— *In* : Transformations and evolution of the Mediterranean coastline —

Coastal changes in western Turkey; rapid delta progradation in historical times

by

Helmut BRÜCKNER

Department of Geography, University of Marburg, D-35032 Marburg, Germany.

ABSTRACT

The Mediterranean coast of western Turkey witnessed one of the most extensive seaward shifts in the shoreline recorded in history. Famous ancient harbour cities like Ephesos, Miletos, Kaunos and also Troy are now several kilometres inland. High sediment loads of the rivers – often anthropogenetically induced – led to the silting up of the former sea ports; thus the cities lost one of their major functions. The phases of coastal progradation are deciphered by the interpretation of historical sources and geological evidence. A study of sediments and fauna indicates the milieu of deposition (marine, lagoonal, swampy, terrestrial) while radiocarbon dated material and artifacts provide the chronostratigraphical framework. Geoarchaeological research aims to reconstruct the former landscape and trace the phases of sedimentation in historic and prehistoric times. This paper presents information on the evolution of the deltas of Büyük Menderes (Miletos), Küçük Menderes (Ephesos), Dalyan (Kaunos) and Karamenderes (Troy).

RÉSUMÉ

La côte méditerranéenne de la Turquie témoigne d'un des plus importants déplacements vers la mer de la ligne de rivage connus dans l'histoire. Les anciens ports de célèbres cités telles Ephèse, Milet, Kaunos et Troie se trouvent aujourd'hui à plusieurs kilomètres à l'intérieur des terres. Les sédiments transportés en grande quantité par les fleuves – en raison le plus

souvent de l'activité humaine – ont provoqué l'envasement des anciens ports. Les cités ont alors perdu une de leurs fonctions essentielles. Les phases de cette avancée de la côte ont été déchiffrées en interprétant les sources historiques et les faits géologiques. L'étude des sédiments et de la faune renseigne sur le milieu (marin, lagunaire, marécageux ou terrestre) de déposition; le matériel daté au carbone-14 et les artefacts fournissent le cadre chrono-stratigraphique. La recherche géoarchéologique vise à reconstruire le paysage ancien et à retracer les phases de la sédimentation dans les temps préhistoriques et historiques. Ce chapitre documente l'évolution des deltas de Büyük Menderes (Milet), Küçük Menderes (Ephèse), Dalyan (Kaunos) and Karamenderes (Troie).

INTRODUCTION

In the Mediterranean region, deltas have witnessed the most extensive coastal changes in history. They are the geological memory, storing the sediment produced by onshore erosion and supplied by rivers, documenting the transition from natural to cultural environments. Deltas serve as excellent archives for the effects of different settlement phases, but also of sea level fluctuations, earthquakes and other natural phenomena.

Accelerated progradation due to human influence is known from nearly all of these deltas. Since coastal regions have often served as major settlement sites their growth is well documented. It is only in the last decades that, due to reservoir building and freshwater extraction for irrigation purposes, sediment budgets have become negative, leading to coastal erosion in some places.

The beginning of the evolution of nearly all these deltas is the same: at the maximum of the last glacial epoch, around 18,000 years ago, sea level reached its lowest point, ca. 120 m below that of today; several present-day islands were then connected with the mainland (*e.g.* Samos). From ca. 14,000 BP on, sea level rose at an average speed of 1.5 cm/yr, presumably reaching its present position (or close to it) around 6,000-5,500 BP. This Late Glacial-Holocene transgression caused enormous flooding worldwide (and is possibly the essence of the Atlantis Saga). Along the Aegean coast of Turkey, marine embayments reaching a long way inland were created. In some Mediterranean areas, this furthest inland shoreline is marked by Neolithic sites (*e.g.* in Andalucia, cf. BRÜCKNER and HOFFMANN, 1992). Thereafter, delta evolution in a geomorphological sense was able to start. In the following 5,500 or so years, many of the former marine embayments have silted up, mainly due to fluvial sedimentation but also as a result of some marine sediment input (coastal erosion of headlands and longshore drift).

This study focuses on four deltas of western Turkey, since they are among the best studied ones (Figure 1): those of Büyük Menderes (in antiquity: Maiandros), Küçük Menderes (Kaystros), Dalyan Çayi (Kalbis) and Karamenderes (Scamandros); each of them is well-known because of their famous ancient cities: Miletos, Ephesos, Kaunos and Troy, respectively. Their evolution was not synchronous but is closely connected to different phases of settlement, specific tectonic patterns and, of course, sediment supply.

GEOLOGICAL AND HYDROLOGICAL SETTING

The collision between the African and Eurasian plates led to the formation of horsts and grabens in western Anatolia, *e.g.* the E-W trending grabens of the Big and Little Meander rivers (HÜTTEROTH, 1982). Earthquakes testify that this is an ongoing process; along with wars and fires, they were one of the causes of the destruction of classical sites. An important factor for the sediment budget of the rivers is the outcropping of easily erodible metamorphic and sedimentary rocks. For instance, in the Büyük and Küçük Menderes basins these are Paleozoic mica schists and Neogene marls; both rank among the Turkish rivers with the highest denudation rates in their drainage basins (EGGELING, 1978). Furthermore, in the unstable Mediterranean ecosystem it is well known that even a relatively small human intervention into the natural equilibrium may have catastrophic effects (ROTHER, 1993; BRÜCKNER, 1994).

Figure 1 – Map of western Turkey with the areas of research.

Typical Mediterranean rivers show a seasonal discharge: running (nearly) dry in summer and flooding the coastal plains in winter. Rhythmic sedimentation and delta growth, mainly in winter and spring, are the consequences. Before the building of reservoirs in the hinterland, the Büyük Menderes used to flood parts of its alluvial plain from January until May (PHILIPPSON, 1936). The extended estuaries are closed towards the sea by a complex of lagoons, beach ridges and low dunes. Old river channels, oxbows, deserted levees, swamps and, of course, the meandering rivers are characteristics of the extremely flat flood plains. A topographic map shows in an impressive manner the reason why the "meandering" of a river is derived from the Büyük Menderes (Maiandros) (Figure 2).

Silting up of ports, rising water tables, most probably due to sea-level rise (possibly since the first millennium BC; KAYAN, 1995, Figure 3), swamping of the lowlands, and spreading of malaria has increased since the 3rd/4th century AD. Together with the continuously shifting shoreline, these problems led to the decline of the formerly flourishing port cities.

BÜYÜK MENDERES (MAIANDROS) DELTA

How far inland was the maximum extension of the Holocene transgression? Near Söke, nowadays 30 km inland, a commercial drilling for a water-well showed 63 m thick marine-lagoonal sediments, –70 to –7 m bsl. (below present sea level), covered by alluvial deposits from the Menderes

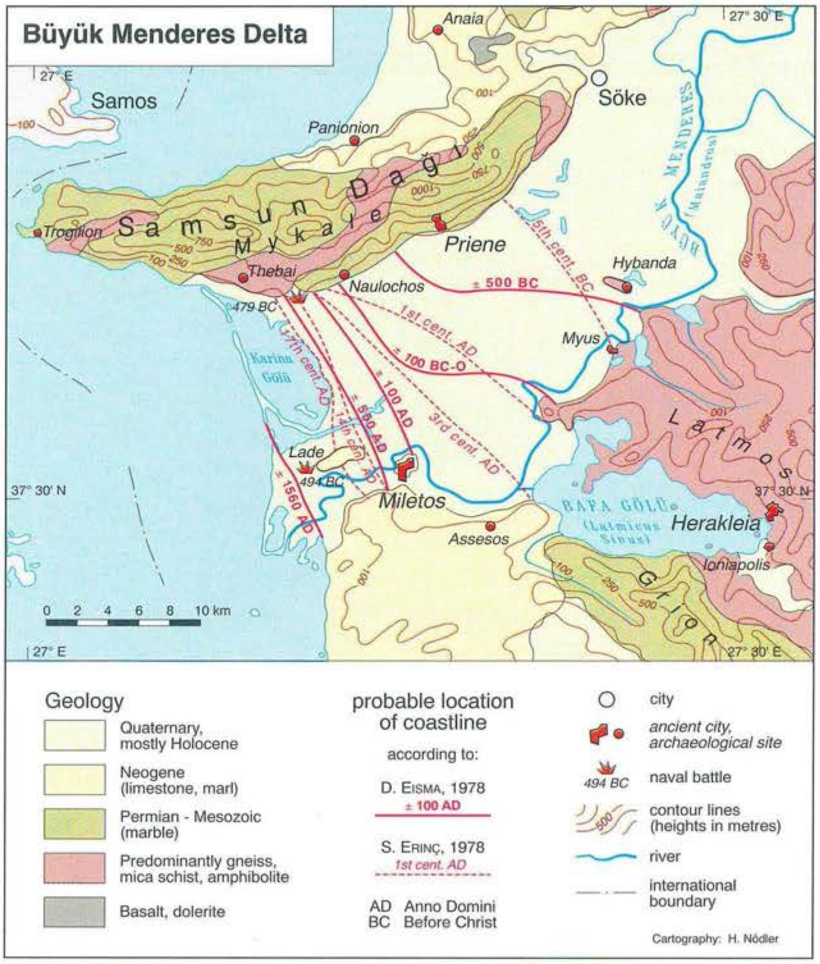

Figure 2 – Progradation of the Büyük Menderes delta in historical times. The scenarios proposed by Eisma (1978) and Erinç (1978) are only based on evidence from the literature. The discrepancies can be solved by geological cores and radiocarbon dates of the sediments.
Sources: Eisma (1978: Fig. 2), Erinç (1978: Fig. 5); supplemented by: Geological map of Turkey, 1:500,000, Sheet Denizli, Ankara 1964 (slightly modified); Stier et al. (1990); letter from H. Lohmann (1996); own research.

(up to +10 m asl.) (BRÜCKNER, 1996). Therefore, the transgression peak must have been considerably further eastward, probably up to Aydın which is now more than 65 km inland (see SCHRÖDER and BAY, 1996).

The subsequent enormous delta growth is shown (a) by the still brackish Bafa Gölü (in modern Greek : Bastarda Thalassa, *i.e* the false sea), the Lake of Herakleia, once a marine embayment in the Latmian Gulf, and (b) by the total integration of the former Island of Lade, site of a naval battle in 494 BC, into the plain.

The Milesian Peninsula with its deeply incised bays was an ideal shelter for ships. According to tradition, the city had four harbours (most famous are the Lions' Harbour and Theatre Bay); all of them have silted up in historic times. Up to the Middle Ages, there was an access to the open sea (KLEINER, 1968). The present coastline is ca. 9 km west of Miletos.

The same fate happened to other cities bordering the former Latmian Gulf (see KLEINER, 1968) : the harbour of Priene had already been shifted westward in the 4th century BC (Strabo, XII.8,17); Myus with an open harbour around 500 BC (Herodot, V.36) from where the stones for the Archaic city wall of Miletos were shipped, had to be given up at the latest in the period of Augustus (Strabo, XIV.1,10; see also Vitruvius, IV.1,4). Herakleia was a flourishing harbour city only in the Hellenistic era; according to PHILIPPSON's (1936) interpretation, the definite transformation of the former Latmian Gulf into a lake occurred in the 4th century AD.

The question of when the delta front reached Miletos is still open : EISMA (1978) comes to the conclusion that the Menderes delta progressed rapidly between 500 BC and 100 AD and slowed down when it reached the city. ERINÇ (1978) reconstructs the delta front in the vicinity of the city definitely after the 3rd century AD. According to PHILIPPSON (1936) the silting up of Miletos took place approximately around the 6th century AD. WIEGAND (1929, quoted by EISMA, 1978) mentions the report of a Greek sailor from ca. 1560 AD, locating the coastline roughly in its present position (except for the youngest delta).

Geological cross-sections generated from our cores showed that at the height of the Holocene transgression the later "Milesian Peninsula" was still an island; boreholes around the Theatre Hill revealed strata, several metres thick, containing marine macro- and microfauna. The same is true for the topographic position of the first settlement, the Minoan-Mycenaean Miletos (inhabited at least since 1700 BC). Due to the lack of C-14 datings, the time of transition from island to peninsula is not yet known.

Harbour sediments are often rich in fossils and artifacts. Our cores in the Lions' Harbour demonstrated (a) a former maximum water depth of ca. 12 m, (b) slow sedimentation between ca. 3,875 and 450 BC, and rapid sedimentation in Hellenistic and especially Roman times. The transition from a marine-lagoonal to a swampy-terrestrial environment probably occurred in Early Byzantine times (5th-7th centuries AD) (BRÜCKNER, 1996).

KÜÇÜK MENDERES (KAYSTROS) DELTA

The extensive progradation of the Küçük Menderes (*i.e.* Little Meander River, in antiquity Kaystros) delta after the maximum of the Holocene transgression around 5,500 BP is shown by (a) the total integration of the former Island of Syrie (Kurudağ or Kuru Tepe, + 84 m asl.) into the plain;

(b) the lakes at the northern flank of the graben, once marine embayments; (c) the ancient harbour city of Ephesos, now lying 7 km inland.

It is not yet known how far the Holocene transgression reached eastward. Our core in the central Menderes valley ca. 3 km NNE of Çiftlik Tepe (Figure 3) shows about 10 m thick fluvial deposits topping more than 20 m of marine stratum (the bottom contact was not reached). It is our assumption that the transgression went at least up to Belevi, now at a distance of 18 km from the sea.

Graeco-Roman times witnessed the expansion of Ephesos. Hosting the Temple of Artemis (the Roman Diana) – one of the Seven Wonders of the World – the capital of the province of Asia Minor with an estimated 2-300,000 inhabitants was amongst the most important cities in the Roman Empire; it had one of the first Christian churches (cf. the apostle Paul's well-known activities here).

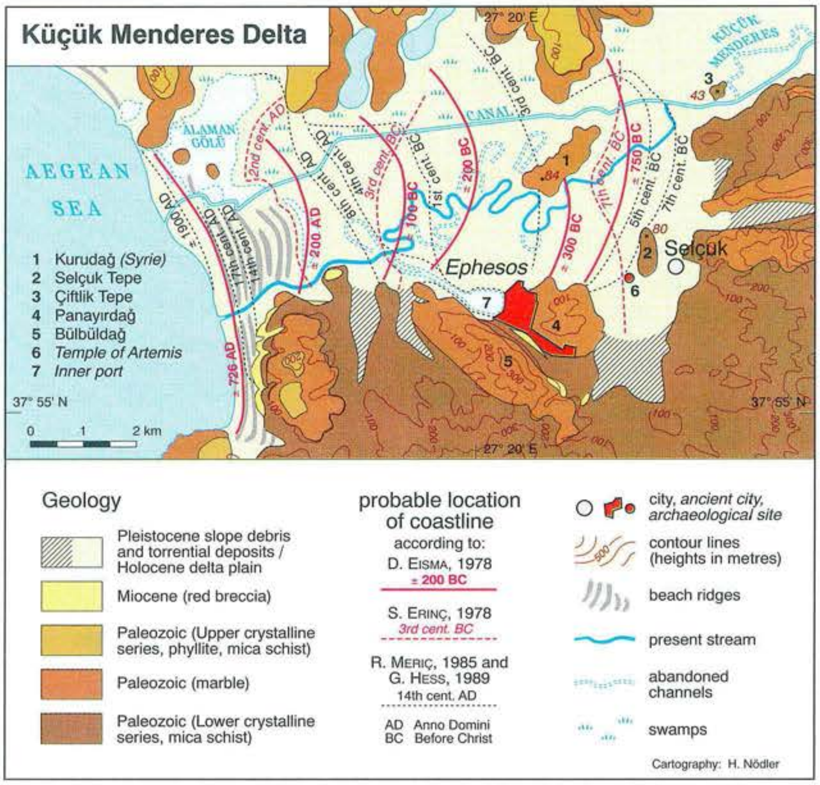

Figure 3 – Progradation of the Küçük Menderes delta in historical times. As in the case of the Büyük Menderes, the scenarios presented – Eisma (1978), Erinç (1978), Meriç (1985) and Hess (1989) – are only based on literary evidence. Geoarchaeological studies are needed to answer the open questions.
Sources: Eisma (1978: Fig. 2), Erinç (1978: Fig. 4), Meriç (1985: Abb. 1, Tafel VI), Hess (1989: Abb. 2); supplemented by: Geological map of Turkey, 1:500,000, Sheet Denizli, Ankara 1964; W. Vetters (1972): Geologische Übersichtskarte der Umgebung von Ephesos-Selçuk; Stuhlmüller (Diploma Thesis, University of Marburg, 1996); own research.

Based on literary evidence, EISMA (1978) developed a scenario for the delta progradation (Figure 3): it progressed slowly in Archaic and Classic times (>1 km, 750-300 BC, reaching the former Island of Syrie), then strongly in Hellenistic times (5 km, 300-100 BC); in Roman times the speed decreased (2 km, 100 BC-200 AD) and since ca. 700 AD the coast has remained stationary. The latest modification is due to the building of a canal in 1934-1935. The longshore drift has taken over so that the delta has no outreach into the Aegean Sea (unlike the Büyük Menderes where the longshore drift is barred off by Samos and Samsun Dağı; see Figure 2).

The strange assumption of a relatively stable coastline since ca. 700 AD is based on EISMA's wrong attribution of a pumice find within the penultimate beach ridge to the Santorini eruption of 726 AD. MERIÇ (1985), on the contrary, argued that during the 14th century Alaman Gölü served as a harbour and the coastline did not take this position until 1329 AD. Moreover, pumice may also be found along the present Aegean coasts.

In ERINÇ's (1978) interpretation of ancient sources, Syrie and the Artemision site were reached by the delta during the 7th century BC; the delta front occupied the outer port position during early Hellenistic times; in the following 500 or so years it only advanced 1.5-2.5 km (Figure 3).

Based on A. Bammer's excavations, KARWIESE (1995) mentions the first evidence of buildings in the Artemision area from the late 9th century BC. BAMMER (1994) even assumes the lowest level to be Mycenaean. In any case, part of that area must have been dry land for the erection of a building since at least the late 9th century BC.

Ancient sources write about the incorporation of Syrie as a part of the flood plain during the 3rd century BC. Around 100 BC, Strabo (XVI.1,24) describes an attempt to save the harbour of Ephesos by building a dam and a pipe-like connection to the sea. The "inner port" (Figure 3) was still in operation until Late Antiquity (5th-7th centuries AD), connected with the sea by a canal. Thereafter, an "outer port" was needed (Panormos), and since the 14th century AD a second one (Alaman Gölü) (cf. MERIÇ, 1985; HESS, 1989).

Our own cores in a transect from Panayırdağ to Syrie (ca. 1.3 km west of the Artemision) show slope debris on top of the bedrock in the valley bottom. In the central part of this transect, the marine sediments start at a depth of about –30 m bsl. Late Pleistocene transgression facies (gravel, sand) documents the first beach transition. The subsequent sedimentation rate is very slow. Then the advancing delta front during the course of regression causes a high sedimentation which creates thick foreset beds (grey micaceous silt). The second beach transition is followed by the deposition of topset beds. In this transect they consist of lagoonal facies (4-8 m thick clay) and Menderes alluvium. The latter starts at about –1 m bsl. and is ca. 4 m thick.

To solve the question of the shoreline shifts, it is essential to date the transition between marine-lagoonal and lagoonal-terrestrial facies. In our transect this second beach transition occurred 353-220 BC near Panayırdağ and 111-32 BC in the central part (BRÜCKNER, 1997): the siltation started at the southern mountain in the early Hellenistic period when the Marnas (Derbent), a southern affluent of Küçük Menderes, developed its delta there. At that time the central part was still navigable, closing up only 200 years later, in early Roman times.

A comparison of these C-14 results with the scenarios presented in Figure 3 reveals that ERINC's reconstruction cannot be right, whereas EISMA's may be accepted for the part close to the mountain, but not, however, for the central part.

All of this shows that reconstructing shorelines is a very complex task; all the more so if the coastal region consists of lagoons, swamps and barrier beaches and the shoreline is not clearly defined. A lot of research has still to be done.

DALYAN (KALBIS) DELTA

The evolution of the Dalyan delta has only been recently researched by RIEDEL (1995, 1996). His scenario is based on the interpretation of 77 cores up to an average depth of nine metres; fifteen C-14 dated peat samples provide the chronological framework, molluscs reveal the milieu of sediment deposition, and ceramic fragments show the evidence of the different cultural epochs. The following summary is based on RIEDEL's (1995, 1996, pers. communication) studies (Figure 4).

The Dalyan River, which flows out of Köycegiz Lake, an ideal sediment trap, cannot have silted up the former marine embayment. The major contributor was the Dalaman River, running down from the Taurus Mountains, which progressively pushed the delta front seaward. A gravel line still indicates its former influence. The Dalaman is now buiding up its own delta east of the Dalyan plain.

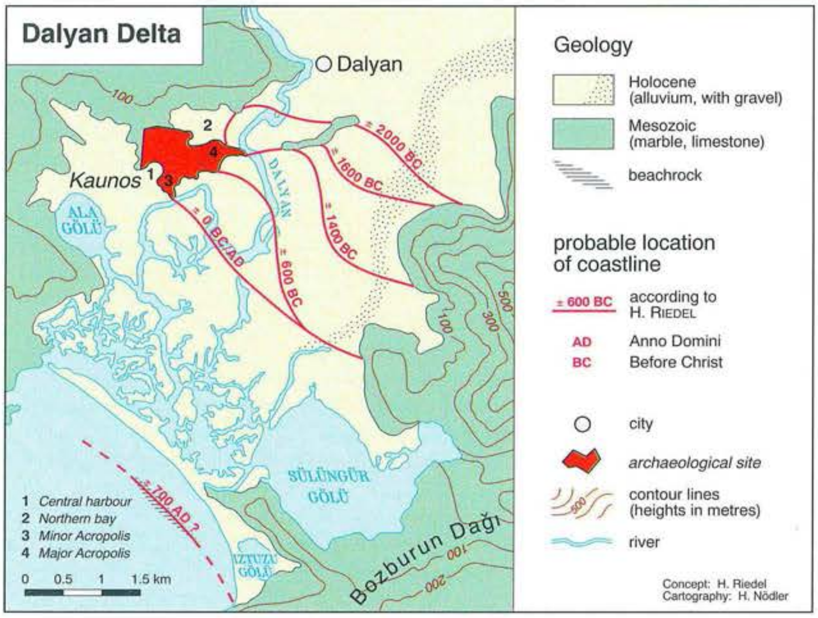

Figure 4 – Progradation of the Dalyan delta in historical times.
Sources: RIEDEL (1995, 1996, oral communication); supplemented by: Geological map of Turkey, 1:500,000, Sheet Denizli, Ankara 1964 (slightly modified); dates are based on corrected and calibrated radiocarbon years.

The oldest verifiable coastline dates from ca. 2,000 BC. This is based on a radiocarbon-dated peat formation north of it, lying six metres below present sea level. At that time Köycegiz Gölü was already in existence and even the so-called Northern Bay had been filled with sediments (RIEDEL, 1996).

In the course of the following millennium, the main alluviation occurred in the eastern part of the marine embayment. Around 500 BC, the drainage regime shifted westward so that the city of Kaunos witnessed major coastal changes during Graeco-Roman times. The central harbour of Kaunos is now three kilometres inland. By the beginning of the Christian era the south-eastern part of the city had lost its connection to the open sea. Considerable delta growth seems to have occurred, especially during the first half of the first millennium AD. The high sediment load of the Dalaman may have been the result of increased erosion in the Taurus.

An offshore beachrock represents a former coastal spit (Figure 4). Its age is unknown. There are only indirect arguments for its formation around 700 AD. If that is correct, the subsequent transgression may be explained by (a) the generally rising sea level since then, and (b) the lack of sediment supply due to a changed drainage: the western arm of the Dalaman River had shifted eastwards, turning the deposition budget negative. The rising water table caused the growth of coastal swamps and a new barrier spit further inland.

KARAMENDERES (SCAMANDROS) DELTA

Troy (Troia) is one of the most legendary archaeological sites, due to Homer's Iliad, the epos of the "Trojan War", and due to Heinrich Schliemann's excavations between 1871 and 1890. The city rises over the flood plain of Karamenderes, the ancient Scamandros or Scamander. Geoarchaeological research has been carried out for many years by I. Kayan. The scenario of the flood-plain progradation in Figure 5 is taken from his publication in 1995.

The situation of Troy is different from that of the other cities described above in that Troy was only a harbour city in the early Bronze age. However, even in the succeeding centuries, Troy controlled navigation to and from the Black Sea via the Dardanelles. With quite frequent northern winds in the eastern Mediterranean, ships had to anchor in Beşik Bay when winds were unfavourable since they were unable to sail to windward. It was then that Troy could collect taxes.

KAYAN's (1995) scenario is based on roughly 200 cores in the flood plain. Earlier work (KRAFT *et al.,* 1980) had proven the Holocene transgression peak to be at least north of Pınarbaşı, if not even further south. If Kayan's reconstruction is correct, then Troia I and II (2920-2450 BC) were still situated by the sea. During the settlement phases of Troia III to VII (2390-1020 BC), the delta advanced from the 3000-2500 BC position to the one at 1000-500 BC. (The so-called "Trojan War", probably Homer's legendary condensation of several wars around Troy, is traditionally placed in the 13th century BC.; destruction of Troia VI ?) During Troia VIII (Greek Troy = Ilion, 800-85 BC) and Troia IX (Roman Troy = Ilium, 85 BC-500 AD) the shift in the shoreline continued until today over about 3 km (see also KRAFT *et al.*, 1980; KORFMANN, 1993; KORFMANN and KROMER, 1993). For even higher resolution more cores and C-14 dates need to be acquired.

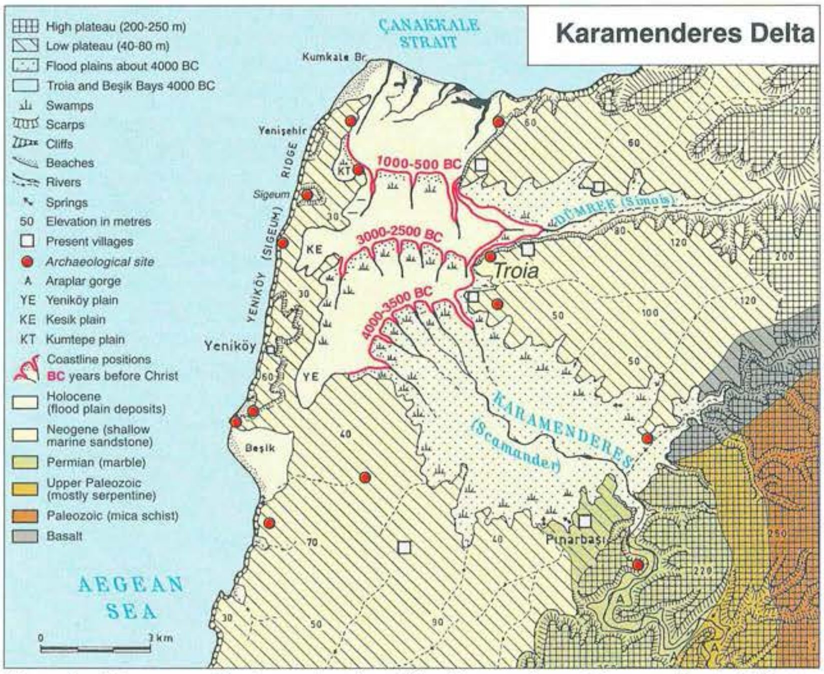

Figure 5 – Paleogeographical reconstruction of the Karamenderes plain according to I. KAYAN (1995: Fig. 8; slightly modified).
Supplemented by: Geological Map of Turkey, 1:500,000, Sheets Izmir and Istanbul, Ankara (1964); International Geological Map of Europe and the Mediterranean Regions, 1:1,500,000, Sheet E6 Ankara, Hannover (1995); I. KAYAN (1996), pers. comm.; dates are based on corrected and calibrated radiocarbon years.

CONCLUSION

A major topic of geoarchaeological research is to reconstruct the paleolandscape, especially the phases of delta growth in historical times. Different scenarios are presented here for the areas around the ancient cities of Miletos, Ephesos, Kaunos and Troy. It is important to note that the scenarios for Büyük and Küçük Menderes (Figures 2 and 3) are based on literary evidence alone; those for Dalyan and Karamenderes (Figures 4 and 5), however, are based on geological cores and C-14 dates. Therefore, they are not directly comparable. Many discrepancies must still be settled. More cores will have to be taken, investigated and dated to create an unambiguous chronostratigraphy of the events.

ACKNOWLEDGEMENTS

This paper is a contribution to the UNESCO IGCP (International Geological Correlation Program), Project n° 367: Late Quaternary Coastal Records of Rapid Change. Application to Present and Future Conditions (Rapid Coastal Changes). I express my thanks to Prof. Dr. I. Kayan (Izmir) and Dr. H. Riedel (Marburg) for allowing me to use their maps. Thanks are also due to Dr. A.C. Hinton (Leeds, UK) for smoothing my English.

REFERENCES

BAMMER A., 1994. — Geschichte-neu geschrieben: Mykene im Artemision von Ephesos. — *Jahreshefte des Österreichischen Archäologischen Instituts*, **63**: 30-39.

BRÜCKNER H., 1986. — Man's Impact on the Evolution of the Physical Environment in the Mediterranean Region in Historical Times. — *GeoJournal*, **13**, 1: 7-17.

BRÜCKNER H., 1994. — Das Mittelmeergebiet als Naturraum. — *In*: Das Alte Rom., J. Martin ed., C. Bertelsmann, Gütersloh, München, 454 p.

BRÜCKNER H., 1995. — Geomorphologie und Paläo-Environment der Milesia. — *Archäologischer Anzeiger*, **1995**: 329-330.

BRÜCKNER H., 1996. — Geoarchäologie an der türkischen Ägäisküste-Landschaftswandel im Spiegel geologischer und archäologischer Zeugnisse. — *Geographische Rundschau*, Jg. **48**, 10/1996: 568-574.

BRÜCKNER H., 1997. — Geoarchäologische Forschungen in der Westtürkei - das Beispiel Ephesos. — *Passauer Schriften zur Geographie (Rother-Festschrift), in press.*

BRÜCKNER H. and HOFFMANN G., 1992. — Human-induced erosion processes in Mediterranean countries. Evidences from archeology, pedology and geology. — *Geoöko-Plus*, **3**: 97-110.

EGGELING W.J., 1978. — Türkei. Land, Volk, Wirtschaft in Stichworten. — Wien; Verlag Ferdinand Hirt, 163 p.

EISMA D., 1978. — Stream deposition and Erosion by the Eastern shore of the Aegean. — *In:* The Environmental History of the Near and Middle East since the last ice age., W.C. Brice ed., Academic Press, London, New York, San Francisco, 384 p.

ERINÇ S., 1978. — Changes in the physical environment in Turkey since the end of the last glacial. — *In:* The Environmental History of the Near and Middle East since the last ice age., W.C. Brice ed., Academic Press, London, New York, San Francisco, 384 p.

GRAEVE V. v. *et al.*, 1995. — Milet, 1992-1993. — *Archäologischer Anzeiger*, **1995**: 195-292.

HESS G., 1989. — Die Entwicklung des Küçük-Menderes-Deltas in historischer Zeit. — *Essener Geographische Arbeiten*, **17**: 203-215.

HÜTTEROTH W.-D., 1982. — Türkei. — Darmstadt, Wissenschaftliche Buchgesellschaft, 548 p.

KARWIESE St., 1995. — Groß ist die Artemis von Ephesos. Die Geschichte einer der großen Städte der Antike. — Wien, Phoibos Verlag, 204 p.

KAYAN I., 1995. — The Troia Bay and supposed harbour sites in the Bronze age. — *Studia Troica*, **5**: 211-235.

KLEINER G., 1968. — Die Ruinen von Milet. — Berlin, Walter de Gruyter & Co., 164 p.

KORFMANN M., 1993. — Troia. — *In:* Türkei. Baedeker Allianz Reiseführer., Baedeker ed., Verlag Karl Baedeker, Ostfildern/Stuttgart, 608 p.

KORFMANN M. and KROMER B., 1993. — Demircihüyük, Besik-Tepe, Troia; eine Zwischenbilanz zur Chronologie dreier Orte in Westanatolien. — *Studia Troica*, **3** : 135-171.

KRAFT J.C., KAYAN I. and EROL O., 1980. — Geomorphic reconstructions in the environs of ancient Troy. — *Science*, **209** : 776-782.

LOHMANN H., 1995. — Survey in der Chora von Milet. — *Archäologischer Anzeiger*, **1995** : 293-328.

MERIÇ R., 1985. — Zur Lage des ephesischen Außenhafens Panormos. — *In* : Lebendige Altertumswissenschaft. Festschrift für Hermann Vetters., Wien, Verlag Adolf Holzhausens NFg., 430 p.

PHILIPPSON A., 1936 — Das südliche Jonien. — *In* : Milet. Vol. III, 5, Th. Wiegand ed., Berlin, Leipzig, Walter de Gruyter & Co., 34 p.

RIEDEL H., 1995. — Die spätholozäne Entwicklung des Dalyan-Deltas (SW-Türkei); ein Beitrag zur Paläogeographie Kariens. — *Kölner Geographische Arbeiten*, **66** : 83-96.

RIEDEL H., 1996. — Die holozäne Entwicklung des Dalyan-Deltas (Südwest-Türkei). — *Marburger Geographische Schriften*, **130** : 1-216.

ROTHER K., 1993. — Der Mittelmeerraum. — Stuttgart, B.G. Teubner, 212 p.

SCHRÖDER B. and BAY B., 1996. — Late Holocene rapid coastal change in western Anatolia. Büyük Menderes plain as a case study. — *Zeitschrift für Geomorphologie, N.F.*, Suppl.-Bd. **102** : 61-70.

STIER H.-E., KIRSTEN E., WÜHR W., QUIRIN H., TRILLMICH W., CZYBULKA G., PINNOW H. and EBELING H. eds., 1990. — Der große Atlas zur Weltgeschichte. — Westermann Schulbuchverlag, Sonderausgabe Orbis Verlag, Braunschweig, 248 p.