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Landscape Development and Changing Environment of Troia (North-western Anatolia)

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Abstract

Troia, the epic city of ancient times, has a unique geographical position at the entry of the Çanakkale Strait. This area consists of Upper Miocene shallow marine sediments, which constitute a low horst–graben system. Between plateau ridges about 50–100 m high, the lower course of the Karamenderes (ancient *Scamander*) River flows in an alluvial plain. During the Holocene sea-level rise, marine intrusion transformed this part of the valley into a marine embayment. In this area, the relative sea level reached its present position ca. 7000–6000 years ago, and the coastline arrived close to the southern end of the embayment. Then, deltaic progradation processes of the Karamenderes River dominated the embayment filling, leading the coastline to reach the west of Troia ca. 4000 years ago. A 2–3 m sea level fall during the Late Bronze Age (LBA) was probably caused by the acceleration of the deltaic progradation. Later, slightly rising sea reached to the present level again around the time of the Emperor Augustus (27 BC to 14 AD). However, alluviation compensated this small sea-level rise, and deltaic progradation continued slowly to reach the coastline to the Çanakkale Strait.

Keywords

Karamenderes • Troia • Late Bronze Age • Turkey

12.1 Introduction

The geomorphological outlines of the Aegean coastal region of Anatolia are mainly controlled by neotectonic movements. The major landform units, which generally run on the W-E direction, consist of horsts and grabens between the main fault zones. Precisely, regional landforms comprise many large blocks broken by faults extending in different directions. The main geodynamic factors of this break-up are the activity of the North Anatolian Fault, the Southern Aegean subduction and the emergence of the Menderes Massif in the western Anatolia (Fig. 12.1). Their cumulative effects have caused a great tensional stress on the upper lithosphere and block faulting.

The northern part of this system, the Biga Peninsula, is also its biggest block. Extending ca. 150 km in the E-W direction and 100 km in the N-S direction, it is situated in the transition zone between the North Anatolian Transform Fault Zone (NAF) and the Aegean Extensional Province. West to east it lies between the depression zones of the Marmara Sea and Saros Gulf to the north, which are both related to the NAF activity, and the Edremit Gulf of the Aegean graben system (e.g. the Aegean Extensional Province) to the south. The structural extension of the peninsula continues widely at the bottom of the Aegean Sea to the west. Above this shelf rise the islands of Limnos, Gökçeada and Bozcaada. During the Last Glacial Maximum (LGM), when the sea level was more than 100 m lower than today, these islands were most probably connected to the Anatolian mainland. If correct, when the sea level was about −50 m (i.e. in the Early Holocene ca. 10,000 years ago), the islands were separated from one another and from the Biga Peninsula by narrow straits. However, Bozcaada Island was still connected with the mainland (Fig. 12.2).

Recent archaeological research on the western coastal zone of the Biga Peninsula has revealed that the settlement history goes back to the end of the Neolithic period when the sea almost reached its present level. This rapid rise caused ingressions especially towards the low parts of valleys where elongated marine embayments developed. Accordingly, delta plains and their coastlines at those times were located much further inland than they are now. Since then (about the last 7–6 thousand years), sea level has not changed significantly, alluvial deposition has been dominant and the

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Fig. 12.1 Location of the Biga Peninsula between the major structural zones of the region (Base image from Google Earth)

Fig. 12.2 A closer view to the Biga Peninsula and its major structural units extending in the NE-SW direction. White lines indicate isobaths (depths in metres) (Base image from Google Earth)

present-day delta–floodplains formed in the embayments. Therefore, alluvial aggradation and coastline changes in the delta plains have been very important and recurrent throughout the cultural history of the area since the Neolithic times.

During the warming period that followed the end of the Last Glacial, the rising sea penetrated the Çanakkale Strait, separating the Gelibolu and Biga Peninsulas from each other. In the meantime, marine intrusion progressed within the mouth of the formerly continental lower part of the Karamenderes River, forming a marine embayment 3–5 km wide and extending ca. 17 km inland. Once the sea reached its maximum level (end of Early Holocene, ca. 7000 years ago), the Karamenderes River alluvium started to fill-in the embayment, replacing progressively the marine environment by the present delta–floodplain. Since the Late Neolithic, the inhabitants of the sites around the plain witnessed these environmental changes, adapted to them and lived with them.

In order to characterize these Last Glacial and Holocene geographical progressions and changes, and in addition to seven rather deep (down to 75 m) core drillings carried out in 1977 by the MTA (Mineral Research and Exploration Institute), a total number of 327 shallow (generally down to 20 m) core drillings have been performed in the alluvial plains of Troia area since 1983. These latter cores were part of a joint project between Ege University on the one hand, and the archaeological research and excavation project of the Tübingen University, led by Prof. Dr. M. O. Korfmann. The drilling locations concentrated in the surroundings of the Troia area, with the addition of some others in the small Beşik coastal plain to the west. Based on data obtained from core analyses (sedimentology, ^{14}C dating, microfossils, pollen), the Holocene stratigraphical units were described and interpreted, thus providing a local reconstruction, which produced a model for the regional palaeogeographical evolution during the Holocene (Kayan 2014).

12.2 Structural Outlines of the Biga Peninsula

Although the rectangular frame of the Biga Peninsula exhibits a dominant E-W direction, the outlines of the geological structure and geomorphological units are mainly NE-SW elongated. From SE to NW, the Kaz Mountain high zone, a chain of depressions along the Ezine–Bayramiç–Çan–Biga, the Salihler plateau, trough of the Çanakkale Strait, Gelibolu plateau ridge and trough of the Saros Gulf are the main high and low structural landform units (Fig. 12.2). The Kaz Mountain (peak at 1774 m a.s.l.) in the mountainous range north of the Edremit Gulf constitutes the basement of the peninsula with its crystalline rock formations and the backbone of the morphology (Fig. 12.3).

The crystalline rocks constitute also the base of the Salihler plateau (Fig. 12.3). However, this basement is widely covered by Tertiary volcanic rocks, which expands in the central part of the Biga Peninsula (Fig. 12.3). While the surface of the Salihler plateau is ca. 250–300 m a.s.l. and low-undulating westwards, some ridges and hills rise up to 700–800 m a.s.l. towards NE. On the other side, the Salihler plateau surface descends towards north and west, passing to the lower plateau (ca. 50–100 m high) in the western direction towards the Aegean Sea. The Çanakkale Strait and the lower part of the Karamenderes Valley developed on this low plateau surface formed on the Late Miocene shallow marine sediments. The Gelibolu Peninsula on the other side of the Çanakkale Strait consists of the Late Miocene formations overlying Eocene sedimentary formations.

On a broader scale, the NE-SW extending structural base units of the Biga Peninsula are a part of the Alpine system inserted between the regional massifs (Thrace to the NW and Menderes-Sakarya to the SE). In addition, Tertiary volcanic formations cover wide areas in the central part of the peninsula. Since the Middle Miocene, the tectonic rise tilted the peninsula towards the north-west, as a block. Structural depressions appeared, in varying palaeogeographical contexts defined by erosional–depositional processes changing through time. From time to time during the Late Miocene, a shallow sea covered the Thracian–North Aegean region, in which series of marine, brackish and lacustrine sediments were deposited. The different facies and geographical distribution of these Late Miocene formations in the western part of the Biga Peninsula indicate a connection between the Paratethys and the Mediterranean by a trough wider than the present Çanakkale Strait (Yaltırak and Sakınç 2005). This is evidenced by the sediments deposited in a neritic environment, which extended on both sides of today's Çanakkale Strait, over a land strip ca. 5–10 km wide. This formation widens towards the opening of the strait into the Aegean Sea and narrows gradually further south along the western coastal zone of the Biga Peninsula (Fig. 12.4).

Towards the end of Miocene, the area was uplifted and shallow marine sediments were covered by basaltic volcanic rocks followed by the deposition of reddish-brown torrential-type flow deposits indicating a terrestrial semi-arid depositional environment (Figs. 12.5 and 12.6). This sediment cover is very important for the interpretation of environmental changes in the area. The palaeogeographical evidence suggests indeed a strong relationship with the Messinian drought and the semi-arid climate of the Pliocene. The source of this reddish-brown material was the higher relief (mainly the high plateau of the Biga Peninsula) to the east and south (Fig. 12.7). Today, erosion of this terrestrial cover peels it away in patches towards the north and west.

The Ezine–Bayramiç tectonic depression, which opens widely in the western central part of the Biga Peninsula, was

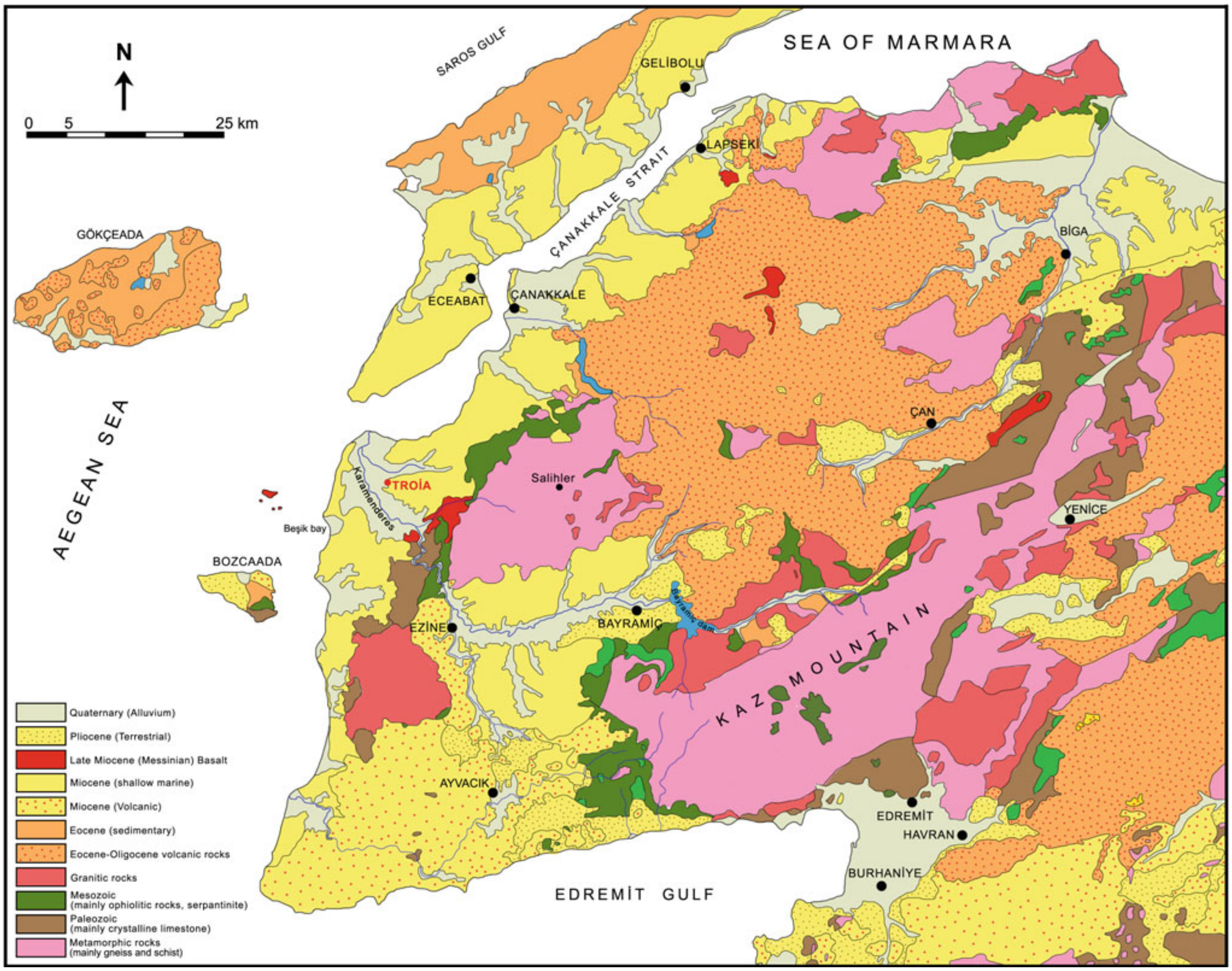

Fig. 12.3 Geological map of the Biga Peninsula (Simplified from Geological Map of Turkey, Scale 1/500.000, MTA 2002)

a separate basin in the Late Miocene–Pliocene periods. The shallow sea could not intrude into it from the north-eastern Aegean, and a lacustrine sedimentation developed. Here, the upper terrestrial cover, which seals shallow marine formations on the coastal side, covers lacustrine sediments (Fig. 12.3).

The present drainage system is established over the post-Late Miocene terrestrial cover, in accordance with climate change from arid to semi-arid conditions during the Pliocene. The major drainage system of the region developed according to the main NE-SW extending depression zone in the middle of the Biga Peninsula, between the Kaz Mountain to the south and the Salihler plateau to the north. In the middle of this depression zone, the Ağı Mountain (989 m) separates two different drainage systems. The north-eastern part is drained to the Sea of Marmara by the Çan and Biga Rivers. The south-western part is drained by the Karamenderes River which flows first westwards in the Bayramiç–Ezine depression, then turns north, and passes through the Araplar Gorge to reach the southern end of the Çanakkale Strait (Fig. 12.3).

The Karamenderes River is fed mainly by waters from the northern slopes of the Kaz Mountain, descending first into the Bayramiç–Ezine structural depression (Fig. 12.3). Its upper tributaries erode the reddish-brown terrestrial cover, incising down to the lacustrine bedrock in places. At the bottom of the depression, alluvium input has formed a floodplain. At the western end of the basin, the Karamenderes River sharply bends north to enter the Araplar Gorge. The gorge is incised in pre-Tertiary basement formations (mainly ophiolite–serpentinite). Its course meanders deep within the plateau. The plateau being covered by the Early Pliocene terrestrial cover, the superimposition of the valley in the western extension of the Salihler plateau testifies for uplift during or after Early Pliocene, and for the Pliocene existence of a palaeo-Karamenderes River.

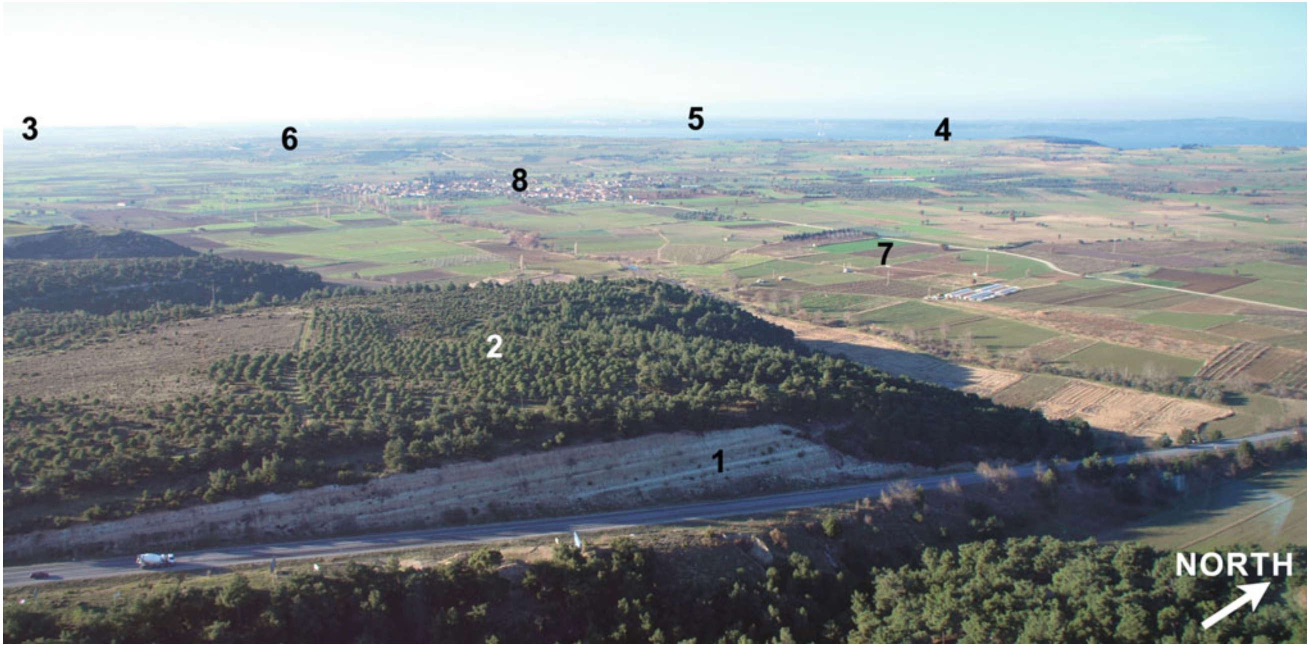

Fig. 12.4 Uplifted and slightly tilted strata of the Late Miocene shallow marine sediments (1) of the Troia lower plateau ridge (2). The photograph is taken from the east of the Troia ridge. The right end of the package of strata is cut by the Troia fault extending straight in the west–east direction (See Fig. 12.10). Aegean Sea (3), Çanakkale Strait (4), Gelibolu Peninsula (5), Karamenderes delta–floodplain (6), Lower Dümrek (Simois) floodplain (7), Kumkale village (8) (see also Fig. 12.7). Photograph by courtesy of R. Aslan

Downstream the gorge, the lowest course of the Karamenderes River enters an ultimate depression where an elongated floodplain develops before the river reaches the sea at the southern end of the Çanakkale Strait (Figs. 12.3 and 12.7). Below the sea, bathymetry indicates that during the LGM, when the sea level was lower by 100–120 m, the Karamenderes River was a major tributary of a river flowing to the Marmara Sea at the bottom of the present Çanakkale Strait (Kraft et al. 1980).

12.3 Morpho-structural Development of the Karamenderes Lower Valley

12.3.1 The Plateaus

North of the Araplar Gorge, the Karamenderes River formed an alluvial plain ca. 17 km long and 3–5 km wide between low (50–70 m a.s.l.) plateau ridges (Fig. 12.7). Bedrock of these ridges is Late Miocene shallow marine deposits, uplifted without much deformation except for some slight tilting in two directions: eastwards in the west, and southwards in the east.

There are four plateau blocks in the Troia area. Two are situated west, and two east of the Karamenderes floodplain. Separated from each other by local faulted depressions, that can be considered as small horsts. Their surfaces are covered by the (mainly) Early Pliocene continental torrential deposits, which predate the tectonic break-up of the shallow marine sediment blocks, which formed the plateaus later. The cover is thicker in the south on the foot-slope of the higher plateau, but thins northwards. This indicates that it results from the erosion of higher landforms located east and south, i.e. the low-undulating Salihler plateau ca. 200–250 m high, which truncates the pre-Tertiary formations (Figs. 12.3, 12.7).

North of the Araplar Gorge, a large alluvial fan was deposited by the Karamenderes River at the end or after deposition of the terrestrial cover. Here, patches of gravelly-sandy fluvial deposits overlay the terrestrial cover and form terraces on both sides of the gorge exit. These terraces provide geomorphological evidence of the initial stages of the post-Early Pliocene fluvial incision. Indeed, the post-Late Miocene terrestrial cover has a loose structure and is thus easily erodible. Erosion and transport proceeded towards the north and west where the cover is thinner. In such places, the surface of the plateau extends directly over the Late Miocene layers and is flatter. Southwards, the cover is thicker and the Late Miocene layers do not outcrop at the surface. Here, in some places where the surface of the plateau is higher (100–120 m) and the cover thicker, erosion has been more effective and the surface is slightly undulating.

The Yeniköy Ridge, which is one of the two horst-type plateau blocks to the west of the Karamenderes floodplain, is only 1–2 km wide and separates the plain from the Aegean

Fig. 12.5 A basaltic lava flow pertaining to the latest volcanic activity in the Troia area (aged probably end of Miocene–Messinian). This flow was emitted from a fissure related to one of the major fault zones south of the Troia area, which runs in the NE-SW direction. Covering the serpentine bedrock, it crops out along the steep slopes between the Upper and Lower Plateau surfaces (see Figs. 12.3, 12.7 and 12.8)

Sea (Figs. 12.7 and 12.9). The ridge is slightly asymmetrical because layers of the Late Miocene shallow marine bedrock dip eastwards at a low angle. The slope is very steep and straight to the west, eroded by waves to form cliffs. The more calcareous upper pack forms a mesa-type plateau. On the other side, the gently inclined slopes facing the plain present indentations at the contact with the plain floor.

One of the two plateau ridges in the east, the Kumkale horst-block, is also asymmetrical. However, layers dip gently southwards. Therefore, the northern slope facing the Çanakkale Strait is steep and cliffed, while the southern slope facing the Dümrek Valley is gentle. The more southerly Troia plateau ridge has similar features (Figs. 12.10 and 12.11). Its northern straight scarp corresponds to a fault along which outcrops of the Late Miocene shallow marine layer occur. The Dümrek River, the last tributary of the Karamenderes River, drains a small graben (or half-graben) between the Kumkale and Troia Plateau ridges. The valley is asymmetric, in agreement with the structure. There is no floodplain in its narrow upstream part, but in the west a small plain merges with the Karamenderes plain to the north of Troia. South of the horst-type Troia Ridge, the Çıplak Valley resembles that of the Dümrek. Its asymmetric profile is noticeable in the lowermost part (west, near Kalafat) (Figs. 12.7 and 12.11).

The lower plateau is separated from the higher one by a NE-SW-oriented fault zone forming fault scarps to the south. Here, this higher plateau (ca. 200–250 m a.s.l.) is the western extension of the Salihler. This is an erosional surface, which is formed on the pre-Tertiary basement. The most recent basaltic lava flows in the region occurred along this fault zone (Figs. 12.3, 12.5, 12.7 and 12.8).

12.3.2 The Valleys

All valley depressions, which separate the plateau blocks from each other, correspond to local fault zones. The

Fig. 12.6 Torrential type of flow deposit covering the Late Miocene shallow marine formations (Figs. 12.4 and 12.8). Photograph from the east of the Troia ridge

drainage system has been established first on the terrestrial cover surface in the Pliocene when climatic conditions were semi-arid. The initial incision adapted to a low-rate subsidence affecting blocks (small grabens) that lied between slowly uplifting horst-blocks (plateau ridges).

During the Quaternary, valleys have formed responding to changing climatic conditions and flow regimes. The palaeogeographical evidence indicates that, in the meantime, tectonic movements and regional uplift continued. For example, results from core drillings indicate that the Dümrek–Troia fault extends westwards under the alluvium of the Karamenderes River (Figs. 12.7, 12.11 and 12.12; Kraft et al. 1980; Kayan 2000). The Quaternary uplift also means that initially, the plateau surfaces were not as high as today.

There are many small indentations along the edges of the Karamenderes Valley bottom (Fig. 12.7). They coincide with mouths or lower reaches of small creeks incising the low-inclined plateau slopes. Although their lineation implies structural control, their formation is more dependent on slope inclination (consequent), on their flow regime and on the easily erodible loose terrestrial material on the surface. The indented edge morphology implies that the bottom level of the Karamenderes plain was lower than today, most probably during the LGM because of the very low sea level. In fact, the core drilling evidence indicates that, west of Troia, the bottom of the valley was about 30 m lower than present. Accordingly, with the Holocene sea level rise followed by marine then alluvial drowning of the mouths of small stream, the present indented edge morphology of the Karamenderes plain has formed.

12.4 Geomorphological Development of the Karamenderes Floodplain and Geoarchaeological Interpretation

Sedimentological data and ^{14}C dates of marine shells provided by samples from core drillings performed in the Karamenderes floodplain indicate that the sea intruded the Karamenderes embayment even during high sea-level Quaternary periods previous to the Last Glacial stage (Fig. 12.12). During the Last Glacial regression, the ancestral channel of the Karamenderes incising older Pleistocene marine sediments was ca. 40 m below the present sea level to the west of Troia. According to ^{14}C dates, the rising sea in the Holocene invaded first this channel ca. 10,000 years ago. Later, 8000 years ago, the sea inundated the former valley bottom when reaching 25–30 m below the present sea level. After slowing down, the sea-level rise finally stopped ca. 6000 years ago (Fig. 12.13). The coastline was located near the exit of the Araplar Gorge to the south of the embayment. Here, the sedimentological evidence indicates the existence of a small alluvial fan of the Karamenderes River, extending towards the north. However, it was rapidly transformed to a delta plain due to the environmental change from fluvial to marine (Fig. 12.15).

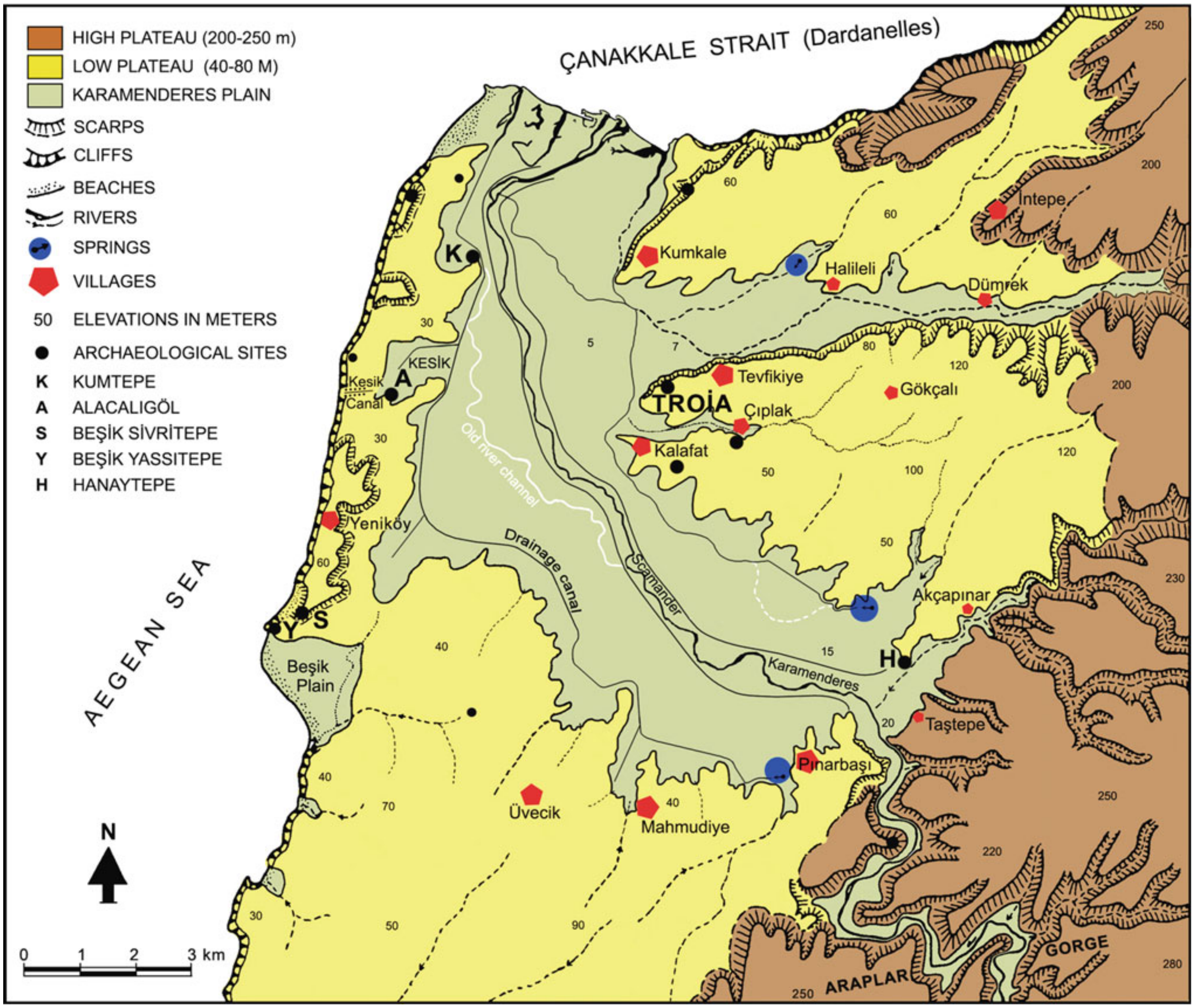

Fig. 12.7 Geomorphological map of the area surrounding the Karamenderes lower valley

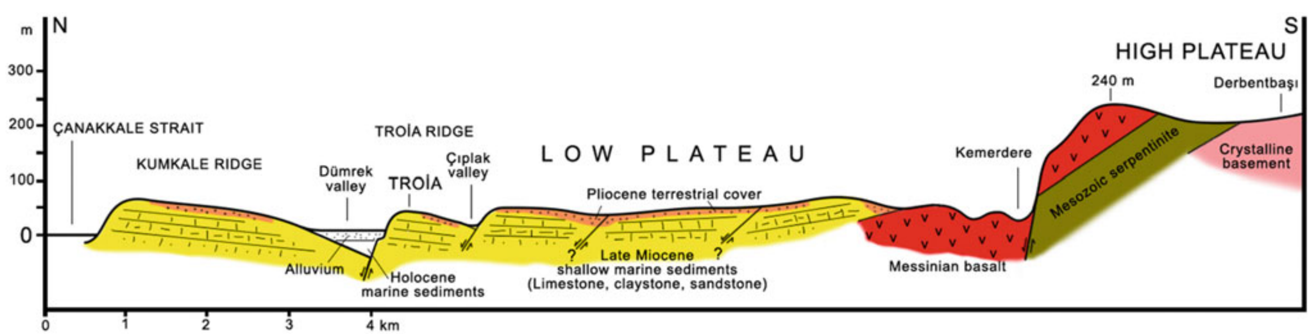

Fig. 12.8 A schematic geological cross section of the geomorphological units east of the lower Karamenderes plain (modified from Kayan 2000)

Archaeological surveys and excavations revealed that from 7000 to 5000 years ago, Late Neolithic and Chalcolithic settlements were established along the shoreline of the Karamenderes embayment. These sites are: Kumtepe, Alacalıgöl, Beşik Sivritepe to the west; Troia, Kalafat, Çıplak to the east; and Hanaytepe to the south (Fig. 12.7; Blum et al.

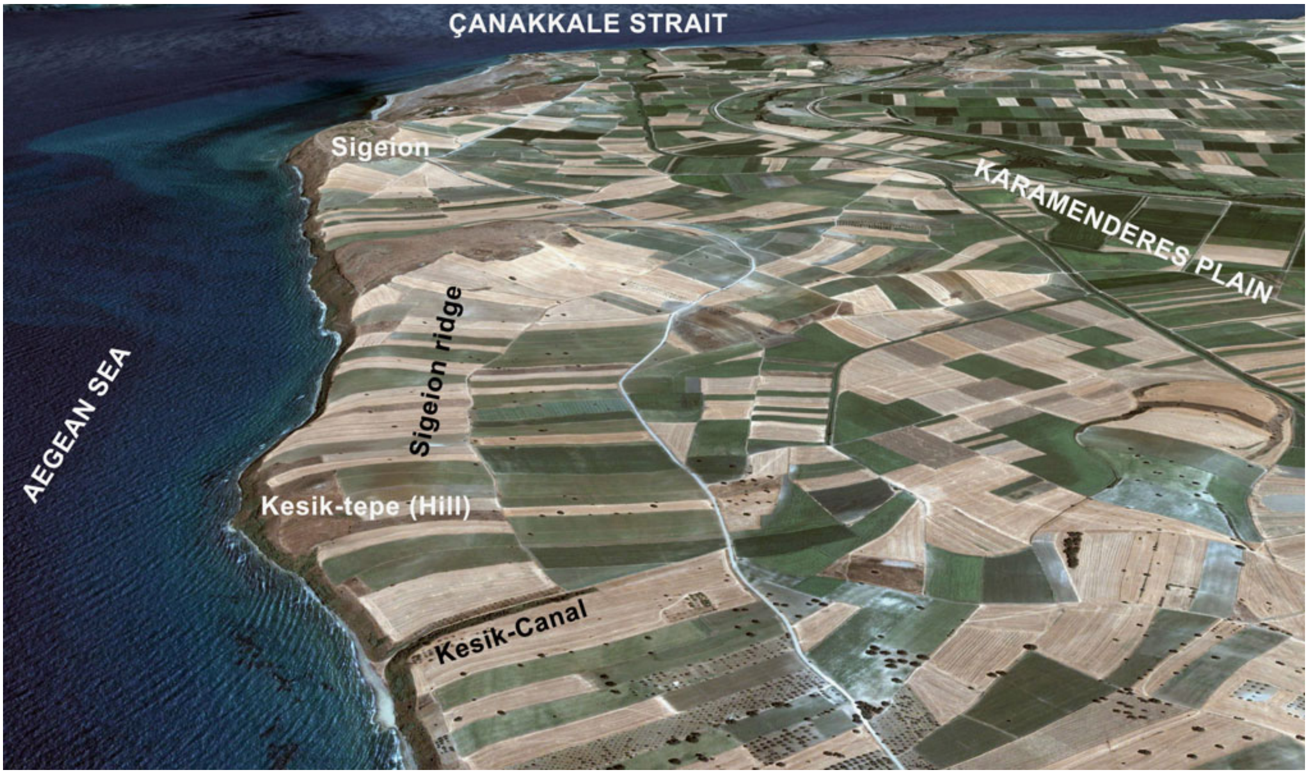

Fig. 12.9 Yeniköy (Sigeion) ridge between the Aegean Sea and the Karamenderes plain. Looking from the south (Google Earth view; Aug. 2011)

2014). Meanwhile between 6000 and 5000 years ago, the sea level reached its maximum and has remained stable since, and the Karamenderes delta prograded into the embayment.

Certainly, the best-known prehistoric settlement in the Karamenderes floodplain area is Troia, a site located on the western edge of the low plateau ridge to the east of the lower Karamenderes plain. Until recently, Troia was thought to have been established ca. 5000 years ago. According to recent archaeological investigation, the oldest cultural layers at the site seem to date a little earlier, i.e. Late Chalcolithic (Korfmann 1991). Nine main settlement periods have been distinguished in Troia. During the first three of them, the occupied area was located on the eastern coast of the Karamenderes marine embayment. During Troia IV and V periods, an advancing deltaic coast of the Karamenderes River reached the western part of the site (Figs. 12.14 and 12.15). According to the core drillings, in that period the sea occupied a small indentation (inlet) north of Troia towards the Dümrek Valley. At this location, today's surface of the plain is ca. 7 m above the present sea level. All through these 7 upper metres, archaeological material (mostly potsherds) was retrieved from the sediments; they have been transported from the Troia acropolis by slope-wash during heavy rains. At the depth equivalent to the present sea level, cores hit an archaeological layer (most probably fireplaces surrounded by small stones, with ash and burnt plant remains, charcoal, burnt animal bones and marine shells). This layer covers an almost horizontal structural platform developed in the Late Miocene bedrock of the Troia Ridge. A piece of potsherd found on this platform was dated to the Troia IV period. According to the ^{14}C dating of coastal sediments from the core, we can infer that this area was a coastal location even in the period of Troia IV (Figs. 12.14 and 12.15; Kayan 1996, 2002).

Studies performed in the Beşik plain on the western coast evidence a small sea-level drop of ca. 2–3 m between 5000 and 3500 years ago (Fig. 12.13; Kayan 1991). This regional-relative sea-level change caused an increase of deltaic progradation in the shallow Karamenderes embayment. Palaeogeographical record evidences this drop in the delta coastal plain of the Karamenderes during the Late Bronze Age city, Troia VI, in the period of 3700–3250 years ago (Fig. 12.15). Besides, Homer gives descriptions about the environment of the area, especially about the west of Troia where the Trojan War is supposed to have occurred at the end of Late Bronze Age. For example, he describes the battlefield as a dusty place with river channels, a landscape suiting the proximity of a delta coast at the time.

Following this small sea-level drop, the sea rose again slowly, reaching its present level ca. 2000 years ago. This slow rise did not cause any new ingression because of compensation by the great amount of alluvium brought in by

Fig. 12.10 Troia Ridge from the west. The ridge is one of the horst-type low plateau blocks in the southwards slightly tilted Late Miocene shallow marine sediments (1) and their terrestrial cover, which extends southwards (2). The plateau ridge is cut north by a local W-E-oriented fault (the "Troia fault": 3). The Dümrek (Simois) River flows in an elongated depression (half-graben) to the north; its lower part is a floodplain (4). The high surface of the Salihler plateau profiles in the horizon. Ruins of Troia are at the front (5), and the modern village Tevfikiye at the rear (6) (Photograph by courtesy of R. Aslan)

Fig. 12.11 Two plateau surfaces of the Troia area. The upper one (Salihler plateau) truncates pre-Tertiary formations (mainly crystalline based). The erosional surface has a 200–250 m altitude (1). The surface of the lower plateau, ca. 50–100 m high, is formed on the Late Miocene shallow marine sediment layers which are broken-up by local fault zones (2). Troia (3) is located on one of the ridges forming this lower plateau, east of the Karamenderes delta–floodplain (4) (looking from the west)

the Karamenderes River; the alluvial and deltaic environment continued to expand slowly, pushing the coastline to retreat steadily. Afterwards, when the coastline came close to its present location, currents from the Çanakkale Strait forced the deltaic progradation to slow down. According to Strabon, the coastline of the delta was to the west of

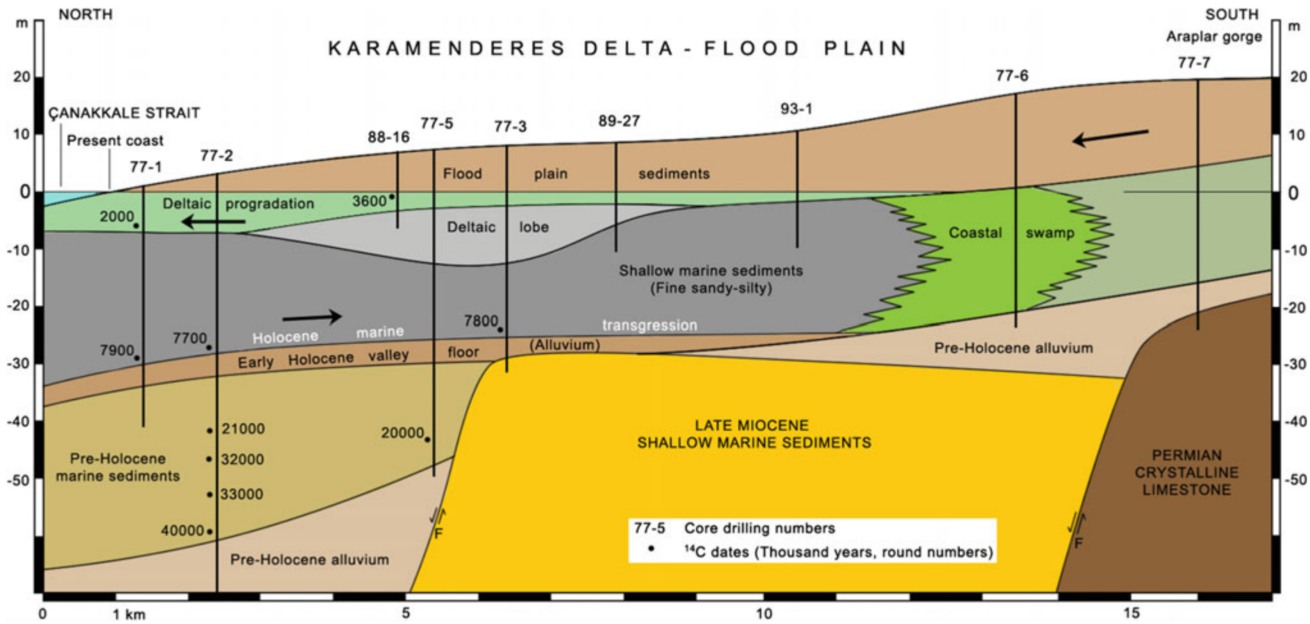

Fig. 12.12 Longitudinal N-S cross section of the lower Karamenderes alluvial plain (modified from Kraft et al. 1980)

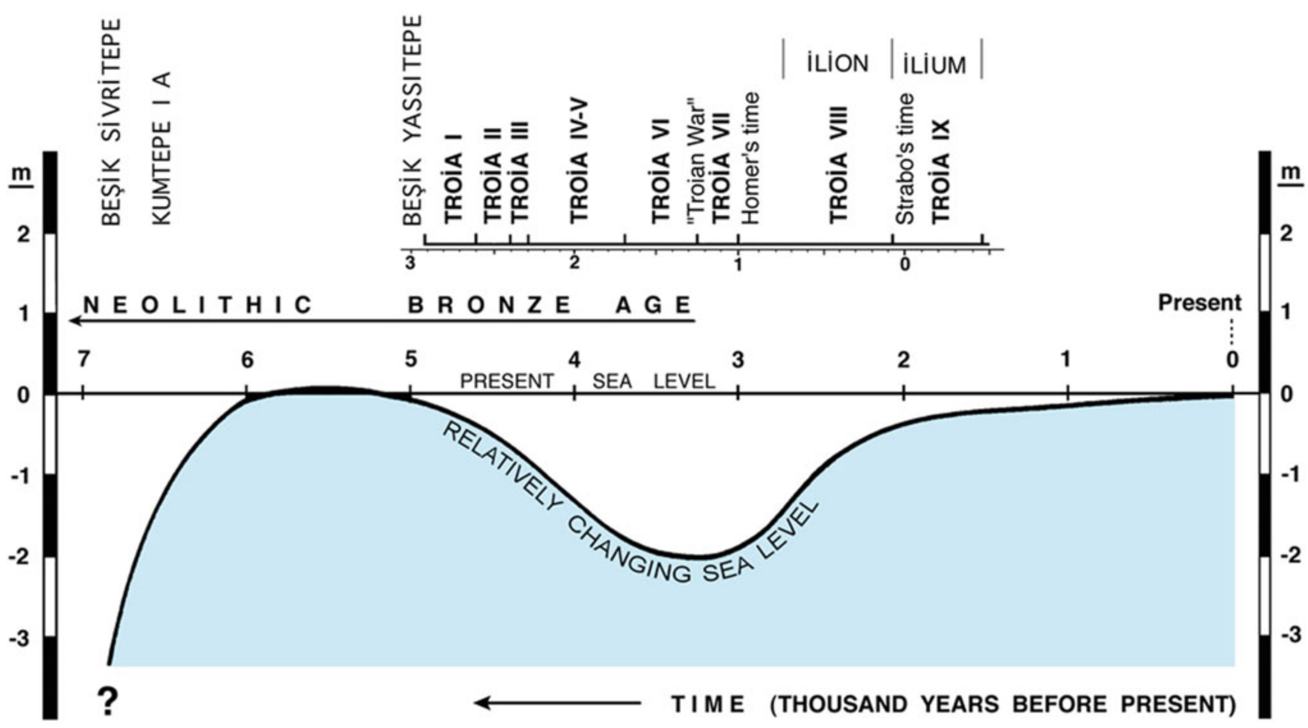

Fig. 12.13 Relative sea-level changes in the Troia area since the Late Neolithic times, compared with the settlement periods of Troia (Kayan 1991)

Kumkale at the beginning of the Christian era. This also agrees with the geomorphological and sedimentological evidence from cores (Fig. 12.15).

Today, strong currents of the Çanakkale Strait prevent further deltaic progradation. Thus, the delta coast which had initially progressed rapidly in a narrow and shallow marine embayment stopped when reaching the northern end of the western ridge, and the fine sandy alluvium transported by the Karamenderes River started to be distributed along the Aegean coast south of the Çanakkale Strait. This material is

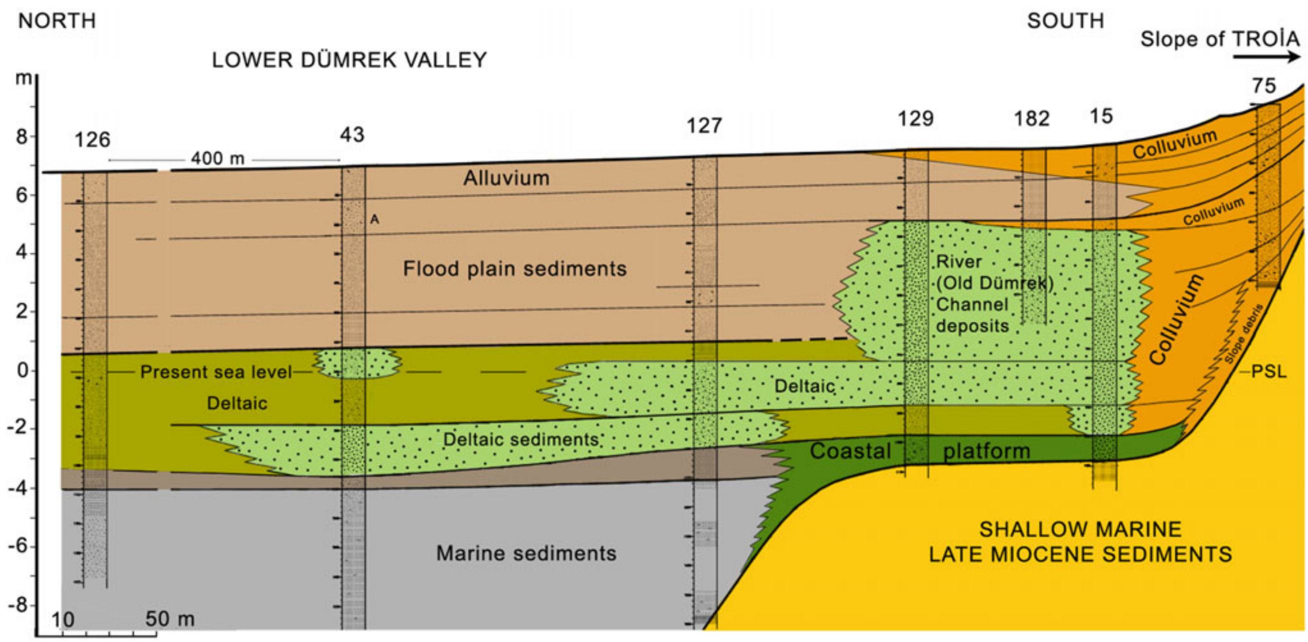

Fig. 12.14 Based on core drillings, north–south cross section of the northern foot-slope of Troia. During the Early Holocene, the rising sea surrounded the western end of the Troia Ridge. A bedrock platform extending over Late Miocene marine sediments along the northern foot-slope was a narrow coastal environment in the Late Bronze Age (about 3500 years ago). Some fire remains on the platform indicate that human used it for hunting and cooking. During that time, the sea was a few metres lower than the present level. Later, a deltaic shoreline formed here in the Karamenderes Valley. Deltaic shoreline in the Karamenderes Valley reached here with various sedimentary facies, following this period. Finally, floodplain deposits and colluvium from adjacent slope covered the whole bottom of Karamenderes and Dümrek Valleys (Modified from Kayan 2002)

transported by littoral drift, forming beaches and coastal dunes along the western coast. The filling-in and straightening of the Beşik coastal plain and the progressive development of sand ridges are one of the clear consequences of this process (Fig. 12.15).

12.4.1 Geoarchaeology

Holocene sea-level changes strongly impacted the geomorphological development of the Karamenderes floodplain, and indirectly also the occupation of the area by human societies. No coastal terrace or other feature related to a sea level higher than the present is encountered, whether along the coastlines of the northern and western ridges or around the Karamenderes floodplain. Cores along the foot of the low plateau slopes at the edge of the alluvial plain reached a coastal deposit (i.e. shell-rich marine sand) at a depth corresponding to the present sea level. ^{14}C dated to ca. 6000 years ago, this sand deposit indicates the time when the sea reached its present position. Below this material, marine or terrestrial sediment units are encountered depending on the core location. Afterwards, only the 2–3 m drop between 5000 and 3500 years ago introduced a change in the sea level before it rose again around Christ time (Fig. 12.13). This model does not fit the global sea-level change curves (Fleming et al. 1998; Lambeck and Purcell 2005). Of course, this result is debated, especially with arguments evoking regional tectonic activity. There is, however, no geomorphological or sedimentological evidence supporting such a tectonic impact on Holocene sea-level records in this region.

The archaeologists wondered much about the location of Troia's harbour or harbours. However, there has been no finding related to, nor evidence of any harbour, whether during archaeological surveys and excavations or in the cores studying the "Troia Bay" (Kayan 1995). One of the reasons for this absence may be the shallowness of the former deltaic coastal zones in the embayment, which is best evidenced by the sedimentological characteristics of the drilled sequences. However, small boats may have approached the land at some convenient locations without any need of a specific harbour construction in the earlier times of Troia. In addition, the rapidly progressing deltaic coast was not convenient for a stable and permanent harbour construction. The prevailing and influential northerly winds in Troia also created unfavourable conditions for sailing and harbouring in the embayment.

In the period when the city was most developed (i.e. Troia VI: 3700–3250 years ago), the landscape surrounding Troia had already changed from marine to terrestrial. Instead

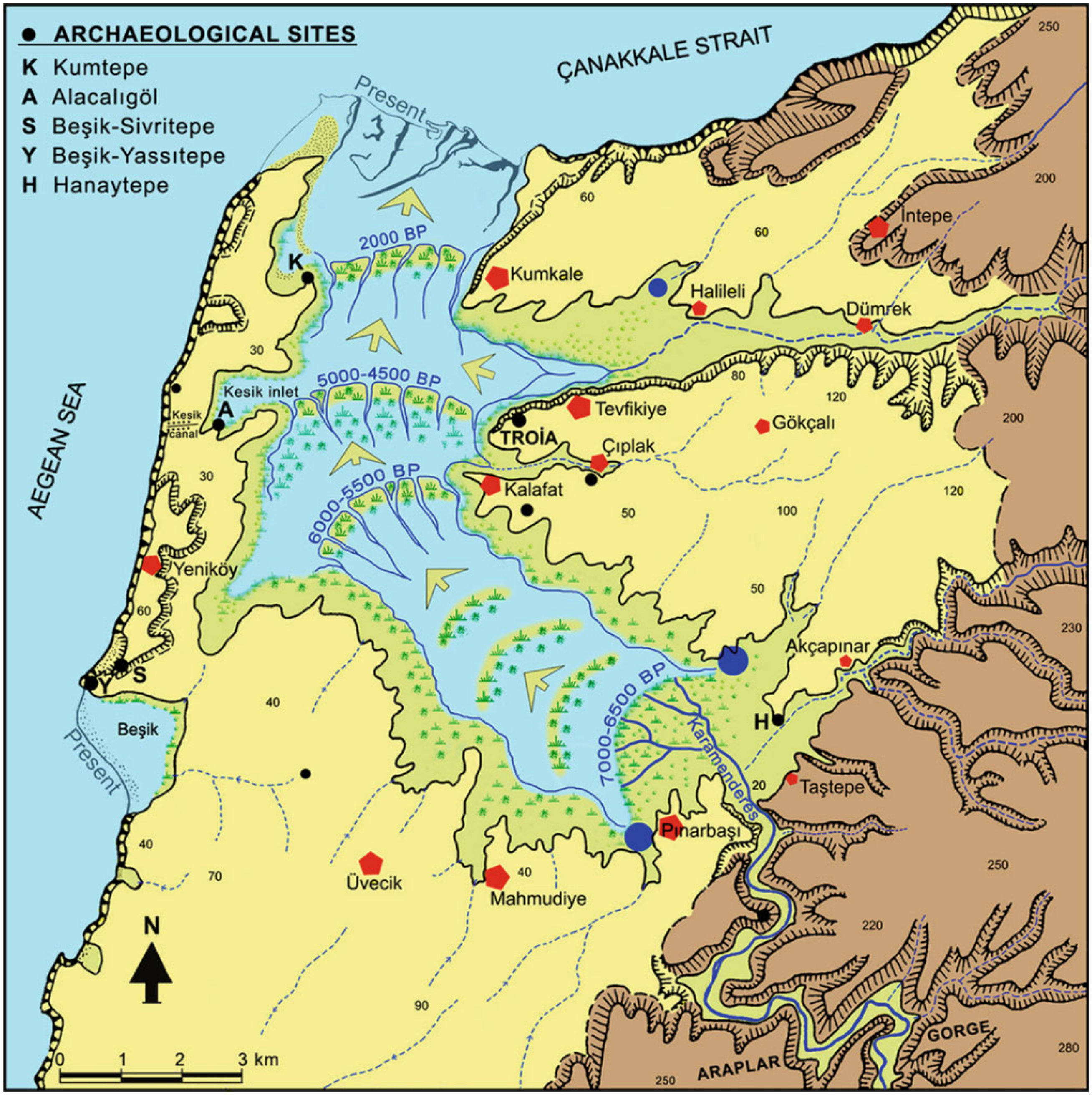

Fig. 12.15 Lower Karamenderes marine embayment in the Troia area 7000–6000 years ago, and its change into a floodplain through time. Blue numbers indicate coastline positions during the progradation of the delta plain and floodplain. For legend, see Fig. 12.7 (modified from Kayan 2001)

of looking for a harbour in the Karamenderes embayment, the small Beşik inlet on the Aegean coast has been regarded as an environment suitable for Troia's harbour during the Late Bronze Age. It was even proposed that the Beşik inlet was the naval harbour of the Achaean fleet during Iliad's Trojan War. Core drillings indicate that the inlet was already small during the maximum extension of the sea ca. 7000–6000 years ago (Figs. 12.7 and 12.15; Kayan 1991). There is no major river arriving here to form a delta plain. However, the inlet was filled progressively with the construction of a coastal barrier damming a lagoon. By LBA time, the inlet changed into a small coastal plain, a dynamics that may have been accentuated by the LBA 2–3 m sea-level drop. In addition, no evidence of any major harbour has been found in the inlet. Therefore, although the Beşik inlet may have been used as a natural landing area, it cannot have been a major harbour location during the Troia VI period. It is interesting to note that the whole western Aegean coast in the Troia region forms continuous cliffs, which are not good landing sites, or sites convenient for naval activity.

On the other hand, there is an archaeological argument that ancient Troia's main harbours may be located in some inner coastal inlets within the Karamenderes embayment. Indeed, indentations along the eastern edge of the western plateau ridge are seem as good natural harbour locations. Especially, the Kesik indentation in the middle is intriguing because of a canal feature connecting the inlet to the Aegean Sea to the west (Fig. 12.7). The question of whether the Kesik inlet was a Troia's harbour connected to the sea by a man-made canal has been raised. Our intensive drilling studies in the canal and inlet revealed, however, that this is not possible (Kayan 1991, 2009). Although the Kesik indentation was a marine inlet during the maximum extension reached by the Mid-Holocene marine transgression, the progressing deltaic coast of the Karamenderes River had already changed it into land by LBA time. In addition, the canal has never been a waterway: its narrow floor is much higher (ca. +13 m) than the sea, and nothing related with water was found on its bottom aside ca. 2-m-thick colluvial deposits. Also, nothing was found that would suggest extensive human use of this gate (canal). Another interpretation of the canal is that it may result from an uncompleted human attempt, by taking advantage of a pre-Holocene fault-line, to drain swamps occupying the inlet.

In spite of the expectations of the archaeologists, the results from the hundreds of cores performed in the area agree that the coastal zones of the Troia area, whether the Karamenderes embayment or the sea coasts, were never suitable for any major harbour constructions in ancient times. It seems that, in spite of what could have been thought, the geographical position of Troia was not convenient for any massive naval activity supporting trade and transportation.

12.4.2 Recent Period

The Karamenderes was a frequently flooding river until the middle of the last century. However, even strong floods were not much damaging because agriculture was not well developed on the plain. Only recently agriculture developing on the fertile plain started to suffer from floods. Therefore, artificial levees were constructed along both sides of the river channel (Fig. 12.7). In addition, natural lowlands such as backswamps on the plain where surface waters would accumulate were drained by canals, with the ultimate aim to acquire more arable land. In time, the income from agricultural products increased, while intensive practices such as irrigation farming (with nutriments and pesticides) improved productivity. However, irrigation needed deeper and deeper pumping to withdraw increasingly high amounts of groundwater. This resulted in groundwater level lowering and reserve depletion, also decreasing the water level in the Karamenderes active channel. In order to supply increasing water needs for these ever-growing activities and domestic use, the Bayramiç Dam was constructed recently in the upper valley of the Karamenderes, for collecting water to be used in irrigation of the Bayramiç–Ezine basin. Later, a flow regulator was constructed at the opening of the Araplar Gorge to raise the water level for another irrigation system in the entire lower part of the Karamenderes plain. The implementation of such schemes stopped the damaging floods of the Karamenderes River completely. However, this also caused a decrease in river discharge and in alluvium transport in the Karamenderes River plain, transforming it into a stable system vulnerable to pollution. As would be expected, these modern human actions added to natural dynamics, affecting and arresting the deltaic progradation of the Karamenderes River.

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