TROY

THE ARCHAEOLOGICAL GEOLOGY

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I • GEOLOGY AND PALEOGEOGRAPHIC RECONSTRUCTIONS OF THE VICINITY OF TROY

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INNUMERABLE discussions, arguments, and rationalizations have stemmed from the *Iliad* regarding the geographic setting of those events that supposedly occurred more than three thousand years ago at Troy. Twenty-five hundred years ago commentators on the *Iliad* believed that the Trojan War had occurred and, further, that they understood fairly well its geographic setting. By Strabo's time, specific descriptions and commentaries were written on Trojan topography. But by the nineteenth century A.D. the opinion of some scholars had swung against the very existence of Troy.

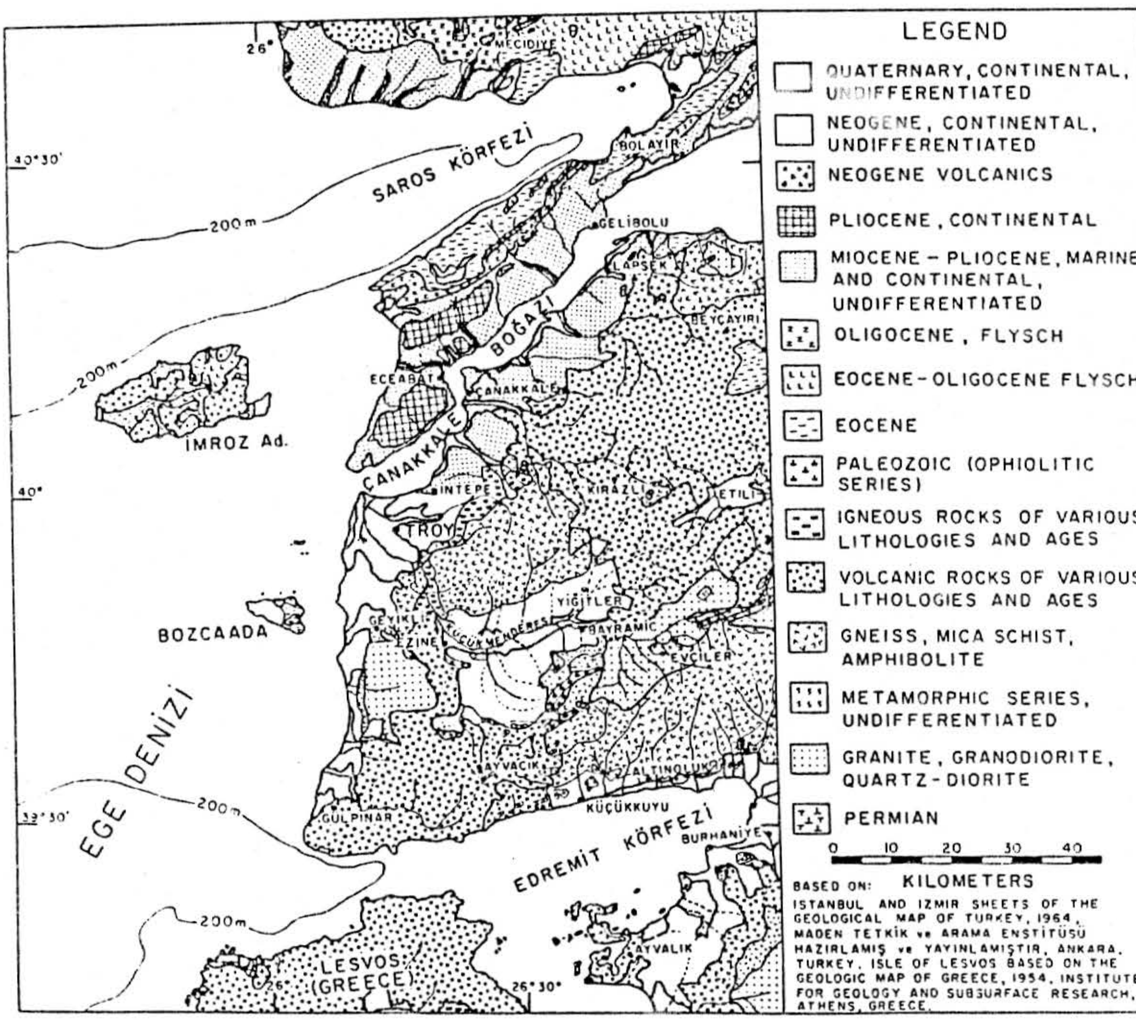
Heinrich Schliemann, however, like the ancient Greeks, believed without question that the *Iliad* represents a record of an historical event, and this belief led him to the location and excavation of the Hisarlık tell. Wilhelm Dörpfeld continued the digging in 1893 and 1894, and concluded that the Sixth Settlement was Homeric Troy. Only after the publication of the reports on the Cincinnati excavations,[1] under the direction of Carl W. Blegen, was it generally accepted that the chronological framework of the Trojan War is related to the VIIa Settlement. But as recently as 1974, almost a century after Schliemann's excavations, and despite Blegen's fundamental assertion of the reality of the place and event,[2] at least one classical scholar maintained that there is no physical evidence that the Trojan War as described by Homer ever took place anywhere.[3] And of those who at least accept the Hisarlık-Troy equation, several have recently questioned whether or not the events described in the *Iliad* are to be associated with Troy VIIa or even Troy VIh, the immediately preceding phase.[4] From a dispassionately scientific viewpoint, however, none of these controversies is relevant to the inquiry of this chapter, which is the topography of the environs of the archaeological site at Hisarlık during the past five thousand years.[5]

[1] Blegen *et al.*, 1950-1958. [2] Blegen, 1963, p. 20. [3] Finley, 1974, p. 22.
[4] Schachermeyer, 1977; Hiller, 1977; Akurgal, 1977.
[5] For this study we were extremely fortunate to have the very close cooperation of the Maden Tetkik ve Arama Enstitüsü (M.T.A.). Individuals of this organization are recognized in the acknowledgments. Without information from seven holes drilled in the summer of 1977, our study would remain almost as speculative as those of Virchow and Bilgin.

GEOLOGY OF THE TROAD

The geology of the region known as the Troad, or Biga Peninsula, has been studied extensively by the Maden Tetkik ve Arama Enstitüsü (Institute of Mineral Research and Exploration) of Turkey. High and low plateaus characterize the geomorphology of the region. These plateaus were all deeply incised by erosional events of the Quaternary Period (Fig. 1).[6]

The Saros Körfezi (Gulf) and the Çanakkale Boğazı (Dardanelles) are marine reentrants or narrow straits formed by erosion during the Pleistocene Epoch but probably with a very strong structural control related to the Anatolian Fault and subsidiary tectonic features. As documented in Chapter II, the area of the Troad is extremely active tectonically.



1. A geologic map of the Troad showing complex interrelationships of the various Cenezoic rock units. Note the relationship of the "Miocene-Pliocene Marine and Continental Sediments" with the Çanakkale Boğazı (Dardanelles Strait).

[6] Bilgin, 1969, presents an excellent summary of the geology of the Troad.

It is known that the Dardanelles has been a transitional region between the Tethys and Paratethys seas at least since the beginning of Miocene time. The nature of the connection between these two major sedimentary basins has been controlled by vertical tectonic movements of the continental thresholds of the Aegean, Dardanelles, and Bosporus areas. Repeated connections existed between the Aegean and Black seas during the past ten million years. As a result, thick sequences of Miocene fluvio-lacustrine-marine sediments have been deposited in the Dardanelles area.[7] After slight folding and faulting of these Upper Miocene (Sarmatian) sediments in about Middle Pliocene time, a continental phase of deposition began in the area. The surrounding highlands were eroded and thick fluvio-lacustrine sedimentary sequences were deposited in the topographically lower regions such as the Gallipoli Peninsula. It is generally accepted that a peneplain-like erosional-depositional surface developed in the Marmara region near the end of Pliocene time.[8]

During the Early and Middle Quaternary the Dardanelles area still appears to have been connected to the Black Sea (Paratethys) basin. Based on the distribution of the Tchaudean (Caspian affinities) brackish water deposits in the Mürefte and Gelibolu areas[9] and in the Aegean area,[10] one can say that a tectonic-erosional depression extending from the Black Sea through the Sea of Marmara toward the Aegean probably developed during this stage. This depression was the precursor of the present straits. A part of this Marmara-Dardanelles depression, the large fluvial-erosional basin of the paleo-Karamenderes (Scamander) Valley, developed on the northern side of the Kaz Dağları-Baba Burnu watershed, 50 to 80 km. south of the site of Troy.

The first invasion of the waters of the Mediterranean seems to have occurred during the Milazzian Stage (which began from 70,000 to 60,000 B.P.) of the Upper Pleistocene, although the presence of typical Milazzian marine fauna and the different heights of the deposits of this stage remain a subject of discussion.[11] There are, however, clear evidences of Tyrrhenian, Monastrian, and Versilian transgressions of the Mediterranean during the interglacials and interstadials, and of regressions during the glacials of the Quaternary Period. Thus marine and fluvial features, especially terraces and their deposits of later Quaternary age, were developed in the present Dardanelles area. The final capture of the northward-flowing pre-Dardanelles drainage by rivers directed toward the Aegean-Saros Bay seems to have occurred during the last Würm glacial regression of the sea.[12] Thus, although very near the Aegean Sea, the valley of the Scamander initially developed as a part of the northeastward-directed, pre-Dardanelles drainage system.

This brief summary of the geology of the Troad provides a basis for the

[7] Erentöz-Erünal, 1956; Erol, 1969; Taner, 1978.
[8] Bilgin, 1969; Ardel, 1957; Yalçinlar, 1949; Erol, 1969. [9] Erol, 1976. [10] Gillet, 1957.
[11] Erol, 1976. [12] *ibid.*

following discussion of paleogeographies in the valleys of the Küçük Menderes Çayı (hereafter referred to as the Scamander River) and the Dümrek Çayı (the Simois River).

GEOMORPHOLOGY OF TROY AND ENVIRONS

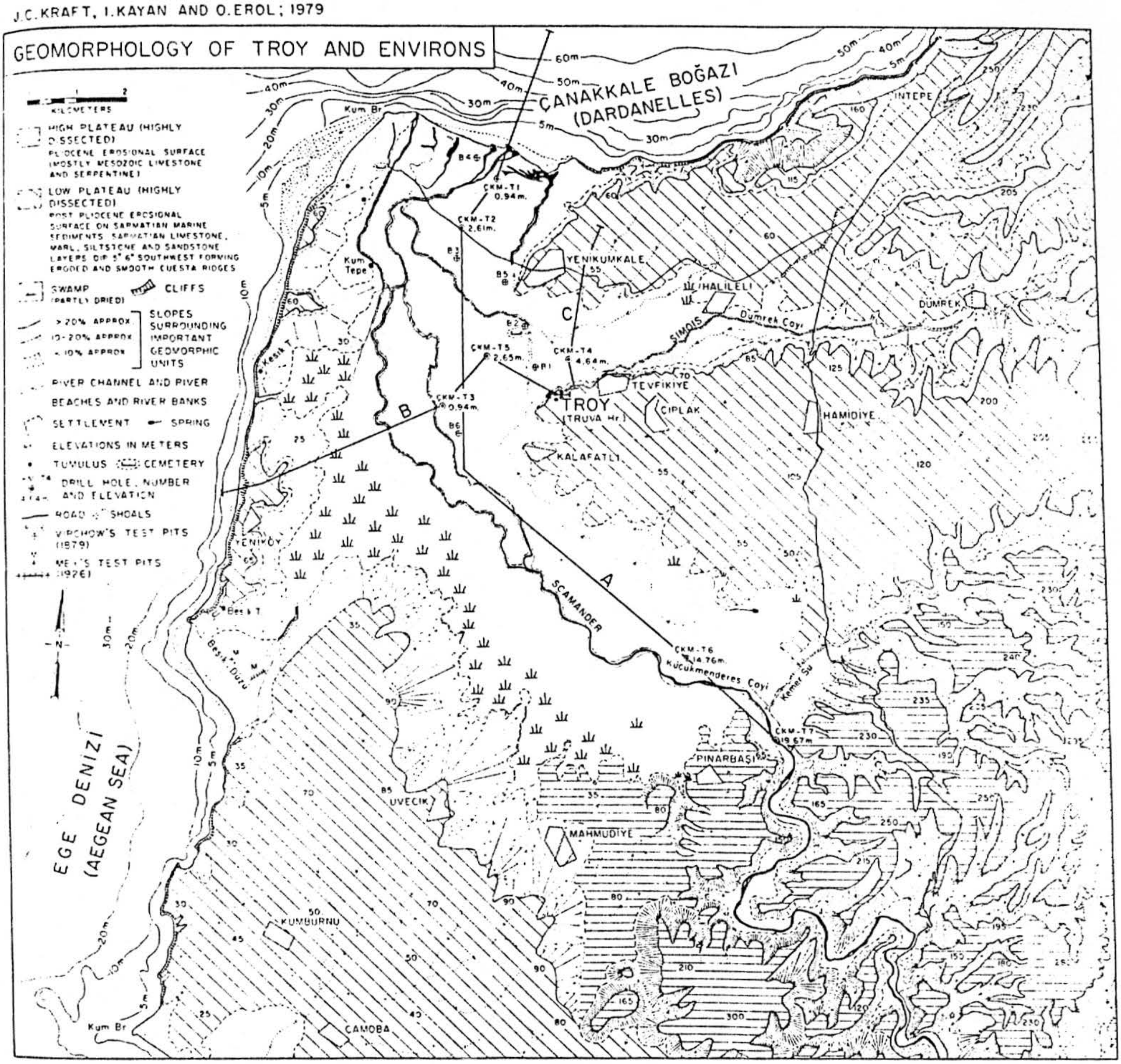
Figure 2 is a large-scale map of the geomorphology of the region around Troy. On this map, the Scamander River is portrayed as flowing through an entrenched meander valley incised in a deeply dissected high plateau. Near the modern village of Pınarbaşı the incised Scamander River emerges onto its alluvial plain and flows northward to the Dardanelles. Two major tributaries join the Scamander on its floodplain. At the head of the plain, the Kemer Su converges from the northeast; the second tributary, more important to this study, is the Simois River, which flows in from the east to join the Scamander near its delta. Bilgin provides a detailed summary and discussion of the geomorphology of this area,[13] and the reader is referred to his excellent volume for details.

The southeastern end of the Scamander Plain, near the springs and village of Pınarbaşı, is bounded by a surface of older limestones that are cut by a fault between the high and low plateaus (Fig. 2). The low-lying plateau north of Pınarbaşı is composed of sedimentary rocks of Middle to Late Miocene age (Sarmatian), including marine limestones, sandstones, and continental conglomerates. This lower, highly dissected plateau lies at elevations from 30 to 250 m. above present sea level; it surrounds the plains of the Scamander and Simois rivers and includes a north-south ridge (the Sigeum Promontory of antiquity) extending along the Aegean Sea. The western side of the ridge exhibits a steep cliff shoreline with apparently rapid cliff retreat caused by the open west and northwest wave fetch across the northern Aegean Sea. There are several indentations along this cliff-dominated coast, the major one being at Beşik Körfezi (Besika Bay).

East of the Scamander Valley the low plateau takes the form of two cuestas, or asymmetrical escarpments. The northern cuesta is the Rhoeteum Promontory of antiquity (the modern ridge of Yenikumkale), which has a steep cliff facing north toward the Dardanelles and a broad, low-angled (5-6°) dip slope to the south-southeast. Similarly, Troy lies at the western end of the southern cuesta that also trends west-southwest.

The physiography of the Scamander and Simois valleys is discussed in considerable detail in studies by Virchow and Burnouf.[14] The area of the two river plains comprises approximately 70 $km.^2$ As noted by Bilgin,[15] the southeastern end of the Scamander Valley near Pınarbaşı is 18 to 20 m. above sea level. Along the center of the Scamander Valley, 5 km. south-southwest of Troy, the alluvial

[13] Bilgin, 1969. [14] Virchow, 1879; Burnouf, in Schliemann, 1880, pp. 79-84.
[15] Bilgin, 1969, p. 139.



2. The geomorphology of Troy and its environs, showing a high, deeply dissected plateau and Pliocene erosional surface with the deeply entrenched Küçük Menderes Cayı (Scamander) incised valley, the broad, lower, highly dissected plateau of a post-Pliocene erosional surface on Sarmatian sedimentary rocks, the present alluvial plains of the Scamander and the Simois (Dümrek) rivers, and nearshore bottom topography based on U.S. Hydrographic Office charts. Cross-section lines A, B, and C are also shown.

surface is approximately 10 m. above sea level. From this point northward the alluvial surface drops to sea level in the delta at the Dardanelles. The grade of the valley is therefore about 1:1000, a hardly perceptible inclination.

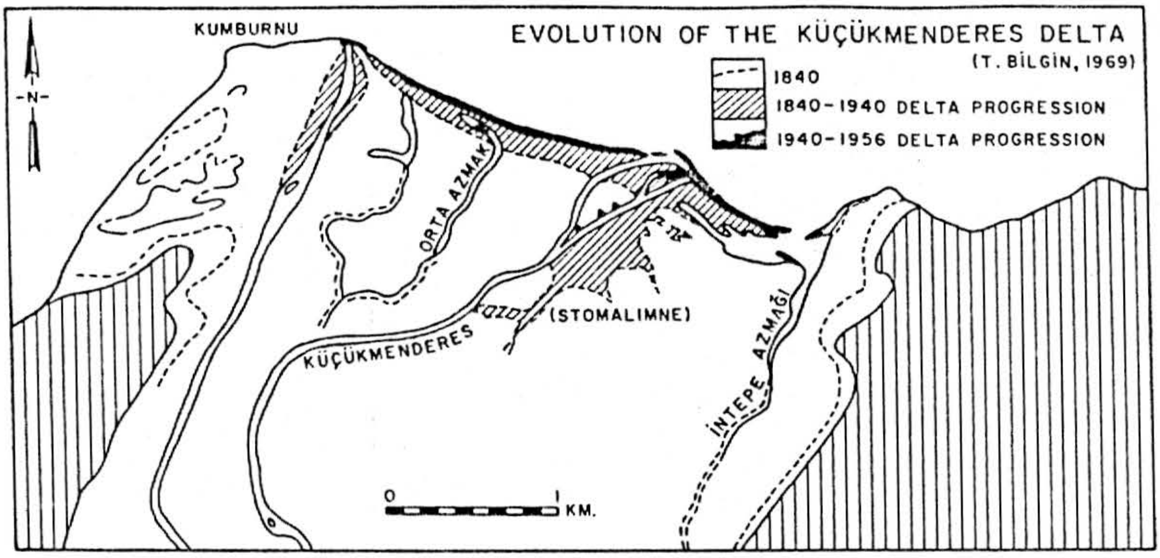
Alluviation on the Scamander Plain appears to have occurred mainly along the northwestern and central portions; the southeastern sector is covered by extensive upland marshes. These are fed in part by the large springs near Pınarbaşı. During the past several hundred years there have been many attempts to drain this flow of water from the Pınarbaşı springs via an artificial canal through the Sigeum Promontory into Besika Bay. It remains uncertain why the Scamander's dominant deposition should be in the central and northwestern sectors of the plain and not evenly distributed across it. We hypothesize that deposition is in part structurally controlled and may be related to neotectonics in the region.

T.A.B. Spratt produced the first modern, detailed map of the Scamander River.[16] As he noted, it had five to six seasonal channels flowing across the floodplain, with a dominant channel occupied throughout the year. The subsidiary flood channels, partly at sea level in the delta region, are called *asmaks*. Schliemann also noted that particularly during the winter the entire Scamander Plain would become flooded, with muddy water rising and flowing at a rapid rate in the main and subsidiary channels. Unfortunately, a study of the modern plain in an attempt to discover precise river channels of antiquity would not suffice because the difference between the modern, well-drained Scamander Plain and that of only one hundred years ago is too great.

An important aspect of the plain of the Scamander noted by Burnouf and others is that it did not possess high natural levees. Some have taken this to indicate that the surface of the alluvial plain has not been aggrading, or building upwards, over the past few hundred years, or that the Scamander has recently begun a period of major incision. However, the descriptions of many other travellers in this region over the past several hundred years indicate that this is not so. It is obvious that the major geomorphic changes in the Scamander Plain over the past seven thousand years have comprised progradation toward the Dardanelles, with concomitant upward aggradation of the alluvial sedimentary sequence.

Most of the present surface of the Scamander and Simois plains is covered by fine sediments (silt and clay); the coarser sandy sediments usually are associated with the river channels. However, in some areas across the plains, notably to the northwest of Troy, some of these channel sands have been windblown into low dune fields, providing higher relief to the plains of both rivers. The general vertical sequence across the plains reflects the interbedding of fluvial silts and clays with sand and gravel deposits of the continually shifting channels. A major argument during the past hundred years has raged over whether or not the geography of the Scamander and Simois plains has changed significantly in the past three thousand years. Virchow attacked this problem by digging a number of

[16] Admiralty, 1839.



3. The evolution of the Scamander River delta from A.D. 1840 to the present (redrawn from Bilgin, 1969).

test pits in the Scamander plain (Fig. 2).[17] Unfortunately, his test pits only penetrated 1.5 to 2 m., and encountered only fluvial sediments. Virchow therefore concluded that in the entire area of the Scamander and Simois plains there had been a continual deposition of alluvium for many thousands of years, implying that the topography of the plains had not changed appreciably since the time of the Trojan War. This concept is untenable in terms of our present understanding of Late Pleistocene erosion and Holocene sea level changes.

More recently, Bilgin noted the possibility that a pre-Versilian (10,000 B.P.) channel incised more than 90 m. below present sea level might have existed in this area,[18] and further suggested that this channel would have been flooded by rising waters of the Versilian (or Holocene) Transgression southward to the vicinity of Pınarbaşı. He noted that as there were no borings on the Scamander Plain this suggestion could not be tested. Bilgin further considered the modern evolution of the Scamander Delta, noting that delta progradation to the north at a rate of 1.25 m. per year over the past century is indicated by maps and charts of the area (Fig. 3).

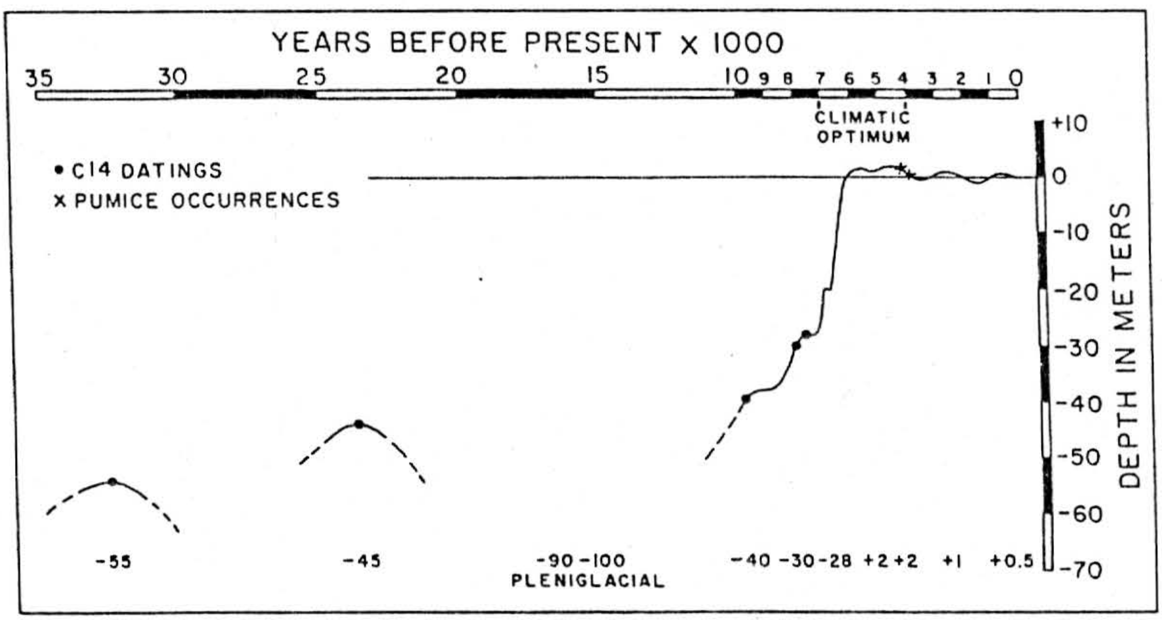
RELATIVE AND ABSOLUTE SEA LEVEL CHANGES

There were several major lowerings of world sea level during the Würm glaciation; the latest, at about 16,000 B.P., reached a maximum of approximately 100 m. below present sea level. From that time onward world sea level rose rapidly; however, the precise course of this rise is still in dispute.

[17] Virchow, 1879, pp. 147-150. [18] Bilgin, 1969, p. 146.

Recent observations concerning the postglacial sea level rise (the Versilian Transgression) along the east coast of the Aegean, combined with radiocarbon dating of samples obtained from our borings in the Scamander Plain, now allow us to draw a curve of sea level rise during the Late Pleistocene and Holocene epochs (Fig. 4).[19] According to this curve, the Scamander Valley drainage was captured at an earlier stage of Würm glacial regression, and the sediments at -55 m. (older than 30,000 B.P.) were deposited in this earlier Würm valley. An erosional phase followed the deposition of these sediments. The sediments at -45 m. (older than 20,000 B.P.) were probably deposited in the latest stage of the Würm glaciation following the pleniglacial regression of the Mediterranean noted above. Other radiocarbon dates indicate that sea level was at -40 m. about 9700 B.P., and at -28 to -30 m. from 7700 to 7800 B.P. We hypothesize stillstands of sea level at about -30 m. and -20 m., at which depths there are traces of terraces.[20]

Following the stillstands at -20 and -30 m. a rapid marine transgression occurred, with the Mediterranean invading the coastal reaches of all river valleys of western Anatolia, at times as far as 40 km. inland.[21] The sea advanced about 18 km. inland along the Scamander Valley. This rapid transgression may correspond roughly with global atmospheric warming during the Climatic Optimum, when at 6500-5500 B.P. the world ocean probably attained a level 2 m. higher than at present. Erol believes that there is geomorphological evidence along the Aegean and Mediterranean coasts of Anatolia for a double sea level maximum during this



4. A eustatic sea level curve for Anatolia constructed by O. Erol. This curve is believed to be primarily eustatic, but may include some variants from regional or local tectonic activity.

[19] This work includes Erol, 1975, 1976; Göçmen, 1976. [20] Erol, 1976. [21] *ibid.*; Eisma, 1978.

period; that is, an initial rise of +2 m. at about 6500-5500 B.P. and of +1 m. at about 3000-2000 B.P., with a +0.5 m. high sea level stand at about 800-900 B.P.[22] These oscillations correspond roughly to Fairbridge's world sea level curve and Federov's curve for the Black Sea.[23]

It may be argued that the sea level curve presented in Figure 4 is incorrect both in terms of absolute (eustatic) sea level and the chronological framework. Indeed, there are at present several schools of thought, including the suggestion that sea level has been rising rapidly during the Holocene Epoch (the past ten thousand years) and is still slowly rising; or, that sea level reached its present position approximately six thousand years ago and has fluctuated about this level ever since. Without presuming to solve this ongoing argument, we present Figure 4 as the best approximation of a relative sea level curve for western Anatolia that can be constructed from available data.[24] In any case, it is clear that we are at present experiencing a relatively high sea level stand of the Versilian Transgression.

The 100 m.-drop of world sea level in Würm pleniglacial times relative to its present position created a dramatically different coastal geography along the northwest Troad, as along most other coasts. Hypothetical shorelines for about 15,000 and 10,000 B.P. are illustrated in Figure 5. With the onset of the Versilian Transgression, the sea would have rapidly flooded the land surface that had existed previously from the Sigeum Promontory to the island of Lemnos.

GEOMORPHOLOGY OF THE SCAMANDER AND SIMOIS PLAINS

Figure 6 is a large-scale map of the present surface morphology of the Scamander and Simois valleys, the vicinity of Troy, and the Sigeum Promontory. This map also shows part of the hypothetical shoreline of about 10,000 B.P. that is illustrated in the previous figure. During the Versilian Transgression the shoreline was displaced both by sea level rise and by coastal erosion eastward to the Neogene cliffs of the Sigeum Promontory between Beşik Burnu and Kumburnu. We can assume that these cliffs are presently eroding at a rate of approximately 1 to 2 m. per year. This figure is based in part on rates of cliff retreat determined by Kraft and Aschenbrenner in the Methoni Embayment of the southwestern Peloponnese,[25] and is presented only as an estimate of the rate of cliff retreat in Neogene sedimentary rocks facing westward into the Aegean. It is possible that cliff retreat across this low-lying, relatively flat surface during the Versilian Transgression may have resulted in the loss of less than 500 m. of the Neogene

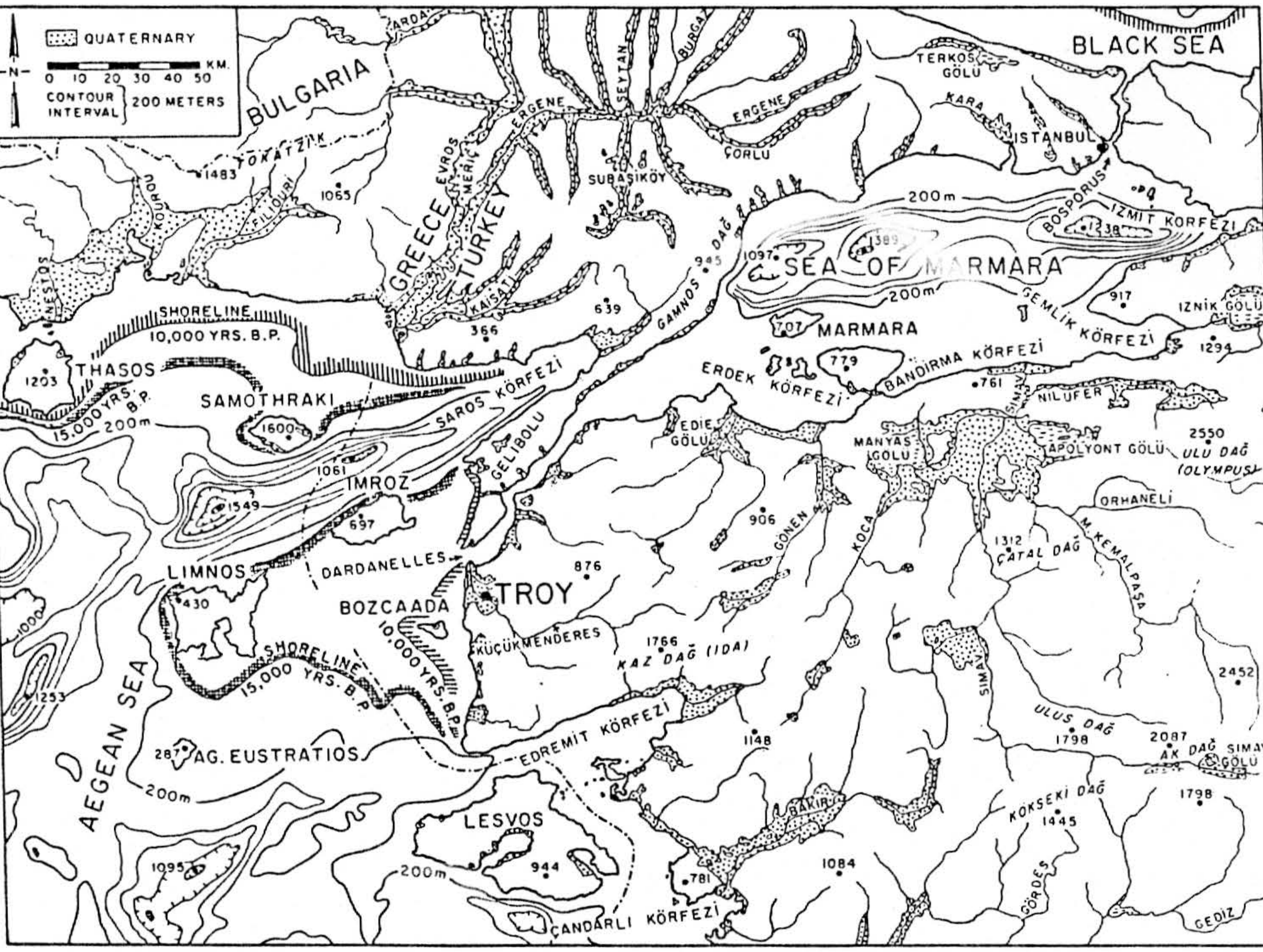
[22] *ibid.* [23] Fairbridge, 1972; Federov, 1977.

[24] Flemming, 1978, pp. 433-434, suggested that sea level in Anatolia has remained within a meter or so of its present level for the period from 3500 to 4000 years B.P. Erol, 1976, defines the specific problems of shoreline changes along the coastline of Anatolia. Local tectonism would preclude uncritical correlation of our curve with the evidence from other areas.

[25] Kraft and Aschenbrenner, 1977.

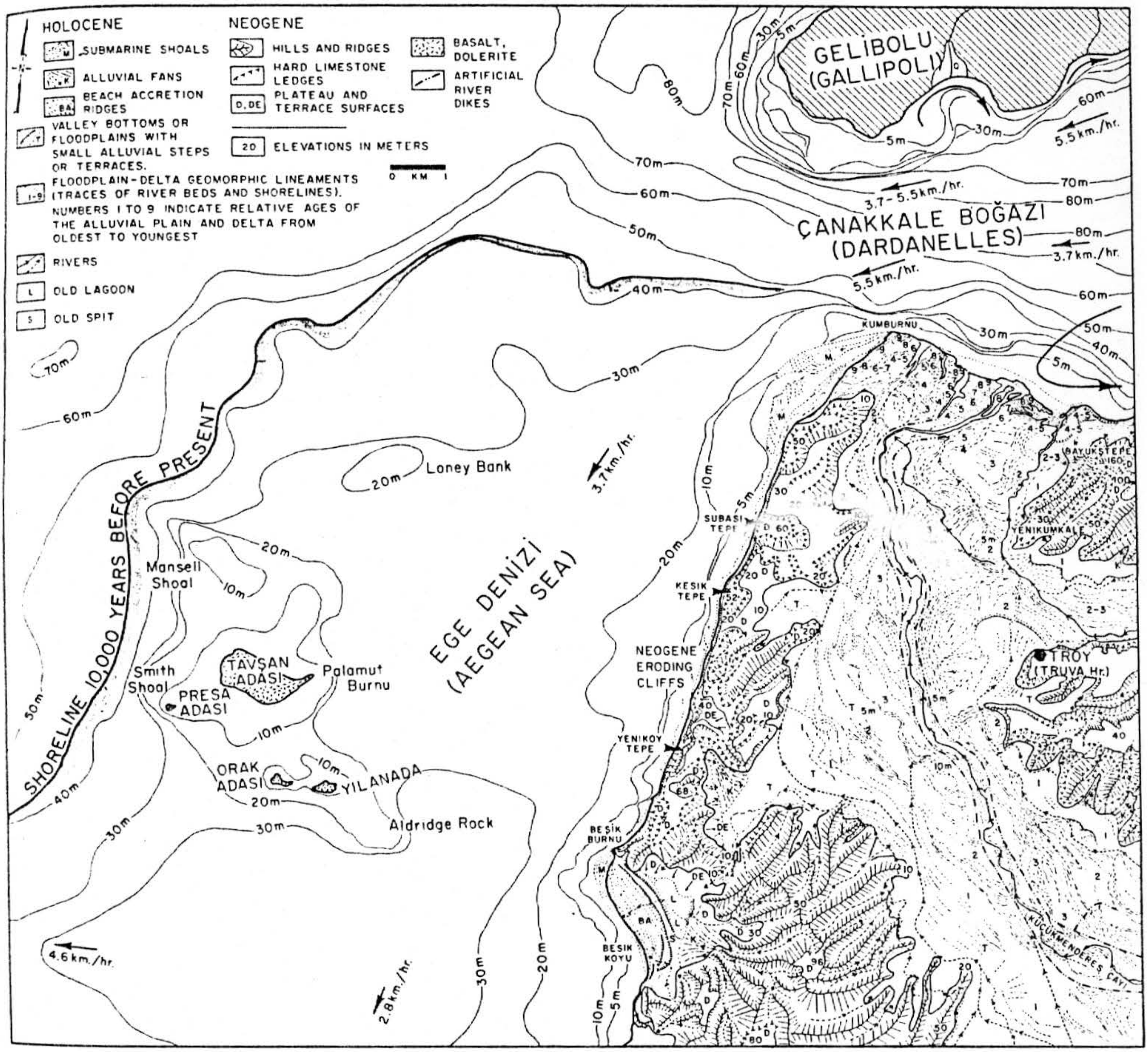
sedimentary rock. Similar cliff retreat probably occurred during the previous high sea stands of the Quaternary.

From aerial photography of the vicinity of Troy, Erol has produced a detailed lineation analysis of the floodplains of the Scamander and Simois rivers;[26] Figure 6 summarizes the results of this study. Erol theorized that some of the lineaments, which are almost undetectable at ground level, may be related to ancient shorelines, but also noted the possibility that they are only relicts of previous morphologies of the alluvial plains. For instance, in the southern half of the



5. A map of the area of the northeastern Aegean Sea, the Sea of Marmara, and the Black Sea showing hypothesized shorelines of 15,000 and 10,000 B.P. Areas of Quaternary alluvial fill are stippled.

[26] Erol, 1972.



6. A geomorphic map of the plains of the Scamander and Simois rivers, the Sigeum Promontory, and the adjacent northeastern Aegean Sea. Topography of the dissected plateaus and the lineaments on the Scamander and Simois plains derived from air photo interpretation (Erol, 1972). A part of the hypothetical 10,000 B.P. shoreline is also shown.

Scamander Plain most lineaments are subparallel to the river valley axis, with some evidence of slight meandering. Along the center of the valley to the west of Troy, and northward to the west of Yenikumkale, the lineaments become highly curved and reminiscent of meander loops or possibly a highly indented shoreline. In the Scamander Delta, between Yenikumkale and the Sigeum Promontory south of Kum Burnu, the lineaments are subparallel to the present Dardanelles shoreline and may represent recent beach accretion ridges. As noted by Erol[27] the lineaments can be arranged in a relative chronology from oldest (number 1, in the south of the Scamander Valley) to youngest (number 9, along the Dardanelles shore). These lineaments are extremely important in attempts to reconstruct the paleogeography of the plains.

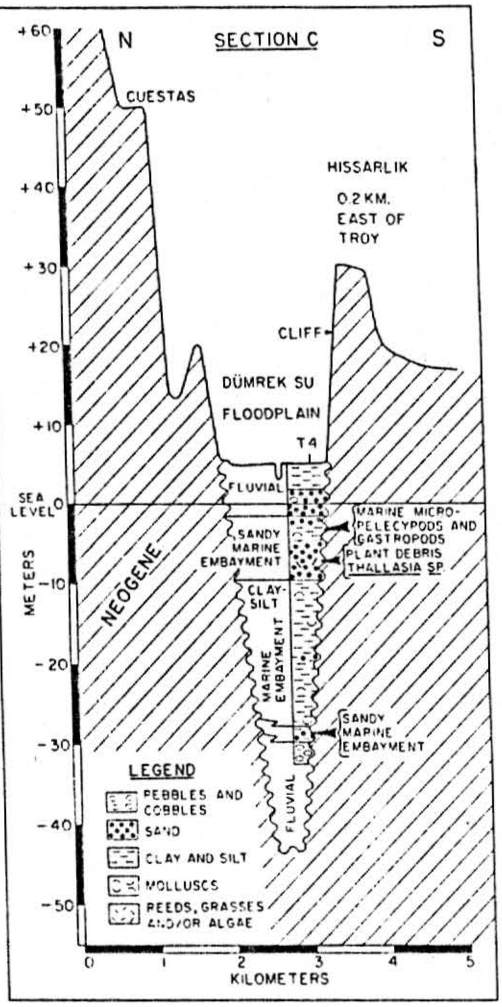
Erol suggested preliminary shoreline positions based on the lineaments. From our data, we now know more precisely where the actual shorelines may have been in the embayment at Troy during the past ten thousand years. These data, when combined with the lineaments as defined by Erol, may be used to establish a preliminary set of fairly precise paleogeographies for the plains of the Scamander and Simois rivers.

SEDIMENTARY ENVIRONMENTS AND SUBSURFACE STRATIGRAPHY

In a series of studies in southern Greece, Kraft and others[28] showed that subsurface borings could be used to define Holocene sedimentary lithosomes. The law of correlation of sedimentary facies, established by Johannes Walther,[29] allows projection of existing depositional environments below the ground surface and thus reconstruction of their three-dimensional boundaries. An absolute time frame may be imposed on the third, or vertical, dimension if sufficient material datable by radiocarbon analysis can be recovered from core sediments. It is thus possible to make paleogeographic reconstructions of coastal changes that have been controlled primarily by the marine Versilian Transgression of the last ten thousand years. Such reconstructions may be considered to be as precise as the quantity and quality of stratigraphic data available.

Figures 7, 8, and 9 present a preliminary description and interpretation of the drill cores. Figure 7 is a north-south section ("C" on Fig. 2) across the valley of the Simois River. Borehole T4 passed through a vertical sequence of about 45 m. of sediment that has accumulated at this point in the valley. Initially, fluvial sands were deposited; these were followed (at approximately 30 m. below present sea level) by deposition of sand in a shallow marine embayment. The sandy marine sediments are overlain by clay-silts of a slightly deeper marine embayment, and are in turn overlain by muddy sands (including an abundant marine fauna) of a more recent sandy marine embayment. Finally, the upper sandy marine embay-

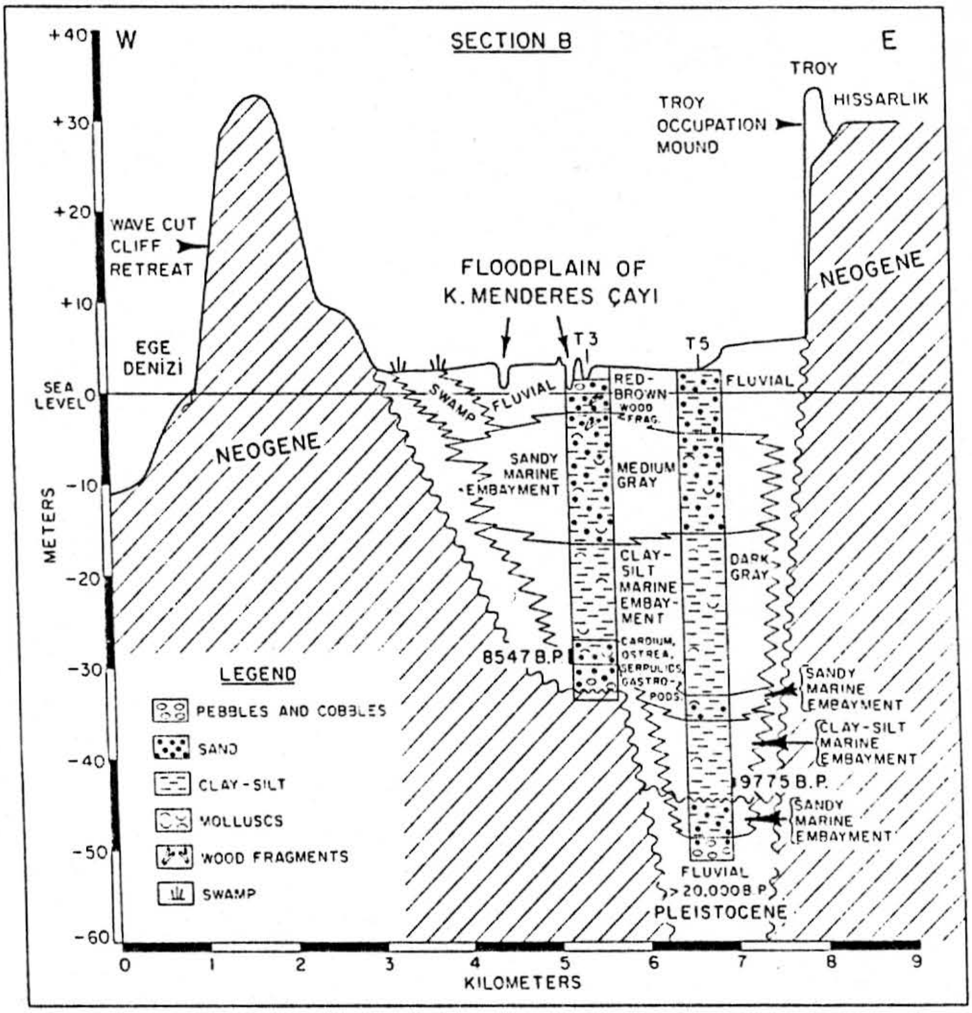
[27] *ibid.*, Fig. 6. [28] Kraft, 1972; Kraft *et al.*, 1975, 1977. [29] as discussed in Middleton, 1973.



7. A north-south cross section ("C" on Fig. 2) across the lower Simois plain between Yenikumkale and the cliff at Troy. In this and in Figures 8, 9, and 10 note the large vertical exaggeration typical of geological cross sections.

ment sediments are overlain by fluvial sediments deposited by the Simois. If an accurate time frame can be determined, precise paleogeographic reconstructions based on Figure 7 are possible.

Similarly, Figure 8 is an east-west cross section ("B"on Fig. 2) from the mound of Troy through the Sigeum Promontory just north of the modern town of Yeniköy and into the Aegean Sea. The alluvial surface is highest in the center and to the east of the Scamander Plain. The slight scarp on the edge of the plain immediately east of borehole T5 may be an incision scarp reflecting a change in river grade, or it may represent low-lying dune fields such as those that occur a short distance to the north. The continuation of this lineament (east and then south to the cliff at Troy) appears as a scarp between the alluvial plain of the Scamander River and the lower plain of the Simois. When viewed westward from the plain of the Simois the



8. An east-west cross section ("B" on Fig. 2) from the Aegean Sea and wave-cut cliff north of Yeniköy across the Scamander Plain to the mound of Troy. Sedimentary facies are indicated and interpreted for the Holocene Epoch and a portion of the Pleistocene Epoch.

slight scarp appears to be a depositional by-pass scarp along the junction of the two plains.[30]

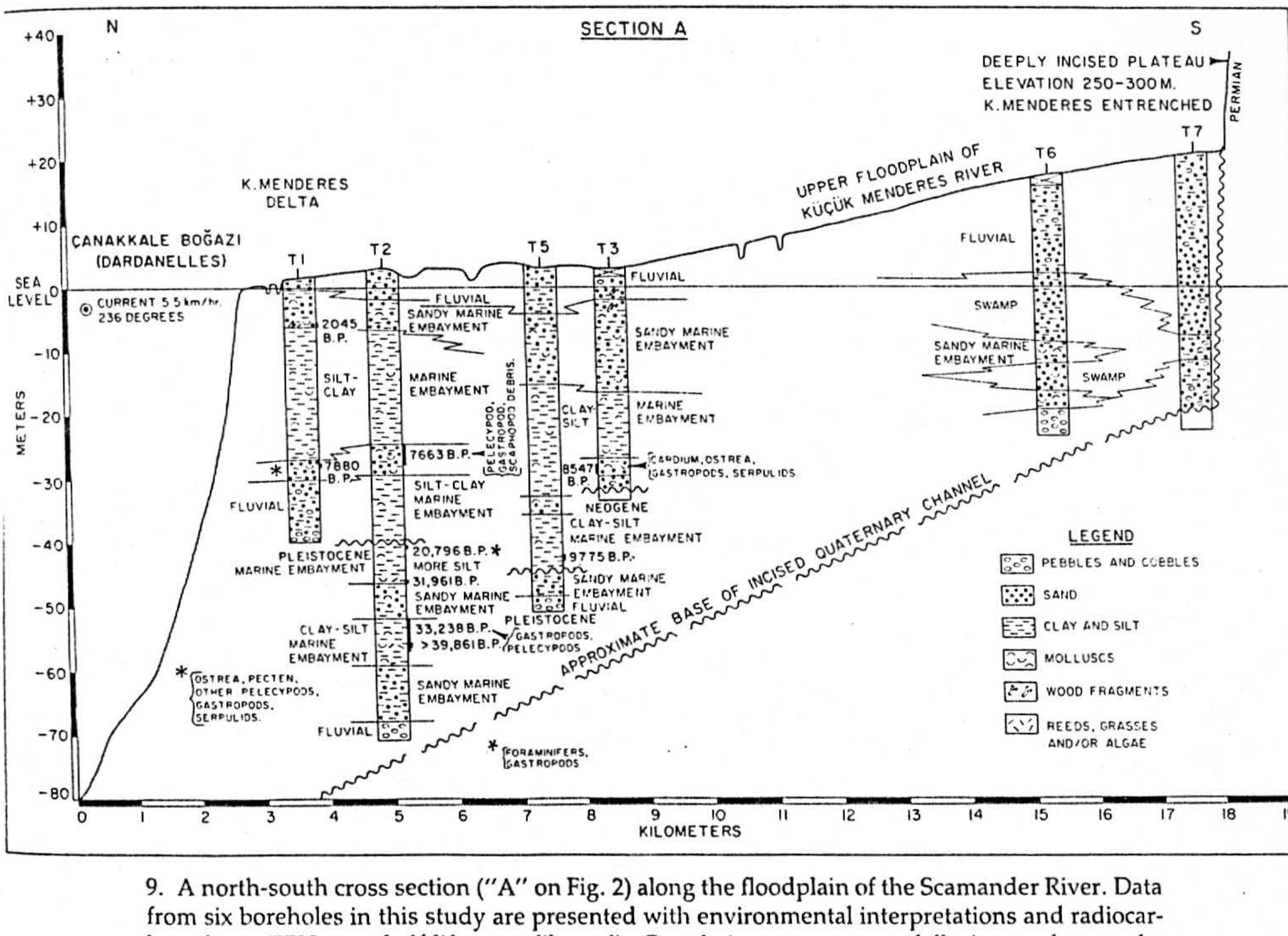
The sedimentary environments identified in boreholes T3 and T5, (Fig. 8) include a basal section of Late Pleistocene fluvial sediments. These are overlain by a nearly complete Holocene sequence. At the base of this sequence, dated to about 9800 B.P., are clear indications that a marine embayment floored by clay-silt sediment had occupied the Scamander Valley. This portion of the sequence is overlain by sandy sediments containing a marine molluscan fauna radiocarbon dated to 7663-8547 B.P. Overlying these sediments are clay-silt marine embayment

[30] A similar depositional by-pass scarp may be seen today when viewing the delta of the Büyük Menderes River from Bafa Gölü near Miletus.

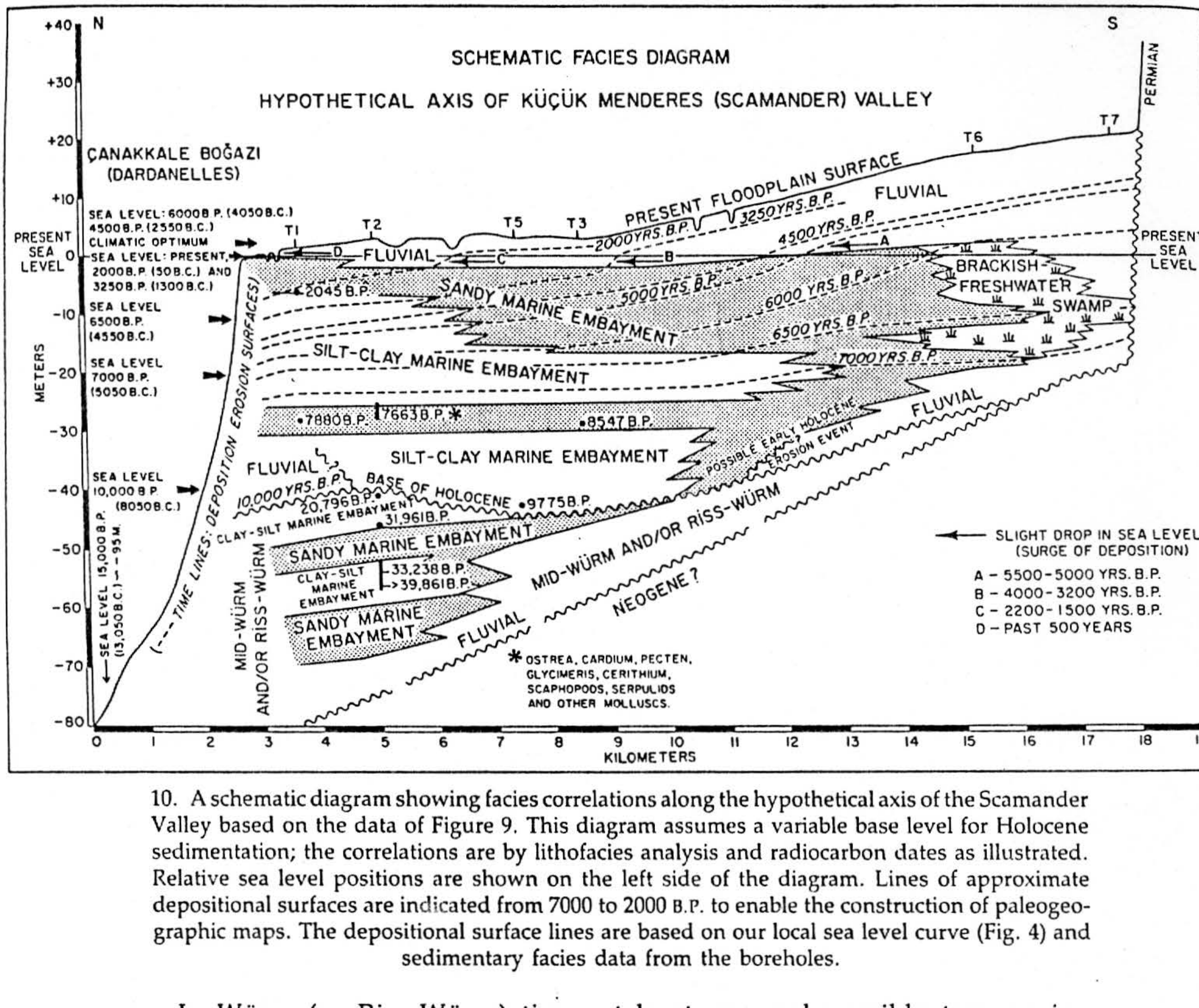
sediments, which in turn are overlain by more sandy marine embayment sediments. The sequence is capped by Late Holocene progradational alluvial sands and silts of the Scamander River.

Figure 9 shows a north-south section ("A" on Fig. 2) projected along the axis of the Late Pleistocene paleo-Scamander Valley. Correlations among the various lithosomes are indirect because the boreholes were not located exactly along the valley axis. Numerous radiocarbon dates from shell samples (all corrected to the 5730-year half-life, but not calibrated) allow precise determination of sedimentary environments, both in the Holocene and the Late Pleistocene valley fill.

Figure 10 is a schematic sedimentary facies diagram again constructed along Section A of Fig. 2, the deepest axis of the Scamander Valley; here lithosome correlations from borehole to borehole are presented.



9. A north-south cross section ("A" on Fig. 2) along the floodplain of the Scamander River. Data from six boreholes in this study are presented with environmental interpretations and radiocarbon dates (5730-year half-life, uncalibrated). Correlations are purposefully incomplete as the borehole data were not all obtained from precisely along the axis of the river valley.



10. A schematic diagram showing facies correlations along the hypothetical axis of the Scamander Valley based on the data of Figure 9. This diagram assumes a variable base level for Holocene sedimentation; the correlations are by lithofacies analysis and radiocarbon dates as illustrated. Relative sea level positions are shown on the left side of the diagram. Lines of approximate depositional surfaces are indicated from 7000 to 2000 B.P. to enable the construction of paleogeographic maps. The depositional surface lines are based on our local sea level curve (Fig. 4) and sedimentary facies data from the boreholes.

In Würm (or Riss-Würm) time, at least one and possibly two marine transgression-regression cycles occurred in this valley. With the waning of the last Würm glaciation, we assume sea level rose according to the curve presented in Figure 4. By about 9800 B.P. a relatively deep marine embayment containing clay-silt bottom sediments had penetrated about 10 km. up the valley.

Positions of local, relative sea levels (in radiocarbon years and based on Fig. 4) are indicated by arrows to the left on Figure 10. Some form of a regression event is indicated by the shallow marine sandy embayment of the eighth and ninth millenia B.P. This was followed by a major mid-Holocene transgression having a peak between 7000 and 6000 B.P. The radiocarbon dates prove the existence of a marine reentrant up to 16 km. south of the Dardanelles and possibly to the vicinity of Pınarbaşı during that period.

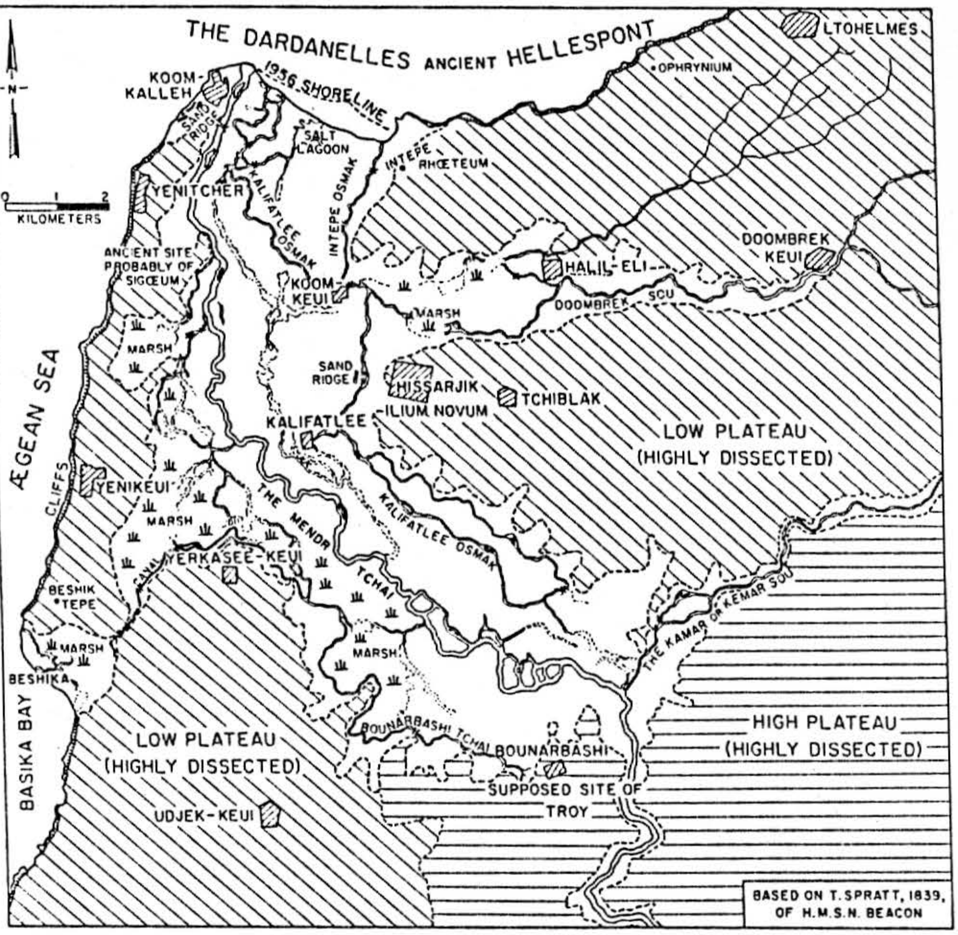
With continuing fluctuation of sea level from 6000 B.P. to the present, a major marine regression began. The deposition of fluvial sediment in the Scamander Embayment would have been highly irregular as continuing slight sea level fluctuations induced changes in river grade. Climatological changes also may have affected this regression, but our core data are not precise enough to allow any climatological statements.

By using the curve of sea level shown in Figure 4, we find it is possible to determine times of potential "surges," or episodes of accelerated fluvial sedimentation. These surges, caused by minor but relatively sudden sea level drops, are indicated in Figure 10 by points A through D. We assume that a minor drop in sea level would result in increased erosion and transportation of sediment in the upper reaches of river drainage basins while simultaneously producing deposition (both aggradation and progradation) in floodplains. Such sea level minima might have been associated with a colder, drier climate and with accelerated erosion during winter rainstorms. Conversely, warmer and moister periods with slightly higher sea levels (and therefore lower river grades) would foster an increase in vegetation cover and a resulting decrease in erosion and deposition.

Some may argue with this method of determining surges of alluviation. We recognize that other, nonquantifiable elements such as climatological fluctuations may have led to very different erosional-depositional regimes. It might further be argued that with alternate assumptions concerning sea level changes, such climatological changes might have totally controlled the depositional regime of the Scamander Valley. However, it appears to us fruitless to call on paleoclimatological variations of northwestern or southern Europe, or elsewhere, and apply them to a precise single problem in the area of northwestern Anatolia. If the future holds a more precise climatological determination for the Aegean region, then the interpretations presented here may need to be slightly modified. In any case, in view of our new data it is evident that a major marine transgression occurred with its peak from 7000 to 6500 B.P., and from that time onward there was progradation and aggradation of marine and then fluvial sediments from the southern end of the Scamander Valley near Pınarbaşı northward to the present delta at the Dardanelles.

PREVIOUS PALEOGEOGRAPHIC RECONSTRUCTIONS OF THE VICINITY OF TROY

One of the best ways to assess earlier attempts at reconstructing the ancient geography of the vicinity of Troy is to begin by considering the 1839 map (redrawn as Fig. 11) of Commander T.A.B. Spratt, R.N., who was the first to complete an accurate survey of the northwestern Troad. His map shows the valleys of the Scamander and Simois rivers to be alluviating, and emphasizes the extensively developed swamps on the southwestern side of the Scamander Valley, a feature



11. A simplified version of the map of Commander T. A. B. Spratt, R.N., published in 1839. Spratt was careful to illustrate the many channels of the Scamander River and the morphology of its floodplain, at a period before major drainage and irrigation projects began to alter the local topography. (Spellings are mid-nineteenth century; areas of the high and low plateaus, and the recent Dardanelles shoreline have been added.)

that is still extant. Spratt also shows the primary channel and multiple flood channels of the Scamander, which in his time flowed more closely along the Sigeum Promontory and emptied into the Dardanelles near Kumkale.

At least by the first century B.C., commentaries on possible topographic changes at Troy were being written; unfortunately only brief mention of those of Demetrius of Scepsis and Hestiaea of Alexandria Troas survive in Strabo's *Geography*. Hestiaea, in fact, seems to have been among the first to suggest that the battles of the *Iliad* could not have been fought northwest of the classical town of Ilium, as the plain in that area (according to her lost commentary on the *Iliad*) is a later deposit of the rivers.[31] This makes great sense to us.

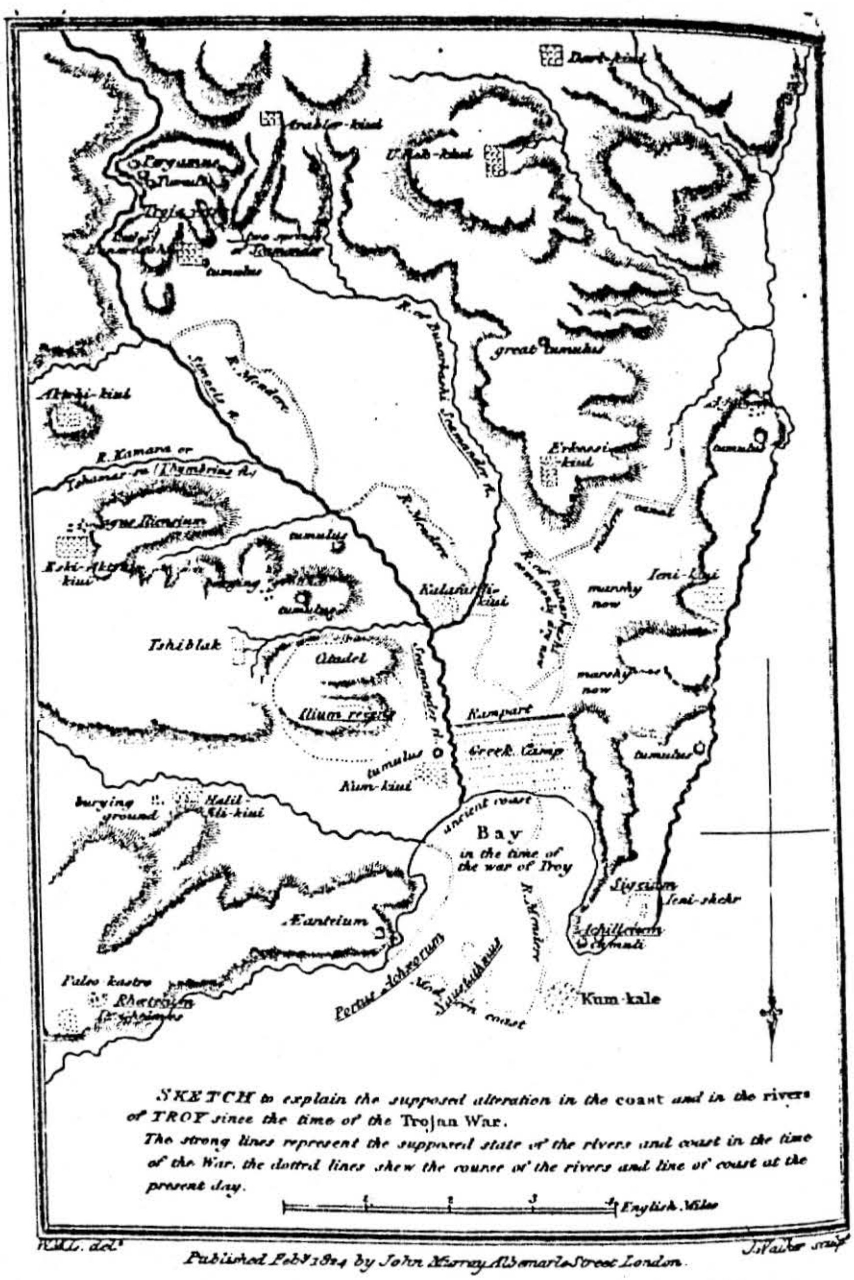
[31] as paraphrased by Demetrius in Strabo's *Geography*, xiii, 599.

Pliny, in the first century A.D., referred to the Scamander River as being "navigable."[32] Most commentators on the question of a navigable Scamander River assume that some mistake in copying or observation has been made, perhaps through observations of the *asmaks* of the lower delta plain near the Dardanelles. Over the past century many authors have called attention to the name of the Kalafatlı *asmak*, which lies near the end of the ridge just southwest of Troy. During that time the village of Kalafatlı lay in the middle of the Scamander Plain along this easternmost channel (Fig. 11). The word *kalafatlı* refers to a place for tarring and repairing ships. The authors feel that Pliny's statements as well as other, more recent, statements regarding the Kalafatlı channel probably do indicate that it once was navigable to the position of the old village of Kalafatlı. Nearly all the coastal alluvial plains of western Anatolia and Greece have long since been drained by the straightening and diking of their river channels. The effect of draining the plains and diverting water for irrigation has been to reduce the discharge of these rivers significantly. In addition, one should not think in terms of modern ships and their requirements for accessibility to the sea when judging where people of earlier times might have sailed. Certainly in the winter flood stage it would have been possible to take shallow-draft vessels far inland on the Scamander Plain. Also, it is possible that the flow regime of the Scamander River may have been different several hundreds of years before present and indeed over the nineteen hundred years back to Pliny's time. However, it appears obvious from the application of normal physiographic principles that one should not assume the channels of the present Scamander River are relicts or palimpsests of those of antiquity. The Scamander Plain is both aggradational and progradational; its subsurface stratigraphic record clearly shows numerous buried stream channels scattered throughout the 10-15 m. of alluvium that occur there. Thus, many former channels have flowed across this plain over the past six thousand years, and the arguments about identifying the particular channel active at the time of the Trojan War have no merit.

Leake, following the writings of Strabo, assumed that there was indeed a small marine embayment penetrating into the Scamander Plain and that its shoreline was approximately 2 km. northwest of Troy.[33] Leake produced a literal topographic reconstruction from Strabo's comments (Fig. 12), in which he illustrated this arcuate embayment and placed the Scamander River between what he called the Greek Camp and the site of "Troja" (incorrectly located near Pinarbaşı). He also made the interesting, if questionable, calculation that at least 1.5 mi.^{2} of the plain would have been required to beach the ships of the Achaeans and provide camp space for their fifty to one hundred thousand troops.

Leaf, having devoted an entire appendix in his study to the problem of the ancient course of the Scamander, concluded that Strabo's comments were wrong and that long before the Trojan War the Scamander Delta was already very much

[32] Pliny, *Natural History*, v. 88. [33] Leake, 1824, p. 279.



12. "Sketch to Explain the Supposed Alteration in the Coast and in the Rivers of Troy since the Time of the Trojan War" (from Leake, 1824).

the same as in his day.[34] Cook, as the most recent commentator on the topography and archaeology of the Troad, has thoroughly discussed all aspects of the nature of the Scamander Embayment and also the possibility that the Achaeans might have beached their ships southwest of Troy at Besika Bay on the Aegean shoreline.[35]

[34] Leaf, 1912. [35] Cook, 1973, pp. 181-188.

As noted previously, Bilgin made an intensive analysis of the possibilities of correlating surficial data with the paleogeography of the Scamander Valley at the time of the Trojan War. He relied heavily on Strabo for his determinations of the shoreline positions of approximately two thousand years ago.[36]

A thorough study of the historical literature regarding the geomorphology of the river plains at Troy has been made by Bintliff.[37] In an outstanding analysis of the literature, he presents well-documented concepts regarding the form of the delta northwest of Troy. From the time of Strabo onward, Bintliff's reasoning appears to be applicable. However, our surface and subsurface geologic studies suggest that projections of this type before 2000 B.P. are at least inaccurate and probably totally invalid. In any case, Bintliff's very careful analysis of the literature represents the best possible application of his technique in the reconstruction of paleogeographies for the past two millenia. Bintliff relies heavily on assumed climatological change to create colder and wetter climates that result in massive erosion of drainage basin slopes and widespread alluviation of coastal plains. By the same reasoning he suggests that minimal progradation (by deltaic advance) would occur with the onset of drier periods. He also states that the rivers around Troy are presently incising and notes that as there are no significant levees, no alluviation is occurring on the Scamander Plain.

We disagree somewhat with this last conclusion in that clearly, from historical records of winter floods during the past century, the plain is alluviating. Admittedly, with the coming of intensive agriculture, drainage, and irrigation, this point might not be evident. Bintliff also assumes a continuing sea level rise over the past four thousand years. As noted previously, there is another school of thought that would have sea level oscillating around its present position for the past five to six thousand years.[38] This is what the data for the coast of Anatolia suggest (Fig. 4).

Much of Bintliff's argument and hypotheses is based on applications of Vita-Finzi's regional-climatological framework for recent geologic changes in the Mediterranean Basin. The latter's studies suggest that the alluvium of most Mediterranean river valleys consists of an "Older Fill" of Würm age and a "Younger Fill" of post-Classical age.[39] In our studies of subsurface stratigraphy in the Scamander Plain we found no support for this relatively short and restricted period of deposition of a "Younger Fill"; rather, it appears there is a continuum of alluviation in the floodplain beginning at least by 9800 B.P. There is, however, a fill (or fills) of Würm (or possibly Riss-Würm) age at the base of most of our boreholes that might be identified with Vita-Finzi's "Older Fill."

A fundamental problem in all of the arguments considered here is the nature of the Holocene sea level curve. As Vita-Finzi observes, "The idea of coastal stability has been described in some quarters as a myth which casts doubt on all attempts to define a truly eustatic curve of sea level rise . . . while a eustatic curve of global

[36] Bilgin, 1969. [37] Bintliff, 1977. [38] Fairbridge, 1976, fig. 3. [39] Vita-Finzi, 1969, 1973.

applicability comes to be dismissed as chimerical."[40] Whether or not a global eustatic curve is ever attainable, the local curve of sea level rise used in this study, if not "truly" eustatic, at least has the support of a large quantity of evidence from the shorelines of Anatolia. This is all that is required to complete the exercise of developing paleogeographies for the Trojan Plain.

Of the two schools of thought—that there was an embayment on the lower Scamander Plain three thousand and more years ago or that the lower Scamander Plain was then approximately in the same position as today—we find the latter to be untenable. It is now evident that there was a major marine embayment in the plains of the Scamander and Simois rivers during the past ten millenia.

DETAILED PALEOGEOGRAPHIC RECONSTRUCTIONS OF THE PLAIN OF TROY

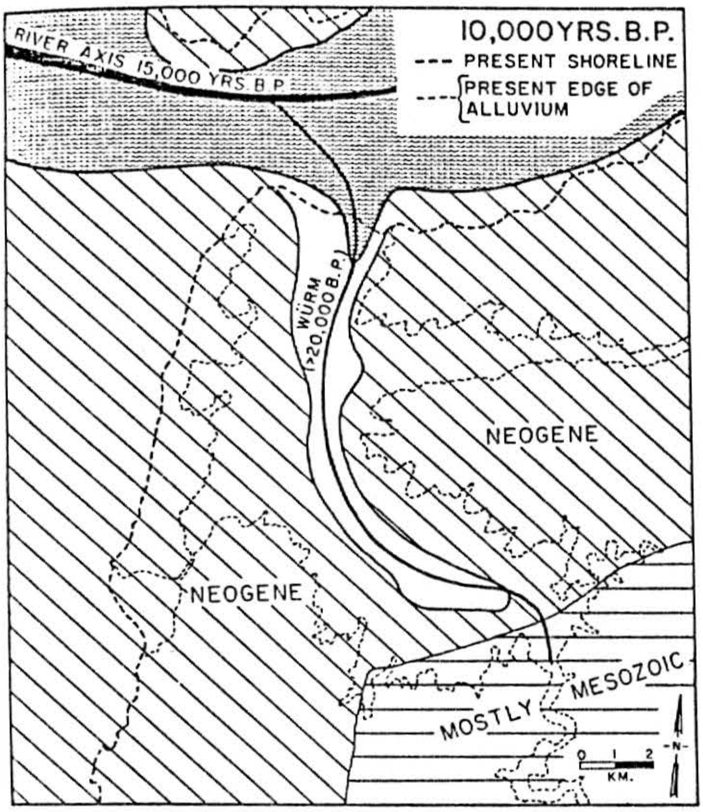
Using the data obtained from our boreholes (as summarized and interpreted in Fig. 10), and aided by the detailed photographic analysis of Erol (Fig. 6), we have constructed fairly precise paleogeographies of the Trojan Plain for several periods over the past ten thousand years. The reader must remember that these reconstructions are based on seven boreholes, a rather limited number. To gain further precision would merely require a higher density of holes and radiocarbon dates across the plain.

Figure 13 presents a paleogeographic reconstruction of the area near the mouth of the Dardanelles at about ten thousand years ago; it also shows the axis of a river that flowed in a valley incised through the modern Dardanelles Strait approximately fifteen thousand years ago. The alluvium was found in several boreholes and is dated at greater than 20,000 B.P., or Würm age. This paleogeographic reconstruction is very schematic, being based on a limited number of data points plus the forms of the visible Neogene topography.

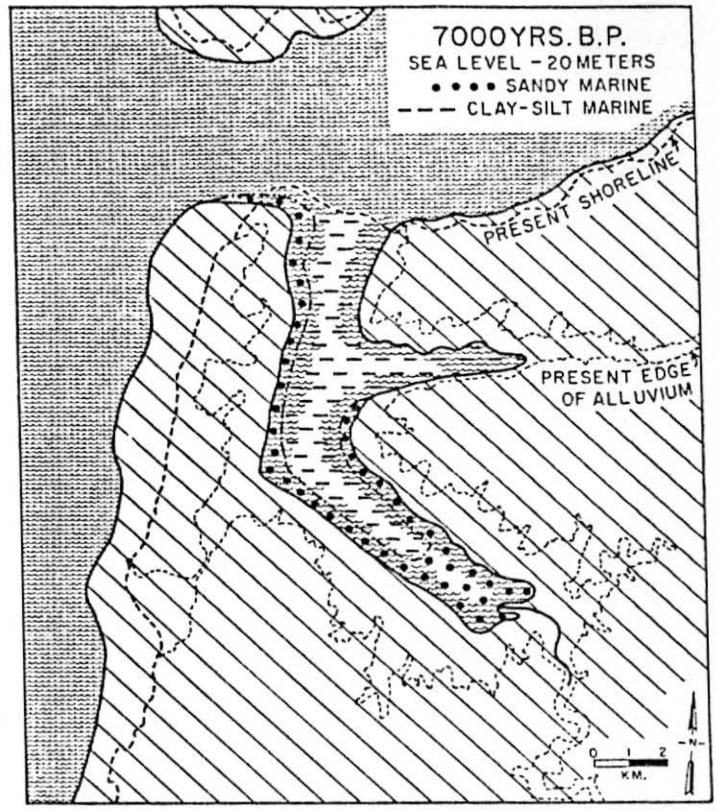
By 7000 B.P. (Fig. 14), we can be more precise in reconstructing paleogeography. A major marine transgression had occurred along the axis of the paleo-Scamander Valley (Fig. 10 illustrates the extreme inland limit of this mid-Holocene transgression). A sand or clay-silt-floored marine embayment extended over 15 km. southward and southeastward from the present Dardanelles. In this marine embayment a fringing zone of sands and muddy sands probably was deposited in very shallow water while deposition in the central, deeper area consisted of dark grey muds. The molluscan faunas found in these sediments clearly identify the nature of these depositional environments.

Figures 15 and 17 show environmental reconstructions for approximately 4500 B.P. and 3250 B.P. These times were chosen specifically for their importance to archaeologists.

[40] *ibid.*, 1973, p. 59.



13. A paleogeographic reconstruction of the vicinity of the present plain of the Scamander River ca. 10,000 B.P., showing the axis of a river that flowed in the valley of the present Dardanelles about 15,000 years ago.

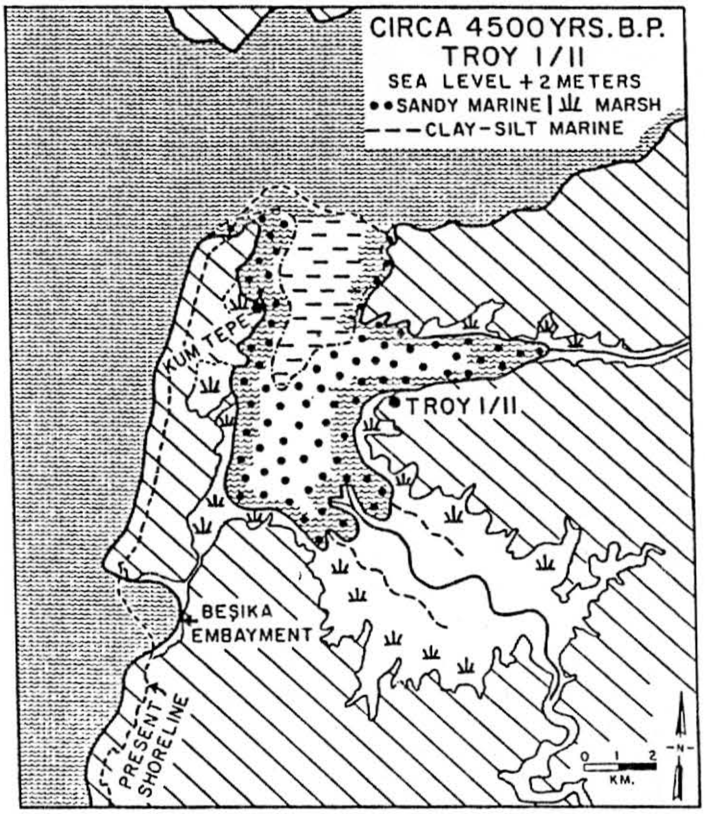


14. A paleogeographic reconstruction of the topography and depositional environments of the marine embayment at Troy ca. 7000 B.P. Dotted zone represents sandy marine sediments, dashed area represents clay-silt marine sediments.

Figure 15, a reconstruction of the period about 4500 B.P., represents the time of the First and Second Settlements of Troy. Also shown is the site of Kumtepe near the northern end of the Sigeum Promontory, which was occupied several hundred years prior to and during the First Settlement. In his report on the excavation at Kumtepe, Sperling noted the possibility that the site was picked in part because "the alluvial soil of the adjacent part of the plain is easily cultivable."[41] Our data indicate that Kumtepe had immediate access to the seafood resources of the embayment. Sperling mentions that Kumtepe shows a heavy reliance on shellfish as a food resource. As may be seen in Figure 15, the broad marine embayment was fringed by a sandy bottom; in the deeper water toward the center and north a bottom of clay-silt was dominant.

It is interesting that in 1811 Maudit noted[42] sea shells on a slight mound on the Scamander Plain near Sigeum. This possibly was the site later to be excavated and known as Kumtepe. Indeed Bilgin also observed that southwest of Troy a clean,

[41] Sperling, 1976, p. 355. [42] as quoted in Virchow, 1879, p. 153.

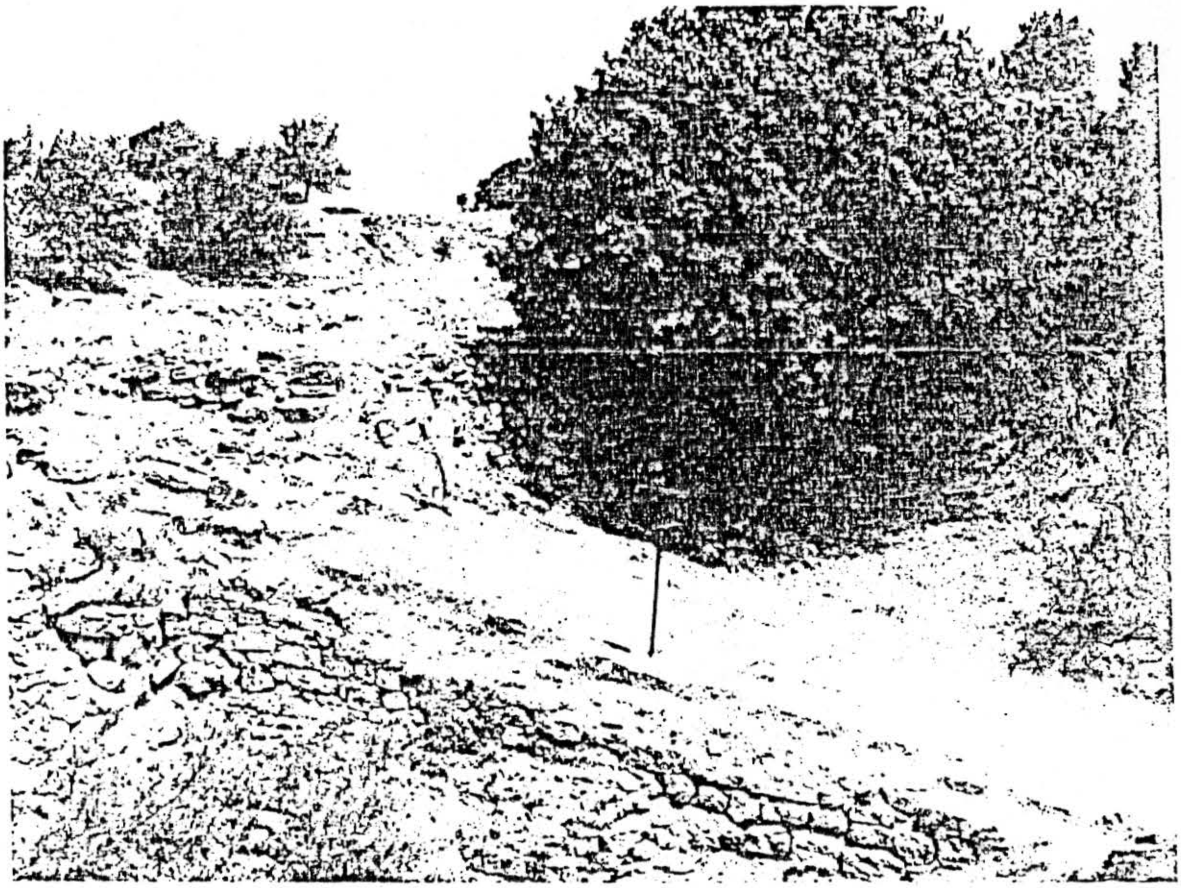


15. A paleogeographic reconstruction of the vicinity of Troy ca. 4500 B.P., showing the nature of the marine embayment around Troy at the time of the First and Second Settlements. Note the enlargement of the marine embayment at Besika Bay.

well-sorted shelly sand deposit occurred in a 2-3 m.-deep drainage ditch on the western side of the plain. Probably these sands, with their marine molluscan fauna, are part of the sandy marine embayment of about 4500 B.P.

As indicated in Figure 15, at the time of Troy I and II the steep cliffs to the northeast of Yenikumkale (see Fig. 2 for location) were sea cliffs subject to attack and erosion by westerly waves refracted around the north end of the Sigeum Promontory. At the same time, the Aegean cliff coast of that promontory was also undergoing erosion.

The marine embayment schematically reconstructed in Figure 15 extended to within a few hundred meters of the citadel in the time of Troy I and II. The coastal plain fringing the bay on that side was therefore quite narrow, and the Trojans could easily have used some part of the nearby shoreline as a landing place for ships of their own. One might speculate that the high-angled, limestone-paved ramp from Gate FM of Troy IIc (Fig. 16) led down to the vicinity of this landing. We recall Blegen's statement "that already in the middle phases of Troy I relations had

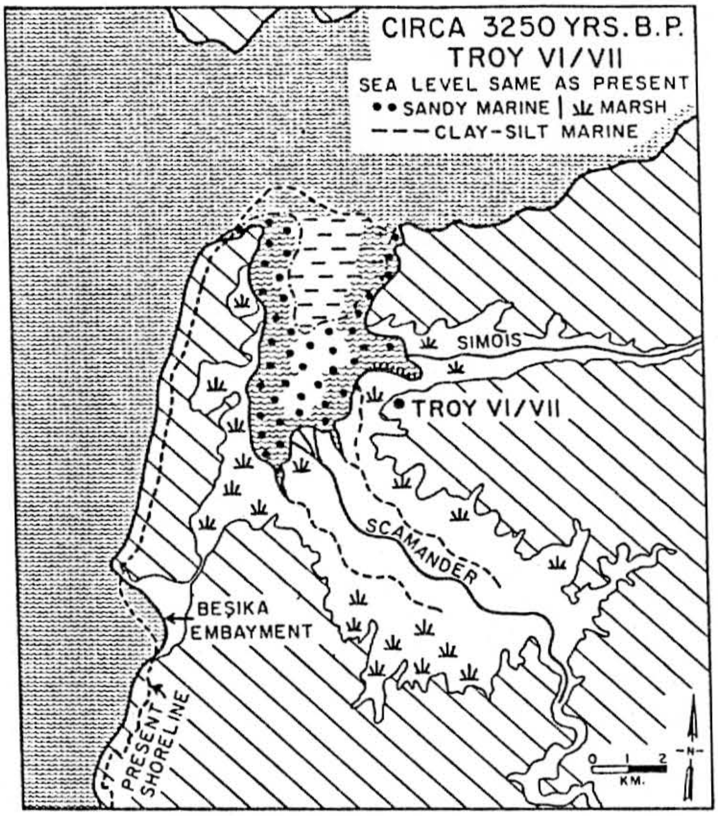


16. The ramp leading from Gate FM of Troy IIc. It is probable that it led to a very narrow coastal plain and a beaching area for ships.

been established with Early Aegean centers, and there can be no doubt that the communications were carried on by sea."[43] This is an intriguing speculation for the later settlements of Troy as well, because the Trojan fleet is scarcely ever mentioned by commentators on the *Iliad*. Surely a fortified city on a promontory overlooking a marine embayment controlling the Dardanelles must have had some ships. From the paleogeographic reconstructions here presented it would seem logical that any Bronze Age Trojan harbor or landing would have been located immediately west of the citadel or to the north, across the valley of the present Simois River toward the modern town of Yenikumkale (see Figs. 2 and 15).

Many of the readers of this chapter will be interested in the coastal geography at the time of the "Trojan War." Figure 17 is a reconstruction of the plains of the Scamander and Simois rivers about 3250 B.P., or at the time of Troy VI and VII. We believe that the major marine embayment shown in Figure 17 is realistic and well-supported by our data. The precise location of the shoreline is, of course, arguable

[43] Blegen *et al.*, I, p. 39.



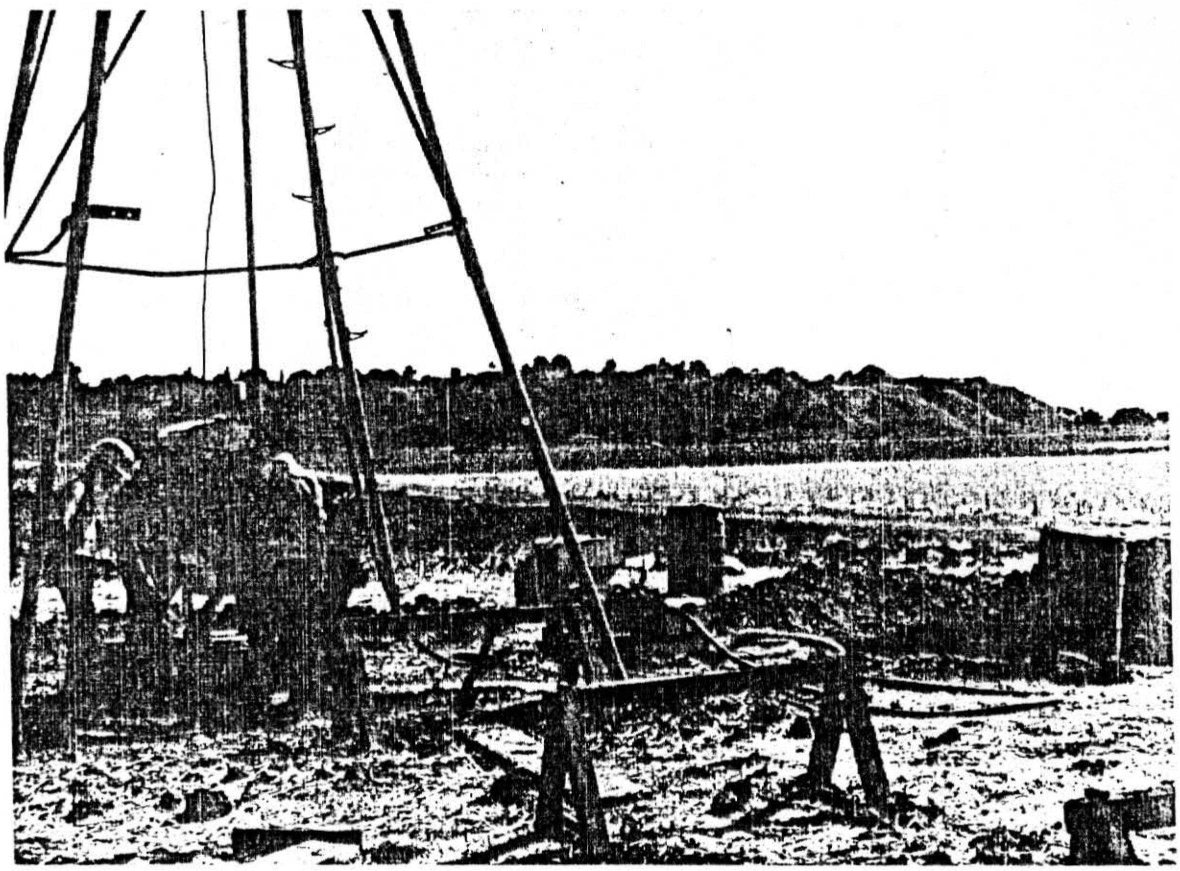
17. A paleogeographic reconstruction of the vicinity of Troy ca. 3250 B.P. (VI and VII). An extensive marine embayment still existed northwest of the city.

due to our limited number of boreholes and assumptions of contemporary sea level.

Bilgin noted that the 5m.-contour on the Scamander Plain extends further south on the western than on the eastern side of the plain. We have attempted to incorporate this observation in our reconstructions as a reflection of more rapid deltaic progradation in the central and eastern sectors of the embayment. Again, clay-silt sediments predominated in the deeper water of the central and northern portions of the embayment. We assume that shellfish resources continued to be immediately accessible to the inhabitants of Troy VI and VII. In fact, abundant oyster and cockle shells are found in the strata of all the Bronze Age settlements of Troy (see Appendix II, Marine Mollusc Shells).

Figure 18 is a photograph from the site of borehole T4 looking southward toward the mound of Troy and its Bronze Age sea cliff.

There appears to be little reason to doubt Strabo's description of the topography of the Scamander Plain adjacent to Troy, other than in terms of precise distances and his projections back to the time of the Trojan War. Strabo notes specific distances; from Troy to the seacoast is given as 12 stadia, or about 2.2 km., and he



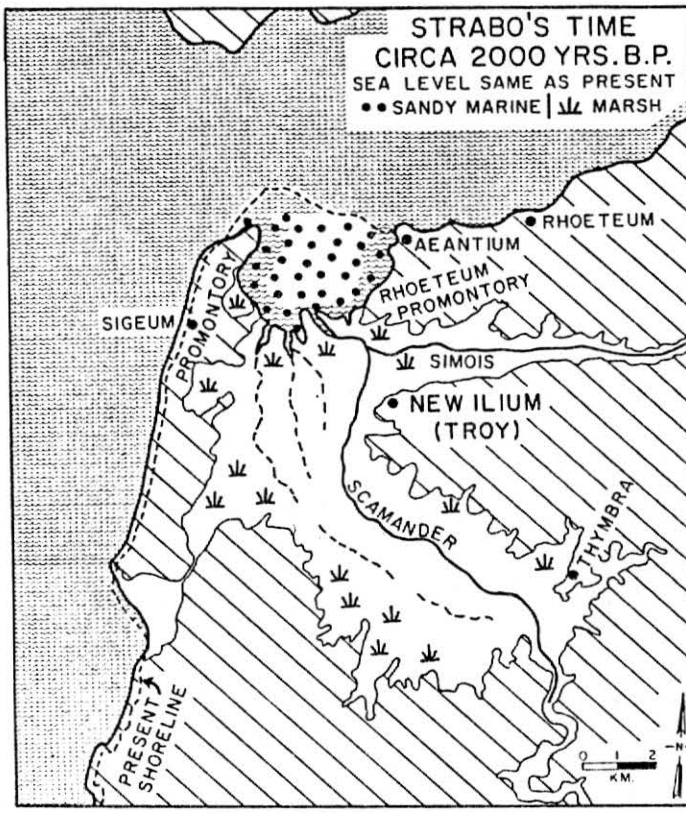
18. A photograph from borehole site T4 on the Simois floodplain, looking south to the sea-cliff shoreline of Bronze Age Troy.

estimates the distance to have been half that figure at the time of the Trojan War.[45] We suggest that the difference in position of the shoreline was much greater than that assumed by Strabo. However, we have attempted to use his contemporary description of the area[46] for a more detailed reconstruction of the plain of Troy about 2000 B.P. (Fig. 19). Certainly the shoreline of this time would have been complex, with marshes, muddy sands, many *asmaks*, and a possible birdsfoot delta of the Scamander River extending northwest toward the tip of the Sigeum Promontory.

THE BESIKA HYPOTHESIS

There have always been questions whether or not the Achaean fleet in fact anchored in an embayment of the Dardanelles (Hellespont). Some scholars have thought that the term "Hellespont" as used in the *Iliad* was originally applied to the entire region and included the nearby shoreline of the Aegean Sea. Whether or not this is the case, the possibility that the Achaeans landed at the small

[45] Strabo, *Geography*, xiii, 598. [46] *ibid.*, xiii, 595-596.



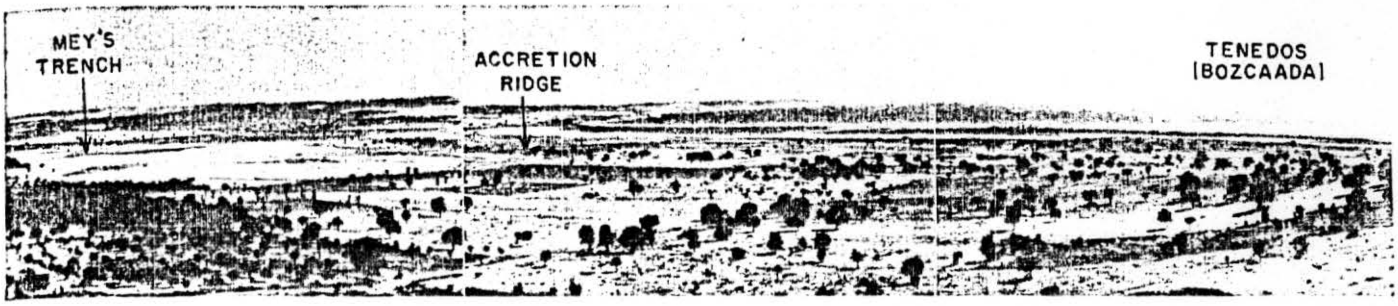
19. A paleogeographic reconstruction of the vicinity of Troy ca. 2000 B.P. based on information from our drilling program and the description of Strabo.

embayment known as Besika—southwest of Troy along the coast of the Aegean Sea (Fig. 20)—must be considered.

Mey and others excavated a 3 m.-deep trench (located in Fig. 2) approximately one km. landward of the present shoreline on the plain at Besika.[47] In this trench (Fig. 21) a superficial layer of marly humus was penetrated first. Under this lay a stratum of sand with some thin, intercalated clay layers. Fragments of over-fired ceramic material (*Ziegelstücke*) were observed approximately 1.3 m. below the surface. In the lower part of the sand unit abundant mollusc shells (mostly the edible cockle, *Cerastoderma glaucum*) were encountered. Three large potsherds and a flint flake were also found in this stratum. The potsherds were believed by Schede to be comparable in age to pottery types excavated from Troy I strata.[48]

Both Mey and Schede hypothesized that the quartz sand layer that overlies dark clayey marl approximately one km. inland from the Besika Bay shoreline represents an infilling of beach or nearshore marine sands. Schede noted the suggestion of Brückner that Besika Bay was actually a much more suitable landing place than the Scamander Plain northwest of Troy for the Greeks of the

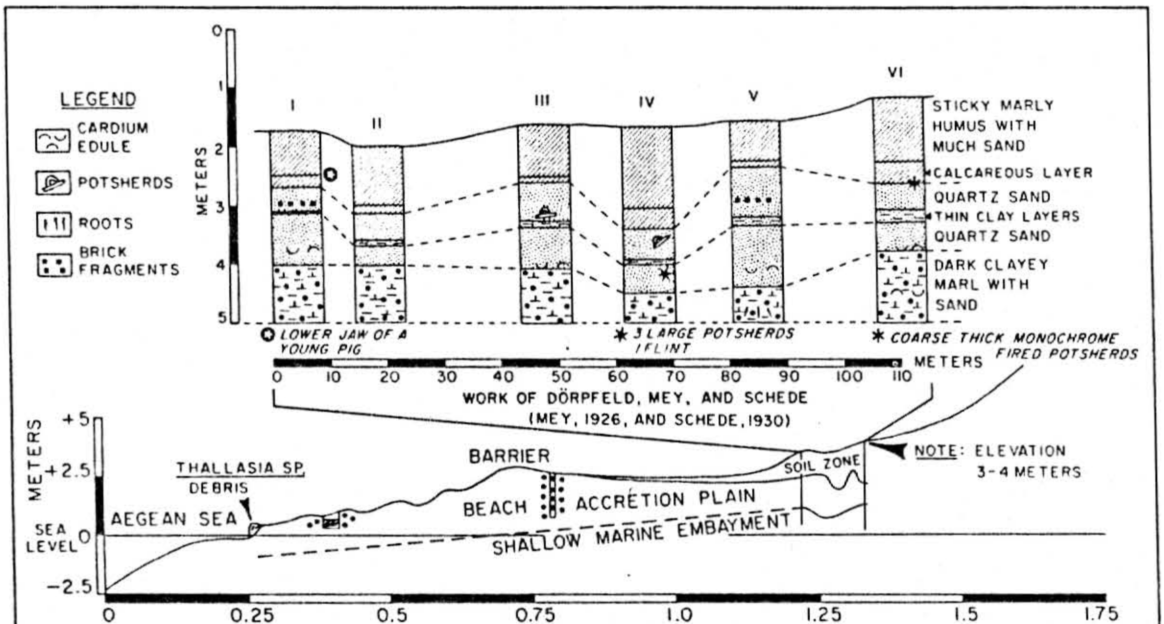
[47] Mey, 1926. [48] Schede, 1930, p. 362.



20. A panorama of the accretion plain (infilled embayment) at Besika. The island of Tenedos (Bozcaada) lies in the mist offshore. The trench dug by Mey, Dörpfeld, and Schede (Fig. 21) was located in the left center of the panorama, approximately one km. from the present shoreline, at an elevation of 3 to 4 m. above sea level.

Iliad. This theory was also proposed early in the twentieth century by the French scholar Bérard.[49] Mey noted that there was some logic for the Besika theory in that better drinking water was available there, that the promontories surrounding the embayment would have provided better flank protection for the Greek fleet, and that "a deep bay and flat beach, upon which the ships could be placed in successive rows," may have existed there at the time of the Trojan War.

Utilizing the data of Dörpfeld, Mey, and Schede, we have included a reconstruction of the embayment at Besika in Figures 15, 17 and 19. Bintliff raises



21. Diagram of the trench excavated by Mey, Dörpfeld, and Schede, showing the present alluvial soil surface, the marine beach accretion sandy unit, and the underlying clay unit as related to the beach accretion plain of Besika (redrawn from Mey, 1926).

[49] as presented (and rejected) by Leaf, 1912, pp. 257-260.

the objection that the deposits at Besika excavated by Dörpfeld, Mey, and Schede are above present sea level.[50] If one accepts the hypothesis that sea level slowly rose over the past several millenia to its present position, then there could not have been a marine embayment at this location unless recent tectonic uplift of the shoreline is invoked. However, it should be noted that repeated episodes of slightly higher sea level are indicated on the relative sea level curve used in this study (Fig. 4). Furthermore, the sedimentary data gathered by Mey (Fig. 21), and the central spit or barrier in the embayment noted by Erol[51] are themselves evidence for a higher sea level stand three to five thousand years ago.

In view of this, there seems to be no problem in reconstructing a more indented marine embayment at Besika from 5000 B.P. to the historic past. Gradually, through accretion of beach sediment transported by littoral drift processes, the shore of Besika Bay grew seaward. In fact, a trench recently dug by one of the authors, John C. Kraft, on the Besika Plain near the shoreline showed that accretion is continuing. Thus, if one believes the *Iliad* to be at least semi-factual, one must seriously consider the possibility that the Greek fleet was beached in the embayment at Besika, particularly in light of the shoreline adjacent to Troy. As relatively unprotected as it is, the British and French fleets used Besika as an anchorage and watering station during the Crimean War. Further, and rather fascinating, is the fact that although Schliemann during his excavations at Troy was in the habit of taking his morning bath in the waters of the Dardanelles, on those occasions when he had tools and equipment shipped to the site, the vessels always unloaded at Besika Bay. Since this process was merely repeating a pattern of transport that had been occurring in the area for the past four or five thousand years, it is surprising that its significance was unappreciated by Schliemann.

CONCLUSIONS

The data that we have obtained from our boreholes on the plains of the Scamander and Simois rivers represent a considerable departure from previous paleogeographic reconstructions of the region; they prove that there was a major marine embayment stretching about 15 km. south of the Dardanelles at the peak of the Versilian Transgression. A local regression then occurred in which a shallow, sandy marine environment with a deeper, silt-clay marine environment to the north gradually was infilled over the ensuing six thousand years, almost to the present. The delta of the Scamander River now has prograded to the point where any significant volume of sediment from winter floods is discharged into the deep channel of the Dardanelles.

Subsurface data related to geomorphologic analyses of the Scamander Plain show that it is feasible to produce fairly accurate paleogeographies of the area that can be of considerable use to archaeologists and historians. It is possible that our

[50] Bintliff, 1977, p. 39-40. [51] Erol, 1972, p. 4.

reconstructions are not sufficiently precise and that future work in the area will somewhat modify the ideas herein presented. However, whether one agrees with our sea level reconstruction or believes that other sea level curves—or other climatic or tectonic factors—should be utilized in making interpretations for this area, it remains clear that a transgression occurred and that the time of this transgression relates to the time of the occupancy of all nine settlements at Troy.

Future work might focus on obtaining an extremely precise paleogeography for any time period on the middle and lower Scamander Plain by drilling a large number of boreholes and obtaining sufficient radiocarbon material for dating. Our attempts at dating many of the organic samples failed because the drill core size was small and the quantity of material recovered was not sufficient for radiocarbon analysis using conventional techniques. The near future promises application of a technique by which very small amounts of organic carbon may be dated. With such a guarantee of more accurate chronological control, studies of the type presented here could be expanded and the precision of the paleogeographic reconstructions could be increased significantly. As noted at the beginning of this chapter, the authors do not presume to argue whether the Trojan War as described in the *Iliad* was a factual or a mythological event. On the other hand, the great interest in the past geography of the Scamander and Simois valleys dictates that geologists and other natural scientists should become more involved in such research.