A Geologic Analysis of Ancient Landscapes and the Harbors of Ephesus and the Artemision in Anatolia

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John C. KRAFT – İlhan KAYAN – Helmut BRÜCKNER – George (Rip) RAPP, Jr.

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INHALT

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A GEOLOGIC ANALYSIS OF ANCIENT LANDSCAPES AND THE HARBORS OF EPHESUS AND THE ARTEMISION IN ANATOLIA

Summary

A more precise understanding of ancient geographies of the harbors of Ephesus and the Artemision is attained by a careful integration of clues from the written record with sedimentologic facies studies. We can use comments from antiquity to improve upon coastal environmental delineations of antiquity. For instance, Archestratus of Gela, in early Hellenistic time, speaks of the (fat) fish in the brackish Selinus River near the Artemision. Sedimentologic studies show a low-lying prograding deltaic shoreline near the Artemision at that time. Thus, the estuarine mouth of the Selinus River was probably nearby. Livy (37, 14 ff.) comments on the mouth of the Great Harbor of Ephesus during a siege by the Roman, Pergamene, and Rhodian fleet (190 BC): »... the mouth of the harbor was like a river long, narrow and full of shoals«. Similarly, Strabo, writing in the time of Tiberius notes a destructive harbor engineering »improvement« attempt by Attalus II Philadelphus, who built a mole to narrow the harbor mouth in order to prevent siltation, while in fact creating a sediment trap which further diminished the usefulness of the harbor (perhaps the most frequently quoted negative environmental impact action by peoples of antiquity). Hadrian undertook a diversion of the Cayster River (Manthites River?) to prevent further damage (sedimentation) »in the harbors of the city«. These and many other comments on harbor dredging, infill, expansion, and relocation throughout the long history of Ephesus tell us much about coastal and harbor evolution at Ephesus over one and a half millennia.

Geologic mapping of sedimentary sequences in the lower Cayster (Küçük Menderes) River and floodplain allows relatively precise delineation of the shoreline and harbor features of ancient Ephesus. With reflections upon Androclus of Ionian times and from Archaic time (600 BC) to Byzantine/Selçuk times, we show a continuing adaptation of urban systems of ancient Ephesus to an ever changing landscape. During Hellenistic and early Roman (senate) time, marine waters still lapped against the northeastern flank of Mount Pion and close to the Artemision at the base of Ayasuluk hill to the east. By then, however, the prograding delta began to bypass the north flank of Mount Pion requiring that the Sacred Harbor for the Artemision be continuously displaced westward. We show that the lower Hellenistic, Roman, and Byzantine city of Ephesus was built seaward (west) of the Archaic, Classical and early Hellenistic shoreline which lay close to the base of Mounts Pion (Panayırdağ) and Preon (Bülbüldağ). The longer term destruction of the harbor of Ephesus throughout the first millennium AD, was accompanied by anoxic silting and continuous dredging of the harbor and its ever lengthening channel to the sea, while alternate more seasonal harbors were occupied into the fifteenth century AD.

Apart from the abbreviations listed in AA 1997, 612 ff. and those according to the editors of this volume the following abbreviations are employed:

Kraft et al. 1975 = J. C. Kraft – G. Rapp, Jr. – S. Aschenbrenner, Late Holocene Paleogeography of the Coastal Plain of Messenia, Greece, and its Relationships to Archaeological Settings and Coastal Change, Bulletin of the Geological Society of America 86, 1975, 1191–1208.

Kraft et al. 1977 = J. C. Kraft – S. Aschenbrenner – G. Rapp, Jr., Paleogeographic Reconstructions of Coastal Aegean Archaeological Sites, Science 195, 1977, 941–947.

Kraft – Aschenbrenner 1977 = J. C. Kraft – S. E. Aschenbrenner, Paleogeographic Projections in the Methoni Embayment in Greece, JFieldA 4, 1977, 19–44.

Kraft et al. 1982 = J. C. Kraft – İ. Kayan – O. Erol, Geology and Paleogeographic Reconstructions of the Vicinity of Troy, in: G. Rapp, Jr. – J. A. Gifford (eds.), Troy. The Archaeological Geology (1982) 11–41.

Kraft et al. 1987 = J. C. Kraft – G. Rapp, Jr. – G. J. Szemler – C. Tziavos – E. W. Kase, The Pass at Thermopylae, Greece, JFieldA 14, 1987, 181–198.

Kraft – Rapp 1988 = J. C. Kraft – G. Rapp, Jr., Geological Reconstructions of Ancient Coastal Landforms in Greece with Predictions of Future Coastal Changes, in: P. G. Marinos – G. C. Koukis (eds.), Proceedings of an International Symposium on the Engineering Geology of Ancient Works, Monuments, and Historical Sites III (1988) 1545–1556.

Kayan 1996 = İ. Kayan, Holocene Coastal Development and Archaeology in Turkey, Zeitschrift für Geomorphologie N. F. Suppl. 102, 1996, 37–59.

Introduction

The primary goal of this research is to reconstruct the various morphologies of coastal sedimentary environments of deposition as they varied over several millennia of peoples occupying of the environs of Ephesus and the Artemision. We need to rethink the nature of people's occupancy and resultant environmental impacts to this example of long term adaptations to life in an ever changing coastal zone in antiquity. Coastal areas have always hosted a large percentage of the world's population, its major cities, and its commerce. The Aegean coasts of Turkey in the first millennium BC and first millennium AD were important loci of the cultural and economic evolution of the western world. Many of its great cities were located on marine embayments that provided nearly ideal geographic conditions for life and maritime commerce. However, such embayments are ephemeral features of the dynamic landscapes of the mid-late Holocene.

We have been involved for sometime, individually and in partnerships[1] in detailing the impact that geomorphic processes have had on the birth, growth, and demise of early Aegean urban areas. Herodotus, Strabo, Pausanias, Livy, and others noted shoreline changes but had no context for analyzing them. Our interdisciplinary concepts and methodologies are illustrated in a number of research projects involving prograding delta-floodplains in Messenia, at Thermopylae, and at Troy[2]. We rely on a number of geologic concepts and methodologies to investigate geomorphic change along active coasts. The initial phase of a paleogeomorphic reconstruction relies on detailed field geomorphology to ascertain the broad scheme of landscape evolution. This is frequently aided by knowledge of the stratigraphic position of dated archaeological structures or horizons and first-hand reports from ancient texts. However, in nearly three decades of work we have found that intensive core drilling with detailed analysis of the sedimentary record is necessary to provide an adequate picture of the sequence of coastal environments and their associated chronologies (i. e., a geologic history of environmental or geomorphologic changes over time).

In coastal areas three geologic processes combine to drive geomorphic change. Eustatic and relative sea level changes have an immediate impact on the coastal zone. Vertical (up or down) tectonic movements offset or augment the impact of eustatic sea level rise or fall. Finally, erosion and deposition cause transgressional or regressional migration of the shoreline. These processes leave a record in the local sediments; hence our research methodology leans heavily on geologic

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Brückner 1997a = H. Brückner, Geoarchäologische Forschungen in der Westtürkei – das Beispiel Ephesos, in: T. Breuer (ed.), Geographische Forschungen im Mittelmeerraum und in der Neuen Welt, Passauer Schriften zur Geographie 15, 1997, 39–51.

Brückner 1997b = H. Brückner, Coastal Changes in western Turkey. Rapid delta progradation in historical times, in: F. Briand – A. Maldonado (eds.), Transformations and Evolution of the Mediterranean Coastline, CIESM Sciences Series 3, Bulletin de l'Institut Oceanographique spécial 18, 1997, 63–74.

[1] Kraft et al. 1975; Kraft et al. 1977; Kraft – Aschenbrenner 1977; J. C. Kraft – S. Aschenbrenner – G. Rapp, Jr., Late Holocene Paleo-geographic Reconstructions in the Area of the Bay of Navarino: Sandy Pylos, Journal of Archaeological Science 7, 1980, 187–210; Kraft et al. 1982; J. C. Kraft – İ. Kayan – S. E. Aschenbrenner, Geological Studies of Coastal Change applied to Archaeological Settings, in: G. Rapp – J. Gifford (eds.), Archaeological Geology (1985) 57–84; Kraft et al. 1987; Kraft – Rapp 1988; İ. Kayan, Holocene Geomorphic Evolution of the Beşik Plain and Changing Environment of Ancient Man, Studia Troica 1, 1991, 71–92; idem, The Troia Bay and Supposed Harbour Sites in the Bronze Age, Studia Troica 5, 1995, 211–235; idem, Holocene Stratigraphy of the Lower Karamenderes-Dümrek Plain and Archaeological Debris in the Alluvial Sediments to the North of the Troia Ridge, Studia Troica 6, 1996, 1–11; Kayan 1996; İ. Kayan, Geomorphological Evolution of the Çiplak Valley and Archaeological Material in the Alluvial Sediments to the South of the Lower city of Troia, Studia Troica 7, 1997, 489–507; Brückner 1997a; Brückner 1997b; H. Brückner, Coastal Research and geoarchaeology in the Mediterranean region, in: D. H. Kelletat (ed.), German geographical coastal research – The last decade (1998) 235–258; G. Rapp, Jr. – J. C. Kraft, Holocene Coastal Changes in Greece and Aegean Turkey, in: P. Nick Kardulias (ed.), Beyond the Site: Regional Studies in the Aegean Area (1994) 69–90.

[2] Kraft et al. 1975; Kraft et al. 1982; Kraft et al. 1987.

core drilling and extensive analysis of the core sediments[3]. Microfaunal and microfloral remains in the sediments record environmental parameters such as salinity, water depth, and even pollution.

Our studies of the embayments in Greece and Aegean Turkey have shown that each embayment has its own local relative sea-level curve[4]. This can be expected from the fact that these embayments are nearly always tectonic basins. D. F. Belknap and J. C. Kraft[5] demonstrated the influence of the antecedent geology on the stratigraphic preservation potential of Holocene marine transgression as well as the later infill of the embayments by alluvial and deltaic sedimentation. Our work draws heavily on Walther's Law of the Correlation of Facies, which provides a means of interpreting environmental changes. According to Walther's Law, only those sedimentary facies that occur in laterally adjacent environments of deposition can occur in conformable vertical sequence[6]. This provides a powerful conceptual tool that enables us to use three-dimensional stratigraphic sequences in the reconstruction of ancient (sedimentary) landscapes through time and space. This concept is particularly useful in shoreline studies.

Another final aspect of our research that should be noted is our efforts to identify the major impacts of human land use. The progradation and aggradation of the delta floodplains of many rivers that empty into the Aegean Sea apparently began about five thousand years ago[7]. This may reflect a major deforestation event with the coming of intensive agriculture in the uplands. We believe we can record the impact of cycles of coastal erosion and deposition on the harbor works from the Bronze Age to Byzantine times at ancient Ephesus. Finally, our intensive analyses of the late Holocene sedimentary environments of deposition, allied with the evidences of archaeology and history, allow for refinement of the ancient geographies of Ephesus and the Artemision as compared with the pioneering works of D. Eisma and S. Erinç[8].

The Geologic Setting

Regional Geology

The western coast of Anatolia is tectonically active, a partial result of the collision between the African and European crustal plates. Neogene and Quaternary tectonics have resulted in major horsts, (Bülbüldağ, Ayasuluk, and Korudağ) and grabens (Küçük Menderes valley)[9]. The Menderes Massif is a crystalline complex of metamorphic rocks, basically Paleozoic gneiss and granite-mica schist and Upper Paleozoic and Lower Mesozoic phyllite, quartzite, and marble. By Miocene (Neogene) time freshwater sediments – conglomerate, marly limestone, sandstone, and clay were deposited throughout the region. With the Neogene/Pleistocene uplift, a great amount of erosional modification and denudation has occurred. The mountainous horsts to the north of the Küçük Menderes plain are comprised chiefly of marble frequently overlain by a carbon/phyllite

[3] J. C. Kraft, Sedimentary Facies Patterns and Geologic History of a Holocene Marine Transgression, Bulletin of the Geological Society of America 82, 1971, 2131–2158.

[4] Kraft – Rapp 1988.

[5] D. F. Belknap – J. C. Kraft, Influence of Antecedent Geology on Stratigraphic Preservation Potential and Evolution of Delaware's Barrier Systems, Marine Geology 63, 1985, 235–262.

[6] G. Middleton, Johannes Walther's law of the correlation of facies, Bulletin of the Geological Society of America 84, 1973, 979–987.

[7] Kraft et al. 1977.

[8] D. Eisma, Stream Deposition and Erosion by the Eastern Shore of the Aegean, in: W. C. Brice (ed.), The Environmental History of the Near and Middle East since the last Ice Age (1978) 66–81; S. Erinç, Changes in the Physical Environment in Turkey since the End of the Last Glacial, in: op. cit. 87–110.

[9] Kayan 1996; İ. Kayan, Geomorphological Outlines of Turkey, in: Ş. Demirci – A. M. Özert – G. D. Summers (eds.), Archaeometry 94. Proceedings of the 29th International Symposium on Archaeometry, Ankara Tübitak (1996) 365–374; Brückner 1997a; Brückner 1997b.

and limestone/mica schist. The mid-graben horst (small hill) – Korudağ (ancient Syrie) consists of Mesozoic marble as in the flanking mountains of the ancient city of Ephesus: Bülbüldağ (Preon) and Panayırdağ (Pion). The remainder of the southern horst region of the area around the city of Selçuk is dominated by muscovite schist.

Late Neogene/Quaternary incision (erosion) of the region led to a deeply incised paleo-valley (up to 30 m deep below present sea level in the vicinity of Ephesus/Selçuk) with numerous northerly and southerly trending tributary streams. The region is tectonically active, and a number of earthquakes throughout the last two and one half millennia have played an important role in affecting inhabitants and their structures in the region. During the last glacial maximum (ca. 18 000 years BP) marine regression and therefore sea level lay west of the present floodplain area, between 120–130 m below present sea level. Adjacent islands such as Samos were at that time connected to the mainland. Since then, sea level has risen continually, although possibly with a number of disruptions or reversals, to its present sea level approximately 5 000 to 6 000 years BP. At that time we encounter marine sediments of the Holocene Epoch transgression greater than 30 m deep in the vicinity of ancient Ephesus.

Sedimentary Facies and Environments of Deposition

In this paper, we strive to delineate specific paleogeographies of the region surrounding ancient Ephesus over the past three millennia. To do this, we have integrated a study of surficial geomorphology of the Küçük Menderes (ancient Cayster River) floodplain and its adjacent tributaries as related to the flanking mountains. To us, a sedimentary environment of deposition is both a geomorphologic feature and a stratigraphic unit including the record of deposition in many varied sedimentary environments over times past. Thus, floodplains, backswamps, lakes, marshes, lagoons, barrier accretion plains, talus slopes, alluvial fans, and other such features are the surficial expression of sedimentary environments of deposition. The sedimentary units are in turn characterized by the varied types of sediments included such as sand, silt, clay, gravel, talus (rock debris) and their enclosed organic remains. Floral elements of importance include wood and plant fragments such as marsh grasses and microforms such as charophytes as well as spores and pollen. Faunal elements of importance in this type of study include enclosed mollusc, arthropod, foraminifer and ostracode remains. The various sources of sediment will determine the mineralogy of the sediment components. The shells of molluscs and the microforms – *foraminifera* and *ostracoda* – can help us to determine with precision the sedimentary environment of deposition, such as the relative salinities of water and in some cases the depth of waters. However, although these include environmentally sensitive organisms, they cannot be used to differentiate precise depths of shallow marine waters in terms of meters or fractions of meters.

Figure 1 (see p. 201 ff.) shows physiographic elements of the Küçük Menderes (Cayster River) floodplain as determined from geologic field studies and photogrammetric analyses. These elements of the floodplain and coastal zones are surficial expressions of internal sedimentary environmental lithosomes. Each lithosome is a three-dimensional body representing a particular environment of deposition. If we can analyze and understand the three dimensional distribution of sedimentary environmental lithosomes and their lateral and vertical correlation as well as the date or time of deposition, we can precisely delineate ancient geomorphologies of the study area. The many drill cores that we have taken in the immediate environs of the ancient city of Ephesus and the Artemision, provide the three dimensional control and information on identification of the sedimentary environments of deposition and their resultant three dimensional lithosomes (fig. 2).

Radiocarbon 14 dating is an important requisite of a study of this type. We have accumulated over three dozen radiocarbon dates in our research to date. These radiocarbon dates allow us to define and time areal distribution of sedimentary (and geomorphologic) environments of deposition. In addition, they allow us to determine relative sea levels in relation to these environments.

Figure 3 is a eustatic sea level curve established by İ. Kayan[10] mainly from his studies in the vicinity of Troy by the Dardanelles but also includes a composite of information of other areas along the western coast of Anatolia. This 'sea level curve' shows that sea level rose to its present level about 5 000 to 6 000 years BP in the vicinity of Ephesus. Sea level later dropped to about –2 m 3 000 to 3 500 years BP and since then has again slowly risen to its present position. A more precise definition of our sedimentologic studies and the detailed geologic analyses of sediments encountered in the borings shown in figure 2, are presented elsewhere[11].

The Nature of Evidence: Caveats

This paper is an attempt to reconstruct past geomorphologies of the seaways, harbors, coastlines, and delta-floodplains that have surrounded ancient Ephesus and the Artemision. To do this we must be able to identify correctly the sedimentary environments of deposition, and therefore the geologic, geomorphic, and environmental elements in which those sediments were deposited. Lateral and vertical sedimentary facies correlations are critical in such an analysis. A number of empirical methodologies are involved in scientific studies of these types. The guiding principles follow the dictates of Walther's Law of the Correlation of Facies.

Radiocarbon dates are critical. Our radiocarbon (C-14) dates are all corrected with standard dendrochronologic methods as well as a carbon reservoir correction where appropriate[12]. The application of all of these corrections is critical in resolving differences between radiocarbon dates from organic (woody) materials as differentiated from the $CaCO_3$ remains of molluscs and other organisms. Consistent with such practice, our dates shown have a 1 sigma error range within the 67% confidence level and a simple (sometimes 2 or 3) calculated intercept date which we have used in our map delineations. Thus, a 166 (89) 9 BC date of a *Cerastoderma edule* shell encountered near the top of the marine sediments under the 'Feigengarten excavation' shows that the latest 3 m deep marine waters in this area close to the talus slope at the foot of Mount Pion were there in 89 BC; but, the dated marine molluscs could have lived as early as 166 BC or as late as 9 BC (or indeed between 233 BC to AD 63 if one considers the two sigma range with a 95% confidence level). Herein lies the nature of (and problems that arise in) the usage of C-14 dates. Marine carbonates are reservoir corrected 406 years as determined from measurements in the Bafa/Miletus area to the south. We note with much encouragement that once the marine reservoir correction is made for all $CaCO_3$ marine fossils, their dates correlated well with other C-14 dates of plant materials from the same strata. Failure to use these corrections would place our paleogeographies into an incorrect time frame in light of the interests of the classicists and archaeologists.

We also use the archaeological evidence. For instance, a site excavated is 'absolute' in its ancient geographic position. However, the same is not necessarily true of artifacts encountered within the sediment. In many cases we can tell that pottery sherds have been 'rolled' and therefore

[10] İ. Kayan, Late Holocene Sea-level Change on the Western Anatolian Coast. Paleogeography, Paleoclimatology, Paleoecology 68, 1988, 205–218; idem, Bronze Age Regression and Change of Sedimentation on the Aegean Coastal Plains of Anatolia (Turkey), in: H. N. Dalfes – G. Kukla – H. Weiss (eds.), Third Millennium BC Climate Change and Old World Collapse, NATO ASI Series (1997) 431–450.

[11] P. Stuhlmüller, Holozäne Sedimentation im Tal des Kaystros (Küçük Menderes). Ein Beitrag zur Paläogeographie der Ephesia (Türkei) (ungedr. Mag. Marburg 1996); H. Brückner – W. W. Jungmann, Geologische Sondierungen – Kurzbericht 1995, ÖJh 65, 1996, Grabungen 1995, 20–21; H. Brückner, Ephesos 1996 – Geologische Sondierungen, ÖJh 66, 1997, Grabungen 1996, 24–26; Brückner 1997a; Brückner 1997b; İ. Kayan, Efes'te Artemision ilea Coresus kapısı arasında eski kıyı Çizgisi üzerine paleocoğrafya araştırmaları, XVII. Uluslarası Kazı Araştırma ve Arkeometri Sempozyumu (1996) 1–6; İ. Kayan – J. C. Kraft, Selçuk ovasında Efes kültürünün gelişimine coğrafi çevrenin etkileri, in: From Past to Present. First International Symposium on Selçuk (1998) 113–123.

[12] M. Stuiver – T. F. Braziunas, Modeling Atmospheric 14 C Influences and 14 C Ages of Marine Samples to 10,000 BC, Radiocarbon 35, 1993, 137–189.

transported and out of place. *In situ* plant material such as roots, marsh grasses and trees may provide 'absolute' information. However, the molluscs create another problem. When bivalves such as pelecypods have two shells in growth position in the sediment, we may assume they have not been removed or transported. Therefore, a date of a pelecypod shell such as *Cerastoderma edule* in growth position becomes an important key in determining both the sedimentary environment of deposition and the time of such deposition as evidenced by the corrected radiocarbon dates of the shell. Wood and other organic materials are also used in a determination of the time of deposition of a sedimentary environment. However, here we must be very careful. In floodplain and deltaic conditions, removal and transport are common. We always strive to determine whether or not a dated specimen is in 'growth position'. However, we do use materials not in growth position in order to provide an approximate time frame for some of our stratigraphic correlations.

Throughout the past three millennia, there has been a pervasive shift westward of all of the harbors of Ephesus and the Artemision. However, this was not an orderly linear progression, as sediment by-passing and the isolation of small flanking harbors were common. It is important to remember that some ancient historians tended to copy or repeat events previously recorded; thus, the time of »an action« may be misinterpreted. Further, the dates of our sedimentary units are constricted by our usage of the 'RC-14 intercept date'; thus, the actual date may vary considerably as shown by the 67th and 95th percent range, let alone the possibility of a systematic correction error. Nevertheless, our shorelines depicted from Ionian to Classical times appear to be correct as they are formed far ahead of the rapidly advancing Cayster River delta. Yet, we have also shown that the overwhelming sedimentary infill of greater than 30 meters of silt in the ancestral Gulf of Ephesus occurred both 'near to' and 'far seaward' of the Cayster delta's shoreline.

The greatest problems of harbor delineation are those of Hellenistic time. From our borings, we can identify with precision the shoreline, nearshore environments, and the deeper harbor waters of Lysimachus' time along the west flank of Mount Pion and near the gates of the Hellenistic Agora. Still, our borings show a shoal area immediately west of the northwesterly promontory of Mount Pion, with water depths of 1 m in the area of the north side of the later Olympieion. Indeed, a thin layer of sediment indicates brackish water with infusions of fresh water in the area between the Olympieion and the Harbor Gymnasium (i. e. possibly a harbor, a natural lagoon, a fresh water infusion from subterranean springs, or an artifact of a lower sea level in the 3rd millennium BP). Likewise, Peter Scherrer has kindly, and we believe correctly, suggested that elements of Hellenistic harbors are buried under the land fill upon which the lower Roman city was later built[13].

Thus, the Imperial Roman harbor was certainly built to the west of the earliest Hellenistic harbor(s). Question remains about the mid-Hellenistic and Roman Republic times; and, as Scherrer has noted, there were likely more than one Hellenistic harbors extant at any one time!

We attribute the southwesterly trending harbor mole extension to the large northern harbor mole, which effectively closes the great harbor at its narrow exit, to the actions of Hellenistic engineers at the instruction of Attalus II Philadelphus (159–138 BC) as noted by Strabo[14]. If this is not the mole of Attalus II Philadelphus, then we must conclude that his »destructive harbor works« as recorded by Strabo, lay to the east under Roman fill. Awkwardly, we must then conclude that later Roman Imperial engineers repeated the same mistake of Attalus, the Hellenistic king.

Such are conundrums encountered in our attempts to integrate the historical and prehistorical record, studies of sedimentary facies patterns and processes, and a patina of questions in radiocarbon-14 dating accuracies and ranges in our search for the paleogeographies of antiquity.

[13] P. Scherrer, oral communication.

[14] see no. 2 on fig. 10, and appendices H and I.

Paleogeographic Analyses of the Environs of Ancient Ephesus and the Artemision

A Blending of History, Archaeology, and Geology

We have shown in past studies that historical (Classical), archaeological, and geologic records can be blended into a composite interpretation of landscape evolution that is far superior to that which one can attain via the separate individual disciplines involved; i. e., the composite picture is greater than the sum of the separate parts. The historical and archaeological record are the important starting point in considering ancient landscape configurations. However, only the study of the three-dimensional geometry of sedimentary environmental lithosomes can lead to accurate analysis of ancient depositional landscapes. To this end, we have continually sought the advice and help of our historian and archaeologist colleagues in our research at Ephesus and the Artemision. The appendix presents a summation of pertinent historical notes in regard to the coastal and deltaic landforms and the harbors of ancient Ephesus. As we proceed through the paleogeographic analyses that follow, we shall refer to these comments in the classical and historical records.

The Ancestral Gulf of Ephesus: A Marine Embayment in Mid-Holocene Time

Figure 4 is a geologic cross-section from Ayasuluk hill and the Artemision excavation across the floodplain of the Küçük Menderes to the hill Korudağ (ancient Syrie). Our interpretation of this geologic profile shows the underlying pre-Holocene terrestrial sediment topography inundated by the mid-Late Holocene Epoch sea level rise[15]. This surface is overlain by transgressive marine sands and gravels which include an abundant clear water molluscan fauna as observed in drill boring EPH 89-6. Radiocarbon dates of the molluscs date the marine transgression at about 7 000 years BP. For a long time thereafter, clear marine embayment waters of an arm of the Aegean Sea covered the region. By Classical times the pro-delta shallow marine silts advancing in front of the ancient Cayster River delta arrived in the area north of the Artemision. In one boring we encountered the Classical marine bottom sediments at –14 m below present sea level. Thereafter, the prograding distal and proximal delta/marine silts began to infill the embayment rapidly. As discussed previously, we cannot identify a prograding foreset sedimentary sequence. Rather, we believe that the wind and wave driven currents were distributing the very fine sandy silts throughout the embayment. Eventually, the alluvium of the delta-floodplain arrived in the line of section. However, our radiocarbon dates of delta sediments suggest that the coastline lay to the east of the line of section as late as Hellenistic times.

A mid-Holocene Epoch paleogeographic map (fig. 5) shows that a clear water marine embayment in Neolithic times extended into the Belevi Gorge 8 km to the northeast of the later site of the Artemision. These marine waters were greater than 30 m deep between Ayasuluk and the mid-floodplain hill of Korudağ (then island – ancient Syrie). To date, two Neolithic settlements have been identified along the flanks of the ancestral Gulf of Ephesus. We interpret the ancestral Gulf of Ephesus to have been a clear water marine embayment with no significant beaches or barriers along the delta shorelines, as wind and wave driven littoral transport was minimal far into this semi-enclosed arm of the Aegean sea. The small streams tributary to the embayment were building alluvial fans into the flanking valley indentations. However, with the possible exception of the drainage systems of the Marnas/Selinus Rivers to the south of the Artemision, no significant floodplains had developed. The rocky slopes dropping sharply into the marine embayment had talus slopes extending at a high angle into the ancestral marine waters.

[15] Kayan (note 11) 1–6; Kayan – Kraft (note 11) 113–123.

Essentially, this mid-Holocene configuration is the same as that present in the region at the time of the arrival of the Ionian Greeks, ca. three millennia BP.

Further, the location of the Koressos settlement of Androclus (Appendix A), when combined with O. Benndorf's comments (Appendix B), supports the location of the original Koressos settlement on the northeasterly flank of Mount Pion. Although we understand that tradition locates the Koressos settlement as shown in map figure 6 (see line A), we again note that it is just as likely that the locale of the Koressos settlement lays in the vicinity of the northeasterly corner of Mount Pion at the edge of the Marnas/Selinus floodplain of 1000 BC and within the seven stades limit of walking distance from the Artemision (see line B).

The Arrival of the Ionian Greeks and the Location of the Koressos Settlement

At the time of the arrival of the Ionian Greeks under Androclus, the southern shoreline of the ancestral Gulf of Ephesus was much as shown in figure 5, with rocky, cliff-like coastlines and small tributary alluvial fans. Figure 6 portrays the shoreline of Archaic and Classical Ephesus and the Artemision. This shoreline depicted is essentially the same as that of 1000 BC, the approximate time of the arrival of the Ionian Greek peoples to the Ephesus region. We show the composite floodplain of the Marnas and Selinus Rivers with a shoreline drawn at the landward/southward limitation of marine sediments encountered in our drill cores. We attempted to drill through the Marnas/Selinus floodplain sediments to determine whether or not a major marine embayment extension extended further south where our drill tests did not encounter any marine section. However, it is possible that we have not penetrated deeply enough through these coarse clastic more torrential type floodplain deposits to test the theory of a more southerly marine embayment. Nevertheless, to the best of our present evidence, the limits of the marine embayment between Mount Pion and Ayasuluk are as shown in figures 5 and 6.

Historic notes (Appendix A) tell the legend of Androclus and the Greek colonists searching for a settlement site along the southern flanks of the ancestral Gulf of Ephesus. Traditionally, the site of Androclus' settlement has been placed on the north/northwesterly flank of Mount Pion. However, to date, pottery sherds only date to the end of the eighth century BC in this region (fig. 6). In our estimation, colonists searching the southern shoreline of the embayment would have found a rocky, defensible position or location closely associated with a broad floodplain for agricultural use between the northeasterly corner of Mount Pion and the westerly end of Ayasuluk. Here lay the Marnas and Selinus River floodplains. We can show that an indentation of the sea lay immediately east of the northeasterly corner of Mount Pion and the southwesterly most point of Ayasuluk. This was later to become the locus of the Sacred Harbor of the Artemision. H. Engelmann and M. Büyükkolancı[16] discuss archaeological and epigraphical information derived from the area of the 'Meter Sanctuary', which is located on the northeastern slopes of Mount Pion and facing the small arm or marine embayment – the Sacred Harbor (Appendix B). In Ionian times this sheltered marine embayment formed an excellent natural harbor configuration adjacent to the hilly slopes of Mounts Pion and Ayasuluk. To Archaic and Classical Greeks this was the 'sacred place' of their forefathers or ancestors who immigrated to the region with Androclus (Appendix B). We suggest that a most logical position for the site of ancient Koressos and Androclus' initial settlement would be in the vicinity of the Meter Sanctuary on the slopes of northeastern Mount Pion and the 'fertile floodplains' immediately adjacent along the coastline of the sheltered marine embayment that was later to become the Sacred Harbor. This area lies seven stades from the Artemision by land, a criterion used by Herodotus in determining the locale of the Koressos settlement of Androclus and his colonists (fig. 6). From the point of view of topography,

[16] H. Engelmann – M. Büyükkolancı, Ein Meterrelief mit einer Weihung an die Götter der Väter, ZPE 120, 1998, 73–74.

agricultural resource availability, and other factors such as the location of the Artemision and its nearby Archaic city at the foot of the Ayasuluk, this seems to be an excellent candidate for the location of the Ionian Koressos colony.

H. Engelmann, citing O. Benndorf and reasoning from Herodotus and others, comments on the location of Koressos settlement. For the sake of argument, let us take a look at some of the historical notes as related to the location of Koressos and the Sacred Harbor(s) of the Artemision: Herodotus (see also Appendix C), writing in the fifth century BC, tells us that the Koressos settlement was seven stadia distance from the Artemision[17]. Further, the orator Aelius Aristeides, second century AD, speaks of a »gymnasium in Koressos«[18]. Assuming this relates to the Gymnasium of Vedius, the location of Koressos settlement is correctly placed on the north side of Mount Pion (Panayırdağ) in the vicinity of the Stadion.

However, let us analyze statements about Androclus and his founding of his colony at Koressos[19]. Kreophylos tells of Androclus' long search for a suitable place for his colony (Appendix A). He turned to the oracle of Apollo and there received a response that he should settle at the place a fish would show him and to which a wild boar would drive him. The oracle was fulfilled on a beautiful day when Androclus had a picnic at the shore. Fishermen were also resting there, and one had placed fish on the fire; a fish jumped from the coals, a flaming piece of vegetation (cabbage?) ignited a reed and a wild boar saved itself from the burning reed by running onto a mountain flank. Androclus pursued the beast, killed it, and constructed his colony at that place. It is said the fishermen prepare their meal there, where the foundation (source) is that which Hypelaios called, and which (is) the Sacred Harbor. We submit that the Sacred Harbor of Archaic, Classical, and Hellenistic times as well as in earlier Ionian times, if such term is appropriate for ca. 1000 BC, was between the northeast corner of Mount Pion and the southwesterly extension of Ayasuluk and not near the Gymnasium of Vedius (see fig. 6 including locations of our supporting proof: drill core data).

H. Engelmann and M. Büyükkolancı[20] give a description of a relief stele of sitting Meter with a lion on her lap, in the left the Tympanon, near her stands a masculine figure, presumably a scepter in the right hand; on the edge is a worn-off inscription from ca. fourth century BC (see Meter Sanctuary on fig. 6). This stele is from the lower slopes of Mount Pion (Panayırdağ) on the very northeast corner facing the Artemision and said by Engelmann and Büyükkolancı[21] to represent the Great Mother (Goddess) of the Greek immigrants. They further speak of »The temple precinct of the Theoi patroioi ... on the northern slope of Mount Pion ... . On this slope Androclus had once settled; he had built his lower city at the Koressos harbor and the upper city on a mountain side above the harbor. His two settlements existed for a long time: only King Croesus forced the settlers to give up the upper city and to move down to the city around the Artemision.«

Further H. Engelmann states that according to Pausanias 5, 24, 7 f. the cities of Knidos and Ephesus had a peculiarity[22]: In both cities there were quarters, clearly separated from the rest of the city. In Knidos these were the so-called Cherronese; they lived on an island, a causeway (bridge) connected the island with the city quarters on the mainland. In Ephesus the Koressians were separated from the other city quarters. Unfortunately, Pausanias does not say what the barrier was in Ephesus. One can presume that the Hellenistic city wall separated the quarters from each other. If this assumption is correct, the Koressos settlement must have lain outside the city walls. Unfortunately, here archaeology lets us down. It is not known whether the Hellenistic

[17] Hdt. 1, 26.
[18] Aristeid. 2, 82 p. 413 [Keil].
[19] Kreophylos in Athen. 8, 62 p. 361c–e: FGrH 417 F 1; Strab. 14, 1, 21.
[20] Engelmann – Büyükkolancı (note 16) 73–74.
[21] Ibidem 73–74.
[22] H. Engelmann, Der Koressos, ein ephesisches Stadtviertel, ZPE 115, 1997, 131–135; see also Appendix E.

(walls) came down from Panayırdağ (Pion) to the coast. J. Keil theorizes that the Byzantine city wall went from the saddle of Panayırdağ to the Stadion and to the Gymnasium of Vedius[23]. Keil concluded that the settlement Koressos should be sought east of the Stadion and Gymnasium of Vedius (in the vicinity of the small embayment between the Stadion and the 'Feigengarten excavation' [see fig. 6]). These conclusions are based on two assumptions:

1) the barrier which Pausanias does not name must be the city wall;
2) the city wall must have come down around the embayment by the Stadion to the ancient shoreline.

The waters in this embayment area as defined by H. Engelmann were approximately 8 m deep in 1000 BC (see fig. 5). Thus, the Koressos harbor could certainly have been in the small embayment between the Stadion and the vicinity of the 'Feigengarten excavation'.

However, can we not also speculate that it is possible that Koressos was located in the vicinity of the Meter stele (and others) on the very northeasterly corner of the slopes of Mount Pion and/or the immediately adjacent narrow floodplain of the Marnas River to the south of the coast of the later to be named Sacred Harbor of the Artemision (which we herein locate by geologic means). Further, we note that significantly different locales may be considered for the first Ionian Greek settlement and Androclus' encounter if 'the seven stadia' distance from the Artemision are 'by foot' as contrasted with 'as the crow flies' (fig. 6). Seven stadia by foot from the Artemision via the shoreline of the Sacred Harbor of Archaic time leads to the vicinity of the Meter Sanctuary at the northeastern foot of Mount Pion, among possible sites for Koressos. If we examine the legend of Androclus and the fish and wild boar (Appendix A), would it not be more likely that a shore with reeds and fishermen along the edge of the sea might be better located in Ionian times on a coastline at the edge of a narrow floodplain east-northeast of Pion facing the Artemision (as we have shown in fig. 6) as opposed to on the steep (maximum several meters wide) talus slope at the north base of Mount Pion in the 'conventional' location of Koressos harbor west of the 'Feigengarten excavations' and below the Stadion? Clearly, there was hardly any room for fishermen, the fire, the chase of the boar, etc., let alone a 'city' on the then extant foot of the steep, narrow talus slope shoreline by the edge of the sea in Ionian times near the location of the later Stadion (see fig. 2).

Let us go a little farther with this. H. Engelmann has provided a clue from a fragment of the poet Archestratus of Gela (Appendix F)[24]. These lines of poetry are about a certain fish that requires brackish water and throve in the Selinus River by the Artemision and is estuarine in its habitat. Archestratus of Gela was a contemporary of Alexander the Great, in the second half of the fourth century BC. He talks about »the [fish] Aurata from Ephesus, the product of the exalted Selinus [River]« in an epic about good food and drinking. If indeed Archestratus has it correct that this fish lived near the Artemision then we should search for the estuary of the Selinus River to be flowing into the Sacred Harbor as shown in map figure 6. Xenophon also relates in the Anabasis (5, 7) that there were many fish and mussels in the Selinus River (Appendix F). However, Xenophon does not note brackish or marine waters, as do modern glossaries regarding the fish Aurata. With present data we cannot be specific about river estuary configurations flowing into an arm of the sea between Mount Pion and the Artemision 2 300–2 400 years ago. However, we can define the shape of the marine embayment (fig. 6) and the likelihood of lower river estuaries along the shoreline of the Sacred Harbor of that time. This might remove some of the arguments now extant that suggest that the Selinus River, because it was estuarine, must therefore lie many kilometers away to the northwest on the opposite side of the Cayster River floodplain, because that is where estuarine-brackish waters occurred a millennium or more later. We (all students of antiquity) must remember that present coastal configurations frequently are

[23] J. Keil. Ein Grabbau mit Unterweltsarkophag aus Ephesos, ÖJh 17, 1914, 133–134.

[24] Personal communication H. Engelmann; H. Lloyd-Jones – P. Parsons (eds.), Supplementum Hellenisticum (1983) fr. 143.

not relicts or palimpsests of coastlines in antiquity. Throughout Holocene times, coastal landforms have greatly changed in sedimentary depositional locales and morphologies.

If the ships of Ionian Androclus required a sandy/silty shoreline so that they could be 'beached' as in Bronze Age times, then we are constricted in locales for the harbor of Androclus to the flanks of the Selinus-Marnas floodplain at the Meter Sanctuary at the northeast foot of Mount Pion, and the long arcuate shoreline extending easterly to the Artemision (or the less likely site of the later Hellenistic Agora). The 'conventional' site of Koressos harbor, to the east and below the later Stadion was an open roadstead with a rocky shore and talus debris in Ionian times.

Although we understand that tradition locates the Koressos settlement near the Stadion (see fig. 2), we again note that it is just as likely that the locale of the Koressos settlement lay in the vicinity of the northeasterly corner of Mount Pion at the edge of the Marnas/Selinus floodplain of 1000 BC and within the seven stades limit of distance from the Artemision (see fig. 6). In addition, Pausanias' comments about the separation of two portions of Ionian Ephesus (Appendix E) also fit these geometries, with Koressos lying at the base of Mount Pion and on the edge of the Marnas floodplain while the 'upper city' perched on Pion's adjacent heights. The map of Archaic and Classical Ephesus (fig. 6) also shows the broad floodplains of the Marnas and Selinus Rivers which may be the locale of the Athenian invasion of 409 BC (Appendix G).

The Artemision and its Sacred Harbor

Figure 7 shows the Artemision excavation in relation to the sedimentary strata in which it was constructed and later buried. Underlying the center of the later Artemision area is evidence of shallow marine silts and very fine sand deposited in the immediate coastal zone of an early Bronze Age marine embayment (C-14 date: 2633 BC). At that time, this marine embayment was clear water with only minor sediment intrusion from tributary streams. The geologic cross-section shows a geologic disconformity in the sediments and then a shoreface sand which progrades seaward from the middle of the (later built) Artemision area (notice the prograding stripes in the figure).

In Hellenistic and Classical times the shoreline lay as depicted in figure 6. Our drilling program within the environs of the Artemision includes over twenty test holes including nine in the immediate Artemision building complex. Radiocarbon dates obtained from *Cerastoderma edule* pelecypods in probable living growth position in the shoreface sands, show that the Artemision from Archaic to Hellenistic time was located on the immediate southern shoreline of the marine embayment. Clearly, this configuration existed in Archaic and Classical times and at any earlier structures on this site.

Our intensive drill core program at the Artemision was specifically designed to define the sedimentary environmental lithosome geometry around and under the Artemision. Certainly in Bronze Age times the shoreline lay close to the base of Ayasuluk hill and under the middle of the later Artemision. By Archaic times, the prograding sediments of the Cayster River and Klaseas River deltas encroached around the northeasterly periphery of Ayasuluk. Thus, in Archaic and Classical times the coastline configuration was much as shown in figure 6. We show that the Archaic and Classical city of Ephesus lay close to and partially surrounded the Artemision landward to the south and east. We hypothesize this position based on a few known archaeological sites including the recently discovered major Classical cemetery at the southerly foot of Ayasuluk along the main street of Selçuk.

We find it of particular interest that the shoreface sands date to Hellenistic time, 182 or 200 BC. Thus, even as late as Hellenistic times the Artemision lay on a small, protruding alluvial/colluvial fan perched along the shoreline of the ancestral Gulf of Ephesus at the westerly flank of Ayasuluk. Certainly, this was a beautiful location for this predominant temple of the goddess Artemis; the early builders chose an excellent site. Surrounded by waters deep enough for approach by ships into the Sacred Harbor, the Artemision in a westerly facing coastal setting must have been most impressive to those arriving by sea. We delineate the Sacred Harbor as lying within 100 m to the west of the Artemision buildings. We cannot date with absolute certainty the timing of the torrential deposits which included cobbles and boulders (fig. 8). Some of the substructural material that we have encountered with the drill was probably temple foundation support. However, other parts of this protruding delta fan-like shape (see the topographic contours on top of the cobble and boulder fan in relation to sea level as shown on fig. 6) may have been in part emplaced by sediments of the Klaseas River coming from the east or the Selinus and Marnas Rivers coming from the southeast. Figure 8 also shows that the torrential fan deposits of the Klaseas, Selinus and Marnas Rivers streamed around the foot of the Artemision complex and extended into the marine waters of Archaic, Classical, and Hellenistic times. Note that the alluvial sediments as shown in cross-section figures 7 and 8, and the topographic contours on figure 6 reinforce the fact that the Artemision, after destruction, was buried by continuing torrential deposits coming around the flanks of Ayasuluk burying the ruins of the Artemision (a process which probably continued throughout the past two millennia since destruction). More regional aspects of this wedge of alluvium/colluvium that eventually covered the Artemision ruins are shown on cross-section figure 4. The topographic contours showing the hemispherical embayment on the southwest side and a projecting promontory on the northeasterly side are based on first encounter by the drill of major rocks (boulders, cobbles) and thus impenetrable by our drilling techniques. At the same time, continual settlement apparently also occurred to the west-southwest on the far side of Mount Pion as shown by the location of the city of Smyrna and the sixth to fourth century BC graves extending seaward to the coastline at the base of the ravine between Mounts Pion and Preon.

Thus far, we have avoided comment on tectonic movement of sediments along the southern flank of the Küçük Menderes (Cayster River) floodplain. W. Vetters made a detailed study of supposed uplift and down warp of the sediments in the vicinity of the Artemision as caused by earthquake activity[25]. We neither dispute nor support his conclusions. However, we note that none of our subsurface stratigraphic studies showed conclusive proof of such movement. The greatest problem of subsidence or uplift interpretations in sediments is that the correlative boundaries of the various sedimentary lithosomes may deposit at significantly variable elevations as related to sea level (at the time of deposition). For instance, drill core EPH (EKK)1992-01 at the 'Feigengarten excavation' (see figs. 9 and 10) shows river alluvium to a depth of –2.5 m below sea level. These fluvial deposits may represent:

1) prograding Cayster River alluvium into 'edge of marine' waters up to 3 m deep;
2) a surge of alluvium from the tributary Marnas or Selinus Rivers;
3) somewhat compacted (and subsided) alluvium under the later colluvial and structural debris of the Damianos Stoa – Feigengarten area; or
4) a thickened sedimentary 'wedge' formed by tectonic subsidence during or shortly after deposition.

Further, cross-section figure 9 also shows that the base of the alluvium is certainly not a depositional time line; rather, it is a cross-time sedimentary facies boundary.

In summary, we submit that the geomorphic and environmental configuration depicted is a reasonable interpretation of the coastal morphologies of Archaic, Classical, and Hellenistic times in the environs of the Artemision. We further believe that the morphologies shown lend themselves to a credible interpretation that the initial settlement site of Androclus and his Ionian Greek colonists at Koressos could lie on the northeastern side of Mount Pion in the vicinity of the Meter Sanctuary as shown in figure 6.

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[25] W. Vetters, Die Küstenverschiebungen Kleinasiens: eine Konsequenz tektonischer Ursachen, in: Lebendige Altertumswissenschaft. Festschrift H. Vetters (1985) 33–37.

The Via Sacra and the Sacred Harbor: Changing Configurations

The geomorphic configurations of the coastline as shown around the Artemision in Archaic, Classical, and Hellenistic times raise some constrictions on the locations of the Via Sacra, from the Magnesian Gate of Lysimachus' city between Mounts Pion and Preon to the Artemision. Stratigraphic section figure 9 shows an archaeological excavation of the western end of the Via Sacra leading from the North Gate of the city of Ephesus at the Damianos Stoa from ca. 30 AD to the time of Septimius Severus and later. However, before 0 AD marine waters up to 8 m deep occurred along the entire north flank of Mount Pion. In the Hellenistic times (and earlier) and Roman Republic the Via Sacra, extended from the Magnesian Gate of Lysimachus' city around the immediate foot of the eastern flank of Mount Pion and thence to the northeast around the edge of the marine embayment of the Sacred Harbor to the main entrance to the Artemision in the immediate environs of the seashore within ca. 100 m of the Artemision (fig. 10).

The 'Feigengarten excavation' (of the Damianos Stoa) of the second century AD conducted by D. Knibbe in 1992, is at the southern edge of the Cayster River floodplain at the base of the talus slope of Mount Pion. Cross-section (fig. 9) illustrates the nature of the thin alluvial sheet, of Cayster River alluvium which covers a marine sediment section of very fine sandy silts. Radiocarbon dates and the sediments show the final progradation of deltaic sediments into the formerly clear marine waters of the ancestral Gulf of Ephesus. A series of 'sacred roads to the Artemision' stacked over one another, were discovered in the 'Feigengarten excavation' by D. Knibbe and E. Trinkl. Note that the earliest sacred road from this northerly gate of the city of Ephesus to the Artemision is directly and specifically controlled by the time of deposition of the first fluvial floodplain sediments in the area, since the underlying land surface was flooded by marine waters 6 000 years before present (see fig. 5).

Figure 10 is a paleogeographic map of the environs of Ephesus and the Artemision in Hellenistic and late Roman Republic times (323 BC to 0 AD). The summation of sedimentary environmental and geomorphic data in stratigraphic section figure 9 and the map interpretation figure 10 in relationship to the 'Feigengarten excavation' and the Artemision show that until the end of the late Roman Republic the only viable route of the Via Sacra from the Lysimachean city is via the southeast flank of Mount Pion, then across the delta-floodplain of the Marnas and Selinus Rivers skirting the Sacred Harbor and thence to the western entrance to the Artemision complex. Only after the relatively firm floodplain surface evolved about 0 AD, could the sacred road extend from the northern gate of the city of Ephesus in the vicinity of the Damianos Stoa in a direct straight line to the front of the Artemision across the alluvial infill of the former marine embayment of the Sacred Harbor[26].

The Sacred Harbor existed immediately adjacent to the Artemision as late as 200 BC. However, there are many problems in precise delineation of the Sacred Harbor area after 200 BC. The shallow marine waters evidenced by pro-delta silts as shown in figures 9 and 10, were deep enough to provide harbor-like settings of 1 to 2 m depth as shown into the first century BC. Thus, a Sacred Harbor in the small coastal indentation immediately east of the Stadion is probable. Further, we can hypothesize that a last or final Sacred Harbor existed at one time at the northwest base of Mount Pion north of the Olympieion in the vicinity of the small islet (now rocky hill) that then existed offshore.

The literature is equivocal in regard to this period. However, later in Imperial Roman time, when Hadrian Caesar undertook an effort to protect the harbor and divert the Cayster River, more than one harbor is still indicated for the city of Ephesus. An inscription from the year 129 AD

[26] D. Knibbe, Via Sacra – Damianosstoa, ÖJh 62, 1993, Grabungen 1992, 19–20; D. Knibbe – H. Thür, Via Sacra Ephesiaca II, BerMatÖAI 6 (1995); J. Hrůska – P. Mitronga – G. Fuchs – D. Knibbe – W. Pietsch, Bericht über die geophysikalische Untersuchung der Via Sacra in Ephesos (1995).

clearly mentions several harbors: The Cayster River damaged all harbors of the city, not only the Great Harbor (see Appendix K with IvE 274). The best locale that we can identify for such a late Sacred Harbor must have been to the north of the Great Harbor of the lower city of then extant Imperial Roman Ephesus. We cannot know precise shoreline configurations of the rapidly prograding delta edge where the highly-varied and rapidly changing delta distributary positions came and went with great frequency in a fanlike prograding delta pattern. It is possible that flanking subsidence and sediment compaction could have allowed for minimal draft ships to utilize these isolated little pockets of marine lagoonal waters along the southerly flank of the Cayster River floodplain long after the great mole had been established to fend off Cayster River sediments from the quiescent Great Harbor. We note that a delta prograding between two flanking hills into a deeper marine embayment will tend to deposit its maximum sediment load toward the middle of the embayment leaving behind quiet water lagoons or quiescent embayment conditions along the flanks. Even today we can see the remanents of such sediment bypassing small marine remanents, now converted to freshwater lakes such as the Gebekirse and Çatal lakes on the north flank of the Küçük Menderes floodplain (see fig. 1). These freshwater lakes were so indicated even in Strabo's time. With this model we can envisage various possible loci of the Sacred Harbors of Ephesus after their forced migration westward from the initial position immediately by the Artemision.

The City of Lysimachus and Harbor through the Late Roman Republic

Figure 10 shows the location of the shoreline at the time when Lysimachus moved the city to the area between Mounts Preon and Pion about 300 BC. The Lysimachean strand was at the western foot of Mount Pion and the northern foot of Mount Preon was bordered by a narrow beach and swamp. However, by his time, prograding distal and pro-delta marine silts were already circling around the northwest promontory of Mount Pion and a great shoaling event was occurring in the area that was later to be the location of the Roman/Byzantine lower city. At the time of Lysimachus, at least three small, rocky islets existed offshore immediately west of Mount Pion. Drill core evidence in the vicinity of the lower city and the Great Harbor is shown in geologic cross-section figures 11, 12, and 13. Map figures 2 and 10 show the loci of our test drilling sites. St. Karwiese supervised an archaeological trench along the northeast flank of the Byzantine Archbishop's Palace (figs. 11 and 12)[27]. At the bottom of the foundation walls of the palace he encountered a mix of construction debris fill. Our drill boring EPH 92-5 in the bottom of Karwiese's trench encountered shallow marine sands and muds; details of the sediments encountered are shown in figure 12. Underneath the construction debris, which included a number of shells of *Cerastodoma edule* mixed in with the construction fill as well as sandy muds and evidences of a coastal swamp, we encountered a blackish-gray, coarse to very coarse, loose sand with many marine mollusc shells. Underlying this shoreline deposit lay a thin shallow marine mud with coastal swamp debris immediately overlying the marble bedrock of the foot of the slope of western Mount Pion. Radiocarbon dates of a crab claw, *Cerastodoma edule* shells in the marine environment, and a buried log are all of Classical time (465–401 BC). Thus, we can identify a shoreline at the immediate foot of the westerly flank of Mount Pion that existed before the pro-delta silts of the prograding Cayster River arrived in the area. From this and the small rocky islets buried in and around the lower city we can show a shallow shoaling edge of the arcuate shoreline that was occupied by Lysimachus and his city about 100 years later. There is evidence that by Lysimachus' time the prograding distal pro-delta silts were already beginning to fill in the edge of the embayment. However, in Lysimachus' time a narrow beach still arced around tight against

[27] St. Karwiese, Marienkirche, ÖJh 62, 1993, Grabungen 1992, 16–19.

the foot of Mounts Preon and Pion. With the major lower city construction of Lysimachus' time, sedimentary infill plus construction fill progressively pushed the shoreline of the marine harbor waters westward to the edge of the Great Harbor that is still evident as the smoothly rounded lineaments of the moles and harbor walls that bordered the great Roman and Byzantine harbor. Water depths in the immediate coastal zone at Lysimachus' time were still about 2 m.

Cross-section figures 11, 12, and 13 present the evidence for the shoreline position of the Hellenistic and Classical coast at the immediate foot of Mount Pion. Shoreline positions dating back over three millennia to Neolithic time can be observed in cross-section figure 13 from the Tetragonos Agora at the foot of Mounts Pion and Preon to the north harbor mole. Here, in the Agora in the bottom of excavations by P. Scherrer, we drilled into a sedimentologic sequence which indicated the edge of a marine embayment from Mesolithic to Hellenistic times, followed by the eventual progressive, rapid infill that allowed the lower city to be built over the area of the former marine waters. The marine muds shown in cross-section figures 11 and 13 are indicative of the pro-delta silts that were flooding the marine embayment in advance of the prograding Cayster delta to the northeast by Hellenistic time.

Again, evidence from the literature is very important. We know that by Hellenistic time through the late Roman Republic, it had been necessary to build a mole along the northern flank of the Great Harbor to protect the harbor from the advancing deltaic sediments. Classical literature and epigraphy articulate the problems of the harbor in the second century BC. Livy (ca. 59 BC–17 AD; see Appendix H) reports on a Roman and allied Greek city-state fleet holding siege to the harbor of Ephesus. A discussion occurs among the commanders of the attacking fleet (Rhodian, Pergamene and Roman), including a suggestion that the allied fleet could block egress of the Ephesian fleet in a simple venture: one had only to sink several heavily loaded cargo ships at the harbor outlet, and the harbor would be completely blocked, »because the mouth of the harbor was like a river: long and narrow and full of shoals«. Strabo, writing at the time of Tiberius, refers to perhaps the best-known statement in antiquity regarding a counter-productive or negative environmental impact action (Appendix I). Again, the mouth of the harbor was considered to be problematic in that the harbor was continually »silting in«. Attalus II Philadelphus (159–138 BC) and his engineers decided that the wide end of the harbor with its many shoals was the cause of the siltation and shoaling waters problem, and that by narrowing the harbor entrance they could stop siltation which was leading to considerable navigational problems for shipping. Our interpretation of the shoals in the wide harbor entrance in the time of Attalus II Philadelphus and his harbor construction engineering solution is shown on figure 10. By cutting off and narrowing the formerly wide harbor mouth with its many shoals, Attalus II Philadelphus had created an ideal quiescent »settling tank« and thus a massive increase in the deposition of fine silt and clay. In fact, there was probably little that the Hellenistic kings and later Roman senate leaders could have done to prevent silting of the harbor and embayment of their time. Indeed, from then on, there are many comments in the literature (Appendix J) in regard to the silting problems, cleaning and dredging the harbor, and laws to prevent dumping of industrial materials into the harbor. In fact, the problems seem so persistent that the peoples of Ephesus themselves probably were a major part of the problem in their use of the harbor as a convenient dump area for their trash including industrial refuse.

Roman Imperial Ephesus

Figure 14 is a schematic profile illustrating the major depositional elements of a prograding thin veneer of alluvium over a relatively thick sequence of aggrading and prograding marine muds (mainly silt) into a marine embayment bounded on three sides by mountains. Again, there is no evidence that major amounts of coarser sands and gravels were deposited in the marine strata in the embayment. Further, there are similarities to the distributaries and thin barriers and lagoons presently extant in the Büyük Menderes delta to the south, west of ancient Miletus. The rapid aggradation of shallow marine silts in proximal and distal pro-delta configurations was accompanied by the marine silt redistribution by wave and current action in the marine embayment. This led to a pattern of shallow marine aggradation merging with the present sea level over a wide area. The silts and clays of the shallow marine muds undergoing deposition may have been subject to many cycles of resuspension, transport, and redeposition by shoaling storm waves that entered the Ephesian Gulf. However, bottom organism biologic activities may have lead to coarser mud aggregates and somewhat muted mud particle redeposition. The lower floodplain distributaries of Roman and earlier times contributed very little sand and gravel into the edges of the embayment, and therefore floodplain aggradation initially was very low with no evidence of coastal barriers. As indicated by the location of the coastal barriers on figure 1, large amounts of sand did not enter the marine embayment until the middle and upper level eastern floodplains of the Cayster River had aggraded to a higher level with incremental slope and resultant increased flow velocities. It is imperative that any reconstructions of shoreline and coastal configurations in the lower delta and nearshore marine area recognize the import of differentiating processes of pro-delta marine silt distribution from relatively narrow delta distributaries and the progradation of coarser clastic sand in littoral barrier accretion plains. Figure 14 emphasizes this point. Further, information on the depth of water from all of our borings through the floodplain sediments and into the underlying marine sediments in the environs of Ephesus, the Artemision, and the isle of Syrie to the north show gradual shoaling or shallowing of the mud bottoms (silt and clay) far to the west in the distal pro-delta region of the Gulf of Ephesus. Waters were as deep as 14–15 m in Classical time as shown in our lines of cross-section north of Ephesus (figs. 4. 7. 9 and 14). Of course, all of the waters of Classical and later times shoaled off close to the shorelines in irregular patterns. By Hellenistic time we found no water depths in the marine environs to the north of Ephesus greater than 5 m deep. By late Hellenistic time all waters north of Ephesus were less than 3 m deep. By then the prograding edge of the fluvial environments (i. e., the distributaries, lagoons, and swamps) rapidly prograded seaward and overlay the marine silts. The drill core information is pervasive. Always a marine mud (mainly silt with lesser clay) infills the marine embayment from Classical times onwards. The underlying deeper radiocarbon dates related to open marine waters date to Neolithic times across wide areas of the embayment.

Appendix K discusses Hadrian Caesar's forceful effort to protect the harbor. Hadrian Caesar built a dam to divert the Cayster River in order to stop the sediment flow into the harbor (early second century AD). Further inscriptional evidence suggests that a dam was built across the Manthites River believed to be the ancient Klaseas River to the east of Ayasuluk (modern Şirince River) based on the findspot of the inscription. However, it is not certain that the two events, the dam on the Manthites River and the diversion effort of Hadrian are the same. Indeed, we have no precise method of determining where Hadrian undertook his diversion effort. A logical place for such construction would be to the northeast of a line between Ayasuluk and Syrie in an attempt to divert the Cayster River into the marine embayment region north of Syrie and thus divert major sedimentation away from the harbors of Ephesus (see fig. 15). We may never know the precise location of Hadrian's river diversions. It may be that the diversion was an attempt to deflect a sudden surge of sediment from a new distributary which had broken through an older east-west levee and turned south toward the Great Harbor of Ephesus itself (see fig. 15, north to the harbor mole). Dams forming sediment traps and river diversion can be effective over the short term. Nevertheless, the greater problem of the harbors of Ephesus in antiquity was caused by the Cayster River delta front by-passing far beyond the harbor mouths, thus changing the harbors into quiescent settlings basins, entrapping all silt and clay from the annual floods.

We do know from the stratigraphic record (figs. 11 and 13) that large amounts of sediment were continually dredged from the Great Harbor onto the north mole of the harbor. In later Roman Imperial to Byzantine time this mole may have supported a number of buildings. There is a structure with columns and a marble pavement in the immediate shoreline area at the north part of the harbor onto the mole (fig. 13). Further, a farmer's barn on the northern mole has a vaulted arch foundation and his fields are now strewn with roof tiles and other artifacts. Large quantities of fossiliferous marine sediments dredged from the harbor form the soil of the mole's surfaces. Also, it is clear that the mole along the tube-like extension of the entrance to the harbor is also made of dredge spoil. A second century AD grave on the channel dredge bank reported by J. Keil[28] helps to date the continuing construction of the long extension of the mole westward in an attempt to keep the tube or long channel entrance of the harbor open to the Aegean Sea. Thus as early as the second century AD, continual dredging was in process to keep the harbor entrance open (see fig. 15).

Byzantine Time: The Demise of the Great Harbor

In figure 15 we show positions of the prograding shoreline of the Cayster River delta in Roman Imperial-early Byzantine times, high Byzantine time, and late Byzantine time. The evidence is in part circumstantial, in part supported by inscription and literature, and in part definitive from our drill core studies. For instance, we know from the literature (Appendix L) that, at the end of the second century AD, the politician Titus Flavius Damianus had already constructed artificial islands in the 'offshore area' near the entrance to the channel into the city harbor. The only reason for artificial islands along the outer deltaic shoreline or along the southern edge of the marine embayment would be to off-load heavily laden ships so that with their lighter draft they could proceed into the harbor or that lesser draft ships could re-ship the cargo into the harbor of Ephesus. Thus, in early Roman Imperial time there were major shipping problems, the beginnings of which were already evident and required remedial action as early as late Hellenistic time. In summary, from the third century BC to the second century AD, major efforts were made to prevent damage to the main harbor, while the next five centuries were devoted to dredging the channel, building extra-harbor off-loading facilities, and eventually utilizing alternative outer harbors (Appendices J and L).

From the first to the third century AD, inscriptions note many attempts to clean or dredge the Great Harbor and to pass laws prohibiting the dumping of waste such as construction emery or dust into the harbor (e. g. *proconsul* Soranus, mid first century AD; *prytanis* C. Licinius Maximus Julianus, ca. 100 AD; an 'archpriest', early third century AD). Further, politician Valerius Festus, greatly enlarged the harbor in the mid third century AD (Appendix J). The historical record notes that in 431 AD, »the harbor basin in the center city was still in operation, seaworthy ships went about and dropped anchor [outside the harbor] and loaded their cargo in barks that reached the inner city harbor above the runoff channel.«[29]. The Byzantine bishop arrived by ship at the mouth of the harbor and was forced to board a smaller boat or barge »at the island or mole that Damian built« in order to proceed into the harbor of early Byzantine Ephesus (Appendix L). C. Foss notes »when the Byzantine walls in the lower city were built in the seventh or eighth century AD, the harbor evidently still functioned for the fortification came down to its edge and included a tower to protect the port.«[30] (Appendix M). Foss also notes that by the early ninth century AD the Byzantine fleet could no longer use the harbor and instead sailed from Phygela on the coast southwest of the Cayster River embayment[31] (see fig. 16 for later harbor alternates).

Much discussion occurs as to the harbors of Ephesus in late Byzantine time and into the time of ascendancy of the Selçuk Turks (Appendix N). C. Foss[32] and G. Hess[33] suggest locales for an

[28] Keil (note 23) 133–134.

[29] H. Engelmann, Der ephesische Hafen in einer koptischen Erzählung, ZPE 112, 1996, 134.

[30] C. Foss, Ephesus after Antiquity: A Late Antique, Byzantine, and Turkish City (1979) 185 f.

[31] Ibidem 185.

[32] Ibidem 149.

[33] G. Hess, Die Entwicklung des Küçük-Menderes-Deltas in historischer Zeit, Essener Geographische Arbeiten 17, 1989, 1–12.

outer harbor of Ephesus, namely Panormus that was possibly located along the southerly flank of the then rapidly westward infilling Gulf of Ephesus (Appendix M). One possibility is a late Roman-early Byzantine harbor along the lower floodplain area of the Kenchrios River. We drilled two cores in the lower Kenchrios floodplain area but could not identify any marine sediments. However, here again, problems arose as our drilling equipment had difficulties in penetrating coarse clastics including boulders or cobbles. Thus, the possibility of a harbor in this locale remains but is in doubt. A later harbor for late Byzantine-Turkish-Venetian commerce may have lain one kilometer to the west in another small cove along the low, rocky cliffs of the southern part of the embayment between the Kenchrios river and the modern resort Pamucak (figs. 15. 16). The coastal barriers, which first developed in late Byzantine times do not extend to or merge with the southwesterly flanking hills of the embayment. This might be caused by currents of the Cayster River still flowing between the ends of the barriers and the flanking hills. It might also be caused by dredging actions that were continued by late Byzantine and Selçuk peoples to keep open access into possible small harbor areas.

R. Meriç takes another position (Appendix N)[34]. He proposed that the probability is high that Panormos harbor was located in the northwesterly corner of the lower Cayster River embayment near the village of Zeytinköy (fig. 16). Meriç bases this location on »toponymic inferences« (Pananos, a recent name applied to the area). Further, a raised viaduct or roadway constructed of marble blocks (some from Ephesus) extends into a presently low-lying marsh toward modern Zeytinköy (see the Selçuk Turk viaduct shown on fig. 1). A major support for Meriç's position is that the northwesterly corner of the ancestral Gulf of Ephesus received lesser amounts of fluvium from the Cayster River throughout antiquity than did the central and southerly regions. Indeed, present morphologies still show broad, partially saline, swampy area in the vicinity of the present Turkish town of Zeytinköy. Very clearly, the latest major marine embayment in the Cayster River delta-floodplain lay in this region. Meriç notes that the region under the control of Aydınoğulları in the city of Aydın to the southeast was still active in trade relationships with the Venetians and Genovese through Ayasuluk (Ephesus) and that Turkish fleets sailed from here in 1319 and 1329 AD.

Our best estimates of the positions of Imperial Roman-early Byzantine coastline, the high Byzantine coastline, and the late Byzantine coastal barrier accretion plain and swamps are shown in figure 15. As noted, we cannot definitively show these later coastal positions in part from lack of more extensive detailed drill core data. However, the coastlines shown are designed to fit the ancient literature and the concept that at a certain point in time the flow velocities of the lower Cayster River were great enough to transport large amounts of sand-sized particles from the interior drainage basin to the coastal distributaries where the sand was redistributed by Aegean waves via littoral transport processes into the coastal barrier accretion plain that extends to the present day (see figs. 1. 14 and 15). The modern delta of the Küçük Menderes protrudes into the Aegean Sea as a modified small symmetrical cuspate delta accretion plain. Nineteenth and twentieth century irrigation practices have drastically reduced the flow of sediment across the lower Küçük Menderes delta accretion floodplain. The late twentieth century coast continues to undergo adjustment to the lower river sediment load and to waves from the Aegean Sea.

Modern – Ancient Analogs

The entire concept of what we present in paleogeographic reconstructions is dependent upon our ability to make a modern/ancient analog comparison and thus correctly identify 'ancient or paleo-geomorphologies'. We utilize our knowledge gained from study of the three dimensions of sedimentary environmental lithosome distribution to form paleogeographic reconstructions of the various environments (floodplains, swamps, lagoons, coastlines, marine and freshwaters, etc.). At

[34] R. Meriç, Zur Lage des ephesischen Außenhafens Panormos, in: Lebendige Altertumswissenschaft. Festschrift H. Vetters (1985) 30–32.

Ephesus, a large marine embayment has undergone inundation during the major marine transgression of mid-Holocene Epoch time. This was followed by a marine regression caused by delta progradation and aggradation as the sediments of the ancient Cayster River and its tributaries infilled the edge of the marine embayment and literally pushed the coastline up to 15 km westward, bypassing the sites of the ancient harbors of Ephesus and the Artemision. Both the sedimentary environments encountered in our drill studies plus surficial morphologies provide clues for our use in paleogeographic reconstruction. One cannot simply take geologic principles of delta progradation based on other areas of the world and apply them here with any degree of accuracy in paleogeographic reconstruction. For instance, the majority of the Cayster River delta sediments that initially led to the infilling of the marine embayment formerly greater than 30 m deep in our study area, do not follow standard topset/foreset/bottomset type geometries of delta progradation. Rather, our studies have determined that the major infill of the ancestral Gulf of Ephesus (the marine embayment) has been by the introduction of mud (silt and clay size sediments) mixed with the very finest sand sizes into a prograding proximal and distal pro-delta marine configuration. This is overlain by lower deltaic sediments of river distributaries, broad swamps, and shallow coastal lagoons. The final alluvial aggradation of the delta surface came much later in time. Thus, today, we observe a dominant alluvial process. However, as the delta of the ancient Cayster River bypassed the Ephesus/Artemision region several millennia ago, siltation or infill of the marine embayment was a dominant process. For instance, we have encountered no evidence on the surface or in our subsurface drill studies of any linear barriers underlying the floodplains adjacent to the site of ancient Ephesus. The first visible geomorphic expressions of coastal barriers lay about 3.5 km west of the Great Harbor. Further, our drill cores have not hit any channel sand or gravel deposits in the floodplain area. This of course, is anticipated as channel sand deposits are very narrow. We could, of course penetrate channel sands by simply going into the abandoned meander channels that are still visible on the present floodplain surface.

One might ask: Where is the modern analog of such a situation? We believe that we have an equivalent modern analog on the other side of the Aegean Sea in the Gulf of Malia in the lower floodplain of the Spherchios River delta to the north of the ancient battle site of Thermopylae in the region of ancient Phokis in eastern Greece[35]. Here, W. M. Leake published an excellent map of the Spherchios delta as evolving in the late eighteenth and early nineteenth century[36]. Clearly at that time, people had developed the lower Spherchios delta region for agricultural and salt production purposes and had diverted the river to flow around a broad region of rice cultivation (fig. 17). As in the Cayster River delta of one to three millennia ago, no coastal barriers occur in the lower delta region of the Spherchios River. This is attributed to the fact that the sand and gravel size sediments carried by the Spherchios River distributaries are limited to only the sedimentary bedloads of narrow distributaries. A coarse sand sediment load is deposited on higher slope floodplain aggradation surfaces upstream. A similar situation existed in the sedimentary deposits of the ancient Cayster (Küçük Menderes) River floodplain. Indeed, it appears that the much broader floodplain of the Küçük Menderes River east of the Belevi Gorge has formed a natural sediment trap for the coarser sediments. Until aggradation of the surface of the floodplain reached a critical slope, large amounts of coarser clastics (sands and gravels) were not transported downstream through the narrow, lower river distributaries. We estimate that the major influx of sand into the Aegean Sea occurred in the lower Cayster River delta in late Byzantine time – the beginning of the construction of the barrier accretion plain that now lies along the low-lying westerly end of the modern Küçük Menderes delta-floodplain system.

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[35] Kraft et al. 1987; J. C. Kraft, Geology of the Great Isthmus Corridor, in: E. W: Kase – G. J. Szemler – N. C. Wilkie – P. W. Wallace (eds.), The Great Isthmus Corridor Route (1991) 1–16 figs. 1, 1–1, 13 pls. 1, 1–1, 14; G. J. Szemler – W. J. Cherf – J. C. Kraft, Thermopylae. Myth and Reality in 480 B.C. (1996).

[36] W. M. Leake, Travels in Northern Greece II (1836).

This assumption of modern/ancient analogs and correlative geomorphic features becomes very important when we examine the potentials of people occupying the lower floodplain regions adjacent to and north of the environs of Ephesus in the past two millennia. We note that eighteenth and early nineteenth century Greek peoples (pre-mechanized agriculture) were occupying over 25 km² of the lowermost Spherchios River delta in a manner clearly possible to the northeast of the Artemision in Hellenistic and Classical times and to the north and northwest of the city of Ephesus in Roman/Byzantine times (see paleographic maps herein, figs. 10 and 15).

Occupancy of the Lower Delta Floodplain in Antiquity

Whether the broad delta floodplains were occupied as they evolved during the progradation of the Cayster River delta to the ancestral Gulf of Ephesus remains an open question. In 1997, the foundation of a large villa or other building of marble and Roman brick, buried under 1 m of alluvium, was discovered in a field north of the Pamucak highway and airport west of Ephesus (fig. 15). A marble statue was recovered at the 'villa'. While we are not certain as to the precise age of this structure, it is tentatively dated ca. 500 AD or younger. This finding of a major building on the lower delta floodplain was surprising. Nevertheless, there is considerable evidence that lower delta floodplains were occupied throughout antiquity to present time (see fig. 15). These newly created lands are extremely fertile and excellent areas in which to develop wet crop agriculture such as rice, or with proper diversion and drainage, other drier agriculture. Further, the lowest (coastal edge) of these floodplains, albeit extremely low-lying and muddy, have served as constructed saltpans and were major sources of salt throughout antiquity in western European and Mediterranean regions[37]. We refer the reader to W. M. Leake and his map of the lower Spherchios River delta at the head of the Gulf of Malia in eastern Greece[38]. In fact, the record of occupancy of low-lying coastal zones in Greece frequently shows intensive agricultural development or commercial salt industry development throughout antiquity. The pre-barrier accretion plain and low-lying delta of high Byzantine times probably was very similar to the lower Spherchios River delta in the Gulf of Malia. With the discovery of the significant buildings on the delta floodplain ca. 500 AD or later, the probability must be raised that there may be large numbers of such structures scattered across and buried in the shallow alluvium of the lower Cayster River delta floodplain.

Conclusions

We have shown that intensive drill core studies of the sedimentary sequences in the prograding delta floodplain and shallow marine embayment regions of the ancestral Gulf of Ephesus in the vicinity of the ancient city of Ephesus and the Artemision can be used to make precise paleogeographic reconstructions in some regions and to at least shed light on the geomorphology of the remainder of the lower delta regions. Of particular interest, as presented herein, is our combination of statements from history, the classics, and epigraphy with the archaeological and sedimentologic records. Supplemented with C-14 data, our map interpretations show the evolution of ancient coastal morphologies from the Neolithic to the present. We hope that such an approach will encourage the future utilization of such interdisciplinary studies in research on the Cayster River delta floodplain as well as in other coastal geomorphic situations or configurations in the Mediterranean region.

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[37] Ibidem; Kraft – Aschenbrenner 1977.

[38] Leake (note 36).

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See also H. Zabehlicky[39] for a discussion of harbor peripheral structure elements, C. Foss[40] for an intensive review of Ephesus and its harbors in 'late antiquity', and R. Meriç[41] for a review of the problems in identifying the locale of the late Ephesus harbor of Panormus.

Note
We have used geologic reasoning (or logic) in our interpretation of the historical record. We are natural scientists and we tread in the footsteps of epigraphers, historians, and archaeologists with some trepidation, but no less enthusiasm in our attempts to reconstruct landscapes of ancient times.

Appendix:
Pertinent Comments from the Literature and Epigraphy[42]

A) Androclus founded the Ionian Colony at Koressos Harbor circa 1000 BC

Kreophylos tells the legend of how Androclus came to Ephesus. Androclus had searched for a long time for a suitable place for a colony but had found nothing: he turned to the oracle of Apollo and there received the response that he should settle at the place a fish would show him and to which a wild boar would drive him. The oracle was fulfilled on a beautiful day when Androclus made a picnic at the shore. Fishermen were also resting there, and one had placed fish on the fire. A fish jumped from the coals, a flaming piece of vegetation (cabbage?) ignited a reed, and a wild boar saved itself from the burning reed by running onto a mountain flank. Androclus pursued the

[39] H. Zabehlicky, Preliminary Views of the Ephesian Harbor, in: H. Koester (ed.), Ephesos. Metropolis of Asia, Harvard Theological Studies 41 (1995) 201–215.
[40] Foss (note 30).
[41] Meriç (note 34).
[42] Helmut Engelmann kindly provided the notes, A through L. We, of course, accept all responsibility for any errors in translation or interpretation.

beast, killed it, and constructed his colony at that place. So goes the legend. The place at which the fishermen rested is described as follows: »... it is said that the fishermen prepared their meal there, where the foundation [source] is which Hypelaios called, and which [is] the sacred harbor.«[43]

B) Meter (Cybele) Sanctuary

The sanctuary of Meter and the sacred precinct of the ἴεοὶ πατρῶιοι was located on the northern slope of Mount Panayır (herein called Pion). Androclus had once settled at this slope; he had built the lower city at the Koressos harbor and the upper city on a mountain side above the harbor[44]. Its two settlements existed for a long time: only King Croesus forced the resettlement to the upper city and forced the settlers to give up the Artemision. The oldest inscriptions in the temple precinct of the ϑεοὶ πατρῶιοι occurred a few decades after Croesus forced resettlement (ca. 600 BC). The grandsons and great-grandsons of the colonists would have recalled their (ancestors') dedications and no doubt remembered that the old family associations had a religious sanctuary to the ϑεοὶ πατρῶιοι, and their fathers had lived on the northern slope of Mount Panayır.

Meter (Cybele) was not the only mistress of the precinct (district) in this era, she shared it with other gods who bore the titularly epithet πατρῶιος. Apparently the cult of the ϑεοὶ πατρῶιοι diminished with the founding of Lysimachean Ephesus and the resettlement combined with it. The Great Mother became again the sole mistress of the temple precinct on Mount Panayır, just as she had no doubt already been before the immigration of the Greeks (ca. 1000 BC).

C) The Koressos Settlement in the Sixth Century (Hdt. 1, 26)

The Koressos settlement was seven stadia distant from Artemision. An inscription from the Roman Empire (second century AD) mentions Koressians *from the gate up to the Stadion*[45]. The Stadion is known: it lays on the north side of Panayırdağ. The gate, which is mentioned in the inscription, is not known. If Herodotus and the inscription are combined, they indicate that the Koressos settlement lays on the north side of Panayırdağ. The settlement reached up to the Stadion in the Roman Imperial period. The orator Aelius Aristeides (second century AD) speaks of a »Gymnasium in Koressos«[46]. It is generally assumed that this refers to the Gymnasium of Vedius. If this assumption is correct, we are again on the north side of Panayırdağ and at the altitude of the Stadion.

However, we must reconsider the distance: seven stadia in the light of reconstructed paleo-geographies of 1000 BC (Ionian times) to Archaic time when the Artemision was constructed. Seven stadia must be measured in 'distance walked', not 'as the bird flies'.

[43] Kreophylos in Athen. 8, 62 p. 361c–e; FGrH 417 F 1; Strab. 14, 1, 21.
[44] see Engelmann (note 22) 134.
[45] IvE 730; Engelmann (note 22) 133.
[46] Aristeid. 2, 82, p. 413 (Keil).

D) Otto Benndorf on the Sacred Harbor[47]

»When wandering foreigners, the Greeks had preserved the seat of the great nature goddess, who reminded them of their Artemis, before the gates of the existing settlement not within it. Here, as can already be presupposed from Pliny, was the Sacred Harbor of Ephesus which Strabo no longer knows. Hence, the sanctuary opening toward the west was the 'port sanctuary' of the city of which the asylum laws wrote from the time of the city's founding when it protected strangers (together) with the goods of the Emporium. In every respect this elucidates and mentions the tradition of the older city, this neighbour relationship of the Artemision and the city.«

Speaking of the mountain (hill) Ayasuluk: »… along the entire geographical length of its peak, voyages into the Gulf [of Ephesus] could be monitored. On all sides, ascending freely from the plain, it [the mountain Ayasuluk] resembles something like the limestone Athenian hill fortress [the Acropolis of Athens]. … At the edge of the Primary Gulf in early historic times the known Sacred Harbor was already avoided by warships around the turn of the sixth–fifth centuries BC.«[48] (cf. fig. 6).

E) Pausanias describes the Separation of the Koressos Quarter of Ephesus

According to Pausanias 5, 24, 7 (second century AD), the cities of Knidos and Ephesus had a peculiarity. In both cities there are quarters which were clearly separated from the rest of the city. In Knidos these were the so-called Cherronese; they lived on an island, with the city quarters on the mainland. In Ephesus, the Koressians were separated from the other city quarters. J. Keil, assuming the separation was the city wall, located the upper and lower cities near the Stadion, presumably with the Koressos harbor immediately below. However, in Herodotus' time, seven stadia to the stadion location would be across the waters of the ancestral Gulf of Ephesus and the Sacred Harbor; whereas, by land seven stadia distance only reaches to northeast Mount Pion by the Meter/Cybele Sanctuary (fig. 6).

F) A Clue from a Fragment of the Poet Archestratus of Gela (fr. 143)[49]

It confirms that the Selinus in Hellenistic time carried (or conveyed) brackish water: a certain fish that requires brackish water throve extremely well in this river (namely) at the Artemision. »The [fish] Aurata from Ephesus, do not disregard the fat ones, that the people there [in Ephesus] call Ioniskos, take it, the product of the exalted Selinus … .« Archestratus of Gela was a contemporary of Alexander the Great; we are therefore in the second half of the fourth century BC. The poet wrote an epic about good food and drinking, but only a few verses of his 'epicurean letter' remain.

The Aurata is »a sea-fish, but frequenting the inshore waters or the estuaries. … Cuvier says ›they gather in large number at the mouth of rivers … this fish does not leave the shore and enters into salty ponds, where it fattens up considerably‹.«[50].

Xenophon relates in Anabasis 5, 7, that there were many fish and mussels in the Selinus (he says nothing about water salinity).

47 O. Benndorf, FiE I (1906) 23.
48 Ibidem 43.
49 Lloyd-Jones – Parker (note 24) fr. 143.
50 D. A. W. Thompson, Glossary of Greek Fishes (1947) 292.

G) Athenian Army attacks Ephesus

In the summer of 409 BC, the Athenian Thrasyllos attacked Ephesus which Tissaphernes successfully defended with the support of other allies. The incident is recounted in Xenophon, Hellenica 1, 3, 1–10, by Diodorus of Sicily 13, 64, 1, and in a new papyrus fragment of Hellenica Oxyrhyncia[51]. The Athenians advanced against the city on two sides: one citation from the papyrus reads, »... but when [the Ephesians] saw Thrasyllos and his troops just arriving, they met them in a battle near the harbor called Koressos.«[52].

H) Livy on the Entrance to the Harbor of Ephesus in 190 BC

The Roman/Rhodian/Pergamene allied fleet tried to attack the fleet of the Seleucid king, Antiochus III, trapped in the harbor of Ephesus. The 'allied' fleet anchored for days on the high sea before the harbor of Ephesus. Finally the Roman commander lost patience and proposed to his allies to block the egress from the Ephesian harbor. That would be a simple venture: one had only to sink several heavily loaded cargo ships at the harbor outlet, and the harbor would be completely blocked, *quod in fluminis modum longum et angustum et vaduosum ostium portus sit,* »because the mouth of the harbor was like a river: long and narrow and full of shoals« (Liv. 37, 14–15).

I) Attalus II Philadelphus makes a big Mistake

Strabo, writing at the time of Tiberius, referred to the time of Attalus Philadelphus II (159–138 BC): »The city has both an arsenal and a harbor. The mouth of the harbor was made narrower by the engineers, but they, along with the king who ordered it, were deceived as to the result. I mean Attalus Philadelphus; for he thought that the entrance would be deep enough for large merchant vessels – as also the harbor itself, which formerly had shallow places because of silt deposited by the Cayster River – if a mole were thrown up at the mouth, which was very wide, and therefore ordered that the mole should be built. But the result was the opposite, for as the silt, thus hemmed in, made the whole of the harbor, as far as the mouth, more shallow. Before this time the ebb and flow of the tides would carry away the silt and draw it to the sea outside.« (Strab. 14, 1, 24).

Attalus II Philadelphus and his engineers had created an ideal settling basin.

J) Efforts to clean the Harbor

1) Under Nero Caesar (54–68 AD) the *proconsul* Soranus tried to clear the Ephesian harbor (Tac. ann. 16, 23).
2) Around 100 AD, the *prytanis* C. Licinius Maximus Julianus gave gold for the further expansion of the harbor (IvE 3066, lines 14–15).
3) At the beginning of the second century AD, the archpriest T. Flavius Montanus paid 75 000 *denarii* for the enlargement of the harbor (IvE 2061).
4) In the middle of the second century AD the *proconsul* L. Antonius Albus prohibited the dumping of heavy loads from the bulkhead (sheet piling wall) of the harbor canal and sawing up building material and to throwing the emery and stone dust into the canal (IvE 23).
5) At the beginning of the third century AD, an archpriest gave 20 000 *denarii* in order to clean the harbor: ... δόντα καὶ ἐν τῷ καιρῷ τῆς ἀρχιερωσύνης εἰς τὴν ἀνακάθαρσιν τοῦ λιμένος δηναρίων μυριάδας δύο ... (IvE 3071).

[51] L. Koenen (ed.), Studia Papyrologica 15 (1976) 55–67 and 69–76; cf. G. A. Lehmann, ZPE 26, 1977, 181 ff.; H. Wankel, ZPE 29, 1978, 54 ff.

[52] Koenen (note 51) 57 (lines 10–12).

6) In the middle of the third century AD, the politician Valerius Festus enlarged the harbor *as* [if] *Croesus himself had been able to do it*[53].

K) Hadrian Caesar undertook a forceful Effort to protect the Harbor of the City (129 AD)

He diverted the Cayster and let a large dam [ohoma levee] *store up* [the sediment]. *He made the harbor further accessible and diverted the River Cayster, which* [had] *caused serious damage to the harbor.*[54] The inscription comes from the year 129 AD and mentions several harbors. The Cayster River damaged all harbors of the city, not only the Great Harbor. Hadrian (117–138 AD) diverted the river in order to contain the damage which the Cayster incurred. The damages that occurred were the reason of his actions.

The city of the Ephesians had erected a dam of 60 feet [= 18 m] *on the right bank of the Manthites River at the command of Caesar.*[55] The inscription was found when a lemon grove was being laid out on the street towards Zeytinköy, a few meters from where this street branches off from the main thoroughfare of Selçuk–Izmir. The workers stated that the stone was found *in situ*, if true, Manthites was the ancient name of the river which comes down from the Şirince Valley, before it was named the Klaseas River.

L) Artificial Islands and Transfer of Cargos (west of the Great Harbor)

At the end of the second century AD the millionaire, sophist, and politician Titus Flavius Damianus constructed artificial islands in order that cargo ships could anchor safely in the 'island harbors' and transfer their cargo to the city[56].

In the fifth century AD (431 AD), the harbor basin in the center of the city still was in operation, seaworthy ships went about, dropped anchor (outside the harbor), and loaded their cargo on barks that reached the inner city harbor above the runoff channel[57].

The Coptic text quoting a Byzantine bishop says: »Because our ship could not travel inside the harbor, ... I boarded a small boat [or barge] ...«[58].

M) Byzantine Harbors (Seventh Century AD and later)

»When the Byzantine walls were built in the seventh or eighth century, the Harbor evidently still functioned for the fortifications came down to its edge and include a town to protect the port. Writers of the time frequently mention Ephesus as a port, but by the early ninth century it was no longer adequate for the Byzantine fleet, which sailed instead from Phygela on the coast to the southwest. ... After the ancient harbor fell into disuse, a new port was established three kilometers down the river. This site is well known from the fourteenth and fifteenth centuries when it was the commercial center of Ephesus and the base of the Italian merchants who frequented the area. ... After the fifteenth century, this port also apparently succumbed to silting ... Ephesus lost all commercial importance.«[59] G. Hess[60] reinforces the locale of the outer harbor of Ephesus, (Panor-

[53] D. Knibbe – B. İplikçioğlu, Neue Inschriften aus Ephesos IX, ÖJh 55, 1984, 130 f.
[54] IvE 274.
[55] D. Knibbe – B. İplikçioğlu – H. Engelmann, Neue Inschriften aus Ephesos XII, ÖJh 62, 1993, 122 no. 12.
[56] Philostr. soph. 2, 23.
[57] Engelmann (note 29) 134.
[58] see the Coptic narrative about Abbot Victor: Engelmann (note 27) 134.
[59] Foss (note 30) 185 f.
[60] Hess (note 33) 1–12.

mus, of the eighth century AD) as located by A. Schindler's 1897 map[61], at the base of the Kenchrios valley, »2.5 km. west of Ephesus«, based on the 723 AD visit of Willibald as documented by his biographer, Hugelburc in 778 AD. Other distances from the eighth century reference suggest that Phygela, the harbor for the ninth century Byzantine fleet, was either at the locale of modern Kuşadası to the southwest or in the small, open Aegean Sea embayment at the modern resort of Pamucak due west of Ephesus on the Aegean coast.

N) An alternate Location for the late Byzantine/Turkish Harbor – Panormos

Contrary to G. Hess, R. Meriç locates the outer harbor of Panormos at the northwest corner of the marine/delta interface of late Byzantine times, near the modern town of Zeytinköy: »A toponymic reference supports our identifying Panormos with Alaman Gölü. The region around Alaman Gölü at present bears the name Pananos. We believe we can recognize a continuation of the name Panormos in this word, although the lake at a later time was renamed into Alaman Gölü, after formerly belonging to a German farm.«[62]

The outer harbor Panormos played a significant role during the fourteenth century AD as the most important naval and commercial port during the rapid development of the Aydınoğulları dynasty. At that time Ayasuluk (Altoluogo) was located far from the sea. The Ephesian region was silted up through the actions of the Cayster for the most part; a direct connection between the open sea was no longer available. The only possibility consisted in construction of a paved course through the alluvium to the port. Extensive remains of such a course still exist in the eastern part of Alaman Gölü south-southeast the village of Zeytinköy. This ancient course (road), 3.50 m wide, lies approximately 1 m above the modern corridor level. There are numerous pieces of building material carried off from Ephesus, where the foundation was laid with small stones using architectural blocks. The course indicates underpasses at intervals of every 20 m which should have enabled water presumably stored in the swamps or alluvium to flow out.

The historical events of the fourteenth century AD clearly indicate that Ayasuluk had one (or more) harbors. On July 12, 1319, a Turkish fleet sailed from Ayasuluk in order to besiege Chios. Umur Bey conquered Izmir in the year 1329 after an expedition that he initiated from the port of Ayasuluk. A second expedition to Chios followed shortly after this.

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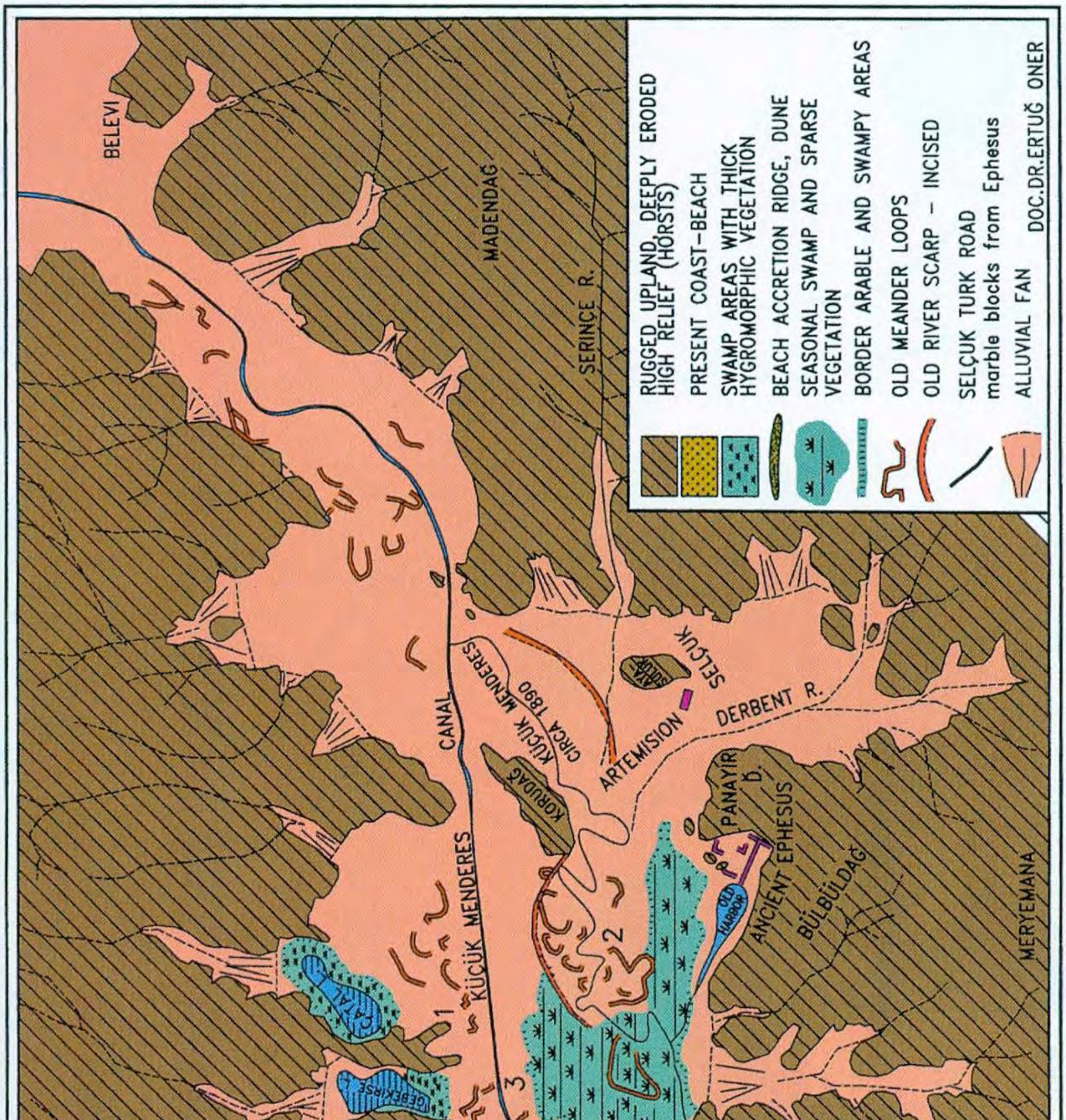
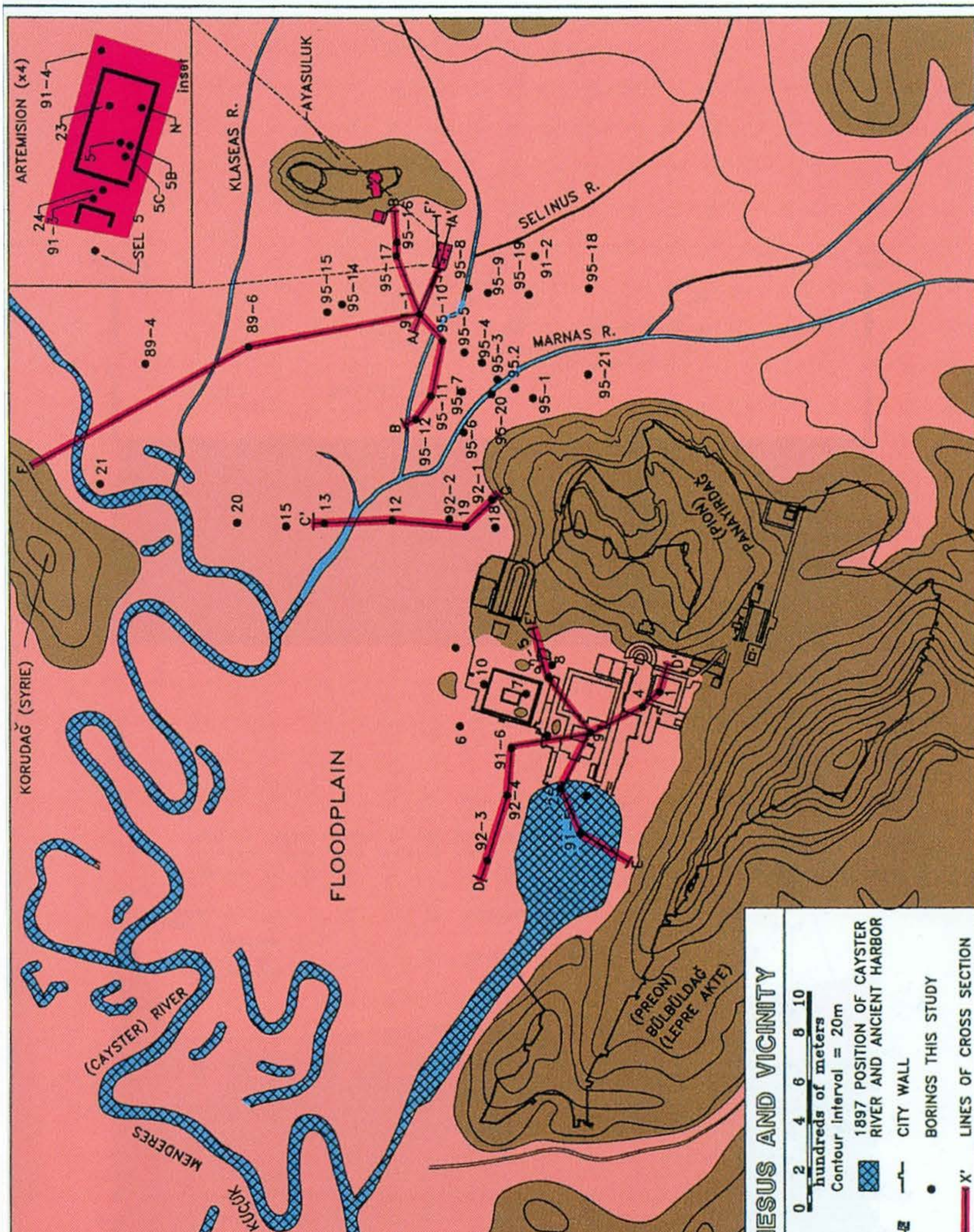
References of figures: Fig. 1–17: All figures by the authors.

[61] A. Schindler, Umgebung von Ephesos, 1:25 000, in: FiE I (1906).
[62] Meriç (note 34) 30–32.

FIGURES 1-17

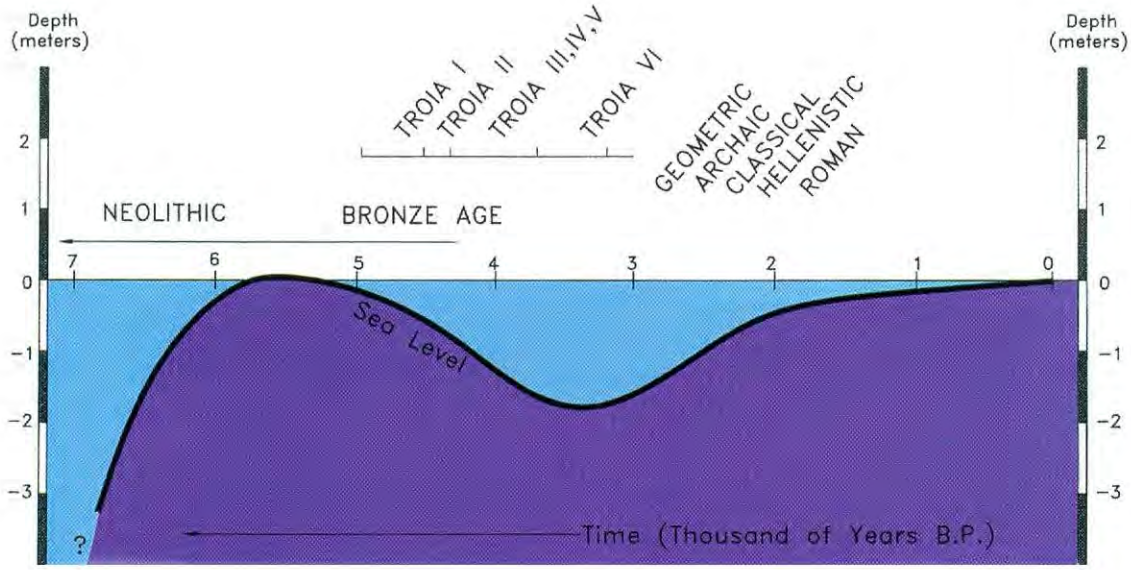


1 Physiographic map of the Küçük Menderes (Cayster River) floodplain showing sedimentary environments and their morphologies. 1 = old river channel oxbows, 2 = abandoned young river channels, and 3 = modern drainage/irrigation canal. Photogeomorphic study by Dr. Ertuğ Öner.

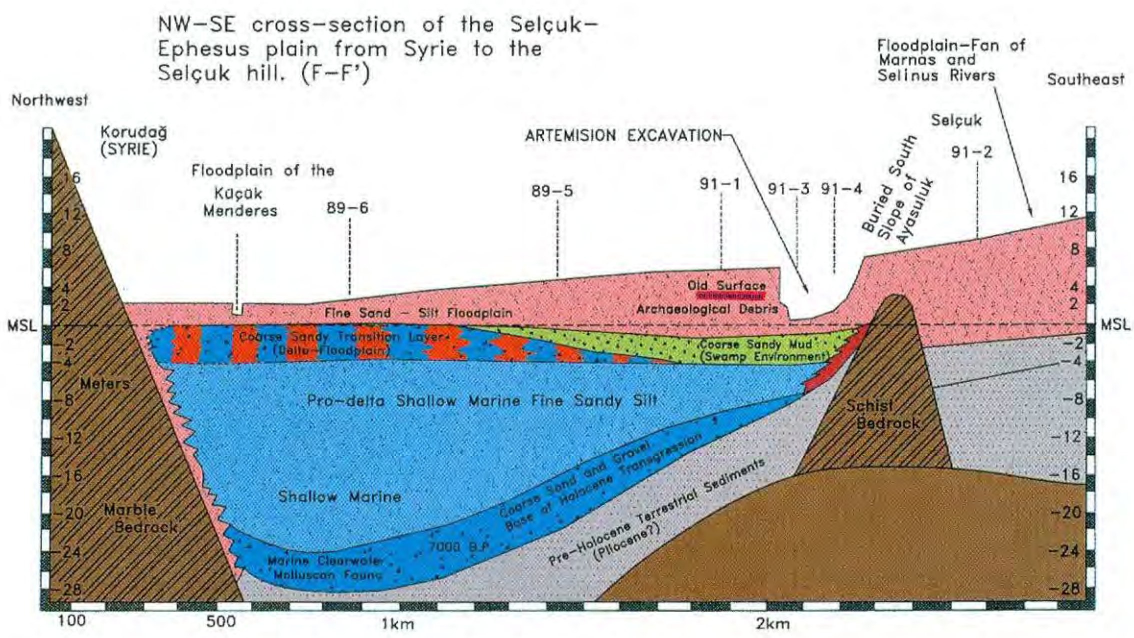


2

2 The vicinity of Ephesus and the Artemision in their nineteenth century environmental settings showing our lines of cross-section and geologic borings used in this study. Based on a map by A. Schindler, 1897. The city walls of Lysimachus (early Hellenistic) are shown in relation to the flanking mountainous terrain.
See A. Bammer, Das Heiligtum der Artemis von Ephesos (1984); St. Karwiese, Groß ist die Artemis von Ephesos (1995); P. Scherrer (ed.), Ephesos. Der neue Führer (1995) resp. idem (ed.), Ephesus. The New Guide (2000); and E. Akurgal, Ancient Civilizations and Ruins of Turkey (1985) for detailed summaries of the archaeological sites and site histories of Ephesus.



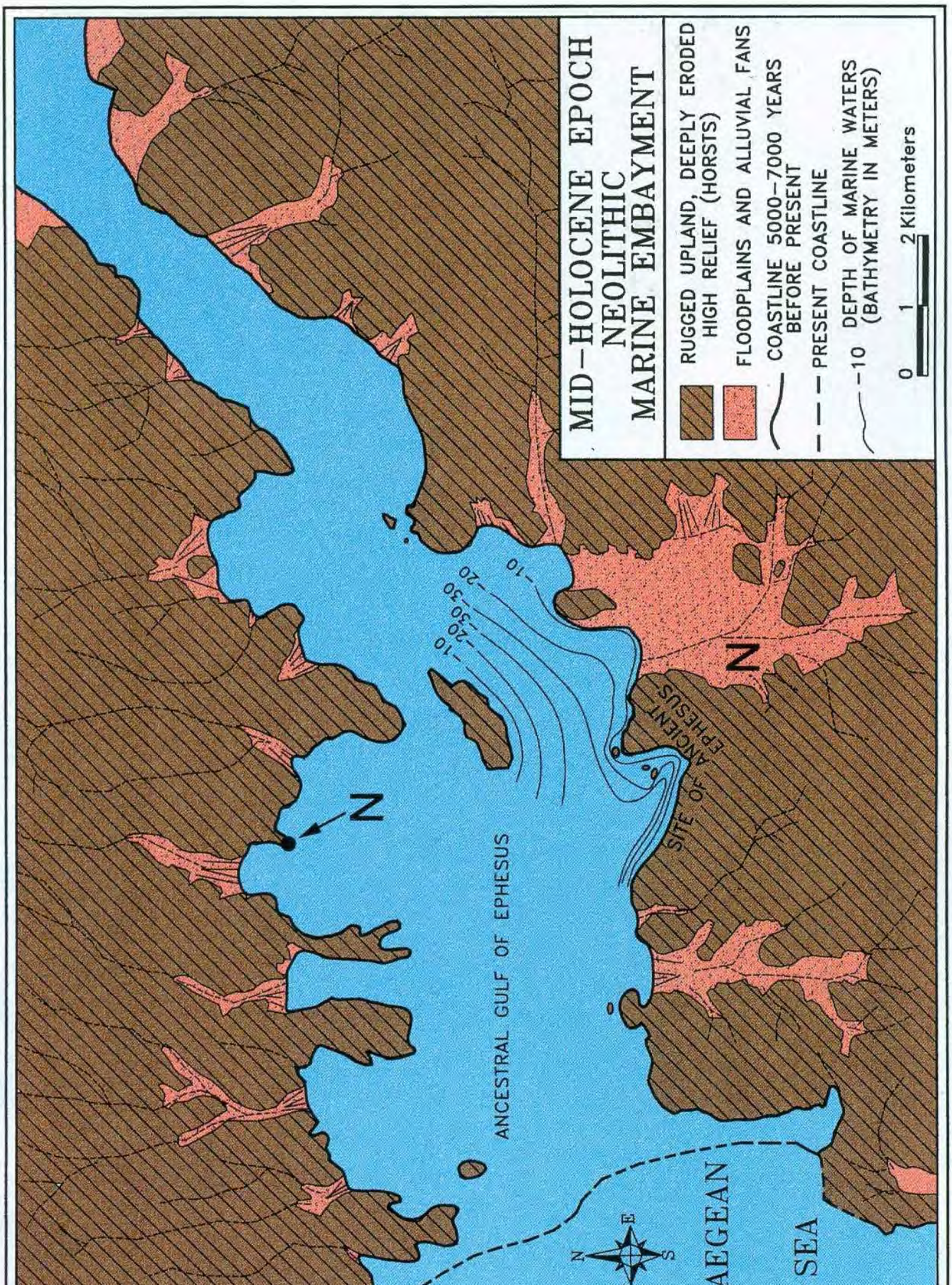
3



4

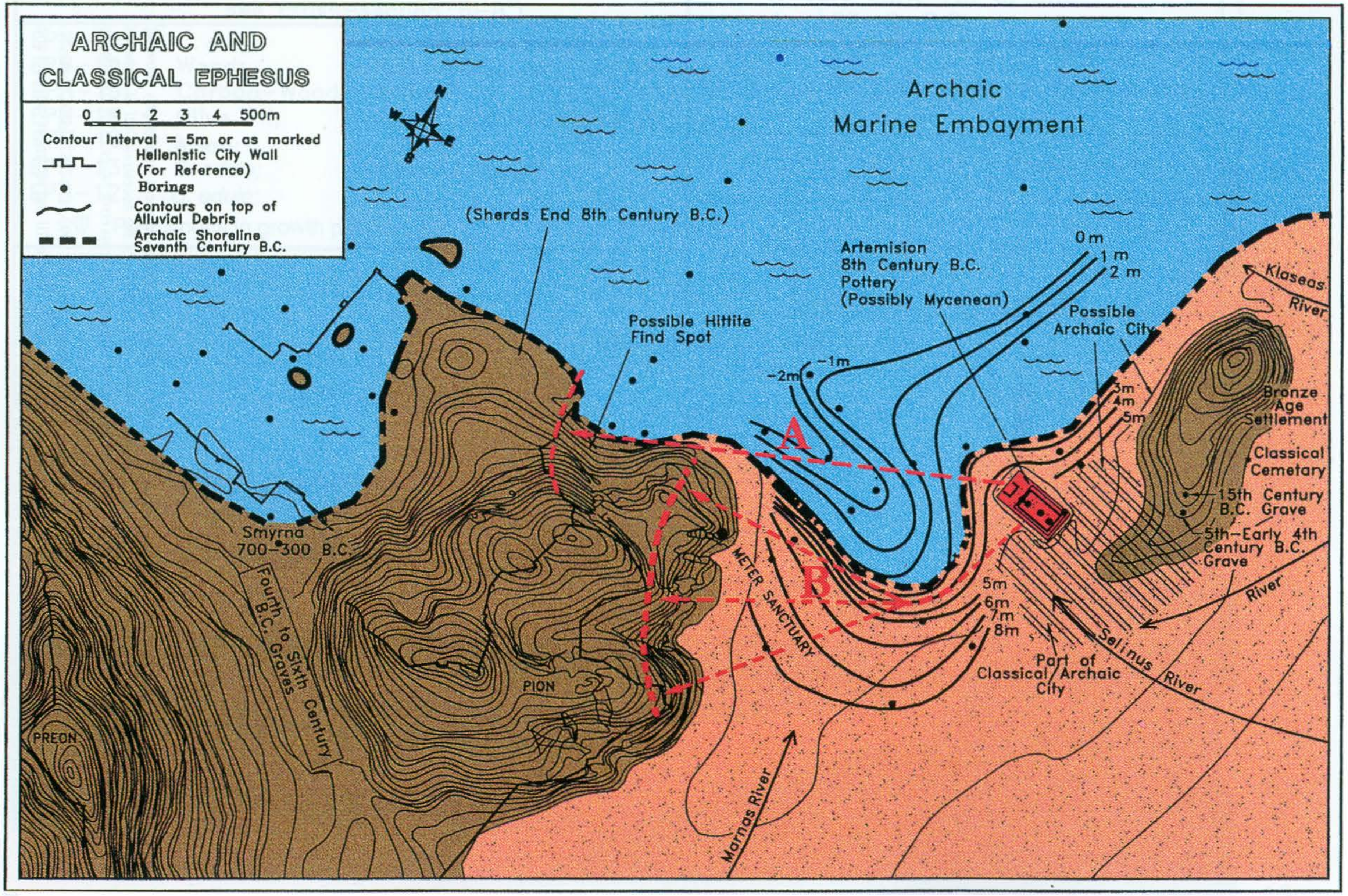
3 A eustatic sea-level curve for the western shore of Anatolia, based on studies of paleogeographic shoreline reconstructions at Troy and other sites along the Aegean coast (Kayan [note 9:1988] and idem [note 1:1991]). The rising sea level during the Holocene Epoch reached present sea level about 6 000 years ago, then dropped about 2 m between 3500–3000 BP, and finally approached its present level again about 2000 BP.

4 A geologic cross-section across the floodplain of the Küçük Menderes River between the Artemision/Ayasuluk hill and the mid-floodplain outlier Korudağ (former island Syrie). The higher surface of the floodplain in the vicinity of the Artemision is formed partly of colluvium from Ayasuluk and mostly of torrential sediments of the Klaseas, Marnas and Selinus Rivers tributary to the former Cayster River (Küçük Menderes). Although alluvial sediments dominate the upper portion of the cross-section, the major portion of the former marine embayment was infilled by shallow marine – pro-delta fine sandy silts. The basal Holocene transgressive sands and gravels indicate (based on a clear water molluscan fauna) a clear water marine embayment up to 28 m deep in the line of section ca. 7000 BP.

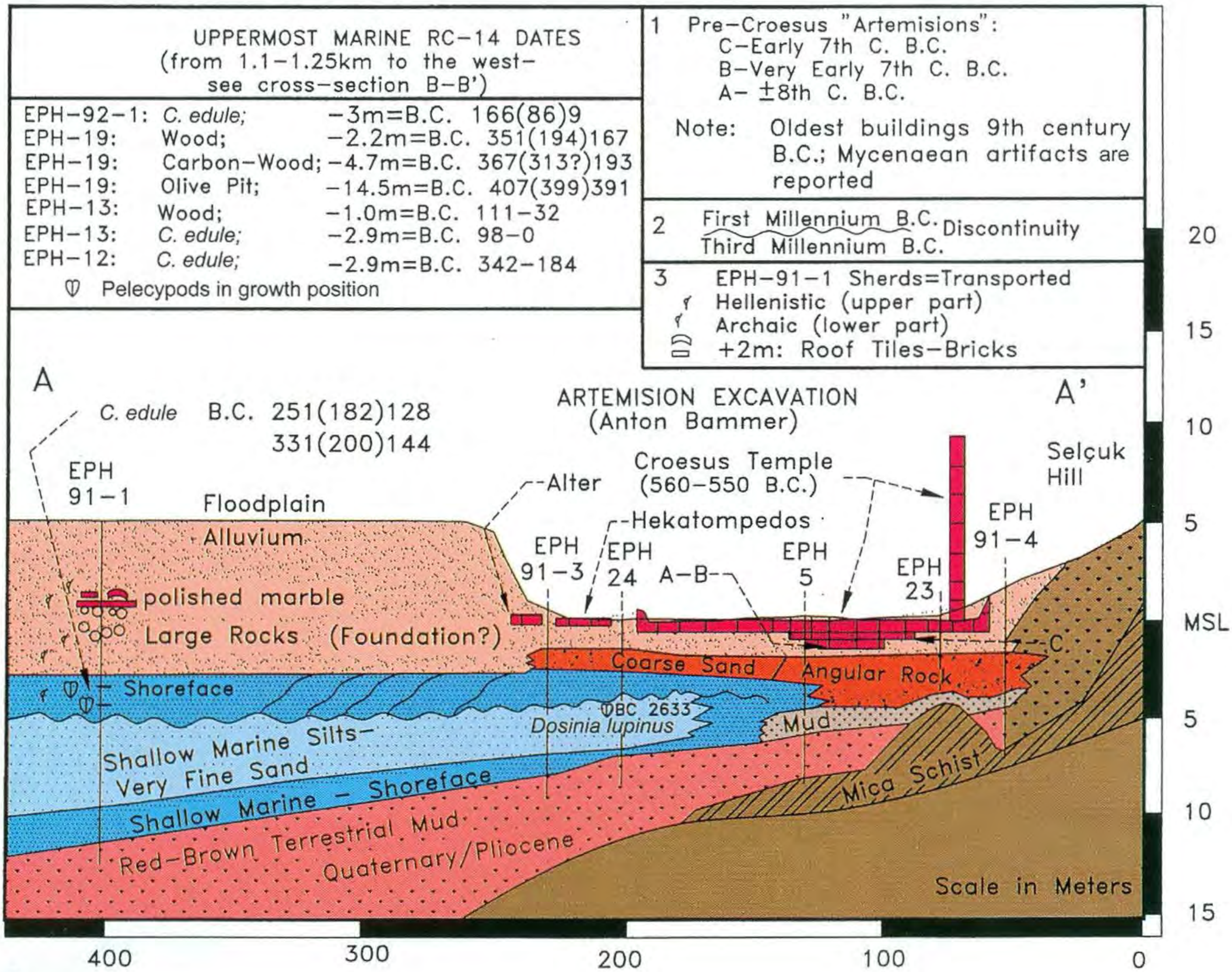


5

5 The mid-Holocene Epoch Neolithic marine embayment, the ancestral Gulf of Ephesus. Water depths at the peak transgression – 5 000–7 000 years ago – are shown in the vicinity of ancient Ephesus and the Artemision. Sea level was about the same as present day. N = two known Neolithic sites. Marine waters were greater than 30 m deep in the Neolithic.


ARCHAIC AND CLASSICAL EPHESUS
0 1 2 3 4 500m
Contour Interval = 5m or as marked
Hellenistic City Wall (For Reference)
Borings
Contours on top of Alluvial Debris
Archaic Shoreline Seventh Century B.C.
Archaic Marine Embayment
(Sherds End 8th Century B.C.)
Possible Hittite Find Spot
Artemision 8th Century B.C. Pottery (Possibly Mycenean)
Possible Archaic City
Klaseas River
Bronze Age Settlement
Classical Cemetary
15th Century B.C. Grave
5th–Early 4th Century B.C. Grave
Smyrna 700–300 B.C.
Fourth to Sixth Century B.C. Graves
METER SANCTUARY
PION
PREON
A
B
Part of Classical/Archaic City
Selinus River
River
Marnas River
0 m
1 m
2 m
-1m
-2m
3m
4m
5m
5m
6m
7m
8m

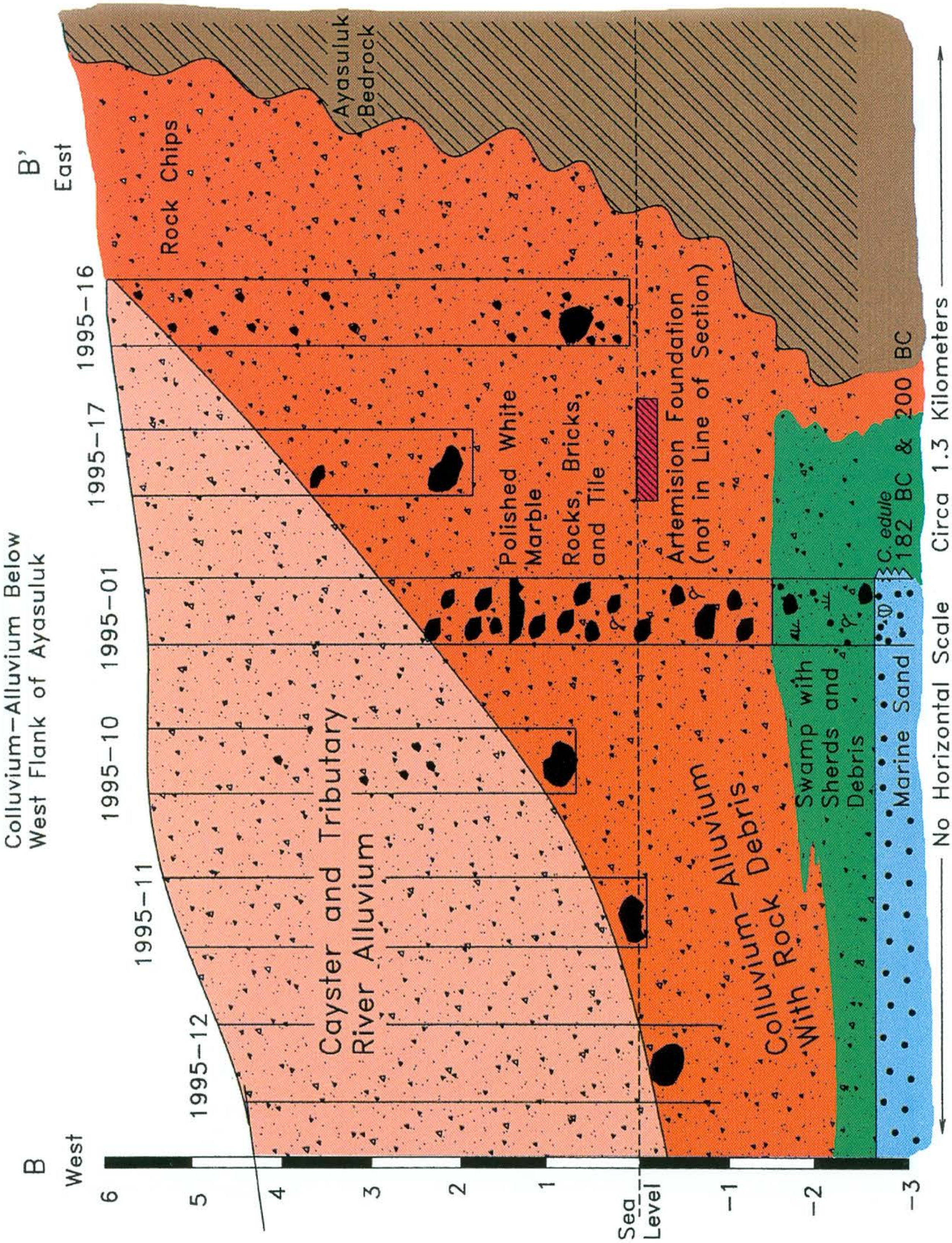
6 Paleogeographic map of the environs of Ephesus and the Artemision showing the configuration of the Archaic and Classical shoreline as related to the ancient cities of Smyrna and Ephesus and the Artemision of the 7th century BC. The Artemision was constructed in a beautiful coastal setting on the southern shoreline of the ancient Gulf of Ephesus, on a sedimentary projection (torrential alluvial fan?) immediately adjacent to the southern foot of Ayasuluk hill (outlier). Findspots of Archaic/Classical and earlier archaeological sites are shown.
Dots = drill cores for this study. Line A indicates seven stades from the Artemision 'as the bird flies' radius; while line B indicates seven stades distance by walking around the shoreline of the Archaic Sacred Harbor to the Koressos settlement (see Hdt. 1, 26).
Transgressing marine waters first reached the vicinity of the Artemision in the Neolithic, at which time the torrential alluvium of the Selinus and Marnas Rivers was confined to their valleys to the south of Ayasuluk (figs. 3. 5). After a 4th millennium BP regression of the sea, rising marine waters again approached the vicinity of the Artemision in the early 3rd millennium, now transgressing over Selinus River alluvium upon which the earlier 8th and 7th century BC temples were built (fig. 7). M. Kerschner dates active erosion and sediment infill in an alluvial channel under the eastern portion of the Croesus Temple to the early 7th century BC with a protective wall for the smaller temple of that time (M. Kerschner, Ein stratifizierter Opferkomplex des 7. Jh.s v. Chr. aus dem Artemision von Ephesos, ÖJh 66, 1997, Beibl. 85–226). Similarly, Kerschner reports another river channel under the middle of the Artemision complex in the 8th century (Michael Kerschner, oral communication). Thus, the Artemisions were clearly built upon an active alluvial plain. Our contours, as shown on the top of the coarse alluvial (boulder and cobble) debris, vary from the typical alluvial fan configuration because of tectonic subsidence along a north-south down faulted zone (graben), roughly parallel to the Selinus/Marnus valley (Vetters [note 25]). This colluvial/alluvial fan of coarse sand, gravel, and rock debris including some structural fill, was deposited by the ancient Marnas and Selinus Rivers. After final destruction and abandonment the ruins of the Artemision were buried within the later torrential deposits (i. e., 4 m of torrential alluvial debris has deposited since the 19th century AD in the vicinity of the new bus station at Selçuk to the south).
We envisage a narrow alluvial fan lobe protruding into the edge of the ancient Gulf of Ephesus. Immediately offshore waters were 1–4 m deep. Possible freshwater springs at the foot of the Paleozoic outlier (Ayasuluk) and buried sand and gravel channels of the nearby Marnas/Selinus Rivers provided water for the temple complex and the surrounding city of Ephesus in Archaic/Classical times.



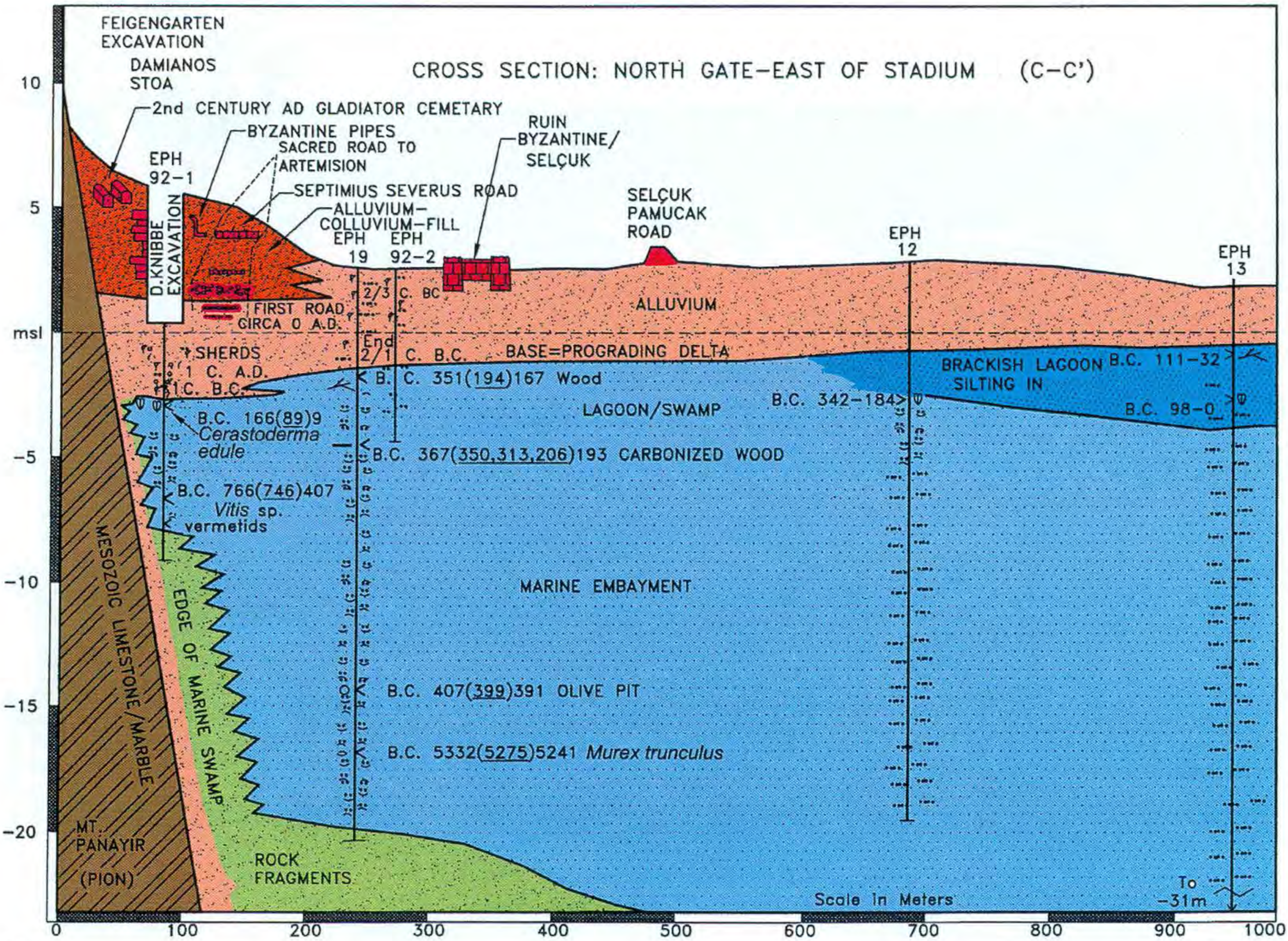
7

7 Stratigraphic cross-section A–A' (see fig. 2) through the Artemision excavation and adjacent stratigraphy showing the mid Late Holocene marine transgression and regression where the shoreline of the ancestral Gulf of Ephesus retreated away from the Artemision after 182–200 BC. Radiocarbon dates with 1 sigma error range (67% confidence level) with mid-intercept date shown.

See A. Bammer, Die Geschichte des Sekos im Artemision von Ephesos, ÖJh 62, 1993, 138–167; idem, Ephesos. Stadt an Fluß und Meer (1988) for details of the archaeological excavations into the fill and sediment substrate and analysis of the regional physiography of the archaeological sites of Ephesus.

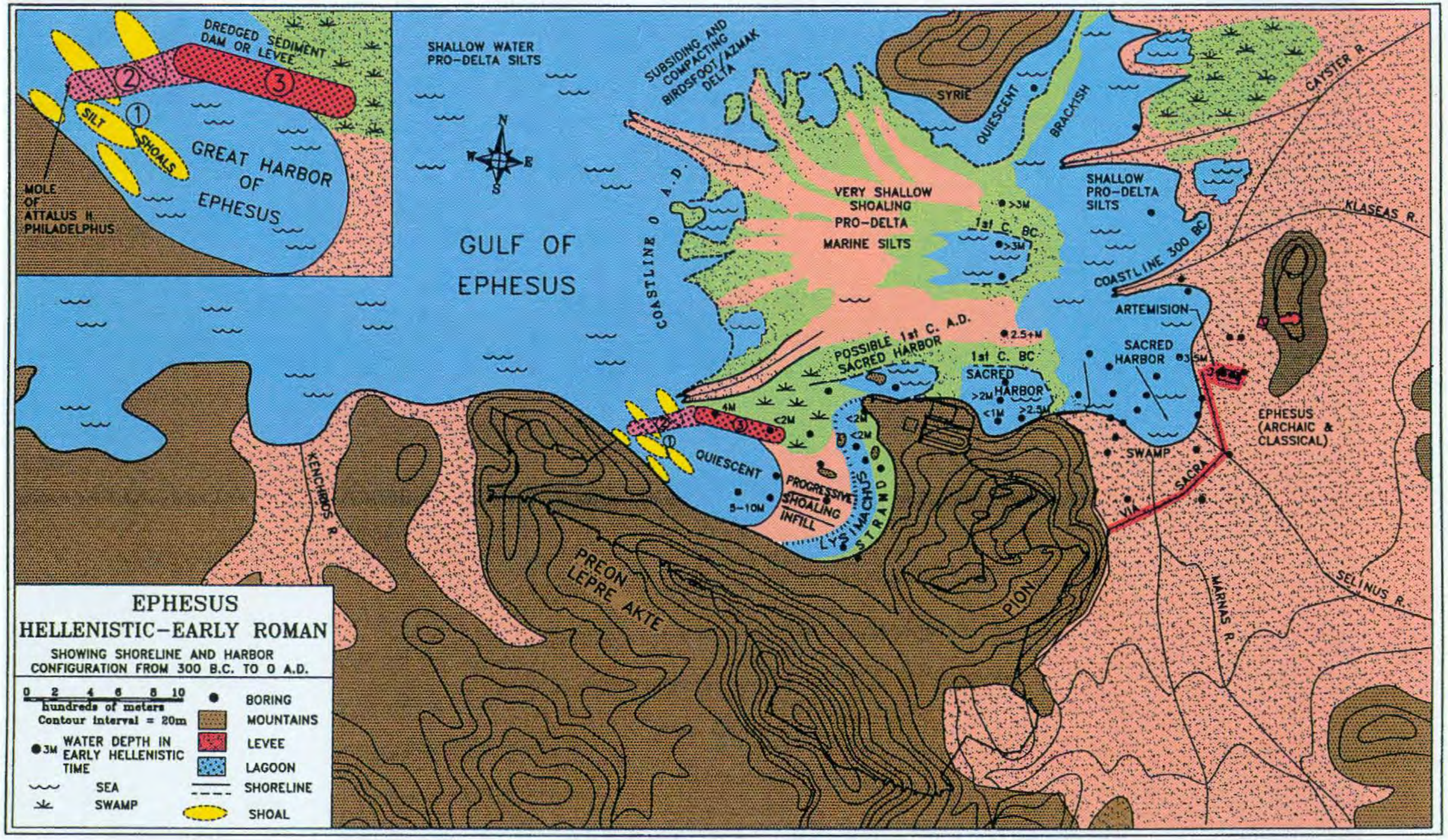


8 Stratigraphic cross-section B–B', showing the relationship of the Artemision to a colluvial/torrential alluvial fan (Selinus River) of coarse sediment and rocks upon which the Artemision was constructed and in which it was later buried. The Artemision complex lies about 200 m east-southeast of drill core 91-1 and is not in the line of section (see figs. 2 and 7).



9

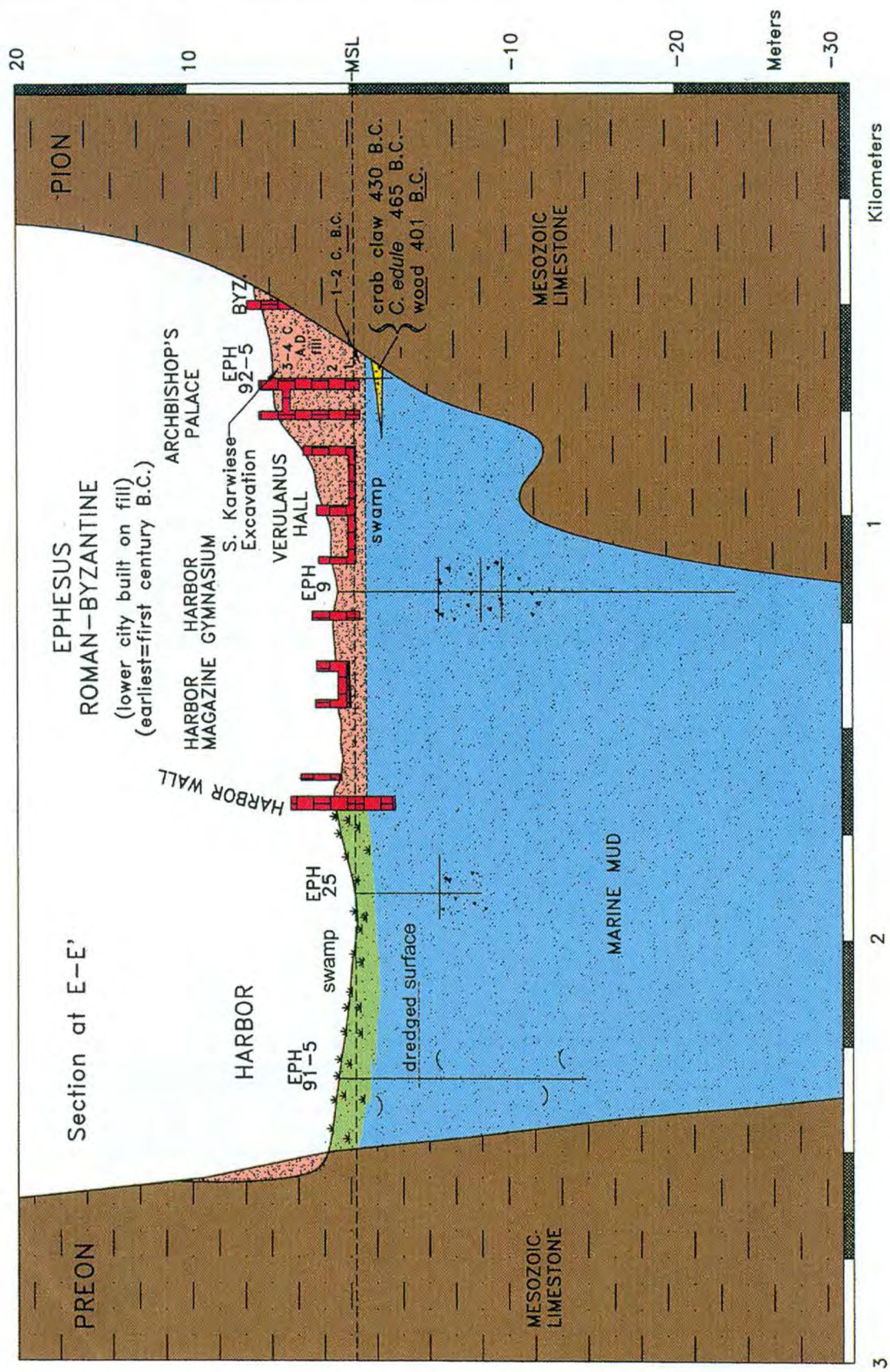
9 Stratigraphic cross-section C–C', from the 'Feigengarten excavations' (Damianos Stoa, north side of Mount Pion (Panayırdağ), second century AD extending northward across a portion of the Cayster River (Küçük Menderes) floodplain. The section illustrates the nature of the relatively thin alluvial sheet of sediment (Cayster River alluvium) which covers a relatively thick marine sediment section of very fine sandy silts. Radiocarbon dates shown may be used to date the incursion of marine waters and their depths in of the Gulf of Ephesus. The vertical series of 'sacred roads to the Artemision' were discovered in the 'Feigengarten excavation' by D. Knibbe and E. Trinkl (1993). Note that the earliest 'sacred road' from this northerly gate of the city of Ephesus to the Artemision is directly and specifically controlled by the presence of the first fluvial sediments in the area, and therefore the first land surface since early Holocene times. Radiocarbon dates with a 1 sigma error range at 67% confidence level with mid-intercept date are shown. All corrections are made including marine carbonate correction in $CaCO_3$ fossils dated.


EPHESUS
HELLENISTIC–EARLY ROMAN
SHOWING SHORELINE AND HARBOR CONFIGURATION FROM 300 B.C. TO 0 A.D.
0 2 4 6 8 10
hundreds of meters
Contour interval = 20m
3M WATER DEPTH IN EARLY HELLENISTIC TIME
SEA
SWAMP
BORING
MOUNTAINS
LEVEE
LAGOON
SHORELINE
SHOAL
DREDGED SEDIMENT DAM OR LEVEE
GREAT HARBOR OF EPHESUS
SILT
SHOALS
MOLE OF ATTALUS II. PHILADELPHUS
SHALLOW WATER PRO-DELTA SILTS
GULF OF EPHESUS
SUBSIDING AND COMPACTING BIRDSFOOT/AZMAK DELTA
COASTLINE 0 A.D.
VERY SHALLOW SHOALING PRO-DELTA
MARINE SILTS
SYRIE
QUIESCENT
BRACKISH
SHALLOW PRO-DELTA SILTS
COASTLINE 300 BC
CAYSTER R.
KLASEAS R.
1st C. BC
POSSIBLE 1st C. A.D. SACRED HARBOR
1st C. BC SACRED HARBOR
ARTEMISION
SACRED HARBOR
EPHESUS (ARCHAIC & CLASSICAL)
SWAMP
VIA SACRA
QUIESCENT
PROGRESSIVE SHOALING INFILL
LYSIMACHUS STRAND
KENCHRIOS R.
PREON LEPRE AKTE
PION
MARNAS R.
SELINUS R.

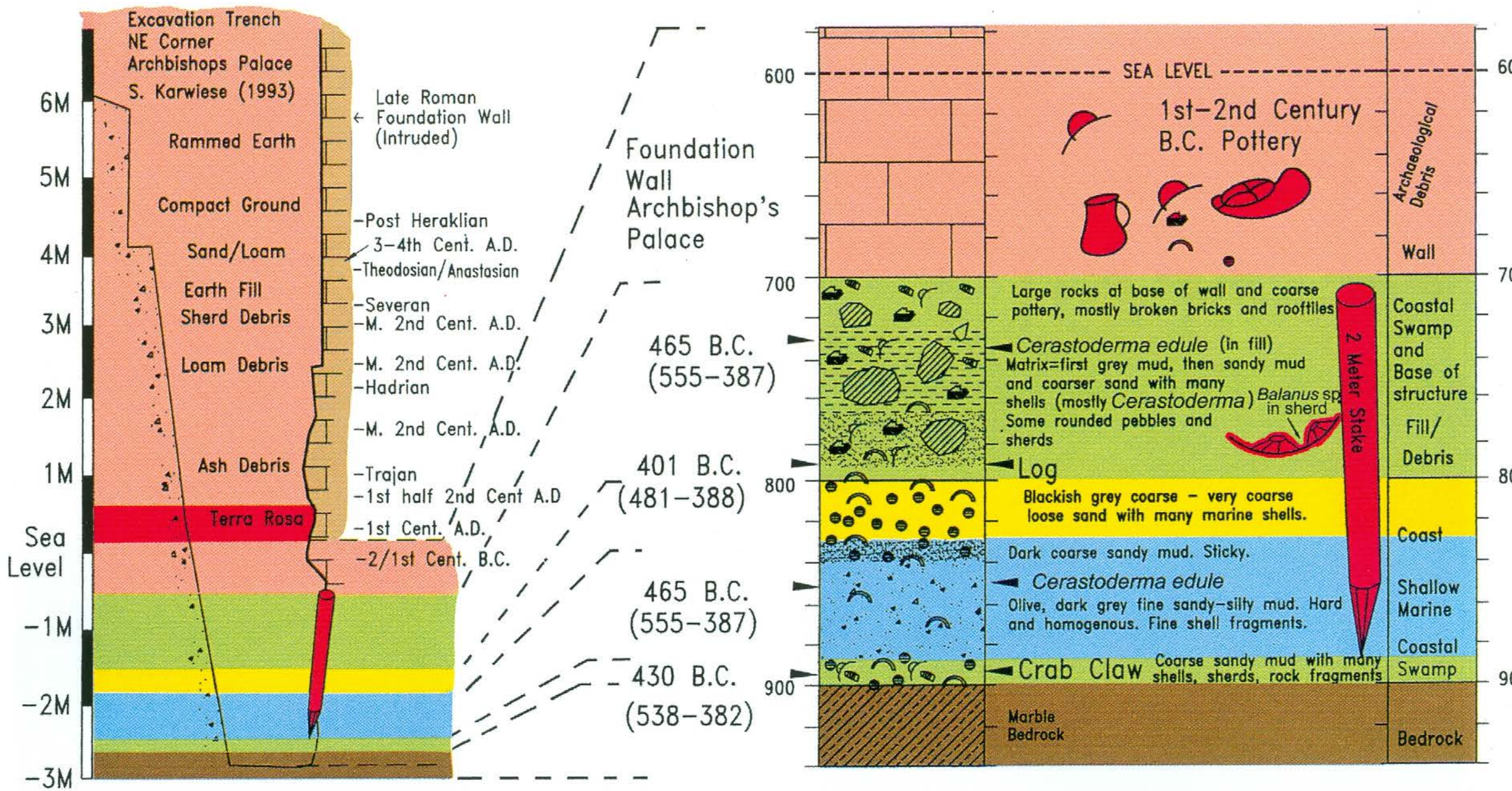
10 Paleogeographic map of the environs of Ephesus, and the Artemision in Hellenistic and the Roman Republic time – 323 BC to 0 AD. Minimum depths of water are shown at selected drill core loci. Significant amounts of sand or coarse sized fluvial sediments have not yet reached the sea in the vicinity of the prograding shorelines. Wave energy from the Aegean Sea into the Gulf of Ephesus was dampened by the shallow proximal and distal prodelta silts.

The Sacred Harbor initially adjacent to the Artemision complex, is progressively 'forced' westward by the prograding shoreline to the small embayment to the northeast of the Stadion and possibly still further westward by the 1st century AD to the area north of the Olympieion/Macellum. The land/sea interface (coastline) over the time period represented is highly irregular and varies greatly as sediment compaction and subsidence 'competes' with fluvial silt/sediment input. Offshore silt shoals, coastal swamps, lagoons (swamp ponds), and narrow river distributaries dominate the rapidly changing coastal zone.

The early Hellenistic shoreline of Lysimachus' time lay at the immediate western foot of Mount Pion with a relatively deep water harbor west of the Tetragonos Agora. Some Hellenistic harbor works are likely buried under the lower Roman city fill. We locate the destructive harbor works of Attalus II Philadelphus at location (no. 2). By-passed quiescent flanking harbors may have remained in use long after the main delta front of the Cayster River had prograded west of the lower city.

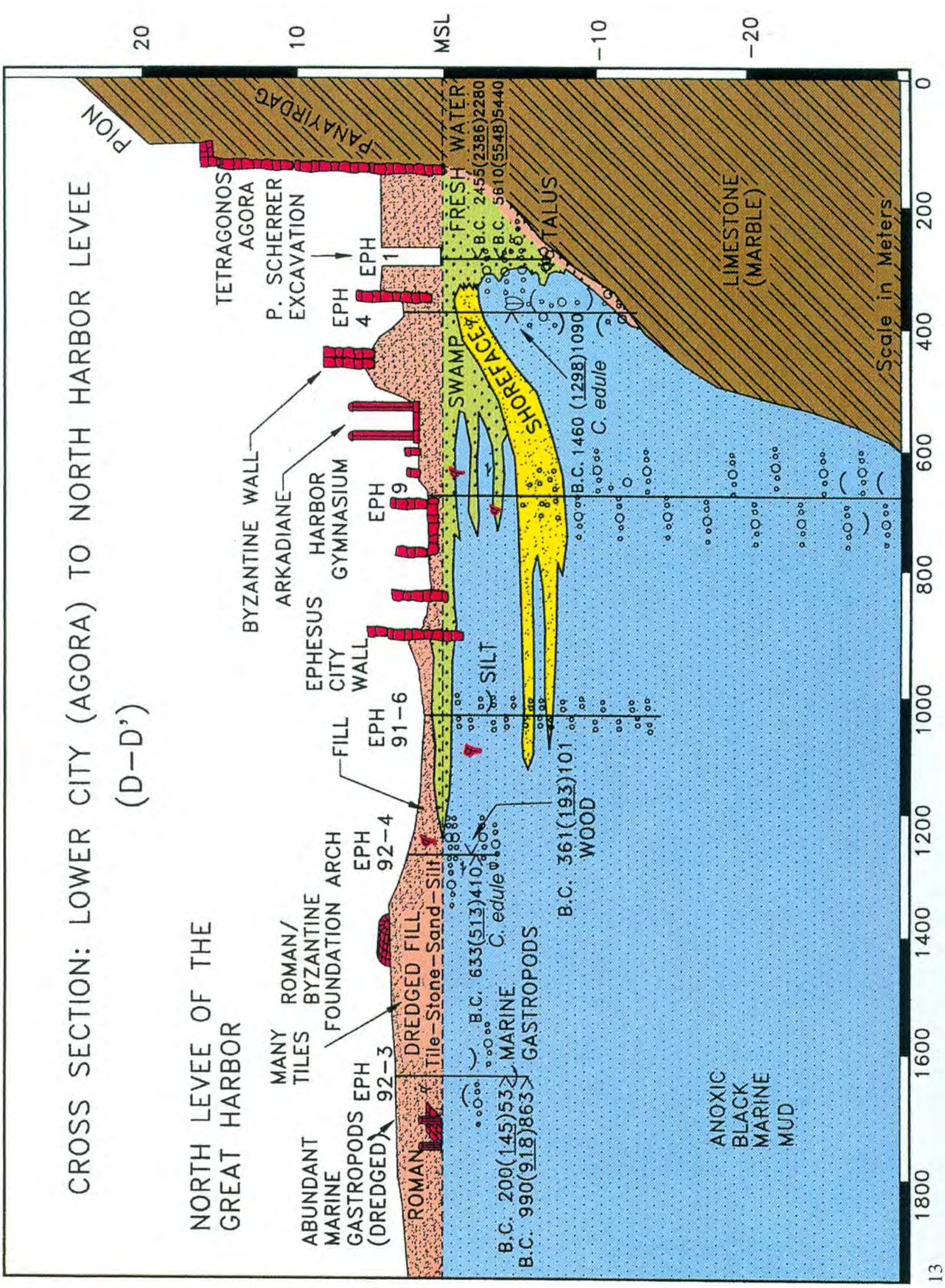


11 Geologic cross-section E–E' (see fig. 2) extending from Byzantine Archbishop's Palace across the lower city of Ephesus and the Great Harbor region to Mount Preon/Lepre Akte (Bülbüldağ). Here again, the stratigraphy encountered in our borings clearly shows that a formerly deep marine embayment (> 30 m) has been filled in with marine muds, swept into the area by the prograding Cayster River delta and people's environmental impact: harbor siltation. In borings, EPH 91-5 and 25, we identify a dredge line relating to the continuous centuries of dredging by the peoples of Ephesus in an attempt to keep the Great Harbor open to maritime shipping.


Excavation Trench
NE Corner
Archbishops Palace
S. Karwiese (1993)
Rammed Earth
Compact Ground
Sand/Loam
Earth Fill
Sherd Debris
Loam Debris
Ash Debris
Terra Rosa
Late Roman
Foundation Wall
(Intruded)
-Post Heraklian
3-4th Cent. A.D.
-Theodosian/Anastasian
-Severan
-M. 2nd Cent. A.D.
-M. 2nd Cent. A.D.
-Hadrian
-M. 2nd Cent. A.D.
-Trajan
-1st half 2nd Cent A.D
-1st Cent. A.D.
-2/1st Cent. B.C.
6M
5M
4M
3M
2M
1M
Sea
Level
-1M
-2M
-3M
Foundation
Wall
Archbishop's
Palace
465 B.C.
(555-387)
401 B.C.
(481-388)
465 B.C.
(555-387)
430 B.C.
(538-382)
600
700
800
900
SEA LEVEL
1st-2nd Century
B.C. Pottery
Archaeological
Debris
Wall
Large rocks at base of wall and coarse
pottery, mostly broken bricks and rooftiles
Cerastoderma edule (in fill)
Matrix=first grey mud, then sandy mud
and coarser sand with many
shells (mostly Cerastoderma)
Balanus sp
in sherd
Some rounded pebbles and
sherds
Log
2 Meter Stake
Coastal
Swamp
and
Base of
structure
Fill/
Debris
Blackish grey coarse - very coarse
loose sand with many marine shells.
Coast
Dark coarse sandy mud. Sticky.
Cerastoderma edule
Olive, dark grey fine sandy-silty mud. Hard
and homogenous. Fine shell fragments.
Shallow
Marine
Coastal
Swamp
Crab Claw
Coarse sandy mud with many
shells, sherds, rock fragments
Marble
Bedrock
Bedrock

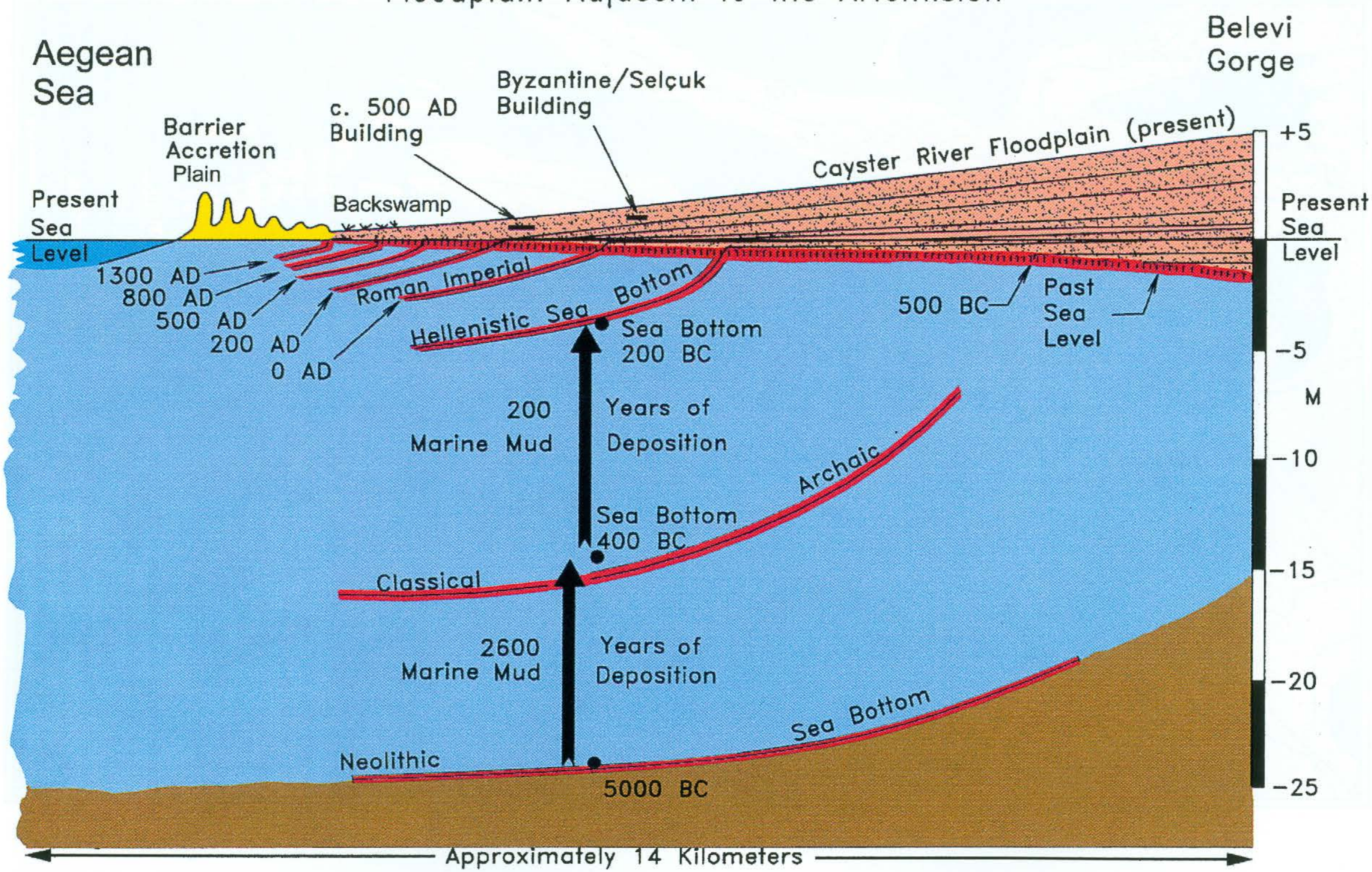
12 A schematic diagram of sediments encountered in a geologic boring from the bottom of an excavation trench by St. Karwiese (see note 27) along the northeastern wall of the Archbishop's Palace in the lower city of Ephesus. Karwiese's trench showed a continual history of debris, artifacts, etc., dating from several centuries BC until Byzantine times. These are indicated on the left side of the diagram with appropriate dates and a schematic listing of the types of sediments encountered by the archaeologists. Our geologic interpretation is shown at right, in expanded detail for the bottom 2½ m below the archaeologists' trench. This shows that a tremendous amount of fill was deposited during the time of occupancy of the city of Ephesus.

However, perhaps of equal importance is the fact that shallow marine waters extended into this region (the western base of Mount Pion [Panayırdağ]) as late as Classical times. We can specifically identify a coastal swamp and shallow marine (coastal) environments overlain by a sandy shoreline and then construction debris dumped into a coastal swamp. An interesting find was a several meter wooden stake with a sharpened point, standing in the sediments. One can speculate that the stake was driven into the beach in order to tie a rope to anchor a nearby small boat. Alternatively, if the stake is of late Roman early Byzantine time, it may have served some purpose in foundation construction. *Balanus* sp. (barnacles) attached to pottery sherds affirm the marine depositional environment of the sherds.



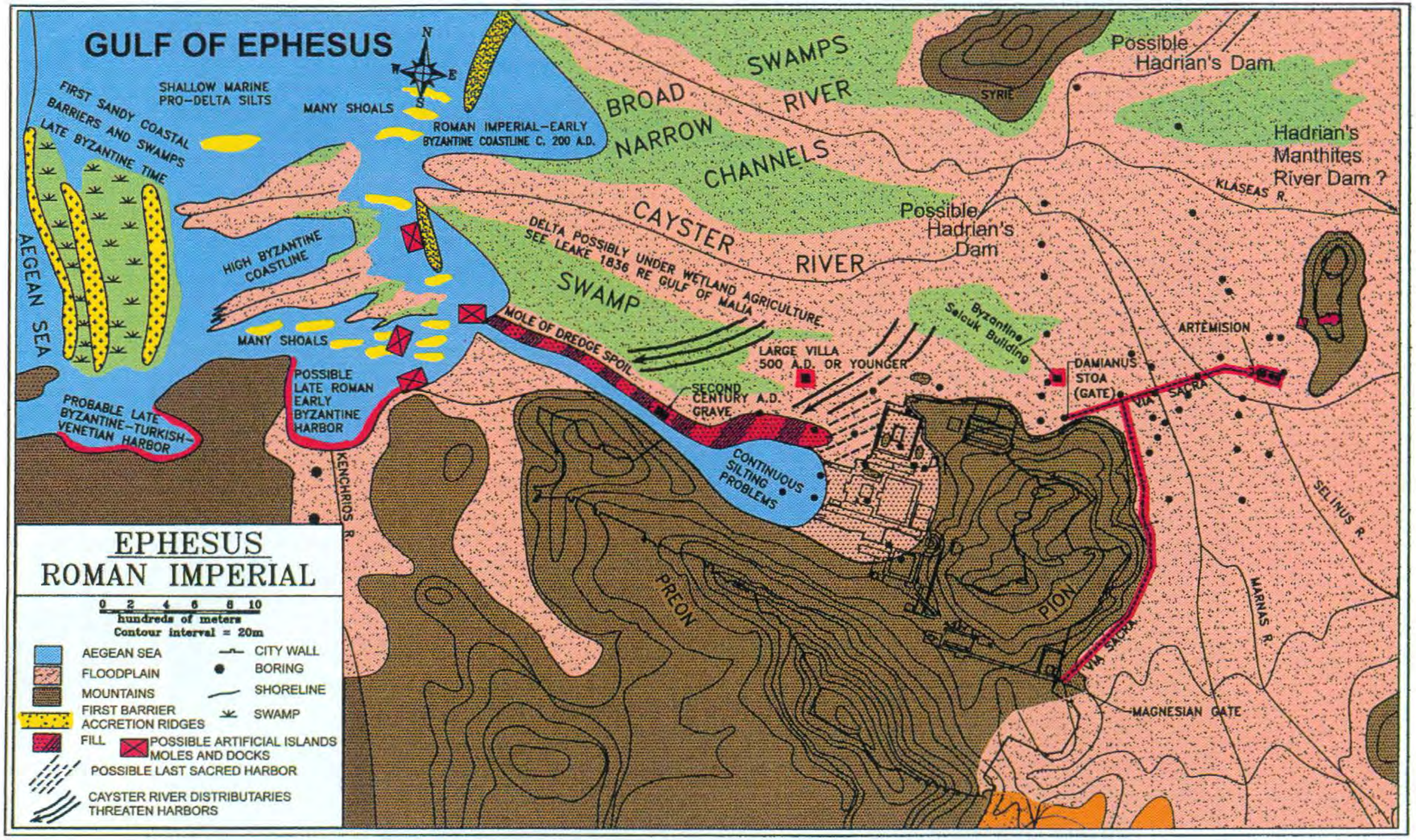
13 Geologic cross-section D–D' (see fig. 2) extending from the Tetragonos Agora excavations (P. Scherrer) of the lower city of Ephesus at the basal junction of Mount Pion (Panayırdağ) and Mount Preon/Lepre Akte (Bülbüldağ) to the northern harbor mole (barrier to the prograding delta of the ancient Cayster River). The lower city of Hellenistic and Roman times was built across an area that previously was infilled by marine silts – sediments introduced into the Gulf of Ephesus by the prograding Cayster River and probably by major infill (debris) of the shallow waters by the Hellenistic and Roman populace.

An Axial Profile of the Küçük Menderes (Cayster River) Floodplain Adjacent to the Artemision



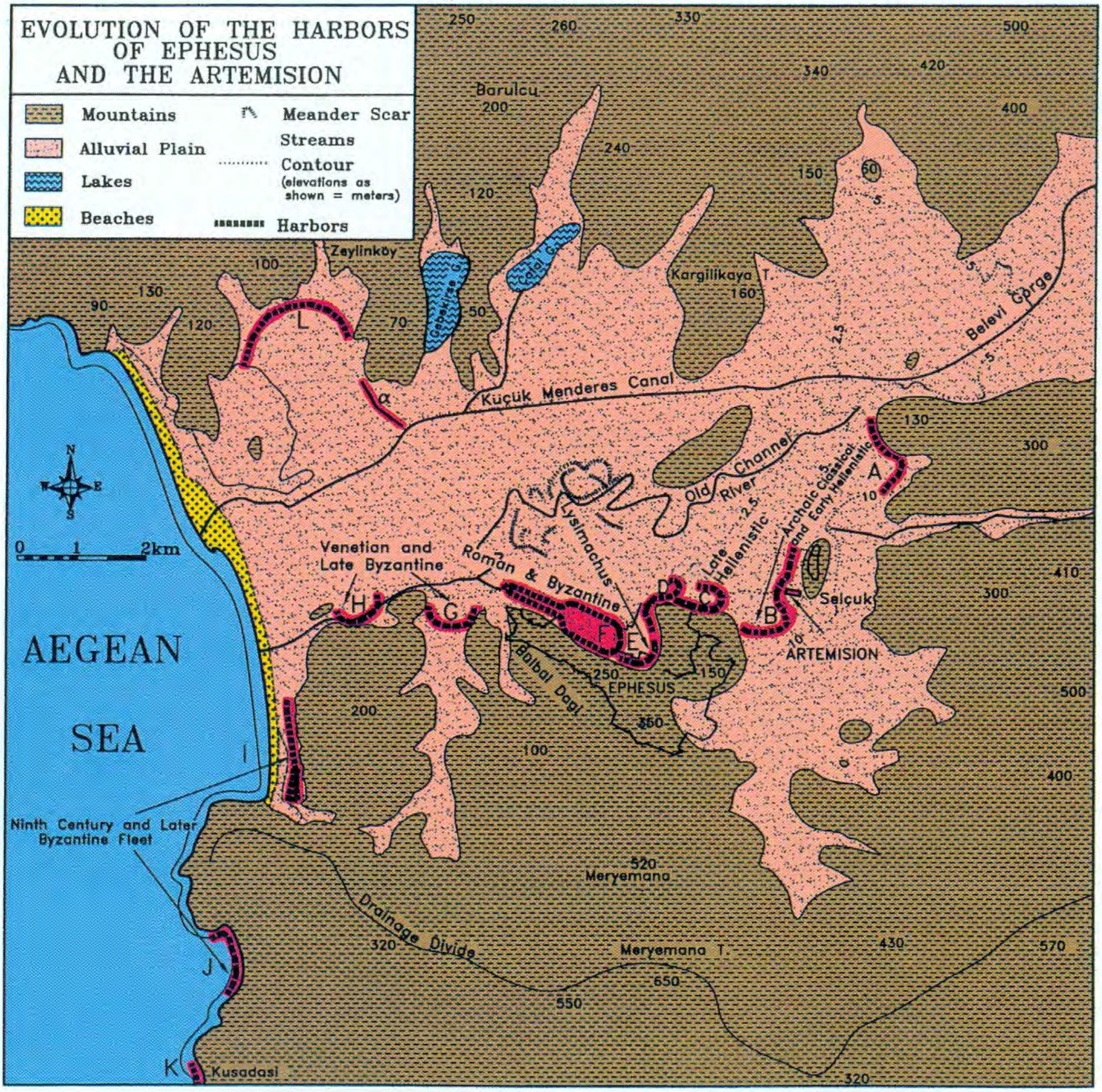
14 A conceptual sketch showing elements of sedimentary infill into the Gulf of Ephesus as the prograding and aggrading Cayster River (Küçük Menderes) delta moved ever westward, bypassing the ancient city of Ephesus and its harbors. The embayment has been infilled predominantly by muds (clay and silt) mainly derived from the deeply weathered Paleozoic mica schists and Neogene marls of the Cayster River drainage basin. The dominant depositional process throughout the Holocene epoch was that of aggrading prodelta silts (distal and proximal). These silts would have been widely redeposited by wave-incurred action across the embayment as it slowly infilled. The delta front and the shoreline edge itself was probably never in a high angle slope configuration (i. e., foreset) and may have moved rapidly across the area as the aggrading floodplain sediments prograded westward. Probably there never was a zone of shore face or foreset beds as in standard geologic models.

As exemplified by modern analogs such as that of the Spherchios River delta in the Gulf of Malia in eastern Greece, shorelines in this type of embayment often do not have sandy barriers (see fig. 17). Frequently the delta distributary channels rapidly prograde across the area in thin 'pencil-like' projections surrounded by brackish to hypersaline (shallow to ephemeral) lagoons, coastal swamps, or marshes to be then covered by alluviating/aggrading floodplain sediments. Eventually, the major channel deposits (sands and gravels) of the prograding river distributaries reach the open sea. There they are intercepted by the storm waves of the Aegean and are redistributed by littoral transport into of coastal barriers and barrier accretion plains (see fig. 1). A Byzantine/Selçuk building is in the floodplain alluvium approximately 200 m north of the 'Feigengarten excavation' (see fig. 9.). The ca. 500 AD building lies in the floodplain approximately 600 m north of the Great Harbor mole (see fig. 15).


GULF OF EPHESUS
N
E
S
W
SHALLOW MARINE PRO-DELTA SILTS
MANY SHOALS
FIRST SANDY COASTAL BARRIERS AND SWAMPS LATE BYZANTINE TIME
ROMAN IMPERIAL-EARLY BYZANTINE COASTLINE C. 200 A.D.
AEGEAN SEA
HIGH BYZANTINE COASTLINE
MANY SHOALS
BROAD
NARROW
SWAMPS
RIVER
CHANNELS
CAYSTER
RIVER
SWAMP
DELTA POSSIBLY UNDER WETLAND AGRICULTURE.
SEE LEAKE 1836 RE GULF OF MALIA
MOLE OF DREDGE SPOIL
SYRIE
Possible Hadrian's Dam
Hadrian's Manthites River Dam ?
KLASEAS R.
Possible Hadrian's Dam
Byzantine/ Selcuk Building
ARTEMISION
LARGE VILLA 500 A.D. OR YOUNGER
SECOND CENTURY A.D. GRAVE
DAMIANUS STOA (GATE)
VIA SACRA
POSSIBLE LATE ROMAN EARLY BYZANTINE HARBOR
PROBABLE LATE BYZANTINE-TURKISH-VENETIAN HARBOR
CONTINUOUS SILTING PROBLEMS
KENCHRIOS R.
PREON
PION
VIA SACRA
SELINUS R.
MARNAS R.
MAGNESIAN GATE
EPHESUS
ROMAN IMPERIAL
0 2 4 6 8 10
hundreds of meters
Contour interval = 20m
AEGEAN SEA
FLOODPLAIN
MOUNTAINS
FIRST BARRIER ACCRETION RIDGES
FILL
CITY WALL
BORING
SHORELINE
SWAMP
POSSIBLE ARTIFICIAL ISLANDS MOLES AND DOCKS
POSSIBLE LAST SACRED HARBOR
CAYSTER RIVER DISTRIBUTARIES THREATEN HARBORS

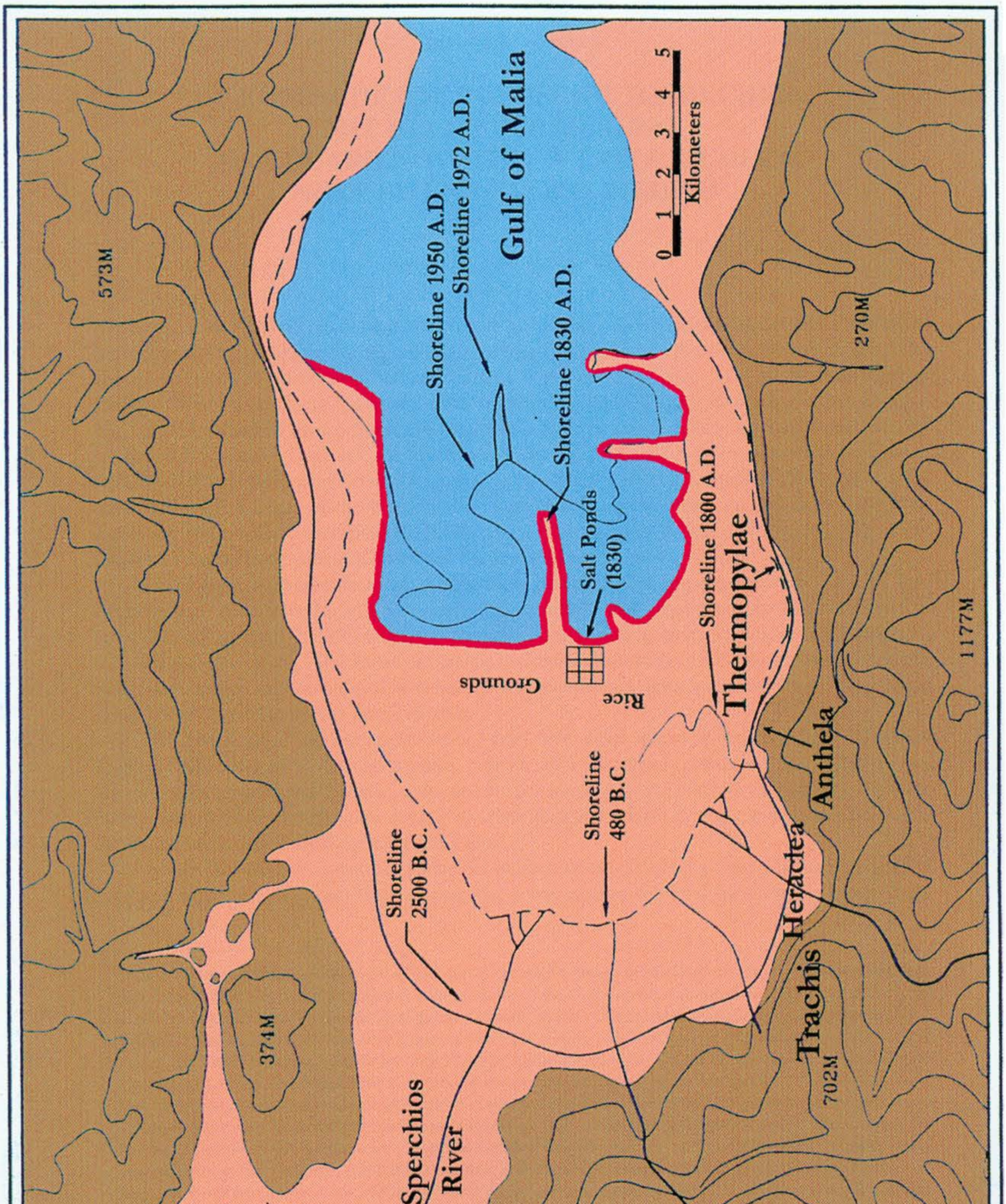
15 A paleogeomorphic map of the environs of ancient Ephesus in Roman Imperial, Byzantine, and later times. The ever-prograding coastline is shown in a schematic form from the early Roman Imperial time to late Byzantine time. As the delta prograded beyond the Great Harbor area of Ephesus, a continuing dredging effort raising the elevation of the adjacent mole or barrier to the encroaching Cayster River (Küçük Menderes) delta was made to prevent silting or infilling the Great Harbor and the long 'tube' or shipping channel. Attempts to accommodate this problem, as evidenced by the ancient literature and in some of the physiographic features that we have studied, include possible locations for artificial islands and beach off-loading sites, possibly later harbor areas, etc., as included in the discussion herein.

Emperor Hadrian's dam(s) cannot be identified. Two possibilities occur: 1) the dam was constructed to divert the Cayster River distributaries that immediately threatened the Great Harbor or 2) to the northeast of the map area (island of Syrie) in an attempt to force the Cayster River sediments in the northerly portion of the ancient Gulf of Ephesus. If the Klaseas River is the Manthites River (east end of map), then Hadrian's Manthites dam may have been constructed to stop or divert torrential deposits from reaching the Artemision complex. Note comments and analog discussions in the text showing possibilities of major agriculture potentials of lower deltas, until coastal barriers form and produce pestilential swamps (see also fig. 17).



16

16 A summation of the evolution of harbors associated with ancient Ephesus and the Artemision and later Selçuk Turk-Venetian and Genoan commercial interface times. The map shows all of the potential harbors over two millennia of time as envisaged from our research as well as interpretations made from various literature sources. A = possible earliest harbor; B = Sacred Harbor; C = late Hellenistic/early Roman Sacred Harbor; D = possible last Roman Sacred Harbor; E = Lysimachean Great Harbor; F = latest Hellenistic, Roman Republic, Roman Imperial, Byzantine Great Harbor; G = possible Panormus harbor; H = possible Late Byzantine/Selçuk harbor; I, J, K = open sea harbors; and L = Panormus harbor of R. Meriç. α = Selçuk road/viaduct to Turkish harbor. The earliest harbors (Bronze Age to Archaic time) need only to have been sheltered natural embayed areas with sandy beaches along the shores of the ancestral Gulf of Ephesus.



17

17 Variations in modern (18th to 20th century AD) and ancient shorelines of the Gulf of Malia – Spherchios River delta floodplain of eastern Greece. Adapted from Kraft et al. 1987. With mid-Holocene high sea stand, the waters of the Malian Gulf flooded the graben/embayment west to the cliffs of Trachis-Heraclea. Subsequent progradation led to the present rapidly varying protruding 'birds foot' distributary, low-lying coastal swamp along the coast, and the very shallow silt shoals of the western Gulf of Malia. W. M. Leake (see note 36) carefully mapped the low coastal plain showing a major river diversion, large area of wetland rice cultivation, and saltpan (salt production) in the pre-industrial revolution low coastal flood zone – a viable modern analog for Byzantine/Selçuk Turkish occupation of the lower Cayster delta before the coastal barriers formed (see fig. 15).

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