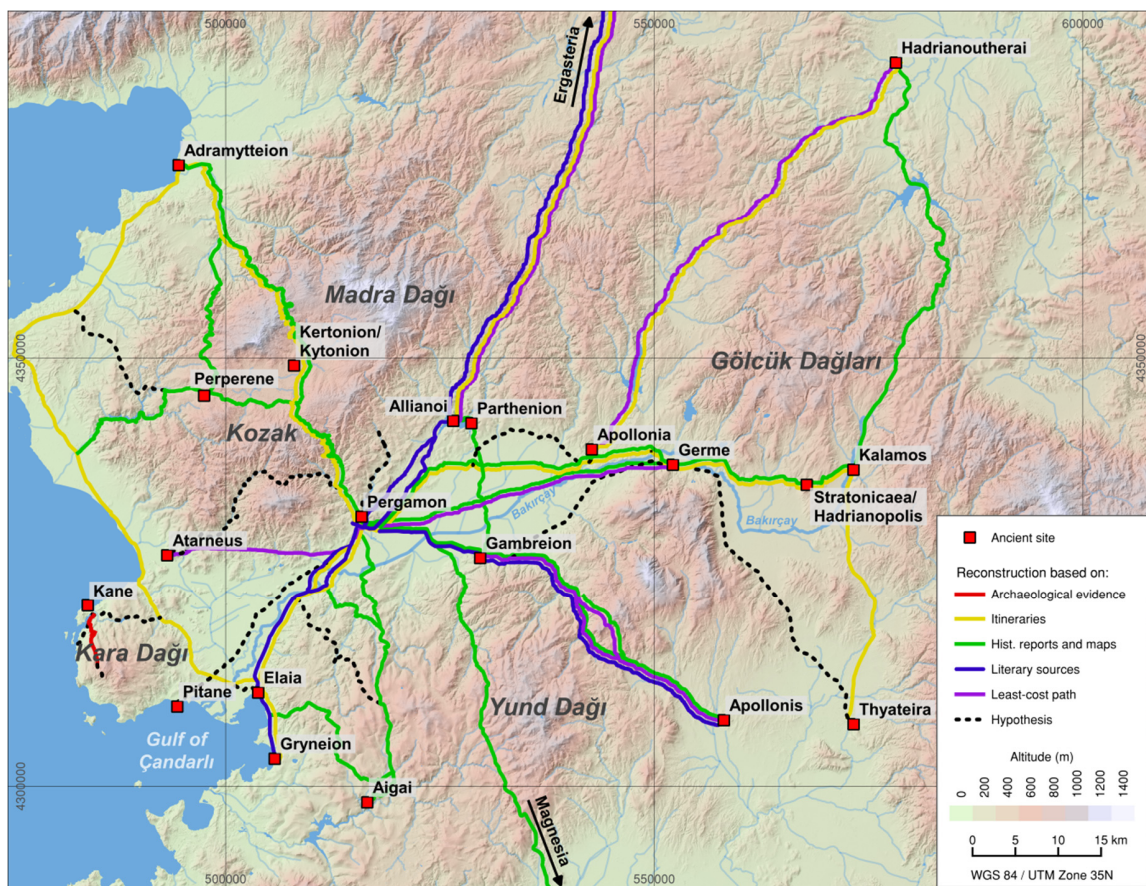


Figure 29. Reconstructed route network in Pergamon's surroundings.

**Table 4.** Reconstructed routes with their code and distance.

Code	Route	Distance (km)
A	Adramytteion – Thyateira	152.42–176.14 <sup>1</sup>
A1	Adramytteion – Pergamon (via Kytonion)	71.17
A1.1	Adramytteion – Pergamon (via Perperene)	75.98
A2	Pergamon – Germe (via Apollonia)	41.75
A2.1	Pergamon – Germe (through the plain)	40.85
A2.2	Pergamon – Germe (along the northern edge of the eastern lower Bakırçay Valley)	44.80
A2.3	Pergamon – Germe (along the southern edge of the eastern lower Bakırçay Valley)	41.35
A3	Germe – Thyateira (via Stratonicea/Hadrianopolis and Kalamos)	55.36
A3.1	Germe – Thyateira (via Kirkağaç)	40.40
<b>B</b>	<b>(Ephesus –) Gryneion – Pergamon (via Elaia)</b>	<b>54.51–54.52<sup>1</sup></b>
B1	Gryneion – Elaia and around Elaia	29.88
B2	Elaia – Pergamon (via bridge 3)	24.64
B2.1	Elaia – Pergamon (via bridge 2)	24.63
<b>C</b>	<b>Adramytteion – Elaia</b>	<b>82.30</b>
<b>D</b>	<b>(Cyzicus –) Ergasteria – Pergamon</b>	<b>87.65–89.62<sup>1</sup></b>
D1	Ergasteria – Pergamon (via Parthenion and Alliano through the Bakırçay Valley)	89.62
D1.1	Ergasteria – Pergamon (via Parthenion and Alliano through the Kestel Creek Valley)	87.65
<b>E</b>	<b>Hadrianoutherai – Pergamon</b>	<b>104.10</b>
E1	Hadrianoutherai – Apollonia	70.70
E2	Apollonia – Pergamon (=A2 in parts)	33.40
<b>F</b>	<b>Hadrianoutherai – Thyateira</b>	<b>91.30</b>
F1	Hadrianoutherai – Kalamos	60.41
F2	Kalamos – Thyateira (A3 in parts)	30.89
<b>G</b>	<b>(Sardis –) Apollonis – Pergamon</b>	<b>58.73</b>
G1	Apollonis – Gambreion	42.71
G2	Gambreion – Pergamon	16.02
<b>H</b>	<b>Parthenion – Gambreion</b>	<b>19.89</b>
<b>I</b>	<b>Magnesia – Pergamon</b>	<b>69.03</b>
<b>J</b>	<b>Aigai – Pergamon</b>	<b>40.69–48.47<sup>1</sup></b>
J1	Aigai – Pergamon	43.97
J1.1	Aigai – Pergamon (eastern route)	40.69
J1.2	Aigai – Pergamon (western route)	48.47
<b>K</b>	<b>Aigai – Coastal road (Elaia)</b>	<b>28.94</b>
<b>L</b>	<b>Atarneus – Pergamon</b>	<b>25.90–38.12<sup>1</sup></b>
L1	Atarneus – Pergamon	25.90
L1.1	Atarneus – Pergamon (through the Kozak Mountains)	38.12
<b>M</b>	<b>Pitane – Pergamon</b>	<b>32.39</b>
<b>N</b>	<b>Kane – Coastal road (C Adramytteion – Elaia)</b>	<b>10.88</b>
<b>O</b>	<b>Kane – Kara Dağı Mountains</b>	<b>14.67</b>
<b>P</b>	<b>Kane – Ilica North and Ilica South</b>	<b>8.90</b>
<b>Q</b>	<b>Perperene – Coastal road (near Ayvalık)</b>	<b>22.32</b>
<b>R</b>	<b>Perperene – Coastal road (near Altınova)</b>	<b>22.64</b>
<b>S</b>	<b>Kozak Mountains and Kestel Creek Valley – Pergamon</b>	<b>13.18</b>

<sup>1</sup> Shortest and longest distance.

Other goods such as timber and firewood or stones such as granite and marble were mainly carried from the Kozak Mountains to Pergamon ([3] (pp. 19–20), [63], [90] (p. 164)). The main traffic routes for such resources were the connections to Perperene (route A1.1) and Kytonion (route A1), and through

the Kestel Creek Valley (route S). Imports from more distant regions could be transported to Pergamon via the routes from Adramytteion (route A1, A1.1), Ergasteria (route D), Hadrianoutherai (route E), Thyateira (route A2, A2.1, A2.2, A3, A3.1), Apollonis (route G), Magnesia (route I) or Aigai (route J).

Due to cheaper sea transport and the easier and safer route through the western lower Bakırçay Valley, a large amount of the supra-regional trade and transport is supposed to have been carried out via the harbors of Elaia and Pitane [85]. Elaia, as the main harbor of Pergamon, had the advantage of the shortest land connection to city. But at least since the Roman Imperial Period, Pitane, which is only a few kilometers away from Elaia, became even more important for Pergamon due to the extension of its harbor. The two routes through the western lower Bakırçay Valley (Elaia: route B2, B2.1; Pitane: route M) are thus probably among the most important roads for the city.

### 6.2. Route Network as Element of Cultural Processes

Cult places such as tumuli or natural sanctuaries can be described as landmarks and their positioning is part of a spatial strategy during the Attalid rule [73]. Even though the mythical-religious topography of the surrounding countryside changed during the Roman Imperial Period, these prominent structures remained and continued to form an impressive overture for people using the routes through the western lower Bakırçay Valley to Pergamon ([3] (p. 11), [73]).

The monumental buildings on the city hill, such as the Trajaneum, the Great Altar, or the Athena sanctuary are deliberately oriented to the southwest and thus create visual connections to the western lower Bakırçay Valley (cf. [73] with further literature). This architectural layout is therefore particularly impressive when arriving via the routes from Elaia and Pitane (route B2, B2.1 and M). These examples illustrate that the course of routes and the placement of monuments along them have also been used as a means of demonstrating power.

Visual connections [78] between Pergamon and extra-urban natural sanctuaries such as Kapıkaya or Mamurt Kale have already been proven. They can now be supplemented by the routes reconstructed here and create new perspectives for the investigation of the relation between the city and extra-urban natural sanctuaries.

The connection to other suburban facilities such as the Roman thermal bath Kleopatra Güzellik Ilıcısı [92] or the Asklepieion on the outskirts of modern Bergama must remain the subject of future investigations in the context of the urban street system.

### 6.3. Control and Securing of the Route Network

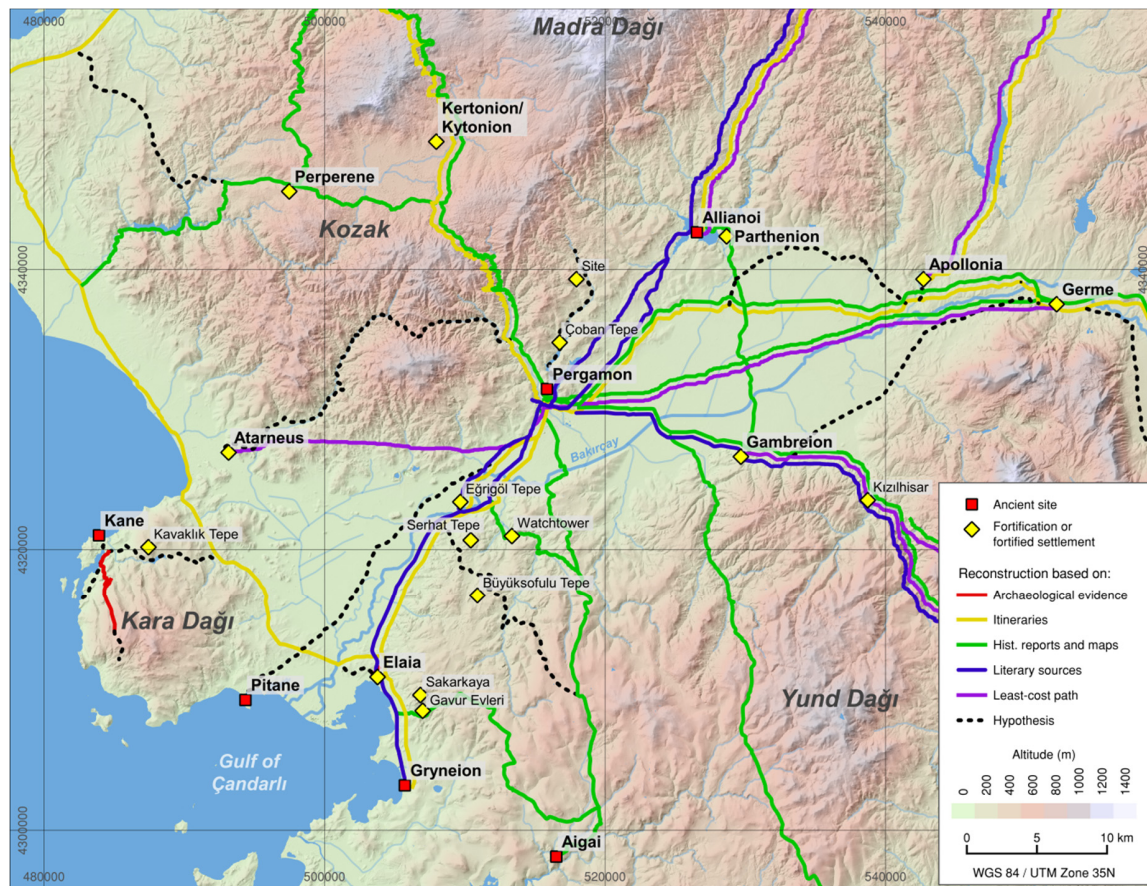
The reconstructed routes in the region surrounding Pergamon represent the lifelines of the city. They ensured the supply of the city with resources and food, and enabled regional and supra-regional exchange of information, goods, and people. It was therefore vital for Pergamon to control and secure these routes and the regions they accessed. Although numerous fortresses and fortified settlements in Pergamon's surroundings are known from the Hellenistic Period, the function of most sites has not yet been analyzed. By reconstructing the route network, the function of many places now becomes particularly clear. All routes leading into the lower Bakırçay Valley passed a fortress or fortified settlement, which guaranteed control and protection (Figure 30).

The Hellenistic fortress on Eğrigöl Tepe, which is identified with ancient Halisarna, was located about 10 km southwest of Pergamon. Directly next to the hill passed the route to Pitane, and the route to Elaia crossed the Bakırçay River nearby as well (bridge 1). Due to its location, the site served as an important landmark [3] (p. 13) and at the same time controlled the traffic routes in the western lower Bakırçay ([3] (p. 9), [19] (pp. 116–117)).

Only 3 km east of Eğrigöl Tepe, the Değirmendere opens into the Bakırçay Valley. One of the main routes from the Yund Dağı Mountains ran through this valley, leading from Aigai to Pergamon (route J). Close to the end of the valley and 1 km southwest of Karahıdırlı, a Hellenistic watchtower was situated on a hill above the route [80]. This watchtower controlled the entrance from the Yund



Dağı Mountains in the Hellenistic Period. In the Roman Imperial Period, this role was probably taken over by a nearby fortress ([12] (p. 28), [19] (p. 117)).



**Figure 30.** Reconstructed route network in the surroundings of Pergamon. The yellow squares represent fortifications or fortified settlements.

The western route from Aigai to Pergamon (route J1.2) led through a fertile basin and open valleys into the Bakırçay Valley. This area and the route were controlled by two fortresses dating back to the Hellenistic Period. From a fortress on the Büyüksofulu Tepe [24] (pp. 117–118), large parts of the route could be observed (Figure 22). The site also provided line-of-sight connections across the Bakırçay Valley to Pergamon and to the fortress on Serhat Tepe ([18] (pp. 213–214)). This place offered an extraordinary view into the Bakırçay Valley, to Pergamon, and over the foothills of the Yund Dağı Mountains, whose routes could be controlled from here.

Southeast of Elaia, another route from the Yund Dağı Mountains led to the coastal road. This route was controlled by the fortresses on the Sakarkaya ([22] (p. 201), [82] (pp. 171–173)) and the Gavur Evleri ([19] (p. 114), [22] (pp. 166–167, 200–201)), both of which were used during the Hellenistic period. Elaia, which was located at the bottleneck between the foothills of the Yund Dağı Mountains and the coast (Figure 10), also served as a checkpoint at the southwestern entrance to the lower Bakırçay Valley ([1,93]).

The routes from the harbors and landing sites along the Kara Dağı Mountains were also controlled by watchtowers [19] (100–101). In this context, the fortress on the Kavaklık Tepe ([19] (p. 119), [94]) in the northern Kara Dağı Mountains, which could observe and secure the route to Kane (route N), should be highlighted.

The northwestern entrance to the lower Bakırçay valley could be secured by Atarneus (Figure 13) or the fortress on the Dede Tepe.

The important routes from Perperene and Adramytteion (route A1, A1.1) to Pergamon must have been secured as well. Although W. von Diest [12] (p. 9) describes Kapıkaya as a watchtower that would actually be predestined for this purpose, this place primarily had a ritual function [95]. For the routes from the western Kozak Mountains, Perperene was considered the primary fortress ([3] (p. 19), [61]). The same function was fulfilled by Kytonion ([19] (p. 124), [61] (pp. 13–14)) for the western route from Adramytteion to Pergamon.

Near Kaleardı, about 4 km northeast of Pergamon, a watchtower was located on the small Çoban Tepe [19] (pp. 128–129). From this location, the road leading through the Kestel Creek Valley to Pergamon (route S) could be well controlled. In addition, 5 km northeast of Çoban Tepe, above the western bank of the Kestel Creek, another site offered a view over the entire valley up to Pergamon.

The routes that led to Pergamon via the eastern lower Bakırçay Valley were secured at the entrance to the plain by larger settlements such as Parthenion, Apollonia, Germe and Gambreion. A Byzantine fortress ([12] (p. 15), [19] (pp. 130–131), [27] (pp. 231–232)) located in the valley southwest of Gambreion controlled the route through the Yund Dağı Mountains. Whether previous buildings from the Roman Imperial Period or Hellenistic Period exist at this site has yet to be analyzed.

As a concluding remark, it can be stated that all routes leading to the lower Bakırçay Valley and thus to the core territory of Pergamon were controlled and secured by fortifications or fortified settlements in the Hellenistic Period. In the Roman Imperial Period this situation seems to have changed during which time several sites were abandoned (cf. [96] (p. 113)). Whether the fortifications or fortified settlements were part of a superordinate network, e.g., on the basis of mutual visibility, and what role they played for Pergamon in securing the routes and territory in the Hellenistic and Roman Imperial Period should be investigated more specifically in future studies.

## 7. Conclusions

The aim of this study was the reconstruction of the ancient route network in the region surrounding Pergamon by combining historical and archeological sources with modern computer-aided least-cost path analyses. Despite the limited number of archeologically known ancient roads or other infrastructural elements in the vicinity of Pergamon, this study has succeeded in drawing a comprehensive overview of the ancient route network in the region. The great importance of a well-developed route network for the development and prosperity of a city like Pergamon becomes obvious. The routes enabled not only regional and supra-regional trade but also communication and the supply of food and resources. In addition, they facilitated military movements and essential routes were controlled and secured by the construction of specific fortifications in the Hellenistic Period. Many aspects of social life are therefore based on the use of these routes.

The study of routes in the surroundings of Pergamon cannot yet be considered complete. Nevertheless, the results already offer new perspectives in the investigation of the relationship between the ancient city of Pergamon and its surrounding landscape and they provide new opportunities for the study of human-environment relations within the Pergamon Micro-Region.

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